RULEMAKING ISSUE
(Affirmation)

November 26, 1990

SECY-90-387

For: The Commissioners

From: James M. Taylor, Executive Director for Operations

Subject: TRANSMITTAL OF REVISED PART 20

Purpose: To transmit to the Commission the corrected version of the revised Part 20 rule for final approval.

Category: Major action fo. affirmation.

Discussion: On July 30, 1990, the Secretary issued a Staff Requirements Memorandum (SRM) containing the Commission's approval for issuing the revised 10 CFR Part 20 as a final rule. The SRM contained eight areas where additions, corrections, or other changes were requested. The modified Federal Register Notice is Enclosure A to this paper. Enclosure B contains copies of the SRM and the Federal Register Notice marked to indicate where all changes have been made to Enclosure 3 (Statement), Enclosure 4 (Rule), and Enclosure 5 (Appendices) of SECY-88-315. Enclosure B also contains a marked-up version of Enclosure 6 to SECY-88-315 (listing of changes from the proposed rule) as the SRM requested that a check be performed on whether all of these changes were addressed in the statement of considerations. Changes resulting from the annotated copy of SECY-88-315 that accompanied the SRM were also made and are identified in the markup. The sections relating to the implementation date have been revised to conform with the SRM of November 20, 1990 on the Part 20 implementation date.

Enclosure C is the final Regulatory Analysis (including the flexibility analysis). Enclosure D is the final Environmental Assessment, Enclosure E is the final Backfit Analysis, Enclosure F contains the letters to congressional committees informing them of the issuance of this rule and providing copies to them, and Enclosure G is the Press Release for the press briefing announcing the issuance of the revised Part 20.

NOTE: TO BE MADE PUBLICLY AVAILABLE WHEN THE FINAL SRM IS MADE AVAILABLE

Contact:
H. T. Peterson, Jr., RES
49-23640

DF02

The revised Part 20 contains the changes to SECY-88-315 that have been identified in SECY-89-267 and SECY-90-237 in addition to those changes requested in the SRM of July 30, 1990. We have also modified the effective date to be thirty days after publication in the Federal Register, except that the information collection requirements (recordkeeping and reporting) will not be effective until publication of the OMB approval.

The modifications have been reviewed by the Part 20 Working Group and Steering Committee and the entire document has been reviewed by a technical editor. An earlier draft incorporating the SECY-89-267 changes was reviewed by staff of the Regulatory Publications Branch, DFIPS, ADM and the Information & Records Management Branch, IRMB, IRM and their suggested changes have been incorporated into the enclosed Federal Register Notice.

The extensive table of radionuclide intake and concentration limits in Appendix B was compared with a pre-publication draft of Federal Guidance Report #11 (FRP #11) which also contains derived air concentrations and annual limits for occupational exposure. Adjustments were made by NRC and EPA to both sets of tables so that they are mutually consistent. Because of this, the Statement (Preamble) endorses the use of FRP #11 for calculating doses and determining compliance with 10 CFR Part 20 occupational limits (FRP #11 does not address exposure of members of the general population).

The changes made subsequent to the July 30, 1990 Staff Requirements Memorandum are as follows (item numbers correspond to items in the SRM):

1. Replacement of the discussion of the Backfit Analysis in the statement with the revised text of the Commission's determination from staff's final backfit analysis and adding the paragraph from item #1 of the Staff Requirements Memorandum to both the FRN discussion and the final Backfit Analysis (Enclosure F).

2.(a) Modification of the effective date of the rule for NRC licensees from January 1, 1992 (SECY-88-315) to 30 days after publication, so that the January 1, 1991 codification of the existing Part 20 can be used by licensees who do not choose early implementation. The final date of implementation for NRC licensees is January 1, 1993.

2.(b) Addition of text to pages 40 and 54 to indicate that flexibility is provided for more precise dose evaluations, but this provides the same degree of health protection.

3. Modification of Section V of the Statement of Considerations (Preamble) and addition of a revised § 20.8 and a new § 20.9 (old § 20.8) to provide for early implementation of the revised Part 20 and guidance on relationship to license conditions and technical specifications based on the existing Part 20.

4. The basis of the dose design criterion for generally-licensed radioactive devices was not changed by the conforming amendments to Part 32. The design criterion remains at 10 percent of the occupational dose limit or 500 millirem per year. This design criterion is no longer equal to the dose limit for members of the general public (now 100 millirem per year). Design criteria for generally-licensed radioactive devices are being considered in connection with the reexamination of exemptions and general license conditions (See SECY-90-175 of May 14, 1990 and the Staff Requirements Memorandum of August 13, 1990).

5. The Federal Register Notice has been updated to reflect issuance of the Commission's Policy Statement on Below Regulatory Concern. These updates appear in the discussion of ongoing related activities or page 15 and in the discussion of public comments on BRC levels on page 25 of the Preamble (Statement of Considerations).

6. Staff has replaced the definition of "natural background" with "background radiation" and included residual global fallout and radon in ambient concentrations within this definition. "Global fallout" could not be encompassed within the scope of "natural background" as it is man-made. Sources of radiation considered to be "background radiation" are excluded from coverage under Part 20 (See §§ 20.1 and 20.2).

7. As noted above, quality control checks have been carried out by comparison with the July 30, 1990 SRM; with the Enclosures in SECY-88-315, especially with Enclosure 6; with Enclosure 3 of SECY-89-267; and with SECY-90-237. A marked copy of Enclosure 6 (changes from the proposed rule) is in Enclosure B.

ENCLOSURE A

FEDERAL REGISTER NOTICE

[7590-01]

NUCLEAR REGULATORY COMMISSION

10 CFR PART 20
and 10 CFR Parts 2, 19, 31, 32, 34, 35, 39, 40, 50, and 61

RIN 3150 - AA38

Standards for Protection Against Radiation

AGENCY: Nuclear Regulatory Commission.

ACTION: Final rule.

SUMMARY: The Nuclear Regulatory Commission (NRC) is revising its standards for protection against ionizing radiation. This action is necessary to incorporate updated scientific information and to reflect changes in the basic philosophy of radiation protection. The revision conforms the Commission's regulations to the Presidential Radiation Protection Guidance to Federal Agencies for Occupational Exposure and to recommendations of national and international radiation protection organizations.

EFFECTIVE DATE: This regulation becomes effective on (30 days after publication in the Federal Register). However, licensees may defer implementation of this rule until January 1, 1993. The information collection requirements are not effective until NRC publishes the OMB Clearance in the Federal Register.

ADDRESS: Copies of documents relating to the January 9, 1986 proposed rule (51 FR 1092) or this document may be examined and copied for a fee in the Commission's Public Document Room at 2120 L Street NW (Lower-Level), Washington, DC 20555.

FOR FURTHER INFORMATION CONTACT: Harold T. Peterson, Jr., Division of Regulatory Applications, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, DC 20555, Telephone (301)492-3640.

SUPPLEMENTARY INFORMATION:

I. Introduction

A. Purpose of the Revision

The purpose of this revision of 10 CFR Part 20 is to modify the NRC's radiation protection standards to reflect developments in the principles and scientific knowledge underlying radiation protection that have occurred since Part 20 was originally issued more than 30 years ago. These developments not only include updated scientific information on radionuclide uptake and metabolism, but also reflect changes in the basic philosophy of radiation protection. Incorporation of these changes will ensure that Part 20 continues to provide adequate protection of public health and safety.

It is also the purpose of this revision to implement the 1987 Presidential guidance on occupational radiation exposure (see Section II.D). The Atomic Energy Commission (AEC) and the NRC have followed past Federal radiation protection guidance, and conformance with the guidance is viewed by the Commission as being necessary to ensure that NRC licensees are using levels of protection comparable to those used by Federal agencies.

The AEC and the NRC have generally followed the basic radiation protection recommendations of the International Commission on Radiological Protection (ICRP) and its U.S. counterpart, the National Council on Radiation Protection and Measurements (NCRP), in formulating basic radiation protection standards. In 1977, ICRP issued revised recommendations for a system of radiation dose limitation. This system, which was described in ICRP Publication 26,[1] introduced a number of significant modifications to existing concepts and recommendations of the ICRP and the NCRP that are now being incorporated in the NRC regulations. In particular, this revision of Part 20 puts into practice

---

1 Recommendations of the International Commission on Radiological Protection, January 13, 1977, ICRP Publication No. 26 (1977). (Available for sale from Pergamon Press, Inc., Elmsford, NY 10523.)

recommendations from ICRP Publication 26 and subsequent ICRP publications. The Federal radiation protection guidance signed by the President on January 20, 1987, is also based upon the ICRP 1977 recommendations in ICRP Publication 26.

In adopting the basic tenets of the ICRP system of dose limitation, the Nuclear Regulatory Commission recognizes that, when application of the dose limits is combined with the principle of keeping all radiation exposures "as low as is reasonably achievable," the degree of protection could be significantly greater than from relying upon the dose limits alone.

B. Fundamental Radiation Protection Principles

The radiation protection standards in this part are based upon the assumptions that--

(1) Within the range of exposure conditions usually encountered in radiation work, there is a linear relationship, without threshold, between dose and probability of stochastic health effects (such as latent cancer and genetic effects) occurring;

(2) The severity of each type of stochastic health effect is independent of dose; and

(3) Nonstochastic (nonrandom) radiation-induced health effects can be prevented by limiting exposures so that doses are below the thresholds for their induction.

The first assumption, the linear nonthreshold dose-effect relationship, implies that the potential health risk is proportional to the dose received and that there is an incremental health risk associated with even very small doses, even radiation doses much smaller than doses received from naturally occurring radiation sources. These health risks, such as cancer, are termed stochastic because they are statistical in nature; i.e., for a given level of dose, not every person exposed would exhibit the effect. The second assumption means that when a stochastic effect is induced, the severity of the effect is not related to the radiation dose received. The third assumption implies that there are effects, termed nonstochastic effects, for which there is an apparent threshold; i.e., a dose level below which the effect is unlikely to occur. An

example of a nonstochastic effect is the formation of radiation-induced cataracts of the eyes.

The above assumptions are necessary because it is generally impossible to determine whether or not there are any increases in the incidence of disease at very low doses and low dose rates, particularly in the range of doses to members of the general public resulting from NRC-licensed activities. It is firmly established, both from animal studies and human epidemiological studies (such as those of the radium dial painters, radiologists, and the atomic bomb survivors) that there is an increased incidence of certain cancers associated with radiation exposure at high doses and high dose rates. However, whether these effects occur at very low doses and, if they occur, whether their occurrence is linearly proportional to dose are not firmly established. This creates considerable uncertainty in the magnitude of the risk at low doses and low dose rates. There is no clear human evidence of radiation-induced genetic damage to the children of irradiated parents. Such effects are inferred from studies of mice and nonmammalian species (e.g., fruit flies).

In the absence of convincing evidence that there is a dose threshold or that low levels of radiation are beneficial, the Commission believes that the assumptions regarding a linear nonthreshold dose-effect model for cancers and genetic effects and the existence of thresholds only for certain nonstochastic effects remain appropriate for formulating radiation protection standards and planning radiation protection programs.

C. Background

Standards for radiation protection were originally issued by the former AEC in the late 1950s (22 FR 548, January 29, 1957) and republished in 1960. These standards have been modified since that time by a series of amendments relating to specific issues; however, no complete revision of Part 20 has been made since the original standards were issued.

The NRC issued an Advance Notice of Proposed Rulemaking (ANPRM) in the Federal Register of March 20, 1980 (45 FR 18023). This ANPRM requested comments

on possible topics that should be revised in a proposed revision of Part 20. The responses received to this announcement were considered in the formulation of the proposed revision.

During the development of this rule, early comments from licensees, labor unions, public interest groups, other Federal agencies, and scientific organizations were solicited, discussed, and considered in formulating the proposed rule. In addition, the NRC staff has benefited from its participation in several public meetings held by the Environmental Protection Agency (EPA) in connection with the guidance for occupational radiation exposure. The revised Part 20 and the Federal guidance on occupational exposure were developed in parallel and are both based primarily on the ICRP recommendations. The comments made in these EPA-sponsored meetings and those received by EPA on the draft guidance published by EPA in the January 23, 1981 Federal Register (46 FR 7836) were reviewed by the NRC staff and considered in preparing the proposed Part 20.

The NRC published the proposed revision of the 10 CFR Part 20 rule in the January 9, 1986 Federal Register (51 FR 1092). More than 800 sets of public comments were received on the proposed revision. The public comments on the proposed revision were categorized, analyzed, and taken into account in developing the final rule. The principal public comments and the NRC staff responses to them are discussed in Section VI.

II. Developments Since the Proposed Revision Was Issued

A. ICRP 1985 Paris Meeting

In March 1985, the International Commission on Radiological Protection (ICRP) held a meeting in Paris, France, to review the work of the various ICRP task groups and committees. One of the outcomes of this meeting was an ICRP statement[2] that the ICRP intended the principal dose limit for members of

---

2 International Commission on Radiological Protection, "Statement from the 1985 Paris Meeting of the [ICRP]," British Journal of Radiology, Vol. 58, page 910: 1985; also Health Physics, 48(6): 828-829 (June 1985)

the general public to be 1 millisievert (100 millirems) in a year, rather than 5 millisieverts (500 millirems). This clarification has been taken into account for the limits adopted for members of the public in the final rule and is discussed more fully in the discussion on § 20.301.

A second recommendation of the ICRP made at that time concerned the appropriate quality factor for converting the absorbed dose from neutrons (in rads or grays) to a dose equivalent (in rems or sieverts). The ICRP statement recommended increasing the quality factor for high-energy neutrons by a factor of 2. The quality factor for fast neutrons, for example, would be increased from 10 to 20. This change has the effect of doubling the apparent biological effectiveness of high-energy neutrons. For reasons explained in the discussion of quality factors (see the discussion of § 20.4), the NRC has not adopted this recommendation in this revision of Part 20.

B. ICRP 1987 Washington Meeting

The primary focus of the statement issued by the ICRP following the 1987 meeting in Washington[3] was ICRP Publication No. 48.[4] That publication discussed higher transfer factors for transport of certain transuranic elements across the intestinal walls. These higher fractional absorption factors have been incorporated in revisions to the annual limits on intake (ALIs) and derived air concentrations (DACs) in Appendix B of the final rule. The changes resulting from the use of these revised factors would not change either the ingestion or inhalation ALIs for plutonium in the oxide or nitrate forms, but would lower the ALIs for other compounds or mixtures by a factor of 10. The transfer factor for the gut transfer of neptunium was found to be an order of magnitude lower than the value used in ICRP-30 and, consequently, the ingestion ALI can be increased by almost an order of magnitude. The transfer factors for

---

3 International Commission on Radiological Protection, "ICRP Statement from 1987 Washington Meeting," Health Physics 53(3): 335-342 (1987).

4 International Commission on Radiological Protection, "The Metabolism of Plutonium and Related Elements," ICRP Publication No. 48 (Available for sale from Pergamon Press, Inc., Elmsford, NY 10523.) (1986).

americium, curium, and californium were found to be a factor of 2 higher than the ICRP-30 value so the ingestion ALIs are reduced by a factor of 2. Parameters applicable to inhalation ALIs and DACs are less affected than the ingestion ALIs as the transfer from the gastrointestinal (GI) tract to the blood for these radionuclides generally is less significant than transfer from the lung to the blood.

C. ICRP 1987 Como Meeting

Following its 1987 meeting in Como, Italy, the ICRP issued a statement[5] that reviewed the existing estimates of the biological risks of ionizing radiation and, in particular, the preliminary data from the reanalysis of the Hiroshima-Nagasaki atomic bomb followup studies. Reanalysis of these data indicated that the risks from gamma radiation are approximately a factor of 2 higher than previous estimates for the general population and are also higher, but by a smaller factor, for workers. The ICRP concluded in 1987 that this information alone was "not considered sufficient at that time to warrant a change in the dose limits for occupational exposure and, for the general population, the increase in risk indicated by the new data is not considered to require an immediate change in the recommended dose limits, following the reduction by the ICRP (in 1985) in the principal limit from 5 to 1 mSv in a year (from sources other than medical and natural background radiation)." The ICRP also noted that the potential higher risks indicated by the reanalysis of the atomic bomb data should not be a major consideration as the dose limits should not be of primary importance in controlling doses if the principle of keeping radiation exposures "as low as is reasonably achievable" is being practiced. This position has since been modified by the ICRP 1990 Statement (see Section II.I below).

D. Federal Radiation Protection Guidance on Occupational Exposure

On January 20, 1987, President Reagan approved revised guidance to Federal agencies for occupational radiation protection. This guidance, which was

5 International Commission on Radiological Protection, "Statement from the 1987 Como Meeting of the [ICRP]," Health Physics, 54(1): 125-132 (1988).

published in the Federal Register (52 FR 2822; January 27, 1987), generally adopts the philosophy and methodology of ICRP Publications 26 and 30. The Part 20 revision was developed in parallel with the development of the guidance. Because of this parallel development, the proposed Part 20 rule conformed with the draft Federal guidance available at the time the proposed Part 20 rule was written. However, because of changes made to both the draft guidance and the draft Part 20 revision, there were a few differences between the guidance in its final published form and the proposed Part 20 revision. As discussed in the respective sections below, changes to the proposed rule have been made in order to implement the final version of the Federal guidance.

E. NCRP Report No. 91

On June 1, 1987, the National Council on Radiation Protection and Measurements (NCRP) issued a report[6] containing updated NCRP recommendations for radiation protection limits. These recommendations replace recommendations published in 1971. The majority of these recommendations are in accord with the 1977 recommendations of the ICRP and, consequently, were already reflected in the proposed Part 20 rule. There are, however, several NCRP recommendations that were not in the ICRP-26 recommendations. These NCRP recommendations are:

(1) A general "guideline" that the cumulative effective dose equivalent to a worker should not exceed 1 times the worker's age in years; i.e., 1 x N instead of the former 5(N - 18) formula;

(2) Use of committed effective dose equivalent for planning purposes and the use of annual (rather than committed) doses for post-(internal) exposure control;

---

6 National Council on Radiation Protection and Measurements (NCRP), "Recommendations on Limits for Exposure to Ionizing Radiation," NCRP Report No. 91 (June 1, 1987). (Available for sale from the NCRP, 7910 Woodmont Avenue, Suite 800, Bethesda, MD 20814-3095.)

(3) A monthly dose limit as well as a limit on total gestation dose to the embryo/fetus;

(4) Adoption of a 0.1-rem (1 mSv) effective dose equivalent limit for exposure of the general public with the condition that the "site operator" assess the total exposure to the most exposed individual if estimated or measured exposures exceed 25 percent of this limit (25 millirems or 0.25 mSv per year);

(5) The use of "reference levels" set up by the radiation user below the regulatory limits;

(6) A Negligible Individual Risk Level of 1 millirem (0.01 mSv) per year. This level is the "...average annual excess risk of fatal health effects attributable to irradiation, below which further effort to reduce radiation exposure to the individual is unwarranted" (NCRP No. 91, p. 43).

These NCRP recommendations were issued after publication of the proposed Part 20 rule and, consequently, there has not been an opportunity for public comment on them. For this reason, these NCRP recommendations are not being adopted in the revised Part 20 rule at this time.

F. The 1988 Report of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR-88)

The United Nations Scientific Committee on the Effects of Atomic Radiation has analyzed data on the sources and effects of atomic radiation and published a series of reports containing summaries of the sources of radiation, the doses received by workers and members of the general public from these sources, and an analysis of the potential health risks from exposure to ionizing radiation.

The latest report in this series is the 1988 report. The 1988 report[7] contains more recent information on the health risks of ionizing radiation determined from a reevaluation of the data on the survivors of the Hiroshima-Nagasaki atomic bombings. Based upon these data, the radiation risk at high doses and high dose rates is estimated to be 7.1×10^{-4} fatal health effects per rad (0.071 effects per gray). For estimating the risk from radiation doses below 100 rads, the UNSCEAR report recommended that a dose rate reduction factor be applied to account for the reduced effectiveness of lower doses and lower dose rates. This would lead to an estimated risk of fatality of between (0.7 to 3.5) $\times 10^{-4}$ health effects per rad for low doses such as those encountered in routine occupational exposure and the even lower doses that might be received by members of the general public from NRC- (or Agreement State) licensed activities. The fatal cancer risk value associated with the 1977 ICRP recommendations,[1] is 1.25×10^{-4} (the proposed Part 20 rule, 51 FR 1102, January 9, 1986) so that the risks as estimated by the 1988 UNSCEAR report for low doses are between 0.6 to 2.8 times higher than the earlier ICRP estimate. The implications of the increased risk are discussed in Section II.I.

G. The 1988 Report of the National Academy of Sciences' Committee on the Biological Effects of Ionizing Radiation (BEIR-IV)[8]

The 1988 BEIR-IV report supplements the 1980 BEIR-III report by providing a more detailed analysis of the risks from internal alpha-emitting radionuclides to complement the emphasis of the BEIR-III report on gamma and beta radiation. Revised risk estimates are given for intakes of radon, radium, polonium, thorium, uranium, and higher transuranic elements (e.g., plutonium).

---

7 United Nations Scientific Committee on the Effects of Ionizing Radiation (UNSCEAR), "Sources, Effects and Risks of Ionizing Radiation, 1988 Report to the General Assembly, Sales Section, United Nations, NY 10017 (1988)

8 National Academy of Sciences-National Research Council, Committee on the Biological Effects of Ionizing Radiation "Health Risks of Radon and Other Internally Deposited Alpha-Emitters, (BEIR-IV)," National Research Council, National Academy Press, Washington, DC 20418 (1988).

The radionuclide given the greatest emphasis in the BEIR-IV report is radon (radon-222), the gaseous decay product of radium-226. The radon dose conversion factor in the BEIR-IV report for exposure conditions representative of those of the general public is consistent with the value used to derive the airborne effluent concentration limit for radon-222 in Appendix B, Table 2 of the revised 10 CFR Part 20.

H. The 1990 Report of the National Academy of Sciences' Committee on the Biological Effects of Ionizing Radiation (BEIR-V)[9]

The BEIR-V report is another comprehensive reevaluation of the health risks of radiation exposure based upon the revised dose estimates for the survivors of the atomic bombings of Hiroshima and Nagasaki. The BEIR-V report gives risk estimates for leukemia and non-leukemia (solid cancers) that are about two to five times higher than the estimates in the 1980 BEIR-III report. The BEIR-V report gives the following factors as the principal reasons for this increase: (1) use of different dose-response and risk projection models, (2) revised estimates of the doses to the individual survivors of the atomic bombings in Japan, and (3) improved epidemiological data from additional years of followup studies since the BEIR-III was completed in 1980.

The BEIR-V Committee uses the linear dose response model and the relative risk projection model to extrapolate the fatal tumor risk to future periods. The relative risk projection model assumes the risk to be proportional to the natural cancer incidence, which generally increases with age. Because of this dependence on age, the relative risk model generally predicts higher future (lifetime) risks than the absolute risk model which employs a constant added risk per year with increasing age. Estimates are given of the risk as a function of the time since the exposure occurred and the age and sex of the exposed person. The BEIR-V report, like the UNSCEAR-88 report, indicates that

---

9 National Academy of Sciences-National Research Council, Committee on the Biological Effects of Ionizing Radiation, "Health Effects of Exposure to Low Levels of Ionizing Radiation (BEIR-V)," National Research Council, National Academy Press, Washington, DC 20418 (1990).

a reduction factor should be applied to the risk estimates derived from high doses and dose rates in order to apply them to low dose and low dose-rate situations. Although neither the BEIR-V report nor the UNSCEAR-88 report recommends a specific value for this factor, both reports indicate that this factor should be greater than 2 (larger reduction factors would give a lower risk per unit dose). Assuming a factor of 2 reduction in the risk estimates derived from high doses and high dose rates, BEIR-V would give a lifetime risk of a radiation-induced cancer fatality of about 4×10^{-4} fatal cancers/rem (0.04 per sievert) for workers and 5×10^{-4} per rem (0.05 per sievert) for the general population, the higher value for the public being associated with the higher sensitivity and the longer period of elevated risk associated with the younger ages present in the general population. The value of 5×10^{-4} is three times as large as the recommended value in the 1980 BEIR-III report and four times as large as the estimate in the 1977 ICRP-26[1] report (see Section II.F).

The BEIR-V report also summarized the data on the frequency of severe mental retardation found in the children of Hiroshima and Nagasaki atomic bomb survivors. These children were exposed in utero at gestational ages of 8-15 weeks and the risk of severe mental retardation during this period is about 4×10^{-3} per rem with less of a risk at other gestational ages.

The estimates of genetic effects to the offspring of irradiated individuals remained similar to those in the 1972 BEIR-I and 1980 BEIR-III reports. As radiation-induced inherited abnormalities have not been observed directly in humans, estimates of genetic effects have been based primarily upon experimental studies with mice. These studies suggest that it would take a dose of about 100 rads to double the natural frequency of genetically transmitted diseases.

I. ICRP 1990 Recommendations

On June 22, 1990, the International Commission on Radiological Protection issued a press release indicating that it would issue revised recommendations for radiation protection based upon the newer studies of radiation risks (such as those described in Sections F, G, and H above). The press release indicated

that the ICRP would recommend a reduction in the occupational dose limit from an equivalent of 5 rems per year to an average of 2 rems per year with some allowance for year-to-year flexibility. The ICRP dose limit for long-term exposure of members of the general public would remain equivalent to the level adopted in this revision of Part 20, 0.1 rem per year.

The Nuclear Regulatory Commission does not believe that additional reductions in the dose limits are urgently required by the latest radiation risk estimates. Few individuals in either the work force or in the general public are exposed at or near the limits, and most of these will not be exposed at such levels over long periods of time. Due to the practice of ALARA ("as low as is reasonably achievable"), the average radiation dose to occupationally exposed individuals is well below the limits in either the existing or revised Part 20 and also below the changes being considered by the ICRP. For example, in 1987 about 97 percent of the workers in nuclear power plants, industrial radiography, reactor fuel fabrication, and radioisotope manufacturing, four of the industries having the highest potential for occupational radiation exposures, were below an annual dose of 2 rems so that an immediate reduction in the occupational dose limits would result in only a small reduction in the population dose and in the potential health impact. Although the risk per unit dose is higher than previously thought, individual annual exposures averaged over a lifetime in the highest exposed groups in the working population appear to be about 2-3 rems per year (50-60% of the 5-rem annual limit). Therefore, a factor of 2 increase in the risk per unit dose would result in estimated potential risks associated with actual lifetime exposures that are comparable to the previous risk estimate applied to an assumed lifetime exposure of 5 rems per year.

As a result of the application of the ALARA philosophy to effluent release standards in Appendix I to 10 CFR Part 50 for nuclear power reactors and EPA's 40 CFR Part 190 for the uranium fuel cycle, doses from radioactive effluents from fuel cycle facilities are already much less than the 0.1 rem per year standard in the revised Part 20. The 0.1 rem per year remains as the level recommended by the ICRP for protection of the general public.

Until the final ICRP recommendations are published, and the need for further revisions in NRC standards established, the Commission believes it would be advisable to proceed with the promulgation of the proposed dose limits, rather than deferring the dose reductions that are already associated with the revised Part 20 rule. The Commission will carefully review the final recommendations of the International Commission on Radiological Protection, the comments of the scientific community and others on these recommendations, and the ICRP response to these comments. In addition, the Commission staff will review the recommendations of other expert bodies, such as the National Council on Radiation Protection and Measurements, and participate in the deliberations of the U.S. Committee on Radiation Research and Policy Coordination and any interagency task force convened by the Environmental Protection Agency to consider revised Federal radiation guidance. Any future reductions in the dose limits by the Commission would be the subject of a future rulemaking proceeding.

III. Issues Being Resolved Separately

As noted in the above discussion. there are several areas where the Commission believes a better scientific consensus is needed before adopting values different from those in the present Part 20. There are also several areas where issues raised in the public comments (see Section V) are being resolved in other NRC rulemaking proceedings because of either their scope, complexity, or timing. The following issues are being or will be resolved in other NRC rulemaking proceedings:

(1) Establishment of "Below Regulatory Concern (BRC)" levels (related to de minimis levels and a negligible level of risk). On June 27, 1990, the Commission announced the issuance of a policy statement on Below Regulatory Concern, which was subsequently published in the Federal Register on July 3, 1990 (55 FR 27522). This policy statement establishes the framework for the Commission to formulate rules and licensing decisions to exempt certain practices involving small quantities of radioactive materials from some or all regulatory controls. The BRC policy statement sets forth criteria for protection of both individuals (individual dose criteria) and population groups (a collective dose criterion).

(2) Limits for decommissioning of nuclear facilities and for residual radioactive contamination. This is being actively pursued by the NRC staff by developing criteria for residual contamination of soils and structures, which is one aspect of the implementation of the Below Regulatory Concern policy, and by NRC staff participation on an EPA Interagency Task Force on Residual Radioactivity.

(3) Limits and calculational procedures for dealing with the "hot particle" issue (small particles found in nuclear reactors that, because of their high activity and small size, produce high localized doses to skin). The NRC notes that the National Council on Radiation Protection and Measurements (NCRP) has recently issued new recommendations regarding "hot particles" in NCRP Report No. 106, "Limit for Exposure to 'Hot Particles' On the Skin," December 31, 1989. A modified NRC enforcement policy statement with regard to the "hot particle issue" was published in the July 31, 1990 Federal Register (55 FR 31113). The NCRP report, together with a forthcoming ICRP report on the biological effects of skin irradiation and other technical analyses, will be considered in a future rulemaking to set limits for skin irradiation.

(4) Modification of NRC incident notification requirements. A modification of the incident notification requirements was issued for public comment on May 14, 1990 (55 FR 19890). If this proposal is adopted as a final rule, it would modify both the existing Part 20 and this revision.

(5) Publication of a separate rule for large irradiators. A new Part 36 is being proposed for public comment. The detailed requirements for irradiators presently in the revised Part 20 (§ 20.603) will eventually be deleted and replaced by the provisions incorporated in the new Part 36.

There are also additional areas where the scientific basis is not yet resolved sufficiently to justify a change from current practice. These two areas require better scientific consensus on the appropriate position: (1) The need for and impact of a lifetime cumulative dose limit of 1 rem per year of age and (2) quality

factors, especially for neutrons, low-energy beta-emitters, and high-energy gamma photons. These issues will be reconsidered as consensus positions are reached by the scientific community.

IV. Need for Additional Regulatory Guidance

The Commission recognizes that the incorporation of many new concepts into Part 20 will require additional guidance and explanation on their application to practical problems in radiation protection. The Commission also notes the desirability of having such additional guidance available at the same time that the final rule is issued in effective form. However, it was impractical, both for reasons of scheduling and availability of resources, for these guides to be developed concurrently with Part 20. Some of the regulatory guides being developed or revised to assist in the implementation of the revised Part 20 are:

(1) Content of Radiation Protection Programs at Nuclear Power Plants;

(2) Interpretation of Bioassay Measurements (Draft Regulatory Guide 8.9, Revision 1),

(3) Criteria and Procedures for Summation of Internal and External Occupational Doses,

(4) Acceptable Criteria for Planned Special Exposures and for Satisfying Documentation Requirements;

(5) Methods and Parameters for Calculating the Dose to the Embryo/Fetus;

(6) Instructions for Recording and Reporting Occupational Radiation Exposures (includes NRC Forms 4 and 5).

The Commission has instructed the staff to have these and other draft guides published for public comment early in 1991.

V. Implementation and Existing License Conditions

Section 20.8 of the rule provides that NRC licensees must implement the Part 20 rule on or before January 1, 1993. Licensees that adopt the provisions of this rule prior to the required implementation date are required to notify the NRC. Early implementation may benefit applicants for new licenses or license renewals as they could avoid having to adopt and implement one version of Part 20 for only a short period of time prior to the required implementation date of this revision. Licensees choosing early implementation must adopt the entire revised Part 20. Compliance will be required with the version of 10 CFR Part 20 codified in the Code of Federal Regulations on January 1, 1991 until January 1, 1993, or until the licensee notifies the Commission of early implementation of the revised Part 20.

License conditions and reactor technical specifications may contain citations to portions of the existing 10 CFR Part 20. After adoption of the revised Part 20 by the licensee or after January 1, 1993, the applicable section of the revised Part 20 that corresponds to the same topic should be used in place of any section of the Part 20 in effect on or before January 1, 1991 that is cited in the technical specifications or license conditions. When there is no corresponding section in the revised Part 20 to these cited provisions, the current license condition based on the Part 20 in effect on or before January 1, 1991 shall remain in force until there is a technical specification change, or license amendment or renewal. If a license condition or technical specification exempted a licensee from a provision of Part 20, it will be assumed to also exempt the licensee from the applicable provision of the revised Part 20. If the license condition or technical specification is more restrictive than the revised Part 20, it shall remain in force until it is modified by a technical specification change or license amendment or renewal.

The NRC will issue a regulatory guide that provides the section and paragraph identifiers in the revised Part 20 and the corresponding sections or paragraphs in the earlier Part 20. This document will issued shortly after the publication of this rule and will enable licensees to locate sections of the revised Part 20 that correspond to sections of the earlier Part 20 cited in license conditions and technical specifications.

VI. Summary of Public Comments and Changes from Proposed Rule

The purpose of this section is to respond to comments raised on the proposed rule and to explain and highlight the changes made to the proposed rule. This section presents, for each paragraph or section of the rule, the principal public comments on the proposed rule, an NRC staff response to the comments (where appropriate), and a summary of the principal changes that were made to the proposed rule. This section has been arranged so that it corresponds to the structure of the rule. Although it follows the format of the final rule, the following text is not intended to create any additional requirement not already in the regulatory text.

Subpart A -- General Provisions

Section 20.1 Purpose.

Final Rule: A new sentence was added to convey the intent of the former § 20.9 in the proposed rule (which has been removed) that the regulations in Part 20 should not hinder a licensee's actions to protect health and safety in the event of an emergency. It is the Commission's intent that the regulations be observed to the extent practicable during emergencies, but that conformance with the regulations should not hinder any actions that are necessary to protect public health and safety such as lifesaving or maintaining confinement of radioactive materials.

In this regard, the Commission notes that the Federal guidance on occupational radiation protection states that those dose standards only apply to normal operating conditions. The Commission believes that the dose limits for normal operation should remain the primary guidelines in emergencies. However, the Commission also recognizes that, in an emergency, operations that do not conform to the regulations may have to be carried out to achieve the high-priority tasks of worker, public, and facility protection. The purpose of the addition to this section is to assure licensees that their first priority should be to carry out those actions that are necessary to protect workers and the public

from radiation exposure, to perform lifesaving activities, to prevent or limit the spread of radioactive contamination or the release of radioactive materials to the environment, and to preserve an adequate margin of safety. In evaluating any ensuing violations and their severity, the Commission will consider on a case-by-case basis any extenuating circumstances.

Section 20.2 Scope.

Final Rule: The statement of scope remains essentially the same as in the proposed rule except that "background radiation" has replaced "natural background." This change was made to include residual global fallout and ambient radon levels within the definition of "background."

Section 20.3 Definitions.

General: Because of the large number of comments that dealt primarily with wording changes or that questioned the need for or the use of a particular definition, the individual comments will not be discussed separately. However, these comments did result in substantial revisions to many of the definitions that appeared in the proposed rule. Those definitions that were added, modified, or deleted as a result of the public comments are listed below.

Comment: Differentiation among different kinds of dose equivalents. The potential for confusion among different dose equivalents was noted. Commenters noted that effective dose equivalents, committed effective dose equivalents, and doses to the lens of eye, skin, or extremities were all expressed in units of rems or sieverts and may be difficult to distinguish from one another.

Response: In the final rule the NRC staff has applied unique names for these previously undesignated quantities including: eye dose equivalent, shallow-dose equivalent (skin), shallow-dose equivalent (extremities), and total effective dose equivalent. The ICRP did not give these quantities specific names. The use of characteristic names is intended to reduce confusion in using

these units. In this regard, it should be noted that the licensee is required to designate, in a clear and unambiguous manner, the quantities that are being recorded (see paragraph 20.1101(b)).

Final Rule: All the important definitions in the revised rule have been collected into one section, § 20.3 Definitions. Unlike the proposed rule, which employed groups of related terms ("Area Terms," "Dose Terms," "Monitoring Terms," etc.), all the definitions in the final rule are listed in strict alphabetical order. This organization also avoids the presence of "local definitions" that appear only in a specific section of the regulation.

1. New Terms. The following definitions have been added to the final rule. These definitions have been added to clarify the meaning of the terms:

a. "Activity"
b. "Background radiation"
c. "Derived air concentration-hours" ("DAC-hours")
d. "Dosimetry processor"
e. "Entrance or access point"
f. "Generally applicable environmental standard"
g. "Individual monitoring device"
h. "Quality factor"
i. "Sanitary sewerage"
j. "Total effective dose equivalent (TEDE)."

2. Revised Definitions. The following definitions have been revised or modified from the definition used in the proposed rule:

a. "Absorbed dose"
b. "Annual limit on intake"
c. "Class"
d. "Committed dose equivalent"
e. "Committed effective dose equivalent"
f. "Derived air concentration"
g. "Dose equivalent"

h. "Effective dose equivalent"
i. "Embryo/fetus"
j. "Eye dose equivalent"
k. "Member of the public"
l. "Nonstochastic"
m. "Person"
n. "Planned special exposure"
o. "Quarter"
p. "Survey"
q. "Weighting factor"
r. "Working level"
s. "Year"

3. Definitions and terms deleted. Two definitions were deleted because the terms no longer appear in the rule: "Collective effective dose equivalent" and "Roentgen." "Natural background" has been replaced by "Background radiation."

Section 20.4 Units of Radiation Dose.

Comment: Choice of the system of units. Several commenters expressed a preference for retaining the older "special" units (the curie, rad, and rem) rather than allowing the use of the newer SI units. Reasons cited for retaining the older system included: present widespread use and licensee familiarity, potential for misunderstandings with the newer units, the need for worker retraining (particularly while learning the new ICRP system of dose limitation), and the costs associated with changing recordkeeping systems. A smaller number of commenters favored changing over to the SI units: becquerels, grays, and sieverts.

Response: Although both the "special units" and the SI units appear in the text of Part 20 (to increase the familiarity of licensees with the SI units), the Commission has decided that adoption of the SI units at this time is not necessary. The Commission recognizes that the new terms and methodological approaches in the revised Part 20 are complex and that imposition of the SI

system of units on top of this complexity would further increase the potential for confusion. Consequently, at the present time, the recordkeeping, reporting, and notification requirements require the use of the "special units," the rad, the rem, and the curie. However, as the national move to metrication continues, as anticipated in Section 5164 of the Omnibus Trade and Competitiveness Act of 1988 (P.L. 100-418), at some later time there may be amendments to Part 20 that would require the use of SI units only (becquerels, grays, and sieverts).

Final Rule: The final Part 20 rule includes the International System of Units (SI units) for distance, area, and volume. The older "special units" are retained for activity (curie), absorbed dose (rad), and dose equivalent (rem).

Comment: Quality factors for neutrons. The quality factor is the conversion factor between the absorbed dose (rads) and the dose equivalent (rems). Several publications[2,3,4,10,11] have recommended changes in neutron quality factors that are a factor of 2 higher than those in proposed Part 20. These changes would raise the quality factor for fast neutrons from 10 to 20.

Response: Increases in the quality factor for neutrons are suggested by some animal experimental data on the relative biological effectiveness (RBE) of neutrons. However, there appears to be considerable uncertainty as to whether the data actually demonstrate an increase in the hazard of neutrons. Because the RBE is defined as a ratio of doses to produce equivalent biological effects, it is not clear whether the apparent increase in the neutron RBE is due to the increased effectiveness of neutrons or whether it actually results from the decreased effectiveness of the reference gamma radiation at low doses.

---

10 International Commission on Radiological Units and Measurements, "The Quality Factor in Radiation Protection," ICRU Report No. 40 (1986). (Available for sale from ICRU Publications, 7910 Woodmont Avenue, Suite 800, Bethesda, MD 20814-3095.)

11 International Commission on Radiological Protection, "Data for Use in Protection Against External Radiation," ICRP Publication No. 51 (January 1988). (Available for sale from Pergamon Press, Inc., Elmsford, NY 10523.)

Final Rule: The NRC has decided not to revise the neutron quality factor at this time but to defer any change until there is greater scientific consensus on the most appropriate value. A major consideration underlying this decision is that neutron exposures at most NRC-licensed facilities are currently small and the potential increase of a factor of 2 would not have a major health or regulatory impact.

The decision to defer any change is consistent with recommendations of the Committee on Interagency Radiation Research and Policy Coordination (CIRRPC) of the Office of Science and Technology Policy that there should not be a revision of the value of the neutron quality factor at this time without more study. This position is also reflected in papers from the United Kingdom National Radiological Protection Board (UK NRPB)[12] and a statement on the neutron quality factor from the British Committee on Radiation Units and Measurements.[13]

Comment: Table of neutron quality factors. Several commenters questioned the accuracy and timeliness of the table of neutron quality factors and fluence rates (to give dose equivalents of 1 rem) that appeared in the proposed rule. Some commenters suggested that there were more appropriate tables published by the NCRP or ICRP.

Response: The tables in the proposed and revised rules were taken from NCRP Report No 38[14] and are appropriate for the neutron dose equivalent at a soft tissue depth of 1 centimeter (which is the depth specified for the determination of the deep dose equivalent). There are newer tables from the ICRP,

---

12 J.A. Dennis, "The Relative Biological Effectiveness of Neutron Radiation and Its Implications for Quality Factor and Dose Limitation," Nuclear Energy 20(2). 133-149 (1987).

13 British Committee on Radiation Units and Measurements (BCRU), "Memorandum from the BCRU: Effective Quality Factor for Neutrons," Physics in Medicine and Biology 31 (7):797-799 (1986).

14 National Council on Radiation Protection and Measurements, "Protection Against Neutron Radiation," NCRP Report No. 38 (January 1971). (Available for sale from the NCRP, 7910 Woodmont Avenue, Suite 800, Bethesda, MD 20814-3095.)

but these tables incorporate the factor of 2 increase in the neutron quality factor. (See the preceding discussion of the neutron quality factor.)

Subpart B -- Radiation Protection Programs

Section 20.101 Radiation Protection Programs ["As Low As Is Reasonably Achievable" (ALARA)] (§ 20.102 of the Proposed Rule).

Comment: The concept of ALARA is a philosophical principle of radiation protection and, as such, it should not be made into a regulatory requirement. A primary objection to changing the status of ALARA from the hortatory suggestion in the current Part 20 ("licensees should") to a mandatory requirement ("licensees shall") is that there are no guidelines (except for light-water-reactor (LWR) effluents) as to what constitutes ALARA. Because of the subjective nature of an "ALARA level," there are problems in the retrospective evaluation of licensee performance by NRC inspectors and, at least in one case, interpretations by the courts concerning whether the levels achieved were truly "as low as is reasonably achievable."

Response: There were a number of comments that expressed similar concerns regarding the proposed implementation of "ALARA." The emphasis on ALARA actions has been revised from detailed requirements to document all ALARA actions to a requirement to have a radiation protection program that includes measures to keep doses and intakes "as low as is reasonably achievable." This shift is to emphasize that the ALARA concept is intended to be an operating principle rather than an absolute minimization of exposures.

Comment: Any requirement for ALARA should include a lower bound. Many commenters felt that there should be a "floor" for ALARA necessary.

Response: The Commission agrees that there would be advantages to establishing such a "floor," below which efforts to further reduce doses would not

be necessary. An NRC policy statement on "Below Regulatory Concern" was announced on June 27, 1990, and published in the Federal Register on July 3, 1990 (27522). The Below Regulatory Concern levels in that policy statement delineate criteria below which additional licensee actions to further reduce doses would not be required. Specific rulemaking actions will be carried out to define operational thresholds for particular classes of activities such as disposal of very low-level contaminated materials. The BRC policy statement provides a framework for evaluating these case-specific actions. (See also discussion on § 20.304.)

Comment: Compliance with "ALARA-based" standards should constitute being ALARA. Several commenters supported the statement in the proposed Part 20 (§ 20.102(b)) that compliance with EPA's 40 CFR Part 190 and with Appendix I to 10 CFR Part 50 should constitute de facto compliance with the requirement to keep LWR effluents ALARA. Environmental Protection Agency (EPA) comments did not support this view.

Response: Appendix I to 10 CFR Part 50 defines ALARA levels of radioactive materials in LWR effluents. If the design objectives of Appendix I are met, it constitutes a demonstration that the effluents are ALARA and no additional effort is required to reduce the effluent levels. Although the EPA interprets 40 CFR Part 190 as an "ALARA-based" standard, it also believes that 40 CFR Part 190 constitutes an upper bound, not a lower bound, to ALARA efforts.[15] Consequently, compliance with 40 CFR Part 190 is not in itself sufficient to demonstrate that releases and doses are ALARA.

As Appendix I to Part 50 defines ALARA design objectives that constitute ALARA effluent levels, meeting these levels is sufficient to demonstrate ALARA

15 Letter of January 7, 1986, from Sheldon Meyers, Director, Office of Radiation Programs, Office of Air and Radiation, U.S. Environmental Protection Agency, to Robert B. Minogue, Director, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission. (This letter is reproduced as Enclosure B to the comments of the Environmental Protection Agency on the 10 CFR Part 20 revision (Docket PR-19, 20, 30 et al., 50 FR 51992, Comment # 769).)

that direct radiation from on[illegible] sources (gamma radiation from external rad-
waste tanks and turbine gener[illegible]rs ("turbine shine")) is also ALARA, and that

effluent releases. In order for light-water reactors to demonstrate that doses from both effluents and direct radiation are ALARA, it is necessary to demonstrate that effluents meet the design objectives of Appendix I to 10 CFR Part 50, the total dose to any member of the public is within the numerical standards in 40 CFR Part 190. Meeting these conditions will constitute sufficient evidence that offsite doses from LWRs are ALARA and in conformance with both Appendix I and 40 CFR Part 190.

Comment: The NRC should establish "reference levels" in its rules. One commenter thought that the NRC should have "reference levels" for licensee action in Part 20.

Response: The Commission recognizes that licensees generally establish their own lower "reference levels" in order to keep from reaching and exceeding the Commission's formal dose limits. Based upon the public comments on the reference level for exposure of members of the public, which was in the proposed § 20.303, this approach would not be favored by a majority of licensees. Several commenters viewed the reference level for the dose to members of the public as being applied exactly as if it were a limit. Consequently, if the NRC were to specify generic reference levels for licensee action, the impact might be similar to lowering the magnitude of the dose limits. The Commission believes that the use of the ALARA philosophy is a preferable means to keep exposures well below the limits established by the Commission.

Final Rule: The final rule establishes a requirement for all licensees to have a radiation protection program that includes provisions for keeping radiation doses ALARA. It is expressly intended that the level of this program and efforts to document it are commensurate with the size of the licensed facility and the potential hazards from radiation exposure and the intake of radioactive materials.

The requirement for a radiation protection program is not new; it was discussed in the proposed rule (under ALARA) and is consistent with requirements

in Part 33 (§§ 33.13, 33.14, and 33.15), Part 34 (§ 34.11), Part 35 (§§ 35.20-35.31), and Part 40 (§ 40.32) of the NRC regulations, with the information requested in Chapter 12 of Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants," and with the conditions in most licenses issued by the Commission. The extent of this program and requirements for written records and procedures for operating the program are intended to be commensurate with the scope and potential hazards associated with the licensee's activities. The Commission recognizes the need to provide guidance on the scopes of radiation protection programs and such guidance will be prepared in the form of regulatory guides.

The Commission continues to emphasize the importance of the ALARA concept to an adequate radiation protection program. In order to strengthen this concept, the Commission has adopted a requirement that all licensees include provisions for maintaining radiation doses and intakes of radioactive materials as low as is reasonably achievable as part of their radiation protection programs. Compliance with this requirement will be judged on whether the licensee has incorporated measures to track and, if necessary, to reduce exposures and not whether exposures and doses represent an absolute minimum or whether the licensee has used all possible methods to reduce exposures. This shift in emphasis should reduce potential problems of retrospective evaluation of licensee performance under admittedly subjective criteria. However, the licensee should be able to demonstrate that periodic reviews of performance have been made and that efforts have been made to achieve ALARA. As noted above, the level of effort expended on the radiation protection programs should reflect the magnitude of the potential exposures, both the magnitude of average and maximum individual doses and, in facilities with large numbers of employees, collective (population) doses. A nuclear power reactor licensee would be expected to have a considerably larger program than a licensee with only small sealed sources.

The Commission has not adopted a requirement that a numerical cost-benefit analysis (optimization analysis) be used to demonstrate ALARA. The quantitative approach is useful for those situations where both costs and benefits (dose reduction) can be quantitated, such as in shielding design or analysis of

decontamination methods. The Commission encourages licensees to employ quantified analyses to define ALARA, but their use is not required. One reason for this is that many ALARA procedures simply reflect sound operating practice and do not lend themselves to a numerical analysis. Another reason is that cost-benefit analyses could have a cost associated with obtaining the necessary information and carrying out the analysis that may exceed the monetary value of the dose reduction. Thus, the quantitative optimization analysis would be expected to be used primarily in situations where both the costs of control and the resultant benefits were not only quantifiable, but also appreciable compared to the cost of performing the analysis.

Subpart C--Occupational Dose Limits

Section 20.201 Occupational Dose Limits for Adults.

Comment: Elimination of the 5(N - 18) age-prorated cumulative dose limit and the adoption of the 5-rem annual effective dose limit. Most commenters favored this change noting that licensees have generally succeeded in keeping doses below 5 rems per year for the past few years and, therefore, are already meeting the new limit.

Comment: Lifetime dose limits. A few commenters believe that there should be a limit on the cumulative total dose that can be received by any individual in a lifetime.

Response: The Commission considered the use of a lifetime dose limit but rejected it. The EPA had proposed such a limit (100 rems) in its proposed Federal Guidance on Occupational Radiation Exposure (46 FR 7836, January 23, 1981) but withdrew it.

If the magnitude of the annual dose is limited, there is a de facto limitation of the lifetime dose that can be received. The Commission believes that such a de facto lifetime limit is preferable to an actual cumulative lifetime

dose limit because the cumulative limit could act to limit employability. This, in turn, raises questions concerning the right of an individual to pursue employment in a chosen profession. If an individual were to deplete the "dose bank" provided by a lifetime dose limit, it might be difficult to obtain future employment using ionizing radiation.

Comment: Quarterly dose limit. A number of commenters noted that the ICRP system of dose limitation does not have quarterly or other limits covering periods less than a year. The public comments also noted the possibility of giving rise to two violations for the same event (i.e., the possibility of exceeding both the quarterly and annual dose limits in one event), thereby incurring two penalties.

Response: The quarterly limit (only for deep-dose equivalent) had been retained in the proposed rule as a result of suggestions received from several groups during the development of the rule. The primary protection function of retaining a quarterly limit was to reduce the potential for receiving several high doses within a relatively short period of time. However, there is not much of a radiobiological significance between 10 rems (two 5-rem doses) and 6 rems (two 3-rem doses) received in a short time period. One consideration is the employability of a worker who has exceeded the dose limit. A worker who exceeded the 5-rem annual dose limit might have to work in a job not involving radiation for a year (or take part in a planned special exposure) instead of only a calendar quarter if a quarterly dose was used.

Final Rule: In order to maintain compatibility with the ICRP and to eliminate the possibility of double violations, the quarterly limit has not been kept and only annual limits are stated.

Comment: Eye dose limit. Some commenters questioned the 15-rem (0.15-sievert) eye limit used in the proposed rule noting that ICRP Publication No. 26 contains a recommended value of 0.3 sieverts (30 rems).

Response: The ICRP recommended a reduction in the limit for the eye to 0.15 sieverts (15 rems) at their Brighton, England, meeting in 1980.[16] This was done because the ICRP concluded that, for a lifetime of occupational exposure at the former 0.3-sievert (30-rem) limit, some opacities in the lense of the eye might be produced that could develop to the point of causing deterioration of vision (even without further radiation exposure). In most situations, the limits for the deep-dose equivalent and the shallow-dose equivalent to the skin should ensure that the eye dose limit is also met. Consequently, the reduction from 30 rems to 15 rems is not expected to have a significant impact on either health protection or control cost.

Comment: Parameters defining the shallow-dose equivalent ("skin dose"). The proposed rule would have established a dose limit for the skin of 50 rems averaged over 10 square centimeters (10 cm^2). There were several comments concerning the scientific basis for this area. Some commenters suggested other surface areas, such as 15 cm^2, as being better suited to measurement conditions. Proponents of the larger areas generally favored these areas because of their compatibility with either contamination survey practices or with the physical size of survey instrument detector probes.

One set of comments prepared by the developer of the NRC's VARSKIN computer program for skin dose calculation (comment letter No. 262 in the NRC Public Document Room) contains a well-documented discussion of the selection of an appropriate area over which to average the skin dose. These comments conclude that 1 cm^2 is a more appropriate area than either 10 cm^2 or 100 cm^2.

Response: ICRP Publication 26 contains two recommendations for such areas: a 100-cm^2 area and a 1-cm^2 area, the larger area being associated with routine monitoring for skin contamination and the smaller area being associated with

16 International Commission on Radiological Protection, "Statement and Recommendations of the 1980 Brighton Meeting," Annuals of the ICRP 4(3/4) Oxford, England: Pergamon Press (1980). (Available for sale from Pergamon Press, Inc., Elmsford, NY 10523.)

accident dose evaluation. After reviewing these comments and various recommendations regarding skin dose measurements, the Commission has decided to use the smaller area of 1 cm^2 for routine skin dose evaluations. The 1-cm^2 area is consistent with the prior recommendations in NCRP Report No. 39[17] and ICRP Publication No. 9[18] as well as the smaller area recommended in ICRP Publication No. 26.

Within the past several years, there have been instances where very small (5-250 μm) "hot" particles of fuel or activated corrosion products have been discovered in reactor facilities, on workers or their clothing, and, in a few isolated cases, in worker's vehicles or homes. These particles are generally too large to pose a significant risk from inhalation, but are capable of producing intense beta-radiation doses over very small areas of the skin. The principal hazard appears to be skin ulceration if the particles remain localized on the skin surface. The primary uncertainty associated with evaluating the hazard of these small particles is determining the skin area or tissue volume to which the dose is to be computed (or even whether "dose" is the most appropriate indicator of the hazard). The NRC requested the National Council on Radiation Protection and Measurements (NCRP) to look into the hot particle issue and make recommendations. The NCRP's recommendations have been published in NCRP Report No. 106[19] and use a criterion based upon the number of radioactive disintegrations that have occurred (μCi-hours) rather than dose. The NRC staff is reviewing these recommendations and has issued an Information Notice on a modified enforcement policy for hot particles.

Final Rule: This revision of Part 20 specifies an area of 1 cm^2 for skin dose evaluations.

---

17 National Council on Radiation Protection and Measurements, "Basic Radiation Protection Criteria," NCRP Report No. 39 (January 15, 1971), page 79, paragraph 207. (Available for sale from the NCRP, Bethesda, MD 20814.)

18 International Commission on Radiological Protection, "Recommendations of the International Commission on Radiological Protection (adopted September 17, 1965)," ICRP Publication No. 9 (1966), page 6, paragraph 28. (Available for sale from Pergamon, Press, Inc., Inc., Elmsford, NY 10523.)

19 National Council on Radiation Protection and Measurements, "Limit for Exposure to 'Hot Particles' on the Skin," NCRP Report No. 106 (December 31, 1989). (Available for sale from the NCRP, Bethesda, MD 20814.)

Comment: Effective dose equivalent for external exposure. The most prevalent comment concerning the effective dose equivalent is the restriction in the proposed rule of the risk-weighted organ dose "effective dose" concept to internal doses without permitting a similar approach to be employed for external doses. There were several comments that noted the desirability of using organ weighting factors for external doses.

Response: The ICRP and NCRP recommendations and the 1987 Federal guidance on occupational radiation exposure in principle permit the use of external weighting factors. However, none of the principal standard-setting organizations has included specific recommendations for the use of weighting factors for external dose.

The application of weighting factors also entails calculation of organ doses instead of whole-body doses from external radiation. One component of this calculation is estimation of the attenuation of the radiation as a function of the depth of the organ in the body. There are practical problems in the determination of the type and energies of the radiation involved and of the orientation of the individual with respect to the source of the radiation that have to be considered in making such calculations. Therefore, application of weighting factors for external exposures will be evaluated on a case-by-case basis until more guidance and additional weighting factors (such as for the head and the extremities) are recommended.

Final Rule: External doses to the head, trunk (including male gonads), arms above the elbow, or legs above the knee are to be treated as whole-body doses. For the purpose of weighting the external whole-body dose (for adding it to the internal dose), a single weighting factor, $w_T = 1.0$, has been specified. The use of other weighting factors for external exposure may be approved on a case-by-case basis upon request to the NRC.

Comment: Allowance for exposure after limits are exceeded. Commenters noted that allowance of an additional 1 rem per quarter dose limit for a worker who had already exceeded the 5-rem annual limit might be counterproductive. Workers who remain under the annual limit, and whose dose was X rems, would be

constrained to receive (5 - X) rems, whereas workers who received more than 5 rems in the first quarter could be allowed an additional 4 rems (1 rem in each of the four quarters). One commenter suggested that this could provide an incentive for individuals who are approaching the dose limit to deliberately exceed the limit and thereby protect their employability by taking advantage of the extra dose allowance available to those who have exceeded the limits. Another commenter believed that such a blanket authorization to exceed the limits was inappropriate and preferred prior NRC review of the use of these extra doses on a case-by-case basis.

Response: The purpose of the dose allowance was to protect the worker's employability after having received a dose above the dose limits. Although intentionally getting additional exposure might be in the worker's interest for employability reasons, such an action would not be in the worker's interest with respect to health protection. Licensees having workers with critical skills who are approaching the dose limits early in the year or workers who have received an accidental overexposure should consider use of the planned special exposure (§ 20.206) to permit continued employment.

Final Rule: The allowance of an additional 1 rem per quarter following an exposure in excess of the limits has been deleted.

Section 20.202 Compliance with Requirements for Summation of Internal and External Doses.

Comment: Implementation burden. Many commenters felt that the burden of adding external and internal doses was substantial, particularly as most licensees would be faced with either external exposure situations or internal dose situations, but not both.

Response: The NRC staff disagrees that there will be a substantial record-keeping burden because this summation will be required only if both the internal dose and the external dose are each likely to exceed 10 percent of the dose limit. Thus, in most situations, as noted in the comments, only one component will be required to be measured and, consequently, summation of internal and external doses will not be required.

Final Rule: The requirement remains that the committed effective dose equivalent and the deep-dose equivalent should be summed to give the total effective dose equivalent. However, this summation need only be performed if both components are required to be monitored (i.e., exceed 10% of an applicable dose limit). If the summation of doses is not required, then the limit applies to the component (internal or external) that is measured. The NRC is planning to issue additional guidance in the form of a regulatory guide before the effective date of the revised Part 20. This guide will be on procedures to be used in estimating committed effective dose equivalents and deep-dose equivalents and guidance on when internal and external doses have to be summed.

Comment: Use of individual metabolic or dosimetric data. Several commenters thought that the proposed rule required the use of specific metabolic and dosimetric parameters for the exposed individual. One commenter also thought that the use of such parameters would "invalidate the stochastic approach of the regulation, which presumes that the effects of radiation exposure at these levels are statistical in nature."

Response: It was not intended that licensees would be required to collect and use specific metabolic or dosimetric information on exposed individuals for use in dose assessments. The intent was to permit the use of personal data for dose assessment when such data were available. The use of parameters that are more appropriate for a particular exposed individual than those assumed for the "Reference Man" should improve the accuracy of the dose estimate for that individual. This is unrelated to the concept of stochastic health effects.

The statistical nature of the potential stochastic effects of low doses of ionizing radiation does not require that the associated dose estimates be based on Reference Man doses. However, it is necessary to resort to population-averaged dose-to-risk conversion factors as there are no health risk coefficients available for specific individuals.

[Monitoring thresholds and thresholds for summation of internal and external dose -- see discussion under § 20.502]

Note: Section 20.202(c) states that: "The assigned deep-dose equivalent and shallow-dose equivalent must be for the part of the body receiving the highest exposure." This requirement is intended to apply primarily to situations where there are steep gradients in the radiation dose rate, depending upon location within the facility and spatial orientation of the worker's body. For example, good practice for a worker in a nuclear power plant who is reaching up into a radioactive steam generator would be to wear at least two personnel dosimeters: one to monitor the extremity dose (worn on the finger or wrist) and one to monitor the whole-body dose (worn on the upper arm). For routine monitoring in relatively homogeneous radiation fields, special consideration to identify the actual "highest" exposed area would not be required.

Section 20.203 Determination of External Dose from Airborne Radioactive Material.

Comment: This could be read to require that the air concentration be measured at two locations. This section appears to require that the air concentration be measured at the location of the individual and at the point of maximum concentration in the cloud. The regulation should emphasize the reliance on personnel dosimeters or other monitoring devices.

Response and Final Rule: Section 20.203 has been shortened considerably. The revised section emphasizes the use of survey instruments and personnel monitoring devices to evaluate the external dose. The remaining technical guidance from this section in the proposed rule will be incorporated into a regulatory guide.

Section 20.204 Determination of Internal Exposure.

Comment: Interim dose calculation factors and parameters. Because the existing Part 20 is based on ICRP-2[20] dosimetry and metabolic models and the

---

20 International Commission on Radiological Protection, "Report of Committee II on Permissible Dose for Internal Radiation," ICRP Publication No. 2 (1959). (Available for sale from Pergamon, Press, Inc., Inc., Elmsford, NY 10523.

revised Part 20 employs the ICRP-30[21] dose parameters, there was concern regarding whether the more recent ICRP-30 parameters should be used, particularly when the value is to be compared with the intake limits in the present Part 20.

Response: The NRC is planning to issue a regulatory guide that will address the use of bioassay measurements for determining compliance with Part 20. Appropriate parameters for calculating organ doses from radionuclide intakes can be found in ICRP-30 and its supplements. Dose factors in Federal Guidance Report #11[22] are also acceptable for use in calculating occupational exposures. However, the effective dose equivalent factors in Federal Guidance Report #11 do not employ a rounding method suggested in ICRP-30. For this reason, the dose factors in Report #11 may be be slightly higher (10-20 percent) than the effective dose factors that correspond to the ALIs and DACs in both the revised Part 20 and Report #11. These dose factors would be more restrictive (give slightly higher doses for the same intake) than dose factors computed using the ICRP-30 roundoff procedure, but they can be used for evaluating compliance with Part 20.

Section 20.205 [deleted] Further Provisions -- Internal Exposure Involving Radionuclides with Very Long Effective Half-Lives.

Comment: Exemption for long-lived radionuclides and the use of the committed dose equivalent concept. The use of the concept of a "committed dose equivalent" drew numerous comments. This approach entails assigning to the year of intake the future internal dose (the "committed dose equivalent" over 50 years) from radionuclides taken into the body during that year. The proposed rule (in § 20.205) allowed an exemption from the use of committed dose equivalents for several long-lived radionuclides.

---

21 International Commission on Radiological Protection, "Limits for Intakes of Radionuclides by Workers," ICRP Publication No. 30. (Available for sale from Pergamon, Press, Inc., Inc., Elmsford, NY 10523.)

22 Environmental Protection Agency, Federal Guidance Report No. 11, "Limiting Values of Radionuclide Intake and Air Concentration, and Dose Conversion Factors for Inhalation, Submersion and Ingestion." USEPA Report EPA-520/1-88-020 (September 1988). (Available from the USEPA, Office of Radiation Programs, 401 M Street, S.W., Washington, DC 20460.)

Many of the commenters objected to having to assign the future 50-year dose to a single year. Others suggested that variable integration periods be allowed instead of one fixed 50-year value. One argument offered in support of either of these positions is that many adult workers would not normally be expected to live long enough to accrue the full 50-year committed dose equivalent. Commenters pointed out that while pre-exposure controls (such as the annual limits on intake and the derived air concentrations) should be based upon the committed dose equivalent concept for planning and control, the use of controls based upon limiting the annual effective dose equivalent rate (rather than using the committed dose equivalent) might be preferable for post-exposure management following actual radionuclide intakes.

It was also noted that there were several additional nuclides that had similar half-lives and retention characteristics but were not included in the proposed exception. Among these were cobalt, strontium, and americium. The approach in the proposed rule was characterized as appearing to place almost complete emphasis on the control of the work environment rather than on the assessment and control of the individual worker.

Response: The concept of dose commitment is not new; this concept has been used as the basis for controlling internal doses since the late 1950s when ICRP Publication No. 2[20] and the present 10 CFR Part 20 were published. However, the term "committed dose equivalent" applied to future doses from internal emitters initially appeared in 1977 in ICRP Publication No. 26.[1]

The concentration limits for air and water in Appendix B to the existing Part 20 were based upon concentrations which, if continually inhaled (for air) or ingested (for water) over a 50-year period, would produce a dose rate in the "critical organ" in the 50th year that was numerically equal to the annual organ dose limit. For certain radionuclides that slowly approached a constant body burden, primarily those radionuclides that have both long radiological half-lives and long biological clearance half-times, the limiting organ dose rate is not reached by the 50th year. For shorter-lived radionuclides and those that are rapidly removed from the body, equilibrium may be attained more rapidly and the limiting annual organ dose rate could persist over many years.

The limiting dose rate in the 50th year from a constant intake of a radionuclide each year over a 50-year period is numerically equal to the total dose integrated over the 50-year period from a single year's intake of the same magnitude. Therefore, controlling the integrated future ("committed") dose for each year's radionuclide intake also controls the annual dose rate in the 50th year to be within the dose limit.

It was noted that use of limits to annual doses in some cases would not ensure that doses in future years would be within limits. The example of the ingrowth of americium-241 from plutonium-241 was cited in which, even if the initial annual dose from plutonium-241 were within the limit, the ingrowth of the radiologically more significant americium-241 would lead to doses higher than the limits in subsequent years.

There are only a few radionuclides that would not attain an equilibrium level (and a constant annual organ dose rate) within time periods of less than 50 years. The use of the committed dose equivalent, rather than controlling internal dose on the basis of annual dose, substantially overestimates annual doses only for those radionuclides that do not reach an equilibrium level in the body early in the working lifetime. These radionuclides are primarily the long-lived radionuclides for which the exemptions of § 20.205 in the proposed rule were intended. Radionuclides (such as cobalt-60, strontium-90, and americium-241) that were easily measured at airborne concentrations or body burdens below the DAC and ALI values were not included in the list of exempted radionuclides because an exemption was not believed to be necessary for them.

The annual limits on intake and derived air concentrations are used mainly for pre-exposure control rather than post-exposure dose assessment so that fine-tuning these values to specific ages or adjusting them for factors such as the length of the period over which the committed dose is evaluated or to differences in individual organ sizes (as were suggested) is not warranted for occupational dose assessment. The use of age-dependent committed dose factors as suggested by some commenters would add needless complexity to the assessment of internal doses and cannot be justified on the basis of the availability of information on either age-dependent metabolic parameters or age-dependent radiobiological risk information.

The use of an annual dose limitation system, even with a reduction in the allowable dose limit from 5 rems to 3 rems such as in the proposed § 20.205, does not provide a limitation on the lifetime radiation dose or risk equivalent to that provided by the committed dose limitation system of this final rule for all classes of workers. Although long-term workers would be protected to the same degree under either the annual or committed dose systems, short-term or temporary workers could get somewhat higher lifetime doses under a dose limitation system based on limiting only individual annual dose. Furthermore, it is neither reasonable nor practical to expect future employers to take special measures to control radiation dose to workers who transfer because a previous employer, working under annual organ dose limits, permitted intakes that would result in future dose rates that are appreciable fractions of the allowable dose limits. Such a practice would not be fair to workers whose future employability may be limited because of the additional restrictions a new employer would have to put on their exposure, or to future employers of these workers who may have to assess internal doses from residual body burdens of internal radionuclides in order to show compliance. The annual dose system also requires a complex bookkeeping effort because the annual dose limit for each worker depends upon the worker's pre-existing body burden of radioactive materials.

Final Rule. For the reasons discussed above, the Commission has decided not to adopt proposed § 20.205 and the exemptions for certain long-lived radionuclides for the final rule. The use of the committed dose equivalent will be applied uniformly to all radionuclides, regardless of half-life. The Commission recognizes that the removal of this exemption, combined with the lowering of the airborne concentration limits for several radionuclides (notably thorium and uranium), could impact on the current and future facilities that use these materials. Licensees that are affected by these changes may request an extension of the implementation time in order to make the necessary modifications to comply with the revised limits as they relate to long-lived radionuclides identified in the proposed § 20.205. In addition, licensees should note the flexibility provided in the revised rule for more accurate dose assessments to be made that might show that additional controls were not required in order to meet the dose limits. Specifically, § 20.204 allows the use of actual particle-size distributions and physicochemical characteristics of airborne

particulates to define a site-specific derived air concentration to be used in lieu of the generic values in Appendix B. Such adjustments result in the use of more precise dose estimates because of a better characterization of the actual exposure conditions. Although these adjustments might permit higher airborne radionuclide concentration limits to be used, the same degree of health protection would exist because the radiation dose (and risk) would remain the same. This section also allows for whole-body counting or bioassay measurements to determine the behavior of radioactive materials in the individual and the use of these data to calculate internal doses. A 7-month delay between a bioassay or retention measurement and recording of the associated dose is also permitted in order to make confirmatory measurements.

The Commission recognizes that alternative methods may be identified in the future that might achieve the same degree of lifetime risk limitation for both short-term and long-term workers as the dose system recommended by the ICRP, the Radiation Protection Guidance to Federal Agencies for Occupational Exposure, and adopted in the current and revised 10 CFR Part 20. The Commission further believes that, to be acceptable, such alternatives should not result in an adverse impact on worker employability or result in undue recordkeeping or excessive monitoring requirements for the future employers of transferring workers.

Section 20.206 Planned Special Exposures.

Comment: The use of planned special exposures could result in lifetime cumulative doses greater than those doses formerly permitted under the 5(N - 18) formula. One commenter noted that the new regulatory scheme, including planned special exposures, allowed a higher total lifetime dose than was permitted using the 5(N - 18) formula. The calculation presumes a working lifetime of 47 years (starting at age 18 and ending at age 65). Under the revised Part 20, the lifetime limiting dose would be 260 rems (5 rems per year)(47years) + 5(5 rems) (planned special exposures) = 235 + 25 = 260 rems). Under the 5(N - 18) formula, at age 65 (N = 65), the cumulative dose would be 5(47) = 235 rems. The comment further noted that the NCRP recommended [in NCRP Report No. 91] a cumulative dose limit of 1 rem x age; the Department of Energy has proposed a 100-rem lifetime dose limit, and the ICRP at its 1984 Stockholm meeting inferred a goal

of 1 rem per year. Other commenters noted that, because of the potential lifetime dose including the planned special exposure, the claim on page 51, FR 1121 (Table 5), of the proposed rule that "Individuals receiving highest exposure will be reduced" is unjustified and incorrect.

Response: The analysis of maximum doses discussed above is overly simplified because it assumes that there are individuals who will be exposed at the allowable dose limit every year of their working lifetime. Under the old 5(N - 18) formula, the unused portion of the dose limit (the difference between the actual dose received and 5 rems) became part of a "dose bank" that could be drawn on in later years (at a rate up to 3 rems per quarter or 12 rems per year). This "dose bank," which is inherent in the age-prorated formula of 5(N - 18), does not exist with the straight annual dose limit. If the worker's exposure is under the 5-rem annual dose limit, there is no way to recapture the difference for use in future years. Consequently, the average annual dose (for the more highly exposed workers) associated with new Part 20 is expected to be less than under the former rule.

As noted above (see Response under § 20.201 Occupational Dose Limits), the Commission considered the use of a lifetime dose limit but rejected it.

Comment: Planned special exposures should not be limited to external exposures but should also be permitted for internal exposures. Several commenters noted that it was inconsistent to treat internal and external doses as equivalent by summing them and then restricting planned special exposures to only external doses. Commenters also pointed out that the total effective dose equivalent (TEDE) could be minimized in some cases if some external doses were reduced at the expense of incurring some internal doses.

Response: The Commission agrees that restricting the use of planned special exposures to only external doses would be inconsistent with the ALARA principle and the presumed equivalence of internal and external doses inherent in the revised Part 20. Consequently, the requirements have been modified so that internal doses may be included in planned special exposures in order that the total dose (TEDE) can be controlled in keeping with ALARA.

Comment: The annual dose allowed in a planned special exposure does not agree with the recommendations of the ICRP. A few commenters thought that the allowable annual dose from planned special exposures should be 10 rems as stated in the ICRP recommendations. Other commenters agreed with the NRC's modification to reduce the annual dose for planned special exposures to 5 rems.

Response: The NRC has intentionally reduced the dose allowed in any year from a planned special exposure from the 10-rem value proposed by the ICRP to 5 rems. The lifetime total limit from planned special exposures of 25 rems remains the same as the ICRP recommendation. The Commission believes that it would be better to distribute the dose over the lifetime more evenly than to permit a large portion of the cumulative dose to be received within a small period of time. In this sense it should be recalled that the planned special exposure is in addition to the normal dose limits. Under the Part 20 condition, it would be theoretically possible to get a 10-rem dose in 1 year, 5 rems from a planned special exposure and 5 rems from routine operation. This is roughly equivalent to the 12 rems (3 rems/quarter) that could be received under the present Part 20 limitations using the 5(N - 18) formula. The initial ICRP proposal would have permitted a 15-rem dose in 1 year, 10 rems from planned special exposures and 5 rems from routine operation.

Comment: Subtraction of emergency doses. Some commenters suggested that doses received under emergency conditions, up to a lifetime total of 25 rems, not be subtracted from the lifetime allowance for planned special exposures. It was also suggested that the employability of the individual might be jeopardized if the dose "bank" were depleted.

Response: The NRC has not officially sanctioned the 25-rem "forgivable" emergency dose that has been recommended by some organizations for a once-in-a-lifetime dose that would not be counted against an individual's lifetime dose. Consequently, all doses received as a result of occupational exposure must be recorded in an individual worker's record.

The Commission believes that planned special exposures will be used infrequently so that the lack of a dose bank for some individuals would not be a major drawback to their employability.

Comment: The time period for notifying exposed individuals of their dose is too short. A number of commenters thought that the 15-day period for notifying exposed individuals of their exposure from a planned special exposure was too short. Some commenters noted that most NRC reporting requirements provide a 30-day, not a 15-day, period. Other commenters suggested that the 15-day period could give the impression [to the worker] that an inordinate risk was involved when that was not the case.

Response: The 15-day period for notification was intended to be unique and to further emphasize that "planned special exposures" were indeed "special." However, the Commission has extended the time period for notification of the individual from 15 days to 30 days to allow licensees additional time to estimate internal exposures that are now permitted in the revised rule to be part of a planned special exposure. The requirement to notify the NRC (see § 20.1204) that a planned special exposure has taken place is also 30 days.

Comment: Doses received during a planned special exposure that do not exceed the dose limits for normal operation should not have to be recorded as planned special exposures or be subtracted from the lifetime planned special exposure limit. A few commenters expressed concern that exposures during planned special exposures that did not result in doses to an individual in excess of the occupational annual dose limits would nevertheless have to be reported separately and subtracted from the individual's lifetime allotment for planned special exposures.

Response: The intent of the planned special exposure was that it would be used infrequently in circumstances where the elimination of the 5(N - 18) lifetime cumulative limit might create a severe handicap to the licensee's operations. Being able to switch doses between planned special exposures and routine dose limits would tend to encourage the use of planned special exposures as the licensee would have nothing to lose by using the planned special exposure. This is contrary to the Commission's intent that the planned special exposures be restricted to "special" situations. Once a licensee decides to conduct a planned special exposure, all of the unique limitations, reporting, and recordkeeping requirements are to apply, even if the doses actually received fall within the dose limits for routine operations.

Final Rule: The provisions of planned special exposures have been extended to include internal exposures, and the reporting time to the individuals involved has been changed to 30 days to allow sufficient time for analysis of internal dose.

Section 20.207 Occupational Dose Limits for Minors.

Comment: Exposure of Minors. One commenter stated that minors should not be exposed to radiation because they do not meet the criteria for occupational radiation exposure. The commenter argued that minors are not trained regarding radiation protection, do not derive a benefit from employment, and would require the preparation of an NRC Form 4 if they were workers.

Response: Allowing minors to be occupationally exposed to radiation was permitted in the present Part 20 (§ 20.104). All individuals, including minors, who enter a restricted area are required (10 CFR 19.12) to be instructed as to the risks involved. Minors who are employed receive salaries and other associated benefits of employment so that there does not appear to be a major difference in this respect from other workers. Furthermore, licensees are required under the existing and revised Part 20 rules to maintain the same exposure records for minors as for adults.

An alternative to this procedure would be to exclude minors completely from radiation-related work. This does not appear to be desirable as the monetary, experience, and educational benefits that may accrue to the minor appear to outweigh the small incremental risk involved (particularly considering the reduced dose limits applied to minors). Consequently, no change has been made from the proposed rule.

Section 20.208 Dose to an Embryo/Fetus.

Comment: Biological basis for lower dose limits for pregnant women. There were comments that cited older studies and recommendations for dose limits for the embryo/fetus that are considerably higher than 0.5 rem. These comments

questioned the biological basis for the 0.5 rem dose limit for the embryo/fetus in the proposed rule.

Response: The biological effects of ionizing radiation upon the embryo/fetus are summarized in Regulatory Guide 8.13.[23] The limit of 0.5 rem during the entire gestation period is based upon a recommendation by the NCRP in 1977.[24] The International Commission on Radiological Protection (ICRP-26)[1] recommended 0.3 times the annual dose limit or 15 mSv (1.5 rems) over the full gestation period and 5 mSv (0.5 rem) in the first 2 months of pregnancy. More detailed information can be found in publications of the NCRP,[24] ICRP,[25] UNSCEAR,[26] and the OECD/NEA.[27]

Final Rule. The limit for the embryo/fetus of a declared pregnant woman is 0.5 rem over the entire gestation period. There is also an admonition that the licensee avoid substantial variation above the average monthly exposure rate that would comply with the 0.5-rem limit. These conditions are consistent with the Federal guidance on occupational radiation exposure and with the recommendations of the NCRP in NCRP Report No. 91[6].

Comment: Licensee's Responsibilities to Protect the Embryo/Fetus of an Undeclared Pregnant Woman. Several commenters raised the question of whether the licensee had any responsibility for protecting the embryo/fetus of an obviously pregnant female employee who had not formally declared her pregnancy to the employer.

---

23 U.S. Nuclear Regulatory Commission, "Instructions Concerning Prenatal Radiation Exposure," Regulatory Guide 8.13, Rev. 2, December 1987.

24 National Council on Radiation Protection and Measurements, "Review of Radiation Dose Limit for Embryo and Fetus in Occupationally Exposed Women," NCRP Report No. 53 (1977). (Available for sale from the NCRP, 7910 Woodmont Avenue, Suite 800, Bethesda, MD 20814-3095.)

25 International Commission on Radiological Protection, "Developmental Effects of Irradiation on the Brain of the Embryo and Fetus," Annals of the ICRP 16 4) (1986). (Available for sale from Pergamon, Press, Inc., Inc., Elmsford, NY 10523.)

26 United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), Genetic and Somatic Effects of Ionizing Radiation Sales Section, United Nations, NY 1986, particularly Chapter III, Biological Effects of Pre-natal Irradiation."

27 Organization for Economic Cooperation and Development/Nuclear Energy Agency, "The Biological Basis for the Control of Prenatal Irradiation," OECD/NEA, Paris, France (1988).

Response: It is the fundamental responsibility of the pregnant worker to decide when or whether she will formally declare her condition to her employer. This position is derived from court rulings concerning a pregnant woman's rights regarding termination of the pregnancy. Having a woman formally declaring her pregnancy to her employer derives from legal, not health protection, considerations. If she chooses not to declare her pregnancy, the licensee will not be required under the Commission's regulations to limit her dose to the 0.5-rem limit.

Undeclared pregnant women are protected under the NRC regulations for all workers. The normal occupational dose limits would still be in effect and would have to be complied with, and the dose would also have to be kept "as low as is reasonably achievable." In addition, as part of her initial employment, the woman should have received instructions in radiation protection (10 CFR 19.12), and she should have been provided with a copy of Regulatory Guide 8.13.

It might be prudent for a licensee to remind a pregnant, but undeclared, worker of the special limit for protection of the embryo/fetus of a declared pregnant woman and to provide another copy of Regulatory Guide 8.13 to her. However, if the licensee has previously provided this information to the employee, it is not a Commission requirement that it be done again. If the requirements referred to in the previous paragraph have been fulfilled, the licensee will not be cited for a violation of the Commission's regulations if the estimated dose to the embryo/fetus of an undeclared pregnant woman exceeds the 0.5-rem limit, even if the worker's pregnant state seems obvious.

Response: Section 161c. of the Atomic Energy Act gives NRC the authority to require such information to be provided by the worker. However, such a requirement could be considered to be discriminatory and an invasion of personal privacy. It would also be unenforceable because the woman and her physician know when she knew of the pregnancy and patient-doctor communications are privileged. Infringement on personal privacy is also a drawback that applies to requiring the female worker to supply information concerning her "fertility" or "infertility."

Comment: Estimation of Dose to the Embryo/Fetus. The assignment to the embryo/fetus of a dose equal to the dose to the declared pregnant woman was questioned. For example, would it be reasonable to assign to the embryo/fetus a dose based upon the dose received by the woman's shoulder or head?

Commenters also indicated that licensees should be permitted to employ factors other than a factor of 2 and take into account shielding of the embryo/fetus by maternal organs and the placenta in evaluating the external dose component of the embryo/fetus.

Response: The concept used in the proposed rule of relating the dose to the embryo/fetus to the dose received by the mother has been modified. The final rule permits direct calculation of the dose to the embryo/fetus. This was done so that the use of more accurate dose assessments would not be precluded by the rule. The internal dose to the embryo/fetus may or may not be directly proportional to the dose received by the mother.

A forthcoming regulatory guide will provide guidance on methods for calculating the dose to the embryo/fetus. For interim assessments of the dose to the embryo/fetus, it may be assumed that the dose to the embryo/fetus from external radiation and from radionuclides in the body that are relatively uniformly distributed, such as cesium-137 and compounds of tritium and carbon-14 that are not organically bound, is the same as the dose to the mother since under these circumstances the same energy would be deposited per gram of tissue in both the mother and the fetus. For external gamma irradiation, the assumption that the dose to the fetus is the same as to the mother should be conservative (yield calculated doses that are somewhat higher than the actual doses determined by more precise evaluations).

Permitting calculations of the embryo/fetal dose using reduction factors for attenuation within the body of the mother would entail knowledge of the energy spectra of the incident radiation. As noted previously (Response for § 20.201), photon spectral measurements, although technically feasible, are not currently required by the Commission and are considered to be beyond the scope of routine radiation protection survey measurements. The small amount of reduction in the calculated dose afforded by such attenuation corrections

would be secondary in importance compared to uncertainties due to body orientation, partial-body exposure from collimated beams of radiation, and the radiobiological sensitivity of the embryo/fetus.

In situations where the use of a single dose measurement would be inappropriate for both the woman and the embryo/fetus, a solution would be to monitor the two doses separately.

Comment: Additional Dose Increment Allowed to Pregnant Women Beyond the Dose Limits. The rationale was requested by a few commenters for permitting an extra 0.05 rem (0.5 millisievert) beyond the 0.5-rem (5 millisieverts) dose limit to an embryo/fetus.

Response: The small additional dose is intended to apply in situations where the embryo/fetus has accumulated a substantial fraction of the dose limit or has already exceeded the limit before the woman formally declares herself to be a "declared pregnant woman." If the incremental 0.05-rem dose were not available, a woman having already received a dose in excess of the 0.5-rem limit might not be able to be further employed in a radiation-related job. The licensee could be in "instant noncompliance" as the embryo/fetus dose limit could have been exceeded before the licensee was aware that it was applicable (i.e., before the woman declared her pregnancy). Thus, the small incremental 0.05-rem dose provides a means of ensuring continued employment for the woman and also removes the threat of inadvertent noncompliance on the part of the licensee. The additional risk posed by this incremental dose to the embryo/fetus is small compared to the potential risk from the overall 0.5-rem dose limit.

Final Rule: The final rule corrects an anomaly in the proposed rule regarding the application of the additional 0.05-rem incremental dose. In the proposed rule, the additional 0.05-rem dose was available if the embryo/fetal dose limit had been exceeded prior to the woman's declaration of pregnancy (even if the dose were 0.501 rem). However, the additional 0.05-rem dose increment would not have been available if the embryo/fetal dose were less than the

0.5-rem limit (even if the dose were as much as 0.499 rem). There is no significant difference in risk between 0.551 (0.501 + 0.05) rem and 0.549 (0.499 + 0.05) rem. This provision would have resulted in unnecessary penalties to both the licensee and the declared pregnant woman. In the final rule, the 0.05-rem dose increment is available as an additional dose if the embryo/fetal dose at the time of declaration is greater than 0.45 rem (0.45 = 0.5 - 0.05).

Subpart D--Radiation Dose Limits for Individual Members of the Public

Section 20.301 Dose Limits for Individual Members of the Public.

Comment: NRC should defer changes to limits for the general public until the EPA issues revised Federal guidance. The EPA suggested that NRC not modify its radiation limits for protection of the general public until EPA prepares revised Federal guidance on dose limits applicable to the general public (the recently issued Federal guidance applied only to occupational radiation protection).

Response: Although it would be desirable to use Federal guidance as a basis for the revision of the limits for the public, the Commission believes that Part 20 needs to be based on a consistent set of principles and concepts rather than having its standards for workers using one dose limitation system and its standards for the general public using an entirely different (and outmoded) system. The latest Federal guidance does not address radiation exposure of the general public and, although the NRC staff is represented on an EPA Task Group which is developing draft Federal guidance on doses to members of the general public, the Commission has chosen not to defer these limits until this Task Group has completed drafting the guidance and EPA makes recommendations to the President for its issuance. The Commission's intent to address these limits was noted explictly in the statement of considerations that accompanied the proposed rule (51 FR 1118, Section XXVIII).

Comment: Facilities that are subject to other lower standards should not have to demonstrate compliance with the 0.1-rem limit ["reference level"]. Several commenters expressed concern that additional efforts would be required to demonstrate compliance with the proposed 0.1-rem "reference level." For licensees that were already subject to the 0.025-rem (25-millirem) limits of EPA's 40 CFR Part 190, this appeared to be an unnecessary burden.

Response: The concept that 0.1 rem represents a "Reference Level" has been eliminated. The 0.1-rem value in the final rule represents the primary dose limit for protection of the public. This change from the proposed rule reflects the clarifications by the ICRP (see Section II.A.) regarding the usage of the 0.1-rem and 0.5-rem recommended dose levels. This change does not represent a major change from the proposed rule. Many commenters had indicated a belief that, because of the reporting and control requirements associated with the 0.1-rem reference level, it already represented a de facto limit.

Demonstration of compliance with the limits in 40 CFR Part 190 or with the design objectives of Appendix I to 10 CFR Part 50 will be deemed to demonstrate compliance with the 0.1-rem dose limit for most licensed facilities. Power reactor licensees that comply with Appendix I may also have to demonstrate that they are within the 0.025-rem limit in 40 CFR Part 190. Demonstration of compliance with the limits of 40 CFR Part 190 will be considered to demonstrate compliance with the 0.1-rem limit. For uranium mills, it will be necessary to show that the dose from radon and its daughters, when added to the dose calculated for 40 CFR Part 190 compliance, does not exceed 0.1 rem.

The dose rate limit of 2 millirems in any 1 hour from § 20.105(b)(1) of the present Part 20 was omitted in the proposed rule but has been reinstated in the revised rule. The reason for this is that this limit provides a more readily measurable quantity than the 100 millirem per year value and can be more easily verified by short-term measurements.

Comment: Inclusion of doses from other licensed or unlicensed radiation sources. Many commenters expressed an opinion that the dose should not be all-inclusive and should not include fallout from nuclear weapons tests, transportation of radioactive material, or other sources of radiation not under the control of the licensee.

Response: The new lower dose limit for members of the general public (which was described as a "reference level" in the proposed rule) applies only to doses from radiation and radioactive materials under the licensee's control. The EPA's generally applicable environmental radiation limit for nuclear power operations (40 CFR Part 190) does apply to the total dose from all sources within the uranium fuel cycle. However, in its practical implementation, the sources would have to be located within a few miles of each other for the combined dose contributions to be significantly different from the dose from either facility alone.

The definition of "natural background" has been replaced by "background radiation," which includes natural background, global fallout, and radon not associated with licensed material. This clarifies sources of radiation and radionuclides that can be excluded from evaluations of the dose from licensed activities.

Comment: Differentiation of limits for long-term operation and for shorter-term transient operation. A number of commenters noted that ICRP-26 described the 0.1 rem (1 mSv) per year value as intended to be an average goal for long-term operation but that 0.5 rem (5 mSv) was intended as the primary annual dose limit for members of the public. Some commenters suggested that a lifetime dose limit be established for members of the public.

Response: As noted above in Section II.A., the ICRP has modified its interpretation in the ICRP statement issued following their 1985 Paris meeting,[2] so that the primary standard is 1 mSv (0.1 rem) per year. This clarification of ICRP philosophy is reflected in Part 20 by the change of the 0.1 rem per year value from a "reference level" in the proposed rule to a primary limit in the final rule.

Final Rule: It should be emphasized that the 0.1 rem per year limit in Part 20 is not intended to be applied as a long-term average goal: it is an annual limit. As a matter of practicality, long-term (or lifetime) dose limits for members of the public cannot be implemented unless each year's dose is kept within the long-term goal. Doses to individuals in the general public are not usually monitored directly (locations rather than individuals in the offsite environment are monitored). As individuals may change residency and there is no reporting or tracking system, lifetime doses to specific individuals in the general population are very difficult to determine.

The 0.5 rem per year limit is available only upon specific application to and approval by the Commission (see § 20.301(c)). A 0.5-rem value has been retained in order to apply to transient situations and to alleviate the immediate need to redesign or reshield existing facilities that were designed to meet the former 0.5-rem limit. The 0.5-rem limit is intended to be applied primarily to temporary situations where operation of a facility, or the person's exposure to radiation and radioactive emissions, is not expected to result in doses above 0.1 rem over long periods of time. For design of new installations, the 0.1-rem limit should be used. However, existing facilities may apply for NRC approval to use the 0.5-rem limit while more complete evaluation of the need for any additional modifications is performed.

The Commission is aware that some categories of licensees, such as uranium mills and *in situ* uranium mining facilities, may experience difficulties in determining compliance with the revised values in Appendix B, Table 2, for radionuclides such as radon-222. Provision has been made for licensees to use air and water concentration limits for protection of members of the general public that are different from those in Appendix B, Table 2, if the licensee can demonstrate that the physicochemical properties of the effluent justify such modification and the revised value is approved by the NRC. For example, uranium mill licensees could, under this provision, adjust the Table 2 value for radon (with daughters) to take into account the actual degree of equilibrium present in the environment. This provision permits (upon NRC approval) the use of concentration limits for members of the general public that better represent actual exposure conditions. This is similar to the allowance for use of modified derived air concentrations (with Commission approval) in § 20.204(c)(3).

In both situations, licensees would be permitted to propose radionuclide concentration limits for their facility that reflect actual properties of the effluents rather than using the generic concentration-to-dose assumptions associated with Appendix B values. These adjustments tailor the concentration limits to specific conditions, provide the same limitation of dose, and do not permit any greater risk even though the adjusted concentration limits (for members of the general public or for workers) may be higher than the Appendix B generic values.

Use of this provision, applied to the percentage of radionuclide equilibrium existing in radioactive decay chains, could provide a factor of 2 or 3 upward change in the appropriate air concentration limit. In addition, the licensee can demonstrate compliance by calculating the dose to the nearest resident rather than meeting the air concentration limit at the site boundary. This should provide an additional factor of 2 or 3 allowance. Lastly, if the 0.1-rem effective dose limit still cannot be met, the licensee can apply to NRC under § 20.301(c) for permission to use a temporary 0.5 rem per year limit rather than the 0.1 rem per year limit. Section 20.301(c) of the revised rule requires that, in order to receive permission for use of this higher dose limit, the licensee has to specify (1) the need for and expected duration of the higher value, (2) their program to assess and control doses, and (3) procedures to control doses to be ALARA. These options used singularly or in combination coupled with process or operational modifications of these facilities is expected to provide sufficient flexibility to enable most uranium recovery facilities to comply with the provisions of the revised 10 CFR Part 20.

Section 20.303 [Reserved].

The former 0.1-rem "Reference Level" and the EPA Standard for Nuclear Power Operations that were in this section in the proposed rule are included as primary limits for members of the public in § 20.301 of the final rule.

Section 20.304 [Deleted] De Minimis Level and Collective Dose Evaluations.

Comment: Adoption of a threshold for calculating collective (population) doses. The proposed § 20.304 would have allowed licensees to disregard doses to individuals that were less than 1 millirem per year when evaluating collective (population or "person-rem") doses. A major criticism of this section was the narrowness of its scope. The section pertained only to a change in the calculational methodology for estimating collective doses and would not have permitted unrestricted release of any materials or equipment.

Most comments from people and organizations within the nuclear power and radiation applications industry favored this measure as an initial step toward developing more general "below regulatory concern" (BRC) levels. Several commenters thought that NRC acknowledgment of the concept of a BRC level was more important than the specific proposal to truncate collective dose calculations. Many commenters thought that a generic BRC level would limit unnecessary expenditure of resources that would otherwise have to be spent to control inconsequential risks.

There were also a number of comments that were not in favor of either the proposed collective dose cutoff or the more general application of the concept of below regulatory concern. A few commenters expressed opinions that it did not appear feasible to arrive at a universal de minimis level because the level that would appear to be truly insignificant to most people would be too low to result in any appreciable saving to the industry. There also were comments that noted that the proposed collective dose cutoff could cause large numbers of potential adverse health effects to be overlooked if they resulted from small radiation doses delivered to very large numbers of people. Many commenters, both pro and con regarding the adoption of a BRC level, thought that a threshold value for collective dose should also be developed. A few commenters noted that the focus of the more generic BRC concept tended to be for single licensees and that it might be necessary to consider the impacts from multiple licensees.

Many of the commenters who supported a generic BRC concept did not agree with the numerical value (0.001 rem per year) proposed for the cutoff, believing it to be too low. An explanation for this opinion was that if 0.001 rem represented an insignificant level of risk, then all larger doses might be perceived as representing "significant" levels of risk. A value of 0.010 rem was noted by several commenters as being a more suitable value and still represented an inconsequential risk.

Response: The Commission agrees that "Below Regulatory Concern" levels would be useful and has issued policy statements on the application of the concept of below regulatory concern with regard to waste disposal ("Radioactive Waste Below Regulatory Concern," Federal Register of August 29, 1986 (51 FR 30839)) and a general policy statement on below regulatory concern was announced on June 27, 1990, and was subsequently published in the Federal Register on July 3, 1990 (55 FR 27522). The general policy statement establishes the framework for the Commission to formulate rules and licensing decisions to exempt certain practices involving small quantities of radioactive materials from some or all regulatory controls. The BRC policy statement sets forth criteria for protection of both individuals (individual dose criteria) and population groups (a collective dose criterion).

In order to ensure that any computational changes reflect the policy that evolves from the effort to develop generic BRC policy, the Commission removed the threshold for truncating collective doses (§ 20.304) from Part 20 and has included such a threshold in the generic BRC policy statement. This deletion is also consistent with comments that noted that this section described a method for calculating a quantity (collective dose) that was not required to be calculated by Part 20 and comments that such details of calculations would be better in a regulatory guide rather than in a regulation.

Subpart E--[Reserved]

Subpart F--Surveys and Monitoring

Section 20.501 Surveys.

Comment: Accreditation of Personnel Monitoring Processors. There were a number of comments concerning the desirability of requiring accreditation of personnel dosimetry processors.

It was also noted that the National Voluntary Laboratory Accreditation Program (NVLAP) does not provide accreditation for doses delivered to the lens of the eye, a depth equivalent to approximately 0.3 centimeter (an areal density of 300 milligrams per square centimeter). The only tissue depth equivalents that are accredited at this time are 1.0 centimeter (the deep-dose equivalent) and 0.007 centimeter (the shallow or "skin" dose equivalent).

Response: The issuance of a dosimetry accreditation requirement or "NVLAP Rule" overlapped the Part 20 rulemaking. Because this issue was the subject of a recent separate NRC rulemaking, issues concerning the desirability of such a program were considered and addressed in the rulemaking on accreditation. No revision from the dosimeter processor accreditation rule (52 FR 4601) has been made, and the final Part 20 rule incorporates the final form of the accreditation rule.

As noted in the discussion of the "eye dose equivalent" in Section XI, "Standards for Occupational Exposure of Individuals," of the proposed Part 20 rule, the Commission believes that compliance with the eye dose limit will be generally ensured by compliance with the deep-dose limit. Consequently, the lack of accreditation for this depth should not have a major impact on the degree of protection of the eye.

Comment: The accreditation requirement requires the use of a commercial dosimetry service.

Response: This is an incorrect interpretation of the dosimetry accreditation rule (52 FR 4601). That rule, which is incorporated into the revised Part 20, states that the dosimetry processor must be accredited. It is possible for licensees that provide their own dosimetry services to be accredited.

Comment: Lack of specificity in monitoring requirements. Commenters noted that the monitoring requirements, both in the present Part 20 and in the proposed rule, were general and imprecise.

Response: Many portions of Part 20 are not very specific and detailed because Part 20 contains the NRC's general radiation protection requirements and applies to all classes of licensees, including large power reactors, universities, and medical institutions as well as small radionuclide and sealed source users. Because of this breadth of application, the requirements in Part 20 cannot be very detailed for any one type of facility. However, the requirements in Part 20 are designed to provide the framework for all licensees and to establish provisions that the NRC considers to be fundamental to basic radiation protection.

Section 20.502 Conditions Requiring Individual Monitoring of External and Internal Occupational Dose.

Comment: Monitoring Thresholds. A number of commenters questioned the rationale for the lack of agreement of the thresholds in the proposed rule for monitoring external doses (10 percent of the annual limits) and for requiring monitoring of internal doses (30 percent of the annual limit). It was frequently mentioned that starting to require monitoring at 30 percent of the dose limit could result in overlooking doses of 1.5 rems (30 percent of 5 rems). The 1.5-rem value would have been above the limits for minors and for the embryo/fetus (0.5 rem) and was characterized as being a rather substantial fraction of the deep-dose equivalent limit. In this connection, it was also noted that the possibility existed, when large external doses were expected, of exceeding a total effective dose equivalent limit of 5 rems because the licensee was not aware of the internal dose contribution.

Some commenters thought that the monitoring thresholds would be understood more easily if they were expressed as doses instead of percentages.

Response: The unequal thresholds for requiring monitoring of internal doses (30 percent of the dose limit) and external doses (10 percent of the dose limit) were originally set because of the difficulties in performing low-level bioassay analyses of alpha-emitting radionuclides at fuel fabrication and other facilities where actinides may be prevalent. (Bioassays for the radionuclides most commonly found at nuclear power reactors were viewed as generally being able to meet the 10 percent threshold set for external doses.) In situations such as bioassay for alpha-emitting radionuclides, it may be difficult to detect 10 percent of the ALI or 10 percent of the dose limit by bioassay measurements on excreta.

The monitoring threshold is a predetermined level of anticipated dose for carrying out bioassay procedures and does not represent a required level of detection sensitivity. If, by a reasonable analysis of the working environment, it appears that a worker is likely to inhale radioactive materials at concentrations that could produce an annual committed effective dose equivalent of 0.5 rem (10 percent of the 5-rem limit) or more, then that worker's intake should be monitored using measurements of exposure (e.g., estimates of DAC-hours based upon measured air concentrations) or intake (such as by whole-body counting or other bioassay technique) or by measurements of both exposure and intake. Whether the actual doses received were in excess of 10 percent of the limits could only be determined from these subsequent measurements.

The monitoring thresholds are specified as percentages of the dose limits rather than as doses because the thresholds apply to several different dose limits: the total effective dose equivalent, the eye dose equivalent, and the shallow-dose equivalent.

Final Rule: The threshold for monitoring internal doses has been dropped from 30 percent of the dose limit to 10 percent of the limit. This provides consistency in the internal and external monitoring requirements. The Commission acknowledges that, in some cases, particularly bioassay measurements of transuranic elements, it may not be feasible to actually confirm such levels

by bioassay. However, the monitoring threshold is not a requirement on the capability of the measurement. Average airborne radionuclide concentrations and the expected time of exposure can be used to estimate radionuclide intakes and the need for bioassay or other monitoring methods.

The Commission intends to issue a regulatory guide on the procedures to be used in estimating committed effective dose equivalents and deep-dose equivalents and guidance on when they have to be summed.

Comment: Evaluation of radionuclide intakes for respirator wearers. Several commenters mentioned that internal dose monitoring, such as bioassays, should not be required solely because respiratory protection devices were used. The rationale given by the commenters was that the requirement provides a negative incentive for using respirators and is, therefore, counter to ALARA operating practices.

Response: The requirement (in § 20.502(b)(3)of the proposed rule) for bioassays for anyone using respiratory protection has been dropped. The Commission agrees that such a requirement might be a disincentive for using respirators as part of an ALARA effort. There is, however, a requirement (in § 20.703) for bioassays to be conducted, as appropriate, as part of a respiratory protection program. Whether bioassays are necessary for a particular individual will depend upon whether that individual could have exceeded 10 percent of the annual limit on intake (ALI) or was exposed to airborne radionuclide concentrations in excess of the monitoring threshold. An evaluation of internal dose would be required if there were a potential for exceeding 10 percent of an annual limit on intake (0.1 ALI), whether or not a respirator is worn.

[Note: Because the requirement for performing bioassays for a particular individual has been separated from the wearing of a respirator, the concentrations to be used for evaluating monitoring thresholds are those of the ambient atmosphere before credit is taken for respiratory protective factors. One of the purposes of such bioassays is to confirm the effectiveness of the respiratory protection being provided. If bioassay were made dependent upon the corrected air concentration (after dividing by the protection factor), it would be

equivalent to assuming that the intended protection factor was correct without further verification.]

Subpart G--Control of Exposure from External Sources in Restricted Areas

Sections 20.601, 20.602, and 20.603 Control of Access to High and Very High Radiation Areas.

Comment: Inapplicability of requirements to nuclear power reactors. Many commenters indicated that the proposed requirements for control of entry into very high radiation areas could not be applied to nuclear power reactors because of the number and size of potential "very high radiation areas" and the physical inability to restrict access to these areas. Similarly, interlocks that can result in the withdrawal or cessation of the radiation source may be unworkable in nuclear power reactors. Several commenters proposed incorporating requirements for power reactors that are similar to reactor license conditions in reactor technical specifications.

Response: The Commission recognizes that the detailed requirements applicable to large irradiators that were formerly in § 20.203(c)(6) should be in a specific regulation dealing with these facilities rather than in Part 20. For this reason, these detailed requirements will be placed in a future Part 36 of Title 10 which is being issued for public comment and applies specifically to irradiators. At the time that that rule is made effective, the Commission will transfer these requirements from Part 20 to Part 36. In the meantime, the NRC staff will issue a regulatory guide that provides more specific detailed guidance for nuclear power reactors on high and very high radiation areas.

Comment: Choice of Dose Rate Defining a "Very High Radiation Area." Several commenters believed that the 500 rads per hour dose rate that defines a "very high radiation area" was too high, noting the proximity of this value to the median lethal dose (LD_{50}) for acute radiation exposures. Alternative values, such as 1 rem per hour at 30 centimeters, were proposed.

Response: The seriousness of this dose rate was a factor in its adoption. The 500 rads per hour value appears in the previous 10 CFR 20.203(c)(6) as a criterion for additional access controls for irradiators (similar in scope to the requirements of § 20.603 in the final rule). However, the previous Part 20 did not use a unique designation such as the "very high radiation area" designation used in the proposed and revised Part 20 rules. The difference between the 1 rem per hour definition of a "very-high" radiation area used in reactor technical specifications and the 500 rads per hour definition used in the revised Part 20 is discussed in a regulatory guide currently being prepared.

Comment: Meaning of "direct surveillance." Several commenters thought that the term "direct surveillance" used in the proposed § 20.601 could be interpreted to require stationing an observer at the entrance to the "high" or "very high" radiation areas.

Response: The final rule permits "...continuous direct or electronic surveillance over a high radiation area that is capable of preventing unauthorized entry..." This removes the burden of having to station a person in or near a "radiation area," but requires interlocks or electronic locks so that the remotely located observer may prevent entry into the area when necessary.

Final Rule: The section on very high radiation areas has been divided into two sections. Section 20.602 provides a general requirement for restricting access to such areas. This general requirement applies to all very high radiation areas, regardless of the type of licensed operation, including those at nuclear power reactors. A second, more detailed, set of requirements applies only to large gamma irradiators. This section, § 20.603, restates requirements for irradiators that are in § 20.203(c)(6) of the present 10 CFR Part 20.

Subpart H -- Respiratory Protection and Controls to Restrict Internal Exposure in Restricted Areas

Sections 20.701 and 20.702 Use of Process or Other Engineering Controls and Use of Other Controls.

Comment: "Use of other controls." Commenters suggested that, if workers could be exposed to concentrations of radioactive materials greater than 1 derived air concentration, ALARA should be applied to the total of internal and external doses (to the total effective dose equivalent). It was noted that this condition was included in the Federal Guidance on Occupational Radiation Exposure.

Response: Modifications have been made in the final rule to permit ALARA considerations to apply to the total effective dose equivalent rather than just the internal dose portion.

Comment: Some commenters indicated that the use of respirators should be permitted even if their use would not be able to reduce airborne concentrations below 1 DAC. They noted that this would be consistent with the ALARA philosophy.

Response: Section 20.702 has been rewritten to clarify the intent that the concentration of 1 DAC is not a cutoff on the voluntary use of respirators but is intended to be the point where some corrective action (including, but not limited to, the use of respirators) by the licensee would be required when the use of ventilation and process controls cannot further reduce the airborne concentrations of radioactive materials.

Section 20.703 Use of Individual Respiratory Protection Equipment.

Comment: The proposed rule permits low estimates but not high estimates of intake to be corrected. Commenters noted the the proposed rule (§ 20.703(a)(1)) was not balanced as correction of intake estimates based upon dividing DAC-hours by the respirator protection factor and was only permitted if the initial estimate was later shown (by bioassay results) to have been low.

Response: The rule has been modified so that corrected estimates of actual intake can be used in records in place of earlier estimated intakes, regardless of whether the change would result in an increase or in a decrease in the intake estimate.

Comment: NRC should provide a recommended minimum acceptable standard for determining an individual's physical fitness for respirator use. Part 20 requires that a physician determine that an individual worker is physically able to wear a respirator. NRC should, therefore, provide guidance to the physician on minimum standards for wearing respirators.

Response: The NRC policy is that the decision as to medical fitness has been, and continues to be, left to the physician; i.e., the medical doctor should decide what constitutes minimum health standards for respirator wearers. Furthermore, the requirements may vary, depending on the respirator used and physical situations, such as the type of work to be performed, which are outside the scope of Part 20. Licensees desiring more guidance should obtain ANSI Standard Z88.6(1984), "For Respiratory Protection -- Respirator Use -- Physical Qualifications For Personnel," which was developed as an industry consensus standard that provides definitive guidance to "identify the responsibilities of the physician, the employee, and management in determining the employee's ability to use a respirator."

Comment: NRC should permit a health professional to certify physical capability to use a respirator rather than requiring a physician to perform each required certification. The proposed rule requires that a physician annually certify a worker's physical suitability for using a respirator. This should be broadened to permit any qualified health professional, acting under a physician's orders, to perform the actual certification rather than requiring a doctor to do this.

Response: As noted in the previous response, the decision on the physical ability of an individual to wear a respirator is a subjective judgment that, in the Commission's opinion, requires the decisionmaker to have a medical degree. The Commission notes that this annual certification could easily be included in an annual physical checkup.

Comment: The selection of respirator protection factors based upon "average concentrations" and not "peak airborne concentrations" is an improvement. The proposed rule, unlike the previous Part 20, permitted protection factors to be applied to the time-averaged air concentration rather than the peak air concentration.

Response: Despite some favorable comments on this change, the Commission has determined that the use of the average airborne concentration may not provide an adequate margin for health protection and, in the final rule, has reverted to the use of the anticipated peak concentration.

Final Rule: The proposed rule has been modified to require a respiratory protection program when respiratory protection devices are being used to limit intakes, whether or not credit is taken for respiratory protection factors. Allowance has been made for use of respirators that do not provide protection factors that would keep exposures below the derived air concentrations if (and only if) such use would keep the total effective dose equivalent ALARA.

Section 20.704 Further Restrictions on the Use of Respiratory Protection Equipment.

Comment: Section 20.704 should be deleted. This section, which states that the Commission may impose additional conditions on respirator use, is not necessary because § 20.1302 permits the NRC to place additional requirements on a licensee.

Response: Although the commenters are correct that § 20.1302 gives the Commission general authority to impose additional requirements on licensees, the Commission believes that the restatement of this policy in a section pertaining specifically to respiratory protection is desirable. As noted by the comments, this section does not create any additional requirement not otherwise contained in the regulations.

Final Rule: The requirements contained in the proposed rule are retained.

Subpart I--Storage and Control of Licensed Material

Sections 20.801 and 20.802 Security of Stored Material and Control of Material Not in Storage.

Comment: Definition of "secure." Several commenters requested a definition of the term "secure," which they felt was vague and did not provide an indication of the required licensee action.

Response: The phrase has been rearranged and now reads "secure from unauthorized removal or access," which is similar to the wording in the previous Part 20. This should provide sufficient clarification of what was intended by "secure."

Comment: Unnecessary restrictions on research. One commenter thought that the requirement to secure small quantities of radioactive materials when they are not in use would interfere with university research.

Response: The Commission believes that locking radiotracer laboratories when they are not being used is a small nuisance compared to the consequences of unauthorized access to or theft of the radioactive materials, which could result in contamination of unrestricted areas or exposure of individuals, as well as having to report a loss of licensed material to the NRC.

Subpart J--Precautionary Procedures

Section 20.901 Caution Signs.

Comment: Black should be permitted as an acceptable color for the radiation warning symbol. Several commenters requested that the color black should also be allowed to be used on signs and for stenciling on packages. The fading of magenta inks in sunlight and the use of black for marking international shipments were cited as supporting this position.

Response: The Commission believes that, although the "magenta-on-yellow" color scheme has provided a unique warning of possible radiation hazards, black-on-yellow would also be acceptable. The fading of the magenta color as cited above may reduce the visibility of the sign with time. Because of the cost impacts if existing warning signs had to be replaced, the Commission is permitting the use of black in addition to continued approval of magenta and purple, rather than as a required replacement.

Final Rule: This section has been modified to add black as an acceptable color for the radiation warning symbol.

Section 20.902 Posting Requirements.

Comment: The terms "Caution" and "Danger" are not used consistently. Commenters noted that "Caution" or "Danger" could be used on signs for "Radiation Areas," "High Radiation Areas," and "Very High Radiation Areas" despite the considerable variation in the hazards that might exist in these different areas.

Response and Final Rule: The Commission agrees that the terms "Caution" and "Danger" should be used in a more consistent manner. The final rule permits only the term "Caution" to be used in "Radiation Areas." "Caution" or "Danger" may be used in "High Radiation Areas," since it covers a considerable range from 0.1 rem per hour to over 500 rads per hour. Only "Grave Danger" may be used in "Very High Radiation Areas." This should provide more emphasis on the use of "Danger," the importance of which might have been diminished by its prior applicability to the lower haz , "Radiation Area." "Caution" is inappropriate for use in "very high radiation areas" because of the potential hazard.

Comment: There should be a requirement to post all "restricted areas" whether or not it is a radiation or an airborne radioactivity area.

Response: The objective of posting is to warn personnel of a potential hazard. A "restricted area," per se, does not warrant such a warning. There is nothing to prevent a licensee from posting a notice designating a "restricted area," but such action is not required.

Comment: The definition of "airborne radioactivity area" would require tracking of employee "stay times" (time spent in the area). The second option to the definition of "airborne radioactivity area" would require performing surveys of airborne activity and tracking the time spent by workers in the area. The present rule would have only necessitated the survey.

Response: There are two alternative definitions of an "airborne radioactivity area"; only the second one would require consideration of stay times. This second option does not require posting in areas that have low occupancy times and airborne radioactivity concentrations between 0.3 and 1.0 times the applicable DACs.

Comment: Areas containing only noble gases should not require posting as "airborne radioactivity areas." The hazard associated with such areas is primarily from external radiation.

Response: The DACs in Appendix B that apply to noble gases (and define an "airborne radioactivity area") are based upon submersion doses; therefore, the relationship remains valid. It should be noted that, because some short-lived noble gases have particulate daughters (such as ^{88}Rb and ^{138}Cs), the warning denoted by posting as an "airborne radioactivity area" may still be required.

Comment: There is no evident need to post all rooms containing 10 times the Appendix C levels. The requirement to post a caution sign in rooms that store ten times the Appendix C concentrations is unwarranted. There was some concern noted that such posting could deter firefighters or other emergency workers from entering an otherwise safe area, and increased damages could result.

Response: Complete dispersion of 10 times the Appendix C activities could produce air concentrations for some radionuclides in excess of the occupational DACs. For example, if 10 times the Appendix C quantities were dispersed in a 1,000 cubic foot (10 ft. x 10 ft. x 10 ft.) room, the resulting concentrations would be 35 times the DAC for organic carbon-14, 58 times the DAC for cesium-137, about 18 times the DACs for iodine-131 and tritium (water vapor), and approximately 6 times the DAC for technetium-99m. These appear to be sufficiently large to justify a posting requirement, particularly to caution firefighters in case of a fire.

Comment: The posting requirement should not be applied to sealed sources, such as gauges. Posting the entrances to areas having radioisotopic gauges could require multiple postings in large buildings.

Response: Posting is only required at entrances to the room containing the source and only when the dose rate at 30 centimeters would exceed 0.005 rem (0.05 mSv) in any hour (§ 20.903(c)) unless areas outside the room warrant posting as "radiation areas" and are already posted.

Section 20.903 Exceptions to Posting Requirements.

Comment: The proposed rule omits the past exemption for posting rooms containing only packages prepared for transportation.

Response: The Commission believes that there should be posting of these areas because there is no restriction on the length of time that packages may remain in a room. If the packages contain only small quantities of radioactive materials, then posting of the room would still be exempted under the remaining exemptions. The term "prepared for transportation" does include packages that are intended to be carried in a "sole use" vehicle. Such packages are permitted to have higher allowable dose rates than those specified in DOT (or NRC) limits for general shipment.

Final Rule: The exception for posting areas containing packages prepared for transportation has not been reinstated.

Comment: The requirement for a person in attendance would be unworkable in a hospital. The requirement (in lieu of posting the room containing a radiotherapy patient) for a person in attendance in order to prevent entry was interpreted as requiring a 24-hour escort for each radiotherapy patient.

Response: The intent was to generally require posting of therapy patients' rooms. (As noted in one of the comments, the dose rate from patients even with

diagnostic nuclear medicine treatments might exceed dose rates of 0.002 rem per hour.) The intent of "in attendance" would be satisfied by a duty nurse at a nursing station, providing that the station was in sight of the entrance to the patient's room.

Section 20.904 Labeling Containers.

Comment: There is no way to meet the requirement to label containers in some nuclear power plants or in hot cells. It is difficult to mark the detailed information on a container in some areas of a plant or in hot cells.

Response: Section 20.905 contains exceptions to the labeling requirements that take care of the problem noted by the commenter.

[Note: For the purpose of this section, "Mixed Fission Products" and "Fission and Activation Products" may be regarded as radionuclides, provided that the total activity is also specified. Designations as to the process stream or location sampled or type of sample (e.g., "primary coolant") may also be helpful as an additional designation of the potential hazard.]

Section 20.905 Exemptions to Labeling Requirements.

Comment: The proposed rule omits existing exemptions for packages containing only exempt quantities and those containing less than 10 mCi or less of tritium, iodine-125, carbon-14, and sulfur-35.

Response: While these sources pose little external hazard from gamma radiation, the quantities could be a potential internal hazard if the package were ruptured and the contents were released. Consequently, some warning remains appropriate.

Comment: The proposed rule omitted the existing exemption from labeling for packages labeled for shipment in accordance with DOT requirements.

Response and Final Rule: The exemption for DOT-labeled packages has been restored because the Commission agrees that the DOT labeling is sufficient to denote the presence of radioactive materials and provide an indication of any potential hazard. Quantities and concentrations not requiring DOT labels would not warrant an NRC labeling requirement. (See § 20.905(d).)

Section 20.906 Procedures for Handling Packages.

Comment: The requirement to monitor all packages is unnecessary. The requirement to monitor all incoming packages containing radioactive materials is unnecessary and in large installations creates a substantial monitoring burden.

Response: This requirement has been reevaluated and modified in order to reduce the burden.

Final Rule: Section 20.906 in the final rule requires incoming packages to be monitored when: (1) they are labeled as containing radioactive materials according to DOT regulations, or (2) when a package is damaged or leaking. The first provision would reinstate the exemption from monitoring for shipments of small quantities of radioactive materials that would not require DOT labeling.

Comment: The requirement to survey external surfaces of packages is unnecessary. Several commenters with extensive experience in monitoring packages noted that external contamination was rarely if ever present and that wipe tests are time-consuming both to make the smears and to count them.

Response: Experience in the shipment of thousands of packages each year has been very good. However, potential problems with leaking packages during transit warrant continued monitoring upon receipt to ensure that leaking packages are found and reported. Appropriate action can then be taken to determine the extent of contamination in transport vehicles and storage areas in order to limit the consequences and avoid recurrence. However, an exemption from the

contamination survey requirement has been provided for special form (sealed) sources that are being moved to and from work sites in licensee owned or operated vehicles. This partially restores an exemption from the package survey requirements in the existing Part 20 (§ 20.205(b)(iii)) for all special form sources.

The Commission believes that restoring this exemption will not result in any additional hazard. An external radiation survey of the package is still required. The primary purpose of this external survey of sealed sources is to ensure that the source is still properly secured and shielded after transporting it.

Final Rule: The requirement to monitor external surfaces of packages has been retained and applies to the two classes of packages for which surveys are required (labeled "radioactive" and damaged or leaking). A partial exemption to sealed sources transported for field use has been reinstated because of the difficulty in making field measurements of surface contamination and because the transporting vehicle is not in general commerce.

Comment: The requirement to monitor packages within 3 hours is unwarranted. This requirement would be difficult to meet for several types of licensees, some of which do not have a full-time health physics staff person.

Response: Licensees receiving labeled packages of radioactive materials to which this requirement applies are expected to have available persons who are qualified to perform such monitoring. However, the person monitoring the package need not be a board-certified health physicist.

Final Rule: The 3-hour period in the current Part 20 (§ 20.205(b)(1)(5)) has been retained except if the package is received after normal working hours.

Subpart K--Waste Disposal

Section 20.1001 General Requirements.

Comment: Decay in storage as a disposal option. Many commenters noted favorably the addition of "decay in storage" as an allowed waste disposal option. Several commenters, however, did not believe that the option, as expressed in the proposed rule, was particularly helpful.

Response: Technically, the "decay in storage" option has always been available to a licensee since the license permitted possession of the radioactive materials and these materials naturally underwent radioactive decay. The option was formally included in the proposed and final rules because the list of disposal options is exclusive and there have been questions as to whether this was allowed under the previous Part 20. It should be noted that this option does not allow material that has "decayed in storage" to be released to unrestricted areas unless it meets the requirements of one of the other allowed forms of waste disposal in Part 20, or the requirements of § 35.92, "Decay-in-Storage," of 10 CFR Part 35, or the specific requirements given in any NRC or Agreement State license conditions.

The NRC staff considered adding a separate "Disposal by Decay in Storage" option with specific criteria for unrestricted release of material after decay. These criteria are commonly included in source and byproduct material licenses. However, the provisions included in 10 CFR 35.92 and certain specific license conditions pertain to relatively short-lived radionuclides and are neither appropriate nor applicable to other classes of licenses, such as those issued under Part 50. Also, when evaluated for a specific licensed activity, it is possible to consider existing pathways of exposure and to establish specific criteria for decay.

General criteria in a rule would need to be sufficiently conservative to take into account all reasonably conceivable pathways, thereby reducing the applicable level from what would be permitted in a case-by-case evaluation.

Final Rule: The final rule has been modified to explicitly list "decay-in-storage" as an authorized form of disposal. Section 20.1001 has been modified to incorporate the requirements that were in § 20.1002(b) of the proposed rule. These provisions require NRC licenses for persons who receive wastes containing licensed radioactive materials for treatment, for treatment or disposal by incineration, decay-in-storage, or disposal in facilities licensed under Part 60 or Part 61.

Section 20.1003 Disposal by Release into Sanitary Sewerage.

Comment: Removal of allowance for disposal of "dispersible wastes." A number of commenters felt that the restriction of wastes released to sanitary sewers to soluble wastes would have an adverse impact on certain licensees that, under the previous rule, had disposed of "dispersible" but insoluble radioactive materials. In particular, the practice was mentioned of grinding up animal carcasses with subsequent sewer disposal of the ground residue. This practice is permitted by the previous Part 20 but would not have been permitted under the proposed rule.

Response: In the final rule, the Commission has modified the conditions in the proposed rule for disposal of radioactive wastes into sanitary sewer systems so that "dispersible biological materials" may continue to be disposed of by release to sanitary sewers. This means of disposal is advantageous compared with other alternatives for disposal of this type of biological material.

The prohibition on disposal of insoluble materials via the sanitary sewer was intended to prevent disposal via sanitary sewers of material in which the radioactive material is primarily in an insoluble form. Such materials may accumulate in the sewer system, in the sewer treatment plants, and in the sewer sludge.

Final Rule: The final rule permits disposal into sanitary sewers of: (1) radionuclides in soluble form or (2) radionuclides in readily dispersible biological material, provided that the limits in Appendix B, Table 3, on the

average monthly concentrations and the limits in § 20.1003(a)(4) on the total activity released annually are met. The revised rule no longer permits the disposal of nonbiological insoluble materials because of potential reconcentration of these materials in the sanitary sewer system, sewage treatment plants, and sewage sludge. This prohibition for insoluble materials is the reason why there are no values listed in Table 3 of Appendix B for insoluble materials.

Comment: The rationale for the reduction in the limits for sewer disposal is not explained. The concentration limits for radionuclides released to sanitary sewer systems in the proposed rule have been reduced by a factor of 10 from the former rule. This reduction did not appear to take into account the dilution afforded from multiple users of the sewer system. Commenters indicated that they thought that this reduction would increase the amount of material that would have to be disposed of via a low-level radioactive waste burial site and could result in increased radiation doses to workers having to package this material.

Response: The assumption noted by many commenters that radionuclides discharged into sanitary sewer systems are not ingested is not necessarily true because water in large lake or river systems may be recycled. The dilution afforded by having multiple users of a sewer system can be offset in part because there can also be several users that discharge radioactive wastes into the same sewer system. The revised Part 20 rule permits a higher concentration limit for discharges into sanitary sewers than for other liquid effluent releases of radioactive materials, but has lower concentration limits than were formerly allowed for sewage. In view of past contamination incidents (involving cobalt-60 and americium-241) and the reduction in the dose limit for members of the public, the Commission believes that continuation of the higher limits is no longer desirable.

The NRC has under way a study of the dose pathways associated with disposal of radioactive materials via sanitary sewers. This study will help clarify the potential for human exposure.

Comment: The exemption on disposal of human excreta should be removed. Hospitals should have to comply with the same regulations as other licensees.

Response: Disposal into a sanitary sewer system (which was designed specifically to handle this type of waste) is the preferred method of disposal because of the other health considerations in handling human excreta in addition to radiation protection. This exemption is in the current Part 20.

Section 20.1004 Treatment or Disposal by Incineration.

Comment: Relaxation of specific NRC authorization for incineration. A number of comments questioned the need for the existing requirement that incineration of radioactive materials requires specific prior NRC approval (except for small quantities of tritium and carbon-14, which are specifically exempted). These commenters noted that the source of the released material (from an incinerator stack or from a fume hood vent) should not be the basis of requiring specific prior NRC approval of incineration while permitting general effluent releases.

Response: Relaxation of the prior approval requirement for incineration was considered in connection with the revision of Part 20. The requirement for prior NRC approval of incineration remains in the revised Part 20 because the acceptability of incineration as a disposal option, except for exempted quantities of radioactive materials, must be determined on a site-specific basis considering (1) incinerator design to safely dispose of hazardous materials, (2) the variable nature of the material to be burned both in terms of isotopic composition and activity, and (3) because many of these incinerators can be located in urban areas, special calculational methods may be required to assess doses to people located near these facilities.

Final Rule: Disposal by incineration still requires specific approval by the Commission (or Agreement State) whether done only for wastes from the licensed facility or whether done for wastes received from other licensees.

Section 20.1005 Disposal of Specific Wastes.

Comment: There should be a definition of ALARA for solid wastes. Many commenters suggested the need for ALARA or exempt quantities of radioactive material in solid wastes so that very low-level solid wastes could be disposed of without regard to their radioactivity.

Response: The Commission agrees that such levels would be useful and has developed a policy statement regarding levels of dose and risk that can be used to determine that specific practices involve radiation hazards that are Below Regulatory Concern (BRC). This policy statement was published in the Federal Register on July 3, 1990 (55 FR 27522). The BRC policy statement provides a comprehensive policy that will establish a disciplined and consistent framework for all future Commission exemption decisions. This includes potential application to rulemaking or licensing actions for disposal of slightly contaminated solid radioactive wastes. The Commission is developing a program for implementing the BRC policy separate from this Part 20 rulemaking.

Section 20.1006 Transfer for disposal and manifests.

Comment: This section should not be in Part 20.

Response and Final Rule: This section is in Part 20 because it relates to the radiation protection aspects of low-level waste shipments.

Section 20.1[illegible]iance with Environmental and Health Protection [illegible]ations.

Final R[illegible] is section has a counterpart in the present Part 20 and in the proposed rule (§ 20.1005) stating that meeting Part 20 requirements does not remove the responsibility of licensees, when disposing of licensed radioactive materials, from meeting the requirements of other applicable Federal, State, and local regulations applicable to toxic or hazardous wastes.

The advisory statement in the final rule has been expanded to cover all methods of waste disposal. This section of the rule is advisory and is not intended to imply that NRC will take enforcement action for violations of other environmental protection regulations issued under statutes other than the Atomic Energy Act.

Subpart L--Records

Standardization of Record Retention Requirements.

Final Rule: Records directly pertaining to effluents released to the general environment, waste disposal, and doses received by individuals are to be kept until the "Commission terminates each pertinent license requiring the record." Other record retention requirements in this subpart generally have been modified to be for 3 years after the record is made. This change is in conformance with the final rule published in the Federal Register of May 27, 1988 (53 FR 19240) on record retention requirements for other parts of the NRC regulations. This change provides for consistent record retention requirements throughout the NRC regulations in Title 10 of the Code of Federal Regulations.

Section 20.1101 General Requirements.

Comment: The units used in records should be limited to those commonly in use: the rad, the rem, and the curie. Some commenters thought that the use of SI units (gray, sievert, and becquerel) should not be allowed.

Response and Final Rule: The Commission agrees that the use of "special units," the rad, the rem, and the curie, is preferable at this time. This will avoid any difficulties arising from trying to implement both a new regulation and new units. This will reduce potential problems in records and reports that could result from some licensees using the "SI units" and some using the older "special units." The final rule requires the use of the "special units" instead of the "SI units." See the discussion of this topic under § 20.4 Units.

Section 20.1102 Records of Radiation Protection Programs.

Comment: Added implementation burden associated with requirements for formal radiation programs. A number of commenters thought that the requirement to have a formal ALARA program would result in substantial increased costs due to additional recordkeeping, procedural requirements, and quality assurance requirements.

Response: As discussed under § 20.101, these provisions have been modified to require ALARA as one part of a licensee's radiation protection program. The adoption of requirements for licensees to have a formal radiation protection program was not intended to cause large implementation costs. Much of the cost associated with the recordkeeping requirements in the proposed rule was a result of the ALARA documentation requirements. These recordkeeping requirements have been reduced in the final rule by deleting specific reference to documenting ALARA actions. Specific types of records will be developed by each licensee as part of its radiation protection program. Therefore, this section contains general recordkeeping requirements associated with the radiation protection program.

Comment: The recordkeeping burden for small licensees requires a commitment of resources that is not commensurate with the risk. (In Section XXXVI of the proposed rule (51 FR 1121-1122), NRC specifically requested comments on the magnitude of the impact of the proposed rule on small licensees and requested suggestions on how these impacts could be reduced.) Quite a few commenters expressed their belief that the proposed rule will require more extensive monitoring and recordkeeping efforts than were required by the existing Part 20. Several commenters suggested that the NRC explore possible exemptions or exclusions for academic licensees and other users of small quantities of licensed material. Other commenters expressed the view that the protection of public health for both the worker and the general public should be the same regardless of the size or economic resources of the licensee.

Response: Because of the changes to reduce the recordkeeping burden discussed in response to the preceding comment and because the basic requirement in § 20.101 calls for effort "... commensurate with the scope and extent of licensed activities ...," the Commission has not made further exemptions or exclusions from the recordkeeping requirements in this section for certain types of licensees.

Section 20.1104 Determination of Prior Occupational Dose.

Comment: Medical and academic licensees would have difficulty in complying with the requirement to determine prior exposures. The transitory nature of personnel in these facilities would make meeting these requirements very costly. Doses to employees are small fractions of the limits so that such costs would be difficult to justify.

Response: The requirement to determine dose received in the current year implements the annual dose limits. The requirement to attempt to obtain records of lifetime cumulative doses follows one of the provisions of the guidance to Federal agencies on occupational radiation protection. Efforts to obtain prior exposure histories are only required for workers who are required to be monitored under § 20.502. Determination of prior doses received during planned special exposures or doses in excess of the annual limits are required only for workers who will be used in planned special exposures.

Comment: The recording of "fictitious" radiation doses should be avoided. The present and proposed rules state that, when information is not available regarding the dose received for a specific period, the licensee should assume that the dose received was at the dose limit. Several commenters thought that this was inappropriate. Some commenters mentioned that this practice might be nonconservative as it would tend to overestimate the dose used in any epidemiological studies of radiation effects, thereby resulting in an underestimate of the risk associated with a unit radiation dose.

Response and Final Rule: The final rule has been modified so that it does not require any assumed dose value to be recorded in case of incomplete prior dose histories. Only the lack of data must be recorded for periods where there is no information. However, for the current year, where there are missing data, an assumption is to be made for establishing administrative controls: the portion of the dose limit remaining for the current year is reduced by 1.25 rems for each calendar quarter for which information is missing. (The values for other limits, such as the shallow dose equivalent or eye dose equivalent should be reduced by a one-quarter of their annual limit for each unreported quarter.) The licensee must note the absence of this information on the employee's record but should not enter the assumed dose value as part of the employee's permanent dose record. For example, an employee who had prior radiation working experience joins Company X on July 1st but does not have the prior radiation records. This employee's dose should be limited to 2.5 rems (5 rems - 2(1.25) = 2.5 rems) until such time as the records are obtained.

Comment: There should be a quarterly dose limit to cover workers whose records have not been received from a former employer. A 0.5-rem dose might be appropriate for this purpose.

Response: If data were missing for all four quarters (employment commenced late in the fourth calendar quarter), then the employee could not be exposed to radiation above the level for a member of the general public. However, this limit is 0.1 rem per year not 0.5 rem.

Section 20.1105 Records of Planned Special Exposures.

See discussion under § 20.1204.

Section 10.1106 Records of Individual Monitoring Results.

Comment: NRC should not require reporting or recording of cumulative dose. A number of commenters noted that the ICRP system of dose limitation is based [as one of the principles] on controlling annual doses. Consequently, they questioned the need for recording cumulative doses.

Response: Although the commenters are correct that there is no longer a cumulative dose restriction in Part 20 (such as the former 5(N - 18) formula), the Federal Guidance on Occupational Exposure (see Section II.D) contains a recommendation that cumulative dose records be maintained and provided to the worker.

Comment: The proposed rule does not require recording annual doses as listed in the 1987 Federal occupational guidance.

Response: "Annual dose" is specified in the guidance and is the same as the annual deep-dose equivalent for external doses. However, "annual dose" is not required to be recorded by the revised Part 20 for internal doses. This is consistent with an exception noted in footnote 5 to the Federal guidance (Federal Register of January 27, 1977; 52 FR 2832):

> "When these conditions on intake of radioactive materials have been satisfied [i.e., meeting the committed dose limits], it is not necessary to assess contributions from such intakes to annual doses in future years, and, as an operational procedure, such doses may be assigned to the year of intake for the purpose of assessing compliance."

Paragraph 20.1106(b) -- See discussion under § 20.1204.

Comment: The recordkeeping requirement in the proposed § 20.1106(d)(2) would require that all records begin at the beginning of a calendar year. This would create an unnecessary hardship on dosimeter processors since they could not stagger the dosimeter changeover schedules to provide a more uniform workload distribution.

Response and Final Rule: The term "year" replaces the term "calendar year" in § 20.3 and permits the licensee to define the year to begin anytime in January. A licensee may change the starting date, provided that the change is made at the beginning of the year and provided that no day is omitted and no day is included twice in consecutive years.

Comment: The requirement in § 20.1106(e) for each licensee to keep a copy of the dosimeter processor's accreditation certificate creates an undue burden on commercial processors. Commercial dosimeter processors would have to print and distribute thousands of their certificates so that each user had a copy.

Response: The proposed rule contained a requirement for the licensee to maintain a copy of the dosimetry processing accreditation certificate issued to the processor providing dosimetry services to the licensee. This requirement, which was in the proposed dosimetry accreditation rule, was considered unnecessary and was dropped as a requirement in the final version of that rule. Consequently, it has been deleted from revised Part 20. Licensees who provide their own dosimeter processing services do have to maintain a copy of their NVLAP accreditation certificate for inspection.

Comment: The NRC should consider a "traveling dose history" that can move with the worker. This was suggested, particularly for transient workers and for workers employed concurrently by two employers. The master record will reside with the current employer and would have to be transmitted by the worker to a new employer.

Response: Because the NRC can only regulate its licensees and has no authority over individual workers, the recordkeeping and transmittal requirements for dose histories are placed on the licensee and not on the worker. The concept of a "passport" incorporating security and dosimetry data has been used successfully in Japan and elsewhere. The requirements for determination of prior exposures that are in § 20.1104 provide a similar record to a "moving history," but this would have to be updated by each new employer.

Concurrent employment with two (or more) employers requires special attention so that the combined doses from both employers would not exceed the dose limits. When two employers are aware of such concurrent employment, the simplest expedient to achieve this goal is for them to agree that the dose limit they will use for this employee in the individual programs is less than one-half of the NRC dose limits (the fraction of the dose limit allocated to each employer might also be determined on the basis of the relative amount of time worked at each location).

The problem of dual employment is more of a problem when the employee has not confided in the employer. The licensee is required to ascertain the employment and dose record for the current year for new employees (§ 20.1104). If the employee deliberately falsifies this information, the licensee would not know of concurrent employment and the licensee would not be penalized for combined doses from both employers that exceeded the dose limits. If a current employee takes on additional outside radiation work without informing the employer, the employer should not be penalized. It should be noted that, under the new reporting requirements in § 20.1206, individual dose records will be required to be submitted to the NRC for all workers for those categories of licensees formerly subject to § 20.407, including nuclear power reactor licensees.

Final Rule: Section 20.1106 has been modified in order to separate the requirement for keeping a record from the format of the record. A clarification has been added that the dose information on an embryo/fetus be kept with the mother's dose record.

Section 20.1107 Records of Dose to Individual Members of the Public.

Comment: Reporting requirements for exceeding "reference levels." The proposed rule contained requirements for reporting exposures in excess of the "reference levels" for doses to members of the general public. Many commenters thought that this was excessive because this was not an actual regulatory limit.

Response: The 100 millirems per year "reference level" for doses to members of the general public in the proposed rule has been incorporated as the dose limit in the final rule for members of the general public so that the associated recording and reporting requirements now pertain to a regulatory limit.

Final Rule: Section 20.1107 has been broadened in scope from "effluents" to pertain to records of all estimates of doses received by individual members of the public. Doses to members of the public are calculated from measurements of direct radiation, and radionuclides in effluents, and the environment rather than as measurements pertaining to a a particular individual. This difference in method of dose assessment from the more direct measurements used for occupational exposure does not imply any lessening of requirements for keeping adequate records of effluents released to unrestricted areas.

Section 20.1108 Records of Waste Disposal.

Final Rule: Section 20.1108 is unchanged from the proposed rule.

Section 20.1109 Records of Testing Entry Control Devices for Very High Radiation Areas.

Final Rule: Section 20.1109 contains an addition to the proposed rule for keeping records of tests of entry control devices for very high radiation areas. This addition is based upon a requirement in § 20.203(c)(6) of the present Part 20.

Section 20.1110 Form of Records.

Comment: NRC should allow computerized recordkeeping systems to handle records. A few licensees suggested that NRC allow "electronic" recordkeeping systems and provide guidance for their use.

Response: The Commission agrees that there is great value in the use of "electronic media." There are a growing number of licensees that are using computer information networks for retaining and transmitting radiation dose histories and other worker-related information among different facilities.

Final Rule: The final Part 20 expands the definition of "record" to include "electronic media." The use of electronic media requires authentication and the prevention of alteration or loss of the records. As with existing requirements for paper records, the electronic media must be capable of producing a legible copy of the record.

Subpart M--Reports

Section 20.1201 Reports of Theft or Loss of Licensed Material.

Comment: The term "substantial exposure" in § 20.1201(a) should be defined. The requirement to report the loss of radiation sources capable of producing "substantial exposure" needs to be more precise.

Response: The term "substantial exposure" has been replaced by a specific designation of the activity of lost source that requires immediate reporting to the Commission. This quantity is 1,000 times the Appendix C activity levels. For sealed sources of cobalt-60, cesium-137, or iridium-192, this activity would produce a dose of around 25 rems at 1 foot over a 30-day period (25 rems is the worker dose that requires immediate Commission notification). Although somewhat similar doses may be projected from inhalation of dispersible material, the exact exposure conditions would have to be known in order to make a valid activity-to-dose relationship.

Final Rule: The final rule now contains specific activity criteria for immediate reporting rather than the vague term, "substantial exposure."

Comment: The quantity for reporting the loss of a source is too low (too high). The reportable quantity of 10 times the Appendix C activity values appeared to some commenters to be overly restrictive; others thought that all lost or missing radiation sources should be reported.

Response: The specified 30-day reporting level is a compromise between having higher reporting levels and having a requirement that all lost or missing sources be reported. Further, the report permits review of the circumstances involved including any lack of security of materials or weakness in the licensee's control program that may be unrelated to the sources being stolen or lost, but may be pertinent in avoiding recurrent theft or loss.

Final Rule: The activity levels in Appendix C for some long-lived radionuclides have been increased from those specified in the proposed rule. This increase means that the loss of milligram quantities of natural uranium will no longer have to be reported.

Comment: A 30-day telephone report should not be required concomitant with a written report. Sections 20.1201(a)(1)(ii) and 20.1201(b) both call for a 30-day report; the first requires a telephone report and the latter section requires a written report.

Response and Final Rule: The rule has been revised to clarify that the written reports required by § 20.1201(b) are to be submitted within 30 days of the telephone notification required by § 20.1201(a), rather than both being within 30 days of learning of the theft or loss.

Comment: The rule should provide for a "grace period" before having to report a lost source to NRC. Commenters noted that, in many instances, a source "lost" in transit eventually turns up. Some specified period, such as 7 days, should be permitted before a "lost" source would have to be reported to the NRC.

Response: The rule contains two notification requirements: the one for immediate notification only pertains to those sources that exceed 1,000 times the Appendix C activity levels. The second notification requirement pertains to sources that exceed 10 times the activity levels in Appendix C and that are still missing after 30 days. This provides a grace period of 30 days for reporting the loss of most sources.

Section 20.1202 Notification of Incidents.

Comment: The requirements for immediate notification of NRC are too low. Some commenters thought that the doses associated with the requirements for immediate reporting to NRC (five times the respective annual limits) would not produce any discernible harmful effects to the individual to warrant immediate reporting.

Response: Doses of the order of 25 rems (5 times the 5-rem annual dose limit) can produce discernible biological effects in the body in the form of chromosome aberrations and changes in the white blood cell populations. Although the majority of these effects are temporary, they could be discerned. However, irrespective of the potential for discernible effects, doses at these levels represent a major breakdown in the licensee's control over the radioactive material, and the Commission believes that it is important that NRC be promptly notified so that it can take actions, if necessary, to limit further consequences.

Final Rule: The final rule retains the previous reporting requirement.

Comment: Immediate reporting should be required if there is any potential for dose reduction. The Environmental Protection Agency (EPA) suggested that incidents always be reported if there is the potential for significantly reducing public doses through protective actions. It is believed by the EPA that this would occur at doses significantly less than those of the proposed reporting criteria.

Response: The incident reporting levels and response times have been selected to limit attention to the more potentially serious events without the entire NRC emergency response network being activated unduly for events involving only small quantities of radioactive materials. For most cases, it is expected that the licensee would have initiated any necessary remedial measures.

Comment: Immediate and 24-hour notification requirements should be suspended in the case of a declared emergency at a nuclear power plant. Commenters felt that any emergency at a nuclear power plant will involve onsite NRC staff and that stopping emergency activities to make the Part 20 incident reports could be a burden on the licensee.

Response and Final Rule: These reports are particularly easy to make for nuclear power reactors (the reactor operator merely has to pick up the dedicated NRC telephone line to get the NRC Operations Center). There are certain functions of the NRC (such as activating the NRC Incident Response Plan) that require that NRC be notified; therefore, this notification requirement has been retained.

Section 20.1203 Reports of Exposures, Radiation Levels, and Concentrations.

Comment: There is no requirement for reporting doses that exceed the limit for protection of the embryo/fetus in § 20.208.

Response and Final Rule: A requirement has been added to the final rule in § 20.1203(a)(2)(iii).

Comment: The identifiers required in § 20.1203(b)(2) for the embryo/fetus should be those of the mother. As the fetus has no date of birth and no Social Security account number, those of the mother should be used.

Response and Final Rule: A footnote to this effect has been added to § 20.1203.

Comment: Reports of exceeding the 0.1-rem reference level should not be required. A number of commenters noted that the 0.1-rem reference level was not a limit and, therefore, exceeding it should not necessitate a report to the NRC.

Response: As a result of changes in the ICRP interpretation of the 0.1-rem level and the former 0.5-rem dose limit, the 0.1-rem level is now the recommended limit. Consequently, 0.1 rem is the primary limit applicable to members of the general public and reports are justified when it is exceeded.

Comment: Smaller licensees, such as nuclear medicine facilities, should be exempted from the reporting requirements of § 20.1203. Licensees are required to report concentrations in unrestricted areas that exceed 10 times any applicable limit in the license. Because some nuclear medicine units use the room air volume for dilution, calculated concentrations exceeding 10 times the Appendix B limits might frequently occur. This would require either more frequent reporting to NRC or use of more sophisticated atmospheric dispersion models.

Response: The reporting requirements are very similar to those in the previous Part 20. Part 35 of the Commission's regulations, which deals with medical applications, covers the medical use of noble gases and in § 35.205(a) limits airborne concentrations to the 10 CFR Part 20 Appendix B concentrations. Experience has not indicated large numbers of reports of such limits being exceeded.

§ 20.1204 Reports of Planned Special Exposures

Comment: The licensee should not have to file a separate report to NRC for Planned Special Exposures. Several commenters objected to having to file these separate reports each time a Planned Special Exposure is carried out. This was viewed as representing a reporting requirement for operating within the NRC regulations. It was suggested that this information be included in the employee's records without reporting to NRC.

Response: Because of the newness of the concept, the NRC wishes to monitor carefully the use of the Planned Special Exposures. Further, while the Planned Special Exposures are provided in the final rule, its use does represent a situation in which the licensee is operating outside of the normal dose limits, and of which the Commission should be aware.

Comment: Period for reporting planned special exposures. Several commenters noted that the 15-day period for reporting planned special exposures is shorter than the 30-day period usually allowed for similar reports.

Response: The reporting period of a planned special exposure has been increased from 15 days to 30 days to be more consistent with other reporting requirements.

Section 20.1206 Reports of Individual Monitoring.

Comment: Could the requirement for the reporting of individual exposures be construed as an invasion of privacy? Some commenters believed that requiring the reporting of individual doses rather than a statistical summary might constitute an invasion of personal privacy.

Response: The Commission does not believe that submission of individual dose data constitutes an invasion of privacy. Such data have been reported to the NRC routinely in the termination reports for some time. Such information

will be protected in accordance with the Privacy Act and will be restricted, as it has been in the past, to use by NRC officials, NRC contractors, or qualified scientific investigators. Instructions on protecting this information appear in § 20.1106(d).

Comment: If the radiation exposure data are collected into a central repository, would the NRC be the proper place for it? One commenter felt that the radiation exposure data might be better maintained by an agency whose charter encompasses the analysis of the data for estimates of risk.

Response: Arguments might be made for other agencies having the lead role in the storage and analysis of those data; however, it is the NRC that has the statutory authority to require that these data be collected. Although the Part 20 recordkeeping requirements are intended primarily to fulfill NRC's information needs for regulation, the NRC has continuing contacts with agencies that have expertise in conducting epidemiological studies (such as the National Cancer Institute of the National Institutes of Health and the Office of Health and Safety of the Department of Energy) to ensure that the Part 20 reporting and recordkeeping requirements do not lose information that would be vital to carrying out studies of this type.

Comment: The total collective (person-rem) dose should be reported. It was felt by one commenter that NRC should require the total collective dose to be reported so that the numbers used in NUREG-0473 (NRC's annual summary of occupational radiation doses) will be the same as those calculated by the licensee.

Response: The reason for a possible discrepancy between a licensee's estimate of the collective dose to workers and the estimate published by the NRC has been that the licensee may sum the actual individual doses and the NRC estimate is based upon the statistical summary rather than the actual individual dose reports. Such differences should be reduced in the future because NRC will also be using dose information for individuals. The final rule requires licensees who previously submitted the dose summaries to report the individual dose data to NRC. Both collective dose calculations should then be using the same data base.

Comment: The termination report required in § 20.1207 should (or should not) be replaced with an annual report for all personnel monitored. Some commenters felt that an annual report just to the NRC should replace the present requirement for a termination report. Other commenters felt that annual reports to the NRC of doses to individuals constituted a considerably larger burden than did a statistical summary. Some commenters, who disagree with filing an annual report to the NRC, were in favor of giving such an annual dose summary to the worker. Other commenters suggested that all licensees be required to submit an annual report to NRC on each monitored individual.

Response: The reporting of individual monitoring data will help track doses to individuals who are exposed at several facilities during any given year and whose total dose would be underreported by statistical reports prepared at each work site. Such information is shown at the present time only by analysis of the termination reports.

Licensees who were previously required to file both annual statistical summaries and termination reports with the NRC will, instead, submit annual dose reports to NRC for all workers for whom monitoring was required under § 20.502. A copy of the annual report to NRC could also be given to the individual worker in order to satisfy the revised reporting requirement in § 19.13 of 10 CFR Part 19. Although this may entail some additional burden to licensees, the use of "electronic media" for recordkeeping might in fact reduce overall costs. It is intended that large employers (such as nuclear power reactor licensees) would submit an electronic copy of their dose reports in a prescribed format to the NRC in lieu of paper copies of individual records.

Subpart N--Exemptions and Additional Requirements

Section 20.1301 Applications for Exemptions.

Comment: NRC should make the issuance of exemptions a matter of public record. Several commenters felt that the issuance of any exemptions under this section should require public notice and comment. The EPA stated that exemptions could adversely affect its ability to control radionuclides under the Safe Drinking Water Act.

Response: The NRC has issued few exemptions under this longstanding provision and has not exempted anyone from the dose limits for a worker or for a member of the public. The Safe Drinking Water Act was not intended to control effluents and, although radionuclide concentrations at downstream water supplies are routinely calculated as part of licensing evaluations, the licensee must meet the Part 20 concentration limits at the effluent release point, not at the drinking water intake after dilution occurs.

Appendix A

Comment: The protection factor for air-purifying respirators with particulate elements is too low. The listed protection factor for air-purifying respirators with particulate filters is 50, whereas both ANSI Z88.2 and the OSHA regulations in 29 CFR Part 134 use 100.

Response: The NRC never endorsed ANSI Z88.2-1980, whereas the OSHA regulations generally follow ANSI standards. The current NRC-allowed protection factors (PFs) are based upon research conducted by the Los Alamos National Laboratory (LANL). These recommendations included a PF of 50 for full face respirators, based on experimental data on actual testing of personnel using respirators under carefully controlled conditions. In actual use, there is essentially no difference between a PF of 50 versus a PF of 100, so that there should be little or no real impact on field use of respirators or on operations at nuclear facilities that would result from using the higher protect on factor.

Comment: Several respiratory equipment specifications in Appendix A should be applicable only for areas that are "immediately dangerous to life and health." Footnotes "h" and "i" contain specifications for air flow rates and flow calibration and a requirement for standby rescuers to be available when using supplied-air suits. These were felt to be unneeded considering that, if the air flow failed, the person could withstand a small exposure to the airborne radionuclides while exiting the area after removing the protective hood.

Response: The supposition that conditions "immediately dangerous to life and health" do not exist is not always correct. Failure of an airline in supplied-air suits may be considered as "immediately dangerous to life and health" because there is an acute danger of suffocation if the air supply is interrupted and the hood cannot be removed by the wearer. Rapid recovery of and assistance to the individual in the supplied-air suit necessitates the presence of a pre-equipped rescuer.

Appendix B

General comments: Most of the comments from radiation protection professionals favored the adoption of the ICRP-26/ICRP-30 annual limits on intake and the derived air concentrations. Comments from private citizens were against adoption of the ICRP values because the majority of the values would increase (as stated in Section XXIX of the proposed rule, 51 FR 1120).

Response: From an occupational protection standpoint, the changes that result from adoption of the ICRP risk-based approach lead to higher limiting intake values than in the previous Part 20. These increases result from the increase in the allowable ceiling for organ doses. The values that served as the basis for calculating the concentration limits used in the former Part 20 were organ dose limits of 5, 15, and 30 rems. The new concentration limits are based upon the effective (weighted) organ dose or upon the nonstochastic limit that forms an organ dose ceiling when the stochastic risk is not limiting. These changes increase the limiting annual organ doses (when only one organ is irradiated) for those doses that are limited by the stochastic (effective dose) limit from 5 rems to 20 rems for the gonads, from 15 rems to 32 rems per year for the breast, and from 15 rems to 42 rems for the lung. Limiting doses to other organs increase from the former 15- and 30-rem values to the 50-rem nonstochastic limit.

The former ICRP-2 "critical organ" concept based the limiting intake upon controlling the dose rate to the organ receiving the highest dose rate (the "critical organ") The doses to organs other than the critical organ did not

have to be evaluated, even if these doses were close to the estimated dose to the critical organ. The new ICRP-26/30 system evaluates the doses to the major organs and the six remaining organs that receive the next highest doses. These doses are then multiplied by the appropriate weighting factors (w_T) and are summed to give a risk-weighted "effective dose." The concentration limits that are based upon this newer ICRP approach reflect the doses to all principal organs that are irradiated, not just the one organ that receives the highest dose as was done in the former Part 20.

Many of the comments from private citizens do not appear to reflect the proposed rule because many of the comments objected to raising the limits for radionuclide concentrations applicable to the general public. As noted in the discussion of Appendix B in the notice of proposed rulemaking (Section XXIX, 51 FR 1119-1120), the concentration limits for members of the public were based upon a "reference level" dose (now the dose limit for members of the general public) of 0.1 rem per year and incorporated an additional factor of 2 reduction (Proposed Appendix B; 51 FR 1145) for age-dependency and combined air and water intakes. Thus, the concentration limits for the public reflect a reduction in their basis from a whole-body annual dose of 0.5 rem in the former Part 20 to 0.05 rem in the proposed and final rules.

The concentration limits for individual radionuclides may be higher or lower for members of the general public in unrestricted areas in the final Appendix B than in the former tables because of changes that occurred in the intervening 25 years in the metabolic and other parameters used to calculate internal doses. These changes are reflected in ICRP Publication 30 and its supplements and amendments. However, these changes are a result of changes in the scientific techniques and parameters used in calculating doses and do not reflect an increase in the allowable dose limits, which, in reality, have been decreased in the revised Part 20.

Comment: NRC should consider deleting Table 2 from Appendix B. The concentration limits in Appendix B do not provide adequate protection of children and infants because they do not take into account age dependency in a proper manner. Compliance with the dose limits, rather than with these concentration limits, should be required.

Response: The use of the effective dose equivalent concept reduces the importance of age-dependent intake-to-dose factors. Age dependency is of primary importance in calculating organ doses. Those organs for which age dependency is important, such as the thyroid gland, are of lesser importance because of lower w_T values (for the thyroid, for example, $w_T = 0.03$) used to calculate the effective dose. A factor of 2 is included in the calculation of concentration limits for release to air and water, which, in part, accounts for age dependency. In addition, the Commission believes that there is a lack of detailed age-dependent metabolic data for all but the most common radionuclides that will inhibit such attempts to increase the precision of the dose estimates.

Many smaller licensees routinely use concentrations and the Appendix B tables in order to demonstrate compliance. The use of concentration limits for determining compliance is a well-established practice that is economical for many of the smaller licensees. Despite the growing availability of simplified dose assessment models, the Commission is continuing to accept the use of concentrations to demonstrate compliance with the dose limits.

Comment: The Appendix B tables fail to account for the chemical toxicity of natural and low-enriched uranium. This fails to take into account the possible kidney (renal) damage associated with the chemical toxicity.

Response: There is a separate limit for uranium intake that is based upon the chemical toxicity. This limit was expressed as footnote 3 to Appendix B, page 1199 of the January 9, 1986 notice of proposed rulemaking and also as § 20.204(i) on page 1131. In the revised rule, it still appears as footnote 3 in Appendix B, but the limit also has been moved up in the text to the section on dose limits and now appears as § 20.201(e).

Comment: The limits for occupational and nonoccupational exposure to radon-222 and its particulate daughters do not appear to be consistent with the airborne concentration limits for other radionuclides in terms of risk.

Response: The occupational concentration limits for radon-222 are based on the existing Federal guidance, which is 4 WLM (4 Working-Level Months) per year. The annual limit on intake (ALI) is stated as 100 μCi or 4 working-level months. The derived air concentration (DAC) in Part 20 for occupational exposure to radon-222 of 3×10^{-8} is equivalent to 0.33 working levels (this equivalence is also given in the Appendix B table). The concentration limit for members of the general public is a factor of 300 lower and, like the other airborne concentration limits, represents an effective dose of 0.05 rem per year.

Comment: Concentration limits for tritium omit chemical forms other than for tritiated water vapor.

Response: As there is expected to be no occupational intake via oral ingestion, and most of the commonly used organic tritiated compounds are not volatile, inhalation and transpiration through the skin are the principal pathways of exposure. Different intake limits would apply to hydrogen gas (HT or T_2) and tritiated water vapor(HTO). The HT or T_2 gas is rapidly converted to HTO by isotopic exchange and oxidation (both in air and in the body) so that specifying a submersion dose limit for HT would understate the actual radiological impact. Comparison with other derived limits for other chemical forms shows that the use of the concentration limits for HTO provides an adequate level of protection for most of the other chemical forms.

Comment: No concentration limits are listed for natural thorium. There are limits for natural uranium, but corresponding concentration limits for natural thorium are not given. The isotopic composition of thorium can vary somewhat with different ores and with different times after chemical separation.

Response: A licensee should use the thorium-232 value or, if a more precise value is desired, use the procedure for mixtures in Appendix B applied to the actual isotopic concentrations present.

Comment: The derived air concentrations for the general public are not always 0.1 times the occupational values.

Response: The limits for the general public are calculated solely from the stochastic risks. This differs from ICRP, which would use a "capping" organ dose limit of 5 rems (0.1 x the nonstochastic limit of 50 rems) in deriving the organ dose limit for organs that are limited by the nonstochastic risk. If there is a threshold for nonstochastic effects for the worker at 50 rems, it would also apply to a member of the public. Rather than applying a factor of 10 reduction to a nonstochastic value, the limiting stochastic (effective) dose was used to calculate the concentration limits for the general public. Values are not based on the nonstochastic risk for members of the public, even if they were the basis for the calculation of the DACs and ALIs for the worker. This difference in method of calculation accounts for the lack of a consistent ratio between worker DACs and effluent limits for the public.

Appendix C

Comment: The reduction from 100 μCi to 0.001 μCi for thorium values will require posting of areas where thoriated-nickel machine parts are used.

Response: On the basis of specific activity considerations, the existing 100 μCi limit has been retained for long-lived radionuclides (half-lives longer than 10^8 years) such as thorium-232, which would require several grams of material to produce the stated activity level. Because this is based on half-life, two isotopes may be treated differently, e.g., uranium-235 which does not meet the half-life criterion has an Appendix C value of 0.001 μCi, and uranium -238 which does meet the criterion has a value of 100 μCi.

Appendix D contains the NRC Regional Office addresses and telephone numbers.

Appendix E [Reserved]

Final Rule: The calculational guidelines and equations that appeared in Appendix E are being incorporated into a regulatory guide on summation of internal and external doses. This will make it easier to revise and clarify the

calculational methods without having to resort to formal rulemaking. (Note: NRC routinely issues regulatory guides for public comment before making them final.)

Appendix F

[Note: Appendix F is derived directly from requirements inserted by the Part 61 rulemaking proceeding on low-level radioactive waste disposal sites. These requirements were in § 20.311 of the existing 10 CFR Part 20. Because these requirements are relatively recent, they were not modified in the Part 20 revision. The Commission is considering revisions to the manifest requirements in a rulemaking separate from the Part 20 rulemaking.]

Appendix G

No comments on Appendix G were received.

VII. Conforming Amendments

Accompanying the revised rule are amendments to other parts of Chapter I that update citations to 10 CFR Part 20 that are found in these other regulations. Two amendments are particularly important as they go beyond updating cross-reference citations. One amendment to Appendix C to 10 CFR Part 2 updates and modifies the examples of the severity levels associated with violations of 10 CFR Part 20. Because Appendix C relates to the administrative policy of the Commission and because the listed violations are used as examples of different severity levels and are not all inclusive, the Commission does not believe that solicitation of public comment is required before these are issued in final form.

The second major change to other parts is the requirement to provide all workers with information on their radiation doses. This modification was made to conform to the 1987 Federal guidance on occupational radiation exposure. Formerly, Part 19 required licensees to furnish such a report at least annually

upon the request of the worker. The change deletes the words "upon request." Public comment is not being solicited on this change as the comments were requested in the proposed rule (Section XXVII, 51 FR 1118) on the option of requiring reports to individual workers. (These comments are discussed with regard to § 20.1106.) Part 19 has been revised to require licensees to advise each worker at least annually of the worker's dose recorded pursuant to § 20.1106.

VIII. Finding of No Significant Environmental Impact: Availability

The Commission has determined under the National Environmental Policy Act of 1969, as amended and the Commission's regulations in Subpart A of 10 CFR Part 51 that this rule is not a major Federal action significantly affecting the quality of the human environment and therefore an environmental impact statement is not required. The revised 10 CFR Part 20 changes the level for protection of the general public from an implicit limit of 0.5 rem per year to an explicit limit of 0.1 rem per year. There are also numerous changes in airborne and water radionuclide concentration limits. These changes result from changes in the models and parameters used to estimate the radiation dose associated with intake of a radionuclide. Some of the concentration limits for the general public in this revision are higher or lower than present concentration limits; and some are similar to the present limits.

Despite the changes in the dose and concentration limits, the Commission believes that issuance of the final Part 20 rule will not have a major impact on the environment. The primary basis for this conclusion is that, in addition to 10 CFR Part 20, there are other regulations that govern allowable doses to members of the public and that remain unchanged by the changes to Part 20. These other regulations include Appendix I to 10 CFR Part 50, 10 CFR Part 60, and 10 CFR Part 61, the EPA's generally applicable environmental standards in 40 CFR Part 190 and the National Emission Standards for Hazardous Air Pollutants (NESHAP) in 40 CFR Part 61 Subpart I. These standards set limits or design objectives (Appendix I) for releases of radioactive material to the general environment that are generally more restrictive than the dose limits in Part 20. Consequently, since these more restrictive standards remained essentially

unchanged by the Part 20 revision, the level of public protection and the associated environmental impact are not changed appreciably from those associated with the current rule and the aforenamed regulations.

The environmental assessment and finding of no significant impact on which this determination is based are available for inspection at the NRC Public Document Room, 2120 L Street NW (Lower-Level), Washington, DC 20555. Single copies of the environmental assessment and finding of no significant impact are available from Harold T. Peterson, Jr., Nuclear Regulatory Commission, NL/S-139, Washington, DC 20555, Telephone: (301)492-3640.

IX. Paperwork Reduction Act Statement

This final rule amends information collection requirements that are subject to the Paperwork Reduction Act of 1980 (44 U.S.C. 3501, et seq.). These information collection requirements in this final rule have not been reviewed by the Office of Management and Budget (OMB), but will be submitted by NRC for approval by OMB. These information collection requirements will not become effective until approved by OMB. The OMB approval will be published in the Federal Register.

Public reporting burden for this collection of information is estimated to average 33 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to the Information and Records Management Branch (MNBB 7714), U.S. Nuclear Regulatory Commission, Washington, DC 20555, and to the Desk Officer, Office of Information and Regulatory Affairs, NEOB-3019 (3150-0014, 3150-0044, 3150-0005, and 3150-0006), Office of Management and Budget, Washington, DC 20503.

X. Revised Regulatory Analysis

The Commission has issued a final regulatory analysis for this regulation. This revised analysis was based on the draft regulatory analysis as modified to account for the changes from the proposed rule resulting from public comments on both the proposed rule and the staff's revised rule in SECY-88-315 and supplemental papers. Copies of both the draft and final regulatory analysis are available for inspection and copying for a fee in the NRC Public Document Room. (See Address.)

XI. Final Regulatory Flexibility Analysis

In accordance with the Regulatory Flexibility Act of 1980, 5 U.S.C. 605(b), the Commission has prepared a regulatory flexibility analysis that indicated the revised rule will apply to all NRC licensees. The NRC has approximately 7,500 licensees, approximately one-quarter of which are classified as small entities. (Note: Agreement States, which implement comparable regulations under Section 274 of the Atomic Energy Act of 1954, as amended, have about 16,000 licensees of which a comparable number are assumed to be small entities.) The types of small entities that would be affected by this rule include physicians, small hospitals, small laboratories, industrial applications in small industries, radiographers, and well loggers.

Copies of the draft and final regulatory analysis are available for inspection and copying, for a fee, in the NRC Public Document Room. (See Address.)

XII. Backfit Analysis

A final backfit analysis has been prepared for this rule and may be examined and copied for a fee in the Commission's Public Document Room (see Address). For the reasons stated in this backfit analysis, the Commission believes that the reductions in allowable dose limits that are embodied in the revised Part 20 constitute substantial increases in the protection of public

health and safety. Although current practice, including the philosophy of keeping radiation exposures as low as is reasonably achievable (ALARA), generally has kept radiation exposures well below the existing limits, the reductions in the allowable dose limits ensure that such doses will also remain low in the future.

In addition to the quantifiable safety benefits accruing from dose reductions and other improvements in the revised Part 20, there are several qualitative factors that support issuing the Part 20 revision. One of the main qualitative fac ors is that it is necessary to revise the 30-year-old existing Part 20 to ensure that the NRC regulations reflect the current state of radiation protection science. Any future revisions in dose limits recommended by ICRP or NCRP would undoubtedly be based upon the 1977 ICRP and 1987 NCRP recommendations and, therefore, would be more easily incorporated into the framework of the revised Part 20 than in the framework of the current Part 20. Other qualitative factors include: maintaining consistency with international radiation protection factors, keeping the radiation protection requirements consistent with current risk assessment methodologies, and having the NRC's standards conform to Federal radiation protection guidance.

Based upon the conclusions in the final backfit analysis, the revised Part 20 provides a substantial increase in public health and safety compared to current standards, including a determination that, when the quantitative and qualitative safety benefits of the revision are considered, the costs of implementing the revised Part 20 are justified, the Commission finds that the requirements of the "Backfit Rule" (§ 50.109) are satisfied and that the Part 20 revision should be issued as final rule.

The Commission is adopting the final rule based on the conclusions of this analysis that the rule provides for a substantial increase in the overall protection of the public health and safety and that the direct and indirect costs of its implementation are justified in terms of the quantitative and qualitative benefits associated with the rule. The Commission notes, however, that, even had the analysis not concluded that the revised Part 20 provides a substantial increase in the overall public health and safety, it could have gone forward

with the rule because the changes made to Part 20 also amount to a redefinition of the level of adequate protection and the backfit rule's substantial increase in protection and cost justification standards do not apply to a redefinition of adequate protection.

XIII. Additional Views of Commissioner Curtiss

I approve the revisions to 10 CFR Part 20 and related changes to other regulations as outlined in SECY-88-315 and SECY-89-267, subject to the modifications discussed below.

Backfit: I have examined the proposed Part 20 amendments from the standpoint of whether and, if so, how the backfit rule should apply to this particular rulemaking. The nature and effects of the proposed changes to Part 20 lead me to the conclusion that the proposed amendments, in essence, would redefine what is necessary for adequate protection of the public health and safety in the radiation protection area. Thus, while I believe that we should apply the backfit rule to this Part 20 rulemaking effort, I also believe that this rulemaking constitutes a redefinition of adequate protection as described in 10 CFR § 50.109(a)(4)(iii) and that the usual backfit analysis and cost-benefit balancing are therefore not required in this instance.

On the question of whether such an approach would require this rule to be renoticed for further public comment, I have concluded that there was ample indication in the notice of proposed rulemaking that the Commission is rethinking its radiation protection standards across-the-board in this Part 20 rulemaking. Moreover, this initiative was explained in a manner that could logically be construed to encompass the approach to backfitting described above. Of particular importance, the notice of proposed rulemaking itself seems to indicate that the Commission is contemplating an action that would redefine what is necessary for adequate protection in the radiation protection area. For example, the notice states that:

> [T]he Nuclear Regulatory Commission (NRC) is proposing a major revision of its regulations in 10 CFR Part 20 which provide the requirements for the protection of individuals who are exposed . . . to ionizing radiation from routine activities . . . which are licensed by the NRC. . . . The intent of the revision is to improve NRC radiation protection standards by reflecting developments in the principles that underlie radiation protection and advances in related sciences that have occurred since the promulgation of 10 CFR Part 20 nearly thirty years ago. . . . The expected result of promulgating and implementing the proposed revised rule is an improved rule that provides better assurance of protection; establishes a clear health protection basis for limits and other regulatory actions taken to protect public health; applies to all licensees in a consistent manner; and reflects current information on health risk, dosimetry, and radiation protection practices and experiences.
>
> 51 Fed. Reg. 1092 (January 9, 1986).

With regard to existing Part 20 standards, the Commission noted that:

> [i]n promulgating these standards, the AEC emphasized "that the standards are subject to change with the development of new knowledge, with significant increase in the average exposure of the whole population to radiation and with further experience in the administration of the Commission's regulatory program." Consistent with this emphasis, the proposed revision reflects new knowledge, increased uses of radiation and generation of radiation sources, and experience gained during the past twenty years. . . . [Earlier] revisions [to the existing Part 20] have not kept the regulations in accord with more recent recommendations of scientific organizations . . . to improve overall protection and establish a clear health risk rationale. . . . [T]he central thrust of the revision [is] to ensure that radiation protection is adequate and defendable when judged by good protection practices and contemporary standards.
>
> 51 Fed. Reg. 1093, 1094 (citations omitted).

In discussing the benefits of the proposed rulemaking, the Commission indicated that:

> [t]he proposed revision to Part 20 includes numerous changes required to bring the radiation protections standards into accord with current defendable [sic] scientific knowledge, and to reflect contemporary scientific and philosophical approaches to protection against radiation. . . . The Commission anticipates

> that promulgating and implementing the proposed rule will result in a regulation that provides better assurance of protection, establishes a clear health protection basis for limits, applies to all licensees, including small entities, in a consistent manner, and reflects current information on health risk, dosimetry, and radiation protection practices and experiences.

51 Fed. Reg. 1120, 1122.

Consistent with all of these statements on the nature of the proposed changes to Part 20, a supplemental notice of proposed rulemaking that requested comments on a proposed backfit analysis indicated that:

> [T]his is the first complete revision of these regulations in over 25 years. This revision will bring the Commission's radiation protection standards into accord with current recommendations of the International Commission on Radiological Protection (ICRP).

The proposed revision to 10 CFR Part 20 [is] intended to:

a. Update the quarter-century-old 10 CFR Part 20 to incorporate advances in science and new concepts of radiation protection methodology and philosophy;

b. Implement pending Federal radiation guidance on occupational radiation protection;

c. Implement the principal current dose-limiting recommendations of the ICRP;

d. Incorporate the ICRP "effective dose equivalent" concept;

e. Update the limits on airborne radionuclide intakes, effluent releases and doses from inhaled or ingested radionuclides using up-to-date metabolic models and dose factors; and

f. Require that licensees have programs for keeping radiation exposures "as low as is reasonably achievable" (ALARA).

51 Fed. Reg. 30870, 30871 (August 29, 1986).

Overall, these various characteristics of the purpose, intent, and nature of the proposed changes to Part 20 lead to the conclusion that the Commission is, in fact, rethinking its radiation protection standards. For these reasons, I believe that the notice adequately describes the nature and substance of the proposed rule changes and that renoticing to further reflect a Commission judgment that the proposed changes constitute a re-definition of adequate protection is not necessary.

Implementation date: I would have preferred a common implementation date of January 1, 1994 for both NRC and Agreement State licensees to allow adequate time for all licensees to implement the revised Part 20 on the same schedule.

XIV. List of Subjects

Part 20 - Byproduct material, licensed material, nuclear materials, nuclear power plants and reactors, occupational safety and health, packaging and containers, penalty, radiation protection, reporting and recordkeeping requirements, special nuclear material, source material, waste treatment and disposal.

Parts 2, 19, 20, 31, 32, 34, 35, 39, 40, 50, and 61 - Radiation protection.

Under the authority of the Atomic Energy Act of 1954, as amended, the Energy Reorganization Act of 1974, as amended, and 5 U.S.C. 552 and 553, the following amendments to 10 CFR Parts 2, 19, 20, 31, 32, 34, 35, 39, 40, 50, and 61 are published as a document subject to codification.

1. 10 CFR Part 20 is revised to read as follows:

PART 20 - STANDARDS FOR PROTECTION AGAINST RADIATION

SUBPART A--GENERAL PROVISIONS

Section

20.1 Purpose.

20.2 Scope.

20.3 Definitions.

20.4 Units of radiation dose.

20.5 Units of radioactivity.

20.6 Interpretations.

20.7 Communications.

20.8 Implementation.

20.9 Reporting, recording, and application requirements: OMB approval.

SUBPART B--RADIATION PROTECTION PROGRAMS

20.101 Radiation protection programs.

SUBPART C--OCCUPATIONAL DOSE LIMITS

20.201 Occupational dose limits for adults.

20.202 Compliance with requirements for summation of external and internal doses.

20.203 Determination of external dose from airborne radioactive material.

20.204 Determination of internal exposure.

20.205 [Reserved]

20.206 Planned special exposures.

20.207 Occupational dose limits for minors.

20.208 Dose to an embryo/fetus.

SUBPART D--RADIATION DOSE LIMITS FOR
INDIVIDUAL MEMBERS OF THE PUBLIC

20.301 Dose limits for individual members of the public.

20.302 Compliance with dose limits for individual members of the public.

SUBPART E--[RESERVED]

SUBPART F--SURVEYS AND MONITORING

20.501 General.

20.502 Conditions requiring individual monitoring of external and internal occupational dose.

SUBPART G--CONTROL OF EXPOSURE FROM EXTERNAL SOURCES IN
RESTRICTED AREAS

20.601 Control of access to high radiation areas.

20.602 Control of access to very high radiation areas.

20.603 Control of access to very high radiation areas - irradiators.

SUBPART H--RESPIRATORY PROTECTION AND CONTROLS TO RESTRICT
INTERNAL EXPOSURE IN RESTRICTED AREAS

20.701 Use of process or other engineering controls.

20.702 Use of other controls.

20.703 Use of individual respiratory protection equipment.

20.704 Further restrictions on the use of respiratory protection equipment.

SUBPART I--STORAGE AND CONTROL OF LICENSED MATERIAL

20.801 Security of stored material.

20.802 Control of material not in storage.

SUBPART J--PRECAUTIONARY PROCEDURES

20.901 Caution signs.

20.902 Posting requirements.

20.903 Exceptions to posting requirements.

20.904 Labeling containers.

20.905 Exemptions to labeling requirements.

20.906 Procedures for receiving and opening packages.

SUBPART K--WASTE DISPOSAL

20.1001 General requirements.

20.1002 Method for obtaining approval of proposed disposal procedures.

20.1003 Disposal by release into sanitary sewerage.

20.1004 Treatment or disposal by incineration.

20.1005 Disposal of specific wastes.

20.1006 Transfer for disposal and manifests.

20.1007 Compliance with environmental and health protection regulations.

SUBPART L--RECORDS

20.1101 General provisions.

20.1102 Records of radiation protection programs.

20.1103 Records of surveys.

20.1104 Determination of prior occupational dose.

20.1105 Records of planned special exposures.

20.1106 Records of individual monitoring results.

20.1107 Records of dose to individual members of the public.
20.1108 Records of waste disposal.
20.1109 Records of testing entry control devices for very high radiation areas.
20.1110 Form of records.

SUBPART M--REPORTS

20.1201 Reports of theft or loss of licensed material.
20.1202 Notification of incidents.
20.1203 Reports of exposures, radiation levels, and concentrations of radioactive material exceeding the limits.
20.1204 Reports of planned special exposures.
20.1205 [Reserved]
20.1206 Reports of individual monitoring.

SUBPART N--EXEMPTIONS AND ADDITIONAL REQUIREMENTS

20.1301 Applications for exemptions.
20.1302 Additional requirements.

SUBPART O--ENFORCEMENT

20.1401 Violations.

APPENDICES

Appendix A Protection factors for respirators.

Appendix B Annual limits on intake (ALIs) and derived air concentrations (DACs) of radionuclides for occupational exposure; effluent concentrations; concentrations for release to sewerage.

Appendix C Quantities of licensed material requiring labeling.

Appendix D United States Nuclear Regulatory Commission Regional Offices.

Appendix E [Reserved]

Appendix F Requirements for low-level waste transfer for disposal at land disposal facilities and manifests.

AUTHORITY: Secs. 53, 63, 65, 81, 103, 104, 161, 182, 186, 68 Stat. 930, 933, 935, 936, 937, 948, 953, 955, as amended (42 U.S.C. 2073, 2093, 2095, 2111, 2133, 2134, 2201, 2232, 2236): secs. 201, as amended, 202, 206, 88 Stat. 1242, as amended, 1244, 1246 (42 U.S.C. 5841, 5842, 5546). For the purposes of sec. 223, 68 Stat. 958, as amended (42 U.S.C. 2273), §§ 20.102, 20.201 - 20.204, 20.206, 20.207, 20.208, 20.301, 20.302, 20.501, 20.502, 20.601(a) and (d), 20.602, 20.603, 20.701, 20.704, 20.801, 20.802, 20.901(a), 20.902, 20.904, 20.906, 20.1001, 20.1002, 20.1003, 20.1004, 20.1005(b) - (d), 20.1006, 20.1101 - 20.1110, 20.1201 - 20.1206, and 20.1301 are issued under sec. 161b., 68 Stat. 948 (42 U.S.C. 2201(b)) and § 20.1106(d) is issued under the Privacy Act of 1974, Pub.L. 93-579, 5 U.S.C. 552a: and §§ 20.102(a)(2) and (4), 20.204(c), 20.206(g) and (h), 20.904(c)(4), 20.905(c) and (d), 20.1005(c), 20.1006(b) - (d), 20.1101 - 20.1103, 20.1104(b) - (d), 20.1105 - 20.1108, and 20.1201 - 20.1207 are issued under sec. 161o, 68 Stat. 950, as amended (42 U.S.C. 2201(o)).

SUBPART A--GENERAL PROVISIONS

§ 20.1 Purpose.

(a) The regulations in this part establish standards for protection against ionizing radiation resulting from activities conducted under licenses issued by the Nuclear Regulatory Commission. These regulations are issued under the Atomic Energy Act of 1954, as amended, and the Energy Reorganization Act of 1974, as amended.

(b) It is the purpose of the regulations in this part to control the receipt, possession, use, transfer, and disposal of licensed material by any licensee in such a manner that the total dose to an individual (including doses resulting from licensed and unlicensed radioactive material and from radiation sources other than background radiation) does not exceed the standards for protection against radiation prescribed in the regulations in this part. However, nothing in this part shall be construed as limiting actions that may be necessary to protect health and safety.

§ 20.2 Scope.

The regulations in this part apply to persons licensed by the Commission to receive, possess, use, transfer, or dispose of byproduct, source, or special nuclear material or to operate a production or utilization facility under Parts 30 through 35, 39, 40, 50, 60, 61, 70, or 72 of this chapter. The limits in this part do not apply to doses due to background radiation, to exposure of patients to radiation for the purpose of medical diagnosis or therapy, or to voluntary participation in medical research programs.

§ 20.3 Definitions.

As used in this part:

"Absorbed dose" means the energy imparted by ionizing radiation per unit mass of irradiated material. The units of absorbed dose are the rad and the gray (Gy).

"Act" means the Atomic Energy Act of 1954 (42 U.S.C. 2011 et seq.), as amended.

"Activity" is the rate of disintegration (transformation) or decay of radioactive material. The units of activity are the curie (Ci) and the becquerel (Bq).

"Adult" means an individual 18 or more years of age.

"Airborne radioactive material" means radioactive material dispersed in the air in the form of dusts, fumes, particulates, mists, vapors, or gases.

"Airborne radioactivity area" means a room, enclosure, or area in which airborne radioactive materials, composed wholly or partly of licensed material, exist in concentrations--

(1) In excess of the derived air concentrations (DACs) specified in Appendix B, or

(2) To such a degree that an individual present in the area without respiratory protective equipment could exceed, during the hours an individual is present in a week, an intake of 0.6 percent of the annual limit on intake (ALI) or 12 DAC-hours.

"Annual limit on intake" (ALI) means the derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year by the reference man that would result in a committed effective dose equivalent of 5 rems (0.05 Sv) or a committed dose equivalent of 50 rems (0.5 Sv) to any individual organ or tissue. (ALI values for intake by ingestion and by inhalation of selected radionuclides are given in Table 1, Columns 1 and 2, of Appendix B.)

"ALARA" (acronym for "as low as is reasonably achievable") means making every reasonable effort to maintain exposures to radiation as far below the dose limits in this part as is practical consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest.

"Background radiation" means radiation from cosmic sources; naturally occurring radioactive materials, including radon in concentrations or levels commonly found in structures or the environment; and global fallout as it commonly exists in the environment from the testing of nuclear explosive devices. "Background radiation" does not include radiation from source, byproduct, or special nuclear materials regulated by the Commission.

"Bioassay" (radiobioassay) means the determination of kinds, quantities or concentrations, and, in some cases, the locations of radioactive material in the human body, whether by direct measurement (in vivo counting) or by analysis and evaluation of materials excreted or removed from the human body.

"Byproduct material" means --

(1) Any radioactive material (except special nuclear material) yielded in, or made radioactive by, exposure to the radiation incident to the process of producing or utilizing special nuclear material; and

(2) The tailings or wastes produced by the extraction or concentration of uranium or thorium from ore processed primarily for its source material content, including discrete surface wastes resulting from uranium solution extraction processes. Underground ore bodies depleted by these solution extraction operations do not constitute "byproduct material" within this definition.

"Class" (or "lung class" or "inhalation class") means a classification scheme for inhaled material according to its rate of clearance from the pulmonary region of the lung. Materials are classified as D, W, or Y, which applies to a range of clearance half-times: for Class D (Days) of less than 10 days, for Class W (Weeks) from 10 to 100 days, and for Class Y (Years) of greater than 100 days.

"Collective dose" is the sum of the individual doses received in a given period of time by a specified population from exposure to a specified source of radiation.

"Commission" means the Nuclear Regulatory Commission or its duly authorized representatives.

"Committed dose equivalent" ($H_{T,50}$) means the dose equivalent to organs or tissues of reference (T) that will be received from an intake of radioactive material by an individual during the 50-year period following the intake.

"Committed effective dose equivalent" ($H_{E,50}$) is the sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to these organs or tissues ($H_{E,50} = \sum_T w_T H_{T,50}$).

"Controlled area" means an area, outside of a restricted area but inside the site boundary, access to which can be limited by the licensee for any reason.

"Declared pregnant woman" means a woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception.

"Deep-dose equivalent" (H_d), which applies to external whole-body exposure, is the dose equivalent at a tissue depth of 1 cm (1000 mg/cm^2).

"Department" means the Department of Energy established by the Department of Energy Organization Act (Pub. L. 95-91, 91 Stat. 565, 42 U.S.C. 7101 et seq.) to the extent that the Department, or its duly authorized representatives, exercises functions formerly vested in the U.S. Atomic Energy Commission, its Chairman, members, officers, and components and transferred to the U.S. Energy Research and Development Administration and to the Administrator thereof pursuant to sections 104 (b), (c), and (d) of the Energy Reorganization Act of 1974 (Pub. L. 93-438, 88 Stat. 1233 at 1237, 42 U.S.C. 5814) and retransferred to the Secretary of Energy pursuant to section 301(a) of the Department of Energy Organization Act (Pub. L. 95-91, 91 Stat. 565 at 577-578, 42 U.S.C. 7151).

"Derived air concentration" (DAC) means the concentration of a given radionuclide in air which, if breathed by the reference man for a working year of 2,000 hours under conditions of light work (inhalation rate 1.2 cubic meters of air per hour), results in an intake of one ALI. DAC values are given in Table 1, Column 3, of Appendix B.

"Derived air concentration-hour" (DAC-hour) is the product of the concentration of radioactive material in air (expressed as a fraction or multiple of the derived air concentration for each radionuclide) and the time of exposure to that radionuclide, in hours. A licensee may take 2,000 DAC-hours to represent one ALI, equivalent to a committed effective dose equivalent of 5 rems (0.05 Sv).

"Dose" or "radiation dose" is a generic term that means absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, committed effective dose equivalent, or total effective dose equivalent, as defined in other paragraphs of this section.

"Dose equivalent" (H_T) means the product of the absorbed dose in tissue, quality factor, and all other necessary modifying factors at the location of interest. The units of dose equivalent are the rem and sievert (Sv).

"Dosimetry processor" means an individual or an organization that processes and evaluates individual monitoring equipment in order to determine the radiation dose delivered to the equipment.

"Effective dose equivalent" (H_E) is the sum of the products of the dose equivalent to the organ or tissue (H_T) and the weighting factors (w_T) applicable to each of the body organs or tissues that are irradiated ($H_E = \sum_T w_T H_T$).

"Embryo/fetus" means the developing human organism from conception until the time of birth.

"Entrance or access point" means any location through which an individual could gain access to radiation areas or to radioactive materials. This includes entry or exit portals of sufficient size to permit human entry, irrespective of their intended use.

"Exposure" means being exposed to ionizing radiation or to radioactive material.

"External dose" means that portion of the dose equivalent received from radiation sources outside the body.

"Extremities" means hand, elbow, arm below the elbow, foot, knee, and leg below the knee.

"Eye dose equivalent" applies to the external exposure of the lens of the eye and is taken as the dose equivalent at a tissue depth of 0.3 centimeter (300 mg/cm^2).

"Generally applicable environmental radiation standards" means standards issued by the Environmental Protection Agency (EPA) under the authority of the Atomic Energy Act of 1954, as amended, that impose limits on radiation exposures or levels, or concentrations or quantities of radioactive material, in the general environment outside the boundaries of locations under the control of persons possessing or using radioactive material.

"Government agency" means any executive department, commission, independent establishment, corporation wholly or partly owned by the United States of America, which is an instrumentality of the United States, or any board, bureau, division, service, office, officer, authority, administration, or other establishment in the executive branch of the Government.

"Gray" [See § 20.4].

"High radiation area" means an area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

"Individual" means any human being.

"Individual monitoring" means--

(1) The assessment of dose equivalent by the use of devices designed to be worn by an individual;

(2) The assessment of committed effective dose equivalent by bioassay (see Bioassay) or by determination of the time-weighted air concentrations to which an individual has been exposed, i.e., DAC-hours; or

(3) The assessment of dose equivalent by the use of survey data.

"Individual Monitoring Devices" ("individual monitoring equipment") means devices designed to be worn by a single individual for the assessment of dose equivalent such as film badges, thermoluminescent dosimeters (TLDs), pocket ionization chambers, and personal ("lapel") air sampling devices.

"Internal dose" means that portion of the dose equivalent received from radioactive material taken into the body.

"License" means a license issued under the regulations in Parts 30 through 35, 39, 40, 50, 60, 61, 70, or 72 of this chapter.

"Licensee" means the holder of a license.

"Licensed material" means source material, special nuclear material, or byproduct material received, possessed, used, transferred or disposed of under a general or specific license issued by the Commission.

"Limits" (dose limits) means the permissible upper bounds of radiation doses.

"Lost or missing licensed material" means licensed material whose location is unknown. It includes material that has been shipped but has not reached its destination and whose location cannot be readily traced in the transportation system.

"Member of the public" means an individual in a controlled or unrestricted area. However, an individual is not a member of the public during any period in which the individual receives an occupational dose.

"Minor" means an individual less than 18 years of age.

"Monitoring" (radiation monitoring, radiation protection monitoring) means the measurement of radiation levels, concentrations, surface area concentrations or quantities of radioactive material and the use of the results of these measurements to evaluate potential exposures and doses.

"Nonstochastic effect" means health effects, the severity of which varies with the dose and for which a threshold is believed to exist. Radiation-induced cataract formation is an example of a nonstochastic effect.

"NRC" means the Nuclear Regulatory Commission or its duly authorized representatives.

"Occupational dose" means the dose received by an individual in a restricted area or in the course of employment in which the individual's assigned duties involve exposure to radiation and to radioactive material from licensed and unlicensed sources of radiation, whether in the possession of the licensee or other person. Occupational dose does not include dose received from background radiation, as a patient from medical practices, from voluntary participation in medical research programs, or as a member of the general public.

"Person" means--

(1) Any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, Government agency other than the Commission or the Department of Energy (except that the Department shall be considered a person within the meaning of the regulations in 10 CFR Chapter 1 to the extent that its facilities and activities are subject to the licensing and related regulatory authority of the Commission under Section 202 of the Energy Reorganization Act of 1974 (88 Stat. 1244), the Uranium Mill Tailings Radiation Control Act of 1978 (92 Stat. 3021), the Nuclear Waste Policy Act of 1982 (96 Stat. 2201), and Section 3(b)(2) of the Low-Level Radioactive Waste

Policy Amendments Act of 1985 (99 Stat. 1842)), any State or any political subdivision of or any political entity within a State, any foreign government or nation or any political subdivision of any such government or nation, or other entity; and

(2) Any legal successor, representative, agent, or agency of the foregoing.

"Planned special exposure" means an infrequent exposure to radiation, separate from and in addition to the annual dose limits.

"Public dose" means the dose received by a member of the public from exposure to radiation and to radioactive material released by a licensee, or to another source of radiation either within a licensee's controlled area or in unrestricted areas. It does not include occupational dose or doses received from background radiation, as a patient from medical practices, or from voluntary participation in medical research programs.

"Quality Factor" (Q) means the modifying factor (listed in Tables 1 and 2 of § 20.4) that is used to derive dose equivalent from absorbed dose.

"Quarter" means a period of time equal to one-fourth of the year observed by the licensee (approximately 13 consecutive weeks), providing that the beginning of the first quarter in a year coincides with the starting date of the year and that no day is omitted or duplicated in consecutive quarters.

"Rad" [See § 20.4].

"Radiation" (ionizing radiation) means alpha particles, beta particles, gamma rays, x-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions. Radiation, as used in this part, does not include non-ionizing radiation, such as radio- or microwaves, or visible, infrared, or ultraviolet light.

"Radiation area" means an area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.005 rem (0.05 mSv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

"Reference man" means a hypothetical aggregation of human physical and physiological characteristics arrived at by international consensus. These characteristics may be used by researchers and public health workers to standardize results of experiments and to relate biological insult to a common base.

"Rem" [See § 20.4].

"Respiratory protective device" means an apparatus, such as a respirator, used to reduce the individual's intake of airborne radioactive materials.

"Restricted area" means an area, access to which is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials. Restricted area does not include areas used as residential quarters, but separate rooms in a residential building may be set apart as a restricted area.

"Sanitary sewerage" means a system of public sewers for carrying off waste water and refuse, but excluding sewage treatment facilities, septic tanks, and leach fields owned or operated by the licensee.

"Shallow-dose equivalent" (H_s), which applies to the external exposure of the skin or an extremity, is taken as the dose equivalent at a tissue depth of 0.007 centimeter (7 mg/cm^2) averaged over an area of 1 square centimeter.

"Sievert" [See § 20.4].

"Site boundary" means that line beyond which the land or property is not owned, leased, or otherwise controlled by the licensee.

"Source material" means--

(1) Uranium or thorium or any combination of uranium and thorium in any physical or chemical form; or

(2) Ores that contain, by weight, one-twentieth of 1 percent (0.05 percent), or more, of uranium, thorium, or any combination of uranium and thorium. Source material does not include special nuclear material.

"Special nuclear material" means-

(1) Plutonium, uranium-233, uranium enriched in the isotope 233 or in the isotope 235, and any other material that the Commission, pursuant to the provisions of section 51 of the Act, determines to be special nuclear material, but does not include source material; or

(2) Any material artificially enriched by any of the foregoing but does not include source material.

"Stochastic effects" means health effects that occur randomly and for which the probability of the effect occurring, rather than its severity, is assumed to be a linear function of dose without threshold. Hereditary effects and cancer incidence are examples of stochastic effects.

"Survey" means an evaluation of the radiological conditions and potential hazards incident to the production, use, transfer, release, disposal, or presence of radioactive material or other sources of radiation. When appropriate, such an evaluation includes a physical survey of the location of radioactive material and measurements or calculations of levels of radiation, or concentrations or quantities of radioactive material present.

"Total Effective Dose Equivalent" (TEDE) means the sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

"Unrestricted area" means an area, access to which is neither limited nor controlled by the licensee.

"Uranium fuel cycle" means the operations of milling of uranium ore, chemical conversion of uranium, isotopic enrichment of uranium, fabrication of uranium fuel, generation of electricity by a light-water-cooled nuclear power plant using uranium fuel, and reprocessing of spent uranium fuel to the extent that these activities directly support the production of electrical power for public use. Uranium fuel cycle does not include mining operations, operations at waste disposal sites, transportation of radioactive material in support of these operations, and the reuse of recovered non-uranium special nuclear and byproduct materials from the cycle.

"Very high radiation area" means an area, accessible to individuals, in which radiation levels could result in an individual receiving an absorbed dose in excess of 500 rads (5 grays) in 1 hour at 1 meter from a radiation source or from any surface that the radiation penetrates. [Note: At very high doses received at high dose rates, units of absorbed dose (e.g., rads and grays) are appropriate, rather than units of dose equivalent (e.g., rems and sieverts).]

"Week" means 7 consecutive days starting on Sunday.

"Weighting factor," w_T, for an organ or tissue (T) is the proportion of the risk of stochastic effects resulting from irradiation of that organ or tissue to the total risk of stochastic effects when the whole body is irradiated uniformly. For calculating the effective dose equivalent, the values of w_T are:

ORGAN DOSE WEIGHTING FACTORS

Organ or Tissue	w_T
Gonads	0.25
Breast	0.15
Red bone marrow	0.12
Lung	0.12
Thyroid	0.03
Bone surfaces	0.03
Remainder	0.30[a]
Whole Body	1.00[b]

[a] 0.30 results from 0.06 for each of 5 "reminder" organs (excluding the skin and the lens of the eye) that receive the highest doses.

[b] For the purpose of weight.ng the external whole body dose (for adding it to the internal dose), a single weighting factor, $w_T = 1.0$, has been specified. The use of other weighting factors for external exposure will be approved on a case-by-case basis until such time as specific guidance is issued.

"Whole body" means, for purposes of external exposure, head, trunk (including male gonads), arms above the elbow, or legs above the knee.

"Working level" (WL) is any combination of short-lived radon daughters (for radon-222: polonium-218, lead-214, bismuth-214, and polonium-214; and for radon-220: polonium-216, lead-212, bismuth-212, and polonium-212) in 1 liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha particle energy.

"Working level month" (WLM) means an exposure to 1 working level for 170 hours (2,000 working hours per year/12 months per year = approximately 170 hours per month).

"Year" means the period of time beginning in January used to determine compliance with the provisions of this part. The licensee may change the starting date of the year used to determine compliance by the licensee provided that the change is made at the beginning of the year and that no day is omitted or duplicated in consecutive years.

§ 20.4 Units of radiation dose.

(a) As used in this part, the units of radiation dose are:

"Gray" (Gy) is the SI unit of absorbed dose. One gray is equal to an absorbed dose of 1 Joule/kilogram (100 rads).

"Rad" is the special unit of absorbed dose. One rad is equal to an absorbed dose of 100 ergs/gram or 0.01 joule/kilogram (0.01 gray).

"Rem" is the special unit of any of the quantities expressed as dose equivalent. The dose equivalert in rems is equal to the absorbed dose in rads multiplied by the quality factor (1 rem = 0.01 sievert).

"Sievert" is the SI unit of any of the quantities expressed as dose equivalent. The dose equivalent in sieverts is equal to the absorbed dose in grays multiplied by the quality factor (1 Sv = 100 rems).

(b) As used in this part, the quality factors for converting absorbed dose to dose equivalent are shown in Table 1.

TABLE 1
QUALITY FACTORS AND ABSORBED DOSE EQUIVALENCIES

TYPE OF RADIATION	Quality Factor (Q)	Absorbed Dose Equal to a Unit Dose Equivalent[a]
X-, gamma, or beta radiation	1	1
Alpha particles, multiple-charged particles, fission fragments and heavy particles of unknown charge	20	0.05
Neutrons of unknown energy	10	0.1
High-energy protons	10	0.1

[a]Absorbed dose in rad equal to 1 rem or the absorbed dose in gray equal to 1 sievert.

(c) If it is more convenient to measure the neutron fluence rate than to determine the neutron dose equivalent rate in rems per hour or sieverts per hour, as provided in paragraph (b) of this section, 1 rem (0.01 Sv) of neutron radiation of unknown energies may, for purposes of the regulations in this part, be assumed to result from a total fluence of 25 million neutrons per square centimeter incident upon the body. If sufficient information exists to estimate the approximate energy distribution of the neutrons, the licensee may use the fluence rate per unit dose equivalent or the appropriate Q value from Table 2 to convert a measured tissue dose in rads to dose equivalent in rems.

TABLE 2

MEAN QUALITY FACTORS, Q, AND FLUENCE PER UNIT DOSE EQUIVALENT FOR MONOENERGETIC NEUTRONS

	Neutron Energy (MeV)	Quality Factor[a] (Q)	Fluence per Unit Dose Equivalent[b] (neutrons cm^{-2} rem^{-1})
(thermal)	2.5×10^{-8}	2	980×10^6
	1×10^{-7}	2	980×10^6
	1×10^{-6}	2	810×10^6
	1×10^{-5}	2	810×10^6
	1×10^{-4}	2	840×10^6
	1×10^{-3}	2	980×10^6
	1×10^{-2}	2.5	1010×10^6
	1×10^{-1}	7.5	170×10^6
	5×10^{-1}	11	39×10^6
	1	11	27×10^6
	2.5	9	29×10^6
	5	8	23×10^6
	7	7	24×10^6
	10	6.5	24×10^6
	14	7.5	17×10^6
	20	8	16×10^6
	40	7	14×10^6
	60	5.5	16×10^6
	1×10^2	4	20×10^6
	2×10^2	3.5	19×10^6
	3×10^2	3.5	16×10^6
	4×10^2	3.5	14×10^6

[a]Value of quality factor (Q) at the point where the dose equivalent is maximum in a 30-cm diameter cylinder tissue-equivalent phantom.

[b]Monoenergetic neutrons incident normally on a 30-cm diameter cylinder tissue-equivalent phantom.

§ 20.5 Units of radioactivity.

For the purposes of this part, activity is expressed in the special unit of curies (Ci) or in the SI unit of becquerels (Bq), or their multiples, or disintegrations (transformations) per unit of time.

(a) One becquerel = 1 disintegration per second (s^{-1}).

(b) One curie = 3.7×10^{10} disintegrations per second = 3.7×10^{10} becquerels = 2.22×10^{12} disintegrations per minute.

§ 20.6 Interpretations.

Except as specifically authorized by the Commission in writing, no interpretation of the meaning of the regulations in this part by an officer or employee of the Commission other than a written interpretation by the General Counsel will be recognized to be binding upon the Commission.

§ 20.7 Communications.

Unless otherwise specified, communications or reports concerning the regulations in this part should be addressed to the Executive Director for Operations, U.S. Nuclear Regulatory Commission, Washington, DC 20555. A communication, report, or application may be delivered in person to the Commission's offices at 2120 L Street, NW. (Lower Level), Washington, DC 20037, or 11555 Rockville Pike, Rockville, MD 20852.

§ 20.8 Implementation.

(a) Licensees shall implement the provisions of this part on or before January 1, 1993. If a licensee chooses to implement the provisions of this part prior to January 1, 1993, the licensee shall implement all provisions of this part not otherwise exempted by paragraph (d) of this section, and shall provide written notification to either the Director of the Office of Nuclear Materials Safety and Safeguards or the Director of the Office of Nuclear Reactor Regulation, as appropriate, that the licensee is adopting early implementation of this part. Until January 1, 1993, or until the licensee notifies the Commission of early implementation of the provisions of this part, compliance will be required with the 10 CFR Part 20 in the Code of Federal Regulations on January 1, 1991.

(b) After the time the licensee implements this part, the applicable section of this part shall be used in lieu of any section of this part in effect on or before January 1, 1991 that is cited in license conditions or technical specifications, except as specified in paragraphs (c), (d) and (e) of this section. If the requirements of this part are more restrictive than the existing license condition, then the licensee shall comply with this part unless exempted by paragraph (d) of this section.

(c) Any existing license condition or technical specification that is more restrictive than this part remains in force until there is a technical specification change, license amendment, or license renewal.

(d) If a license condition or technical specification exempts a licensee from a provision of Part 20 in effect on or before January 1, 1991, it also exempts the licensee from the corresponding provision of this part.

(e) If no section in this part corresponds to the provisions of Part 20 in effect prior to January 1, 1991 cited in a license condition, a license condition based on Part 20 in effect on or before January 1, 1991 remains in force until either there is a technical specification change, license amendment, or license renewal that modifies or removes this condition.

§ 20.9 Reporting, recording, and application requirements: OMB approval.

(a) The Nuclear Regulatory Commission will submit the information collection requirements contained in this part to the Office of Management and Budget for approval as required by the Paperwork Reduction Act of 1980 (44 U.S.C. 3501 et seq.). The information collection requirements in this part will not become effective until OMB clearance is obtained.

(b) The information collection requirements contained in this part appear in §§ 20.101, 20.202, 20.204, 20.206, 20.301, 20.501, 20.601, 20.603, 20.703, 20.901, 20.902, 20.904, 20.906, 20.1002, 20.1004, 20.1006, 20.1102, 20.1103, 20.1104, 20.1105, 20.1106, 20.1107, 20.1108, 20.1109, 20.1110, 20.1201, 20.1202, 20.1203, 20.1204, 20.1206, and Appendix F.

SUBPART B--RADIATION PROTECTION PROGRAMS

§ 20.101 Radiation protection programs.

(a) Each licensee shall develop, document, and implement a radiation protection program commensurate with the scope and extent of licensed activities and sufficient to ensure compliance with the provisions of this part. (See § 20.1102 for recordkeeping requirements relating to these programs.)

(b) The licensee shall use, to the extent practicable, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses and doses to members of the public that are as low as is reasonably achievable (ALARA).

(c) The licensee shall periodically (at least annually) review the radiation protection program content and implementation.

SUBPART C--OCCUPATIONAL DOSE LIMITS

§ 20.201 Occupational dose limits for adults.

(a) The licensee shall control the occupational dose to individual adults, except for planned special exposures under § 20.206, to the following dose limits.

(1) An annual limit, which is the more limiting of--

(i) The total effective dose equivalent being equal to 5 rems (0.05 Sv); or

(ii) The sum of the deep-dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 50 rems (0.5 Sv).

(2) The annual limits to the lens of the eye, to the skin, and to the extremities which are:

(i) An eye dose equivalent of 15 rems (0.15 Sv), and

(ii) A shallow-dose equivalent of 50 rems (0.50 Sv) to the skin or to each of the extremities.

(b) Doses received in excess of the annual limits, including doses received during accidents, emergencies, and planned special exposures, must be subtracted from the limits for planned special exposures that the individual may receive during the current year (see § 20.206(e)(1)) and during the individual's lifetime (see § 20.206(e)(2)).

(c) The assigned deep-dose equivalent and shallow-dose equivalent must be for the part of the body receiving the highest exposure. The deep-dose equivalent, eye dose equivalent and shallow-dose equivalent may be assessed from

surveys or other radiation measurements for the purpose of demonstrating compliance with the occupational dose limits, if the individual monitoring device was not in the region of highest potential exposure, or the results of individual monitoring are unavailable.

(d) Derived air concentration (DAC) and annual limit on intake (ALI) values are presented in Table 1 of Appendix B and may be used to determine the individual's dose (see § 20.1106) and to demonstrate compliance with the occupational dose limits.

(e) In addition to the annual dose limits, the licensee shall limit the soluble uranium intake by an individual to 10 milligrams in a week in consideration of chemical toxicity (see footnote 3 of Appendix B).

(f) The licensee shall reduce the dose that an individual may be allowed to receive in the current year by the amount of occupational dose received while employed by any other person (see § 20.1104(e)).

§ 20.202 Compliance with requirements for summation of external and internal doses.

(a) If the licensee is required to monitor under both §§ 20.502(a) and (b), the licensee shall demonstrate compliance with the dose limits by summing external and internal doses. If the licensee is required to monitor only under § 20.502(a) or only under § 20.502(b), then summation is not required to demonstrate compliance with the dose limits. The licensee may demonstrate compliance with the requirements for summation of external and internal doses by meeting one of the conditions specified in paragraph (b) of this section and the conditions in paragraphs (c) and (d) of this section. (Note: The dose equivalents for the lens of the eye, the skin, and the extremities are not included in the summation, but are subject to separate limits.)

(b) Intake by inhalation. If the only intake of radionuclides is by inhalation, the total effective dose equivalent limit is not exceeded if the sum of the deep-dose equivalent divided by the total effective dose equivalent limit, and one of the following, does not exceed unity:

(1) The sum of the fractions of the inhalation ALI for each radionuclide, or

(2) The total number of derived air concentration-hours (DAC-hours) for all radionuclides divided by 2,000, or

(3) The sum of the calculated committed effective dose equivalents to all significantly irradiated[1] organs or tissues (T) calculated from bioassay data using appropriate biological models and expressed as a fraction of the annual limit.

(c) Intake by oral ingestion. If the occupationally exposed individual also receives an intake of radionuclides by oral ingestion greater than 10 percent of the applicable oral ALI, the licensee shall account for this intake and include it in demonstrating compliance with the limits.

(d) Intake through wounds or absorption through skin. The licensee shall evaluate and, to the extent practical, account for intakes through wounds or skin absorption. (NOTE: The intake through intact skin has been included in the calculation of DAC for hydrogen-3 and does not need to be further evaluated.)

§ 20.203 Determination of external dose from airborne radioactive material.

Licensees shall, when determining the dose from airborne radioactive material, include the contribution to the deep-dose equivalent, eye dose equivalent, and shallow-dose equivalent from external exposure to the radioactive cloud (see Appendix B, footnotes 1 and 2).

NOTE: Airborne radioactivity measurements and DAC values should not be used as the primary means to assess the deep-dose equivalent when the airborne radioactive material includes radionuclides other than noble gases or if the

---

1 An organ or tissue is deemed to be significantly irradiated if, for that organ or tissue, the product of the weighting factors, w_T, and the committed dose equivalent, H_{50}, per unit intake is greater than 10 percent of the maximum weighted value of H_{50} (i.e., $w_T H_{50,T}$) per unit intake for any organ or tissue.

cloud of airborne radioactive material is not relatively uniform. The determination of the deep-dose equivalent to an individual should be based upon measurements using instruments or individual monitoring devices.

§ 20.204 Determination of internal exposure.

(a) For purposes of assessing dose used to determine compliance with occupational dose equivalent limits, the licensee shall, when required under § 20.502, take suitable and timely measurements of--

(1) Concentrations of radioactive materials in air in work areas; or

(2) Quantities of radionuclides in the body; or

(3) Quantities of radionuclides excreted from the body; or

(4) Combinations of these measurements.

(b) Unless respiratory protective equipment is used, as provided in § 20.703, or the assessment of intake is based in bioassays, the licensee shall assume that an individual inhales radioactive material at the airborne concentration in which the individual is present.

(c) When specific information on the physical and biochemical properties of the radionuclides taken into the body or the behavior or the material in an individual is known, the licensee may--

(1) Use that information to calculate the committed effective dose equivalent, and, if used, the licensee shall document that information in the individual's record; and

(2) Upon prior approval of the Commission, adjust the DAC or ALI values to reflect the actual physical and chemical characteristics of airborne radioactive material (e.g., aerosol size distribution or density); and

(3) Separately assess the contribution of fractional intakes of Class D, W, or Y compounds of given radionuclide (see Appendix B) to the committed effective dose equivalent.

(d) If the licensee chooses to assess intakes of Class Y material using the measurements given in § 20.204(a)(2) or (3), the licensee may delay the recording and reporting of the assessments for periods up to 7 months, unless otherwise required by §§ 20.1202 or 20.1203, in order to permit the licensee to make additional measurements basic to the assessments.

(e) If the identity and concentration of each radionuclide in a mixture are known, the fraction of the DAC applicable to the mixture for use in calculating DAC-hours must be either--

(1) The sum of the ratios of the concentration to the appropriate DAC value (e.g., D, W, Y) from Appendix B for each radionuclide in the mixture; or

(2) The ratio of the total concentration for all radionuclides in the mixture to the most restrictive DAC value for any radionuclide in the mixture.

(f) If the identity of each radionuclide in a mixture is known, but the concentration of one or more of the radionuclides in the mixture is not known, the DAC for the mixture must be the most restrictive DAC of any radionuclide in the mixture.

(g) When a mixture of radionuclides in air exists, licensees may disregard certain radionuclides in the mixture if--

(1) The licensee uses the total activity of the mixture in demonstrating compliance with the dose limits in § 20.201 and in complying with the monitoring requirements in § 20.502(b), and

(2) The concentration of any radionuclide disregarded is less than 10 percent of its DAC, and

(3) The sum of these percentages for all of the radionuclides disregarded in the mixture does not exceed 30 percent.

(h)(1) In order to calculate the committed effective dose equivalent, the licensee may assume that the inhalation of one ALI, or an exposure of 2,000 DAC-hours, results in a committed effective dose equivalent of 5 rems (0.05 Sv) for radionuclides that have their ALIs or DACs based on the committed effective dose equivalent.

(2) When the ALI (and the associated DAC) is determined by the nonstochastic organ dose limit of 50 rems (0.5 Sv), the intake of radionuclides that would result in a committed effective dose equivalent of 5 rems (0.05 Sv) (the stochastic ALI) is listed in parentheses in Table 1 of Appendix B. In this case, the licensee may, as a simplifying assumption, use the stochastic ALIs to determine committed effective dose equivalent. However, if the licensee uses the stochastic ALIs, the licensee must also demonstrate that the limit in § 20.201(a)(1)(ii) is met.

§ 20.205 [Reserved]

§ 20.206 Planned special exposures.

A licensee may authorize an adult worker to receive doses in addition to and accounted for separately from the doses received under the limits specified in § 20.201 provided that each of the following conditions is satisfied--

(a) The licensee authorizes a planned special exposure only in an exceptional situation when alternatives that might avoid the higher exposure are unavailable or impractical.

(b) The licensee (and employer if the employer is not the licensee) specifically authorizes the planned special exposure, in writing, before the exposure occurs.

(c) Before a planned special exposure, the licensee ensures that the individuals involved are--

(1) Informed of the purpose of the planned operation;

(2) Informed of the estimated doses and associated potential risks and specific radiation levels or other conditions that might be involved in performing the task; and

(3) Instructed in the measures to be taken to keep the dose ALARA considering other risks that may be present.

(d) Prior to permitting an individual to participate in a planned special exposure, the licensee ascertains prior doses as required by § 20.1104(b) during the lifetime of the individual for each individual involved.

(e) Subject to § 20.201(b), the licensee does not authorize a planned special exposure that would cause an individual to receive a dose from all planned special exposures and all doses in excess of the limits to exceed--

(1) The numerical values of any of the dose limits in § 20.201(a) in any year; and

(2) Five times the annual dose limits in § 20.201(a) during the individual's lifetime.

(f) The licensee maintains records of the conduct of a planned special exposure in accordance with § 20.1105 and submits a written report in accordance with § 20.1204.

(g) The licensee records the best estimate of the dose resulting from the planned special exposure in the individual's record and informs the individual, in writing, of the dose within 30 days from the date of the planned special exposure. The dose from planned special exposures is not to be considered in controlling future occupational dose of the individual under § 20.201(a) but is to be included in evaluations required by § 20.206(d) and (e).

§ 20.207 Occupational dose limits for minors.

The annual occupational dose limits for minors are 10 percent of the annual dose limits specified for adult workers in § 20.201.

§ 20.208 Dose to an embryo/fetus.

(a) The licensee shall ensure that the dose to an embryo/fetus during the entire pregnancy, due to occupational exposure of a declared pregnant woman, does not exceed 0.5 rem (5 mSv). (For recordkeeping requirements, see § 20.1106.)

(b) The licensee shall make efforts to avoid substantial variation above a uniform monthly exposure rate to a declared pregnant woman so as to satisfy the limit in paragraph (a) of this section.

(c) The dose to an embryo/fetus shall be taken as the sum of--

(1) The deep-dose equivalent to the declared pregnant woman; and

(2) The dose to the embryo/fetus from radionuclides in the embryo/fetus and radionuclides in the declared pregnant woman.

(d) If the dose to the embryo/fetus is found to have exceeded 0.5 rem (5 mSv), or is within 0.05 rem (0.5 mSv) of this dose, by the time the woman declares the pregnancy to the licensee, the licensee shall be deemed to be in compliance with paragraph (a) of this section if the additional dose to the embryo/fetus does not exceed 0.05 rem (0.5 mSv) during the remainder of the pregnancy.

SUBPART D--RADIATION DOSE LIMITS FOR INDIVIDUAL MEMBERS OF THE PUBLIC

§ 20.301 Dose limits for individual members of the public.

(a) Each licensee shall conduct operations so that--

(1) The total effective dose equivalent to individual members of the public from the licensed operation does not exceed 0.1 rem (1 mSv) in a year, exclusive of the dose contribution from the licensee's disposal of radioactive material into sanitary sewerage in accordance with § 20.1003, and

(2) The dose in any unrestricted area from external sources does not exceed 0.002 rem (0.02 mSv) in any one hour.

(b) If the licensee permits members of the public to have access to controlled areas, the limits for members of the public continue to apply to those individuals.

(c) A licensee or license applicant may apply for prior NRC authorization to operate up to an annual dose limit for an individual member of the public of 0.5 rem (5 mSv). The licensee or license applicant shall include the following information in this application:

(1) Demonstration of the need for and the expected duration of operations in excess of the limit in paragraph (a) of this section;

(2) The licensee's program to assess and control dose within the 0.5 rem (5 mSv) annual limit; and

(3) The procedures to be followed to maintain the dose as low as is reasonably achievable.

(d) In addition to the requirements of this part, a licensee subject to the provisions of EPA's generally applicable environmental radiation standards in 40 CFR Part 190 shall comply with those standards.

(e) The Commission may impose additional restrictions on radiation levels in unrestricted areas and on the total quantity of radionuclides that a licensee may release in effluents in order to restrict the collective dose.

§ 20.302 Compliance with dose limits for individual members of the public.

(a) The licensee shall make or cause to be made, as appropriate, surveys of radiation levels in unrestricted and controlled areas and radioactive materials in effluents released to unrestricted and controlled areas to demonstrate compliance with the dose limits for individual members of the public in § 20.301.

(b) A licensee shall show compliance with the annual dose limit in § 20.301 by--

(1) Demonstrating by measurement or calculation that the total effective dose equivalent to the individual likely to receive the highest dose from the licensed operation does not exceed the annual dose limit; or

(2) Demonstrating that--

(i) The annual average concentrations of radioactive material released in gaseous and liquid effluents at the boundary of the unrestricted area do not exceed the values specified in Table 2 of Appendix B; and

(ii) If an individual were continually present in an unrestricted area, the dose from external sources would not exceed 0.002 rem (0.02 mSv) in an hour and 0.05 rem (0.5 mSv) in a year.

(c) Upon approval from the Commission, the licensee may adjust the effluent concentration values in Appendix B, Table 2, for members of the public, to take into account the actual physical and chemical characteristics of the effluents (e.g., aerosol size distribution, solubility, density, radioactive decay equilibrium, chemical form).

SUBPART E--[RESERVED]

SUBPART F--SURVEYS AND MONITORING

§ 20.501 General.

(a) Each licensee shall make or cause to be made, surveys that--

(1) May be necessary for the licensee to comply with the regulations in this part; and

(2) Are reasonable under the circumstances to evaluate--

(i) The extent of radiation levels; and

(ii) Concentrations or quantities of radioactive material; and

(iii) The potential radiological hazards that could be present.

(b) The licensee shall ensure that instruments and equipment used for quantitative radiation measurements (e.g., dose rate and effluent monitoring) are calibrated periodically for the radiation measured.

(c) All personnel dosimeters (except for direct and indirect reading pocket ionization chambers and those dosimeters used to measure the dose to the extremities) that require processing to determine the radiation dose and that are used by licensees to comply with § 20.201, with other applicable provisions of this chapter, or with conditions specified in a license must be processed and evaluated by a dosimetry processor--

(1) Holding current personnel dosimetry accreditation from the National Voluntary Laboratory Accreditation Program (NVLAP) of the National Institute of Standards and Technology; and

(2) Approved in this accreditation process for the type of radiation or radiations included in the NVLAP program that most closely approximates the type of radiation or radiations for which the individual wearing the dosimeter is monitored.

§ 20.502 Conditions requiring individual monitoring of external and internal occupational dose.

Each licensee shall monitor exposures to radiation and radioactive material at levels sufficient to demonstrate compliance with the occupational dose limits of this part. As a minimum--

(a) Each licensee shall monitor occupational exposure to radiation and shall supply and require the use of individual monitoring devices by--

(1) Adults likely to receive, in 1 year from sources external to the body, a dose in excess of 10 percent of the limits in § 20.201(a),

(2) Minors and declared pregnant women likely to receive, in 1 year from sources external to the body, a dose in excess of 10 percent of any of the applicable limits in §§ 20.207 or 20.208, and

(3) Individuals entering a high or very high radiation area.

(b) Each licensee shall monitor (see § 20.204) the occupational intake of radioactive material by and assess the committed effective dose equivalent to--

(1) Adults likely to receive, in 1 year, an intake in excess of 10 percent of the applicable ALI(s) in Table 1, Columns 1 and 2, of Appendix B; and

(2) Minors and declared pregnant women likely to receive, in 1 year, a committed effective dose equivalent in excess of 0.05 rem (0.5 mSv).

SUBPART G--CONTROL OF EXPOSURE FROM EXTERNAL SOURCES IN RESTRICTED AREAS

§ 20.601 Control of access to high radiation areas.

(a) The licensee shall ensure that each entrance or access point to a high radiation area has one or more of the following features--

(1) A control device that, upon entry into the area, causes the level of radiation to be reduced below that level at which an individual might receive a deep-dose equivalent of 0.1 rem (1 mSv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates;

(2) A control device that energizes a conspicuous visible or audible alarm signal so that the individual entering the high radiation area and the supervisor of the activity are made aware of the entry; or

(3) Entryways that are locked, except during periods when access to the areas is required, with positive control over each individual entry.

(b) In place of the controls required by paragraph (a) of this section for a high radiation area, the licensee may substitute continuous direct or electronic surveillance that is capable of preventing unauthorized entry.

(c) A licensee may apply to the Commission for approval of alternative methods for controlling access to high radiation areas.

(d) The licensee shall establish the controls required by paragraphs (a) and (c) of this section in a way that does not prevent individuals from leaving a high radiation area.

(e) Control is not required for each entrance or access point to a room or other area that is a high radiation area solely because of the presence of radioactive materials prepared for transport and packaged and labeled in accordance with the regulations of the Department of Transportation provided that--

(1) The packages do not remain in the area longer than 3 days; and

(2) The dose rate at 1 meter from the external surface of any package es not exceed 0.01 rem (0.1 mSv) per hour.

(f) Control of entrance or access to rooms or other areas in hospitals is not required solely because of the presence of patients containing radioactive material, provided that there are personnel in attendance who will take the necessary precautions to prevent the exposure of individuals to radiation or radioactive material in excess of the limits established in this part and to operate within the ALARA provisions of the licensee's radiation protection program.

§ 20.602 Control of access to very high radiation areas.

In addition to the requirements in § 20.601, the licensee shall institute additional measures to ensure that an individual is not able to gain unauthorized or inadvertent access to areas in which radiation levels could be encountered at 500 rads (5 grays) or more in 1 hour at 1 meter from a radiation source or any surface through which the radiation penetrates.

§ 20.603 Control of access to very high radiation areas - irradiators.

(a) Each area in which there may exist radiation levels in excess of 500 rads (5 grays) in 1 hour at 1 meter from a sealed radioactive source[2] that is used to irradiate materials must meet the following requirements.

(1) Each entrance or access point must be equipped with entry control devices which--

(i) Function automatically to prevent any individual from inadvertently entering the area when very high radiation levels exist,

(ii) Permit deliberate entry into the area only after a control device is actuated that causes the radiation level within the area, from the sealed source, to be reduced below that at which it would be possible for an individual to receive a deep-dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour; and

(iii) Prevent operation of the source if the source would produce radiation levels in the area that could result in a deep-dose equivalent to an individual in excess of 0.1 rem (1 mSv) in 1 hour.

(2) Additional control devices must be provided so that, upon failure of the entry control devices to function as required by paragraph (a)(1) of this section--

(i) The radiation level within the area, from the sealed source, is reduced below that at which it would be possible for an individual to receive a deep-dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour; and

(ii) Conspicuous visible and audible alarm signals are generated to make an individual attempting to enter the area aware of the hazard and at least one other authorized individual, who is physically present, familiar with the

---

2 This section applies to radiation from byproduct, source, or special nuclear materials that are used in sealed sources in non-self-shielded irradiators. This section does not apply to radioactive sources that are used in teletherapy, in radiography, or in completely self-shielded irradiators in which the source is both stored and operated within the same shielding radiation barrier and, in the designed configuration of the irradiator, is always physically inaccessible to any individual and cannot create high levels of radiation in an area that is accessible to any individual. This section also does not apply to sources from which the radiation is incidental to some other use or to nuclear reactor-generated radiation.

activity, and prepared to render or summon assistance, aware of the failure of the entry control devicea.

(3) The licensee shall provide control devices so that, upon failure or removal of physical radiation barriers other than the source's shielded storage container--

(i) The radiation level from the source is reduced below that at which it would be possible for an individual to receive a deep-dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour; and

(ii) Conspicuous visible and audible alarm signals are generated to make potentially affected individuals aware of the hazard and the licensee or at least one other individual, who is familiar with the activity and prepared to render or summon assistance, aware of the failure or removal of the physical barrier.

(4) When the shield for the stored source is a liquid, the licensee shall provide means to monitor the integrity of the shield and to signal, automatically, loss of adequate shielding.

(5) Physical radiation barriers that comprise permanent structural components, such as walls, that have no credible probability of failure or removal in ordinary circumstances need not meet the requirements of paragraphs (a)(3) and (4) of this section.

(6) Each area must be equipped with devices that will automatically generate conspicuous visible and audible alarm signals to alert personnel in the area before the source can be put into operation and in sufficient time for any individual in the area to operate a clearly identified control device, which must be installed in the area and which can prevent the source from being put into operation.

(7) Each area must be controlled by use of such administrative procedures and such devices as are necessary to ensure that the area is cleared of personnel prior to each use of the source.

(8) Each area must be checked by a radiation measurement to ensure that, prior to the first individual's entry into the area after any use of the source, the radiation level from the source in the area is below that at which it would be possible for an individual to receive a deep-dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour.

(9) The entry control devices required in paragraph (a)(1) of this section must have been tested for proper functioning (see § 20.1109 for recordkeeping requirements).

(i) Testing must be conducted prior to initial operation with the source of radiation on any day (unless operations were continued uninterrupted from the previous day); and

(ii) Testing must be conducted prior to resumption of operation of the source of radiation after any unintended interruption; and

(iii) The licensee shall submit and adhere to a schedule for periodic tests of the entry control and warning systems.

(10) The licensee may not conduct operations, other than those necessary to place the source in safe condition or to effect repairs on controls, unless control devices are functioning properly.

(11) Entry and exit portals that are used in transporting materials to and from the irradiation area, and that are not intended for use by individuals, must be controlled by such devices and administrative procedures as are necessary to physically protect and warn against inadvertent entry by any individual through these portals. Exit portals for processed materials must be equipped to detect and signal the presence of any loose radiation sources that are carried toward such an exit and to automatically prevent loose radiation sources from being carried out of the area.

(b) Persons holding licenses or applicants for licenses for radiation sources that are within the purview of paragraph (a) of this section and that will be used in a variety of positions or in locations, such as open fields or forests, that make it impracticable to comply with certain requirements of paragraph (a) of this section, such as those for the automatic control of radiation levels, may apply to the Director, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC 20555, for approval of the use of alternative safety measures. Any alternative safety measures must provide a degree of personnel protection at least equivalent to those specified in paragraph (a) of this section. At least one of the alternative measures must include an entry-preventing interlock control based on a measurement of the radiation that ensures the absence of high radiation levels before an individual can gain access to the area where such radiation sources are used.

(c) The entry control devices required by paragraphs (a) and (b) of this section must be established in such a way that no individual will be prevented from leaving the area.

SUBPART H--RESPIRATORY PROTECTION AND CONTROLS TO RESTRICT INTERNAL EXPOSURE IN RESTRICTED AREAS

§ 20.701 Use of process or other engineering contr ls.

The licensee shall use, to the extent practicable, process or other engineering controls (e.g., containment or ventilation) to control the concentrations of radioactive material in air.

§ 20.702 Use of other controls.

When it is not practicable to apply process or other engineering controls to control the concentrations of radioactive material in air to values below those that define an airborne radioactivity area, the licensee shall, consistent with maintaining the total effective dose equivalent ALARA, increase monitoring, and limit intakes by one or more of the following means:

(a) Control of access;

(b) Limitation of exposure times;

(c) Use of respiratory protection equipment; or

(d) Other controls.

§ 20.703 Use of individual respiratory protection equipment.

(a) If the licensee uses respiratory protection equipment to limit intakes pursuant to § 20.702--

(1) The licensee shall use only respiratory protection equipment that is tested and certified or had certification extended by the National Institute for Occupational Safety and Health/Mine Safety and Health Administration (NIOSH/MSHA).

(2) If the licensee wishes to use equipment that has not been tested or certified by NIOSH/MSHA, has not had certification extended by NIOSH/MSHA, or for which there is no schedule for testing or certification, the licensee shall submit an application for authorized use of that equipment, including a demonstration by testing, or a demonstration on the basis of reliable test information, that the material and performance characteristics of the equipment are capable of providing the proposed degree of protection under anticipated conditions of use.

(3) The licensee shall implement and maintain a respiratory protection program that includes--

(i) Air sampling sufficient to identify the potential hazard, permit proper equipment selection, and estimate exposures;

(ii) Surveys and bioassays, as appropriate, to evaluate actual intakes;

(iii) Testing of respirators for operability immediately prior to each use;

(iv) Written procedures regarding selection, fitting, issuance, maintenance, and testing of respirators, including testing for operability immediately prior to each use; supervision and training of personnel; monitoring, including air sampling and bioassays; and recordkeeping; and

(v) Determination by a physician prior to initial fitting of respirators, and at least every 12 months thereafter, that the individual user is physically able to use the respiratory protection equipment.

(4) The licensee shall issue a written policy statement on respirator usage covering--

(i) The use of process or other engineering controls, instead of respirators;

(ii) The routine, nonroutine, and emergency use of respirators; and

(iii) The periods of respirator use and relief from respirator use.

(5) The licensee shall advise each respirator user that the user may leave the area at any time for relief from respirator use in the event of equipment malfunction, physical or psychological distress, procedural or communication failure, significant deterioration of operating conditions, or any other conditions that might require such relief.

(6) The licensee shall use equipment within limitations for type and mode of use and shall provide proper visual, communication, and other special capabilities (such as adequate skin protection) when needed.

(b) In estimating exposure of individuals to airborne radioactive materials, the licensee may make allowance for respiratory protection equipment used to limit intakes pursuant to § 20.702, provided that the following conditions, in addition to those in § 20.703(a), are satisfied:

(1) The licensee selects respiratory protection equipment that provides a protection factor (see Appendix A) greater than the multiple by which peak concentrations of airborne radioactive materials in the working area are expected to exceed the values specified in Appendix B, Table 1, Column 3. If the selection of a respiratory protection device with a protection factor greater than the peak concentration is inconsistent with the goal specified in § 20.702 of keeping the total effective dose equivalent ALARA, the licensee may select respiratory protection equipment with a lower protection factor only if such a selection would result in keeping the total effective dose equivalent ALARA. The concentration of radioactive material in the air that is inhaled when respirators are worn may be initially estimated by dividing the average concentration in air, during each period of uninterrupted use, by the protection factor. If the exposure is later found to be greater than estimated, the corrected value must be used; if the exposure is later found to be less than estimated, the corrected value may be used.

(2) The licensee shall obtain authorization from the Commission before assigning respiratory protection factors in excess of those specified in Appendix A. The Commission may authorize a licensee to use higher protection factors on receipt of an application that--

(i) Describes the situation for which a need exists for higher protection factors, and

(ii) Demonstrates that the respiratory protection equipment provides these higher protection factors under the proposed conditions of use.

(c) The licensee shall use as emergency devices only respiratory protection equipment that has been specifically certified or had certification extended for emergency use by NIOSH/MSHA.

(d) The licensee shall notify, in writing, the Director of the appropriate NRC Regional Office listed in Appendix D at least 30 days before the date that respiratory protection equipment is first used under the provisions of either § 20.703(a) or (b).

§ 20.704 Further restrictions on the use of respiratory protection equipment.

The Commission may impose restrictions in addition to those in §§ 20.702, 20.703, and Appendix A to--

(a) Ensure that the respiratory protection program of the licensee is adequate to limit exposures of individuals to airborne radioactive materials; and

(b) Limit the extent to which a licensee may use respiratory protection equipment instead of process or other engineering controls.

SUBPART I--STORAGE AND CONTROL OF LICENSED MATERIAL

§ 20.801 Security of stored material.

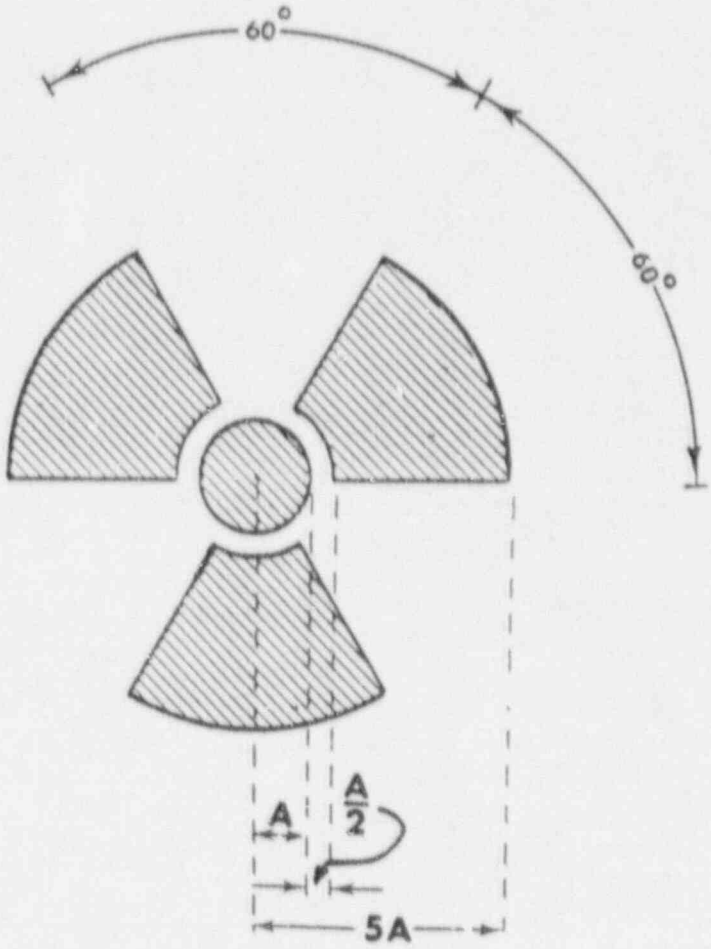
The licensee shall secure from unauthorized removal or access licensed materials that are stored in controlled or unrestricted areas.

§ 20.802 Control of material not in storage.

The licensee shall control and maintain constant surveillance of licensed material that is in a controlled or unrestricted area and that is not in storage.

§ 20.901 Caution signs.

(a) Standard radiation symbol. Unless otherwise authorized by the Commission, the symbol prescribed by this part shall use the colors magenta, or purple, or black on yellow background. The symbol prescribed by this part is the three-bladed design:



RADIATION SYMBOL

(1) Cross-hatched area is to be magenta, or purple, or black, and

(2) The background is to be yellow.

(b) Exception to color requirements for standard radiation symbol. Notwithstanding the requirements of paragraph (a) of this section, licensees are authorized to label sources, source holders, or device components containing sources of licensed materials that are subjected to high temperatures, with conspicuously etched or stamped radiation caution symbols and without a color requirement.

(c) Additional information on signs and labels. In addition to the contents of signs and labels prescribed in this part, the licensee may provide, on or near the required signs and labels, additional information, as appropriate, to make individuals aware of potential radiation exposures and to minimize the exposures.

§ 20.902 Posting requirements.

(a) Posting of radiation areas. The licensee shall post each radiation area with a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION, RADIATION AREA."

(b) Posting of high radiation areas. The licensee shall post each high radiation area with a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION, HIGH RADIATION AREA" or "DANGER, HIGH RADIATION AREA."

(c) Posting of very high radiation areas. The licensee shall post each very high radiation area with a conspicuous sign or signs bearing the radiation symbol and words "GRAVE DANGER, VERY HIGH RADIATION AREA."

(d) Posting of airborne radioactivity areas. The licensee shall post each airborne radioactivity area with a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION, AIRBORNE RADIOACTIVITY AREA" or "DANGER, AIRBORNE RADIOACTIVITY AREA."

(e) Posting of areas or rooms in which licensed material is used or stored. The licensee shall post each area or room in which there is used or stored an amount of licensed material exceeding 10 times the quantity of such material specified in Appendix C with a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION, RADIOACTIVE MATERIAL(S)" or "DANGER, RADIOACTIVE MATERIAL(S)."

§ 20.903 Exceptions to posting requirements.

(a) A licensee is not required to post caution signs in areas or rooms containing radioactive materials for periods of less than 8 hours, if each of the following conditions is met:

(1) The materials are constantly attended during these periods by an individual who takes the precautions necessary to prevent the exposure of individuals to radiation or radioactive materials in excess of the limits established in this part; and

(2) The area or room is subject to the licensee's control.

(b) Rooms or other areas in hospitals that are occupied by patients are not required to be posted with caution signs pursuant to § 20.902 provided that--

(1) The patient is being treated with sealed sources or has been treated with unsealed radioactive material in quantities less than 30 millicuries, or the measured dose rate at 1 meter from the patient is less than 0.005 rem (0.05 mSv) per hour; and

(2) There are personnel in attendance who will take the necessary precautions to prevent the exposure of individuals to radiation or radioactive material in excess of the limits established in this part and to operate within the ALARA provisions of the licensee's radiation protection program.

(c) A room or area is not required to be posted with a caution sign because of the presence of a sealed source provided the radiation level at 30 centimeters from the surface of the source container or housing does not exceed 0.005 rem (0.05 mSv) per hour.

§ 20.904 Labeling containers.

(a) The licensee shall ensure that each container of licensed material bears a durable, clearly visible label bearing the radiation symbol and the words "CAUTION, RADIOACTIVE MATERIAL" or "DANGER, RADIOACTIVE MATERIAL." The label must also provide sufficient information (such as the radionuclide(s) present, an estimate of the quantity of radioactivity, the date for which the

activity is estimated, radiation levels, kinds of materials, and mass enrichment) to permit individuals handling or using the containers, or working in the vicinity of the containers, to take precautions to avoid or minimize exposures.

(b) Each licensee shall, prior to removal or disposal of empty uncontaminated containers to unrestricted areas, remove or deface the radioactive material label or otherwise clearly indicate that the container no longer contains radioactive materials.

§ 20.905 Exemptions to labeling requirements.

A licensee is not required to label--

(a) Containers holding licensed material in quantities less than the quantities listed in Appendix C; or

(b) Containers holding licensed material in concentrations less than those specified in Table 3 of Appendix B; or

(c) Containers attended by an individual who takes the precautions necessary to prevent the exposure of individuals in excess of the limits established by this part; or

(d) Containers when they are in transport and packaged and labeled in accordance with the regulations of the Department of Transportation,[3] or

(e) Containers that are accessible only to individuals authorized to handle or use them, or to work in the vicinity of the containers, if the contents are identified to these individuals by a readily available written record (examples of containers of this type are containers in locations such as water-filled canals, storage vaults, or hot cells). The record must be retained as long as the containers are in use for the purpose indicated on the record; or

---

3 Labeling of packages containing radioactive materials is required by the Department of Transportation (DOT) if the amount and type of radioactive material exceeds the limits for an excepted quantity or article as defined and limited by DOT regulations 49 CFR 173.403(m) and (w) and 173.421-424.

(f) Installed manufacturing or process equipment, such as reactor components, piping, and tanks.

§ 20.906 Procedures for receiving and opening packages.

(a) Each licensee who expects to receive a package containing quantities of radioactive material in excess of a Type A quantity, as defined in § 71.4 and Appendix A to Part 71 of this chapter, shall make arrangements to receive--

(1) The package when the carrier offers it for delivery; or

(2) Notification of the arrival of the package at the carrier's terminal and to take possession of the package expeditiously.

(b) Each licensee shall monitor the external surfaces of a package known to contain radioactive material for radioactive contamination and radiation levels if the package--

(1) Is labeled as containing radioactive material; or

(2) Has evidence of potential contamination, such as packages that are crushed, wet, or damaged.

(c) The licensee shall perform the monitoring required by paragraph (b) of this section as soon as practicable after receipt of the package, but not later than 3 hours after the package is received at the licensee's facility if it is received during the licensee's normal working hours, or not later than 3 hours from the beginning of the next working day if it is received after working hours.

(d) The licensee shall immediately notify the final delivery carrier and, by telephone and telegram, mailgram, or facsimile, the Administrator of the appropriate NRC Regional Office listed in Appendix D when--

(1) Removable radioactive surface contamination exceeds the limits of § 71.87(i) of this chapter; or

(2) External radiation levels exceed the limits of § 71.47 of this chapter.

(e) Each licensee shall--

(1) Establish, maintain, and retain written procedures for safely opening packages in which radioactive material is received; and

(2) Ensure that the procedures are followed and that due consideration is given to special instructions for the type of package being opened.

(f) Licensees transferring special form sources in licensee-owned or licensee-operated vehicles to and from a work site are exempt from the contamination monitoring requirements of paragraph (b), but are not exempt from the survey requirement in paragraph (b) for measuring radiation levels that is required to ensure that the source is still properly lodged in its shield.

SUBPART K--WASTE DISPOSAL

§ 20.1001 General requirements.

(a) A licensee shall dispose of licensed material only--

(1) By transfer to an authorized recipient as provided in § 20.1006 or in the regulations in Parts 30, 40, 60, 61, 70, or 72 of this chapter; or

(2) By decay in storage; or

(3) By release in effluents within the limits in § 20.301; or

(4) As authorized under §§ 20.1002, 20.1003, 20.1004, or 20.1005.

(b) A person must be specifically licensed to receive waste containing licensed material from other persons for:

(1) Treatment prior to disposal; or

(2) Treatment or disposal by incineration; or

(3) Decay in storage; or

(4) Disposal at a land disposal facility licensed under Part 61 of this chapter; or

(5) Disposal at a geologic repository under Part 60 of this chapter.

§ 20.1002 Method for obtaining approval of proposed disposal procedures.

A licensee or applicant for a license may apply to the Commission for approval of proposed procedures, not otherwise authorized in the regulations in this chapter, to dispose of licensed material generated in the licensee's activities. Each application shall include:

(a) A description of the waste containing licensed material to be disposed of, including the physical and chemical properties important to risk

evaluation, and the proposed manner and conditions of waste disposal; and

(b) An analysis and evaluation of pertinent information on the nature of the environment; and

(c) The nature and location of other potentially affected licensed and unlicensed facilities; and

(d) Analyses and procedures to ensure that doses are maintained ALARA and within the dose limits in this part.

§ 20.1003 Disposal by release into sanitary sewerage.

(a) A licensee may discharge licensed material into sanitary sewerage if each of the following conditions is satisfied:

(1) The material is readily soluble (or is readily dispersible biological material) in water; and

(2) The quantity of licensed or other radioactive material that the licensee releases into the sewer in 1 month divided by the average monthly volume of water released into the sewer by the licensee does not exceed the concentration listed in Table 3 of Appendix B; and

(3) If more than one radionuclide is released, the following conditions must also be satisfied:

(i) The licensee shall determine the fraction of the limit in Table 3 of Appendix B represented by discharges into sanitary sewerage by dividing the actual monthly average concentration of each radionuclide released by the licensee into the sewer by the concentration of that radionuclide listed in Table 3 of Appendix B; and

(ii) The sum of the fractions for each radionuclide required by paragraph (a)(3)(i) of this section does not exceed unity; and

(4) The total quantity of licensed and other radioactive material that the licensee releases into the sanitary sewerage system in a year does not exceed 5 curies (185 GBq) of hydrogen-3, 1 curie (37 GBq) of carbon-14, and 1 curie (37 GBq) of all other radioactive materials combined.

(b) Excreta from individuals undergoing medical diagnosis or therapy with radioactive material is not subject to the limitations contained in paragraph (a) of this section.

§ 20.1004 Treatment or disposal by incineration.

A licensee may treat or dispose of licensed material by incineration only in the amounts and forms specified in § 20.1005 or as specifically approved by the Commission pursuant to § 20.1002.

§ 20.1005 Disposal of specific wastes.

(a) A licensee may dispose of the following licensed material as if it were not radioactive:

(1) 0.05 microcurie (1.85 kBq), or less, of hydrogen-3 or carbon-14 per gram of medium used for liquid scintillation counting; and

(2) 0.05 microcurie (1.85 kBq), or less, of hydrogen-3 or carbon-14 per gram of animal tissue, averaged over the weight of the entire animal.

(b) A licensee may not dispose of tissue under paragraph (a)(2) of this section in a manner that would permit its use either as food for humans or as animal feed.

(c) The licensee shall maintain records in accordance with § 20.1108.

§ 20.1006 Transfer for disposal and manifests.

(a) The requirements of this section and Appendix F are designed to control transfers of low-level radioactive waste intended for disposal at a land disposal facility (as defined in Part 61 of this chapter), establish a manifest tracking system, and supplement existing requirements concerning transfers and recordkeeping for those wastes.

(b) Each shipment of radioactive waste intended for disposal at a licensed land disposal facility must be accompanied by a shipment manifest as specified in Section I of Appendix F.

(c) Each shipment manifest must include a certification by the waste generator as specified in Section II of Appendix F.

(d) Each person involved in the transfer for disposal and disposal of waste, including the waste generator, waste collector, waste processor, and disposal facility operator, shall comply with the requirements specified in Section III of Appendix F.

§ 20.1007 Compliance with environmental and health protection regulations.

Nothing in this subpart relieves the licensee from complying with other applicable Federal, State, and local regulations governing any other toxic or hazardous properties of materials that may be disposed of under this subpart.

SUBPART L--RECORDS

§ 20.1101 General provisions.

(a) Each licensee shall use the units: curie, rad, rem, including multiples and subdivisions, and shall clearly indicate the units of all quantities on records required by this part.

(b) The licensee shall make a clear distinction among the quantities entered on the records required by this part (e.g., total effective dose equivalent, shallow-dose equivalent, eye dose equivalent, deep-dose equivalent, committed effective dose equivalent).

§ 20.1102 Records of radiation protection programs.

(a) Each licensee shall maintain records of the radiation protection program, including:

(1) The provisions of the program; and

(2) Audits and other reviews of program content and implementation.

(b) The licensee shall retain the records required by paragraph (a)(1) of this section until the Commission terminates each pertinent license requiring the record. The licensee shall retain the records required by paragraph (a)(2) of this section for 3 years after the record is made.

§ 20.1103 Records of surveys.

(a) Each licensee shall maintain records showing the results of surveys and calibrations required by §§ 20.501 and 20.906(b). The licensee shall retain these records for 3 years after the record is made.

(b) The licensee shall retain each of the following records until the Commission terminates each pertinent license requiring the record:

(1) Records of the results of surveys to determine the dose from external sources and used, in the absence of or in combination with individual monitoring data, in the assessment of individual dose equivalents; and

(2) Records of the results of measurements and calculations used to determine individual intakes of radioactive material and used in the assessment of internal dose; and

(3) Records showing the results of air sampling, surveys, and bioassays required pursuant to § 20.703(a)(3)(i) and (ii); and

(4) Records of the results of measurements and calculations used to evaluate the release of radioactive effluents to the environment.

§ 20.1104 Determination of prior occupational dose.

(a) For each individual who may enter the licensee's restricted or controlled area and is likely to receive, in a year, an occupational dose requiring monitoring pursuant to § 20.502, the licensee shall--

(1) Determine the occupational radiation dose received during the current year; and

(2) Attempt to obtain the records of lifetime cumulative occupational radiation dose.

(b) Prior to permitting an individual to participate in a planned special exposure, the licensee shall determine--

(1) The internal and external doses from all previous planned special exposures; and

(2) All doses in excess of the limits (including doses received during accidents and emergencies) received during the lifetime of the individual.

(c) In complying with the requirements of paragraph (a) of this section, a licensee may--

(1) Accept, as a record of the occupational dose that the individual received during the current year, a written signed statement from the individual, or from the individual's most recent employer for work involving radiation exposure, that discloses the nature and the amount of any occupational dose that the individual may have received during the current year;

(2) Accept, as the record of lifetime cumulative radiation dose, an up-to-date NRC Form 4, or equivalent, signed by the individual and countersigned by an appropriate official of the most recent employer for work involving radiation exposure, or the individual's current employer (if the individual is not employed by the licensee); and

(3) Obtain reports of the individual's dose equivalent(s) from the most recent employer for work involving radiation exposure, or the individual's current employer (if the individual is not employed by the licensee) by telephone, telegram, electronic media, or letter. The licensee shall request a written verification of the dose data if the authenticity of the transmitted report cannot be established.

(d) The licensee shall record the exposure history, as required by paragraph (a) of this section, on NRC Form 4, or other clear and legible record, of all the information required on that form.[4] The form or record must show each period in which the individual received occupational exposure to radiation or radioactive material and must be signed by the individual who received the exposure. For each period for which the licensee obtains reports, the licensee shall use the dose shown in the report in preparing NRC Form 4. For any period in which the licensee does not obtain a report, the licensee shall place a notation on NRC Form 4 indicating the periods of time for which data are not available.

(e) If the licensee is unable to obtain a complete record of an individual's current and previously accumulated occupational dose, the licensee shall assume--

---

4 Licensees are not required to reevaluate the separate external dose equivalents and internal committed dose equivalents or intakes of radionuclides assessed under the regulations in this part in effect before January 1, 1993. Further, occupational exposure histories obtained and recorded on NRC Form 4 before January 1, 1993, would not have included effective dose equivalent, but may be used in the absence of specific information on the intake of radionuclides by the individual.

(1) In establishing administrative controls under § 20.201(f) for the current year, that the allowable dose limit for the individual is reduced by 1.25 rems (12.5 mSv) for each quarter for which records were unavailable and the individual was engaged in activities that could have resulted in occupational radiation exposure; and

(2) That the individual is not available for planned special exposures.

(f) The licensee shall retain the records on NRC Form 4 or equivalent until the Commission terminates each pertinent license requiring this record. The licensee shall retain records used in preparing NRC Form 4 for 3 years after the record is made.

§ 20.1105 Records of planned special exposures.

(a) For each use of the provisions of § 20.206 for planned special exposures, the licensee shall maintain records that describe--

(1) The exceptional circumstances requiring the use of a planned special exposure; and

(2) The name of the management official who authorized the planned special exposure and a copy of the signed authorization; and

(3) What actions were necessary; and

(4) Why the actions were necessary; and

(5) How doses were maintained ALARA; and

(6) What individual and collective doses were expected to result, and the doses actually received in the planned special exposure.

(b) The licensee shall retain the records until the Commission terminates each pertinent license requiring these records.

§ 20.1106 Records of individual monitoring results.

(a) Recordkeeping requirement. Each licensee shall maintain records of doses received by all individuals for whom monitoring was required pursuant to § 20.502, and records of doses received during planned special exposures,

accidents, and emergency conditions. These records[5] must include, when applicable--

(1) The deep-dose equivalent to the whole body, eye dose equivalent, shallow-dose equivalent to the skin, and shallow-dose equivalent to the extremities; and

(2) The estimated intake or body burden of radionuclides (see § 20.202); and

(3) The committed effective dose equivalent assigned to the intake or body burden of radionuclides; and

(4) The specific information used to calculate the committed effective dose equivalent pursuant to § 20.204(c); and

(5) The total effective dose equivalent when required by § 20.202; and

(6) The total of the deep-dose equivalent and the committed dose to the organ receiving the highest total dose.

(b) Recordkeeping frequency. The licensee shall make entries of the records specified in paragraph (a) of this section at least annually.

(c) Recordkeeping format. The licensee shall maintain the records specified in paragraph (a) of this section on NRC Form 5, in accordance with the instructions for NRC Form 5, or in clear and legible records containing all the information required by NRC Form 5.

(d) Privacy protection. The records required under this section should be protected from public disclosure because of their personal privacy nature. These records are protected by most State privacy laws and, when transferred to the NRC, are protected by the Privacy Act of 1974, Pub.L. 93-579, 5 U.S.C. 552a, and the Commission's regulations in 10 CFR Part 9.

(e) The licensee shall maintain the records of dose to an embryo/fetus with the records of dose to the declared pregnant woman. The declaration of pregnancy shall also be kept on file, but may be maintained separately from the dose records.

(f) The licensee shall retain each required form or record until the Commission terminates each pertinent license requiring the record.

---

5 Assessments of dose equivalent and records made using units in effect before January 1, 1993, need not be changed.

§ 20.1107 Records of dose to individual members of the public.

(a) Each licensee shall maintain records sufficient to demonstrate compliance with the dose limit for individual members of the public (see § 20.301).

(b) The licensee shall retain the records required by paragraph (a) of this section until the Commission terminates each pertinent license requiring the record.

§ 20.1108 Records of waste disposal.

(a) Each licensee shall maintain records of the disposal of licensed materials made under §§ 20.1002, 20.1003, 20.1004, 20.1005, Part 61, and disposal by burial in soil, including burials authorized before January 28, 1981.[6]

(b) The licensee shall retain the records required by paragraph (a) of this section until the Commission terminates each pertinent license requiring the record.

§ 20.1109 Records of testing entry control devices for very high radiation areas.

(a) Each licensee shall maintain records of tests made under § 20.603(a)(9) on entry control devices for very high radiation areas. These records must include the date, time, and results of each such test of function.

(b) The licensee shall retain the records required by paragraph (a) of this section for 3 years after the record is made.

---

6 A previous § 20.304 permitted burial of small quantities of licensed materials in soil before January 28, 1981, without specific Commission authorization.

§ 20.1110 Form of records.

Each record required by this part must be legible throughout the specified retention period. The record may be the original or a reproduced copy or a microform provided that the copy or microform is authenticated by authorized personnel and that the microform is capable of producing a clear copy throughout the required retention period. The record may also be stored in electronic media with the capability for producing legible, accurate, and complete records during the required retention period. Records, such as letters, drawings, and specifications, must include all pertinent information, such as stamps, initials, and signatures. The licensee shall maintain adequate safeguards against tampering with and loss of records.

SUBPART M--REPORTS

§ 20.1201 Reports of theft or loss of licensed material.

(a) Telephone reports.

(1) Each licensee shall report by telephone as follows:

(i) Immediately after its occurrence becomes known to the licensee, any lost, stolen, or missing licensed material in an aggregate quantity equal to or greater than 1,000 times the quantity specified in Appendix C under such circumstances that it appears to the licensee that an exposure could result to persons in unrestricted areas; or

(ii) Within 30 days after the occurrence of any lost, stolen, or missing licensed material becomes known to the licensee, all licensed material in a quantity greater than 10 times the quantity specified in Appendix C that is still missing at this time.

(2) Reports must be made as follows:

(i) Licensees having an installed Emergency Notification System shall make the reports to the NRC Operations Center in accordance with § 50.72 of this chapter, and

(ii) All other licensees shall make reports to the NRC Operations Center.

(b) Written reports.

(1) Each licensee required to make a report under paragraph (a) of this section shall, within 30 days after making the telephone report, make a written report setting forth the following information:

(i) A description of the licensed material involved, including kind, quantity, and chemical and physical form; and

(ii) A description of the circumstances under which the loss or theft occurred; and

(iii) A statement of disposition, or probable disposition, of the licensed material involved; and

(iv) Exposures of individuals to radiation, circumstances under which the exposures occurred, and the possible effective dose equivalent to persons in unrestricted areas; and

(v) Actions that have been taken, or will be taken, to recover the material; and

(vi) Procedures or measures that have been, or will be, adopted to ensure against a recurrence of the loss or theft of licensed material.

(2) Reports must be made as follows:

(i) For holders of an operating license for a nuclear power plant, the events included in paragraph (b) of this section must be reported in accordance with the procedures described in § 50.73(b), (c), (d), (e), and (g) of this chapter and must include the information required in paragraph (b)(1) of this section, and

(ii) All other licensees shall make reports to the Administrator of the appropriate NRC Regional Office listed in Appendix D.

(c) A duplicate report is not required under (b) if the licensee is also required to submit a report pursuant to §§ 30.55(c), 40.64(c), 50.72, 50.73, 70.52, 73.27(b), 73.67(e)(3)(vi), 73.67(g)(3)(iii), 73.71, or 150.19(c) of this chapter.

(d) Subsequent to filing the written report, the licensee shall also report any additional substantive information on the loss or theft within 30 days after the licensee learns of such information.

(e) The licensee shall prepare any report filed with the Commission pursuant to this section so that names of individuals who may have received exposure to radiation are stated in a separate and detachable part of the report.

§ 20.1202 Notification of incidents.

(a) Immediate notification. Notwithstanding any other requirements for notification, each licensee shall immediately report any event involving byproduct, source, or special nuclear material possessed by the licensee that may have caused or threatens to cause any of the following conditions--

(1) An individual to receive--

(i) A total effective dose equivalent of 25 rems (0.25 Sv) or more; or

(ii) An eye dose equivalent of 75 rems (0.75 Sv) or more; or

(iii) A shallow-dose equivalent to the skin or extremities of 250 rads (2.5 Gy) or more; or

(2) The release of radioactive material, inside or outside of a restricted area, so that, had an individual been present for 24 hours, the individual could have received an intake five times the occupational annual limit on intake (the provisions of this paragraph do not apply to locations where personnel are not normally stationed during routine operations, such as hot-cells or process enclosures); or

(3) A loss of 1 working week or more of the operation of any facilities affected; or

(4) Damage to property in excess of $200,000.

(b) Twenty-four hour notification. Each licensee shall, within 24 hours of discovery of the event, report any event involving loss of control of licensed material possessed by the licensee that may have caused, or threatens to cause, any of the following conditions:

(1) An individual to receive, in a period of 24 hours--

(i) A total effective dose equivalent exceeding 5 rems (0.05 Sv); or

(ii) An eye dose equivalent exceeding 15 rems (0.15 Sv); or

(iii) A shallow-dose equivalent to the skin or extremities exceeding 50 rems (0.5 Sv); or

(2) The release of radioactive material, inside or outside of a restricted area, so that, had an individual been present for 24 hours, the individual could have received an intake in excess of one occupational annual limit on intake (the provisions of this paragraph do not apply to locations where personnel are not normally stationed during routine operations, such as hot-cells or process enclosures); or

(3) A loss of 1 day or more of the operation of any facilities affected; or

(4) Damage to property in excess of $2,000.

(c) The licensee shall prepare any report filed with the Commission pursuant to this section so that names of individuals who have received exposure to radiation or radioactive material are stated in a separate and detachable part of the report.

(d) Reports made by licensees in response to the requirements of this section must be made as follows:

(1) Licensees having an installed Emergency Notification System shall make the reports required by paragraphs (a) and (b) of this section to the NRC Operations Center in accordance with § 50.72; and

(2) All other licensees shall make the reports required by paragraphs (a) and (b) of this section by telephone to the NRC Operations Center and by telegram, mailgram, or facsimile to the Administrator of the appropriate NRC Regional Office listed in Appendix D.

(e) The provisions of this section do not include doses that result from planned special exposures, that are within the limits for planned special exposures, and that are reported under § 20.1204.

§ 20.1203 Reports of exposures, radiation levels, and concentrations of radioactive material exceeding the limits.

(a) Reportable events. In addition to the notification required by § 20.1202, each licensee shall submit a written report within 30 days after learning of any of the following occurrences:

(1) Any incident for which notification is required by § 20.1202; or

(2) Doses in excess of any of the following:

(i) The occupational dose limits for adults in § 20.201; or

(ii) The occupational dose limits for a minor in § 20.207; or

(iii) The limits for an embryo/fetus of a declared pregnant woman in § 20.208; or

(iv) The limits for an individual member of the public in § 20.301; or

(v) Any applicable limit in the license; or

(3) Levels of radiation or concentrations of radioactive material in--

(i) A restricted area in excess of any applicable limit in the license; or

(ii) An unrestricted area in excess of 10 times any applicable limit set forth in this part or in the license (whether or not involving exposure of any individual in excess of the limits in § 20.301); or

(4) For licensees subject to the provisions of EPA's generally applicable environmental radiation standards, levels of radiation or releases of radioactive material in excess of those standards, or of license conditions related to those standards.

(b) Contents of reports.

(1) Each report required by paragraph (a) of this section must describe the extent of exposure of individuals to radiation and radioactive material, including, as appropriate:

(i) Estimates of each individual's dose; and

(ii) The levels of radiation and concentrations of radioactive material involved; and

(iii) The cause of the elevated exposures, dose rates, or concentrations; and

(iv) Corrective steps taken or planned to ensure against a recurrence, including the schedule for achieving conformance with applicable limits, generally applicable environmental standards, and associated license conditions.

(2) Each report filed pursuant to paragraph (a) of this section must include for each individual[7] exposed: the name, Social Security account number, and date of birth. The report must be prepared so that this information is stated in a separate and detachable part of the report.

(c) For holders of an operating license for a nuclear power plant, the occurrences included in paragraph (a) of this section must be reported in accordance with the procedures described in § 50.73(b), (c), (d), (e), and (g) of this chapter and must also include the information required by paragraph (b) of this section. Occurrences reported in accordance with § 50.73 of this chapter need not be reported by a duplicate report under paragraph (a) of this section.

---

7 With respect to the limit for the embryo/fetus (§ 20.208), the identifiers should be those of the declared pregnant woman.

(d) All licensees, other than those holding an operating license for a nuclear power plant, who make reports under paragraph (a) of this section shall submit the report in writing to the U.S. Nuclear Regulatory Commission, Document Control Desk, Washington, DC 20555, with a copy to the appropriate NRC Regional Office listed in Appendix D.

§ 20.1204 Reports of planned special exposures.

The licensee shall submit a written report to the Administrator of the appropriate NRC Regional Office listed in Appendix D within 30 days following any planned special exposure conducted in accordance with § 20.206, informing the Commission that a planned special exposure was conducted and indicating the date the planned special exposure occurred and the information required by § 20.1105.

§ 20.1205 [Reserved].

§ 20.1206 Reports of individual monitoring.

(a) This section applies to each person licensed by the Commission to--

(1) Operate a nuclear reactor designed to produce electrical or heat energy pursuant to § 50.21(b) or § 50.22 of this chapter or a testing facility as defined in § 50.2 of this chapter; or

(2) Possess or use byproduct material for purposes of radiography pursuant to Parts 30 and 34 of this chapter; or

(3) Possess or use at any one time, for purposes of fuel processing, fabricating, or reprocessing, special nuclear material in a quantity exceeding 5,000 grams of contained uranium-235, uranium-233, or plutonium, or any combination thereof pursuant to Part 70 of this chapter; or

(4) Possess high-level radioactive waste at a geologic repository operations area pursuant to Part 60 of this chapter; or

(5) Possess spent fuel in an independent spent fuel storage installation (ISFSI) pursuant to Part 72 of this chapter; or

(6) Receive radioactive waste from other persons for disposal under Part 61 of this chapter; or

(7) Possess or use at any time, for processing or manufacturing for distribution pursuant to Parts 30, 32, 33 or 35 of this chapter, byproduct material in quantities exceeding any one of the following quantities:

	Quantity of Radionuclide[a] in curies
Cesium-137	1
Cobalt-60	1
Gold-198	100
Iodine-131	1
Iridium-192	10
Krypton-85	1,000
Promethium-147	10
Technetium-99m	1,000

[a]The Commission may require as a license condition, or by rule, regulation, or order pursuant to § 20.1302, reports from licensees who are licensed to use radionuclides not on this list, in quantities sufficient to cause comparable radiation levels.

(b) Each licensee in a category listed in paragraph (a) of this section shall submit an annual report of the results of individual monitoring carried out by the licensee for each individual for whom monitoring was required by § 20.502 during that year. The licensee may include additional data for individuals for whom monitoring was provided but not required. The licensee shall use Form NRC 5 or electronic media containing all the information required by Form NRC 5.

(c) The licensee shall file the report required by § 20.1206(b), covering the preceding year, on or before April 30 of each year. The licensee shall submit the report to the Director, Office of Nuclear Regulatory Research, Nuclear Regulatory Commission, Washington, DC 20555.

SUBPART N--EXEMPTIONS AND ADDITIONAL REQUIREMENTS

§ 20.1301 Applications for exemptions.

The Commission may, upon application by a licensee or upon its own initiative, grant an exemption from the requirements of the regulations in this part if it determines the exemption is authorized by law and would not result in undue hazard to life or property.

§ 20.1302 Additional requirements.

The Commission may, by rule, regulation, or order, impose requirements on a licensee, in addition to those established in the regulations in this part, as it deems appropriate or necessary to protect health or to minimize danger to life or property.

SUBPART O--ENFORCEMENT

§ 20.1401 Violations.

(a) The Commission may obtain an injunction or other court order to prevent a violation of the provisions of--

(1) The Atomic Energy Act of 1954, as amended;

(2) Title II of the Energy Reorganization Act of 1974, as amended; or

(3) A regulation or order issued pursuant to those Acts.

(b) The Commission may obtain a court order for the payment of a civil penalty imposed under Section 234 of the Atomic Energy Act:

(1) For violations of--

(i) Sections 53, 57, 62, 63, 81, 82, 101, 103, 104, 107, or 109 of the Atomic Energy Act of 1954, as amended;

(ii) Section 206 of the Energy Reorganization Act;

(iii) Any rule, regulation, or order issued pursuant to the sections specified in paragraph (b)(1)(i) of this section;

(iv) Any term, condition, or limitation of any license issued under the sections specified in paragraph (b)(1)(i) of this section.

(2) For any violation for which a license may be revoked under Section 186 of the Atomic Energy Act of 1954, as amended.

(c) Any person who willfully violates a provision of the Atomic Energy Act or regulation or order issued under the requirements of that Act may be guilty of a crime and, upon conviction, be punished by fine or imprisonment or both, as provided by law.

APPENDIX A

PROTECTION FACTORS FOR RESPIRATORS[a]

Description[b]	Modes[c]	Protection Factors[d] Particulates only	Particulates, gases, & vapors[e]	Tested & Certified Equipment: National Institute for Occupational Safety and Health / Mine Safety and Health Administration tests for permissibility
I. AIR-PURIFYING RESPIRATORS[f]				
Facepiece, half-mask[g]	NP	10		30 CFR Part 11, Subpart K.
Facepiece, full	NP	50		
Facepiece, half-mask full, or hood	PP	1000		
II. ATMOSPHERE-SUPPLYING RESPIRATORS				
1. Air-line respirator				
Facepiece, half-mask	CF		1000	
Facepiece, half-mask	D		5	
Facepiece, full	CF		2000	
Facepiece, full	D		5	30 CFR Part 11, Subpart J.
Facepiece, full	PD		2000	
Hood	CF		h	
Suit	CF		i	J
2. Self-contained breathing apparatus (SCBA)				
Facepiece, full	D		50	
Facepiece, full	PD		10,000[k]	30 CFR Part 11, Subpart H.
Facepiece, full	RD		50	
Facepiece, full	RP		5,000[l]	
III. COMBINATION RESPIRATORS				
Any combination of air-purifying and atmosphere-supplying respirators		Protection factor for type and mode of operation as listed above		30 CFR Part 11, §11.63(b).

FOOTNOTES

a. For use in the selection of respiratory protective devices to be used only where the contaminants have been identified and the concentrations (or possible concentrations) are known.

b. Only for shaven faces and where nothing interferes with the seal of tight-fitting facepieces against the skin. (Hoods and suits are excepted.)

c. The mode symbols are defined as follows:

CF = continuous flow

D = demand

NP = negative pressure (i.e., negative phase during inhalation)

PD = pressure demand (i.e., always positive pressure)

PP = positive pressure

RD = demand, recirculating (closed circuit)

RP = pressure demand, recirculating (closed circuit)

d.1. The protection factor is a measure of the degree of protection afforded by a respirator, defined as the ratio of the concentration of airborne radioactive material outside the respiratory protective equipment to that inside the equipment (usually inside the facepiece) under conditions of use. It is applied to the ambient airborne concentration to estimate the concentrations inhaled by the wearer according to the following formula:

$$\text{Concentration inhaled} = \frac{\text{Ambient airborne concentration}}{\text{Protection factor}}$$

2. The protection factors apply:

(a) Only for individuals trained in using respirators and wearing properly fitted respirators that are used and maintained under supervision in a well-planned respiratory protective program.

(b) For air-purifying respirators only when high efficiency particulate filters (above 99.97% removal efficiency by thermally generated 0.3 μm dioctyl phthalate (DOP) test or equivalent) are used in atmospheres not deficient in oxygen and not containing radioactive gas or vapor respiratory hazards.

(c) No adjustment is to be made for the use of sorbents against radioactive material in the form of gases or vapors.

(d) For atmosphere-supplying respirators only when supplied with adequate respirable air. Respirable air shall be provided of the quality and quantity required in accordance with NIOSH/MSHA certification (described in 30 CFR Part 11). Oxygen and air shall not be used in the same apparatus.

e. Excluding radioactive contaminants that present an absorption or submersion hazard. For tritium oxide, approximately one-third of the intake occurs by absorption through the skin so that an overall protection factor of less than 2 is appropriate when atmosphere-supplying respirators are used to protect against tritium oxide. If the protection factor for a device is 5 the effective protection factor for tritium is about 1.4; for devices with protection factors of 10 the effective factor for tritium oxide is about 1.7, and for devices with protection factors of 100 or more the effective factor for tritium oxide is about 1.9. Air-purifying respirators are not suitable for protection against tritium oxide. See also footnote i concerning supplied-air suits.

f. Canisters and cartridges shall not be used beyond service-life limitations.

g. Under-chin type only. This type of respirator is not satisfactory for use where it might be possible (e.g., if an accident or emergency were to occur) for the ambient airborne concentrations to reach instantaneous values greater than 10 times the pertinent values in Table 1, Column 3 of Appendix B of this part. This type of respirator is not suitable for protection against plutonium or other high-toxicity materials. The mask is to be tested for fit prior to use, each time it is donned.

h.1. Equipment shall be operated in a manner that ensures that proper air flow-rates are maintained. A protection factor of no more than 1000 may be utilized for tested-and-certified supplied-air hoods when a minimum air flow of 6 cubic feet (0.17 cubic meters) per minute is maintained and calibrated airline pressure gauges or flow measuring devices are used. A protection factor of up to 2000 may be used for tested and certified hoods only when the air flow is maintained at the manufacturer's recommended maximum rate for the equipment, this rate is greater than 6 cubic feet (0.17 cubic meters) per minute, and calibrated airline pressure gauges or flow measuring devices are used.

2. The design of the supplied-air hood or helmet (with a minimum flow of 6 cfm (0.17 m^3 per minute) of air) may determine its overall efficiency and the protection it provides. For example, some hoods aspirate contaminated air into the breathing zone when the wearer works with hands-c -head. This aspiration may be overcome if a short cape-like extension to the hood is worn under a coat or overalls. Other limitations specified by the approval agency shall be considered before using a hood in certain types of atmospheres (see footnote i).

i. Appropriate protection factors shall be determined, taking into account the design of the suit and its permeability to the contaminant under conditions of use. There shall be a standby rescue person equipped with a respirator or other apparatus appropriate for the potential hazards and communications equipment whenever supplied-air suits are used.

j. No approval schedules are currently available for this equipment. Equipment is to be evaluated by testing or on the basis of reliable test information.

k. This type of respirator may provide greater protection and be used as an emergency device in unknown concentrations for protection against inhalation hazards. External radiation hazards and other limitations to permitted exposure, such as skin absorption, must be taken into account in such circumstances.

l. Quantitative fit testing shall be performed on each individual and no more than 0.02% leakage is allowed with this type of apparatus. Perceptible outward leakage of gas from this or any positive pressure self-contained breathing apparatus is unacceptable because service life will be reduced substantially. Special training in the use of this type of apparatus shall be provided to the wearer.

Note 1: Protection factors for respirators as may be approved by the U.S. Bureau of Mines/National Institute for Occupational Safety and Health (NIOSH), according to applicable approvals for respirators for type and mode of use to protect against airborne radionuclides, may be used to the extent that they do not exceed the protection factors listed in this table. The protection factors listed in this table may not be appropriate to circumstances where chemical or other respiratory hazards exist in addition to radioactive hazards. The selection and use of respirators for such circumstances should take into account applicable approvals of the U.S. Bureau of Mines/NIOSH.

Note 2: Radioactive contaminants for which the concentration values in Table 1, Column 3 of Appendix B of this part are based on internal dose due to inhalation may, in addition, present external exposure hazards at higher concentrations. Under these circumstances, limitations on occupancy may have to be governed by external dose limits.

APPENDIX B

ANNUAL LIMITS ON INTAKE (ALIs) AND DERIVED AIR CONCENTRATIONS (DACs) OF RADIONUCLIDES FOR OCCUPATIONAL EXPOSURE; EFFLUENT CONCENTRATIONS; CONCENTRATIONS FOR RELEASE TO SEWERAGE

Introduction

For each radionuclide Table 1 indicates the chemical form which is to be used for selecting the appropriate ALI or DAC value. The ALIs and DACs for inhalation are given for an aerosol with an activity median aerodynamic diameter (AMAD) of 1 μm and for three classes (D,W,Y) of radioactive material, which refer to their retention (approximately days, weeks or years) in the pulmonary region of the lung. This classification applies to a range of clearance half-times for D of less than 10 days, for W from 10 to 100 days, and for Y greater than 100 days. Table 2 provides concentration limits for airborne and liquid effluents released to the general environment. Table 3 provides concentration limits for discharges to sanitary sewer systems.

Notation

The values in Tables 1, 2, and 3 are presented in the computer "E" notation. In this notation a value of 6E-02 represents a value of 6×10^{-2} or 0.06, 6E+2 represents 6×10^{2} or 600, and 6E+0 represents 6×10^{0} or 6.

Table 1 "Occupational"

Note that the columns in Table 1 of this appendix captioned "Oral Ingestion ALI," "Inhalation ALI," and "DAC," are applicable to occupational exposure to radioactive material.

The ALIs in this appendix are the annual intakes of given radionuclide by "Reference Man" which would result in either (1) a committed effective dose equivalent of 5 rems (stochastic ALI) or (2) a committed dose equivalent of 50 rems to an organ or tissue (non-stochastic ALI). The stochastic ALIs were derived to result in a risk, due to irradiation of organs and tissues, comparable to the risk associated with deep dose equivalent to the whole body of 5 rems. The derivation includes multiplying the committed dose equivalent to an organ or tissue by a weighting factor, w_T. This weighting factor is the

proportion of the risk of stochastic effects resulting from irradiation of the organ or tissue, T, to the total risk of stochastic effects when the whole body is irradiated uniformly. The values of w_T are listed under the definition of weighting factor in § 20.3. The non-stochastic ALIs were derived to avoid non-stochastic effects, such as prompt damage to tissue or reduction in organ function.

A value of $w_T = 0.06$ is applicable to each of the five organs or tissues in the "remainder" category receiving the highest dose equivalents, and the dose equivalents of all other remaining tissues may be disregarded. The following parts of the GI tract -- stomach, small intestine, upper large intestine, and lower large intestine -- are to be treated as four separate organs.

Note that the dose equivalents for extremities (hands and forearms, feet and lower legs), skin, and lens of the eye are not considered in computing the committed effective dose equivalent, but are subject to limits that must be met separately.

When an ALI is defined by the stochastic dose limit, this value alone, is given. When an ALI is determined by the non-stochastic dose limit to an organ, the organ or tissue to which the limit applies is shown, and the ALI for the stochastic limit is shown in parentheses. (Abbreviated organ or tissue designations are used:

LLI wall = lower large intestine wall;
St. wall = stomach wall;
Blad wall = bladder wall; and
Bone surf = bone surface.)

The use of the ALIs listed first, the more limiting of the stochastic and non-stochastic ALIs, will ensure that non-stochastic effects are avoided and that the risk of stochastic effects is limited to an acceptably low value. If, in a particular situation involving a radionuclide for which the non-stochastic ALI is limiting, use of that non-stochastic ALI is considered unduly

conservative, the licensee may use the stochastic ALI to determine the committed effective dose equivalent. However, the licensee shall also ensure that the 50-rem dose equivalent limit for any organ or tissue is not exceeded by the sum of the external deep dose equivalent plus the internal committed dose to that organ (not the effective dose). For the case where there is no external dose contribution, this would be demonstrated if the sum of the fractions of the nonstochastic ALIs (ALI_{ns}) that contribute to the committed dose equivalent to the organ receiving the highest dose does not exceed unity (i.e., Σ (intake (in μCi) of each radionuclide/ALI_{ins}) $\leq$ 1.0). If there is an external deep dose equivalent contribution of H_d then this sum must be less than 1 - (H_d/50) instead of being $\leq$ 1.0.

> Note that the dose equivalents for extremities (hand and forearms, feet and lower legs), skin, and lens of the are are not considered in computing the committed effective dose equivalent, but are subject to limits that must be met separately.

The derived air concentration (DAC) values are derived limits intended to control chronic occupational exposures. The relationship between the DAC and the ALI is given by:

$$DAC = ALI(\text{in } \mu Ci)/(2000 \text{ hours per working year} \times 60 \text{ minutes/hour} \times 2 \times 10^4 \text{ ml per minute}) = [ALI/2.4 \times 10^9] \ \mu Ci/ml,$$

where 2×10^4 ml per minute is the volume of air breathed per minute at work by "Reference Man" under working conditions of "light work."

The DAC values relate to one of two modes of exposure: either external submersion or the internal committed dose equivalents resulting from inhalation of radioactive materials. Derived air concentrations based upon submersion are for immersion in a semi-infinite cloud of uniform concentration and apply to each radionuclide separately.

The ALI and DAC values relate to exposure to the single radionuclide named, but also include contributions from the in-growth of any daughter radionuclide produced in the body by the decay of the parent. However, intakes that include both the parent and daughter radionuclides should be treated by the general method appropriate for mixtures.

The value of ALI and DAC do not apply directly when the individual both ingests and inhales a radionuclide, when the individual is exposed to a mixture of radionuclides by either inhalation or ingestion or both, or when the individual is exposed to both internal and external irradiation (see § 20.202). When an individual is exposed to radioactive materials which fall under several of the translocation classifications (i.e., Class D, Class W, or Clas Y) of the same radionuclide, the exposure may be evaluated as if it were a mixture of different radionuclides.

It should be noted that the classification of a compound as Class D, W, or Y is based on the chemical form of the compound and does not take into account the radiological half-life of different radioisotopes. For this reason, values are given for Class D, W, and Y compounds, even for very short-lived radionuclides.

Table 2

The columns in Table 2 of this appendix captioned "Effluents," "Air," and "Water," are applicable to the assessment and control of dose to the public, particularly in the implementation of the provisions of § 20.302. The concentration values given in Columns 1 and 2 of Table 2 are equivalent to the radionuclide concentrations which, if inhaled or ingested continuously over the course of a year, would produce a total effective dose equivalent of 0.05 rem (50 millirem or 0.5 millisieverts)

Consideration of non-stochastic limits has not been included in deriving the air and water effluent concentration limits because non-stochastic effects are presumed not to occur at the dose levels established for individual members of the public. For radionuclides, where the non-stochastic limit was governing in deriving the occupational DAC, the stochastic ALI was used in deriving the corresponding airborne effluent limit in Table 2. For this reason, the DAC and airborne effluent limits are not always proportional as they were the previous Appendix B.

The air concentration values listed in Table 2, Column 1, were derived by one of two methods. For those radionuclides for which the stochastic limit is governing, the occupational stochastic inhalation ALI was divided by 2.4 x 10^9, relating the inhalation ALI to the DAC, as explained above, and then divided by a factor of 300. The factor of 300 includes the following components: a factor of 50 to relate the 5-rem annual occupational dose limit to the 0.1-rem limit for members of the public, a factor of 3 to adjust for the difference in exposure time and the inhalation rate for a worker and that for members of the public; and a factor of 2 to adjust the occupational values (derived for adults) so that they are applicable to other age groups.

For those radionuclides for which submersion (external dose) is limiting, the occupational DAC in Table 1, Column 3, was divided by 219. The factor of 219 is composed of a factor of 50, as described above, and a factor of 4.38 relating occupational exposure for 2,000 hours per year to full-time exposure (8,760 hours per year). Note that an additional factor of 2 for age considerations is not warranted in the submersion case.

The water concentrations were derived by taking the most restrictive occupational stochastic oral ingestion ALI and dividing by 7.3 x 10^7. The factor of 7.3 x 10^7 (ml) includes the following components: the factors of 50 and 2 described above and a factor of 7.3 x 10^5 (ml) which is the annual water intake of "Reference Man."

Note 2 of this appendix provides groupings of radionuclides which are applicable to unknown mixtures of radionuclides. These groupings (including occupational inhalation ALIs and DACs, air and water effluent concentrations and sewerage) require demonstrating that the most limiting radionuclides in successive classes are absent. The limit for the unknown mixture is defined when the presence of the one of the listed radionuclides cannot be definitely excluded as being present either from knowledge of the radionuclide composition of the source or from actual measurements.

Table 3 "Sewer Disposal"

The monthly average concentrations for release to sanitary sewers are applicable to the provisions in § 20.1003. The concentration values were derived by taking the most restrictive occupational stochastic oral ingestion ALI and dividing by 7.3×10^6(ml). The factor of 7.3×10^6(ml) is composed of a factor of 7.3×10^6(ml), the annual water intake by "Reference Man," and a factor of 10, such that the concentrations, if the sewage released by the licensee were the only source of water ingested by a reference man during a year, would result in a committed effective dose equivalent of 0.5 rem.

LIST OF ELEMENTS

Name	Symbol	Atomic Number	Name	Symbol	Atomic Number
Actinium	Ac	89	Mercury	Hg	80
Aluminum	Al	13	Molybdenum	Mo	42
Americium	Am	95	Neodymium	Nd	60
Antimony	Sb	51	Neptunium	Np	93
Argon	Ar	18	Nickel	Ni	28
Arsenic	As	33	Niobium	Nb	41
Astatine	At	85	Osmium	Os	76
Barium	Ba	56	Palladium	Pd	46
Berkelium	Bk	97	Phosphorus	P	15
Beryllium	Be	4	Platinum	Pt	78
Bismuth	Bi	83	Plutonium	Pu	94
Bromine	Br	35	Polonium	Po	84
Cadmium	Cd	48	Potassium	K	19
Calcium	Ca	20	Praseodymium	Pr	59
Californium	Cf	98	Promethium	Pm	61
Carbon	C	6	Protactinium	Pa	91
Cerium	Ce	58	Radium	Ra	88
Cesium	Cs	55	Radon	Rn	86
Chlorine	Cl	17	Rhenium	Re	75
Chromium	Cr	24	Rhodium	Rh	45
Cobalt	Co	27	Rubidium	Rb	37
Copper	Cu	29	Ruthenium	Ru	44
Curium	Cm	96	Samarium	Sm	62
Dysprosium	Dy	66	Scandium	Sc	21
Einsteinium	Es	99	Selenium	Se	34
Erbium	Er	68	Silicon	Si	14
Europium	Eu	63	Silver	Ag	47
Fermium	Fm	100	Sodium	Na	11
Fluorine	F	9	Strontium	Sr	38
Francium	Fr	87	Sulfur	S	16
Gadolinium	Gd	64	Tantalum	Ta	73
Gallium	Ga	31	Technetium	Tc	43
Germanium	Ge	32	Tellurium	Te	52
Gold	Au	79	Terbium	Tb	65
Hafnium	Hf	72	Thallium	Tl	81
Holmium	Ho	67	Thorium	Th	90
Hydrogen	H	1	Thulium	Tm	69
Indium	In	49	Tin	Sn	50
Iodine	I	53	Titanium	Ti	22
Iridium	Ir	77	Tungsten	W	74
Iron	Fe	26	Uranium	U	92
Krypton	Kr	36	Vanadium	V	23
Lanthanum	La	57	Xenon	Xe	54
Lead	Pb	82	Ytterbium	Yb	70
Lutetium	Lu	71	Yttrium	Y	39
Magnesium	Mg	12	Zinc	Zn	30
Manganese	Mn	25	Zirconium	Zr	40
Mendelevium	Md	101			

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
1	Hydrogen-3	Water, DAC includes skin absorption	8E+4	8E+4	2E-5	1E-7	1E-3	1E-2
		Gas (HT or T_2), Submersion[1]	Use above Values as HT and T_2 oxidize in air and in the body to HTO.					
4	Beryllium-7	W, all compounds except those given for Y	4E+4	2E+4	9E-6	3E-8	6E-4	6E-3
		Y, oxides, halides, and nitrates	-	2E+4	8E-6	3E-8	-	-
4	Beryllium-10	W, see ^{7}Be	1E+3	2E+2	6E-8	2E-10	-	-
			LLI wall (1E+3)	-	-	-	2E-5	2E-4
		Y, see ^{7}Be	-	1E+1	6E-9	2E-11	-	-
6	Carbon-11[2]	Monoxide	-	1E+6	5E-4	2E-6	-	-
		Dioxide	-	6E+5	3E-4	9E-7	-	-
		Compounds	4E+5	4E+5	2E-4	6E-7	6E-3	6E-2
6	Carbon-14	Monoxide	-	2E+6	7E-4	2E-6	-	-
		Dioxide	-	2E+5	9E-5	3E-7	-	-
		Compounds	2E+3	2E+3	1E-6	3E-9	3E-5	3E-4

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
9	Fluorine-18[2]	D, fluorides of H, Li, Na, K, Rb, Cs, and Fr	5E+4 St,wall (5E+4)	7E+4	3E-5	1E-7	-	-
				-	-	-	7E-4	7E-3
		W, fluorides of Be, Mg, Ca, Sr, Ba, Ra, Al, Ga, In, Tl, As, Sb, Bi, Fe, Ru, Os, Co, Ni, Pd, Pt, Cu, Ag, Au, Zn, Cd, Hg, Sc, Y, Ti, Zr, V, Nb, Ta, Mn, Tc, and Re	-	9E+4	4E-5	1E-7	-	-
		Y, lanthanum fluoride	-	8E+4	3E-5	1E-7	-	-
11	Sodium-22	D, all compounds	4E+2	6E+2	3E-7	9E-10	6E-6	6E-5
11	Sodium-24	D, all compounds	4E+3	5E+3	2E-6	7E-9	5E-5	5E-4
12	Magnesium-28	D, all compounds except those given for W	7E+2	2E+3	7E-7	2E-9	9E-6	9E-5
		W, oxides, hydroxides, carbides, halides, and nitrates	-	1E+3	5E-7	2E-9	-	-
13	Aluminum-26	D, all compounds except those given for W	4E+2	6E+1	3E-8	9E-11	6E-6	6E-5
		W, oxides, hydroxides, carbides, halides, and nitrates	-	9E+1	4E-8	1E-10	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
14	Silicon-31	D, all compounds except those given for W and Y	9E+3	3E+4	1E-5	4E-8	1E-4	1E-3
		W, oxides, hydroxides, carbides, and nitrates	-	3E+4	1E-5	5E-8	-	-
		Y, aluminosilicate glass	-	3E+4	1E-5	4E-8	-	-
14	Silicon-32	D, see ^{31}Si	2E+3	2E+2	1E-7	3E-10	-	-
			LLI wall (3E+3)	-	-	-	4E-5	4E-4
		W, see ^{31}Si	-	1E+2	5E-8	2E-10	-	-
		Y, see ^{31}Si	-	5E+0	2E-9	7E-12	-	-
15	Phosphorus-32	D, all compounds except phosphates given for W	6E+2	9E+2	4E-7	1E-9	9E-6	9E-5
		W, phosphates of Zn^{2+}, S^{3+}, Mg^{2+}, Fe^{3+}, Bi^{3+}, and lanthanides	-	4E+2	2E-7	5E-10	-	-
15	Phosphorus-33	D, see ^{32}P	6E+3	8E+3	4E-6	1E-8	8E-5	8E-4
		W, see ^{32}P	-	3E+3	1E-6	4E-9	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
16	Sulfur-35	Vapor	-	1E+4	6E-6	2E-8	-	-
		D, sulfides and sulfates except those given for W	6E+3	2E+4	7E-6	2E-8	-	-
			LLI wall (8E+3)	-	-	-	1E-4	1E-3
		W, elemental sulfur, sulfides of Sr, Ba, Ge, Sn, Pb, As, Sb, Bi, Cu, Ag, Au, Zn, Cd, Hg, W, and Mo. Sulfates of Ca, Sr, Ba, Ra, As, Sb, and Bi	-	2E+3	9E-7	3E-9	-	-
17	Chlorine-36	D, chlorides of H, Li, Na, K, Rb, Cs, and Fr	2E+3	2E+3	1E-6	3E-9	2E-5	2E-4
		W, chlorides of lanthanides, Be, Mg, Ca, Sr, Ba, Ra, Al, Ga, In, Tl, Ge, Sn, Pb, As, Sb, Bi, Fe, Ru, Os, Co, Rh, Ir, Ni, Pd, Pt, Cu, Ag, Au, Zn, Cd, Hg, Sc, Y, Ti, Zr, Hf, V, Nb, Ta, Cr, Mo, W, Mn, Tc, and Re	-	2E+2	1E-7	3E-10	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
17	Chlorine-38[2]	D, see ^{36}Cl	2E+4	4E+4	2E-5	6E-8	-	-
			St. wall (3E+4)	-	-	-	3E-4	3E-3
		W, see ^{36}Cl	-	5E+4	2E-5	6E-8	-	-
17	Chlorine-39[2]	D, see ^{36}Cl	2E+4	5E+4	2E-5	7E-8	-	-
			St. wall (4E+4)	-	-	-	5E-4	5E-3
		W, see ^{36}Cl	-	6E+4	2E-5	8E-8	-	-
18	Argon-37	Submersion[1]	-	-	1E+0	6E-3	-	-
18	Argon-39	Submersion[1]	-	-	2E-4	8E-7	-	-
18	Argon-41	Submersion[1]	-	-	3E-6	1E-8	-	-
19	Potassium-40	D, all compounds	3E+2	4E+2	2E-7	6E-10	4E-6	4E-5
19	Potassium-42	D, all compounds	5E+3	5E+3	2E-6	7E-9	6E-5	6E-4
19	Potassium-43	D, all compounds	6E+3	9E+3	4E-6	1E-8	9E-5	9E-4
19	Potassium-44[2]	D, all compounds	2E+4	7E+4	3E-5	9E-8	-	-
			St. wall (4E+4)	-	-	-	5E-4	5E-3
19	Potassium-45[2]	D, all compounds	3E+4	1E+5	5E-5	2E-7	-	-
			St. wall (5E+4)	-	-	-	7E-4	7E-3

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
20	Calcium-41	W, all compounds	3E+3	4E+3	2E-6	-	-	-
			Bone surf (4E+3)	Bone surf (4E+3)	-	5E-9	6E-5	6E-4
20	Calcium-45	W, all compounds	2E+3	8E+2	4E-7	1E-9	2E-5	2E-4
20	Calcium-47	W, all compounds	8E+2	9E+2	4E-7	1E-9	1E-5	1E-4
21	Scandium-43	Y, all compounds	7E+3	2E+4	9E-6	3E-8	1E-4	1E-3
21	Scandium-44m	Y, all compounds	5E+2	7E+2	3E-7	1E-9	7E-6	7E-5
21	Scandium-44	Y, all compounds	4E+3	1E+4	5E-6	2E-8	5E-5	5E-4
21	Scandium-46	Y, all compounds	9E+2	2E+2	1E-7	3E-10	1E-5	1E-4
21	Scandium-47	Y, all compounds	2E+3	3E+3	1E-6	4E-9	-	-
			LLI wall (3E+3)	-	-	-	4E-5	4E-4
21	Scandium-48	Y, all compounds	8E+2	1E+3	6E-7	2E-9	1E-5	1E-4
21	Scandium-49[2]	Y, all compounds	2E+4	5E+4	2E-5	8E-8	3E-4	3E-3
22	Titanium-44	D, all compounds except those given for W and Y	3E+2	1E+1	5E-9	2E-11	4E-6	4E-5
		W, oxides, hydroxides, carbides, halides, and nitrates	-	3E+1	1E-8	4E-11	-	-
		Y, $SrTiO_3$	-	6E+0	2E-9	8E-12	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
22	Titanium-45	D, see ^{44}Ti	9E+3	3E+4	1E-5	3E-8	1E-4	1E-3
		W, see ^{44}Ti	-	4E+4	1E-5	5E-8	-	-
		Y, see ^{44}Ti	-	3E+4	1E-5	4E-8	-	-
23	Vanadium-47[2]	D, all compounds except those given for W	3E+4	8E+4	3E-5	1E-7	-	-
			St. wall (3E+4)	-	-	-	4E-4	4E-3
		W, oxides, hydroxides, carbides, and halides	-	1E+5	4E-5	1E-7	-	-
23	Vanadium-48	D, see ^{47}V	6E+2	1E+3	5E-7	2E-9	9E-6	9E-5
		W, see ^{47}V	-	6E+2	3E-7	9E-10	-	-
23	Vanadium-49	D, see ^{47}V	7E+4	3E+4	1E-5	-	-	-
			LLI wall (9E+4)	Bone surf (3E+4)	-	5E-8	1E-3	1E-2
		W, see ^{47}V	-	2E+4	8E-6	2E-8	-	-
24	Chromium-48	D, all compounds except those given for W and Y	6E+3	1E+4	5E-6	2E-8	8E-5	8E-4
		W, halides and nitrates	-	7E+3	3E-6	1E-8	-	-
		Y, oxides and hydroxides	-	7E+3	3E-6	1E-8	-	-
24	Chromium-49[2]	D, see ^{48}Cr	3E+4	8E+4	4E-5	1E-7	4E-4	4E-3
		W, see ^{48}Cr	-	1E+5	4E-5	1E-7	-	-
		Y, see ^{48}Cr	-	9E+4	4E-5	1E-7	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
24	Chromium-51	D, see ^{48}Cr	4E+4	5E+4	2E-5	6E-8	5E-4	5E-3
		W, see ^{48}Cr	-	2E+4	1E-5	3E-8	-	-
		Y, see ^{48}Cr	-	2E+4	8E-6	3E-8	-	-
25	Manganese-51[2]	D, all compounds except those given for W	2E+4	5E+4	2E-5	7E-8	3E-4	3E-3
		W, oxides, hydroxides, halides, and nitrates	-	6E+4	3E-5	8E-8	-	-
25	Manganese-52m[2]	D, see ^{51}Mn	3E+4 St. wall (4E+4)	9E+4 -	4E-5 -	1E-7 -	- 5E-4	- 5E-3
		W, see ^{51}Mn	-	1E+5	4E-5	1E-7	-	-
25	Manganese-52	D, see ^{51}Mn	7E+2	1E+3	5E-7	2E-9	1E-5	1E-4
		W, see ^{51}Mn	-	9E+2	4E-7	1E-9	-	-
25	Manganese-53	D, see ^{51}Mn	5E+4	1E+4 Bone surf	5E-6	-	7E-4	7E-3
		W, see ^{51}Mn	- -	(2E+4) 1E+4	- 5E-6	3E-8 2E-8	- -	- -
25	Manganese-54	D, see ^{51}Mn	2E+3	9E+2	4E-7	1E-9	3E-5	3E-4
		W, see ^{51}Mn	-	8E+2	3E-7	1E-9	-	-
25	Manganese-56	D, see ^{51}Mn	5E+3	2E+4	6E-6	2E-8	7E-5	7E-4
		W, see ^{51}Mn	-	2E+4	9E-6	3E-8	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
26	Iron-52	D, all compounds except those given for W	9E+2	3E+3	1E-6	4E-9	1E-5	1E-4
		W, oxides, hydroxides, and halides	-	2E+3	1E-6	3E-9	-	-
26	Iron-55	D, see ^{52}Fe	9E+3	2E+3	8E-7	3E-9	1E-4	1E-3
		W, see ^{52}Fe	-	4E+3	2E-6	6E-9	-	-
26	Iron-59	D, see ^{52}Fe	8E+2	3E+2	1E-7	5E-10	1E-5	1E-4
		W, see ^{52}Fe	-	5E+2	2E-7	7E-10	-	-
26	Iron-60	D, see ^{52}Fe	3E+1	6E+0	3E-9	9E-12	4E-7	4E-6
		W, see ^{52}Fe	-	2E+1	8E-9	3E-11	-	-
27	Cobalt-55	W, all compounds except those given for Y	1E+3	3E+3	1E-6	4E-9	2E-5	2E-4
		Y, oxides, hydroxides, halides, and nitrates	-	3E+3	1E-6	4E-9	-	-
27	Cobalt-56	W, see ^{55}Co	4E+2	3E+2	1E-7	4E-10	6E-6	6E-5
		Y, see ^{55}Co	-	2E+2	8E-8	3E-10	-	-
27	Cobalt-57	W, see ^{55}Co	4E+3	3E+3	1E-6	4E-9	6E-5	6E-4
		Y, see ^{55}Co	-	7E+2	3E-7	9E-10	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
27	Cobalt-58m	W, see ^{55}Co	6E+4	9E+4	4E-5	1E-7	8E-4	8E-3
		Y, see ^{55}Co	-	6E+4	3E-5	9E-8	-	-
27	Cobalt-58	W, see ^{55}Co	1E+3	1E+3	5E-7	2E-9	2E-5	2E-4
		Y, see ^{55}Co	-	7E+2	3E-7	1E-9	-	-
27	Cobalt-60m[2]	W, see ^{55}Co	1E+6	1E+6	2E-3	6E-6	-	-
			St. wall (1E+6)	-	-	-	2E-2	2E-1
		Y, see ^{55}Co	-	3E+6	1E-3	4E-6	-	-
27	Cobalt-60	W, see ^{55}Co	2E+2	2E+2	7E-8	2E-10	3E-6	3E-5
		Y, see ^{55}Co	-	3E+1	1E-8	5E-11	-	-
27	Cobalt-61[2]	W, see ^{55}Co	2E+4	6E+4	3E-5	9E-8	3E-4	3E-3
		Y, see ^{55}Co	-	6E+4	2E-5	8E-8	-	-
27	Cobalt-62m[2]	W, see ^{55}Co	4E+4	2E+5	7E-5	2E-7	-	-
			St. wall (5E+4)	-	-	-	7E-4	7E-3
		Y, see ^{55}Co	-	2E+5	6E-5	2E-7	-	-
28	Nickel-56	D, all compounds except those given for W	1E+3	2E+3	8E-7	3E-9	2E-5	2E-4
		W, oxides, hydroxides, and carbides	-	1E+3	5E-7	2E-9	-	-
		Vapor	-	1E+3	5E-7	2E-9	-	-
28	Nickel-57	D, see ^{56}Ni	2E+3	5E+3	2E-6	7E-9	2E-5	2E-4
		W, see ^{56}Ni	-	3E+3	1E-6	4E-9	-	-
		Vapor	-	6E+3	3E-6	9E-9	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
28	Nickel-59	D, see ^{56}Ni	2E+4	4E+3	2E-6	5E-9	3E-4	3E-3
		W, see ^{56}Ni	-	7E+3	3E-6	1E-8	-	-
		Vapor	-	2E+3	8E-7	3E-9	-	-
28	Nickel-63	D, see ^{56}Ni	9E+3	2E+3	7E-7	2E-9	1E-4	1E-3
		W, see ^{56}Ni	-	3E+3	1E-6	4E-9	-	-
		Vapor	-	8E+2	3E-7	1E-9	-	-
28	Nickel-65	D, see ^{56}Ni	8E+3	2E+4	1E-5	3E-8	1E-4	1E-3
		W, see ^{56}Ni	-	3E+4	1E-5	4E-8	-	-
		Vapor	-	2E+4	7E-6	2E-8	-	-
28	Nickel-66	D, see ^{56}Ni	4E+2	2E+3	7E-7	2E-9	-	-
			LLI wall (5E+2)	-	-	-	6E-6	6E-5
		W, see ^{56}Ni	-	6E+2	3E-7	9E-10	-	-
		Vapor	-	3E+3	1E-6	4E-9	-	-
29	Copper-60[2]	D, all compounds except those given for W and Y	3E+4	9E+4	4E-5	1E-7	-	-
			St. wall (3E+4)	-	-	-	4E-4	4E-3
		W, sulfides, halides, and nitrates	-	1E+5	5E-5	2E-7	-	-
		Y, oxides and hydroxides	-	1E+5	4E-5	1E-7	-	-
29	Copper-61	D, see ^{60}Cu	1E+4	3E+4	1E-5	4E-8	2E-4	2E-3
		W, see ^{60}Cu	-	4E+4	2E-5	6E-8	-	-
		Y, see ^{60}Cu	-	4E+4	1E-5	5E-8	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
29	Copper-64	D, see ^{60}Cu	1E+4	3E+4	1E-5	4E-8	2E-4	2E-3
		W, see ^{60}Cu	-	2E+4	1E-5	3E-8	-	-
		Y, see ^{60}Cu	-	2E+4	9E-6	3E-8	-	-
29	Copper-67	D, see ^{60}Cu	5E+3	8E+3	3E-6	1E-8	6E-5	6E-4
		W, see ^{60}Cu	-	5E+3	2E-6	7E-9	-	-
		Y, see ^{60}Cu	-	5E+3	2E-6	6E-9	-	-
30	Zinc-62	Y, all compounds	1E+3	3E+3	1E-6	4E-9	2E-5	2E-4
30	Zinc-63[2]	Y, all compounds	2E+4	7E+4	3E-5	9E-8	-	-
			St. wall (3E+4)	-	-	-	3E-4	3E-3
30	Zinc-65	Y, all compounds	4E+2	3E+2	1E-7	4E-10	5E-6	5E-5
30	Zinc-69m	Y, all compounds	4E+3	7E+3	3E-6	1E-8	6E-5	6E-4
30	Zinc-69[2]	Y, all compounds	6E+4	1E+5	6E-5	2E-7	8E-4	8E-3
30	Zinc-71m	Y, all compounds	6E+3	2E+4	7E-6	2E-8	8E-5	8E-4
30	Zinc-72	Y, all compounds	1E+3	1E+3	5E-7	2E-9	1E-5	1E-4
31	Gallium-65[2]	D, all compounds except those given for W	5E+4	2E+5	7E-5	2E-7	-	-
			St. wall (6E+4)	-	-	-	9E-4	9E-3
		W, oxides, hydroxides, carbides, halides, and nitrates	-	2E+5	8E-5	3E-7	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
31	Gallium-66	D, see ^{65}Ga	1E+3	4E+3	1E-6	5E-9	1E-5	1E-4
		W, see ^{65}Ga	-	3E+3	1E-6	4E-9	-	-
31	Gallium-67	D, see ^{65}Ga	7E+3	1E+4	6E-6	2E-8	1E-4	1E-3
		W, see ^{65}Ga	-	1E+4	4E-6	1E-8	-	-
31	Gallium-68[2]	D, see ^{65}Ga	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{65}Ga	-	5E+4	2E-5	7E-8	-	-
31	Gallium-70[2]	D, see ^{65}Ga	5E+4 St. wall (7E+4)	2E+5	7E-5	2E-7	-	-
		W, see ^{65}Ga	-	2E+5	8E-5	3E-7	1E-3	1E-2
31	Gallium-72	D, see ^{65}Ga	1E+3	4E+3	1E-6	5E-9	2E-5	2E-4
		W, see ^{65}Ga	-	3E+3	1E-6	4E-9	-	-
31	Gallium-73	D, see ^{65}Ga	5E+3	2E+4	6E-6	2E-8	7E-5	7E-4
		W, see ^{65}Ga	-	2E+4	6E-6	2E-8	-	-
32	Germanium-66	D, all compounds except those given for W	2E+4	3E+4	1E-5	4E-8	3E-4	3E-3
		W, oxides, sulfides, and halides	-	2E+4	8E-6	3E-8	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
32	Germanium-67[2]	D, see ^{66}Ge	3E+4	9E+4	4E-5	1E-7	-	-
			St. wall (4E+4)	-	-	-	6E-4	6E-3
		W, see ^{66}Ge	-	1E+5	4E-5	1E-7	-	-
32	Germanium-68	D, see ^{66}Ge	5E+3	4E+3	2E-6	5E-9	6E-5	6E-4
		W, see ^{66}Ge	-	1E+2	4E-8	1E-10	-	-
32	Germanium-69	D, see ^{66}Ge	1E+4	2E+4	6E-6	2E-8	2E-4	2E-3
		W, see ^{66}Ge	-	8E+3	3E-6	1E-8	-	-
32	Germanium-71	D, see ^{66}Ge	5E+5	4E+5	2E-4	6E-7	7E-3	7E-2
		W, see ^{66}Ge	-	4E+4	2E-5	6E-8	-	-
32	Germanium-75[2]	D, see ^{66}Ge	4E+4	8E+4	3E-5	1E-7	-	-
			St. wall (7E+4)	-	-	-	9E-4	9E-3
		W, see ^{66}Ge	-	8E+4	4E-5	1E-7	-	-
32	Germanium-77	D, see ^{66}Ge	9E+3	1E+4	4E-6	1E-8	1E-4	1E-3
		W, see ^{66}Ge	-	6E+3	2E-6	8E-9	-	-
32	Germanium-78[2]	D, see ^{66}Ge	2E+4	2E+4	9E-6	3E-8	-	-
			St. wall (2E+4)	-	-	-	3E-4	3E-3
		W, see ^{66}Ge	-	2E+4	9E-6	3E-8	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
33	Arsenic-69[2]	W, all compounds	3E+4	1E+5	5E-5	2E-7	-	-
			St. wall (4E+4)	-	-	-	6E-4	6E-3
33	Arsenic-70[2]	W, all compounds	1E+4	5E+4	2E-5	7E-8	2E-4	2E-3
33	Arsenic-71	W, all compounds	4E+3	5E+3	2E-6	6E-9	5E-5	5E-4
33	Arsenic-72	W, all compounds	9E+2	1E+3	6E-7	2E-9	1E-5	1E-4
33	Arsenic-73	W, all compounds	8E+3	2E+3	7E-7	2E-9	1E-4	1E-3
33	Arsenic-74	W, all compounds	1E+3	8E+2	3E-7	1E-9	2E-5	2E-4
33	Arsenic-76	W, all compounds	1E+3	1E+3	6E-7	2E-9	1E-5	1E-4
33	Arsenic-77	W, all compounds	4E+3	5E+3	2E-6	7E-9	-	-
			LLI wall (5E+3)	-	-	-	6E-5	6E-4
33	Arsenic-78[2]	W, all compounds	8E+3	2E+4	9E-6	3E-8	1E-4	1E-3
34	Selenium-70[2]	D, all compounds except those given for W	1E+4	4E+4	2E-5	5E-8	1E-4	1E-3
		W, oxides, hydroxides, carbides, and elemental Se	-	4E+4	2E-5	6E-8	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
34	Selenium-73m[2]	D, see ^{70}Se	3E+4	2E+5	6E-5	2E-7	4E-4	4E-3
		W, see ^{70}Se	-	1E+5	6E-5	2E-7	-	-
34	Selenium-73	D, see ^{70}Se	3E+3	1E+4	5E-6	2E-8	4E-5	4E-4
		W, see ^{70}Se	-	2E+4	7E-6	2E-8	-	-
34	Selenium-75	D, see ^{70}Se	5E+2	7E+2	3E-7	1E-9	7E-6	7E-5
		W, see ^{70}Se	-	6E+2	3E-7	8E-10	-	-
34	Selenium-79	D, see ^{70}Se	6E+2	8E+2	3E-7	1E-9	8E-6	8E-5
		W, see ^{70}Se	-	6E+2	2E-7	8E-10	-	-
34	Selenium-81m[2]	D, see ^{70}Se	2E+4	7E+4	3E-5	9E-8	3E-4	3E-3
		W, see ^{70}Se	-	7E+4	3E-5	1E-7	-	-
34	Selenium-81[2]	D, see ^{70}Se	6E+4 St. wall (8E+4)	2E+5	9E-5	3E-7	-	-
				-	-	-	1E-3	1E-2
		W, see ^{70}Se	-	2E+5	1E-4	3E-7	-	-
34	Selenium-83[2]	D, see ^{70}Se	3E+4	1E+5	5E-5	2E-7	4E-4	4E-3
		W, see ^{70}Se	-	1E+5	5E-5	2E-7	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
35	Bromine-74m[2]	D, bromides of H, Li, Na, K, Rb, Cs, and Fr	1E+4	4E+4	2E-5	5E-8	-	-
			St. wall (2E+4)	-	-	-	3E-4	3E-3
		W, bromides of lanthanides, Be, Mg, Ca, Sr, Ba, Ra, Al, Ga, In, Tl, Ge, Sn, Pb, As, Sb, Bi, Fe, Ru, Os, Co, Rh, Ir, Ni, Pd, Pt, Cu, Ag, Au, Zn, Cd, Hg, Sc, Y, Ti, Zr, Hf, V, Nb, Ta, Mn, Tc, and Re	-	4E+4	2E-5	6E-8	-	-
35	Bromine-74[2]	D, see ^{74m}Br	2E+4	7E+4	3E-5	1E-7	-	-
			St. wall (4E+4)	-	-	-	5E-4	5E-3
		W, see ^{74m}Br	-	8E+4	4E-5	1E-7	-	-
35	Bromine-75[2]	D, see ^{74m}Br	3E+4	5E+4	2E-5	7E-8	-	-
			St. wall (4E+4)	-	-	-	5E-4	5E-3
		W, see ^{74m}Br	-	5E+4	2E-5	7E-8	-	-
35	Bromine-76	D, see ^{74m}Br	4E+3	5E+3	2E-6	7E-9	5E-5	5E-4
		W, see ^{74m}Br	-	4E+3	2E-6	6E-9	-	-
35	Bromine-77	D, see ^{74m}Br	2E+4	2E+4	1E-5	3E-8	2E-4	2E-3
		W, see ^{74m}Br	-	2E+4	8E-6	3E-8	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
35	Bromine-80m	D, see ^{74m}Br	2E+4	2E+4	7E-6	2E-8	3E-4	3E-3
		W, see ^{74m}Br	-	1E+4	6E-6	2E-8	-	-
35	Bromine-80[2]	D, see ^{74m}Br	5E+4	2E+5	8E-5	3E-7	-	-
			St. wall (9E+4)	-	-	-	1E-3	1E-2
		W, see ^{74m}Br	-	2E+5	9E-5	3E-7	-	-
35	Bromine-82	D, see ^{74m}Br	3E+3	4E+3	2E-6	6E-9	4E-5	4E-4
		W, see ^{74m}Br	-	4E+3	2E-6	5E-9	-	-
35	Bromine-83	D, see ^{74m}Br	5E+4	6E+4	3E-5	9E-8	-	-
			St. wall (7E+4)	-	-	-	9E-4	9E-3
		W, see ^{74m}Br	-	6E+4	3E-5	9E-8	-	-
35	Bromine-84[2]	D, see ^{74m}Br	2E+4	6E+4	2E-5	8E-8	-	-
			St. wall (3E+4)	-	-	-	4E-4	4E-3
		W, see ^{74m}Br	-	6E+4	3E-5	9E-8	-	-
36	Krypton-74[2]	Submersion[1]	-	-	3E-6	1E-8	-	-
36	Krypton-76	Submersion[1]	-	-	9E-6	4E-8	-	-
36	Krypton-77[2]	Submersion[1]	-	-	4E-6	2E-8	-	-
36	Krypton-79	Submersion[1]	-	-	2E-5	7E-8	-	-
36	Krypton-81	Submersion[1]	-	-	7E-4	3E-6	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
36	Krypton-83m[2]	Submersion[1]	-	-	1E-2	5E-5	-	-
36	Krypton-85m	Submersion[1]	-	-	2E-5	1E-7	-	-
36	Krypton-85	Submersion[1]	-	-	1E-4	7E-7	-	-
36	Krypton-87[2]	Submersion[1]	-	-	5E-6	2E-8	-	-
36	Krypton-88	Submersion[1]	-	-	2E-6	9E-9	-	-
37	Rubidium-79[2]	D, all compounds	4E+4	1E+5	5E-5	2E-7	-	-
			St. wall (6E+4)	-	-	-	8E-4	8E-3
37	Rubidium-81m[2]	D, all compounds	2E+5	3E+5	1E-4	5E-7	-	-
			St. wall (3E+5)	-	-	-	4E-3	4E-2
37	Rubidium-81	D, all compounds	4E+4	5E+4	2E-5	7E-8	5E-4	5E-3
37	Rubidium-82m	D, all compounds	1E+4	2E+4	7E-6	2E-8	2E-4	2E-3
37	Rubidium-83	D, all compounds	6E+2	1E+3	4E-7	1E-9	9E-6	9E-5
37	Rubidium-84	D, all compounds	5E+2	8E+2	3E-7	1E-9	7E-6	7E-5
37	Rubidium-86	D, all compounds	5E+2	8E+2	3E-7	1E-9	7E-6	7E-5
37	Rubidium-87	D, all compounds	1E+3	2E+3		2E-9	1E-5	1E-4

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
37	Rubidium-88[2]	D, all compounds	2E+4	6E+4	3E-5	9E-8	-	-
			St. wall (3E+4)	-	-	-	4E-4	4E-3
37	Rubidium-89[2]	D, all compounds	4E+4	1E+5	6E-5	2E-7	-	-
			St. wall (6E+4)	-	-	-	9E-4	9E-3
38	Strontium-80[2]	D, all soluble compounds except $SrTiO_3$	4E+3	1E+4	5E-6	2E-8	6E-5	6E-4
		Y, all insoluble compounds and $SrTiO_3$	-	1E+4	5E-6	2E-8	-	-
38	Strontium-81[2]	D, see ^{80}Sr	2E+4	8E+4	3E-5	1E-7	3E-4	3E-3
		Y, see ^{80}Sr	-	8E+4	3E-5	1E-7	-	-
38	Strontium-82	D, see ^{80}Sr	2E+2	4E+2	2E-7	6E-10	-	-
			LLI wall (2E+2)	-	-	-	3E-6	3E-5
		Y, see ^{80}Sr	-	9E+1	4E-8	1E-10	-	-
38	Strontium-83	D, see ^{80}Sr	2E+3	7E+3	3E-6	1E-8	3E-5	3E-4
		Y, see ^{80}Sr	-	4E+3	1E-6	5E-9	-	-
38	Strontium-85m[2]	D, see ^{80}Sr	2E+5	6E+5	3E-4	9E-7	3E-3	3E-2
		Y, see ^{80}Sr	-	8E+5	4E-4	1E-6	-	-
38	Strontium-85	D, see ^{80}Sr	3E+3	3E+3	1E-6	4E-9	4E-5	4E-4
		Y, see ^{80}Sr	-	2E+3	6E-7	2E-9	-	-
38	Strontium-87m	D, see ^{80}Sr	4E+4	1E+5	5E-5	2E-7	6E-4	6E-3
		Y, see ^{80}Sr	-	2E+5	6E-5	2E-7	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
38	Strontium-89	D, see ^{80}Sr	5E+2	8E+2	4E-7	1E-9	-	-
			LLI wall (6E+2)	-	-	-	8E-6	8E-5
		Y, see ^{80}Sr	-	1E+2	6E-8	2E-10	-	-
38	Strontium-90	D, see ^{80}Sr	3E+1	2E+1	8E-9	-	-	-
			Bone surf (4E+1)	Bone surf (2E+1)	-	3E-11	5E-7	5E-6
		Y, see ^{80}Sr	-	4E+0	2E-9	6E-12	-	-
38	Strontium-91	D, see ^{80}Sr	2E+3	6E+3	2E-6	8E-9	2E-5	2E-4
		Y, see ^{80}Sr	-	4E+3	1E-6	5E-9	-	-
38	Strontium-92	D, see ^{80}Sr	3E+3	9E+3	4E-6	1E-8	4E-5	4E-4
		Y, see ^{80}Sr	-	7E+3	3E-6	9E-9	-	-
39	Yttrium-86m[2]	W, all compounds except those given for Y	2E+4	6E+4	2E-5	8E-8	3E-4	3E-3
		Y, oxides and hydroxides	-	5E+4	2E-5	8E-8	-	-
39	Yttrium-86	W, see ^{86m}Y	1E+3	3E+3	1E-6	5E-9	2E-5	2E-4
		Y, see ^{86m}Y	-	3E+3	1E-6	5E-9	-	-
39	Yttrium-87	W, see ^{86m}Y	2E+3	3E+3	1E-6	5E-9	3E-5	3E-4
		Y, see ^{86m}Y	-	3E+3	1E-6	5E-9	-	-
39	Yttrium-88	W, see ^{86m}Y	1E+3	3E+2	1E-7	3E-10	1E-5	1E-4
		Y, see ^{86m}Y	-	2E+2	1E-7	3E-10	-	-
39	Yttrium-90m	W, see ^{86m}Y	8E+3	1E+4	5E-6	2E-8	1E-4	1E-3
		Y, see ^{86m}Y	-	1E+4	5E-6	2E-8	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
39	Yttrium-90	W, see ^{86m}Y	4E+2	7E+2	3E-7	9E-10	-	-
			LLI wall (5E+2)	-	-	-	7E-6	7E-5
		Y, see ^{86m}Y	-	6E+2	3E-7	9E-10	-	-
39	Yttrium-91m[2]	W, see ^{86m}Y	1E+5	2E+5	1E-4	3E-7	2E-3	2E-2
		Y, see ^{86m}Y	-	2E+5	7E-5	2E-7	-	-
39	Yttrium-91	W, see ^{86m}Y	5E+2	2E+2	7E-8	2E-10	-	-
			LLI wall (6E+2)	-	-	-	8E-6	8E-5
		Y, see ^{86m}Y	-	1E+2	5E-8	2E-10	-	-
39	Yttrium-92	W, see ^{86m}Y	3E+3	9E+3	4E-6	1E-8	4E-5	4E-4
		Y, see ^{86m}Y	-	8E+3	3E-6	1E-8	-	-
39	Yttrium-93	W, see ^{86m}Y	1E+3	3E+3	1E-6	4E-9	2E-5	2E-4
		Y, see ^{86m}Y	-	2E+3	1E-6	3E-9	-	-
39	Yttrium-94[2]	W, see ^{86m}Y	2E+4	8E+4	3E-5	1E-7	-	-
			St. wall (3E+4)	-	-	-	4E-4	4E-3
		Y, see ^{86m}Y	-	8E+4	3E-5	1E-7	-	-
39	Yttrium-95[2]	W, see ^{86m}Y	4E+4	2E+5	6E-5	2E-7	-	-
			St. wall (5E+4)	-	-	-	7E-4	7E-3
		Y, see ^{86m}Y	-	1E+5	6E-5	2E-7	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
40	Zirconium-86	D, all compounds except those given for W and Y	1E+3	4E+3	2E-6	6E-9	2E-5	2E-4
		W, oxides, hydroxides, halides, and nitrates	-	3E+3	1E-6	4E-9	-	-
		Y, carbide	-	2E+3	1E-6	3E-9	-	-
40	Zirconium-88	D, see ^{86}Zr	4E+3	2E+2	9E-8	3E-10	5E-5	5E-4
		W, see ^{86}Zr	-	5E+2	2E-7	7E-10	-	-
		Y, see ^{86}Zr	-	3E+2	1E-7	4E-10	-	-
40	Zirconium-89	D, see ^{86}Zr	2E+3	4E+3	1E-6	5E-9	2E-5	2E-4
		W, see ^{86}Zr	-	2E+3	1E-6	3E-9	-	-
		Y, see ^{86}Zr	-	2E+3	1E-6	3E-9	-	-
40	Zirconium-93	D, see ^{86}Zr	1E+3	6E+0	3E-9	-	-	-
			Bone surf (3E+3)	Bone surf (2E+1)	-	2E-11	4E-5	4E-4
		W, see ^{86}Zr	-	2E+1	1E-8	-	-	-
			-	Bone surf (6E+1)	-	9E-11	-	-
		Y, see ^{86}Zr	-	6E+1	2E-8	-	-	-
			-	Bone surf (7E+1)	-	9E-11	-	-
40	Zirconium-95	D, see ^{86}Zr	1E+3	1E+2	5E-8	-	2E-5	2E-4
			-	Bone surf (3E+2)	-	4E-10	-	-
		W, see ^{86}Zr	-	4E+2	2E-7	5E-10	-	-
		Y, see ^{86}Zr	-	3E+2	1E-7	4E-10	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
40	Zirconium-97	D, see ^{86}Zr	6E+2	2E+3	8E-7	3E-9	9E-6	9E-5
		W, see ^{86}Zr	-	1E+3	6E-7	2E-9	-	-
		Y, see ^{86}Zr	-	1E+3	5E-7	2E-9	-	-
41	Niobium-88[2]	W, all compounds except those given for Y	5E+4	2E+5	9E-5	3E-7	-	-
			St. wall (7E+4)	-	-	-	1E-3	1E-2
		Y, oxides and hydroxides	-	2E+5	9E-5	3E-7	-	-
41	Niobium-89[2] (66 min)	W, see ^{88}Nb	1E+4	4E+4	2E-5	6E-8	1E-4	1E-3
		Y, see ^{88}Nb	-	4E+4	2E-5	5E-8	-	-
41	Niobium-89 (122 min)	W, see ^{88}Nb	5E+3	2E+4	8E-6	3E-8	7E-5	7E-4
		Y, see ^{88}Nb	-	2E+4	6E-6	2E-8	-	-
41	Niobium-90	W, see ^{88}Nb	1E+3	3E+3	1E-6	4E-9	1E-5	1E-4
		Y, see ^{88}Nb	-	2E+3	1E-6	3E-9	-	-
41	Niobium-93m	W, see ^{88}Nb	9E+3	2E+3	8E-7	3E-9	-	-
			LLI wall (1E+4)	-	-	-	2E-4	2E-3
		Y, see ^{88}Nb	-	2E+2	7E-8	2E-10	-	-
41	Niobium-94	W, see ^{88}Nb	9E+2	2E+2	8E-8	3E-10	1E-5	1E-4
		Y, see ^{88}Nb	-	2E+1	6E-9	2E-11	-	-
41	Niobium-95m	W, see ^{88}Nb	2E+3	3E+3	1E-6	4E-9	-	-
			LLI wall (2E+3)	-	-	-	3E-5	3E-4
		Y, see ^{88}Nb	-	2E+3	9E-7	3E-9	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
41	Niobium-95	W, see ^{88}Nb	2E+3	1E+3	5E-7	2E-9	3E-5	3E-4
		Y, see ^{88}Nb	-	1E+3	5E-7	2E-9	-	-
41	Niobium-96	W, see ^{88}Nb	1E+3	3E+3	1E-6	4E-9	2E-5	2E-4
		Y, see ^{88}Nb	-	2E+3	1E-6	3E-9	-	-
41	Niobium-97[2]	W, see ^{88}Nb	2E+4	8E+4	3E-5	1E-7	3E-4	3E-3
		Y, see ^{88}Nb	-	7E+4	3E-5	1E-7	-	-
41	Niobium-98[2]	W, see ^{88}Nb	1E+4	5E+4	2E-5	8E-8	2E-4	2E-3
		Y, see ^{88}Nb	-	5E+4	2E-5	7E-8	-	-
42	Molybdenum-90	D, all compounds except those given for Y	2E+3	7E+3	3E-6	1E-8	3E-5	3E-4
		Y, oxides, hydroxides, and MoS_2	-	5E+3	2E-6	6E-9	-	-
42	Molybdenum-93m	D, see ^{90}Mo	4E+3	2E+4	7E-6	2E-8	6E-5	6E-4
		Y, see ^{90}Mo	-	1E+4	6E-6	2E-8	-	-
42	Molybdenum-93	D, see ^{90}Mo	4E+3	5E+3	2E-6	8E-9	5E-5	5E-4
		Y, see ^{90}Mo	-	2E+2	8E-8	2E-10	-	-
42	Molybdenum-99	D, see ^{90}Mo	1E+3	3E+3	1E-6	4E-9	-	-
			LLI wall (1E+3)	-	-	-	2E-5	2E-4
		Y, see ^{90}Mo	-	1E+3	6E-7	2E-9	-	-
42	Molybdenum-101[2]	D, see ^{90}Mo	4E+4	1E+5	6E-5	2E-7	-	-
			St. wall (5E+4)	-	-	-	7E-4	7E-3
		Y, see ^{90}Mo	-	1E+5	6E-5	2E-7	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
43	Technetium-93m[2]	D, all compounds except those given for W	7E+4	2E+5	6E-5	2E-7	1E-3	1E-2
		W, oxides, hydroxides, halides, and nitrates	-	3E+5	1E-4	4E-7	-	-
43	Technetium-93	D, see ^{93m}Tc	3E+4	7E+4	3E-5	1E-7	4E-4	4E-3
		W, see ^{93m}Tc	-	1E+5	4E-5	1E-7	-	-
43	Technetium-94m[2]	D, see ^{93m}Tc	2E+4	4E+4	2E-5	6E-8	3E-4	3E-3
		W, see ^{93m}Tc	-	6E+4	2E-5	8E-8	-	-
43	Technetium-94	D, see ^{93m}Tc	9E+3	2E+4	8E-6	3E-8	1E-4	1E-3
		W, see ^{93m}Tc	-	2E+4	1E-5	3E-8	-	-
43	Technetium-95m	D, see ^{93m}Tc	4E+3	5E+3	2E-6	8E-9	5E-5	5E-4
		W, see ^{93m}Tc	-	2E+3	8E-7	3E-9	-	-
43	Technetium-95	D, see ^{93m}Tc	1E+4	2E+4	9E-6	3E-8	1E-4	1E-3
		W, see ^{93m}Tc	-	2E+4	8E-6	3E-8	-	-
43	Technetium-96m[2]	D, see ^{93m}Tc	2E+5	3E+5	1E-4	4E-7	2E-3	2E-2
		W, see ^{93m}Tc	-	2E+5	1E-4	3E-7	-	-
43	Technetium-96	D, see ^{93m}Tc	2E+3	3E+3	1E-6	5E-9	3E-5	3E-4
		W, see ^{93m}Tc	-	2E+3	9E-7	3E-9	-	-
43	Technetium-97m	D, see ^{93m}Tc	5E+3	7E+3	3E-6	-	6E-5	6E-4
			-	St. wall (7E+3)	-	1E-8	-	-
		W, see ^{93m}Tc	-	1E+3	5E-7	2E-9	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
43	Technetium-97	D, see ^{93m}Tc	4E+4	5E+4	2E-5	7E-8	5E-4	5E-3
		W, see ^{93m}Tc	-	6E+3	2E-6	8E-9	-	-
43	Technetium-98	D, see ^{93m}Tc	1E+3	2E+3	7E-7	2E-9	1E-5	1E-4
		W, see ^{93m}Tc	-	3E+2	1E-7	4E-10	-	-
43	Technetium-99m	D, see ^{93m}Tc	8E+4	2E+5	6E-5	2E-7	1E-3	1E-2
		W, see ^{93m}Tc	-	2E+5	1E-4	3E-7	-	-
43	Technetium-99	D, see ^{93m}Tc	4E+3	5E+3	2E-6	-	6E-5	6E-4
			-	St. wall (6E+3)	-	8E-9	-	-
		W, see ^{93m}Tc	-	7E+2	3E-7	9E-10	-	-
43	Technetium-101[2]	D, see ^{93m}Tc	9E+4	3E+5	1E-4	5E-7	-	-
			St. wall (1E+5)	-	-	-	2E-3	2E-2
		W, see ^{93m}Tc	-	4E+5	2E-4	5E-7	-	-
43	Technetium-104[2]	D, see ^{93m}Tc	2E+4	7E+4	3E-5	1E-7	-	-
			St. wall (3E+4)	-	-	-	4E-4	4E-3
		W, see ^{93m}Tc	-	9E+4	4E-5	1E-7	-	-
44	Ruthenium-94[2]	D, all compounds except those given for W and Y	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, halides	-	6E+4	3E-5	9E-8	-	-
		Y, oxides and hydroxides	-	6E+4	2E-5	8E-8	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
44	Ruthenium-97	D, see $^{94}_{94}Ru$	8E+3	2E+4	8E-6	3E-8	1E-4	1E-3
		W, see $^{94}_{94}Ru$	-	1E+4	5E-6	2E-8	-	-
		Y, see $^{94}_{94}Ru$	-	1E+4	5E-6	2E-8	-	-
44	Ruthenium-103	D, see $^{94}_{94}Ru$	2E+3	2E+3	7E-7	2E-9	3E-5	3E-4
		W, see $^{94}_{94}Ru$	-	1E+3	4E-7	1E-9	-	-
		Y, see $^{94}_{94}Ru$	-	6E+2	3E-7	9E-10	-	-
44	Ruthenium-105	D, see $^{94}_{94}Ru$	5E+3	1E+4	6E-6	2E-8	7E-5	7E-4
		W, see $^{94}_{94}Ru$	-	1E+4	6E-6	2E-8	-	-
		Y, see $^{94}_{94}Ru$	-	1E+4	5E-6	2E-8	-	-
44	Ruthenium-106	D, see $^{94}_{94}Ru$	2E+2	9E+1	4E-8	1E-10	-	-
			LLI wall (2E+2)	-	-	-	3E-6	3E-5
		W, see $^{94}_{94}Ru$	-	5E+1	2E-8	8E-11	-	-
		Y, see $^{94}_{94}Ru$	-	1E+1	5E-9	2E-11	-	-
45	Rhodium-99m	D, all compounds except those given for W and Y	2E+4	6E+4	2E-5	8E-8	2E-4	2E-3
		W, halides	-	8E+4	3E-5	1E-7	-	-
		Y, oxides and hydroxides	-	7E+4	3E-5	9E-8	-	-
45	Rhodium-99	D, see $^{99m}_{99m}Rh$	2E+3	3E+3	1E-6	4E-9	3E-5	3E-4
		W, see $^{99m}_{99m}Rh$	-	2E+3	9E-7	3E-9	-	-
		Y, see $^{99m}_{99m}Rh$	-	2E+3	8E-7	3E-9	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
45	Rhodium-100	D, see ^{99m}Rh	2E+3	5E+3	2E-6	7E-9	2E-5	2E-4
		W, see ^{99m}Rh	-	4E+3	2E-6	6E-9	-	-
		Y, see ^{99m}Rh	-	4E+3	2E-6	5E-9	-	-
45	Rhodium-101m	D, see ^{99m}Rh	6E+3	1E+4	5E-6	2E-8	8E-5	8E-4
		W, see ^{99m}Rh	-	8E+3	4E-6	1E-8	-	-
		Y, see ^{99m}Rh	-	8E+3	3E-6	1E-8	-	-
45	Rhodium-101	D, see ^{99m}Rh	2E+3	5E+2	2E-7	7E-10	3E-5	3E-4
		W, see ^{99m}Rh	-	8E+2	3E-7	1E-9	-	-
		Y, see ^{99m}Rh	-	2E+2	6E-8	2E-10	-	-
45	Rhodium-102m	D, see ^{99m}Rh	1E+3	5E+2	2E-7	7E-10	-	-
			LLI wall (1E+3)	-	-	-	2E-5	2E-4
		W, see ^{99m}Rh	-	4E+2	2E-7	5E-10	-	-
		Y, see ^{99m}Rh	-	1E+2	5E-8	2E-10	-	-
45	Rhodium-102	D, see ^{99m}Rh	6E+2	9E+1	4E-8	1E-10	8E-6	8E-5
		W, see ^{99m}Rh	-	2E+2	7E-8	2E-10	-	-
		Y, see ^{99m}Rh	-	6E+1	2E-8	8E-11	-	-
45	Rhodium-103m[2]	D, see ^{99m}Rh	4E+5	1E+6	5E-4	2E-6	6E-3	6E-2
		W, see ^{99m}Rh	-	1E+6	5E-4	2E-6	-	-
		Y, see ^{99m}Rh	-	1E+6	5E-4	2E-6	-	-
45	Rhodium-105	D, see ^{99m}Rh	4E+3	1E+4	5E-6	2E-8	-	-
			LLI wall (4E+3)	-	-	-	5E-5	5E-4
		W, see ^{99m}Rh	-	6E+3	3E-6	9E-9	-	-
		Y, see ^{99m}Rh	-	6E+3	2E-6	8E-9	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation		Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
45	Rhodium-106m	D, see ^{99m}Rh	8E+3	3E+4	1E-5	4E-8	1E-4	1E-3
		W, see ^{99m}Rh	-	4E+4	2E-5	5E-8	-	-
		Y, see ^{99m}Rh	-	4E+4	1E-5	5E-8	-	-
45	Rhodium-107[2]	D, see ^{99m}Rh	7E+4	2E+5	1E-4	3E-7	-	-
			St. wall (9E+4)	-	-	-	1E-3	1E-2
		W, see ^{99m}Rh	-	3E+5	1E-4	4E-7	-	-
		Y, see ^{99m}Rh	-	3E+5	1E-4	3E-7	-	-
46	Palladium-100	D, all compounds except those given for W and Y	1E+3	1E+3	6E-7	2E-9	2E-5	2E-4
		W, nitrates	-	1E+3	5E-7	2E-9	-	-
		Y, oxides and hydroxides	-	1E+3	6E-7	2E-9	-	-
46	Palladium-101	D, see ^{100}Pd	1E+4	3E+4	1E-5	5E-8	2E-4	2E-3
		W, see ^{100}Pd	-	3E+4	1E-5	5E-8	-	-
		Y, see ^{100}Pd	-	3E+4	1E-5	4E-8	-	-
46	Palladium-103	D, see ^{100}Pd	6E+3	6E+3	3E-6	9E-9	-	-
			LLI wall (7E+3)	-	-	-	1E-4	1E-3
		W, see ^{100}Pd	-	4E+3	2E-6	6E-9	-	-
		Y, see ^{100}Pd	-	4E+3	1E-6	5E-9	-	-
46	Palladium-107	D, see ^{100}Pd	3E+4	2E+4	9E-6	-	-	-
			LLI wall (4E+4)	Kidneys (2E+4)	-	3E-8	5E-4	5E-3
		W, see ^{100}Pd	-	7E+3	3E-6	1E-8	-	-
		Y, see ^{100}Pd	-	4E+2	2E-7	6E-10	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
46	Palladium-109	D, see ^{100}Pd	2E+3	6E+3	3E-6	9E-9	3E-5	3E-4
		W, see ^{100}Pd	-	5E+3	2E-6	8E-9	-	-
		Y, see ^{100}Pd	-	5E+3	2E-6	6E-9	-	-
47	Silver-102[2]	D, all compounds except those given for W and Y	5E+4	2E+5	8E-5	2E-7	-	-
			St. wall (6E+4)	-	-	-	9E-4	9E-3
		W, nitrates and sulfides	-	2E+5	9E-5	3E-7	-	-
		Y, oxides and hydroxides	-	2E+5	8E-5	3E-7	-	-
47	Silver-103[2]	D, see ^{102}Ag	4E+4	1E+5	4E-5	1E-7	5E-4	5E-3
		W, see ^{102}Ag	-	1E+5	5E-5	2E-7	-	-
		Y, see ^{102}Ag	-	1E+5	5E-5	2E-7	-	-
47	Silver-104m[2]	D, see ^{102}Ag	3E+4	9E+4	4E-5	1E-7	4E-4	4E-3
		W, see ^{102}Ag	-	1E+5	5E-5	2E-7	-	-
		Y, see ^{102}Ag	-	1E+5	5E-5	2E-7	-	-
47	Silver-104[2]	D, see ^{102}Ag	2E+4	7E+4	3E-5	1E-7	3E-4	3E-3
		W, see ^{102}Ag	-	1E+5	6E-5	2E-7	-	-
		Y, see ^{102}Ag	-	1E+5	6E-5	2E-7	-	-
47	Silver-105	D, see ^{102}Ag	3E+3	1E+3	4E-7	1E-9	4E-5	4E-4
		W, see ^{102}Ag	-	2E+3	7E-7	2E-9	-	-
		Y, see ^{102}Ag	-	2E+3	7E-7	2E-9	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
47	Silver-106m	D, see ^{102}Ag	8E+2	7E+2	3E-7	1E-9	1E-5	1E-4
		W, see ^{102}Ag	-	9E+2	4E-7	1E-9	-	-
		Y, see ^{102}Ag	-	9E+2	4E-7	1E-9	-	-
47	Silver-106[2]	D, see ^{102}Ag	6E+4	2E+5	8E-5	3E-7	-	-
			St. wall (6E+4)	-	-	-	9E-4	9E-3
		W, see ^{102}Ag	-	2E+5	9E-5	3E-7	-	-
		Y, see ^{102}Ag	-	2E+5	8E-5	3E-7	-	-
47	Silver-108m	D, see ^{102}Ag	6E+2	2E+2	8E-8	3E-10	9E-6	9E-5
		W, see ^{102}Ag	-	3E+2	1E-7	4E-10	-	-
		Y, see ^{102}Ag	-	2E+1	1E-8	3E-11	-	-
47	Silver-110m	D, see ^{102}Ag	5E+2	1E+2	5E-8	2E-10	6E-6	6E-5
		W, see ^{102}Ag	-	2E+2	8E-8	3E-10	-	-
		Y, see ^{102}Ag	-	9E+1	4E-8	1E-10	-	-
47	Silver-111	D, see ^{102}Ag	9E+2	2E+3	6E-7	-	-	-
			LLI wall (1E+3)	Liver (2E+3)	-	2E-9	2E-5	2E-4
		W, see ^{102}Ag	-	9E+2	4E-7	1E-9	-	-
		Y, see ^{102}Ag	-	9E+2	4E-7	1E-9	-	-
47	Silver-112	D, see ^{102}Ag	3E+3	8E+3	3E-6	1E-8	4E-5	4E-4
		W, see ^{102}Ag	-	1E+4	4E-6	1E-8	-	-
		Y, see ^{102}Ag	-	9E+3	4E-6	1E-8	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
47	Silver-115[2]	D, see ^{102}Ag	3E+4	9E+3	4E-5	1E-7	-	-
			St. wall (3E+4)	-	-	-	4E-4	4E-3
		W, see ^{102}Ag	-	9E+4	4E-5	1E-7	-	-
		Y, see ^{102}Ag	-	8E+4	3E-5	1E-7	-	-
48	Cadmium-104[2]	D, all compounds except those given for W and Y	2E+4	7E+4	3E-5	9E-8	3E-4	3E-3
		W, sulfides, halides, and nitrates	-	1E+5	5E-5	2E-7	-	-
		Y, oxides and hydroxides	-	1E+5	5E-5	2E-7	-	-
48	Cadmium-107	D, see ^{104}Cd	4E+4	5E+4	2E-5	8E-8	3E-4	3E-3
		W, see ^{104}Cd	-	6E+4	2E-5	8E-8	-	-
		Y, see ^{104}Cd	-	5E+4	2E-5	7E-8	-	-
48	Cadmium-109	D, see ^{104}Cd	3E+2	4E+1	1E-8	-	-	-
			Kidneys (4E+2)	Kidneys (5E+1)	-	7E-11	6E-6	6E-5
		W, see ^{104}Cd	-	1E+2	5E-8	-	-	-
			-	Kidneys (1E+2)	-	2E-10	-	-
		Y, see ^{104}Cd	-	1E+2	5E-8	2E-10	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
48	Cadmium-113m	D, see ^{104}Cd	2E+1 Kidneys (4E+1)	2E+0 Kidneys (4E+0)	1E-9 -	- 5E-12	- 5E-7	- 5E-6
		W, see ^{104}Cd	-	8E+0 Kidneys (1E+1)	4E-9 -	- 2E-11	- -	- -
		Y, see ^{104}Cd	-	1E+1	5E-9	2E-11	-	-
48	Cadmium-113	D, see ^{104}Cd	2E+1 Kidneys (3E+1)	2E+0 Kidneys (3E+0)	9E-10 -	- 5E-12	- 4E-7	- 4E-6
		W, see ^{104}Cd	-	8E+0 Kidneys (1E+1)	3E-9 -	- 2E-11	- -	- -
		Y, see ^{104}Cd	-	1E+1	6E-9	2E-11	-	-
48	Cadmium-115m	D, see ^{104}Cd	3E+2	5E+1 Kidneys (8E+1)	2E-8 -	- 1E-10	4E-6 -	4E-5 -
		W, see ^{104}Cd	-	1E+2	5E-8	2E-10	-	-
		Y, see ^{104}Cd	-	1E+2	6E-8	2E-10	-	-
48	Cadmium-115	D, see ^{104}Cd	9E+2 LLI wall (1E+3)	1E+3 -	6E-7 -	2E-9 -	- 1E-5	- 1E-4
		W, see ^{104}Cd	-	1E+3	5E-7	2E-9	-	-
		Y, see ^{104}Cd	-	1E+3	6E-7	2E-9	-	-
48	Cadmium-117m	D, see ^{104}Cd	5E+3	1E+4	5E-6	2E-8	6E-5	6E-4
		W, see ^{104}Cd	-	2E+4	7E-6	2E-8	-	-
		Y, see ^{104}Cd	-	1E+4	6E-6	2E-8	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
48	Cadmium-117	D, see ^{104}Cd	5E+3	1E+4	5E-6	2E-8	6E-5	6E-4
		W, see ^{104}Cd	-	2E+4	7E-6	2E-8	-	-
		Y, see ^{104}Cd	-	1E+4	6E-6	2E-8	-	-
49	Indium-109	D, all compounds except those given for W	2E+4	4E+4	2E-5	6E-8	3E-4	3E-3
		W, oxides, hydroxides, halides, and nitrates	-	6E+4	3E-5	9E-8	-	-
49	Indium-110[2] (69.1 min)	D, see ^{109}In	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{109}In	-	6E+4	2E-5	8E-8	-	-
49	Indium-110 (4.9 h)	D, see ^{109}In	5E+3	2E+4	7E-6	2E-8	7E-5	7E-4
		W, see ^{109}In	-	2E+4	8E-6	3E-8	-	-
49	Indium-111	D, see ^{109}In	4E+3	6E+3	3E-6	9E-9	6E-5	6E-4
		W, see ^{109}In	-	6E+3	3E-6	9E-9	-	-
49	Indium-112[2]	D, see ^{109}In	2E+5	6E+5	3E-4	9E-7	2E-3	2E-2
		W, see ^{109}In	-	7E+5	3E-4	1E-6	-	-
49	Indium-113[2]	D, see ^{109}In	5E+4	1E+5	6E-5	2E-7	7E-4	7E-3
		W, see ^{109}In	-	2E+5	8E-5	3E-7	-	-
49	Indium-114m	D, see ^{109}In	3E+2	6E+1	3E-8	9E-11	-	-
			LLI wall (4E+2)	-	-	-	5E-6	5E-5
		W, see ^{109}In	-	1E+2	4E-8	1E-10	-	-
49	Indium-115m	D, see ^{109}In	1E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{109}In	-	5E+4	2E-5	7E-8	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation		Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
49	Indium-115	D, see ^{109}In	4E+1	1E+0	6E-10	2E-12	5E-7	5E-6
		W, see ^{109}In	-	5E+0	2E-9	8E-12	-	-
49	Indium-116m[2]	D, see ^{109}In	2E+4	8E+4	3E-5	1E-7	3E-4	3E-3
		W, see ^{109}In	-	1E+5	5E-5	2E-7	-	-
49	Indium-117m[2]	D, see ^{109}In	1E+4	3E+4	1E-5	5E-8	2E-4	2E-3
		W, see ^{109}In	-	4E+4	2E-5	6E-8	-	-
49	Indium-117[2]	D, see ^{109}In	6E+4	2E+5	7E-5	2E-7	8E-4	8E-3
		W, see ^{109}In	-	2E+5	9E-5	3E-7	-	-
49	Indium-119m[2]	D, see ^{109}In	4E+4 St. wall (5E+4)	1E+5	5E-5	2E-7	-	-
		W, see ^{109}In	-	1E+5	6E-5	2E-7	7E-4	7E-3
50	Tin-110	D, all compounds except those given for W	4E+3	1E+4	5E-6	2E-8	5E-5	5E-4
		W, sulfides, oxides, hydroxides, halides, nitrates, and stannic phosphate	-	1E+4	5E-6	2E-8	-	-
50	Tin-111[2]	D, see ^{110}Sn	7E+4	2E+5	9E-5	3E-7	1E-3	1E-2
		W, see ^{110}Sn	-	3E+5	1E-4	4E-7	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation		Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
50	Tin-113	D, see ^{110}Sn	2E+3	1E+3	5E-7	2E-9	-	-
			LLI wall (2E+3)	-	-	-	3E-5	3E-4
		W, see ^{110}Sn	-	5E+2	2E-7	8E-10	-	-
50	Tin-117m	D, see ^{110}Sn	2E+3	1E+3	5E-7	-	-	-
			LLI wall (2E+3)	Bone surf (2E+3)	-	3E-9	3E-5	3E-4
		W, see ^{110}Sn	-	1E+3	6E-7	2E-9	-	-
50	Tin-119m	D, see ^{110}Sn	3E+3	2E+3	1E-6	3E-9	-	-
			LLI wall (4E+3)	-	-	-	6E-5	6E-4
		W, see ^{110}Sn	-	1E+3	4E-7	1E-9	-	-
50	Tin-121m	D, see ^{110}Sn	3E+3	9E+2	4E-7	1E-9	-	-
			LLI wall (4E+3)	-	-	-	5E-5	5E-4
		W, see ^{110}Sn	-	5E+2	2E-7	8E-10	-	-
50	Tin-121	D, see ^{110}Sn	6E+3	2E+4	6E-6	2E-8	-	-
			LLI wall (6E+3)	-	-	-	8E-5	8E-4
		W, see ^{110}Sn	-	1E+4	5E-6	2E-8	-	-
50	Tin-123m[2]	D, see ^{110}Sn	5E+4	1E+5	5E-5	2E-7	7E-4	7E-3
		W, see ^{110}Sn	-	1E+5	6E-5	2E-7	-	-
50	Tin-123	D, see ^{110}Sn	5E+2	6E+2	3E-7	9E-10	-	-
			LLI wall (6E+2)	-	-	-	9E-6	9E-5
		W, see ^{110}Sn	-	2E+2	7E-8	2E-10	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
50	Tin-125	D, see ^{110}Sn	4E+2 LLI wall (5E+2)	9E+2	4E-7	1E-9	-	-
		W, see ^{110}Sn	-	-	-	-	6E-6	6E-5
			-	4E+2	2E-7	5E-10	-	-
50	Tin-126	D, see ^{110}Sn	3E+2	6E+1	2E-8	8E-11	4E-6	4E-5
		W, see ^{110}Sn	-	7E+1	3E-8	9E-11	-	-
50	Tin-127	D, see ^{110}Sn	7E+3	2E+4	8E-6	3E-8	9E-5	9E-4
		W, see ^{110}Sn	-	2E+4	8E-6	3E-8	-	-
50	Tin-128[2]	D, see ^{110}Sn	9E+3	3E+4	1E-5	4E-8	1E-4	1E-3
		W, see ^{110}Sn	-	4E+4	1E-5	5E-8	-	-
51	Antimony-115[2]	D, all compounds except those given for W	8E+4	2E+5	1E-4	3E-7	1E-3	1E-2
		W, oxides, hydroxides, halides, sulfides, sulfates, and nitrates	-	3E+5	1E-4	4E-7	-	-
51	Antimony-116m[2]	D, see ^{115}Sb	2E+4	7E+4	3E-5	1E-7	3E-4	3E-3
		W, see ^{115}Sb	-	1E+5	6E-5	2E-7	-	-
51	Antimony-116[2]	D, see ^{115}Sb	7E+4 St. wall (9E+4)	3E+5	1E-4	4E-7	-	-
		W, see ^{115}Sb	-	-	-	-	1E-3	1E-2
			-	3E+5	1E-4	5E-7	-	-
51	Antimony-117	D, see ^{115}Sb	7E+4	2E+5	9E-5	3E-7	9E-4	9E-3
		W, see ^{115}Sb	-	3E+5	1E-4	4E-7	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
51	Antimony-118m	D, see ^{115}Sb	5E+3	2E+4	8E-6	3E-8	7E-5	7E-4
		W, see ^{115}Sb	-	2E+4	9E-6	3E-8	-	-
51	Antimony-119	D, see ^{115}Sb	1E+4	5E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{115}Sb	-	3E+4	1E-5	4E-8	-	-
51	Antimony-120[2] (16 min)	D, see ^{115}Sb	1E+5	4E+5	2E-4	6E-7	-	-
			St. wall (2E+5)	-	-	-	2E-3	2E-2
		W, see ^{115}Sb	-	5E+5	2E-4	7E-7	-	-
51	Antimony-120 (5.76 d)	D, see ^{115}Sb	9E+2	2E+3	9E-7	3E-9	1E-5	1E-4
		W, see ^{115}Sb	-	1E+3	5E-7	2E-9	-	-
51	Antimony-122	D, see ^{115}Sb	7E+2	2E+3	1E-6	3E-9	-	-
			LLI wall (8E+2)	-	-	-	1E-5	1E-4
		W, see ^{115}Sb	-	1E+3	4E-7	2E-9	-	-
51	Antimony-124m[2]	D, see ^{115}Sb	2E+5	8E+5	4E-4	1E-6	3E-3	3E-2
		W, see ^{115}Sb	-	6E+5	2E-4	8E-7	-	-
51	Antimony-124	D, see ^{115}Sb	5E+2	9E+2	4E-7	1E-9	7E-6	7E-5
		W, see ^{115}Sb	-	2E+2	1E-7	3E-10	-	-
51	Antimony-125	D, see ^{115}Sb	2E+3	2E+3	1E-6	3E-9	3E-5	3E-4
		W, see ^{115}Sb	-	5E+2	2E-7	7E-10	-	-
51	Antimony-126m[2]	D, see ^{115}Sb	5E+4	2E+5	8E-5	3E-7	-	-
			St. wall (7E+4)	-	-	-	9E-4	9E-3
		W, see ^{115}Sb	-	2E+5	8E-5	3E-7	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
51	Antimony-126	D, see ^{115}Sb	5E+2	1E+3	5E-7	2E-9	7E-6	7E-5
		W, see ^{115}Sb	-	5E+2	2E-7	7E-10	-	-
51	Antimony-127	D, see ^{115}Sb	7E+2	2E+3	9E-7	3E-9	-	-
			LLI wall (8E+2)	-	-	-	1E-5	1E-4
		W, see ^{115}Sb	-	9E+2	4E-7	1E-9	-	-
51	Antimony-128[2] (10.4 min)	D, see ^{115}Sb	8E+4	4E+5	2E-4	5E-7	-	-
			St. wall (1E+5)	-	-	-	1E-3	1E-2
		W, see ^{115}Sb	-	4E+5	2E-4	6E-7	-	-
51	Antimony-128 (9.01 h)	D, see ^{115}Sb	1E+3	4E+3	2E-6	6E-9	2E-5	2E-4
		W, see ^{115}Sb	-	3E+3	1E-6	5E-9	-	-
51	Antimony-129	D, see ^{115}Sb	3E+3	9E+3	4E-6	1E-8	4E-5	4E-4
		W, see ^{115}Sb	-	9E+3	4E-6	1E-8	-	-
51	Antimony-130[2]	D, see ^{115}Sb	2E+4	6E+4	3E-5	9E-8	3E-4	3E-3
		W, see ^{115}Sb	-	8E+4	3E-5	1E-7	-	-
51	Antimony-131[2]	D, see ^{115}Sb	1E+4 Thyroid	2E+4 Thyroid	1E-5	-	-	-
			(2E+4)	(4E+4)	-	6E-8	2E-4	2E-3
		W, see ^{115}Sb	-	2E+4 Thyroid	1E-5		-	-
			-	(4E+4)	-	6E-8	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
52	Tellurium-116	D, all compounds except those given for W	8E+3	2E+4	9E-6	3E-8	1E-4	1E-3
		W, oxides, hydroxides, and nitrates	-	3E+4	1E-5	4E-8	-	-
52	Tellurium-121m	D, see ^{116}Te	5E+2 Bone surf (7E+2)	2E+2 Bone surf (4E+2)	8E-8 -	- 5E-10	- 1E-5	- 1E-4
		W, see ^{116}Te	-	4E+2	2E-7	6E-10	-	-
52	Tellurium-121	D, see ^{116}Te	3E+3	4E+3	2E-6	6E-9	4E-5	4E-4
		W, see ^{116}Te	-	3E+3	1E-6	4E-9	-	-
52	Tellurium-123m	D, see ^{116}Te	6E+2 Bone surf (1E+3)	2E+2 Bone surf (5E+2)	9E-7 -	- 8E-10	- 1E-5	- 1E-4
		W, see ^{116}Te	-	5E+2	2E-7	8E-10	-	-
52	Tellurium-123	D, see ^{116}Te	5E+2 Bone surf (1E+3)	2E+2 Bone surf (5E+2)	8E-8 -	- 7E-10	- 2E-5	- 2E-4
		W, see ^{116}Te	- -	4E+2 Bone surf (1E+3)	2E-7 -	- 2E-9	- -	- -
52	Tellurium-125m	D, see ^{116}Te	1E+3 Bone surf (1E+3)	4E+2 Bone surf (1E+3)	2E-7 -	- 1E-9	- 2E-5	- 2E-4
		W, see ^{116}Te	-	7E+2	3E-7	1E-9	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
52	Tellurium-127m	D, see ^{116}Te	6E+2	3E+2	1E-7	-	9E-6	9E-5
			-	Bone surf (4E+2)	-	6E-10	-	-
		W, see ^{116}Te	-	3E+2	1E-7	4E-10	-	-
52	Tellurium-127	D, see ^{116}Te	7E+3	2E+4	9E-6	3E-8	1E-4	1E-3
		W, see ^{116}Te	-	2E+4	7E-6	2E-8	-	-
52	Tellurium-129m	D, see ^{116}Te	5E+2	6E+2	3E-7	9E-10	7E-6	7E-5
		W, see ^{116}Te	-	2E+2	1E-7	3E-10	-	-
52	Tellurium-129[2]	D, see ^{116}Te	3E+4	6E+4	3E-5	9E-8	4E-4	4E-3
		W, see ^{116}Te	-	7E+4	3E-5	1E-7	-	-
52	Tellurium-131m	D, see ^{116}Te	3E+2	4E+2	2E-7	-	-	-
			Thyroid (6E+2)	Thyroid (1E+3)	-	2E-9	8E-6	8E-5
		W, see ^{116}Te	-	4E+2	2E-7	-	-	-
			-	Thyroid (9E+2)	-	1E-9	-	-
52	Tellurium-131[2]	D, see ^{116}Te	3E+3	5E+3	2E-6	-	-	-
			Thyroid (6E+3)	Thyroid (1E+4)	-	2E-8	8E-5	8E-4
		W, see ^{116}Te	-	5E+3	2E-6	-	-	-
			-	Thyroid (1E+4)	-	2E-8	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation		Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
52	Tellurium-132	D, see ^{116}Te	2E+2 Thyroid (7E+2)	2E+2 Thyroid (8E+2)	9E-8 -	- 1E-9	- 9E-6	- 9E-5
		W, see ^{116}Te	- -	2E+2 Thyroid (6E+2)	9E-8 -	- 9E-10	- -	- -
52	Tellurium-133m[2]	D, see ^{116}Te	3E+3 Thyroid (6E+3)	5E+3 Thyroid (1E+4)	2E-6 -	- 2E-8	- 9E-5	- 9E-4
		W, see ^{116}Te	- -	5E+3 Thyroid (1E+4)	2E-6 -	- 2E-8	- -	- -
52	Tellurium-133[2]	D, see ^{116}Te	1E+4 Thyroid (3E+4)	2E+4 Thyroid (6E+4)	9E-6 -	- 8E-8	- 4E-4	- 4E-3
		W, see ^{116}Te	- -	2E+4 Thyroid (6E+4)	9E-6 -	- 8E-8	- -	- -
52	Tellurium-134[2]	D, see ^{116}Te	2E+4 Thyroid (2E+4)	2E+4 Thyroid (5E+4)	1E-5 -	- 7E-8	- 3E-4	- 3E-3
		W, see ^{116}Te	- -	2E+4 Thyroid (5E+4)	1E-5 -	- 7E-8	- -	- -
53	Iodine-120m[2]	D, all compounds	1E+4 Thyroid (1E+4)	2E+4 -	9E-6 -	3E-8 -	- 2E-4	- 2E-3

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
53	Iodine-120[2]	D, all compounds	4E+3 Thyroid (8E+3)	9E+3 Thyroid (1E+4)	4E-6 -	- 2E-8	- 1E-4	- 1E-3
53	Iodine-121	D, all compounds	1E+4 Thyroid (3E+4)	2E+4 Thyroid (5E+4)	8E-6 -	- 7E-8	- 4E-4	- 4E-3
53	Iodine-123	D, all compounds	3E+3 Thyroid (1E+4)	6E+3 Thyroid (2E+4)	3E-6 -	- 2E-8	- 1E-4	- 1E-3
53	Iodine-124	D, all compounds	5E+1 Thyroid (2E+2)	8E+1 Thyroid (3E+2)	3E-8 -	- 4E-10	- 2E-6	- 2E-5
53	Iodine-125	D, all compounds	4E+1 Thyroid (1E+2)	6E+1 Thyroid (2E+2)	3E-8 -	- 3E-10	- 2E-6	- 2E-5
53	Iodine-126	D, all compounds	2E+1 Thyroid (7E+1)	4E+1 Thyroid (1E+2)	1E-8 -	- 2E-10	- 1E-6	- 1E-5
53	Iodine-128[2]	D, all compounds	4E+4 St. wall (6E+4)	1E+5 -	5E-5 -	2E-7 -	- 8E-4	- 8E-3
53	Iodine-129	D, all compounds	5E+0 Thyroid (2E+1)	9E+0 Thyroid (3E+1)	4E-9 -	- 4E-11	- 2E-7	- 2E-6

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation		Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
53	Iodine-130	D, all compounds	4E+2 Thyroid (1E+3)	7E+2 Thyroid (2E+3)	3E-7 -	- 3E-9	- 2E-5	- 2E-4
53	Iodine-131	D, all compounds	3E+1 Thyroid (9E+1)	5E+1 Thyroid (2E+2)	2E-8 -	- 2E-10	- 1E-6	- 1E-5
53	Iodine-132m[2]	D, all compounds	4E+3 Thyroid (1E+4)	8E+3 Thyroid (2E+4)	4E-6 -	- 3E-8	- 1E-4	- 1E-3
53	Iodine-132	D, all compounds	4E+3 Thyroid (9E+3)	8E+3 Thyroid (1E+4)	3E-6 -	- 2E-8	- 1E-4	- 1E-3
53	Iodine-133	D, all compounds	1E+2 Thyroid (5E+2)	3E+2 Thyroid (9E+2)	1E-7 -	- 1E-9	- 7E-6	- 7E-5
53	Iodine-134[2]	D, all compounds	2E+4 Thyroid (3E+4)	5E+4 -	2E-5 -	6E-8 -	- 4E-4	- 4E-3
53	Iodine-135	D, all compounds	8E+2 Thyroid (3E+3)	2E+3 Thyroid (4E+3)	7E-7 -	- 6E-9	- 3E-5	- 3E-4

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
54	Xenon-120[2]	Submersion[1]	-	-	1E-5	4E-8	-	-
54	Xenon-121[2]	Submersion[1]	-	-	2E-6	1E-8	-	-
54	Xenon-122	Submersion[1]	-	-	7E-5	3E-7	-	-
54	Xenon-123	Submersion[1]	-	-	6E-6	3E-8	-	-
54	Xenon-125	Submersion[1]	-	-	2E-5	7E-8	-	-
54	Xenon-127	Submersion[1]	-	-	1E-5	6E-8	-	-
54	Xenon-129m	Submersion[1]	-	-	2E-4	9E-7	-	-
54	Xenon-131m	Submersion[1]	-	-	4E-4	2E-6	-	-
54	Xenon-133m	Submersion[1]	-	-	1E-4	6E-7	-	-
54	Xenon-133	Submersion[1]	-	-	1E-4	5E-7	-	-
54	Xenon-135m[2]	Submersion[1]	-	-	9E-6	4E-8	-	-
54	Xenon-135	Submersion[1]	-	-	1E-5	7E-8	-	-
54	Xenon-138[2]	Submersion[1]	-	-	4E-6	2E-8	-	-
55	Cesium-125[2]	D, all compounds	5E+4 St. wall (9E+4)	1E+5	6E-5	2E-7	-	-
				-	-	-	1E-3	1E-2
55	Cesium-127	D, all compounds	5E+4	9E+4	4E-5	1E-7	9E-4	9E-3

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
55	Cesium-129	D, all compounds	2E+4	3E+4	1E-5	5E-8	3E-4	3E-3
55	Cesium-130[2]	D, all compounds	6E+4	2E+5	8E-5	3E-7	-	-
			St. wall (1E+5)	-	-	-	1E-3	1E-2
55	Cesium-131	D, all compounds	2E+4	3E+4	1E-5	4E-8	3E-4	3E-3
55	Cesium-132	D, all compounds	3E+3	4E+3	2E-6	6E-9	4E-5	4E-4
55	Cesium-134m	D, all compounds	1E+5	1E+5	6E-5	2E-7	-	-
			St. wall (1E+5)	-	-	-	2E-3	2E-2
55	Cesium-134	D, all compounds	7E+1	1E+2	4E-8	2E-10	9E-7	9E-6
55	Cesium-135m[2]	D, all compounds	1E+5	2E+5	8E-5	3E-7	1E-3	1E-2
55	Cesium-135	D, all compounds	7E+2	1E+3	5E-7	2E-9	1E-5	1E-4
55	Cesium-136	D, all compounds	4E+2	7E+2	3E-7	9E-10	6E-6	6E-5
55	Cesium-137	D, all compounds	1E+2	2E+2	6E-8	2E-10	1E-6	1E-5
55	Cesium-138[2]	D, all compounds	2E+4	6E+4	2E-5	8E-8	-	-
			St. wall (3E+4)	-	-	-	4E-4	4E-3
56	Barium-126[2]	D, all compounds	6E+3	2E+4	6E-6	2E-8	8E-5	8E-4

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
56	Barium-128	D, all compounds	5E+2	2E+3	7E-7	2E-9	7E-6	7E-5
56	Barium-131m[2]	D, all compounds	4E+5	1E+6	6E-4	2E-6	-	-
			St. wall (5E+5)	-	-	-	7E-3	7E-2
56	Barium-131	D, all compounds	3E+3	8E+3	3E-6	1E-8	4E-5	4E-4
56	Barium-133m	D, all compounds	2E+3	9E+3	4E-6	1E-8	-	-
			LLI wall (3E+3)	-	-	-	4E-5	4E-4
56	Barium-133	D, all compounds	2E+3	7E+2	3E-7	9E-10	2E-5	2E-4
56	Barium-135m	D, all compounds	3E+3	1E+4	5E-6	2E-8	4E-5	4E-4
56	Barium-139[2]	D, all compounds	1E+4	3E+4	1E-5	4E-8	2E-4	2E-3
56	Barium-140	D, all compounds	5E+2	1E+3	6E-7	2E-9	-	-
			LLI wall (6E+2)	-	-	-	8E-6	8E-5
56	Barium-141[2]	D, all compounds	2E+4	7E+4	3E-5	1E-7	3E-4	3E-3
56	Barium-142[2]	D, all compounds	5E+4	1E+5	6E-5	2E-7	7E-4	7E-3
57	Lanthanum-131[2]	D, all compounds except those given for W	5E+4	1E+5	5E-5	2E-7	6E-4	6E-3
		W, oxides and hydroxides	-	2E+5	7E-5	2E-7	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
57	Lanthanum-132	D, see ^{131}La	3E+3	1E+4	4E-6	1E-8	4E-5	4E-4
		W, see ^{131}La	-	1E+4	5E-6	2E-8	-	-
57	Lanthanum-135	D, see ^{131}La	4E+4	1E+5	4E-5	1E-7	5E-4	5E-3
		W, see ^{131}La	-	9E+4	4E-5	1E-7	-	-
57	Lanthanum-137	D, see ^{131}La	1E+4	6E+1	3E-8	-	2E-4	2E-3
			-	Liver (7E+1)	-	1E-10	-	-
		W, see ^{131}La	-	3E+2	1E-7	-	-	-
			-	Liver (3E+2)	-	4E-10	-	-
57	Lanthanum-138	D, see ^{131}La	9E+2	4E+0	1E-9	5E-12	1E-5	1E-4
		W, see ^{131}La	-	1E+1	6E-9	2E-11	-	-
57	Lanthanum-140	D, see ^{131}La	6E+2	1E+3	6E-7	2E-9	9E-6	9E-5
		W, see ^{131}La	-	1E+3	5E-7	2E-9	-	-
57	Lanthanum-141	D, see ^{131}La	4E+3	9E+3	4E-6	1E-8	5E-5	5E-4
		W, see ^{131}La	-	1E+4	5E-6	2E-8	-	-
57	Lanthanum-142[2]	D, see ^{131}La	8E+3	2E+4	9E-6	3E-8	1E-4	1E-3
		W, see ^{131}La	-	3E+4	1E-5	5E-8	-	-
57	Lanthanum-143[2]	D, see ^{131}La	4E+4	1E+5	4E-5	1E-7	-	-
			St. wall (4E+4)	-	-	-	5E-4	5E-3
		W, see ^{131}La	-	9E+4	4E-5	1E-7	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
58	Cerium-134	W, all compounds except those given for Y	5E+2	7E+2	3E-7	1E-9	-	-
			LLI wall (6E+2)	-	-	-	8E-6	8E-5
		Y, oxides, hydroxides, and fluorides	-	7E+2	3E-7	9E-10	-	-
58	Cerium-135	W, see ^{134}Ce	2E+3	4E+3	2E-6	5E-9	2E-5	2E-4
		Y, see ^{134}Ce	-	4E+3	1E-6	5E-9	-	-
58	Cerium-137m	W, see ^{134}Ce	2E+3	4E+3	2E-6	6E-9	-	-
			LLI wall (2E+3)	-	-	-	3E-5	3E-4
		Y, see ^{134}Ce	-	4E+3	2E-6	5E-9	-	-
58	Cerium-137	W, see ^{134}Ce	5E+4	1E+5	6E-5	2E-7	7E-4	7E-3
		Y, see ^{134}Ce	-	1E+5	5E-5	2E-7	-	-
58	Cerium-139	W, see ^{134}Ce	5E+3	8E+2	3E-7	1E-9	7E-5	7E-4
		Y, see ^{134}Ce	-	7E+2	3E-7	9E-10	-	-
58	Cerium-141	W, see ^{134}Ce	2E+3	7E+2	3E-7	1E-9	-	-
			LLI wall (2E+3)	-	-	-	3E-5	3E-4
		Y, see ^{134}Ce	-	6E+2	2E-7	8E-10	-	-
58	Cerium-143	W, see ^{134}Ce	1E+3	2E+3	8E-7	3E-9	-	-
			LLI wall (1E+3)	-	-	-	2E-5	2E-4
		Y, see ^{134}Ce	-	2E+3	7E-7	2E-9	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
58	Cerium-144	W, see ^{134}Ce	2E+2	3E+1	1E-8	4E-11	-	-
			LLI wall (3E+2)	-	-	-	3E-6	3E-5
		Y, see ^{134}Ce	-	1E+1	6E-9	2E-11	-	-
59	Praseodymium-136[2]	W, all compounds except those given for Y	5E+4	2E+5	1E-4	3E-7	-	-
			St. wall (7E+4)	-	-	-	1E-3	1E-2
		Y, oxides, hydroxides, carbides, and fluorides	-	2E+5	9E-5	3E-7	-	-
59	Praseodymium-137[2]	W, see ^{136}Pr	4E+4	2E+5	6E-5	2E-7	5E-4	5E-3
		Y, see ^{136}Pr	-	1E+5	6E-5	2E-7	-	-
59	Praseodymium-138m	W, see ^{136}Pr	1E+4	5E+4	2E-5	8E-8	1E-4	1E-3
		Y, see ^{136}Pr	-	4E+4	2E-5	6E-8	-	-
59	Praseodymium-139	W, see ^{136}Pr	4E+4	1E+5	5E-5	2E-7	6E-4	6E-3
		Y, see ^{136}Pr	-	1E+5	5E-5	2E-7	-	-
59	Praseodymium-142m[2]	W, see ^{136}Pr	8E+4	2E+5	7E-5	2E-7	1E-3	1E-2
		Y, see ^{136}Pr	-	1E+5	6E-5	2E-7	-	-
59	Praseodymium-142	W, see ^{136}Pr	1E+3	2E+3	9E-7	3E-9	1E-5	1E-4
		Y, see ^{136}Pr	-	2E+3	8E-7	3E-9	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
59	Praseodymium-143	W, see ^{136}Pr	9E+2	8E+2	3E-7	1E-9	-	-
			LLI wall (1E+3)	-	-	-	2E-5	2E-4
		Y, see ^{136}Pr	-	7E+2	3E-7	9E-10	-	-
59	Praseodymium-144[2]	W, se ^{136}Pr	3E+4	1E+5	5E-5	2E-7	-	-
			St. wall (4E+4)	-	-	-	6E-4	6E-3
		Y, see ^{136}Pr	-	1E+5	5E-5	2E-7	-	-
59	Praseodymium-145	W, see ^{136}Pr	3E+3	9E+3	4E-6	1E-8	4E-5	4E-4
		Y, see ^{136}Pr	-	8E+3	3E-6	1E-8	-	-
59	Praseodymium-147[2]	W, see ^{136}Pr	5E+4	2E+5	8E-5	3E-7	-	-
			St. wall (8E+4)	-	-	-	1E-3	1E-2
		Y, see ^{136}Pr	-	2E+5	8E-5	3E-7	-	-
60	Neodymium-136[2]	W, all compounds except those given for Y	1E+4	6E+4	2E-5	8E-8	2E-4	2E-3
		Y, oxides, hydroxides, carbides, and fluorides	-	5E+4	2E-5	8E-8	-	-
60	Neodymium-138	W, see ^{136}Nd	2E+3	6E+3	3E-6	9E-9	3E-5	3E-4
		Y, see ^{136}Nd	-	5E+3	2E-6	7E-9	-	-
60	Neodymium-139m	W, see ^{136}Nd	5E+3	2E+4	7E-6	2E-8	7E-5	7E-4
		Y, see ^{136}Nd	-	1E+4	6E-6	2E-8	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
60	Neodymium-139[2]	W, see ^{136}Nd	9E+4	3E+5	1E-4	5E-7	1E-3	1E-2
		Y, see ^{136}Nd	-	3E+5	1E-4	4E-7	-	-
60	Neodymium-141	W, see ^{136}Nd	2E+5	7E+5	3E-4	1E-6	2E-3	2E-2
		Y, see ^{136}Nd	-	6E+5	3E-4	9E-7	-	-
60	Neodymium-147	W, see ^{136}Nd	1E+3	9E+2	4E-7	1E-9	-	-
			LLI wall (1E+3)	-	-	-	2E-5	2E-4
		Y, see ^{136}Nd	-	8E+2	4E-7	1E-9	-	-
60	Neodymium-149[2]	W, see ^{136}Nd	1E+4	3E+4	1E-5	4E-8	1E-4	1E-3
		Y, see ^{136}Nd	-	2E+4	1E-5	3E-8	-	-
60	Neodymium-151[2]	W, see ^{136}Nd	7E+4	2E+5	8E-5	3E-7	9E-4	9E-3
		Y, see ^{136}Nd	-	2E+5	8E-5	3E-7	-	-
61	Promethium-141[2]	W, all compounds except those given for Y	5E+4	2E+5	8E-5	3E-7	-	-
			St. wall (6E+4)	-	-	-	8E-4	8E-3
		Y, oxides, hydroxides, carbides, and fluorides	-	2E+5	7E-5	2E-7	-	-
61	Promethium-143	W, see ^{141}Pm	5E+3	6E+2	2E-7	8E-10	7E-5	7E-4
		Y, see ^{141}Pm	-	7E+2	3E-7	1E-9	-	-
61	Promethium-144	W, see ^{141}Pm	1E+3	1E+2	5E-8	2E-10	2E-5	2E-4
		Y, see ^{141}Pm	-	1E+2	5E-8	2E-10	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
61	Promethium-145	W, see ^{141}Pm	1E+4	2E+2	7E-8	-	1E-4	1E-3
			-	Bone surf (2E+2)	-	3E-10	-	-
		Y, see ^{141}Pm	-	2E+2	8E-8	3E-10	-	-
61	Promethium-146	W, see ^{141}Pm	2E+3	5E+1	2E-8	7E-11	2E-5	2E-4
		Y, see ^{141}Pm	-	4E+1	2E-8	6E-11	-	-
61	Promethium-147	W, see ^{141}Pm	4E+3	1E+2	5E-8	-	-	-
			LLI wall (5E+3)	Bone surf (2E+2)	-	3E-10	7E-5	7E-4
		Y, see ^{141}Pm	-	1E+2	6E-8	2E-10	-	-
61	Promethium-148m	W, see ^{141}Pm	7E+2	3E+2	1E-7	4E-10	1E-5	1E-4
		Y, see ^{141}Pm	-	3E+2	1E-7	5E-10	-	-
61	Promethium-148	W, see ^{141}Pm	4E+2	5E+2	2E-7	8E-10	-	-
			LLI wall (5E+2)	-	-	-	7E-6	7E-5
		Y, see ^{141}Pm	-	5E+2	2E-7	7E-10	-	-
61	Promethium-149	W, see ^{141}Pm	1E+3	2E+3	8E-7	3E-9	-	-
			LLI wall (1E+3)	-	-	-	2E-5	2E-4
		Y, see ^{141}Pm	-	2E+3	8E-7	2E-9	-	-
61	Promethium-150	W, see ^{141}Pm	5E+3	2E+4	8E-6	3E-8	7E-5	7E-4
		Y, see ^{141}Pm	-	2E+4	7E-6	2E-8	-	-
61	Promethium-151	W, see ^{141}Pm	2E+3	4E+3	1E-6	5E-9	2E-5	2E-4
		Y, see ^{141}Pm	-	3E+3	1E-6	4E-9	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
62	Samarium-141m[2]	W, all compounds	3E+4	1E+5	4E-5	1E-7	4E-4	4E-3
62	Samarium-141[2]	W, all compounds	5E+4	2E+5	8E-5	2E-7	-	-
			St. wall (6E+4)	-	-	-	8E-4	8E-3
62	Samarium-142[2]	W, all compounds	8E+3	3E+4	1E-5	4E-8	1E-4	1E-3
62	Samarium-145	W, all compounds	6E+3	5E+2	2E-7	7E-10	8E-5	8E-4
62	Samarium-146	W, all compounds	1E+1	4E+2	1E-11	-	-	-
			Bone surf (3E+1)	Bone surf (6E-2)	-	9E-14	3E-7	3E-6
62	Samarium-147	W, all compounds	2E+1	4E+2	2E-11	-	-	-
			Bone surf (3E+1)	Bone surf (7E-2)	-	1E-13	4E-7	4E-6
62	Samarium-151	W, all compounds	1E+4	1E+2	4E-8	-	-	-
			LLI wall (1E+4)	Bone surf (2E+2)	-	2E-10	2E-4	2E-3
62	Samarium-153	W, all compounds	2E+3	3E+3	1E-6	4E-9	-	-
			LLI wall (2E+3)	-	-	-	3E-5	3E-4
62	Samarium-155[2]	W, all compounds	6E+4	2E+5	9E-5	3E-7	-	-
			St. wall (8E+4)	-	-	-	1E-3	1E-2

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
62	Samarium-156	W, all compounds	5E+3	9E+3	4E-6	1E-8	7E-5	7E-4
63	Europium-145	W, all compounds	2E+3	2E+3	8E-7	3E-9	2E-5	2E-4
63	Europium-146	W, all compounds	1E+3	1E+3	5E-7	2E-9	1E-5	1E-4
63	Europium-147	W, all compounds	3E+3	2E+3	7E-7	2E-9	4E-5	4E-4
63	Europium-148	W, all compounds	1E+3	4E+2	1E-7	5E-10	1E-5	1E-4
63	Europium-149	W, all compounds	1E+4	3E+3	1E-6	4E-9	2E-4	2E-3
63	Europium-150 (12.62 h)	W, all compounds	3E+3	8E+3	4E-6	1E-8	4E-5	4E-4
63	Europium-150 (34.2 y)	W, all compounds	8E+2	2E+1	8E-9	3E-11	1E-5	1E-4
63	Europium-152m	W, all compounds	3E+3	6E+3	3E-6	9E-9	4E-5	4E-4
63	Europium-152	W, all compounds	8E+2	2E+1	1E-8	3E-11	1E-5	1E-4
63	Europium-154	W, all compounds	5E+2	2E+1	8E-9	3E-11	7E-6	7E-5
63	Europium-155	W, all compounds	4E+3	9E+1	4E-8	-	5E-5	5E-4
			-	Bone surf (1E+2)	-	2E-10	-	-
63	Europium-156	W, all compounds	6E+2	5E+2	2E-7	6E-10	8E-6	8E-5

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation		Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
63	Europium-157	W, all compounds	2E+3	5E+3	2E-6	7E-9	3E-5	3E-4
63	Europium-158[2]	W, all compounds	2E+4	6E+4	2E-5	8E-8	3E-4	3E-3
64	Gadolinium-145[2]	D, all compounds except those given for W	5E+4	2E+5	6E-5	2E-7	-	-
			St. wall (5E+4)	-	-	-	6E-4	6E-3
		W, oxides, hydroxides, and fluorides	-	2E+5	7E-5	2E-7	-	-
64	Gadolinium-146	D, see ^{145}Gd	1E+3	1E+2	5E-8	2E-10	2E-5	2E-4
		W, see ^{145}Gd	-	3E+2	1E-7	4E-10	-	-
64	Gadolinium-147	D, see ^{145}Gd	2E+3	4E+3	2E-6	6E-9	3E-5	3E-4
		W, see ^{145}Gd	-	4E+3	1E-6	5E-9	-	-
64	Gadolinium-148	D, see ^{145}Gd	1E+1	8E+3	3E-12	-	-	-
			Bone surf (2E+1)	Bone surf (2E+2)	-	2E-14	3E-7	3E-6
		W, see ^{145}Gd	-	3E-2	1E-11	-	-	-
			-	Bone surf (6E-2)	-	8E-14	-	-
64	Gadolinium-149	D, see ^{145}Gd	3E+3	2E+3	9E-7	3E-9	4E-5	4E-4
		W, see ^{145}Gd	-	2E+3	1E-6	3E-9	-	-
64	Gadolinium-151	D, see ^{145}Gd	6E+3	4E+2	2E-7	-	9E-5	9E-4
			-	Bone surf (6E+2)	-	9E-10	-	-
		W, see ^{145}Gd	-	1E+3	5E-7	2E-9	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
64	Gadolinium-152	D, see ^{145}Gd	2E+1	1E-2	4E-12	-	-	-
			Bone surf (3E+1)	Bone surf (2E-2)	-	3E-14	4E-7	4E-6
		W, see ^{145}Gd	-	4E-2	2E-11	-	-	-
			-	Bone surf (8E-2)	-	1E-13	-	-
64	Gadolinium-153	D, see ^{145}Gd	5E+3	1E+2	6E-8	-	6E-5	6E-4
			-	Bone surf (2E+2)	-	3E-10	-	-
		W, see ^{145}Gd	-	6E+2	2E-7	8E-10	-	-
64	Gadolinium-159	D, see ^{145}Gd	3E+3	8E+3	3E-6	1E-8	4E-5	4E-4
		W, see ^{145}Gd	-	6E+3	2E-6	8E-9	-	-
65	Terbium-147[2]	W, all compounds	9E+3	3E+4	1E-5	5E-8	1E-4	1E-3
65	Terbium-149	W, all compounds	5E+3	7E+2	3E-7	1E-9	7E-5	7E-4
65	Terbium-150	W, all compounds	5E+3	2E+4	9E-6	3E-8	7E-5	7E-4
65	Terbium-151	W, all compounds	4E+3	9E+3	4E-6	1E-8	5E-5	5E-4
65	Terbium-153	W, all compounds	5E+3	7E+3	3E-6	1E-8	7E-5	7E-4
65	Terbium-154	W, all compounds	2E+3	4E+3	2E-6	6E-9	2E-5	2E-4
65	Terbium-155	W, all compounds	6E+3	8E+3	3E-6	1E-8	8E-5	8E-4
65	Terbium-156m (5.0 h)	W, all compounds	2E+4	3E+4	1E-5	4E-8	2E-4	2E-3

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
65	Terbium-156m (24.4 h)	W, all compounds	7E+3	8E+3	3E-6	1E-8	1E-4	1E-3
65	Terbium-156	W, all compounds	1E+3	1E+3	6E-7	2E-9	1E-5	1E-4
65	Terbium-157	W, all compounds	5E+4	3E+2	1E-7	-	-	-
			LLI wall (5E+4)	Bone surf (6E+2)	-	8E-10	7E-4	7E-3
65	Terbium-158	W, all compounds	1E+3	2E+1	8E-9	3E-11	2E-5	2E-4
65	Terbium-160	W, all compounds	8E+2	2E+2	9E-8	3E-10	1E-5	1E-4
65	Terbium-161	W, all compounds	2E+3	2E+3	7E-7	2E-9	-	-
			LLI wall (2E+3)	-	-	-	3E-5	3E-4
66	Dysprosium-155	W, all compounds	9E+3	3E+4	1E-5	4E-8	1E-4	1E-3
66	Dysprosium-157	W, all compounds	2E+4	6E+4	3E-5	9E-8	3E-4	3E-3
66	Dysprosium-159	W, all compounds	1E+4	2E+3	1E-6	3E-9	2E-4	2E-3
66	Dysprosium-165	W, all compounds	1E+4	5E+4	2E-5	6E-8	2E-4	2E-3
66	Dysprosium-166	W, all compounds	6E+2	7E+2	3E-7	1E-9	-	-
			LLI wall (8E+2)	-	-	-	1E-5	1E-4
67	Holmium-155[2]	W, all compounds	4E+4	2E+5	6E-5	2E-7	6E-4	6E-3

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
67	Holmium-157[2]	W, all compounds	3E+5	1E+6	5E-4	2E-6	4E-3	4E-2
67	Holmium-159[2]	W, all compounds	2E+5	1E+6	4E-4	1E-6	3E-3	3E-2
67	Holmium-161	W, all compounds	1E+5	4E+5	2E-4	6E-7	1E-3	1E-2
67	Holmium-162m[2]	W, all compounds	5E+4	3E+5	1E-4	4E-7	7E-4	7E-3
67	Holmium-162[2]	W, all compounds	5E+5	2E+6	1E-3	3E-6	-	-
			St. wall (8E+5)	-	-	-	1E-2	1E-1
67	Holmium-164m[2]	W, all compounds	1E+5	3E+5	1E-4	4E-7	1E-3	1E-2
67	Holmium-164[2]	W, all compounds	2E+5	6E+5	3E-4	9E-7	-	-
			St. wall (2E+5)	-	-	-	3E-3	3E-2
67	Holmium-166m	W, all compounds	6E+2	7E+0	3E-9	9E-12	9E-6	9E-5
67	Holmium-166	W, all compounds	9E+2	2E+3	7E-7	2E-9	-	-
			LLI wall (9E+2)	-	-	-	1E-5	1E-4
67	Holmium-167	W, all compounds	2E+4	6E+4	2E-5	8E-8	2E-4	2E-3
68	Erbium-161	W, all compounds	2E+4	6E+4	3E-5	9E-8	2E-4	2E-3
68	Erbium-165	W, all compounds	6E+4	2E+5	8E-5	3E-7	9E-4	9E-3

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
68	Erbium-169	W, all compounds	3E+3	3E+3	1E-6	4E-9	-	-
			LLI wall (4E+3)	-	-	-	5E-5	5E-4
68	Erbium-171	W, all compounds	4E+3	1E+4	4E-6	1E-8	5E-5	5E-4
68	Erbium-172	W, all compounds	1E+3	1E+3	6E-7	2E-9	-	-
			LLI wall (1E+3)	-	-	-	2E-5	2E-4
69	Thulium-162[2]	W, all compounds	7E+4	3E+5	1E-4	4E-7	-	-
			St. wall (7E+4)	-	-	-	1E-3	1E-2
69	Thulium-166	W, all compounds	4E+3	1E+4	6E-6	2E-8	6E-5	6E-4
69	Thulium-167	W, all compounds	2E+3	2E+3	8E-7	3E-9	-	-
			LLI wall (2E+3)	-	-	-	3E-5	3E-4
69	Thulium-170	W, all compounds	8E+2	2E+2	9E-8	3E-10	-	-
			LLI wall (1E+3)	-	-	-	1E-5	1E-4
69	Thulium-171	W, all compounds	1E+4	3E+2	1E-7	-	-	-
			LLI wall (1E+4)	Bone surf (6E+2)	-	8E-10	2E-4	2E-3
69	Thulium-172	W, all compounds	7E+2	1E+3	5E-7	2E-9	-	-
			LLI wall (8E+2)	-	-	-	1E-5	1E-4

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
69	Thulium-173	W, all compounds	4E+3	1E+4	5E-6	2E-8	6E-5	6E-4
69	Thulium-175[2]	W, all compounds	7E+4	3E+5	1E-4	4E-7	-	-
			St. wall (9E+4)	-	-	-	1E-3	1E-2
70	Ytterbium-162[2]	W, all compounds except those given for Y	7E+4	3E+5	1E-4	4E-7	1E-3	1E-2
		Y, oxides, hydroxides, and fluorides	-	3E+5	1E-4	4E-7	-	-
70	Ytterbium-166	W, see ^{162}Yb	1E+3	2E+3	8E-7	3E-9	2E-5	2E-4
		Y, see ^{162}Yb	-	2E+3	8E-7	3E-9	-	-
70	Ytterbium-167[2]	W, see ^{162}Yb	3E+5	8E+5	3E-4	1E-6	4E-3	4E-2
		Y, see ^{162}Yb	-	7E+5	3E-4	1E-6	-	-
70	Ytterbium-169	W, see ^{162}Yb	2E+3	8E+2	4E-7	1E-9	2E-5	2E-4
		Y, see ^{162}Yb	-	7E+2	3E-7	1E-9	-	-
70	Ytterbium-175	W, see ^{162}Yb	3E+3	4E+3	1E-6	5E-9	-	-
			LLI wall (3E+3)	-	-	-	4E-5	4E-4
		Y, see ^{162}Yb	-	3E+3	1E-6	5E-9	-	-
70	Ytterbium-177[2]	W, see ^{162}Yb	2E+4	5E+4	2E-5	7E-8	2E-4	2E-3
		Y, see ^{162}Yb	-	5E+4	2E-5	6E-8	-	-
70	Ytterbium-178[2]	W, see ^{162}Yb	1E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		Y, see ^{162}Yb	-	4E+4	2E-5	5E-8	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
71	Lutetium-169	W, all compounds except those given for Y	3E+3	4E+3	2E-6	6E-9	3E-5	3E-4
		Y, oxides, hydroxides, and fluorides	-	4E+3	2E-6	6E-9	-	-
71	Lutetium-170	W, see ^{169}Lu	1E+3	2E+3	9E-7	3E-9	2E-5	2E-4
		Y, see ^{169}Lu	-	2E+3	8E-7	3E-9	-	-
71	Lutetium-171	W, see ^{169}Lu	2E+3	2E+3	8E-7	3E-9	3E-5	3E-4
		Y, see ^{169}Lu	-	2E+3	8E-7	3E-9	-	-
71	Lutetium-172	W, see ^{169}Lu	1E+3	1E+3	5E-7	2E-9	1E-5	1E-4
		Y, see ^{169}Lu	-	1E+3	5E-7	2E-9	-	-
71	Lutetium-173	W, see ^{169}Lu	5E+3	3E+2	1E-7	-	7E-5	7E-4
			-	Bone surf (5E+2)	-	6E-10	-	-
		Y, see ^{169}Lu	-	3E+2	1E-7	4E-10	-	-
71	Lutetium-174m	W, see ^{169}Lu	2E+3	2E+2	1E-7	-	-	-
			LLI wall (3E+3)	Bone surf (3E+2)	-	5E-10	4E-5	4E-4
		Y, see ^{169}Lu	-	2E+2	9E-8	3E-10	-	-
71	Lutetium-174	W, see ^{169}Lu	5E+3	1E+2	5E-8	-	7E-5	7E-4
			-	Bone surf (2E+2)	-	3E-10	-	-
		Y, see ^{169}Lu	-	2E+2	6E-8	2E-10	-	-
71	Lutetium-176m	W, see ^{169}Lu	8E+3	3E+4	1E-5	3E-8	1E-4	1E-3
		Y, see ^{169}Lu	-	2E+4	9E-6	3E-8	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
71	Lutetium-176	W, see ^{169}Lu	7E+2	5E+0	2E-9	-	1E-5	1E-4
			-	Bone surf (1E+1)	-	2E-11	-	-
		Y, see ^{169}Lu	-	8E+0	3E-9	1E-11	-	-
71	Lutetium-177m	W, see ^{169}Lu	7E+2	1E+2	5E-8	-	1E-5	1E-4
			-	Bone surf (1E+2)	-	2E-10	-	-
		Y, see ^{169}Lu	-	8E+1	3E-8	1E-10	-	-
71	Lutetium-177	W, see ^{169}Lu	2E+3	2E+3	9E-7	3E-9	-	-
			LLI wall (3E+3)	-	-	-	4E-5	4E-4
		Y, see ^{169}Lu	-	2E+3	9E-7	3E-9	-	-
71	Lutetium-178m[2]	W, see ^{169}Lu	5E+4	2E+5	8E-5	3E-7	-	-
			St. wall (6E+4)	-	-	-	8E-4	8E-3
		Y, see ^{169}Lu	-	2E+5	7E-5	2E-7	-	-
71	Lutetium-178[2]	W, see ^{169}Lu	4E+4	1E+5	5E-5	2E-7	-	-
			St. wall (4E+4)	-	-	-	6E-4	6E-3
		Y, see ^{169}Lu	-	1E+5	5E-5	2E-7	-	-
71	Lutetium-179	W, see ^{169}Lu	[illegible]+3	2E+4	8E-6	3E-8	9E-5	9E-4
		Y, see ^{169}Lu		2E+4	6E-6	3E-8	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				Monthly Average
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Concentration (μCi/ml)
72	Hafnium-170	D, all compounds except those given for W	3E+3	6E+3	2E-6	8E-9	4E-5	4E-4
		W, oxides, hydroxides, carbides, and nitrates	-	5E+3	2E-6	6E-9	-	-
72	Hafnium-172	D, see ^{170}Hf	1E+3	9E+0	4E-9	-	2E-5	2E-4
			-	Bone surf (2E+1)	-	3E-11	-	-
		W, see ^{170}Hf	-	4E+1	2E-8	-	-	-
			-	Bone surf (6E+1)	-	8E-11	-	-
72	Hafnium-173	D, see ^{170}Hf	5E+3	1E+4	5E-6	2E-8	7E-5	7E-4
		W, see ^{170}Hf	-	1E+4	5E-6	2E-8	-	-
72	Hafnium-175	D, see ^{170}Hf	3E+3	9E+2	4E-7	-	4E-5	4E-4
			-	Bone surf (1E+3)	-	1E-9	-	-
		W, see ^{170}Hf	-	1E+3	5E-7	2E-9	-	-
72	Hafnium-177m[2]	D, see ^{170}Hf	2E+4	6E+4	2E-5	8E-8	3E-4	3E-3
		W, see ^{170}Hf	-	9E+4	4E-5	1E-7	-	-
72	Hafnium-178m	D, see ^{170}Hf	3E+2	1E+0	5E-10	-	3E-6	3E-5
			-	Bone surf (2E+0)	-	3E-12	-	-
		W, see ^{170}Hf	-	5E+0	2E-9	-	-	-
			-	Bone surf (9E+0)	-	1E-11	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
72	Hafnium-179m	D, see ^{170}Hf	1E+3	3E+2	1E-7	-	1E-5	1E-4
			-	Bone surf (6E+2)	-	8E-10	-	-
		W, see ^{170}Hf	-	6E+2	3E-7	8E-10	-	-
72	Hafnium-180m	D, see ^{170}Hf	7E+3	2E+4	9E-6	3E-8	1E-4	1E-3
		W, see ^{170}Hf	-	3E+4	1E-5	4E-8	-	-
72	Hafnium-181	D, see ^{170}Hf	1E+3	2E+2	7E-8	-	2E-5	2E-4
			-	Bone surf (4E+2)	-	6E-10	-	-
		W, see ^{170}Hf	-	4E+2	2E-7	6E-10	-	-
72	Hafnium-182m[2]	D, see ^{170}Hf	4E+4	9E+4	4E-5	1E-7	5E-4	5E-3
		W, see ^{170}Hf	-	1E+5	6E-5	2E-7	-	-
72	Hafnium-182	D, see ^{170}Hf	2E+2	8E-1	3E-10	-	-	-
			Bone surf (4E+2)	Bone surf (2E+0)	-	2E-12	5E-6	5E-5
		W, see ^{170}Hf	-	3E+0	1E-9	-	-	-
			-	Bone surf (7E+0)	-	1E-11	-	-
72	Hafnium-183[2]	D, see ^{170}Hf	2E+4	5E+4	2E-5	6E-8	3E-4	3E-3
		W, see ^{170}Hf	-	6E+4	2E-5	8E-8	-	-
72	Hafnium-184	D, see ^{170}Hf	2E+3	8E+3	3E-6	1E-8	3E-5	3E-4
		W, see ^{170}Hf	-	6E+3	3E-6	9E-9	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table Relea Sewe
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
73	Tantalum-172[2]	W, all compounds except those given for Y	4E+4	1E+5	5E-5	2E-7	5E-4	5E-3
		Y, elemental Ta, oxides, hydroxides, halides, carbides, nitrates, and nitrides	-	1E+5	4E-5	1E-7	-	-
73	Tantalum-173	W, see ^{172}Ta	7E+3	2E+4	8E-6	3E-8	9E-5	9E-4
		Y, see ^{172}Ta	-	2E+4	7E-6	2E-8	-	-
73	Tantalum-174[2]	W, see ^{172}Ta	3E+4	1E+5	4E-5	1E-7	4E-4	4E-3
		Y, see ^{172}Ta	-	9E+4	4E-5	1E-7	-	-
73	Tantalum-175	W, see ^{172}Ta	6E+3	2E+4	7E-6	2E-8	8E-5	8E-4
		Y, see ^{172}Ta	-	1E+4	6E-6	2E-8	-	-
73	Tantalum-176	W, see ^{172}Ta	4E+3	1E+4	5E-6	2E-8	5E-5	5E-4
		Y, see ^{172}Ta	-	1E+4	5E-6	2E-8	-	-
73	Tantalum-177	W, see ^{172}Ta	1E+4	2E+4	8E-6	3E-8	2E-4	2E-3
		Y, see ^{172}Ta	-	2E+4	7E-6	2E-8	-	-
73	Tantalum-178	W, see ^{172}Ta	2E+4	9E+4	4E-5	1E-7	2E-4	2E-3
		Y, see ^{172}Ta	-	7E+4	3E-5	1E-7	-	-
73	Tantalum-179	W, see ^{172}Ta	2E+4	5E+3	2E-6	8E-9	3E-4	3E-3
		Y, see ^{172}Ta	-	9E+2	4E-7	1E-9	-	-
73	Tantalum-180m	W, see ^{172}Ta	2E+4	7E+4	3E-5	9E-8	3E-4	3E-3
		Y, see ^{172}Ta	-	6E+4	2E-5	8E-8	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
73	Tantalum-180	W, see ^{172}Ta	1E+3	4E+2	2E-7	6E-10	2E-5	2E-4
		Y, see ^{172}Ta	-	2E+1	1E-8	3E-11	-	-
73	Tantalum-182m[2]	W, see ^{172}Ta	2E+5	5E+5	2E-4	8E-7	-	-
			St. wall (2E+5)	-	-	-	3E-3	3E-2
		Y, see ^{172}Ta	-	4E+5	2E-4	6E-7	-	-
73	Tantalum-182	W, see ^{172}Ta	8E+2	3E+2	1E-7	5E-10	1E-5	1E-4
		Y, see ^{172}Ta	-	1E+2	6E-8	2E-10	-	-
73	Tantalum-183	W, see ^{172}Ta	9E+2	1E+3	5E-7	2E-9	-	-
			LLI wal (1E+3)	-	-	-	2E-5	2E-4
		Y, see ^{172}Ta	-	1E+3	4E-7	1E-9	-	-
73	Tantalum-184	W, see ^{172}Ta	2E+3	5E+3	2E-6	8E-9	3E-5	3E-4
		Y, see ^{172}Ta	-	5E+3	2E-6	7E-9	-	-
73	Tantalum-185[2]	W, see ^{172}Ta	3E+4	7E+4	3E-5	1E-7	4E-4	4E-3
		Y, see ^{172}Ta	-	6E+4	3E-5	9E-8	-	-
73	Tantalum-186[2]	W, see ^{172}Ta	5E+4	2E+5	1E-4	3E-7	-	-
			St. wall (7E+4)	-	-	-	1E-3	1E-2
		Y, see ^{172}Ta	-	2E+5	9E-5	3E-7	-	-
74	Tungsten-176	D, all compounds	1E+4	5E+4	2E-5	7E-8	1E-4	1E-3
74	Tungsten-177	D, all compounds	2E+4	9E+4	4E-5	1E-7	3E-4	3E-3

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
74	Tungsten-178	D, all compounds	5E+3	2E+4	8E-6	3E-8	7E-5	7E-4
74	Tungsten-179[2]	D, all compounds	5E+5	2E+6	7E-4	2E-6	7E-3	7E-2
74	Tungsten-181	D, all compounds	2E+4	3E+4	1E-5	5E-8	2E-4	2E-3
74	Tungsten-185	D, all compounds	2E+3	7E+3	3E-6	9E-9	-	-
			LLI wall					
			(3E+3)	-	-	-	4E-5	4E-4
74	Tungsten-187	D, all compounds	2E+3	9E+3	4E-6	1E-8	3E-5	3E-4
74	Tungsten-188	D, all compounds	4E+2	1E+3	5E-7	2E-9	-	-
			LLI wall					
			(5E+2)	-	-	-	7E-6	7E-5
75	Rhenium-177[2]	D, all compounds except those given for W	9E+4	3E+5	1E-4	4E-7	-	-
			St. wall					
			(1E+5)	-	-	-	2E-3	2E-2
		W, oxides, hydroxides, and nitrates	-	4E+5	1E-4	5E-7	-	-
75	Rhenium-178[2]	D, see ^{177}Re	7E+4	3E+5	1E-4	4E-7	-	-
			St. wall					
			(1E+5)	-	-	-	1E-3	1E-2
		W, see ^{177}Re	-	3E+5	1E-4	4E-7	-	-
75	Rhenium-181	D, see ^{177}Re	5E+3	9E+3	4E-6	1E-8	7E-5	7E-4
		W, see ^{177}Re	-	9E+3	4E-6	1E-8	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
75	Rhenium-182 (12.7 h)	D, see ^{177}Re	7E+3	1E+4	5E-6	2E-8	9E-5	9E-4
		W, see ^{177}Re	-	2E+4	6E-6	2E-8	-	-
75	Rhenium-182 (64.0 h)	D, see ^{177}Re	1E+3	2E+3	1E-6	3E-9	2E-5	2E-4
		W, see ^{177}Re	-	2E+3	9E-7	3E-9	-	-
75	Rhenium-184m	D, see ^{177}Re	2E+3	3E+3	1E-6	4E-9	3E-5	3E-4
		W, see ^{177}Re	-	4E+2	2E-7	6E-10	-	-
75	Rhenium-184	D, see ^{177}Re	2E+3	4E+3	1E-6	5E-9	3E-5	3E-4
		W, see ^{177}Re	-	1E+3	6E-7	2E-9	-	-
75	Rhenium-186m	D, see ^{177}Re	1E+3	2E+3	7E-7	-	-	-
			St. wall (2E+3)	St. wall (2E+3)	-	3E-9	2E-5	2E-4
		W, see ^{177}Re	-	2E+2	6E-8	2E-10	-	-
75	Rhenium-186	D, see ^{177}Re	2E+3	3E+3	1E-6	4E-9	3E-5	3E-4
		W, see ^{177}Re	-	2E+3	7E-7	2E-9	-	-
75	Rhenium-187	D, see ^{177}Re	6E+5	8E+5	4E-4	-	8E-3	8E-2
			-	St. wall (9E+5)	-	1E-6	-	-
		W, see ^{177}Re	-	1E+5	4E-5	1E-7	-	-
75	Rhenium-188m[2]	D, see ^{177}Re	8E+4	1E+5	6E-5	2E-7	1E-3	1E-2
		W, see ^{177}Re	-	1E+5	6E-5	2E-7	-	-
75	Rhenium-188	D, see ^{177}Re	2E+3	3E+3	1E-6	4E-9	2E-5	2E-4
		W, see ^{177}Re	-	3E+3	1E-6	4E-9	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
75	Rhenium-189	D, see ^{177}Re	3E+3	5E+3	2E-6	7E-9	4E-5	4E-4
		W, see ^{177}Re	-	4E+3	2E-6	6E-9	-	-
76	Osmium-180[2]	D, all compounds except those given for W and Y	1E+5	4E+5	2E-4	5E-7	1E-3	1E-2
		W, halides and nitrates	-	5E+5	2E-4	7E-7	-	-
		Y, oxides and hydroxides	-	5E+5	2E-4	6E-7	-	-
76	Osmium-181[2]	D, see ^{180}Os	1E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{180}Os	-	5E+4	2E-5	6E-8	-	-
		Y, see ^{180}Os	-	4E+4	2E-5	6E-8	-	-
76	Osmium-182	D, see ^{180}Os	2E+3	6E+3	2E-6	8E-9	3E-5	3E-4
		W, see ^{180}Os	-	4E+3	2E-6	6E-9	-	-
		Y, see ^{180}Os	-	4E+3	2E-6	6E-9	-	-
76	Osmium-185	D, see ^{180}Os	2E+3	5E+2	2E-7	7E-10	3E-5	3E-4
		W, see ^{180}Os	-	8E+2	3E-7	1E-9	-	-
		Y, see ^{180}Os	-	8E+2	3E-7	1E-9	-	-
76	Osmium-189m	D, see ^{180}Os	8E+4	2E+5	1E-4	3E-7	1E-3	1E-2
		W, see ^{180}Os	-	2E+5	9E-5	3E-7	-	-
		Y, see ^{180}Os	-	2E+5	7E-5	2E-7	-	-
76	Osmium-191m	D, see ^{180}Os	1E+4	3E+4	1E-5	4E-8	2E-4	2E-3
		W, see ^{180}Os	-	2E+4	8E-6	3E-8	-	-
		Y, see ^{180}Os	-	2E+4	7E-6	2E-8	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
76	Osmium-191	D, see ^{180}Os	2E+3	2E+3	9E-7	3E-9	-	-
			LLI wall (3E+3)	-	-	-	3E-5	3E-4
		W, see ^{180}Os	-	2E+3	7E-7	2E-9	-	-
		Y, see ^{180}Os	-	1E+3	6E-7	2E-9	-	-
76	Osmium-193	D, see ^{180}Os	2E+3	5E+3	2E-6	6E-9	-	-
			LLI wall (2E+3)	-	-	-	2E-5	2E-4
		W, see ^{180}Os	-	3E+3	1E-6	4E-9	-	-
		Y, see ^{180}Os	-	3E+3	1E-6	4E-9	-	-
76	Osmium-194	D, see ^{180}Os	4E+2	4E+1	2E-8	6E-11	-	-
			LLI wall (6E+2)	-	-	-	8E-6	8E-5
		W, see ^{180}Os	-	6E+1	2E-8	8E-11	-	-
		Y, see ^{180}Os	-	8E+0	3E-9	1E-11	-	-
77	Iridium-182[2]	D, all compounds except those given for W and Y	4E+4	1E+5	6E-5	2E-7	-	-
			St. wall (4E+4)	-	-	-	6E-4	6E-3
		W, halides, nitrates, and metallic iridium	-	2E+5	6E-5	2E-7	-	-
		Y, oxides and hydroxides	-	1E+5	5E-5	2E-7	-	-
77	Iridium-184	D, see ^{182}Ir	8E+3	2E+4	1E-5	3E-8	1E-4	1E-3
		W, see ^{182}Ir	-	3E+4	1E-5	5E-8	-	-
		Y, see ^{182}Ir	-	3E+4	1E-5	4E-8	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table 1 Occupational Values Col. 2 Inhalation ALI (μCi)	Table 1 Occupational Values Col. 3 Inhalation DAC (μCi/ml)	Table 2 Effluent Concentrations Col. 1 Air (μCi/ml)	Table 2 Effluent Concentrations Col. 2 Water (μCi/ml)	Table 3 Releases to Sewers Monthly Average Concentration (μCi/ml)
77	Iridium-185	D, see ^{182}Ir	5E+3	1E+4	5E-6	2E-8	7E-5	7E-4
		W, see ^{182}Ir	-	1E+4	5E-6	2E-8	-	-
		Y, see ^{182}Ir	-	1E+4	4E-6	1E-8	-	-
77	Iridium-186	D, see ^{182}Ir	2E+3	8E+3	3E-6	1E-8	3E-5	3E-4
		W, see ^{182}Ir	-	6E+3	3E-6	9E-9	-	-
		Y, see ^{182}Ir	-	6E+3	2E-6	8E-9	-	-
77	Iridium-187	D, see ^{182}Ir	1E+4	3E+4	1E-5	5E-8	1E-4	1E-3
		W, see ^{182}Ir	-	3E+4	1E-5	4E-8	-	-
		Y, see ^{182}Ir	-	3E+4	1E-5	4E-8	-	-
77	Iridium-188	D, see ^{182}Ir	2E+3	5E+3	2E-6	6E-9	3E-5	3E-4
		W, see ^{182}Ir	-	4E+3	1E-6	5E-9	-	-
		Y, see ^{182}Ir	-	3E+3	1E-6	5E-9	-	-
77	Iridium-189	D, see ^{182}Ir	5E+3 LLI wall (5E+3)	5E+3	2E-6	7E-9	-	-
		W, see ^{182}Ir	-	4E+3	2E-6	5E-9	7E-5	7E-4
		Y, see ^{182}Ir	-	4E+3	1E-6	5E-9	-	-
77	Iridium-190m[2]	D, see ^{182}Ir	2E+5	2E+5	8E-5	3E-7	2E-3	2E-2
		W, see ^{182}Ir	-	2E+5	9E-5	3E-7	-	-
		Y, see ^{182}Ir	-	2E+5	8E-5	3E-7	-	-
77	Iridium-190	D, see ^{182}Ir	1E+3	9E+2	4E-7	1E-9	1E-5	1E-4
		W, see ^{182}Ir	-	1E+3	4E-7	1E-9	-	-
		Y, see ^{182}Ir	-	9E+2	4E-7	1E-9	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table 1 Occupational Values Col. 2 Inhalation ALI (μCi)	Table 1 Occupational Values Col. 3 Inhalation DAC (μCi/ml)	Table 2 Effluent Concentrations Col. 1 Air (μCi/ml)	Table 2 Effluent Concentrations Col. 2 Water (μCi/ml)	Table 3 Releases to Sewers Monthly Average Concentration (μCi/ml)
77	Iridium-192m	D, see ^{182}Ir	3E+3	9E+1	4E-8	1E-10	4E-5	4E-4
		W, see ^{182}Ir	-	2E+2	9E-8	3E-10	-	-
		Y, see ^{182}Ir	-	2E+1	6E-9	2E-11	-	-
77	Iridium-192	D, see ^{182}Ir	9E+2	3E+2	1E-7	4E-10	1E-5	1E-4
		W, see ^{182}Ir	-	4E+2	2E-7	6E-10	-	-
		Y, see ^{182}Ir	-	2E+2	9E-8	3E-10	-	-
77	Iridium-194m	D, see ^{182}Ir	6E+2	9E+1	4E-8	1E-10	9E-6	9E-5
		W, see ^{182}Ir	-	2E+2	7E-8	2E-10	-	-
		Y, see ^{182}Ir	-	1E+2	4E-8	1E-10	-	-
77	Iridium-194	D, see ^{182}Ir	1E+3	3E+3	1E-6	4E-9	1E-5	1E-4
		W, see ^{182}Ir	-	2E+3	9E-7	3E-9	-	-
		Y, see ^{182}Ir	-	2E+3	8E-7	3E-9	-	-
77	Iridium-195m	D, see ^{182}Ir	8E+3	2E+4	1E-5	3E-8	1E-4	1E-3
		W, see ^{182}Ir	-	3E+4	1E-5	4E-8	-	-
		Y, see ^{182}Ir	-	2E+4	9E-6	3E-8	-	-
77	Iridium-195	D, see ^{182}Ir	1E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{182}Ir	-	5E+4	2E-5	7E-8	-	-
		Y, see ^{182}Ir	-	4E+4	2E-5	6E-8	-	-
78	Platinum-186	D, all compounds	1E+4	4E+4	2E-5	5E-8	2E-4	2E-3
78	Platinum-188	D, all compounds	2E+3	2E+3	7E-7	2E-9	2E-5	2E-4
78	Platinum-189	D, all compounds	1E+4	3E+4	1E-5	4E-8	1E-4	1E-3
78	Platinum-191	D, all compounds	4E+3	8E+3	4E-6	1E-8	5E-5	5E-4

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
78	Platinum-193m	D, all compounds	3E+3	6E+3	3E-6	8E-9	-	-
			LLI wall (3E+4)	-	-	-	4E-5	4E-4
78	Platinum-193	D, all compounds	4E+4	2E+4	1E-5	3E-8	-	-
			LLI wall (5E+4)	-	-	-	6E-4	6E-3
78	Platinum-195m	D, all compounds	2E+3	4E+3	2E-6	6E-9	-	-
			LLI wall (2E+3)	-	-	-	3E-5	3E-4
78	Platinum-197m[2]	D, all compounds	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3
78	Platinum-197	D, all compounds	3E+3	1E+4	4E-6	1E-8	4E-5	4E-4
78	Platinum-199[2]	D, all compounds	5E+4	1E+5	6E-5	2E-7	7E-4	7E-3
78	Platinum-200	D, all compounds	1E+3	3E+3	1E-6	5E-9	2E-5	2E-4
79	Gold-193	D, all compounds except those given for W and Y	9E+3	3E+4	1E-5	4E-8	1E-4	1E-3
		W, halides and nitrates	-	2E+4	9E-6	3E-8	-	-
		Y, oxides and hydroxides	-	2E+4	8E-6	3E-8	-	-
79	Gold-194	D, see ^{193}Au	3E+3	8E+3	3E-6	1E-8	4E-5	4E-4
		W, see ^{193}Au	-	5E+3	2E-6	8E-9	-	-
		Y, see ^{193}Au	-	5E+3	2E-6	7E-9	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Table 2 Effluent Concentrations Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Table 3 Releases to Sewers Monthly Average Concentration (μCi/ml)
79	Gold-195	D, see ^{193}Au	5E+3	1E+4	5E-6	2E-8	7E-5	7E-4
		W, see ^{193}Au	-	1E+3	6E-7	2E-9	-	-
		Y, see ^{193}Au	-	4E+2	2E-7	6E-10	-	-
79	Gold-198m	D, see ^{193}Au	1E+3	3E+3	1E-6	4E-9	1E-5	1E-4
		W, see ^{193}Au	-	1E+3	5E-7	2E-9	-	-
		Y, see ^{193}Au	-	1E+3	5E-7	2E-9	-	-
79	Gold-198	D, see ^{193}Au	1E+3	4E+3	2E-6	5E-9	2E-5	2E-4
		W, see ^{193}Au	-	2E+3	8E-7	3E-9	-	-
		Y, see ^{193}Au	-	2E+3	7E-7	2E-9	-	-
79	Gold-199	D, see ^{193}Au	3E+3	9E+3	4E-6	1E-8	-	-
			LLI wall (3E+3)	-	-	-	4E-5	4E-4
		W, see ^{193}Au	-	4E+3	2E-6	6E-9	-	-
		Y, see ^{193}Au	-	4E+3	2E-6	5E-9	-	-
79	Gold-200m	D, see ^{193}Au	1E+3	4E+3	1E-6	5E-9	2E-5	2E-4
		W, see ^{193}Au	-	3E+3	1E-6	4E-9	-	-
		Y, see ^{193}Au	-	2E+4	1E-6	3E-9	-	-
79	Gold-200[2]	D, see ^{193}Au	3E+4	6E+4	3E-5	9E-8	4E-4	4E-3
		W, see ^{193}Au	-	8E+4	3E-5	1E-7	-	-
		Y, see ^{193}Au	-	7E+4	3E-5	1E-7	-	-
79	Gold-201[2]	D, see ^{193}Au	7E+4	2E+5	9E-5	3E-7	-	-
			St. wall (9E+4)	-	-	-	1E-3	1E-2
		W, see ^{193}Au	-	2E+5	1E-4	3E-7	-	-
		Y, see ^{193}Au	-	2E+5	9E-5	3E-7	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
80	Mercury-193m	Vapor	-	8E+3	4E-6	1E-8	-	-
		Organic D	4E+3	1E+4	5E-6	2E-8	6E-5	6E-4
		D, sulfates	3E+3	9E+3	4E-6	1E-8	4E-5	4E-4
		W, oxides, hydroxides, halides, nitrates, and sulfides	-	8E+3	3E-6	1E-8	-	-
80	Mercury-193	Vapor	-	3E+4	1E-5	4E-8	-	-
		Organic D	2E+4	6E+4	3E-5	9E-8	3E-4	3E-3
		D, see ^{193m}Hg	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{193m}Hg	-	4E+4	2E-5	6E-8	-	-
80	Mercury-194	Vapor	-	3E+1	1E-8	4E-11	-	-
		Organic D	2E+1	3E+1	1E-8	4E-11	2E-7	2E-6
		D, see ^{193m}Hg	8E+2	4E+1	2E-8	6E-11	1E-5	1E-4
		W, see ^{193m}Hg	-	1E+2	5E-8	2E-10	-	-
80	Mercury-195m	Vapor	-	4E+3	2E-6	6E-9	-	-
		Organic D	3E+3	6E+3	3E-6	8E-9	4E-5	4E-4
		D, see ^{193m}Hg	2E+3	5E+3	2E-6	7E-9	3E-5	3E-4
		W, see ^{193m}Hg	-	4E+3	2E-6	5E-9	-	-
80	Mercury-195	Vapor	-	3E+4	1E-5	4E-8	-	-
		Organic D	2E+4	5E+4	2E-5	6E-8	2E-4	2E-3
		D, see ^{193m}Hg	1E+4	4E+4	1E-5	5E-8	2E-4	2E-3
		W, see ^{193m}Hg	-	3E+4	1E-5	5E-8	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
80	Mercury-197m	Vapor	-	5E+3	2E-6	7E-9	-	-
		Organic D	4E+3	9E+3	4E-6	1E-8	5E-5	5E-4
		D, see ^{193m}Hg	3E+3	7E+3	3E-6	1E-8	4E-5	4E-4
		W, see ^{193m}Hg	-	5E+3	2E-6	7E-9	-	-
80	Mercury-197	Vapor	-	8E+3	4E-6	1E-8	-	-
		Organic D	7E+3	1E+4	6E-6	2E-8	9E-5	9E-4
		D, see ^{193m}Hg	6E+3	1E+4	5E-6	2E-8	8E-5	8E-4
		W, see ^{193m}Hg	-	9E+3	4E-6	1E-8	-	-
80	Mercury-199m[2]	Vapor	-	8E+4	3E-5	1E-7	-	-
		Organic D	6E+4	2E+5	7E-5	2E-7	-	-
			St. wall (1E+5)	-	-	-	1E-3	1E-2
		D, see ^{193m}Hg	6E+4	1E+5	6E-5	2E-7	8E-4	8E-3
		W, see ^{193m}Hg	-	2E+5	7E-5	2E-7	-	-
80	Mercury-203	Vapor	-	8E+2	4E-7	1E-9	-	-
		Organic D	5E+2	8E+2	3E-7	1E-9	7E-6	7E-5
		D, see ^{193m}Hg	2E+3	1E+3	5E-7	2E-9	3E-5	3E-4
		W, see ^{193m}Hg	-	1E+3	5E-7	2E-9	-	-
81	Thallium-194m[2]	D, all compounds	5E+4	2E+5	6E-5	2E-7	-	-
			St. wall (7E+4)	-	-	-	1E-3	1E-2

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
81	Thallium-194[2]	D, all compounds	3E+5	6E+5	2E-4	8E-7	-	-
			St. wall (3E+5)	-	-	-	4E-3	4E-2
81	Thallium-195[2]	D, all compounds	6E+4	1E+5	5E-5	2E-7	9E-4	9E-3
81	Thallium-197	D, all compounds	7E+4	1E+5	5E-5	2E-7	1E-3	1E-2
81	Thallium-198m[2]	D, all compounds	3E+4	5E+4	2E-5	8E-8	4E-4	4E-3
81	Thallium-198	D, all compounds	2E+4	3E+4	1E-5	5E-8	3E-4	3E-3
81	Thallium-199	D, all compounds	6E+4	8E+4	4E-5	1E-7	9E-4	9E-3
81	Thallium-200	D, all compounds	8E+3	1E+4	5E-6	2E-8	1E-4	1E-3
81	Thallium-201	D, all compounds	2E+4	2E+4	9E-6	3E-8	2E-4	2E-3
81	Thallium-202	D, all compounds	4E+3	5E+3	2E-6	7E-9	5E-5	5E-4
81	Thallium-204	D, all compounds	2E+3	2E+3	9E-7	3E-9	2E-5	2E-4
82	Lead-195m[2]	D, all compounds	6E+4	2E+5	8E-5	3E-7	8E-4	8E-3
82	Lead-198	D, all compounds	3E+4	6E+4	3E-5	9E-8	4E-4	4E-3
82	Lead-199[2]	D, all compounds	2E+4	7E+4	3E-5	1E-7	3E-4	3E-3
82	Lead-200	D, all compounds	3E+3	6E+3	3E-6	9E-9	4E-5	4E-4
82	Lead-201	D, all compounds	7E+3	2E+4	8E-6	3E-8	1E-4	1E-3

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation		Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
82	Lead-202m	D, all compounds	9E+3	3E+4	1E-5	4E-8	1E-4	1E-3
82	Lead-202	D, all compounds	1E+2	5E+1	2E-8	7E-11	2E-6	2E-5
82	Lead-203	D, all compounds	5E+3	9E+3	4E-6	1E-8	7E-5	7E-4
82	Lead-205	D, all compounds	4E+3	1E+3	6E-7	2E-9	5E-5	5E-4
82	Lead-209	D, all compounds	2E+4	6E+4	2E-5	8E-8	3E-4	3E-3
82	Lead-210	D, all compounds	6E+1 Bone surf (1E+0)	2E+1 Bone surf (4E-1)	1E-10 -	- 6E-13	- 1E-8	- 1E-7
82	Lead-211[2]	D, all compounds	1E+4	6E+2	3E-7	9E-10	2E-4	2E-3
82	Lead-212	D, all compounds	8E+1 Bone surf (1E+2)	3E+1 -	1E-8 -	5E-11 -	- 2E-6	- 2E-5
82	Lead-214[2]	D, all compounds	9E+3	8E+2	3E-7	1E-9	1E-4	1E-3
83	Bismuth-200[2]	D, nitrates W, all other compounds	3E+4 -	8E+4 1E+5	4E-5 4E-5	1E-7 1E-7	4E-4 -	4E-3 -
83	Bismuth-201[2]	D, see ^{200}Bi W, see ^{200}Bi	1E+4 -	3E+4 4E+4	1E-5 2E-5	4E-8 5E-8	2E-4 -	2E-3 -
83	Bismuth-202[2]	D, see ^{200}Bi W, see ^{200}Bi	1E+4 -	4E+4 8E+4	2E-5 3E-5	6E-8 1E-7	2E-4 -	2E-3 -

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
83	Bismuth-203	D, see ^{200}Bi	2E+3	7E+3	3E-6	9E-9	3E-5	3E-4
		W, see ^{200}Bi	-	6E+3	3E-6	9E-9	-	-
83	Bismuth-205	D, see ^{200}Bi	1E+3	3E+3	1E-6	3E-9	2E-5	2E-
		W, see ^{200}Bi	-	1E+3	5E-7	2E-9	-	-
83	Bismuth-206	D, see ^{200}Bi	6E+2	1E+3	6E-7	2E-9	9E-6	9E-5
		W, see ^{200}Bi	-	9E+2	4E-7	1E-9	-	-
83	Bismuth-207	D, see ^{200}Bi	1E+3	2E+3	7E-7	2E-9	1E-5	1E-4
		W, see ^{200}Bi	-	4E+2	1E-7	5E-10	-	-
83	Bismuth-210m	D, see ^{200}Bi	4E+1 Kidneys (6E+1)	5E+0 Kidneys (6E+0)	2E-9 -	- 9E-12	- 8E-7	- 8E-6
		W, see ^{200}Bi	-	7E-1	3E-10	9E-13	-	-
83	Bismuth-210	D, see ^{200}Bi	8E+2	2E+2 Kidneys	1E-7	-	1E-5	1E-4
			-	(4E+2)	-	5E-10	-	-
		W, see ^{200}Bi	-	3E+1	1E-8	4E-11	-	-
83	Bismuth-212[2]	D, see ^{200}Bi	5E+3	2E+2	1E-7	3E-10	7E-5	7E-4
		W, see ^{200}Bi	-	3E+2	1E-7	4E-10	-	-
83	Bismuth-213[2]	D, see ^{200}Bi	7E+3	3E+2	1E-7	4E-10	1E-4	1E-3
		W, see ^{200}Bi	-	4E+2	1E-7	5E-10	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation		Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
83	Bismuth-214[2]	D, see ^{200}Bi	2E+4	8E+2	3E-7	1E-9	-	-
		St. wall	(2E+4)	-	-	-	3E-4	3E-3
		W, see ^{200}Bi	-	9E-2	4E-7	1E-9	-	-
84	Polonium-203[2]	D, all compounds except those given for W	3E+4	6E+4	3E-5	9E-8	3E-4	3E-3
		W, oxides, hydroxides, and nitrates	-	9E+4	4E-5	1E-7	-	-
84	Polonium-205[2]	D, see ^{203}Po	2E+4	4E+4	2E-5	5E-8	3E-4	3E-3
		W, see ^{203}Po	-	7E+4	3E-5	1E-7	-	-
84	Polonium-207	D, see ^{203}Po	8E+3	3E+4	1E-5	3E-8	1E-4	1E-3
		W, see ^{203}Po	-	3E+4	1E-5	4E-8	-	-
84	Polonium-210	D, see ^{203}Po	3E+0	6E-1	3E-10	9E-13	4E-8	4E-7
		W, see ^{203}Po	-	6E-1	3E-10	9E-13	-	-
85	Astatine-207[2]	D, halides	6E+3	3E+3	1E-6	4E-9	8E-5	8E-4
		W	-	2E+3	9E-7	3E-9	-	-
85	Astatine-211	D, halides	1E+2	8E+1	3E-8	1E-10	2E-6	2E-5
		W	-	5E+1	2E-8	8E-11	-	-
86	Radon-220	With daughters removed	-	2E+4	7E-6	2E-8	-	-
		With daughters present	-	2E+1 (or 12 working level months)	9E-9 (or 1.0 working level)	3E-11	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
86	Radon-222	With daughters removed	-	1E+4	4E-6	1E-8	-	-
		With daughters present	-	1E+2 (or 4 working level months)	3E-8 (or 0.33 working level)	1E-10	-	-
87	Francium-222[2]	D, all compounds	2E+3	5E+2	2E-7	6E-10	3E-5	3E-4
87	Francium-223[2]	D, all compounds	6E+2	8E+2	3E-7	1E-9	8E-6	8E-5
88	Radium-223	W, all compounds	5E+0	7E-1	3E-10	9E-13	-	-
			Bone surf (9E+0)	-	-	-	1E-7	1E-6
88	Radium-224	W, all compounds	8E+0	2E+0	7E-10	2E-12	-	-
			Bone surf (2E+1)	-	-	-	2E-7	2E-6
88	Radium-225	W, all compounds	8E+0	7E-1	3E-10	9E-13	-	-
			Bone surf (2E+1)	-	-	-	2E-7	2E-6
88	Radium-226	W, all compounds	2E+0	6E-1	3E-10	9E-13	-	-
			Bone surf (5E+0)	-	-	-	6E-8	6E-7
88	Radium-227[2]	W, all compounds	2E+4	1E+4	6E-6	-	-	-
			Bone surf (2E+4)	Bone surf (2E+4)	-	3E-8	3E-4	3E-3

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
88	Radium-228	W, all compounds	2E+0	1E+0	5E-10	2E-12	-	-
			Bone surf (4E+0)	-	-	-	6E-8	6E-7
89	Actinium-224	D, all compounds except those given for W and Y	2E+3	3E+1	1E-8	-	-	-
			LLI wall (2E+3)	Bone surf (4E+1)	-	5E-11	3E-5	3E-4
		W, halides and nitrates	-	5E+1	2E-8	7E-11	-	-
		Y, oxides and hydroxides	-	5E+1	2E-8	6E-11	-	-
89	Actinium-225	D, see ^{224}Ac	5E+1	3E-1	1E-10	-	-	-
			LLI wall (5E+1)	Bone surf (5E-1)	-	7E-13	7E-7	7E-6
		W, see ^{224}Ac	-	6E-1	3E-10	9E-13	-	-
		Y, see ^{224}Ac	-	6E-1	3E-10	9E-13	-	-
89	Actinium-226	D, see ^{224}Ac	1E+2	3E+0	1E-9	-	-	-
			LLI wall (1E+2)	Bone surf (4E+0)	-	5E-12	2E-6	2E-5
		W, see ^{224}Ac	-	5E+0	2E-9	7E-12	-	-
		Y, see ^{224}Ac	-	5E+0	2E-9	6E-12	-	-
89	Actinium-227	D, see ^{224}Ac	2E-1	4E-4	2E-13	-	-	-
			Bone surf (4E-1)	Bone surf (8E-4)	-	1E-15	5E-9	5E-8
		W, see ^{224}Ac	-	2E-3	7E-13	-	-	-
			-	Bone surf (3E-3)	-	4E-15	-	-
		Y, see ^{224}Ac	-	4E-3	2E-12	6E-15	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation		Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
89	Actinium-228	D, see ^{224}Ac	2E+3	9E+0	4E-9	-	3E-5	3E-4
			-	Bone surf (2E+1)	-	2E-11	-	-
		W, see ^{224}Ac	-	4E+1	2E-8	-	-	-
			-	Bone surf (6E+1)	-	8E-11	-	-
		Y, see ^{224}Ac	-	4E+1	2E-8	6E-11	-	-
90	Thorium-226[2]	W, all compounds except those given for Y	5E+3	2E+2	6E-8	2E-10	-	-
			St. wall (5E+3)	-	-	-	7E-5	7E-4
		Y, oxides and hydroxides	-	1E+2	6E-8	2E-10	-	-
90	Thorium-227	W, see ^{226}Th	1E+2	3E-1	1E-10	5E-13	2E-6	2E-5
		Y, see ^{226}Th	-	3E-1	1E-10	5E-13	-	-
90	Thorium-228	W, see ^{226}Th	6E+0	1E-2	4E-12	-	-	-
			Bone surf (1E+1)	Bone surf (2E-2)	-	3E-14	2E-7	2E-6
		Y, see ^{226}Th	-	2E-2	7E-12	2E-14	-	-
90	Thorium-229	W, see ^{226}Th	6E-1	9E-4	4E-13	-	-	-
			Bone surf (1E+0)	Bone surf (2E-3)	-	3E-15	2E-8	2E-7
		Y, see ^{226}Th	-	2E-3	1E-12	-	-	-
			-	Bone surf (3E-3)	-	4E-15	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
90	Thorium-230	W, see ^{226}Th	4E+0	6E-3	3E-12	-	-	-
			Bone surf	Bone surf				
			(9E+0)	(2E-2)	-	2E-14	1E-7	1E-6
		Y, see ^{226}	-	2E-2	6E-12	-	-	-
				Bone surf				
			-	(2E-2)	-	3E-14	-	-
90	Thorium-231	W, see ^{226}Th	4E+3	6E+3	3E-6	9E-9	5E-5	5E-4
		Y, see ^{226}Th	-	6E+3	3E-6	9E-9	-	-
90	Thorium-232	W, see ^{226}Th	7E-1	1E-3	5E-13	-	-	-
			Bone surf	Bone surf				
			(2E+0)	(3E-3)	-	4E-15	3E-8	3E-7
		Y, see ^{226}Th	-	3E-3	1E-12	-	-	-
				Bone surf				
			-	(4E-3)	-	6E-15	-	-
90	Thorium-234	W, see ^{226}Th	3E+2	2E+2	8E-8	3E-10	-	-
			LLI wall					
			(4E+2)	-	-	-	5E-6	5E-5
		Y, see ^{226}Th	-	2E+2	6E-8	2E-10	-	-
91	Protactinium-227[2]	W, all compounds except those given for Y	4E+3	1E+2	5E-8	2E-10	5E-5	5E-4
		Y, oxides and hydroxides	-	1E+2	4E-8	1E-10	-	-
91	Protactinium-228	W, see ^{227}Pa	1E+3	1E+1	5E-9	-	2E-5	2E-4
				Bone surf				
			-	(2E+1)	-	3E-11	-	-
		Y, see ^{226}Pa	-	1E+1	5E-9	2E-11	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
91	Protactinium-230	W, see ^{227}Pa	6E+2	5E+0	2E-9	7E-12	-	-
			Bone surf (9E+2)	-	-	-	1E-5	1E-4
		Y, see ^{227}Pa	-	4E+0	1E-9	5E-12	-	-
91	Protactinium-231	W, see ^{227}Pa	2E-1	2E-3	6E-13	-	-	-
			Bone surf (5E-1)	Bone surf (4E-3)	-	6E-15	6E-9	6E-8
		Y, see ^{226}Pa	-	4E-3	2E-12	-	-	-
			-	Bone surf (6E-3)	-	8E-15	-	-
91	Protactinium-232	W, see ^{227}Pa	1E+3	2E+1	9E-9	-	2E-5	2E-4
			-	Bone surf (6E+1)	-	8E-11	-	-
		Y, see ^{227}Pa	-	6E+1	2E-8	-	-	-
			-	Bone surf (7E+1)	-	1E-10	-	-
91	Protactinium-233	W, see ^{227}Pa	1E+3	7E+2	3E-7	1E-9	-	-
			LLI wall (2E+3)	-	-	-	2E-5	2E-4
		Y, see ^{227}Pa	-	6E+2	2E-7	8E-10	-	-
91	Protactinium-234	W, see ^{227}Pa	2E+3	8E+3	3E-6	1E-8	3E-5	3E-4
		Y, see ^{227}Pa	-	7E+3	3E-6	9E-9	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
92	Uranium-230	D, UF_6, UO_2F_2, $UO_2(NO_3)_2$	4E+0 Bone surf (6E+0)	4E-1 Bone surf (6E-1)	2E-10 -	- 8E-13	- 8E-8	- 8E-7
		W, UO_3, UF_4, UCl_4	-	4E-1	1E-10	5E-13	-	-
		Y, UO_2, U_3O_8	-	3E-1	1E-10	4E-13	-	-
92	Uranium-231	D, see ^{230}U	4E+3 LLI wall (4E+3)	8E+3 -	3E-6 -	1E-8 -	- 6E-5	- 6E-4
		W, see ^{230}U	-	6E+3	2E-6	8E-9	-	-
		Y, see ^{230}U	-	5E+3	2E-6	6E-9	-	-
92	Uranium-232	D, see ^{230}U	2E+0 Bone surf (4E+0)	2E-1 Bone surf (4E-1)	9E-11 -	- 6E-13	- 6E-8	- 6E-7
		W, see ^{230}U	-	4E-1	2E-10	5E-13	-	-
		Y, see ^{230}U	-	8E-3	3E-12	1E-14	-	-
92	Uranium-233	D, see ^{230}U	1E+1 Bone surf (2E+1)	1E+0 Bone surf (2E+0)	5E-10 -	- 3E-12	- 3E-7	- 3E-6
		W, see ^{230}U	-	7E-1	3E-10	1E-12	-	-
		Y, see ^{230}U	-	4E-2	2E-11	5E-14	-	-
92	Uranium-234[3]	D, see ^{230}U	1E+1 Bone surf (2E+1)	1E+0 Bone surf (2E+0)	5E-10 -	- 3E-12	- 3E-7	- 3E-6
		W, see ^{230}U	-	7E-1	3E-10	1E-12	-	-
		Y, see ^{230}U	-	4E-2	2E-11	5E-14	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation		Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
92	Uranium-235[3]	D, see ^{230}U	1E+1 Bone surf (2E+1)	1E+0 Bone surf (2E+0)	6E-10 -	- 3E-12	- 3E-7	- 3E-6
		W, see ^{230}U	-	8E-1	3E-10	1E-12	-	-
		Y, see ^{230}U	-	4E-2	2E-11	6E-14	-	-
92	Uranium-236	D, see ^{230}U	1E+1 Bone surf (2E+1)	1E+0 Bone surf (2E+0)	5E-10 -	- 3E-12	- 3E-7	- 3E-6
		W, see ^{230}U	-	8E-1	3E-10	1E-12	-	-
		Y, see ^{230}U	-	4E-2	2E-11	6E-14	-	-
92	Uranium-237	D, see ^{230}U	2E+3 LLI wall (2E+3)	3E+3 -	1E-6 -	4E-9 -	- 3E-5	- 3E-4
		W, see ^{230}U	-	2E+3	7E-7	2E-9	-	-
		Y, see ^{230}U	-	2E+3	6E-7	2E-9	-	-
92	Uranium-238[3]	D, see ^{230}U	1E+1 Bone surf (2E+1)	1E+0 Bone surf (2E+0)	6E-10 -	- 3E-12	- 3E-7	- 3E-6
		W, see ^{230}U	-	8E-1	3E-10	1E-12	-	-
		Y, see ^{230}U	-	4E-2	2E-11	6E-14	-	-
92	Uranium-239[2]	D, see ^{230}U	7E+4	2E+5	8E-5	3E-7	9E-4	9E-3
		W, see ^{230}U	-	2E+5	7E-5	2E-7	-	-
		Y, see ^{230}U	-	2E+5	6E-5	2E-7	-	-
92	Uranium-240	D, see ^{230}U	1E+3	4E+3	2E-6	5E-9	2E-5	2E-4
		W, see ^{230}U	-	3E+3	1E-6	4E-9	-	-
		Y, see ^{230}U	-	2E+3	1E-6	3E-9	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation		Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
92	Uranium-natural[3]	D, see ^{230}U	1E+1 Bone surf (2E+1)	1E+0 Bone surf (2E+0)	5E-10 -	- 3E-12	- 3E-7	- 3E-6
		W, see ^{230}U	-	8E-1	3E-10	9E-13	-	-
		Y, see ^{230}U	-	5E-2	2E-11	9E-14	-	-
93	Neptunium-232[2]	W, all compounds	1E+5 -	2E+3 Bone surf (5E+2)	7E-7 -	- 6E-9	2E-3 -	2E-2 -
93	Neptunium-233[2]	W, all compounds	8E+5	3E+6	1E-3	4E-6	1E-2	1E-1
93	Neptunium-234	W, all compounds	2E+3	3E+3	1E-6	4E-9	3E-5	3E-4
93	Neptunium-235	W, all compounds	2E+4 LLI wall (2E+4)	8E+2 Bone surf (1E+3)	3E-7 -	- 2E-9	- 3E-4	- 3E-3
93	Neptunium-236 (1.15E+5 y)	W, all compounds	3E+0 Bone surf (6E+0)	2E-2 Bone surf (5E-2)	9E-12 -	- 8E-14	- 9E-8	- 9E-7
93	Neptunium-236 (22.5 h)	W, all compounds	3E+3 Bone surf (4E+3)	3E+1 Bone surf (7E+1)	1E-8 -	- 1E-10	- 5E-5	- 5E-4
93	Neptunium-237	W, all compounds	5E-1 Bone surf (1E+0)	4E-3 Bone surf (1E-2)	2E-12 -	- 1E-14	- 2E-8	- 2E-7

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation		Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
93	Neptunium-238	W, all compounds	1E+3	6E+1	3E-8	-	2E-5	2E-4
			-	Bone surf (2E+2)	-	2E-10	-	-
93	Neptunium-239	W, all compounds	2E+3	2E+3	9E-7	3E-9	-	-
			LLI wall (2E+3)	-	-	-	2E-5	2E-4
93	Neptunium-240[2]	W, all compounds	2E+4	8E+4	3E-5	1E-7	3E-4	3E-3
94	Plutonium-234	W, all compounds except PuO_2	8E+3	2E+2	9E-8	3E-10	1E-4	1E-3
		Y, PuO_2	-	2E+2	8E-8	3E-10	-	-
94	Plutonium-235[2]	W, see ^{234}Pu	9E+5	3E+6	1E-3	4E-6	1E-2	1E-1
		Y, see ^{234}Pu	-	3E+6	1E-3	3E-6	-	-
94	Plutonium-236	W, see ^{234}Pu	2E+0	2E-2	8E-12	-	-	-
			Bone surf (4E+0)	Bone surf (4E-2)	-	5E-14	6E-8	6E-7
		Y, see ^{234}Pu	-	4E-2	2E-11	6E-14	-	-
94	Plutonium-237	W, see ^{234}Pu	1E+4	3E+3	1E-6	5E-9	2E-4	2E-3
		Y, see ^{234}Pu	-	3E+3	1E-6	4E-9	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
94	Plutonium-238	W, see ^{234}Pu	9E-1	7E-3	3E-12	-	-	-
			Bone surf	Bone surf				
			(2E+0)	(1E-2)	-	2E-14	2E-8	2E-7
		Y, see ^{234}Pu	-	2E-2	8E-12	2E-14	-	-
94	Plutonium-239	W, see ^{234}Pu	8E-1	6E-3	3E-12	-	-	-
			Bone surf	Bone surf				
			(1E+0)	(1E-2)	-	2E-14	2E-8	2E-7
		Y, see ^{234}Pu	-	2E-2	7E-12	-	-	-
				Bone surf				
			-	(2E-2)	-	2E-14	-	-
94	Plutonium-240	W, see ^{234}Pu	8E-1	6E-3	3E-12	-	-	-
			Bone surf	Bone surf				
			(1E+0)	(1E-2)	-	2E-14	2E-8	2E-7
		Y, see ^{234}Pu	-	2E-2	7E-12	-	-	-
				Bone surf				
			-	(2E-2)	-	2E-14	-	-
94	Plutonium-241	W, see ^{234}Pu	4E+1	3E-1	1E-10	-	-	-
			Bone surf	Bone surf				
			(7E+1)	(6E-1)	-	8E-13	1E-6	1E-5
		Y, see ^{234}Pu	-	8E-1	3E-10	-	-	-
				Bone surf				
			-	(1E+0)	-	1E-12	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
94	Plutonium-242	W, see ^{234}Pu	8E-1	7E-3	3E-12	-	-	-
			Bone surf (1E+0)	Bone surf (1E-2)	-	2E-14	2E-8	2E-7
		Y, see ^{234}Pu	-	2E-2	7E-12	-	-	-
			-	Bone surf (2E-2)	-	2E-14	-	-
94	Plutonium-243	W, see ^{234}Pu	2E+4	4E+4	2E-5	5E-8	2E-4	2E-3
		Y, see ^{234}Pu	-	4E+4	2E-5	5E-8	-	-
94	Plutonium-244	W, see ^{234}Pu	8E-1	7E-3	3E-12	-	-	-
			Bone surf (2E+0)	Bone surf (1E-2)	-	2E-14	2E-8	2E-7
		Y, see ^{234}Pu	-	2E-2	7E-12	-	-	-
			-	Bone surf (2E-2)	-	2E-14	-	-
94	Plutonium-245	W, see ^{234}Pu	2E+3	5E+3	2E-6	6E-9	3E-5	3E-4
		Y, see ^{234}Pu	-	4E+3	2E-6	6E-9	-	-
94	Plutonium-246	W, see ^{234}Pu	4E+2	3E+2	1E-7	4E-10	-	-
			LLI wall (4E+2)	-	-	-	6E-6	6E-5
		Y, see ^{234}Pu	-	3E+2	1E-7	4E-10	-	-
95	Americium-237[2]	W, all compounds	8E+4	3E+5	1E-4	4E-7	1E-3	1E-2
95	Americium-238[2]	W, all compounds	4E+4	3E+3	1E-6	-	5E-4	5E-3
			-	Bone surf (6E+3)	-	9E-9	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
95	Americium-239	W, all compounds	5E+3	1E+4	5E-6	2E-8	7E-5	7E-4
95	Americium-240	W, all compounds	2E+3	3E+3	1E-6	4E-9	3E-5	3E-4
95	Americium-241	W, all compounds	8E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12 -	- 2E-14	- 2E-8	- 2E-7
95	Americium-242m	W, all compounds	8E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12 -	- 2E-14	- 2E-8	- 2E-7
95	Americium-242	W, all compounds	4E+3 -	8E+1 Bone surf (9E+1)	4E-8 -	- 1E-10	5E-5 -	5E-4 -
95	Americium-243	W, all compounds	8E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12 -	- 2E-14	- 2E-8	- 2E-7
95	Americium-244m[2]	W, all compounds	6E+4 St. wall (8E+4)	4E+3 Bone surf (7E+3)	2E-6 -	- 1E-8	- 1E-3	- 1E-2
95	Americium-244	W, all compounds	3E+3 -	2E+2 Bone surf (3E+2)	8E-8 -	- 4E-10	4E-5 -	4E-4 -
95	Americium-245	W, all compounds	3E+4	6E+4	3E-5	1E-7	4E-4	4E-3

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation		Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
95	Americium-246m[2]	W, all compounds	5E+4 St. wall	2E+5	8E-5	3E-7	-	-
			(6E+4)	-	-	-	8E-4	8E-3
95	Americium-246[2]	W, all compounds	3E+4	1E+5	4E-5	1E-7	4E-4	4E-3
96	Curium-238	W, all compounds	2E+4	1E+3	5E-7	2E-9	2E-4	2E-3
96	Curium-240	W, all compounds	6E+1 Bone surf	6E-1 Bone surf	2E-10	-	-	-
			(8E+1)	(6E-1)	-	9E-13	1E-6	1E-5
96	Curium-241	W, all compounds	1E+3	3E+1 Bone surf	1E-8	-	2E-5	2E-4
			-	(4E+1)	-	5E-11	-	-
96	Curium 242	W, all compounds	3E+1 Bone surf	3E-1 Bone surf	1E-10	-	-	-
			(5E+1)	(3E-1)	-	4E-13	7E-7	7E-6
96	Curium-243	W, all compounds	2E+0 Bone surf	9E-3 Bone surf	4E-12	-	-	-
			(2E+0)	(2E-2)	-	2E-14	3E-8	3E-7
96	Curium-244	W, all compounds	1E+0 Bone surf	1E-2 Bone surf	5E-12	-	-	-
			(3E+0)	(2E-2)	-	3E-14	3E-8	3E-7
96	Curium-245	W, all compounds	7E-1 Bone surf	6E-3 Bone surf	3E-12	-	-	-
			(1E+0)	(1E-2)	-	2E-14	2E-8	2E-7

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
96	Curium-246	W, all compounds	7E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12 - -	- 2E-14	- 2E-8	- 2E-7
96	Curium-247	W, all compounds	8E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12 - -	- 2E-14	- 2E-8	- 2E-7
96	Curium-248	W, all compounds	2E-1 Bone surf (4E-1)	2E-3 Bone surf (3E-3)	7E-13 - -	- 4E-15	- 5E-9	- 5E-8
96	Curium-249[2]	W, all compounds	5E+4 - -	2E+4 Bone surf (3E+4)	7E-6 - -	- 4E-8	7E-4 -	7E-3 -
96	Curium-250	W, all compounds	4E-2 Bone surf (6E-2)	3E-4 Bone surf (5E-4)	1E-13 - -	- 8E-16	- 9E-10	- 9E-9
97	Berkelium-245	W, all compounds	2E+3	1E+3	5E-7	2E-9	3E-5	3E-4
97	Berkelium-246	W, all compounds	3E+3	3E+3	1E-6	4E-9	4E-5	4E-4
97	Berkelium-247	W, all compounds	5E-1 Bone surf (1E+0)	4E-3 Bone surf (9E-3)	2E-12 - -	- 1E-14	- 2E-8	- 2E-7
97	Berkelium-249	W, all compounds	2E+2 Bone surf (5E+2)	2E+0 Bone surf (4E+0)	7E-10 - -	- 5E-12	- 6E-6	- 6E-5

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
97	Berkelium-250	W, all compounds	9E+3	3E+2	1E-7	-	1E-4	1E-3
			-	Bone surf (7E+2)	-	1E-9	-	-
98	Californium-244[2]	W, all compounds except those given for Y	3E+4	6E+2	2E-7	8E-10	-	-
			St. wall (3E+4)	-	-	-	4E-4	4E-3
		Y, oxides and hydroxides	-	6E+2	2E-7	8E-10	-	-
98	Californium-246	W, see ^{244}Cf	4E+2	9E+0	4E-9	1E-11	5E-6	5E-5
		Y, see ^{244}Cf	-	9E+0	4E-9	1E-11	-	-
98	Californium-248	W, see ^{244}Cf	8E+0	6E-2	3E-11	-	-	-
			Bone surf (2E+1)	Bone surf (1E-1)	-	2E-13	2E-7	2E-6
		Y, see ^{244}Cf	-	1E-1	4E-11	1E-13	-	-
98	Californium-249	W, see ^{244}Cf	5E-1	4E-3	2E-12	-	-	-
			Bone surf (1E+0)	Bone surf (9E-3)	-	1E-14	2E-8	2E-7
		Y, see ^{244}Cf	-	1E-2	4E-12	-	-	-
			-	Bone surf (1E-2)	-	2E-14	-	-
98	Californium-250	W, see ^{244}Cf	1E+0	9E-3	4E-12	-	-	-
			Bone surf (2E+0)	Bone surf (2E-2)	-	3E-14	3E-8	3E-7
		Y, see ^{244}Cf	-	3E-2	1E-11	4E-14	-	-

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
98	Californium-251	W, see ^{244}Cf	5E-1	4E-3	2E-12	-	-	-
			Bone surf	Bone surf				
			(1E+0)	(9E-3)	-	1E-14	2E-8	2E-7
		Y, see ^{244}Cf	-	1E-2	4E-12	-	-	-
				Bone surf				
			-	(1E-2)	-	2E-14	-	-
98	Californium-252	W, see ^{244}Cf	2E+0	2E-2	8E-12	-	-	-
			Bone surf	Bone surf				
			(5E+0)	(4E-2)	-	5E-14	7E-8	7E-7
		Y, see ^{244}Cf	-	3E-2	1E-11	5E-14	-	-
98	Californium-253	W, see ^{244}Cf	2E+2	2E+0	8E-10	3E-12	-	-
			Bone surf					
			(4E+2)	-	-	-	5E-6	5E-5
		Y, see ^{244}Cf	-	2E+0	7E-10	2E-12	-	-
98	Californium-254	W, see ^{244}Cf	2E+0	2E-2	9E-12	3E-14	3E-8	3E-7
		Y, see ^{244}Cf	-	2E-2	7E-12	2E-14	-	-
99	Einsteinium-250	W, all compounds	4E+4	5E+2	2E-7	-	6E-4	6E-3
				Bone surf				
			-	(1E+3)	-	2E-9	-	-
99	Einsteinium-251	W, all compounds	7E+3	9E+2	4E-7	-	1E-4	1E-3
				Bone surf				
			-	(1E+3)	-	2E-9	-	-
99	Einsteinium-253	W, all compounds	2E+2	1E+0	6E-10	2E-12	2E-6	2E-5

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
99	Einsteinium-254m	W, all compounds	3E+2	1E+1	4E-9	1E-11	-	-
			LLI wall (3E+2)	-	-	-	4E-6	4E-5
99	Einsteinium-254	W, all compounds	8E+0	7E-2	3E-11	-	-	-
			Bone surf (2E+1)	Bone surf (1E-1)	-	2E-13	2E-7	2E-6
100	Fermium-252	W, all compounds	5E+2	1E+1	5E-9	2E-11	6E-6	6E-5
100	Fermium-253	W, all compounds	1E+3	1E+1	4E-9	1E-11	1E-5	1E-4
100	Fermium-254	W, all compounds	3E+3	9E+1	4E-8	1E-10	4E-5	4E-4
100	Fermium-255	W, all compounds	5E+2	2E+1	9E-9	3E-11	7E-6	7E-5
100	Fermium-257	W, all compounds	2E+1	2E-1	7E-11	-	-	-
			Bone surf (4E+1)	Bone surf (2E-1)	-	3E-13	5E-7	5E-6
101	Mendelevium-257	W, all compounds	7E+3	8E+1	4E-8	-	1E-4	1E-3
			-	Bone surf (9E+1)	-	1E-10	-	-
101	Mendelevium-258	W, all compounds	3E+1	2E-1	1E-10	-	-	-
			Bone surf (5E+1)	Bone surf (3E-1)	-	5E-13	6E-7	6E-6

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
-	Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life less than 2 hours	Submersion[1]	-	2E+2	1E-7	1E-9	-	-
-	Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life greater than 2 hours	. . . .	-	2E-1	1E-10	1E-12	1E-8	1E-7
-	Any single radionuclide not listed above that decays by alpha emission or spontaneous fission, or any mixture for which either the identity or the concentration of any radionuclide in the mixture is not known	. . . .	-	4E-4	2E-13	1E-15	2E-9	2E-8

FOOTNOTES:

[1]"Submersion" means that values given are for submersion in a hemispherical semi-infinite cloud of airborne material.

[2]These radionuclides have radiological half-lives of less than 2 hours. The total effective dose equivalent received during operations with these radionuclides might include a significant contribution from external exposure. The DAC values for all radionuclides, other than those designated Class "Submersion," are based upon the committed effective dose equivalent due to the intake of the radionuclide into the body and do NOT include potentially significant contributions to [illegible] equivalent from external exposures. The licensee may substitute 1E-7 μCi/ml for the listed DAC to account for the submersion dose prospectively, but should use individual monitoring devices or other radiation measuring instruments that measure external exposure to demonstrate compliance with the limits. (See § 20.203.)

[3]For soluble mixtures of U-238, U-234, and U-235 in air, chemical toxicity may be the limiting factor (see § 20.201(e)). If the percent by weight (enrichment) of U-235 is not greater than 5, the concentration value for a 40-hour workweek is 0.2 milligrams uranium per cubic meter of air average. For any enrichment, the product of the average concentration and time of exposure during a 40-hour workweek shall not exceed 8E-3 (SA) μCi-hr/ml, where SA is the specific activity of the uranium inhaled. The specific activity for natural uranium is 6.77E-7 curies per gram U. The specific activity for other mixtures of U-238, U-235, and U-234, if not known, shall be:

$$SA = 3.6E\text{-}7 \text{ curies/gram U} \qquad \text{U-depleted}$$

$$SA = [0.4 + 0.38\,(\text{enrichment}) + 0.0034\,(\text{enrichment})^2]\ E\text{-}6\ , \quad \text{enrichment} \geq 0.72$$

where enrichment is the percentage by weight of U-235, expressed as percent.

NOTE:

1. If the identity of each radionuclide in a mixture is known but the concentration of one or more of the radionuclides in the mixture is not known, the DAC for the mixture shall be the most restrictive DAC of any radionuclide in the mixture.

2. If the identity of each radionuclide in the mixture is not known, but it is known that certain radionuclides specified in this appendix are not present in the mixture, the inhalation ALI, DAC, and effluent and sewage concentrations for the mixture are the lowest values specified in this appendix for any radionuclide that is not known to be absent from the mixture; or

	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
	Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
	Oral Ingestion	Inhalation				
Radionuclide	ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
If it is known that Ac-227-D and Cm-250-W are not present	-	7E-4	3E-13	-	-	-
If, in addition, it is known that Ac-227-W,Y, Th-229-W,Y, Th-230-W, Th-232-W,Y, Pa-231-W,Y, Np-237-W, Pu-239-W, Pu-240-W, Pu-242-W, Am-241-W, Am-242m-W, Am-243-W, Cm-245-W, Cm-246-W, Cm-247-W, Cm-248-W, Bk-247-W, Cf-249-W, and Cf-251-W are not present	-	7E-3	3E-12	-	-	-
If, in addition, it is known that Sm-146-W, Sm-147-W, Gd-148-D,W, Gd-152-D,W, Th-228-W,Y, Th-230-Y, U-232-Y, U-233-Y, U-234-Y, U-235-Y, U-236-Y, U-238-Y, Np-236-W, Pu-236-W,Y, Pu-238-W,Y, Pu-239-Y, Pu-240-Y, Pu-242-Y, Pu-244-W,Y, Cm-243-W, Cm-244-W, Cf-248-W, Cf-249-Y, Cf-250-W,Y, Cf-251-Y, Cf-252-W,Y, and Cf-254-W,Y are not present	-	7E-2	3E-11	-	-	-
If, in addition, it is known that Pb-210-D, Bi-210m-W, Po-210-D,W, Ra-223-W, Ra-225-W, Ra-226-W, Ac-225-D,W,Y, Th-227-W,Y, U-230-D,W,Y, U-232-D,W, Pu-241-W, Cm-240-W, Cm-242-W, Cf-248-Y, Es-254-W, Fm-257-W, and Md-258-W are not present	-	7E-1	3E-10	-	-	-

Radionuclide	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
	Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
	Oral Ingestion	Inhalation				
	ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
If, in addition, it is known that Si-32-Y, Ti-44-Y, Fe-60-D, Sr-90-Y, Zr-93-D, Cd-113m-D, Cd-113-D, In-115-D,W, La-138-D, Lu-176-W, Hf-178m-D,W, Hf-182-D,W, Bi-210m-D, Ra-224-W, Ra-228-W, Ac-226-D,W,Y, Pa-230-W,Y, U-233-D,W, U-234-D,W, U-235-D,W, U-236-D,W, U-238-D,W, Pu-241-Y, Bk-249-W, Cf-253-W,Y, and Es-253-W are not present	-	7E+0	3E-9	-	-	-
If it is known that Ac-227-D,W,Y, Th-229-W,Y, Th-232-W,Y, Pa-231-W,Y, Cm-248-W, and Cm-250-W are not present	-	-		1E-14	-	-
If, in addition, it is known that Sm-146-W, Gd-148-D,W, Gd-152-D, Th-228-W,Y, Th-230-W,Y, U-232-Y, U-233-Y, U-234-Y, U-235-Y, U-236-Y, U-238-Y, U-Nat-Y, Np-236-W, Np-237-W, Pu-236-W,Y, Pu-238-W,Y, Pu-239-W,Y, Pu-240-W,Y, Pu-242-W,Y, Pu-244-W,Y, Am-241-W, Am-242m-W, Am-243-W, Cm-243-W, Cm-244-W, Cm-245-W, Cm-246-W, Cm-247-W, Bk-247-W, Cf-249-W,Y, Cf-250-W,Y, Cf-251-W,Y, Cf-252-W,Y, and Cf-254-W,Y are not present	-		-	1E-13	-	-
If, in addition, it is known that Sm-147-W, Gd-152-W, Pb-210-D, Bi-210m-W, Po-210-D,W, Ra-223-W, Ra-225-W, Ra-226-W, Ac-225-D,W,Y, Th-227-W,Y, U-230-D,W,Y, U-232-D,W, U-Nat-W, Pu-241-W, Cm-240-W, Cm-242-W, Cf-248-W,Y, Es-254-W, Fm-257-W, and Md-258-W are not present	-	-	-	1E-12	-	-

Radionuclide	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
	Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
	Oral Ingestion	Inhalation				
	ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
If, in addition it is known that Fe-60, Sr-90, Cd-113m, Cd-113, In-115, I-129, Cs-134, Sm-145, Sm-147, Gd-148, Gd-152, Hg-194 (organic), Bi-210m, Ra-223, Ra-224, Ra-225, Ac-225, Th-228, Th-230, U-233, U-234, U-235, U-236, U-238, U-Nat, Cm-242, Cf-248, Es-254, Fm-257, and Md-258 are not present	-	-	-	-	1E-6	1E-5

3. If a mixture of radionuclides consists of uranium and its daughters in ore dust (30 μm AMAD particle distribution assumed) prior to chemical separation of the uranium from the ore, the following values may be used for the DAC of the mixture: 6E-11 μCi of gross alpha activity from uranium-238, uranium-234, thorium-230, and radium-226 per milliliter of air; 3E-11 μCi of natural uranium per milliliter of air; or 45 micrograms of natural uranium per cubic meter of air.

4. If the identity and concentration of each radionuclide in a mixture are known, the limiting values should be derived as follows: determine, for each radionuclide in the mixture, the ratio between the concentration present in the mixture and the concentration otherwise established in Appendix B for the specific radionuclide when not in a mixture. The sum of such ratios for all of the radionuclides in the mixture may not exceed "1" (i.e., "unity").

Example: If radionuclides "A," "B," and "C" are present in concentrations C_A, C_B, and C_C, and if the applicable DACs are DAC_A, DAC_B, and DAC_C, respectively, then the concentrations shall be limited so that the following relationship exists:

$$\frac{C_A}{DAC_A} + \frac{C_B}{DAC_B} + \frac{C_C}{DAC_C} \leq 1$$

APPENDIX C

QUANTITIES* OF LICENSED MATERIAL REQUIRING LABELING

Radionuclide	Quantity (μCi)	Radionuclide	Quantity (μCi)
Hydrogen-3	1,000	Chromium-48	1,000
Beryllium-7	1,000	Chromium-49	1,000
Beryllium-10	1	Chromium-51	1,000
Carbon-11	1,000	Manganese-51	1,000
Carbon-14	1,000	Manganese-52m	1,000
Fluorine-18	1,000	Manganese-52	100
Sodium-22	10	Manganese-53	1,000
Sodium-24	100	Manganese-54	100
Magnesium-28	100	Manganese-56	1,000
Aluminum-26	10	Iron-52	100
Silicon-31	1,000	Iron-55	100
Silicon-32	1	Iron-59	10
Phosphorus-32	10	Iron-60	1
Phosphorus-33	100	Cobalt-55	100
Sulfur-35	100	Cobalt-56	10
Chlorine-36	0	Cobalt-57	100
Chlorine-38	1,000	Cobalt-58m	1,000
Chlorine-39	1,000	Cobalt-58	100
Argon-39	1,000	Cobalt-60m	1,000
Argon-41	1,000	Cobalt-60	1
Potassium-40	100	Cobalt-61	1,000
Potassium-42	1,000	Cobalt-62m	1,000
Potassium-43	1,000	Nickel-56	100
Potassium-44	1,000	Nickel-57	100
Potassium-45	1,000	Nickel-59	100
Calcium-41	100	Nickel-63	100
Calcium-45	100	Nickel-65	1,000
Calcium-47	100	Nickel-66	10
Scandium-43	1,000	Copper-60	1,000
Scandium-44m	100	Copper-61	1,000
Scandium-44	100	Copper-64	1,000
Scandium-46	10	Copper-67	1,000
Scandium-47	100	Zinc-62	100
Scandium-48	100	Zinc-63	1,000
Scandium-49	1,000	Zinc-65	10
Titanium-44	1	Zinc-69m	100
Titanium-45	1,000	Zinc-69	1,000
Vanadium-47	1,000	Zinc-71m	1,000
Vanadium-48	100	Zinc-72	100
Vanadium-49	1,000	Gallium-65	1,000

Radionuclide	Quantity (μCi)	Radionuclide	Quantity (μCi)
Gallium-66	100	Krypton-85	1,000
Gallium-67	1,000	Krypton-87	1,000
Gallium-68	1,000	Krypton-88	1,000
Gallium-70	1,000	Rubidium-79	1,000
Gallium-72	100	Rubidium-81m	1,000
Gallium-73	1,000	Rubidium-81	1,000
Germanium-66	1,000	Rubidium-82m	1,000
Germanium-67	1,000	Rubidium-83	100
Germanium-68	10	Rubidium-84	100
Germanium-69	1,000	Rubidium-86	100
Germanium-71	1,000	Rubidium-87	100
Germanium-75	1,000	Rubidium-88	1,000
Germanium-77	1,000	Rubidium-89	1,000
Germanium-78	1,000	Strontium-80	100
Arsenic-69	1,000	Strontium-81	1,000
Arsenic-70	1,000	Strontium-83	100
Arsenic-71	100	Strontium-85m	1,000
Arsenic-72	100	Strontium-85	100
Arsenic-73	100	Strontium-87m	1,000
Arsenic-74	100	Strontium-89	10
Arsenic-76	100	Strontium-90	0.1
Arsenic-77	100	Strontium-91	100
Arsenic-78	1,000	Strontium-92	100
Selenium-70	1,000	Yttrium-86m	1,000
Selenium-73m	1,000	Yttrium-86	100
Selenium-73	100	Yttrium-87	100
Selenium-75	100	Yttrium-88	10
Selenium-79	100	Yttrium-90m	1,000
Selenium-81m	1,000	Yttrium-90	10
Selenium-81	1,000	Yttrium-91m	1,000
Selenium-83	1,000	Yttrium-91	10
Bromine-74m	1,000	Yttrium-92	100
Bromine-74	1,000	Yttrium-93	100
Bromine-75	1,000	Yttrium-94	1,000
Bromine-76	100	Yttrium-95	1,000
Bromine-77	1,000	Zirconium-86	100
Bromine-80m	1,000	Zirconium-88	10
Bromine-80	1,000	Zirconium-89	100
Bromine-82	100	Zirconium-93	1
Bromine-83	1,000	Zirconium-95	10
Bromine-84	1,000	Zirconium-97	100
Krypton-74	1,000	Niobium-88	1,000
Krypton-76	1,000	Niobium-89	
Krypton-77	1,000	(66 min)	1,000
Krypton-79	1,000	Niobium-89	
Krypton-81	1,000	(122 min)	1,000
Krypton-83m	1,000	Niobium-90	100
Krypton-85m	1,000	Niobium-93m	10

Radionuclide	Quantity (μCi)	Radionuclide	Quantity (μCi)
Niobium-94	1	Silver-104	1,000
Niobium-95m	100	Silver-105	100
Niobium-85	100	Silver-106m	100
Niobium-96	100	Silver-106	1,000
Niobium-97	1,000	Silver-108m	1
Niobium-98	1,000	Silver-110m	10
Molybdenum-90	100	Silver-111	100
Molybdenum-93m	100	Silver-112	100
Molybdenum-93	10	Silver-115	1,000
Molybdenum-99	100	Cadmium-104	1,000
Molybdenum-101	1,000	Cadmium-107	1,000
Technetium-93m	1,000	Cadmium-109	1
Technetium-93	1,000	Cadmium-113m	0.1
Technetium-94m	1,000	Cadmium-113	100
Technetium-94	1,000	Cadmium-115m	10
Technetium-96m	1,000	Cadmium-115	100
Technetium-96	100	Cadmium-117m	1,000
Technetium-97m	100	Cadmium-117	1,000
Technetium-97	1,000	Indium-109	1,000
Technetium-98	10	Indium-110m	
Technetium-99m	1,000	(69.1m)	1,000
Technetium-99	100	Indium-110m	
Technetium-101	1,000	(4.9h)	1,000
Technetium-104	1,000	Indium-111	100
Ruthenium-94	1,000	Indium-112	1,000
Ruthenium-97	1,000	Indium-113m	1,000
Ruthenium-103	100	Indium-114m	10
Ruthenium-105	1,000	Indium-115m	1,000
Ruthenium-106	1	Indium-115	100
Rhodium-99m	1,000	Indium-116m	1,000
Rhodium-99	100	Indium-117m	1,000
Rhodium-100	100	Indium-117	1,000
Rhodium-101m	1,000	Indium-119m	1,000
Rhodium-101	10	Tin-110	100
Rhodium-102m	10	Tin-111	1,000
Rhodium-102	10	Tin-113	100
Rhodium-103m	1,000	Tin-117m	100
Rhodium-105	100	Tin-119m	100
Rhodium-106m	1,000	Tin-121m	100
Rhodium-107	1,000	Tin-121	1,000
Palladium-100	100	Tin-123m	1,000
Palladium-101	1,000	Tin-123	10
Palladium-103	100	Tin-125	10
Palladium-107	10	Tin-126	10
Palladium-109	100	Tin-127	1,000
Silver-102	1,000	Tin-128	1,000
Silver-103	1,000	Antimony-115	1,000
Silver-104m	1,000	Antimony-116m	1,000

Radionuclide	Quantity (μCi)	Radionuclide	Quantity (μCi)
Antimony-116	1,000	Iodine-131	1
Antimony-117	1,000	Iodine-132m	100
Antimony-118m	1,000	Iodine-132	100
Antimony-119	1,000	Iodine-133	10
Antimony-120 (16m)	1,000	Iodine-134	1,000
		Iodine-135	100
Antimony-120 (5.76d)	100	Xenon-120	1,000
		Xenon-121	1,000
Antimony-122	100	Xenon-122	1,000
Antimony-124m	1,000	Xenon-123	1,000
Antimony-124	10	Xenon-125	1,000
Antimony-125	100	Xenon-127	1,000
Antimony-126m	1,000	Xenon-129m	1,000
Antimony-126	100	Xenon-131m	1,000
Antimony-127	100	Xenon-133m	1,000
Antimony-128 (10.4m)	1,000	Xenon-133	1,000
		Xenon-135m	1,000
Antimony-128 (9.01h)	100	Xenon-135	1,000
		Xenon-138	1,000
Antimony-129	100	Cesium-125	1,000
Antimony-130	1,000	Cesium-127	1,000
Antimony-131	1,000	Cesium-129	1,000
Tellurium-116	1,000	Cesium-130	1,000
Tellurium-121m	10	Cesium-131	1,000
Tellurium-121	100	Cesium-132	100
Tellurium-123m	10	Cesium-134m	1,000
Tellurium-123	100	Cesium-134	10
Tellurium-125m	10	Cesium-135m	1,000
Tellurium-127m	10	Cesium-135	100
Tellurium-127	1,000	Cesium-136	10
Tellurium-129m	10	Cesium-137	10
Tellurium-129	1,000	Cesium-138	1,000
Tellurium-131m	10	Barium-126	1,000
Tellurium-131	100	Barium-128	100
Tellurium-132	10	Barium-131m	1,000
Tellurium-133m	100	Barium-131	100
Tellurium-133	1,000	Barium-133m	100
Tellurium-134	1,000	Barium-133	100
Iodine-120m	1,000	Barium-135m	100
Iodine-120	100	Barium-139	1,000
Iodine-121	1,000	Barium-140	100
Iodine-123	100	Barium-141	1,000
Iodine-124	10	Barium-142	1,000
Iodine-125	1	Lanthanum-131	1,000
Iodine-126	1	Lanthanum-132	100
Iodine-128	1,000	Lanthanum-135	1,000
Iodine-129	1	Lanthanum-137	10
Iodine-130	10	Lanthanum-138	100

Radionuclide	Quantity (μCi)	Radionuclide	Quantity (μCi)
Lanthanum-140	100	Samarium-153	100
Lanthanum-141	100	Samarium-155	1,000
Lanthanum-142	1,000	Samarium-156	1,000
Lanthanum-143	1,000	Europium-145	100
Cerium-134	100	Europium-146	100
Cerium-135	100	Europium-147	100
Cerium-137m	100	Europium-148	10
Cerium-137	1,000	Europium-149	100
Cerium-139	100	Europium-150	
Cerium-141	100	(12.62h)	100
Cerium-143	100	Europium-150	
Cerium-144	1	(34.2y)	1
Praseodymium-136	1,000	Europium-152m	100
Praseodymium-137	1,000	Europium-152	1
Praseodymium-138m	1,000	Europium-154	1
Praseodymium-139	1,000	Europium-155	10
Praseodymium-142m	1,000	Europium-156	100
Praseodymium-142	100	Europium-157	100
Praseodymium-143	100	Europium-158	1,000
Praseodymium-144	1,000	Gadolinium-145	1,000
Praseodymium-145	100	Gadolinium-146	10
Praseodymium-147	1,000	Gadolinium-147	100
Neodymium-136	1,000	Gadolinium-148	0.001
Neodymium-138	100	Gadolinium-149	100
Neodymium-139m	1,000	Gadolinium-151	10
Neodymium-139	1,000	Gadolinium-152	100
Neodymium-141	1,000	Gadolinium-153	10
Neodymium-147	100	Gadolinium-159	100
Neodymium-149	1,000	Terbium-147	000
Neodymium-151	1,000	Terbium-149	100
Promethium-141	1,000	Terbium-150	1,000
Promethium-143	100	Terbium-151	100
Promethium-144	10	Terbium-153	1,000
Promethium-145	10	Terbium-154	100
Promethium-146	1	Terbium-155	1,000
Promethium-147	10	Terbium-156m	
Promethium-148m	10	(5.0h)	1,000
Promethium-148	10	Terbium-156m	
Promethium-149	100	(24.4h)	1,000
Promethium-150	1,000	Terbium-156	100
Promethium-151	100	Terbium-157	10
Samarium-141m	1,000	Terbium-158	1
Samarium-141	1,000	Terbium-160	10
Samarium-142	1,000	Terbium-161	100
Samarium-145	100	Dysprosium-155	1,000
Samarium-146	1	Dysprosium-157	1,000
Samarium-147	100	Dysprosium-159	100
Samarium-151	10	Dysprosium-165	1,000

Radionuclide	Quantity (μCi)	Radionuclide	Quantity (μCi)
Dysprosium-166	100	Hafnium-173	1,000
Holmium-155	1,000	Hafnium-175	100
Holmium-157	1,000	Hafnium-177m	1,000
Holmium-159	1,000	Hafnium-178m	0.1
Holmium-161	1,000	Hafnium-179m	10
Holmium-162m	1,000	Hafnium-180m	1,000
Holmium-162	1,000	Hafnium-181	10
Holmium-164m	1,000	Hafnium-182m	1,000
Holmium-164	1,000	Hafnium-182	0.1
Holmium-166m	1	Hafnium-183	1,000
Holmium-166	100	Hafnium-184	100
Holmium-167	1,000	Tantalum-172	1,000
Erbium-161	1,000	Tantalum-173	1,000
Erbium-165	1,000	Tantalum-174	1,000
Erbium-169	100	Tantalum-175	1,000
Erbium-171	100	Tantalum-176	100
Erbium-172	100	Tantalum-177	1,000
Thulium-162	1,000	Tantalum-178	1,000
Thulium-166	100	Tantalum-179	100
Thulium-167	100	Tantalum-180m	1,000
Thulium-170	10	Tantalum-180	100
Thulium-171	10	Tantalum-182m	1,000
Thulium-172	100	Tantalum-182	10
Thulium-173	100	Tantalum-183	100
Thulium-175	1,000	Tantalum-184	100
Ytterbium-162	1,000	Tantalum-185	1,000
Ytterbium-166	100	Tantalum-186	1,000
Ytterbium-167	1,000	Tungsten-176	1,000
Ytterbium-169	100	Tungsten-177	1,000
Ytterbium-175	100	Tungsten-178	1,000
Ytterbium-177	1,000	Tungsten-179	1,000
Ytterbium-178	1,000	Tungsten-181	1,000
Lutetium-169	100	Tungsten-185	100
Lutetium-170	100	Tungsten-187	100
Lutetium-171	100	Tungsten-188	10
Lutetium-172	100	Rhenium-177	1,000
Lutetium-173	10	Rhenium-178	1,000
Lutetium-174m	10	Rhenium-181	1,000
Lutetium-174	10	Rhenium-182 (12.7h)	1,000
Lutetium-176m	1,000	Rhenium-182 (64.0h)	100
Lutetium-176	100	Rhenium-184m	10
Lutetium-177m	10	Rhenium-184	100
Lutetium-177	100	Rhenium-186m	10
Lutetium-178m	1,000	Rhenium-186	100
Lutetium-178	1,000	Rhenium-187	1,000
Lutetium-179	1,000	Rhenium-188m	1,000
Hafnium-170	100		
Hafnium-172	1		

Radionuclide	Quantity (μCi)	Radionuclide	Quantity (μCi)
Rhenium-188	100	Mercury-194	1
Rhenium-189	100	Mercury-195m	100
Osmium-180	1,000	Mercury-195	1,000
Osmium-181	1,000	Mercury-197m	100
Osmium-182	100	Mercury-197	1,000
Osmium-185	100	Mercury-199m	1,000
Osmium-189m	1,000	Mercury-203	100
Osmium-191m	1,000	Thallium-194m	1,000
Osmium-191	100	Thallium-194	1,000
Osmium-193	100	Thallium-195	1,000
Osmium-194		Thallium-197	1,000
Iridium-182	1,000	Thallium-198m	1,000
Iridium-184	1,000	Thallium-198	1,000
Iridium-185	1,000	Thallium-199	1,000
Iridium-186	100	Thallium-200	1,000
Iridium-187	1,000	Thallium-201	1,000
Iridium-188	100	Thallium-202	100
Iridium-189	100	Thallium-204	100
Iridium-190m	1,000	Lead-195m	1,000
Iridium-190	100	Lead-198	1,000
Iridium-192m	1	Lead-199	1,000
Iridium-192	10	Lead-200	100
Iridium-194m	10	Lead-201	1,000
Iridium-194	100	Lead-202m	1,000
Iridium-195m	1,000	Lead-202	10
Iridium-195	1,000	Lead-203	1,000
Platinum-186	1,000	Lead-205	100
Platinum-188	100	Lead-209	1,000
Platinum-189	1,000	Lead-210	0.01
Platinum-191	100	Lead-211	100
Platinum-193m	100	Lead-212	1
Platinum-193	1,000	Lead-214	100
Platinum-195m	100	Bismuth-200	1,000
Platinum-197m	1,000	Bismuth-201	1,000
Platinum-197	100	Bismuth-202	1,000
Platinum-199	1,000	Bismuth-203	100
Platinum-200	100	Bismuth-205	100
Gold-193	1,000	Bismuth-206	100
Gold-194	100	Bismuth-207	10
Gold-195	10	Bismuth-210m	0.1
Gold-198m	100	Bismuth-210	1
Gold-198	100	Bismuth-212	10
Gold-199	100	Bismuth-213	10
Gold-200m	100	Bismuth-214	100
Gold-200	1,000	Polonium-203	1,000
Gold-201	1,000	Polonium-205	1,000
Mercury-193m	100	Polonium-207	1,000
Mercury-193	1,000	Polonium-210	0.1

Radionuclide	Quantity (μCi)	Radionuclide	Quantity (μCi)
Astatine-207	100	Neptunium-234	100
Astatine-211	10	Neptunium-235	100
Radon-220	1	Neptunium-236	
Radon-222	1	(1.15×10^5y)	0.001
Francium-222	100	Neptunium-236	
Francium-223	100	(22.5h)	1
Radium-223	0.1	Neptunium-237	1.001
Radium-224	0.1	Neptunium-238	10
Radium-225	0.1	Neptunium-239	100
Radium-226	0.1	Neptunium-240	1,000
Radium-227	1,000	Plutonium-234	10
Radium-228	0.1	Plutonium-235	1,000
Actinium-224	1	Plutonium-236	0.001
Actinium-225	0.01	Plutonium-237	100
Actinium-226	0.1	Plutonium-238	0.001
Actinium-227	0.001	Plutonium-239	0.001
Actinium-228	1	Plutonium-240	0.001
Thorium-226	10	Plutonium-241	0.01
Thorium-227	0.01	Plutonium-242	0.001
Thorium-228	0.001	Plutonium-243	1,000
Thorium-229	0.001	Plutonium-244	0.001
Thorium-230	0.001	Plutonium-245	100
Thorium-231	100	Americium-237	1,000
Thorium-232	100	Americium-238	100
Thorium-234	10	Americium-239	1,000
Thorium-natural	100	Americium-240	100
Protactinium-227	10	Americium-241	0.001
Protactinium-228	1	Americium-242m	0.001
Protactinium-230	0.1	Americium-242	10
Protactinium-231	0.001	Americium-243	0.001
Protactinium-232	1	Americium-244m	100
Protactinium-233	100	Americium-244	10
Protactinium-234	100	Americium-245	1,000
Uranium-230	0.01	Americium-246m	1,000
Uranium-231	100	Americium-246	1,000
Uranium-232	0.001	Curium-238	100
Uranium-233	0.001	Curium-240	0.1
Uranium-234	0.001	Curium-241	1
Uranium-235	0.001	Curium-242	0.01
Uranium-236	0.001	Curium-243	0.001
Uranium-237	100	Curium-244	0.001
Uranium-238	100	Curium-245	0.001
Uranium-239	1,000	Curium-246	0.001
Uranium-240	100	Curium-247	0.001
Uranium-natural	100	Curium-248	0.001
Neptunium-232	100	Curium-249	1,000
Neptunium-233	1,000	Berkelium-245	100

Radionuclide	Quantity (μCi)	Radionuclide	Quantity (μCi)
Berkelium-246	100	Einsteinium-250	100
Berkelium-247	0.001	Einsteinium-251	100
Berkelium-249	0.1	Einsteinium-253	0.1
Berkelium-250	10	Einsteinium-254m	1
Californium-244	100	Einsteinium-254	0.01
Californium-246	1	Fermium-252	1
Californium-248	0.01	Fermium-253	1
Californium-249	0.001	Fermium-254	10
Californium-250	0.001	Fermium-255	1
Californium-251	0.001	Fermium-257	0.01
Californium-252	0.001	Mendelevium-257	10
Californium-253	0.1	Mendelevium-258	0.01
Californium-254	0.001		
Any alpha emitting radionuclide not listed above or mixtures of alpha emitters of unknown composition	0.001	Any radionuclide other than alpha emitting radionuclides not listed above, or mixtures of beta emiiters of unknown composition	0.01

NOTE: For purposes of §§ 20.902(e), 20.905(a), and 20.1201(a) where there is involved a combination of radionuclides in known amounts, the limit for the combination should be derived as follows: determine, for each radionuclide in the combination, the ratio between the quantity present in the combination and the limit otherwise established for the specific radionuclide when not in combination. The sum of such ratios for all radionuclides in the combination may not exceed "1" (i.e., "unity").

* The quantities listed above were derived by taking 1/10th of the most restrictive ALI listed in Table 1, Columns 1 and 2, of Appendix B of this part, rounding to the nearest factor of 10, and arbitrarily constraining the values listed between 0.001 and 1,000 μCi. Values of 100 μCi have been assigned for radionuclides having a radioactive half-life in excess of 10^9 years (except rhenium, 1000 μCi) to take into account their low specific activity.

APPENDIX D

UNITED STATES NUCLEAR REGULATORY COMMISSION REGION OFFICES

	Address	Telephone (24 hours)
Region I: Connecticut, Deleware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont.	USNRC, Region I 475 Allendale Road King of Prussia, PA 19406	(215) 337-5000, (FTS) 346-5000.
Region II: Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, Puerto Rico, South Carolina, Tennessee, Virginia, Virgin Islands, and West Virginia.	USNRC, Region II 101 Marietta Street, NW Suite 2900 Atlanta, GA 30323	(404) 331-4503, (FTS) 841-4503.
Region III: Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, and Wisconsin.	USNRC, Region III 799 Roosevelt Road Glen Ellyn, IL 60137	(708) 790-5500, (FTS) 388-5500.
Region IV: Arkansas, Colorado, Idaho, Kansas, Louisiana, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, Utah, and Wyoming.	USNRC, Region IV 611 Ryan Plaza Drive Suite 1000 Arlington, TX 76011	(817) 860-8100 (FTS) 728-8100.
Region IV: Field Office	USNRC, Region IV Uranium Recovery Field Office 730 Simms Street, Suite 100a Golden, CO 80401 Mail: P.O. Box 25325 Denver, CO 80225	(303) 236-2805, (FTS) 776-2805.
Region V: Alaska, Arizona, California, Hawaii, Nevada, Oregon, Washington, and U.S. territories and possessions in the Pacific.	USNRC, Region V 1450 Maria Lane Suite 210 Walnut Creek, CA 94596	(415) 943-3700, (FTS) 463-3700.

APPENDIX E [RESERVED]

APPENDIX F

REQUIREMENTS FOR LOW-LEVEL-WASTE TRANSFER FOR
DISPOSAL AT LAND DISPOSAL FACILITIES AND MANIFESTS

I. MANIFEST

The shipment manifest shall contain the name, address, and telephone number of the person generating the waste. The manifest shall also include the name, address, and telephone number or the name and EPA hazardous waste identification number of the person transporting the waste to the land disposal facility. The manifest must also indicate as completely as practicable: a physical description of the waste, the volume, radionuclide identity and quantity, the total radioactivity, and the principal chemical form. The solidification agent must be specified. Waste containing more than 0.1% chelating agents by weight must be identified and the weight percentage of the chelating agent estimated. Wastes classified as Class A, Class B, or Class C in § 61.55 of this chapter must be clearly identified as such in the manifest. The total quantity of the radionuclides ^{3}H, ^{14}C, ^{99}Tc, and ^{129}I must be shown. The manifest required by this paragraph may be shipping papers used to meet Department of Transportation or Environmental Protection Agency regulations or requirements of the receiver, provided all the required information is included. Copies of manifests required by this section may be legible carbon copies or legible photocopies.

II. CERTIFICATION

The waste generator shall include in the shipment manifest a certification that the transported materials are properly classified, described, packaged, marked, and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation and the

Commission. An authorized representative of the waste generator shall sign and date the manifest.

III. CONTROL AND TRACKING

A. Any generating licensee who transfers radioactive waste to a land disposal facility or a licensed waste collector shall comply with the requirements in paragraphs A.1 through 8 of this section. Any generating licensee who transfers waste to a licensed waste processor who treats or repackages waste shall comply with the requirements of paragraphs A.4 through 8 of this section. A licensee shall:

1. Prepare all wastes so that the waste is classified according to § 61.55 of this chapter and meets the waste characteristics requirements in § 61.56 of this chapter;

2. Label each package of waste to identify whether it is Class A waste, Class B waste, or Class C waste, in accordance with § 61.55 of this chapter;

3. Conduct a quality control program to ensure compliance with §§ 61.55 and 61.56 of this chapter, the program must include management evaluation of audits;

4. Prepare shipping manifests to meet the requirements of sections I and II of this appendix;

5. Forward a copy of the manifest to the intended recipient, at the time of shipment, or deliver to a collector at the time the waste is collected, obtaining acknowledgment of receipt in the form of a signed copy of the manifest or equivalent documentation from the collector;

6. Include one copy of the manifest with the shipment;

7. Retain a copy of the manifest and documentation of acknowledgment of receipt as the record of transfer of licensed material as required by Parts 30, 40, and 70 of this chapter; and

8. For any shipments or any part of a shipment for which acknowledgment of receipt has not been received within the times set forth in this section, conduct an investigation in accordance with paragraph E of this appendix.

B. Any waste collector licensee who handles only prepackaged waste shall:

1. Acknowledge receipt of the waste from the generator within 1 week of receipt by returning a signed copy of the manifest or equivalent documentation.,

2. Prepare a new manifest to reflect consolidated shipments; the new manifest shall serve as a listing or index for the detailed generator manifests. Copies of the generator manifests shall be a part of the new manifest. The waste collector may prepare a new manifest without attaching the generator manifests, provided the new manifest contains for each package the information specified in section I of this appendix. The collector licensee shall certify that nothing has been done to the waste that would invalidate the generator's certification;

3. Forward a copy of the new manifest to the land disposal facility operator at the time of shipment;

4. Include the new manifest with the shipment to the disposal site;

5. Retain a copy of the manifest and documentation of acknowledgment of receipt as the record of transfer of licensed material as required by Parts 30, 40, and 70 of this chapter, and retain information from generator manifest until disposition is authorized by the Commission; and

6. For any shipments or any part of a shipment for which acknowledgment of receipt is not received within the times set forth in this section, conduct an investigation in accordance with paragraph E of this section.

C. Any licensed waste processor who treats or repackages wastes shall:

1. Acknowledge receipt of the waste from the generator within 1 week of receipt by returning a signed copy of the manifest or equivalent documentation;

2. Prepare a new manifest that meets the requirements of sections I and II of this appendix. Preparation of the new manifest reflects that the processor is responsible for the waste;

3. Prepare all wastes so that the waste is classified according to § 61.55 of this chapter and meets the waste characteristics requirements in § 61.56 of this chapter;

4. Label each package of waste to identify whether it is Class A waste, Class B waste, or Class C waste, in accordance with §§ 61.55 and 61.57 of this chapter;

5. Conduct a quality control program to ensure compliance with §§ 61.55 and 61.56 of this chapter. The program shall include management evaluation of audits;

6. Forward a copy of the new manifest to the disposal site operator or waste collector at the time of shipment, or deliver to a collector at the time the waste is collected, obtaining acknowledgment of receipt in the form of a signed copy of the manifest or equivalent documentation by the collector;

7. Include the new manifest with the shipment;

8. Retain copies of original manifests and new manifests and documentation of acknowledgment of receipt as the record of transfer of licensed material required by Parts 30, 40, and 70 of this chapter; and

9. For any shipment or part of a shipment for which acknowledgment is not received within the times set forth in this section, conduct an investigation in accordance with paragraph E of this section.

D. The land disposal facility operator shall:

1. Acknowledge receipt of the waste within 1 week of receipt by returning a signed copy of the manifest or equivalent documentation to the shipper. The shipper to be notified is the licensee who last possessed the waste and transferred the waste to the operator. The returned copy of the manifest or equivalent documentation shall indicate any discrepancies between materials listed on the manifest and materials received.

2. Maintain copies of all completed manifests or equivalent documentation until the Commission authorizes their disposition; and

3. Notify the shipper (i.e., the generator, the collector, or processor) and the Administrator of the nearest Commission Regional Office listed in Appendix D to this part when any shipment or part of a shipment has not arrived within 60 days after the advance manifest was received.

E. Any shipment or part of a shipment for which acknowledgment is not received within the times set forth in this section must:

1. Be investigated by the shipper if the shipper has not received notification or receipt within 20 days after transfer; and

2. Be traced and reported. The investigation shall include tracing the shipment and filing a report with the nearest Commission Regional Office listed

in Appendix D to this part. Each licensee who conducts a trace investigation shall file a written report with the appropriate NRC Regional Office within 2 weeks of completion of the investigation.

CONFORMING AMENDMENTS

The following amendments to other parts of Chapter I of Title 10 generally update citations to 10 CFR Part 20 that are found in these other parts of the NRC regulations. Two amendments are particularly important as they go beyond updating cross-reference citations. The amendment to 10 CFR Part 2 Appendix C updates and modifies the examples of the severity levels associated with violations of 10 CFR Part 20. Because Appendix C relates to administrative policy of the Commission and because the listed violations are used as examples of different severity levels and are not all-inclusive, the Commission is issuing these Part 2 amendments in final form without public comment. The other important change in the conforming amendments is the deletion of "upon request" from § 19.13(b). This has the effect of requiring annual dose reports to all workers rather than only upon a request by the worker. This change conforms to the 1987 Federal Radiation Guidance from the President.

PART 2- RULES OF PRACTICE

2. The authority citation for Part 2 continues to read in part as follows:

Authority: Sec. 161, 68 Stat. 948, as amended (42 U.S.C. 2201); sec. 201, 88 Stat. 1242, as amended (42 U.S.C.5841).

3. Supplement IV -- Severity Categories of Appendix C to 10 CFR Part 2 is amended to read as follows:

Appendix C--General Statement of Policy and Procedures for NRC Enforcement Actions

* * * * *

A. Severity I -- Violations involving for example:

1. Single radiation exposure of a worker in excess of 25 rems total effective dose equivalent, 75 rems to the lens of the eye, or 250 rads to the skin of the whole body, or to the feet, ankles, hands or forearms, or to any other organ or tissue;

2. Single radiation exposure of the embryo/fetus of a declared pregnant woman in excess of 2.5 rems total effective dose equivalent;

3. Single radiation exposure of a minor in excess of 2.5 rems total effective dose equivalent, 7.5 rems to the lens of the eye, or 25 rems to the skin of the whole body, or to the feet, ankles, hands or forearms, or to any other organ or tissue;

4. Annual exposure of a member of the public in excess of 2.5 rems total effective dose equivalent;

5. Release of radioactive material to an unrestricted area at concentrations in excess of 50 times the limits for members of the public in Appendix B, Table 2, of 10 CFR Part 20; or

6. Disposal of licensed material in quantities or concentrations in excess of 10 times the limits of 10 CFR 20.1003.

B. Severity II -- Violations involving for example:

1. Single radiation exposure of a worker in excess of 10 rems total effective dose equivalent, 30 rems to the lens of the eye, or 100 rems to the skin of the whole body, or to the feet, ankles, hands or forearms, or to any other organ or tissue;

[15] Personnel overexposures and associated violations, incurred during a life-saving effort, will be treated on a case-by-case basis.

2. Single radiation exposure of the embryo/fetus of a declared pregnant woman in excess of 1.0 rem total effective dose equivalent;

3. Single radiation exposure of a minor in excess of 1 rem total effective dose equivalent; 3.0 rems to the lens of the eye, or 10 rems to the skin of the whole body, or to the feet, ankles, hands or forearms, or to any other organ or tissue;

4. Annual exposure of a member of the public in excess of 0.5 rem total effective dose equivalent;

5. Release of radioactive material to an unrestricted area at concentrations in excess of 10 times the limits for members of the public in Appendix B, Table 2, of 10 CFR Part 20;

6. Disposal of licensed material in quantities or concentrations in excess of five times the limits of 10 CFR 20.1003; or

7. Failure to make an immediate notification as required by 10 CFR 20.1202(a)(1) or (a)(2).

C. Severity III -- Violations involving for example:

1. Single radiation exposure of a worker in excess of 5 rems total effective dose equivalent, 15 rems to the lens of the eye, or 50 rems to the skin of the whole body or to the feet, ankles, hands or forearms, or to any other organ or tissue;

2. Single radiation exposure of the embryo/fetus of a declared pregnant woman in excess of 0.5 rem total effective dose equivalent;

3. Single radiation exposure of a minor in excess of 0.5 rem total effective dose equivalent; 1.5 rems to the lens of the eye, or 5 rems to the skin of the whole body, or to the feet, ankles, hands or forearms, or to any other organ or tissue;

4. Worker exposure above regulatory limits when such exposure reflects a programmatic (rather than an isolated) weakness in the radiation control program;

5. Annual exposure of a member of the public in excess of 0.1 rem total effective dose equivalent (except when operation up to 0.5 rem a year has been approved by the Commission under § 20.301(c));

6. Release of radioactive material to an unrestricted area at concentrations in excess of two times the limits for members of the public in Appendix B to 10 CFR Part 20 (except when operation up to 0.5 rem a year has been approved by the Commission under § 20.301(c));

7. Failure to make a 24-hour notification required by 10 CFR 20.1202(b) or an immediate notification required by 10 CFR 20.1201(a)(1)(i);

8. Substantial potential for exposures or releases in excess of the applicable limits in 10 CFR Part 20 whether or not such exposure or release occurs (e.g., operation of a radiation facility with a nonfunctioning interlock system or entry into high radiation areas, such as under reactor vessels or in the vicinity of exposed radiographic sources, without having performed an adequate survey);

9. Improper disposal of licensed material not covered in Severity Levels I or II,

10. Release for unrestricted use of contaminated or radioactive material or equipment that poses a realistic potential for exposure of the public to levels or doses exceeding the annual dose limits for member of the public, or that reflects a programmatic (rather than an isolated) weakness in the radiation control program;

11. Conduct of licensee activities by a technically unqualified person; or

12. Significant failure to control licensed material.

D. Severity IV -- Violations involving for example:

1. Exposures in excess of the limits of 10 CFR 20.201, 20.207, or 20.208 not constituting Severity Level I, II, or III violations;

2. Release of radioactive material to an unrestricted area at concentrations in excess of the limits for members of the public in Appendix B to 10 CFR Part 20 (except when operation up to 0.5 rem a year has been approved by the Commission under § 20.301(c));

3. A radiation dose rate in an unrestricted or controlled area in excess of 0.002 rem in any 1 hour (2 millirem/hour) or 50 millirems in a year;

4. Failure to maintain and implement radiation programs to keep radiation exposures as low as is reasonably achievable;

5. Doses to a member of the public in excess of any EPA generally applicable environmental radiation standards, such as 40 CFR Part 190;

6. Failure to make the 30-day notification required by 10 CFR 20.1201(a)(1)(ii) or 20.1203(a);

7. Failure to make a timely written report as required by 10 CFR 20.1201(b), 20.1204, or 20.1206; or

8. Any other matter that has more than a minor safety, health, or environmental significance.

E. Severity V -- Violations that are of a minor safety, health, or environmental significance.

PART 19 - NOTICES, INSTRUCTIONS, AND REPORTS TO WORKERS; INSPECTIONS

4. The authority citation for Part 19 continues to read in part as follows:

Authority: Sec. 161, 68 Stat. 948, as amended (42 U.S.C. 2201); sec. 201, 88 Stat. 1242, as amended (42 U.S.C.5841).

5. Section 19.3 is amended by revising paragraph (e) to read as follows:

§ 19.3 Definitions.

* * * * *

(e) "Restricted area" means an area, access to which is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials. Restricted area does not include areas used as residential quarters, but separate rooms in a residential building may be set apart as a restricted area.

6. In § 19.13, paragraph (d) is amended by changing the reference to "§20.405 and § 20.408" to read "§§20.1202, 20.1203, 20.1204, or 20.1206" and by revising paragraphs (b), (c), and (e) to read as follows:

§ 19.13 Notifications and reports to individuals.

* * * * *

(b) Each licensee shall advise each worker annually of the worker's dose as shown in records maintained by the licensee pursuant to § 20.1106.

(c) At the request of a worker formerly engaged in licensed activities controlled by the licensee, each licensee shall furnish to the worker a report of the worker's exposure to radiation or radioactive material for each year the worker was required to be monitored under § 20.502. Such report shall be furnished within 30 days from the time the request is made, or within 30 days after the exposure of the individual has been determined by the licensee, whichever is later. This report shall cover the period of time that the worker's activities involved exposure to radiation from radioactive materials

licensed by the Commission and shall include the dates and locations of licensed activities in which the worker participated during this period.

* * * * *

(e) At the request of a worker who is terminating employment with the licensee that involved exposure to radiation or radioactive materials, during the current year, each licensee shall provide at termination to each such worker, or to the worker's designee, a written report regarding the radiation dose received by that worker from operations of the licensee during the current year or fraction thereof. If the most recent individual monitoring results are not available at that time, a written estimate of the dose shall be provided together with a clear indication that this is an estimate.

PART 30 - RULES OF GENERAL APPLICABILITY TO DOMESTIC LICENSING OF BYPRODUCT MATERIAL

7. The authority citation for Part 30 continues to read in part as follows:

Authority: Sec. 161, 68 Stat. 948, as amended (42 U.S.C. 2201); sec. 201, 88 Stat. 1242, as amended (42 U.S.C.5841).

§ 30.51 [Amended].

8. In § 30.51(c)(4), the reference to "§ 20.401(c)" is changed to read "§ 20.1108."

PART 31 - GENERAL DOMESTIC LICENSES FOR BYPRODUCT MATERIAL

9. The authority citation for Part 31 continues to read in part as follows:

Authority: Sec. 161, 68 Stat. 948, as amended (42 U.S.C. 2201), sec. 201, 88 Stat. 1242, as amended (42 U.S.C.5841).

§ 31.5 [Amended].

10. In § 31.5(c)(10), the reference to "§§ 20.402 and 20.403" is changed to read "§§ 20.1201 and 20.1202."

§ 31.7 [Amended].

11. In § 31.7(b), the reference to "§§ 20.402 and 20.403" is changed to read "§§ 20.1201 and 20.1202."

§ 31.10 [Amended].

12. In § 31.10(b)(1) the reference to "§ 20.301" is changed to read "§ 20.1001."

13. In § 31.10(b)(3) the reference to "§§ 20.301, 20.402, and 20.403" is changed to read "§§ 20.1001, 20.1201, and 20.1202."

§ 31.11 [Amended]

14. In § 31.11(c)(5), the reference to "§ 20.301" is changed to read "§ 20.1001."

15. In § 31.11(f), the reference to "§§ 20.301, 20.402, and 20.403" is changed to read "§§ 20.1001, 20.1201, and 20.1202."

PART 32 - SPECIFIC DOMESTIC LICENSES TO MANUFACTURE OR TRANSFER CERTAIN ITEMS CONTAINING BYPRODUCT MATERIAL

16. The authority citation for Part 32 continues to read in part as follows:

Authority: Sec. 161, 68 Stat. 948, as amended (42 U.S.C. 2201), Sec. 201, 88 Stat. 1242 as amended (42 U.S.C.5841).

17. Section 32.51 is amended by revising paragraphs (a)(2)(ii) and (c) to read as follow:

§ 32.51 Byproduct material contained in devices for use under § 31.5; requirements for license to manufacture or initially transfer.

(a) * * *

(2) * * *

(ii) Under ordinary conditions of handling, storage, and use of the device, the byproduct material contained in the device will not be released or inadvertently removed from the device, and it is unlikely that any person will receive in any period of 1 year a dose in excess of 10 percent of the annual limits specified in § 20.201(a) of this chapter; and

* * * * *

(c) In the event the applicant desires that the general licensee under § 31.5 of this chapter, or under equivalent regulations of an Agreement State, be authorized to install the device, collect the sample to be analyzed by a specific licensee for leakage of radioactive material, service the device, test the on-off mechanism and indicator, or remove the device from installation, the applicant shall include in the application written instructions to be followed by the general licensee, estimated calendar quarter doses associated with such activity or activities, and the bases for these estimates. The submitted information must demonstrate that performance of this activity or activities by an individual untrained in radiological protection, in addition to other handling, storage, and use of devices under the general license, is unlikely to cause that individual to receive in a year a dose in excess of 10 percent of the annual limits specified in § 20.201(a) of this chapter.

§ 32.61 [Amended].

18. In § 32.61(d), the reference to "§ 20.203(a)" is changed to read "§ 20.901(a)."

§ 32.71 [Amended].

19. In § 32.71(c)(2), the reference to "§ 20.203(a)(1)" is changed to read "§ 20.901(a)."

20. In § 32.71(e), the reference to "§ 20.301" is changed to read "§ 20.1001."

PART 34 - LICENSES FOR RADIOGRAPHY AND RADIATION SAFETY REQUIREMENTS FOR RADIOGRAPHIC OPERATIONS

21. The authority citation for Part 34 continues to read in part as follows:

Authority : Sec. 161, 68 Stat. 948, as amended (42 U.S.C. 2201); Sec. 201, 88 Stat. 1242, as amended (42 U.S.C.5841).

§ 34.29 [Amended]

22. In § 34.29(a), the reference to "§ 20.203(c)(2)(ii), (2)(iii), or (4)" is changed to read "§ 20.601(a)(2), (a)(3), or (b)."

§ 34.41 [Amended].

23. In § 34.41(a), the reference to "§ 20.203(c)(2)" is changed to read "§ 20.601(a)(1), (a)(2), or (a)(3)."

§ 34.42 [Amended].

24. In § 34.42, the reference to "§ 20.204(c)" is changed to read "§ 20.903" and the reference to "§ 20.203(b) and (c)(1)" is changed to read "§ 20.902(a) and (b)."

PART 35 - MEDICAL USE OF BYPRODUCT MATERIAL

25. The authority citation for Part 35 continues to read as follows:

Authority: Sec. 161, 68 Stat. 948, as amended (42 U.S.C. 2201), Sec. 201, 88 Stat. 1242, as amended (42 U.S.C.5841).

§ 35.92(a).

26. Change reference to "§ 20.301" to "§ 20.1001."

§ 35.315(a)(8)

27. Change reference to "§ 20.401(c)(1)" to "§ 20.1106(a)."

§ 35.415.

28. Change reference to "§ 20.105(b)" to "§ 20.301(a)."

§ 35.630(a)(1).

29. Change reference to "National Bureau of Standards" to "National Institute of Standards and Technology."

§ 35.630(a)(2).

30. Change reference to "National Bureau of Standards" to "National Institute of Standards and Technology."

§ 35.641(a)(2)(i).

31. Change reference to "§ 20.101" to "§ 20.201."

§ 35.641(a)(2)(ii).

32. Change reference to "§ 20.105(b)" to "§ 20.301."

§ 35.641(b)(2).

33. Change reference to "§ 20.501" to "§ 20.1301."

§ 35.643 (a).

34. Change reference to "§ 20.105(b)" to "§ 20.301."

§ 35.643(a)(1).

35. Change reference to "§ 20.105(b)" to "§ 20.301."

§ 35.630(a)(2).

36. Change reference to "§ 20.105(a)" to "§ 20.301(c)."

37. Change reference to "§ 20.105(b)" to "§ 20.301(a)."

PART 39 - LICENSES AND RADIATION SAFETY REQUIREMENTS FOR WELL-LOGGING

38. The authority citation for Part 39 continues to read in part as follows:

Authority: Sec. 161, 68 Stat. 948, as amended (42 U.S.C. 2201), Sec. 201, 88 Stat. 1242, as amended (42 U.S.C.5841).

39. In § 39.15(a)(5)(iii)(B), the reference to "§ 20.203" is changed to read ""§ 20.901(a)."

40. In § 39.31(a)(1), the reference to "§ 20.203" is changed to read "§ 20.901(a).

41. In § 39.31(a)(2), the reference to "§ 20.203" is changed to read "§ 20.901(a)."

42. In § 39.77(b), the reference to "§§ 20.402, 20.403, and 20.405" is changed to read "§§ 20.1201 and 20.1203."

PART 40 - DOMESTIC LICENSING OF SOURCE MATERIAL

43. The authority citation for Part 40 continues to read in part as follows:

Authority: Sec. 161, 68 Stat. 948 as amended (42 U.S.C. 2201), Sec. 201, 88 Stat. 1242, as amended (42 U.S.C. 5841).

44. Section § 40.34 is amended by revising paragraph (a)(2) to read as follows:

§ 40.34 Special requirements for issuance of specific licenses.

(a) * * *

(2) The applicant submits sufficient information relating to the design, manufacture, prototype testing, quality control procedures, labeling or marking, proposed uses, and potential hazards of the industrial product or device to provide reasonable assurance that possession, use, or transfer of the depleted uranium in the product or device is not likely to cause any individual to receive in any period of 1 year a radiation dose in excess of 10 percent of the annual limits specified in § 20.201(a) of this chapter; and

* * * * *

§ 40.61 [Amended].

45. In § 40.61(c)(4), the reference to "§ 20.401(c)" is changed to read "§ 20.1108."

Appendix A to Part 40.

46. In the Introduction to Appendix A, the reference to "§ 20.1(c)" is changed to read "§ 20.3."

PART 50 - DOMESTIC LICENSING OF PRODUCTION AND UTILIZATION FACILITIES

47. The authority citation for Part 50 continues to read in part as follows:

Authority: Sec. 161, 68 Stat. 948, as amended (42 U.S.C. 2201); Sec. 201, 88 Stat. 1242, as amended (42 U.S.C.5841).

48. Section 50.34 is amended by revising paragraph (f)(2)(viii) to read as follows:

§ 50.34 Contents of applications; technical information.

* * * * *

(f) * * *

(2) * * *

(viii) Provide a capability to promptly obtain and analyze samples from the reactor coolant system and containment that may contain TID-14844 source term radioactive materials without radiation exposures to any individual exceeding 5 rems to the whole body or 50 rems to the extremities. Materials to be analyzed and quantified include certain radionuclides that are indicators of the degree of core damage (e.g., noble gases, iodines and cesiums, and nonvolatile isotopes), hydrogen in the containment atmosphere, dissolved gases, chloride, and boron concentrations. (II.B.3)

* * * * *

49. In § 50.36a(a), the reference to "§ 20.106" is changed to read "§ 20.301" and paragraph (b) is revised to read as follows:

§ 50.36a Technical specifications on effluents from nuclear power reactors.

* * * *

(b) In establishing and implementing the operating procedures described in paragraph (a) of this section, the licensee shall be guided by the following considerations: Experience with the design, construction, and operation of nuclear power reactors indicates that compliance with the technical specifications described in this section will keep average annual releases of radioactive material in effluents and their resultant committed effective dose equivalents at small percentages of the values specified in § 20.301 of this chapter and in the operating license. At the same time, the licensee is permitted the flexibility of operation, compatible with considerations of health and safety, to assure that the public is provided a dependable source of power even under unusual operating conditions which may temporarily result in releases higher than such small percentages, but still within the dose values specified in § 20.301 of this chapter and in the operating license. It is expected that in using this operational flexibility under unusual operating conditions, the licensee will exert its best efforts to keep levels of radioactive material in

effluents as low as is reasonably achievable. The guides set out in Appendix I provide numerical guidance on limiting conditions for operation for light-water-cooled nuclear power reactors to meet the requirement that radioactive materials in effluents released to unrestricted areas be kept as low as is reasonably achievable.

50. In § 50.72 in paragraph (a), Footnote 1, the reference to "§ 20.205, § 20.403" is changed to read "§ 20.906, § 20.1202," and paragraphs (b)(2)(iv)(A) and (B) are revised to read as follows:

§ 50.72 Immediate notification requirements for operating nuclear power reactors.

* * * * *

(b) * * *

(2) * * *

(iv) (A) Any airborne radioactive release that results in concentrations in unrestricted areas that exceed 20 times the applicable concentration specified in Appendix B, Table 2, Column 1, of Part 20 of this chapter, when averaged over a time period of 1 hour.

(B) Any liquid effluent release that exceeds 20 times the applicable concentration specified in Appendix B, Table 2, Column 2, of Part 20 of this chapter at the point of entry into the receiving waters (i.e., unrestricted area) for all radionuclides except tritium and dissolved noble gases, when averaged over a time period of 1 hour. (Immediate notifications made under this paragraph also satisfy the requirements of paragraphs (a)(2) and (b)(2) of § 20.1202 of this chapter.)

51. Section 50.73 is amended by revising paragraphs (a)(2)(viii)(A) and (B) and (ix) to read as follows:

§ 50.73 Licensee event report system.

(a) * * *

(2) * * *

(viii)(A) Any airborne radioactivity release that exceeded 20 times the applicable concentrations specified in Appendix B, Table 2, Column 1, of Part

20 of this chapter in unrestricted areas, when averaged over a time period of 1 hour.

(B) Any liquid effluent release that exceeded 20 times the applicable concentrations specified in Appendix B, Table 2, Column 2, of Part 20 of this chapter at the point of entry into the receiving water (i.e., unrestricted area) for all radionuclides except tritium and dissolved noble gases, when averaged over a time period of 1 hour.

(ix) Reports submitted to the Commission in accordance with paragraph (a)(2)(viii) of this section also meet the effluent release reporting requirements of § 20.1203(a)(3) of this chapter.

* * * * *

PART 61 - LICENSING REQUIREMENTS FOR LAND DISPOSAL OF RADIOACTIVE WASTE

52. The authority citation for Part 61 continues to read in part as follows:

Authority: Sec. 161, 68 Stat. 948, as amended (42 U.S.C. 2201); Sec. 201, 88 Stat. 1242, as amended (42 U.S.C.5841).

§ 61.52 [Amended].

53. In § 61.52(a)(6), the reference to "§ 20.105" is changed to read "§§ 20.301 and 20.302."

PART 70 - DOMESTIC LICENSING OF SPECIAL NUCLEAR MATERIAL

54. The authority citation for Part 70 continues to read in part as follows:

Authority: Sec. 161, 68 Stat. 948, as amended (42 U.S.C. 2201), Sec. 201, 88 Stat. 1242, as amended (42 U.S.C.5841).

§ 70.51 [Amended].

55. In § 70.51(b)(6), the reference to "§ 20.401(c)" is changed to read "§ 20.1108."

Dated at Rockville, Maryland, this _____ day of _____ 1990.

For the Nuclear Regulatory Commission.

_____

Samuel J. Chilk,

Secretary of the Commission.

ENCLOSURE B

MARKED COPIES OF THE SRM

KEY TO CHANGES TO TEXT OF REVISED
PART 20 FEDERAL REGISTER NOTICE

(REFLECTS CHANGES FROM THE TEXT
FROM APPENDICES 3, 4, AND 5 OF SECY-88-315)

KEY: ___ = Addition; [ ] = Deletion; tr = same wording but transposed order
Vertical lines in margin = large insertion or replacement of text

Margin Code	Reference for Change
267 p.6	SECY-89-267, Enclosure 3, page 6
237 # 2	SECY-90-237, Enclosure A, item 2
SRM # 4	Staff Requirements Memorandum, July 30, 1990, item # 4
KCVS p.3 KCMU p.45	Chairman Carr's Votesheet, page 3 Chairman Carr's Mark-up, page 45
RoVS p. 3 RoMU p. 2	Commissioner Rogers' Votesheet page 2 Commissioner Rogers' Mark-Up page 2
ReVS p. 3 ReMU p 2	Commissioner Remick's Votesheet page 2 Commissioner Remick's Mark-up page 2
JCVS p. 3. JCAC	Commissioner Curtiss's Votesheet p. 3 Commissioner Curtiss's Additional Comments
RuR	Change recommended by Division of Rules and Records
OGC	Change recommended by the Office of General Counsel
IRM	Change recommended by the Office of Information Resource Management
EDC	Editorial Change to improve clarity
EDS	Editorial change to improve style and grammar

Cross-Indices to Documents Used for Quality Assurance:

1. NUREG/BR-0095, "Checklist for Preparation and Review of Federal Register Rulemaking Documents"

2. Staff Requirements Memorandum of July 30, 1990 on SECY-89-247/SECY-88-315/SECY-90-237

3. Markups Accompanying the Votesheets of Chairman Carr, Commission Rogers, and Commissioner Remick, and Commissioner Curtiss's additional comments.

4. Enclosure 6 of SECY-88-315, "Changes from Proposed Rule" per SRM # 7.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

OFFICE OF THE
SECRETARY

July 30, 1990

ACTION - Beckjord, RES

Cys: Taylor
Sniezek
Thompson
Blaha
Murley, NRR
Bernero, NMSS
Jordan, AEOD
Scroggins, OC
✓HPeterson, RES
DMeyer, ADM
BShelton, IRM

MEMORANDUM FOR: James M. Taylor
Executive Director for Operations

William C. Parler
General Counsel

FROM: Samuel J. Chilk, Secretary

SUBJECT: SECY-89-267/SECY-88-315/SECY-90-237 - REVISION OF 10 CFR PART 20 - STANDARDS FOR PROTECTION AGAINST RADIATION

This is to advise you that the Commission (with Chairman Carr and Commissioners Rogers, Curtiss, and Remick agreeing except as noted below) has approved the proposed revisions of 10 CFR Part 20 as presented in SECY-88-315, revised in SECY-89-267 and SECY-90-237, and subject to the modifications listed below.

Following staff completion of the following items the rule should be returned for final Commission review, affirmation and publication in the Federal Register. Publication of the new Part 20 should be accompanied by appropriate efforts to disseminate information about the rule to licensees, other Federal agencies, States, the Congress and the public.

(~~EDO~~/OGC)
(RES) (SECY Suspense: 9/90)

1. The Commission (with Chairman Carr and Commissioners Rogers and Remick approving) has agreed that publication of the rule changes can be supported under the backfit rule as described below.

   The Federal Register Notice should incorporate the staff's summary of the revised backfit analysis based on a finding that the revisions to Part 20 provide for a substantial increase in safety. The analysis should conclude with the following paragraph: Pages 104-105

   "The Commission is adopting the final rule based on the conclusion of this analysis that the rule provides for a substantial increase in the overall protection of the public health and safety and that the direct and indirect costs of its implementation are justified in terms of the quantitative and qualitative benefits associated with Page 105 2nd ¶

NOTE: THIS SRM, THE SUBJECT SECY PAPER, AND THE VOTE SHEETS OF COMMISSIONERS CURTISS, REMICK, AND ROGERS WILL BE MADE PUBLICLY AVAILABLE WHEN THE FEDERAL REGISTER NOTICE IS PUBLISHED.

DATE 7.31.90
TIME 8.30 A

the rule. The Commission would note, however, that, even had the analysis not concluded that revised Part 20 provides a substantial increase in the overall protection of the public health and safety, it could have gone forward with the rule because the changes made to Part 20 also amount to a redefinition of the level of adequate protection and the backfit rule's cost justification standard does not apply to a redefinition of adequate protection."

p 105 2nd ¶

Commissioner Curtiss believes that this rulemaking constitutes a redefinition of adequate protection. He believes that the Statement of Consideration and the backfit discussion should be modified as necessary to reflect this determination; he does not believe that the Commission should attempt to justify the revision as a substantial increase in the overall protection of the public health and safety. His comments on this are included in his vote sheet and are attached hereto.

pages 105-109

2. The revision of Part 20 should become effective on January 1, 1992 and the staff should complete, to the maximum extent practicable, development of the necessary regulatory guidance documents by January 1, 1991. Early completion of the guidance, at least in draft form, should provide time for licensees to review and comment on the guidance and to develop and implement the measures necessary to comply with the new Part 20 by the effective date. In preparing regulatory guidance, the staff should ensure that it provides for the same flexibilities that have been incorporated into the rule, particularly in the areas of (1) determining compliance with the occupational dose limits involving internally deposited radionuclides and (2) establishing site-specific effluent limits in air and water considering physical and environmental characteristics that influence potential doses to members of the public. The language in the Statement of Consideration, the rule, and the guidance documents should clearly emphasize that these flexibilities apply only within an envelope of equivalent safety and protection (i.e., Part 20 provides flexibility in how the dose calculations are performed, but in all cases, unless specifically exempted, the dose limits in Sections 20.201 and 20.301 apply). The language in Enclosure 3, pages 2, 4, and 8 of SECY-89-267 should also be revised to ensure that flexibility is clearly and correctly reflected. E3p2 = p40 bottom; E3p4 = page 54 top; E3p8 (rule - flexibility requires NRC approval)

Refers to regulatory guide content

p 40 last 2 sentences. for workers p 54 top ¶ for public

3. The discussion in the Statement of Consideration (pg. 13 of Enclosure 3 to SECY-88-315) allows licensees to make pen and ink changes to their licenses to reflect these revisions to Part 20. Language should be added to the rule itself in 10 CFR 20.8 to authorize the pen and ink changes.

p 13 rule 20.8

4. The Statement of Consideration should be expanded to clarify the impact, if any, of the change in dose limits for members of the public from 500 to 100 millirem/yr when conforming the general license design standards in Parts 32 and 40 (see conforming amendment in Enclosure 5 to SECY-88-315 on pages 144 and 147). The staff should ensure that the conforming revisions are consistent with the current intent.

does not change remains 500 if they are changed would require import assessment

5. The Federal Register Notice should be updated as appropriate to reflect the Commission's recent decision on the Below Regulatory Concern Policy Statement.

page 15 ¶(2) page 25

page 19
page 52 bottom ¶, page 117 "Backgr..."

6. Staff should clarify the purpose of the rule and the definition of natural background radiation in the Statement of Consideration and the rule, in regard to consideration of sources of radiation exposure that fall outside of the scope of Part 20 (e.g., fallout, NARM, x-rays) (pages 6 and 13 of Enclosure 4 of SECY-88-315).

7. The attached modifications should be considered for incorporation into the Federal Register Notice. Comments not incorporated should be identified within the final rulemaking package. In addition to the inserts provided in SECY-90-237, the notice should be reviewed to assure that no further changes are needed to reflect the national and international radiation protection developments that have occurred since the text was prepared (i.e. BEIR IV and V, UNSCEAR 1988, ICRP's 1990 recommendations, and NCRP's Report No. 106). Finally, the Notice should have a final quality control check, including use of Enclosure 6 of SECY-88-315, to be sure that issues raised in the Statement of Consideration are answered and that all significant changes between the proposed and final rules are discussed.

pages 9-14, pages 45 and 31 completed see attachment

8. The Commission understands that the rationale for the staff's preferred risk coefficient of 5E-4 is that while 4E-4 remains a good working coefficient for occupational exposures, the greater susceptibility of fetuses and children makes 5E-4 a better number for the population as a whole. This should be made plain in the Statement accompanying the rule.

page 12 1st ¶

On p. 5 of Enclosure A to SECY-90-237, the discussion notes that the range of fatal cancer risk from lower doses in UNSCEAR-88 (.7E-4 to 3.5E-4) is .6 to 5 times higher than the 1977 ICRP risk value of 1.25E-4. The correct relationship of 3.5 to 1.25 is about 3 times, not 5.

p 10 changed to "2.8 times higher"

Finally the second paragraph of the discussion of the 1990 ICRP recommendations should be revised to state the following:

> "Until the final ICRP recommendations are published, and the need for further revisions in NRC standards established, the Commission believes it would be advisable to proceed with promulgation of the proposed dose limits, rather than deferring a reduction of the existing limits to a future rulemaking. The Commission plans to review the comments of the professional community and others on the ICRP recommendations and ICRP's response to them. In addition, the Commission will review the recommendations of other expert bodies, such as the National Council on Radiation Protection and Measurements, and participate in the deliberations of the Committee for Interagency Radiation Research and Policy Coordination on the need for further revision of the occupational radiation protection standards after the ICRP recommendations are published."

page 14 2nd ¶

The rule and the Statement of Consideration should be revised to incorporate the additional changes described in Enclosure A to SECY-90-237, as modified in the attached markings. (These changes partially implement items 3 and 7 listed above.)

ENCLOSURE 6 TO SECY-88-315

PART 20 REVISION

SECTION BY SECTION SUMMARY OF CHANGES FROM PROPOSED RULE

Annotation is where discussed in Statement

NOTE: * denotes major change from proposed rule.

General Provisions

* § 20.1 Purpose - sentence added to instruct licensees to take necessary actions in an emergency to protect life and property regardless of Part 20 requirements. This sentence conveys the essence of proposed § 20.9 which would have dispensed licensee from all of Part 20 in an emergency. pages 18-19

§ 20.2 Scope - essentially unchanged. p 19

§ 20.3 Definitions - extensively rewritten and reorganized. Put into pure alphabetical order rather than being grouped (e.g."monitoring terms"). See Statement for lists of new, modified and deleted definitions. pages 19-21

* § 20.101 Description of ICRP Dose Limitation System and linear, non-threshold dose-effect assumption moved to Statement of Considerations, proposed § 20.102 moved to § 20.101 and emphasis changed from ALARA programs to ALARA within the context of an overall Radiation Protection Program. Position on ALARA somewhat less rigid and prescriptive than proposed rule, but more of a requirement than the hortatory "licensees should" in the present rule.

pages 3-4, 24-28

PART 20 REVISION

SECTION BY SECTION SUMMARY OF CHANGES FROM PROPOSED RULE

Occupational Protection

§ 20.201 New terms introduced for "total effective dose equivalent," "eye dose equivalent" and "shallow dose equivalent" to distinguish types of doses. Conditions of measurement (e.g. tissue depth) moved into definitions of terms. Uranium chemical toxicity limit moved into § 20.201 from § 20.204. in rule

* Quarterly dose limit of 3 rem deleted. page 29

§ 20.202 Clarified to set forth when summation of internal and external doses is required, but numerical monitoring thresholds are now only in § 20.502. pages 35, 58-61

§ 20.203 (Submersion Dose) is greatly reduced and advisory, non-regulatory text is deleted. page 35

§ 20.204 Ability of licensee to modify DACs and ALIs based upon local exposure conditions (particle size, solubility, etc.) now requires prior NRC approval. page 40

* § 20.205 Deleted as it is philosophically contrary to existing and past Commission procedures and practices for controlling exposures. pages 37-41

* § 20.206 Changed to permit use of internal dose in Planned Special Exposures in order to keep the total effective dose equivalent ALARA. page 42

§ 20.207 Extends use of 10 % of adult dose limit for minors from deep-dose equivalent to eye dose and shallow dose for skin and extremities. page 45

§ 20.208 Made requirement to keep dose to embryo/fetus uniform into a separate paragraph (provides consistency with NCRP 0.05 rem/month). Deleted advsiory information on Class Y compounds which will be put into Regulatory Guide. page 46

PART 20 REVISION

SECTION BY SECTION SUMMARY OF CHANGES FROM PROPOSED RULE

Public Protection

* § 20.301 and § 20.303 have been combined. Proposed "Reference Level" of 0.1 rem per year has been made the primary limit for members of the public. (Many commenters felt that the "reference level" was a de facto limit as it had the same recordkeeping and reporting provisions as a limit). This change reflects the 1985 clarification by the ICRP regarding the status of the public dose limits. page 51, 3rd ¶

* The 2 millirem per hour limit for doses in unrestricted areas has been reinstated. (Useful for compliance evaluations.) page 52, 2nd ¶

  A 0.5-rem annual limit is available upon NRC approval if the need can be justified. (Primarily intended to provide for teletherapy and similar facilities whose shielding was designed to meet a 0.5-rem annual dose limit for unrestricted areas.) page 53 last ¶

  Revision also clarifies that EPA generally-applicable environmental radiation standards are "limits" not "reference levels." page 52

§ 20.302 is a new section that includes information on methods for complying with § 20.301 limits. Includes some material from former § 20.303. discussed in statement under § 20.301

§ 20.303 [Deleted - see discussion on § 20.301 and § 20.302]. page 55

§ 20.304 [Deleted, pages 55-57]

PART 20 REVISION

SECTION BY SECTION SUMMARY OF CHANGES FROM PROPOSED RULE

Surveys & Monitoring

§ 20.501 Modified to incorporate provisions of final dosimeter processor accreditation rule (adopted by NRC after publication of proposed Part 20 rule. page 57

* § 20.502 Monitoring threshold for internal doses reduced from 30% of dose limit to 10% of limit. (Many commenters thought that monitoring should begin before a 1.5-rem dose could reached, e.g. would have exceeded dose limit for protection of the embryo-fetus) The 10% level was set in consideration that DAC-hours could be used to determine compliance rather than bioassay. pages 5-8-6.3

  Removed counterproductive requirement that bioassay was required for any individual wearing a respirator. (It is required if the individual would be exposed to concentrations exceeding 10% of the Derived Air Concentrations and as part of a respiratory protection program.) pages 60-61

Radiation Areas, High Radiation Areas and Very-High Radiation Areas

§ 20.601 (High Radiation Areas) added clarification that dose measurement applies at the "external surface of any package." rule

* § 20.602 rewritten to provide a general requirement for all licensees to restrict access to "very high radiation areas." (Nuclear power reactors have a technical specification (license condition) that differs from the wording of the proposed rule. This change defers to this technical specification for power reactors.) page 63, 64 FR

* § 20.603 Detailed requirements for large irradiators reinstated from § 20.203g of present Part 20 but rewritten to improve clarity and organization. New § 20.1103 recordkeeping requirement added to conform with requirement to produce record. page 63 13 FR

PART 20 REVISION

SECTION BY SECTION SUMMARY OF CHANGES FROM PROPOSED RULE

Respiratory Protection

§ 20.701 Not significantly changed.

* § 20.702 Modifies protection goal to limit intakes consistent with maintaining total effective dose equivalent ALARA rather than just minimizing internal exposure. (The previous text was noted in several comments as an example of unequal treatment of internal and external doses under old rule.) page 63 "Response"

* § 20.703 Requirement for having a respiratory protection program is now linked to use of respiratory protection equipment to protect workers rather than use of numerical protection factors from Appendix A. page 65 Written procedures are now required for monitoring, air sampling, and bioassay analyses. rule

* As suggested by comments, revision now permits changes in estimates intakes and dose in either direction (upwards or downwards) based upon bioassay results. (Proposed rule only permitted upward revisions.) page 64

* § 20.703(c) Requirement reinstated from present rule that emergency breathing apparatus be NIOSH/MSHA certified.

* § 20.704(a) Requires that licensees subject to OSHA requirements comply with OSHA requirements for respiratory protection (Many of which are already incorporated in Appendix A). This does not constitute a new requirement as the licensee is already required (under OSHA regulations) to conform. However, it saves the NRC staff the effort to conduct rulemaking to place similar conditions in Part 20 (such as conditions for the use of respirators) and also gives the NRC the capability to cite against noncompliance with the OSHA requirements. Deletion per Commission -ers Curtiss' comment page 66

PART 20 REVISION

SECTION BY SECTION SUMMARY OF CHANGES FROM PROPOSED RULE

§ 20.801, § 20.802 Minor word changes to clarify meaning of "secure."

Posting Requirements

§20.901 [Unchanged]

§20.902 Removed use of "DANGER" from signs denoting "Radiation Areas." It was felt that this would induce complacency and detract from importance of warning for "high" and "very-high" radiation areas. Very-high radiation areas (greater than 500 rads/hour) warrant "GRAVE DANGER." pages 67-68

§ 20.903 Present exemption from area posting for packages prepared for shipment and labeled in accord with DOT rules was deleted in proposed rule and continues to be deleted page 70 top

§ 20.905 Exemption from package labeling for packages labeled in accord with DOT requirements was reinstated from present rule. (Deleted in Proposed Rule.) page 71 bottom

* § 20.906 (Picking up and receiving packages) Significantly changed to conform with revised DOT regulations and to conform with revised 10 CFR Part 71. pages 72-73

* Requirements for monitoring incoming packages now restricted to:
  (1) packages expressly labeled externally as containing radioactive materials; or
  (2) packages showing obvious damage or that are leaking.

page 72

PART 20 REVISION

SECTION BY SECTION SUMMARY OF CHANGES FROM PROPOSED RULE

Waste Disposal Requirements

§ 20.1001 Minor change requires licensing of persons receiving wastes from others for decay in storage. pages 73 bottom, 74

§ 20.1002 No major changes.

§ 20.1003 Capability to dispose of "readily dispersible biological material" is restored to allow research laboratories that dispose of test animals by grinding them up followed by disposal into sanitary sewer systems. Proposed rule restricted sewer disposal to soluble materials; present rule permits both "soluble and readily dispersible materials" to be disposed of in sewers. Restriction was imposed to eliminate contamination of sewage treatment plants by metallic radionuclides (e.g., americium-241). pages 75-76

Higher concentration limits for sewer disposal than for other liquid effluents are based upon anticipated dilution by other users of the sewer system (non-radioactive effluents). There has been a long-standing NRC staff position that such disposal does not consitute "disposal into a sanitary sewer system" because disposal into a sanitary sewer system operated for the sole use of the licensee does not provide such dilution. The new definition of a "sanitary sewer system" does not encompass such licensee-owned systems and also excludes "septic tanks." page 76 3rd ¶ rule rule

§ 20.1004, § 20.1005, and § 20.1006 are relatively unchanged from proposed rule. pages 77-78

PART 20 REVISION

SECTION BY SECTION SUMMARY OF CHANGES FROM PROPOSED RULE

Recordkeeping

General change to a record retention period of 3 years to conform to NRC record retention policy.

* § 20.1101 Requires licensee to use "special units" (rad, rem, and curies). page 79

Licensee must also clearly designate what type of dose is being used, e.g., effective dose equivalent, organ dose equivalent, shallow dose equivalent. rule

* § 20.1102 Major change to reflect emphasis on Radiation Protection Programs in § 20.101. Place ALARA recordkeeping in perspective and greatly reduces paperwork burden that would have resulted from the proposed rule. pages 79 bottom

§ 20.1103 no major changes.

§ 20.1104 Eliminated proposed rule requirement for maintaining dosimetry processor accreditation certificate (except for in-house processing). Comments requested change and it conforms to final accreditation rule. pp 83-84 rule

§ 20.1105 no major changes.

§ 20.1106 Split out format of records from requirement to keep record. minor

Clarified use of mother's records and social security account number for embryo/fetus. page 85 and rule

§ 20.1107 Expanded recordkeeping requirement from "effluents" to include all data related to assessment of doses to members of the public. page 85 bottom

§ 20.1108 no major changes.

§ 20.1109 New section contains requirements for records of entry interlock tests required by § 20.603. page 86

* § 20.1110 New section contains requirements on the form of records. Now permits use of "electronic media" providing that the method used is capable of producing a clear legible record and that means are provided for prevention of loss or alteration. page 86

PART 20 REVISION

SECTION BY SECTION SUMMARY OF CHANGES FROM PROPOSED RULE

Reporting Requirements

§ 20.1201 Clarified 30-day written report is 30 days after telephone report. page 88 2nd & 3rd ¶s

§ 20.1202 Reinstated monetary loss and lost time criteria for incident notification (in present rule; removed in proposed rule).

Changed NRC organization to be notified from Regional Office to NRC Operations Center. page 89 bottom, 90 top

§ 20.1203 Separated criteria for reportable events from requirements for contents of reports.

§ 20.1204 Extended reporting period of a planned special exposure from 15 to 30 days. page 44 top

§ 20.1205 [Reserved] (Was on reports of exceeding the "Reference Level" for members of the public. A requirement for reports of exceeding dose limits for members of the public is in § 20.1203.) deletion page 51 bottom ¶

* § 20.1206 (combined with § 20.1207) Eliminates termination and annual statistical reports in favor of individual dose reports from those licensees that were required (old § 20.408) to submit the termination and statistical reports. pages 93 bottom, 94 top

Exceptions §§ 20.1301, 20.1302 No major changes.

Enforcement § 20.1401 Minor editorial changes.

[7590-01]

NUCLEAR REGULATORY COMMISSION

10 CFR PART 20
and 10 CFR Parts 2, 19, 31, 32, 34, 35, 39, 40, 50, and 61

RIN 3150 - AA38 RuR

Standards for Protection Against Radiation

AGENCY: Nuclear Regulatory Commission.

ACTION: Final rule.

SUMMARY: The Nuclear Regulatory Commission (NRC) is revising its standards for protection against ionizing radiation. This action is necessary to incorporate updated scientific information and to reflect changes in the basic philosophy of radiation protection. The revision conforms the Commission's regulations to the Presidential Radiation Protection Guidance to Federal Agencies for Occupational Exposure and to recommendations of national and international radiation protection organizations. [ ]

EFFECTIVE DATE: This regulation becomes effective January 2, 1991. However, licensees may delay implementation of this rule until January 1, 1993. (See § 20.8 of the rule and Part V., "Implementation," of the preamble.) SRM2

ADDRESS: [LED] Copies of documents relating to the January 9, 1986 proposed rule (51 FR 1092) or this document may be examined and copied for a fee in the Commission's Public Document Room at 2120 L Street NW (Lower-Level), Washington, DC 20555. [ ] OGC

FOR FURTHER INFORMATION CONTACT: Harold T. Peterson, Jr., Division of Regulatory Applications, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Telephone (301)492-3640.

SUPPLEMENTARY INFORMATION:

I. Introduction

A. Purpose of the Revision

The purpose of this revision of 10 CFR Part 20 is to modify the NRC's radiation protection standards to reflect developments in the principles and scientific knowledge underlying radiation protection that have occurred since Part 20 was originally issued more than 30 years ago. These developments not only include updated scientific information on radionuclide uptake and metabolism, but also reflect changes in the basic philosophy of radiation protection. Incorporation of these changes will ensure that Part 20 continues to provide adequate protection of public health and safety.

It is also the purpose of this revision to implement the 1987 Presidential guidance on occupational radiation exposure (see Section II.D). The Atomic Energy Commission (AEC) and the NRC have followed past Federal radiation protection guidance, and conformance with the guidance is viewed by the Commission as being necessary to ensure that NRC licensees are using levels of protection comparable to those used by Federal agencies.

The AEC and the NRC have generally followed the basic radiation protection recommendations of the International Commission on Radiological Protection (ICRP) and its U.S. counterpart, the National Council on Radiation Protection and Measurements (NCRP), in formulating basic radiation protection standards. In 1977, ICRP issued revised recommendations for a system of radiation dose limitation. This system, which was described in ICRP Publication 26,[1] introduced a number of significant modifications to existing concepts and recommendations of the ICRP and the NCRP that are now being incorporated in the NRC regulations. In particular, this revision of Part 20 puts into practice recom

[1] Recommendations of the International Commission on Radiological Protection, January 13, 1977, ICRP Publication No. 26, (1977). (Available for sale from Pergamon Press, Elmsford, NY 10523.)

mendations from ICRP Publication 26 and subsequent ICRP publications. The Federal radiation protection guidance signed by the President on January 20, 1987, is also based upon the ICRP 1977 recommendations in ICRP Publication 26.

In adopting the basic tenets of the ICRP system of dose limitation, the Nuclear Regulatory Commission recognizes that, when application of the dose limits is combined with the principle of keeping all radiation exposures "as low as is reasonably achievable," the degree of protection could be significantly greater than from relying upon the dose limits alone.

KCM 83

B. Fundamental Radiation Protection Principles

The radiation protection standards in this part are based upon the assumptions that--

(1) Within the range of exposure conditions usually encountered in radiation work, there is a linear relationship, without threshold, between dose and probability of stochastic health effects (such as latent cancer and genetic effects) occurring;

(2) The severity of each type of stochastic health effect is independent of dose; and

(3) Nonstochastic (nonrandom) radiation-induced health effects can be prevented by limiting exposures so that doses are below the thresholds for their induction.

The first assumption, the linear nonthreshold dose-effect relationship, implies that the potential health risk is proportional to the dose received and that there is an incremental health risk associated with even very small doses, even radiation doses much smaller than doses received from naturally occurring radiation sources. These health risks, such as cancer, are termed stochastic because they are statistical in nature; i.e., for a given level of dose, not every person exposed would exhibit the effect. The second assumption means that when a stochastic effect is induced, the severity of the effect is not related to the radiation dose received. The third assumption implies that there are effects, termed nonstochastic effects, for which there is an apparent threshold; i.e., a dose level below which the effect is unlikely to occur. An

example of a nonstochastic effect is the formation of radiation-induced cataracts of the eyes.

The above assumptions are necessary because it is generally impossible to determine whether or not there are any increases in the incidence of disease at very low doses and low dose rates, particularly in the range of doses to members of the general public resulting from NRC-licensed activities. It is firmly established, both from animal studies and human epidemiological studies (such as those of the radium dial painters, radiologists, and the atomic bomb survivors) that there is an increased incidence of certain cancers associated with radiation exposure at high doses and high dose rates. However, whether these effects occur at very low doses and, if they occur, whether their occurrence is linearly proportional to dose are not firmly established. This creates considerable uncertainty in the magnitude of the risk at low doses and low dose rates. There is no clear human evidence of radiation-induced genetic damage to the children of irradiated parents. Such effects are inferred from studies of mice and nonmammalian species (e.g., fruit flies).

In the absence of convincing evidence that there is a dose threshold or that low levels of radiation are beneficial, the Commission believes that the assumptions regarding a linear non threshold dose-effect model for cancers and genetic effects and the existence of thresholds only for certain nonstochastic effects remain appropriate for formulating radiation protection standards and planning radiation protection programs.

C. Background

Standards for radiation protection were originally issued by the former AEC in the late 1950s (22 FR 548, January 29, 1957) and republished in 1960. These standards have been modified since that time by a series of amendments relating to specific issues., however, no complete revision of Part 20 has been made since the original standards were issued.

[ ] The NRC issued an Advance Notice of Proposed Rulemaking (ANPRM) in the Federal Register of March 20, 1980 (45 FR 18023). This ANPRM requested

comments on possible topics that should be revised in a proposed revision of Part 20. The responses received to this announcement were considered in the formulation of the proposed revision.

During the development of this rule, early comments from licensees, labor unions, public interest groups, other Federal agencies, and scientific organizations were solicited, discussed, and considered in formulating the proposed rule. In addition, the NRC staff has benefited from its participation in several public meetings held by the Environmental Protection Agency (EPA) in connection with the guidance for occupational radiation exposure. The revised Part 20 and the Federal guidance on occupational exposure were developed in parallel and are both based primarily on the ICRP recommendations. The comments made in these EPA-sponsored meetings and those received by EPA on the draft guidance published by EPA in the January 23, 1981 Federal Register (46 FR 7836) were reviewed by the NRC staff and considered in preparing the proposed Part 20.

The NRC published the proposed revision of the 10 CFR Part 20 rule in the January 9, 1986 Federal Register (51 FR 1092). More than 800 sets of public comments were received on the proposed revision. The public comments on the proposed revision were categorized, analyzed, and taken into account in developing the final rule. The principal public comments and the NRC staff responses to them are discussed in Section VI.

II. Developments Since the Proposed Revision Was Issued

A. ICRP 1985 Paris Meeting

In March 1985, the International Commission on Radiological Protection (ICRP) held a meeting in Paris, France, to review the work of the various ICRP task groups and committees. One of the outcomes of this meeting was an ICRP

statement[2] that the ICRP intended the principal dose limit for members of the general public to be 1 millisievert (100 millirems) in a year, rather than 5 millisieverts (500 millirems). This clarification has been taken into account for the limits adopted for members of the public in the final rule and is discussed more fully in the discussion on § 20.301.

A second recommendation of the ICRP made at that time concerned the appropriate quality factor for converting the absorbed dose from neutrons (in rads or grays) to a dose equivalent (in rems or sieverts). The ICRP statement recommended increasing the quality factor for high-energy neutrons by a factor of 2. The quality factor for fast neutrons, for example, would be increased from 10 to 20. This change has the effect of doubling the apparent biological effectiveness of high-energy neutrons. For reasons explained in the discussion of quality factors (see the discussion of § 20.4), the NRC has not adopted this recommendation in this revision of Part 20.

B. ICRP 1987 Washington Meeting

The primary focus of the statement issued by the ICRP following the 1987 meeting in Washington[3] was ICRP Publication No. 48.[4] That publication discussed higher transfer factors for transport of certain transuranic elements across the intestinal walls. These higher fractional absorption factors have been incorporated in revisions to the annual limits on intake (ALIs) and derived air concentrations (DACs) in Appendix B of the final rule. The changes resulting from the use of these revised factors would not change either the ingestion or inhalation ALIs for plutonium in the oxide or nitrate forms, but would lower

R. MU p7

2 International Commission on Radiological Protection, "Statement from the 1985 Paris Meeting of the [ICRP]," British Journal of Radiology, Vol. 58, page 910: 1985, also Health Physics, 48(6): 828-829 (June 1985)

3 International Commission on Radiological Protection, "ICRP Statement from 1987 Washington Meeting," Health Physics 53(3): 335-342 (1987).

4 International Commission on Radiological Protection, "The Metabolism of Plutonium and Related Elements," ICRP Publication No. 48, (Available for sale from Pergamon Press, Elmsford, NY 10523.) (1986).

the ALIs for other compounds or mixtures by a factor of 10. The transfer factor for the gut transfer of neptunium was found to be an order of magnitude lower than the value used in ICRP-30 and, consequently, the ingestion ALI can be increased by almost an order of magnitude. The transfer factors for americium, curium, and californium were found to be a factor of 2 higher than the ICRP-30 value so the ingestion ALIs are reduced by a factor of 2. Parameters applicable to inhalation ALIs and DACs are less affected than the ingestion ALIs as the transfer from the gastrointestinal (GI) tract to the blood for these radionuclides generally is less significant than transfer from the lung to the blood.

KCMH p7

C. ICRP 1987 Como Meeting

Following its 1987 meeting in Como, Italy, the ICRP issued a statement[5] that reviewed the existing estimates of the biological risks of ionizing radiation and, in particular, the preliminary data from the reanalysis of the Hiroshima-Nagasaki atomic bomb followup studies. Reanalysis of these data indicated that the risks from gamma radiation are approximately a factor of 2 higher than previous estimates for the general population and are also higher, but by a smaller factor, for workers. The ICRP concluded in 1987 that this information alone was "not considered sufficient at that time to warrant a change in the dose limits for occupational exposure and, for the general population, the increase in risk indicated by the new data is not considered to require an immediate change in the recommended dose limits, following the reduction by the ICRP (in 1985) in the principal limit from 5 to 1 mSv in a year (from sources other than medical and natural background radiation)." The ICRP also noted that the potential higher risks indicated by the reanalysis of the atomic bomb data should not be a major consideration as the dose limits should not be of primary importance in controlling doses if the principle of keeping radiation exposures "as low as is reasonably achievable" is being practiced. This position has since been modified by the ICRP 1990 Statement (see Section I below).

5 International Commission on Radiological Protection, "Statement from the 1987 Como Meeting of the [ICRP]," Health Physics, 54(1): 125-132 (1988).

D. Federal Radiation Protection Guidance on Occupational Exposure

On January 20, 1987, President Reagan approved revised guidance to Federal agencies for occupational radiation protection. This guidance, which was published in the Federal Register (52 FR 2822; January 27, 1987), generally adopts the philosophy and methodology of ICRP Publications 26 and 30. The Part 20 revision was developed in parallel with the development of the guidance. Because of this parallel development, the proposed Part 20 rule conformed with the draft Federal guidance available at the time the proposed Part 20 rule was written. However, because of changes made to both the draft guidance and the draft Part 20 revision, there were a few differences between the guidance in its final published form and the proposed Part 20 revision. As discussed in the respective sections below, changes to the proposed rule have been made in order to implement the final version of the Federal guidance.

E. NCRP Report No. 91

On June 1, 1987, the National Council on Radiation Protection and Measurements (NCRP) issued a report[6] containing updated NCRP recommendations for radiation protection limits. These recommendations replace recommendations published in 1971. The majority of these recommendations are in accord with the 1977 recommendations of the ICRP and, consequently, were already reflected in the proposed Part 20 rule. There are, however, several NCRP recommendations that were not in the ICRP-26 recommendations. These NCRP recommendations are:

> (1) A general "guideline" that the cumulative effective dose equivalent to a worker should not exceed 1 times the worker's age in years; i.e., 1 x N instead of the former 5(N - 18) formula;

6 National Council on Radiation Protection and Measurements (NCRP), "Recommendations on Limits for Exposure to Ionizing Radiation," NCRP Report No. 91 (June 1, 1987). (Available for sale from the NCRP, 7910 Woodmont Avenue, Suite 800, Bethesda, MD 20814-3095.)

(2) Use of committed effective dose equivalent for planning purposes and the use of annual (rather than committed) doses for post-(internal) exposure control;

(3) A monthly dose limit as well as a limit on total gestation dose to the embryo/fetus;

(4) Adoption of a 0.1-rem (1 mSv) effective dose equivalent limit for exposure of the general public with the condition that the "site operator" assess the total exposure to the most exposed individual if estimated or measured exposures exceed 25 percent of this limit (25 millirems or 0.25 mSv per year);

(5) The use of "reference levels" set up by the radiation user below the regulatory limits;

(6) A Negligible Individual Risk Level of 1 millirem (0.01 mSv) per year. This level is the "...average annual excess risk of fatal health effects attributable to irradiation, below which further effort to reduce radiation exposure to the individual is unwarranted" (NCRP No.91, p. 43).

These NCRP recommendations were issued after publication of the proposed Part 20 rule and, consequently, there has not been an opportunity for public comment on them. For this reason, these NCRP recommendations are not being adopted in the revised Part 20 rule at this time.

F. The 1988 Report of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR-88).

The United Nations Scientific Committee on the Effects of Atomic Radiation has analyzed data on the sources and effects of atomic radiation and published a series of reports containing summaries of the sources of radiation, the doses received by workers and members of the general public from these sources, and an analysis of the potential health risks from exposure to ionizing radiation.

237
#8
SRM1
#7

The latest report in this series is the 1988 report. The 1988 report[7] contains more recent information on the health risks of ionizing radiation determined from a reevaluation of the data on the survivors of the Hiroshima-Nagasaki atomic bombings. Based upon these data, the radiation risk at high doses and high dose rates is estimated to be 7.1×10^{-4} fatal health effects per rad (0.071 effects per gray). For estimating the risk from radiation doses below 100 rads, the UNSCEAR report recommended that a dose rate reduction factor be applied to account for the reduced effectiveness of lower doses and lower dose rates. This would lead to an estimated risk of fatality of between (0.7 to 3.5) $\times 10^{-4}$ health effects per rad for low doses such as those encountered in routine occupational exposure and the even lower doses that might be received by members of the general public from NRC- (or Agreement State) licensed activities. The fatal cancer risk value associated with the 1977 ICRP recommendations,[1] is 1.25×10^{-4} (the proposed Part 20 rule, 51 FR 1102, January 9, 1986) so that the risks as estimated by the 1988 UNSCEAR report for low doses are between 0.6 to 2.8 times higher than the earlier ICRP estimate. The implications of the increased risk are discussed in Section II.I.

237 #8 SRM2 #7 } SRM #8

G. The 1988 Report of the National Academy of Sciences' Committee on the Biological Effects of Ionizing Radiation (BEIR-IV)[8]

The 1988 BEIR-IV report supplements the 1980 BEIR-III report by providing a more detailed analysis of the risks from internal alpha-emitting radionuclides to complement the emphasis of the BEIR-III report on gamma and beta radiation. Revised risk estimates are given for intakes of radon, radium, polonium, thorium, uranium, and higher transuranic elements (e.g., plutonium).

---

7 United Nations Scientific Committee on the Effects of Ionizing Radiation (UNSCEAR), "Sources, Effects and Risks of Ionizing Radiation, 1988 Report to the General Assembly, Sales Section, United Nations, NY 10017 (1988)

8 National Academy of Sciences-National Research Council, Committee on the Biological Effects of Ionizing Radiation "Health Risks of Radon and Other Internally Deposited Alpha-Emitters, (BEIR-IV)," National Research Council, National Academy Press, Washington, DC 20418 (1988).

The radionuclide given the greatest emphasis in the BEIR-IV report is radon (radon-222), the gaseous decay product of radium-226. The radon dose conversion factor in the BEIR-IV report for exposure conditions representative of those of the general public is consistent with the value used to derive the airborne effluent concentration limit for radon-222 in Appendix B, Table 2 of the revised 10 CFR Part 20.

237
#8
SCPM
#7

H. The 1990 Report of the National Academy of Sciences' Committee on the Biological Effects of Ionizing Radiation (BEIR-V)[9]

The BEIR-V report is another comprehensive reevaluation of the health risks of radiation exposure based upon the revised dose estimates for the survivors of the atomic bombings of Hiroshima and Nagasaki. The BEIR-V report gives risk estimates for leukemia and non-leukemia (solid cancers) that are about two to five times higher than the estimates in the 1980 BEIR-III report. The BEIR-V report gives the following factors as the principal reasons for this increase: (1) use of different dose-response and risk projection models, (2) revised estimates of the doses to the individual survivors of the atomic bombings in Japan, and (3) improved epidemiological data from additional years of followup studies since the BEIR-III was completed in 1980.

The BEIR-V Committee uses the linear dose response model and the relative risk projection model to extrapolate the fatal tumor risk to future periods. The relative risk projection model assumes the risk to be proportional to the natural cancer incidence, which generally increases with age. Because of this dependence on age, the relative risk model generally predicts higher future (lifetime) risks than the absolute risk model which employs a constant added risk per year with increasing age. Estimates are given of the risk as a func-

---

9 National Academy of Sciences-National Research Council, Committee on the Biological Effects of Ionizing Radiation, "Health Effects of Exposure to Low Levels of Ionizing Radiation, (BEIR-V)," National Research Council, National Academy Press, Washington, DC 20418 (1990).

tion of the time since the exposure occurred and the age and sex of the exposed person. The BEIR-V report, like the UNSCEAR-88 report, indicates that a reduction factor should be applied to the risk estimates derived from nigh doses and dose rates in order to apply them to low dose and low dose-rate situations. Although neither the BEIR-V report nor the UNSCEAR-88 report recommends a specific value for this factor, both reports indicate that this factor should be greater than 2, (larger reduction factors would give a lower risk per unit dose). Assuming a factor of 2 reduction in the risk estimates derived from high doses and high dose rates, BEIR-V would give a lifetime risk of a radiation-induced cancer fatality of about 4×10^{-4} fatal cancers/rem (0.04 per sievert) for workers and 5×10^{-4} per rem (0.05 per sievert) for the general population, the higher value for the public being associated with the higher sensitivity and the longer period of elevated risk associated with the younger ages present in the general population. The value of 5×10^{-4} is three times as large as the recommended value in the 1980 BEIR-III report and four times as large as the estimate in the 1977 ICRP-26[1] report (see Section II.F).

277 #8

SRM 1 #3

SRM 2 #8

The BEIR-V report also summarized the data on the frequency of severe mental retardation found in the children of Hiroshima and Nagasaki atomic bomb survivors. These children were exposed in utero at gestational ages of 8-15 weeks and the risk of severe mental retardation during this period is about 4×10^{-3} per rem with less of a risk at other gestational ages.

Added in response to comments on SECY-90-237

The estimates of genetic effects to the offspring of irradiated individuals remained similar to those in the 1972 BEIR-I and 1980 BEIR-III reports. As radiation-induced inherited abnormalities have not been observed directly in humans, estimates of genetic effects have been based primarily upon experimental studies with mice. These studies suggest that it would take a dose of about 100 rads to double the natural frequency of genetically transmitted diseases.

I. ICRP 1990 Recommendations

On June 22, 1990, the International Commission on Radiological Protection issued a press release indicating that it would issue revised recommendations

237 #8

SRM II #7

for radiation protection based upon the newer studies of radiation risks (such as those described in Sections F, G, and H above). The press release indicated that the ICRP would recommend a reduction in the occupational dose limit from an equivalent of 5 rems p[illegible] year to an average o[illegible] rems per year with some allowance for year-to-year flexibility. The ICRP dose limit for long-term exposure of members of the general public would remain equivalent to the level adopted in this revision of Part 20, 0.1 rem per year.

237 #8 SRM1 #7

The Nuclear Regulatory Commission does not believe that additional reductions in the dose limits are urgently required by the latest radiation risk estimates. Few individuals in either the work force or in the general public are exposed at or near the limits, and most of these will not be exposed at such levels over long periods of time. Due to the practice of ALARA ("as low as is reasonably achievable"), the average radiation dose to occupationally exposed individuals is well below the limits in either the existing or revised Part 20 and also below the changes being considered by the ICRP. For example, in 1987 about 97 per cent of the workers in nuclear power plants, industrial radiography, reactor fuel fabrication, and radioisotope manufacturing, four of the industries having the highest potential for occupational radiation exposures, were below an annual dose of 2 rems so that an immediate reduction in the occupational dose limits would result in only a small reduction in the population dose and in the potential health impact. Although the risk per unit dose is higher than previously thought, individual annual exposures averaged over a lifetime in the highest exposed groups in the working population appear to be about 2-3 rems per year (50-60 % of the 5-rem annual limit). Therefore, a factor of 2 increase in the risk per unit dose would result in estimated potential risks associated with actual lifetime exposures that are comparable to the previous risk estimate applied to an assumed lifetime exposure of 5 rems per year.

ReVS RoVS

As a result of the application of the ALARA philosophy to effluent release standards in Appendix I to 10 CFR Part 50 for nuclear power reactors and EPA's 40 CFR Part 190 for the uranium fuel cycle, doses from radioactive effluents from fuel cycle facilities are already much less than the 0.1 rem per year standard in the revised Part 20. The 0.1 rem per year remains as the level recommended by the ICRP for protection of the general public.

237 #8 SRM1 #8

2374

SRM 1 #9

Until the final ICRP recommendations are published, and the need for further revisions in NRC standards established, the Commission believes it would be advisable to proceed with the promulgation of the proposed dose limits, rather than deferring the dose reductions that are already associated with the revised Part 20 rule. The Commission will carefully review the final recommendations of the International Commission on Radiological Protection, the comments of the scientific community and others on these recommendations, and the ICRP response to these comments. In addition, the Commission staff will review the recommendations of other expert bodies, such as the National Council on Radiation Protection and Measurements, and participate in the deliberations of the U.S. Committee on Radiation Research and Policy Coordination and any interagency task force convened by the Environmental Protection Agency to consider revised Federal radiation guidance. Any future reductions in the dose limits by the Commission would be the subject of a future rulemaking proceeding.

III. Issues Being Resolved Separately

237 #9

As noted in the above discussion. there are several areas where the Commission believes a better scientific consensus is needed before adopting values different from those in the present Part 20. There are also several areas where issues raised in the public comments (see Section V) are being resolved in other NRC rulemaking proceedings because of either their scope, complexity, or timing. The following issues are being or will be resolved in other NRC rulemaking proceedings:

(1) Establishment of "Below Regulatory Concern (BRC)" levels (related to de minimis levels and a negligible level of risk). On June 27, 1990, the Commission announced the issuance of a policy statement on Below Regulatory Concern, which was subsequently published in the Federal Register on July 3, 1990 (55 FR 27522). This policy statement establishes the framework for the Commission to formulate rules and licensing decisions to exempt certain practices involving small quantities of radioactive materials from some or all regulatory controls. The BRC policy statement sets forth criteria for protection of both individuals (individual dose criteria) and population groups (a collective dose criterion).

(2) Limits for decommissioning of nuclear facilities and for residual radioactive contamination. This is being actively pursued by both the NRC staff, which is developing criteria for residual contamination of soils and structures, which is one aspect of the implementation of the Below Regulatory Concern Policy, and by NRC staff participation on an EPA Interagency Task Force on Residual Radioactivity.

237
#9

(3) Limits and calculational procedures for dealing with the "hot particle" issue (small particles found in nuclear reactors that, because of their high activity and small size, produce high localized doses to skin). The NRC notes that the National Council on Radiation Protection and Measurements (NCRP) has recently issued new recommendations regarding "hot particles" in NCRP Report No. 106, "Limit for Exposure to 'Hot Particles' On the Skin," December 31, 1989. A modified NRC enforcement policy statement with regard to the "hot particle issue" was published in the July 31, 1990 Federal Register (55 FR 31113). The NCRP report, together with a forthcoming ICRP report on the biological effects of skin irradiation and other technical analyses will be considered in a future rulemaking to set limits for skin irradiation.

(4) Modification of NRC incident notification requirements. A modification of the incident notification requirements was issued for public comment on May 14, 1990 (55 FR 19890). If this proposal is adopted as a final rule, it would modify both the existing Part 20 and this revision.

(5) Publication of a separate rule for large irradiators. A new Part 36 is being proposed for public comment. The detailed requirements for irradiators presently in the revised Part 20 (§ 20.603) will eventually be deleted and replaced by the provisions incorporated in the new Part 36.

There are also additional areas where the scientific basis is not yet resolved sufficiently to justify a change from current practice. These two areas require better scientific consensus on the appropriate position: (1) The need for and impact of a lifetime cumulative dose limit of 1 rem per year of age and (2) quality factors, especially for neutrons, low-energy beta-emitters, and

high-energy gamma photons. These issues will be reconsidered as consensus positions are reached by the scientific community.

IV. Need for Additional Regulatory Guidance

The Commission recognizes that the incorporation of many new concepts into Part 20 will require additional guidance and explanation on their application to practical problems in radiation protection. The Commission also notes the desirability of having such additional guidance available at the same time that the final rule is issued in effective form. However, it was impractical, both for reasons of scheduling and availability of resources, for these guides to be developed concurrently with Part 20. Some of the regulatory guides being developed or revised to assist in the implementation of the revised Part 20 are:

updated titles list

(1) Content of Radiation Protection Programs at Nuclear Power Plants;

(2) Interpretation of Bioassay Measurements (Draft Regulatory Guide 8.9, Revision 1),

(3) Criteria and Procedures for Summation of Internal and External Occupational Doses,

(4) Acceptable Criteria for Planned Special Exposures and for Satisfying Documentation Requirements;

(5) Methods and Parameters for Calculating the Dose to the Embryo/Fetus;

(6) Instructions for Recording and Reporting Occupational Radiation Exposures (includes NRC Forms 4 and 5).

The Commission has instructed the staff to have these and other draft guides published for public comment early in 1991 so that there will be ample time to incorporate public comments into the final guides prior to the effective date of the revised Part 20 rule which is January 1, 1993.

V. Implementation and Existing License Conditions

SRM: #3

SRM:

Section 20.8 of the rule provides that NRC licensees must implement the Part 20 rule on or before January 1, 1993. Licensees that adopt the provisions of this rule prior to the required implementation date are required to notify the NRC. Early implementation may benefit applicants for new licenses or license renewals as they could avoid having to adopt and implement one version of Part 20 for only a short period of time prior to the required implementation date of this revision. Licensees choosing early implementation must adopt the entire revised Part 20. Compliance will be required with the version of 10 CFR Part 20 codified in the Code of Federal Regulations on January 1, 1991 until January 1, 1993 or until the licensee notifies the Commission of early implementation of the revised Part 20.

License conditions and reactor technical specifications may contain citations to portions of the existing 10 CFR Part 20. After adoption of the revised Part 20 by the licensee or after January 1, 1993, the applicable section of the revised Part 20 that corresponds to the same topic should be used in lieu of any section of the Part 20 in effect on or before January 1, 1991 that is cited in the technical specifications or license conditions. When there is no corresponding section in the revised Part 20 to these cited provisions, the current license condition based on the Part 20 in effect prior to January 2, 1991 shall remain in force until there is a technical specification change or license amendment or renewal. If a license condition or technical specification exempted a licensee from a provision of Part 20, it will be assumed to also exempt the licensee from the applicable provision of the revised Part 20. If the license condition or technical specification is more restrictive than the revised Part 20, it shall remain in force until it is modified by a technical specification change or license amendment or renewal.

The NRC will issue a regulatory guide that provides the section and paragraph identifiers in the revised Part 20 and the corresponding sections or paragraphs in the earlier Part 20. This document will issued shortly after the publication of this rule and will enable licensees to locate sections of the revised Part 20 that correspond to sections of the earlier Part 20 cited in license conditions and technical specifications.

VI. Summary of Public Comments and Changes from Proposed Rule

The purpose of this section is to respond to comments raised on the proposed rule and to explain and highlight the changes made to the proposed rule. This section presents, for each paragraph or section of the rule, the principal public comments on the proposed rule, an NRC staff response to the comments (where appropriate), and a summary of the principal changes that were made to the proposed rule. This section has been arranged so that it corresponds to the structure of the rule. Although it follows the format of the final rule, the following text is not intended to create any additional requirement not already in the regulatory text. [ ]

Subpart A -- General Provisions

Section 20.1 Purpose.

Final Rule. A new sentence was added to convey the intent of the former § 20.9 in the proposed rule (which has been removed) that the regulations in Part 20 should not hinder a licensee's actions to protect health and safety in the event of an emergency. It is the Commission's intent that the regulations be observed to the extent practicable during emergencies, but that conformance with the regulations should not hinder any actions that are necessary to protect public health and safety such as lifesaving or maintaining confinement of radioactive materials.

In this regard, the Commission notes that the Federal guidance on occupational radiation protection states that those dose standards only apply to normal operating conditions. The Commission believes that the dose limits for normal operation should remain the primary guidelines in emergencies. However, the Commission also recognizes that, in an emergency, operations that do not conform to the regulations may have to be carried out to achieve the high-priority tasks of worker, public, and facility protection. The purpose of the addition to this section is to assure licensees that their first priority should be to carry out those actions that are necessary to protect workers and the public

from radiation exposure, to perform lifesaving activities, to prevent or limit the spread of radioactive contamination or the release of radioactive materials to the environment, and to preserve an adequate margin of safety. In evaluating any ensuing violations and their severity, the Commission will consider on a case-by-case basis any extenuating circumstances.

KCMH p 14

KCMH change was made terms deleted instead.

Section 20.2 Scope.

Final Rule. The statement of scope remains essentially the same as in the proposed rule except that "background radiation" has replaced "natural background." This change was made to include residual global fallout and ambient radon levels within the definition of "background."

Section 20.3 Definitions.

General. Because of the large number of comments that dealt primarily with wording changes or that questioned the need for or the use of a particular definition, the individual comments will not be discussed separately. However, these comments did result in substantial revisions to many of the definitions that appeared in the proposed rule. Those definitions that were added, modified, or deleted as a result of the public comments are listed below.

Comment: Differentiation among different kinds of dose equivalents. The potential for confusion among different dose equivalents was noted. Commenters noted that effective dose equivalents, committed effective dose equivalents, and doses to the lens of eye, skin, or extremities were all expressed in units of rems or sieverts and may be difficult to distinguish from one another.

Response: In the final rule the NRC staff has applied unique names for these previously undesignated quantities including: eye dose equivalent, shallow-dose equivalent (skin), shallow-dose equivalent (extremities), and total effective dose equivalent. The ICRP did not give these quantities specific names. The use of characteristic names is intended to reduce confusion

in using these units. In this regard, it should be noted that the licensee is required to designate, in a clear and unambiguous manner, the quantities that are being recorded (see paragraph 20.1101(b)).

Final Rule. All the important definitions in the revised rule have been collected into one section, f20.3 Definitions. Unlike the proposed rule, which employed groups of related terms ("Area Terms," "Dose Terms," "Monitoring Terms," etc.), all the definitions in the final rule are listed in strict alphabetical order. This organization also avoids the presence of "local definitions" that appear only in a specific section of the regulation.

1. New Terms. The following definitions have been added to the final rule. These definitions have been added to clarify the meaning of the terms:

a. "Activity"
b. "Background radiation" SRM1 #6
c. "Derived air concentration-hours" ("DAC-hours")
d. "Dosimetry processor"
e. "Entrance or access point"
f. "Generally applicable environmental standard"
g. "Individual monitoring device"
h. "Quality factor"
i. "Sanitary sewerage"
j. "Total effective dose equivalent (TEDE)."

[ ] 10 CFR 20.16

2. Revised Definitions. The following definitions have been revised or modified from the definition used in the proposed rule:

a. "Absorbed dose"
b. "Annual limit on intake"
c. "Class"
d. "Committed dose equivalent"
e. "Committed effective dose equivalent"
f. "Derived air concentration"
g. "Dose equivalent"

h. "Effective dose e uivalent"
i. "Embryo/fetus"
j. "Eye dose equivalent"
k. "Member of the public"
l. "Nonstochastic"
m. "Person"
n. "Planned special exposure"
o. "Quarter"
p. "Survey"
q. "Weighting factor"
r. "Working level"
s. "Year"

natural background SRM 1 #8

3. Definitions and terms deleted. Two definitions were deleted because the terms no longer appear in the rule: "Collective effective dose equivalent" and "Roentgen." "Natural background" has been replaced by "Background radiation." SRM 1 #8

Section 20.4 Units of Radiation Dose.

Comment: Choice of the system of units. Several commenters expressed a preference for retaining the older "special" units (the curie, rad, and rem) rather than allowing the use of the newer SI units. Reasons cited for retaining the older system included: present widespread use and licensee familiarity, potential for misunderstandings with the newer units, the need for worker retraining (particularly while learning the new ICRP system of dose limitation), and the costs associated with changing recordkeeping systems. A smaller number of comments favored changing over to the SI units: becquerels, grays, and sieverts.

Response: Although both the "special units" and the SI units appear in the text of Part 20 (to increase the familiarity of licensees with the SI units), the Commission has decided that adoption of the SI units at this time is not necessary. The Commission recognizes that the new terms and methodological approaches in the revised Part 20 are complex and that imposition of the SI

system of units on top of this complexity would further increase the potential for confusion. Consequently, at the present time, the recordkeeping, reporting, and notification requirements require the use of the "special units," the rad, the rem, and the curie. However, as the national move to metrication continues, as anticipated in Section 5164 of the Omnibus Trade and Competitiveness Act of 1988 (P.L. 100-418), at some later time there may be amendments to Part 20 that would require the use of SI units only (becquerels, grays, and sieverts).

Final Rule. The final Part 20 rule includes the International System of Units (SI units) for distance, area, and volume. The older "special units" are retained for activity (curie), absorbed dose (rad), and dose equivalent (rem).

Comment: Quality factors for neutrons. The quality factor is the conversion factor between the absorbed dose (rads) and the dose equivalent (rems). Several publications[2,3,4,7,8] have recommended changes in neutron quality factors that are a factor of 2 higher than those in proposed Part 20. These changes would raise the quality factor for fast neutrons from 10 to 20.

Response: Increases in the quality factor for neutrons are suggested by some animal experimental data on the relative biological effectiveness (RBE) of neutrons. However, there appears to be considerable uncertainty as to whether the data actually demonstrate an increase in the hazard of neutrons. Because the RBE is defined as a ratio of doses to produce equivalent biological effects, it is not clear whether the apparent increase in the neutron RBE is due to the increased effectiveness of neutrons or whether it actually results from the decreased effectiveness of the reference gamma radiation at low doses.

---

7 International Commission on Radiological Units and Measurements, "The Quality Factor in Radiation Protection " ICRU Report No. 40 (1986). (Available for sale from ICRU Publications, 7910 Woodmont Avenue, Suite 800, Bethesda, MD 20814-3095.)

8 International Commission on Radiological Protection, "Data for Use in Protection Against External Radiation," ICRP Publication No. 51 (January 1988). (Available for sale from Pergamon Press, Elmsford, NY 10523.)

Final Rule. The NRC has decided not to revise the neutron quality factor at this time but to defer any change until there is greater scientific consensus on the most appropriate value. A major consideration underlying this decision is that neutron exposures at most NRC-licensed facilities are currently small and the potential increase of a factor of 2 would not have a major health or regulatory impact.

The decision to defer any change is consistent with recommendations of the Committee on Interagency Radiation Research and Policy Coordination (CIRRPC) of the Office of Science and Technology Policy that there should not be a revision of the value of the neutron quality factor at this time without more study. This position is also reflected in papers from the United Kingdom National Radiological Protection Board (UKNRPB)[9] and a statement on the neutron quality factor from the British Committee on Radiation Units and Measurements.[10]

Report not cited as it is not published

Comment: Table of neutron quality factors. Several commenters questioned the accuracy and timeliness of the table of neutron quality factors and fluence rates (to give dose equivalents of 1 rem) that appeared in the proposed rule. Some commenters suggested that there were more appropriate tables published by the NCRP or ICRP.

Response: The tables in the proposed and revised rules were taken from NCRP Report No 38[11] and are appropriate for the neutron dose equivalent at a soft tissue depth of 1 centimeter (which is the depth specified for the deter-

9 J.A. Dennis, "The Relative Biological Effectiveness of Neutron Radiation and Its Implications for Quality Factor and Dose Limitation," Nuclear Energy 20(2). 133-149 (1987).

10 British Committee on Radiation Units and Measurements (BCRU), "Memorandum from the BCRU: Effective Quality Factor for Neutrons," Physics in Medicine and Biology 31 (7):797-799 (1986).

11 National Council on Radiation Protection and Measurements, "Protection Against Neutron Radiation," NCRP Report No. 38 (January 1971). (Available for sale from the NCRP, 7910 Woodmont Avenue, Suite 800, Bethesda, MD 20814-3095.)

mination of the deep dose equivalent). There are newer tables from the ICRP, but these tables incorporate the factor of 2 increase in the neutron quality factor. (See the preceding discussion of the neutron quality factor.)

Subpart B -- Radiation Protection Programs

Section 20.101 Radiation Protection Programs ["As Low As Is Reasonably Achievable" (ALARA)] (f 20.102 of the Proposed Rule).

Comment: The concept of ALARA is a philosophical principle of radiation protection and, as such, it should not be made into a regulatory requirement. A primary objection to changing the status of ALARA from the hortatory suggestion in the current Part 20 ("licensees should") to a mandatory requirement ("licensees shall") is that there are no guidelines (except for light-water-reactor (LWR) effluents) as to what constitutes ALARA. Because of the subjective nature of an "ALARA level," there are problems in the retrospective evaluation of licensee performance by NRC inspectors and, at least in one case, interpretations by the courts concerning whether the levels achieved were truly "as low as is reasonably achievable."

Response: There were a number of comments that expressed similar concerns regarding the proposed implementation of "ALARA." The emphasis on ALARA actions has been revised from detailed requirements to document all ALARA actions to a requirement to have a radiation protection program that includes measures to keep doses and intakes "as low as is reasonably achievable." This shift is to emphasize that the ALARA concept is intended to be an operating principle rather than an absolute minimization of exposures.

Comment: Any requirement for ALARA should include a lower bound. Many commenters felt that there should be a "floor" for ALARA necessary.

Response: The Commission agrees that there would be advantages to establishing such a "floor," below which efforts to further reduce doses would not

be necessary. An NRC policy statement on "Below Regulatory Concern" was announced on June 27, 1990, and published in the Federal Register on July 3, 1990 (55 FR 27522). The "Below Regulatory Concern" levels in that policy statement delineate criteria below which additional licensee actions to further reduce doses would not be required. Specific rulemaking actions will be carried out to define operational thresholds for particular classes of activities such as disposal of very low-level contaminated materials. The BRC policy statement provides a framework for evaluating these case-specific actions. (See also discussion on § 20.304.)

KCMH p2; rewrite of KCMH p2)

Comment: Compliance with "ALARA-based" standards should constitute being ALARA. Several commenters supported the statement in the proposed Part 20 (§ 20.102(b)) that compliance with EPA's 40 CFR Part 190 and with Appendix I to 10 CFR Part 50 should constitute de facto compliance with the requirement to keep LWR effluents ALARA. Environmental Protection Agency (EPA) comments did not support this view.

Response: Appendix I to 10 CFR Part 50 defines ALARA levels of radioactive materials in LWR effluents. If the design objectives of Appendix I are met, it constitutes a demonstration that the effluents are ALARA and no additional effort is required to reduce the effluent levels. Although the EPA interprets 40 CFR Part 190 as an "ALARA-based" standard, it also believes that 40 CFR Part 190 constitutes an upper bound, not a lower bound, to ALARA efforts.[12] Consequently, compliance with 40 CFR Part 190 is not in itself sufficient to demonstrate that releases and doses are ALARA.

As Appendix I to Part 50 defines ALARA design objectives that constitute ALARA effluent levels, meeting these levels is sufficient to demonstrate ALARA

12 Letter of January 7, 1986, from Sheldon Meyers, Director, Office of Radiation Programs, Office of Air and Radiation, U.S. Environmental Protection Agency, to Robert B. Minogue, Director, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission. (This letter is reproduced as Enclosure B to the comments of the Environmental Protection Agency on the 10 CFR Part 20 revision (Docket PR-19, 20, 30 et al., 50 FR 51992, Comment # 769).)

effluent releases. In order for light-water reactors to demonstrate that doses from both effluents and direct radiation are ALARA, it is necessary to demonstrate that effluents meet the design objectives of Appendix I to 10 CFR Part 50, that direct radiation from onsite sources (gamma radiation from external radwaste tanks and turbine generators ("turbine shine")) is also ALARA, and that the total dose to any member of the public is within the numerical standards in 40 CFR Part 190. Meeting these conditions will constitute sufficient evidence that offsite doses from LWRs are ALARA and in conformance with both Appendix I and 40 CFR Part 190.

Comment: The NRC should establish "reference levels" in its rules. One commenter thought that the NRC should have "reference levels" for licensee action in Part 20.

Response: The Commission recognizes that licensees generally establish their own lower "reference levels" in order to keep from reaching and exceeding the Commission's formal dose limits. Based upon the public comments on the reference level for exposure of members of the public, which was in the proposed § 20.303, this approach would not be favored by a majority of licensees. Several commenters viewed the reference level for the dose to members of the public as being applied exactly as if it were a limit. Consequently, if the NRC were to specify generic reference levels for licensee action, the impact might be similar to lowering the magnitude of the dose limits. The Commission believes that the use of the ALARA philosophy is a preferable means to keep exposures well below the limits established by the Commission.

Final Rule. The final rule establishes a requirement for all licensees to have a radiation protection program that includes provisions for keeping radiation doses ALARA. It is expressly intended that the level of this program and efforts to document it are commensurate with the size of the licensed facility and the potential hazards from radiation exposure and the intake of radioactive materials.

The requirement for a radiation protection program is not new; it was discussed in the proposed rule (under ALARA) and is consistent with requirements in Part 33 (§§ 33.13, 33.14, and 33.15), Part 34 (§ 34.11), Part 35 (§§ 35.20-35.31), and Part 40 (§ 40.32) of the NRC regulations, with the information requested in Chapter 12 of Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants," and with the conditions in most licenses issued by the Commission. The extent of this program and requirements for written records and procedures for operating the program are intended to be commensurate with the scope and potential hazards associated with the licensee's activities. The Commission recognizes the need to provide guidance on the scopes of radiation protection programs and such guidance will be prepared in the form of Regulatory Guides.

The Commission continues to emphasize the importance of the ALARA concept to an adequate radiation protection program. In order to strengthen this concept, the Commission has adopted a requirement that all licensees include provisions for maintaining radiation doses and intakes of radioactive materials as low as is reasonably achievable as part of their radiation protection programs. Compliance with this requirement will be judged on whether the licensee has incorporated measures to track and, if necessary, to reduce exposures and not whether exposures and doses represent an absolute minimum or whether the licensee has used all possible methods to reduce exposures. This shift in emphasis should reduce potential problems of retrospective evaluation of licensee performance under admittedly subjective criteria. However, the licensee should be able to demonstrate that periodic reviews of performance have been made and that efforts have been made to achieve ALARA. As noted above, the level of effort expended on the radiation protection programs should reflect the magnitude of the potential exposures, both the magnitude of average and maximum individual doses and, in facilities with large numbers of employees, collective (population) doses. A nuclear power reactor licensee would be expected to have a considerably larger program than a licensee with only small sealed sources.

The Commission has not adopted a requirement that a numerical cost-benefit analysis (optimization analysis) be used to demonstrate ALARA. The quantitative

approach is useful for those situations where both costs and benefits (dose reduction) can be quantitated, such as in shielding design or analysis of decontamination methods. The Commission encourages licensees to employ quantified analyses to define ALARA, but their use is not required. One reason for this is that many ALARA procedures simply reflect sound operating practice and do not lend themselves to a numerical analysis. Another reason is that cost-benefit analyses could have a cost associated with obtaining the necessary information and carrying out the analysis that may exceed the monetary value of the dose reduction. Thus the quantitative optimization analysis would be expected to be used primarily in situations where both the costs of control and the resultant benefits were not only quantifiable, but also appreciable compared to the cost of performing the analysis.

Subpart C--Occupational Dose Limits

Section 20.201 Occupational Dose Limits for Adults.

Comment: Elimination of the 5(N - 18) age-prorated cumulative dose limit and the adoption of the 5-rem annual effective dose limit. Most commenters favored this change noting that licensees have generally succeeded in keeping doses below 5 rems per year for the past few years and, therefore, are already meeting the new limit.

Comment: Lifetime dose limits. A few commenters believe that there should be a limit on the cumulative total dose that can be received by any individual in a lifetime.

Response: The Commission considered the use of a lifetime dose limit but rejected it. The EPA had proposed such a limit (100 rems) in its proposed Federal Guidance on Occupational Radiation Exposure (46 FR 7836, January 23, 1981) but withdrew it.

If the magnitude of the annual dose is limited, there is a de facto limitation of the lifetime dose that can be received. The Commission believes that

such a de facto lifetime limit is preferable to an actual cumulative lifetime dose limit because the cumulative limit could act to limit employability. This, in turn, raises questions concerning the right of an individual to pursue employment in a chosen profession. If an individual were to deplete the "dose bank" provided by a lifetime dose limit, it might be difficult to obtain future employment using ionizing radiation.

Comment: Quarterly dose limit. A number of commenters noted that the ICRP system of dose limitation does not have quarterly or other limits covering periods less than a year. The public comments also noted the possibility of giving rise to two violations for the same event (i.e., the possibility of exceeding both the quarterly and annual dose limits in one event), thereby incurring two penalties.

Response: The quarterly limit (only for deep-dose equivalent) had been retained in the proposed rule as a result of suggestions received from several groups during the development of the rule. The primary protection function of retaining a quarterly limit was to reduce the potential for receiving several high doses within a relatively short period of time. However, there is not much of a radiobiological significance between 10 rems (two 5-rem doses) and 6 rems (two 3-rem doses) received in a short time period. One consideration is the employability of a worker who has exceeded the dose limit. A worker who exceeded the 5-rem annual dose limit might have to work in a job not involving radiation for a year (or take part in a planned special exposure) instead of only a calendar quarter if a quarterly dose was used.

Final Rule. In order to maintain compatibility with the ICRP and to eliminate the possibility of double violations, the quarterly limit has not been kept and only annual limits are stated.

Comment: Eye dose limit. Some commenters questioned the 15-rem (0.15-sievert) eye limit used in the proposed rule noting that ICRP Publication No. 26 contains a recommended value of 0.3 sieverts (30 rems).

Response: The ICRP recommended a reduction in the limit for the eye to 0.15 sieverts (15 rems) at their Brighton, England, meeting in 1980.[13] This was done because the ICRP concluded that, for a lifetime of occupational exposure at the former 0.3-sievert (30-rem) limit, some opacities in the sense of the eye might be produced that could develop to the point of causing deterioration of vision (even without further radiation exposure). In most situations, the limits for the deep-dose equivalent and the shallow-dose equivalent to the skin should ensure that the eye dose limit is also met. Consequently, the reduction from 30 rems to 15 rems is not expected to have a significant impact on either health protection or control cost.

Comment: Parameters defining the shallow-dose equivalent ("skin dose"). The proposed rule would have established a dose limit for the skin of 50 rems averaged over 10 square centimeters (10 cm^2). There were several comments concerning the scientific basis for this area. Some commenters suggested other surface areas, such as 15 cm^2 as being better suited to measurement conditions. Proponents of the larger areas generally favored these areas because of their compatibility with either contamination survey practices or with the physical size of survey instrument detector probes.

One set of comments prepared by the developer of the NRC's VARSKIN computer program for skin dose calculation (comment letter No. 262 in the NRC Public Document Room) contains a well-documented discussion of the selection of an appropriate area over which to average the skin dose. These comments conclude that 1 cm^2 is a more appropriate area than either 10 cm^2 or 100 cm^2.

Response: ICRP Publication 26 contains two recommendations for such areas: a 100-cm^2 area and a 1-cm^2 area, the larger area being associated with routine monitoring for skin contamination and the smaller area being associated with accident dose evaluation. After reviewing these comments and various recommen

13 International Commission on Radiological Protection, "Statement and Recommendations of the 1980 Brighton Meeting," Annuals of the ICRP 4(3/4) Oxford, England: Pergamon Press (1980). (Available for sale from Pergamon Press, Elmsford, NY 10523.)

dations regarding skin dose measurements, the Commission has decided to use the smaller area of 1 cm^2 for routine skin dose evaluations. The 1-cm^2 area is consistent with the prior recommendations in NCRP Report No. 39[14] and ICRP Publication No. 9[15] as well as the smaller area recommended in ICRP Publication No. 26.

Within the past several years, there have been instances where very small (5-250 μm) "hot" particles of fuel or activated corrosion products have been discovered in reactor facilities, on workers or their clothing, and, in a few isolated cases, in worker's vehicles or homes. These particles are generally too large to pose a significant risk from inhalation, but are capable of producing intense beta-radiation doses over very small areas of the skin. The principal hazard appears to be skin ulceration if the particles remain localized on the skin surface. The primary uncertainty associated with evaluating the hazard of these small particles is determining the skin area or tissue volume to which the dose is to be computed (or even whether "dose" is the most appropriate indicator of the hazard). The NRC requested the National Council on Radiation Protection and Measurements (NCRP) to look into the hot particle issue and make recommendations. The NRCP's recommendations have been published in NCRP Report No. 106[16] and use a criterion based upon the number of radioactive disintegrations that have occurred (μCi-hours) rather than dose. The NRC staff is reviewing these recommendations and has issued an Information Notice on a modified enforcement policy for hot particles.

KCMH p 22

KCMH comment not used adding "separation distances from "beta range."

SRM 2 #7

Final Rule. This revision of Part 20 specifies an area of 1 cm^2 for skin dose evaluations.

14 National Council on Radiation Protection and Measurements, "Basic Radiation Protection Criteria," NCRP Report No. 39 (January 15, 1971), page 79, paragraph 207. (Available for sale from the NCRP, Bethesda, MD 20814.)

15 International Commission on Radiological Protection, "Recommendations of the International Commission on Radiological Protection (adopted September 17, 1965)," ICRP Publication No. 9 (1966), page 6, paragraph 28. (Available for sale from Pergamon Press, Inc., Elmsford, NY 10523.)

16 National Council on Radiation Protection and Measurements, "Limit for Exposure to 'Hot Particles' on the Skin," NCRP Report No. 106 (December 31, 1989). (Available for sale from the NCRP, Bethesda, MD 20814.)

SRM I #7

Comment: Effective dose equivalent for external exposure. The most prevalent comment concerning the effective dose equivalent is the restriction in the proposed rule of the risk-weighted organ dose "effective dose" concept to internal doses without permitting a similar approach to be employed for external doses. There were several comments that noted the desirability of using organ weighting factors for external doses.

Response: The ICRP and NCRP recommendations and the 1987 Federal guidance on occupational radiation exposure in principle permit the use of external weighting factors. However, none of the principal standard-setting organizations has included specific recommendations for the use of weighting factors for external dose.

The application of weighting factors also entails calculation of organ doses instead of whole-body doses from external radiation. One component of this calculation is estimation of the attenuation of the radiation as a function of the depth of the organ in the body. There are practical problems in the determination of the type and energies of the radiation involved and of the orientation of the individual with respect to the source of the radiation that have to be considered in making such calculations. Therefore, application of weighting factors for external exposures will be evaluated on a case-by-case basis until more guidance and additional weighting factors (such as for the head and the extremities) are recommended.

Final Rule. External doses to the head, trunk (including male gonads), arms above the elbow, or legs above the knee are to be treated as whole-body doses. For the purpose of weighting the external whole-body dose (for adding it to the internal dose), a single weighting factor, $w_T = 1.0$, has been specified. The use of other weighting factors for external exposure may be approved on a case-by-case basis upon request to the NRC.

Comment: Allowance for exposure after limits are exceeded. Commenters noted that allowance of an additional 1 rem per quarter dose limit for a worker who had already exceeded the 5-rem annual limit might be counterproductive.

Workers who remain under the annual limit, and whose dose was X rems, would be constrained to receive (5 - X) rems, whereas workers who received more than 5 rems in the first quarter could be allowed an additional 4 rems (1 rem in each of the four quarters). One commenter suggested that this could provide an incentive for individuals who are approaching the dose limit to deliberately exceed the limit and thereby protect their employability by taking advantage of the extra dose allowance available to those who have exceeded the limits. Another commenter believed that such a blanket authorization to exceed the limits was inappropriate and preferred prior NRC review of the use of these extra doses on a case-by-case basis.

Response: The purpose of the dose allowance was to protect the worker's employability after having received a dose above the dose limits. Although intentionally getting additional exposure might be in the worker's interest for employability reasons, such an action would not be in the worker's interest with respect to health protection. Licensees having workers with critical skills who are approaching the dose limits early in the year or workers who have received an accidental overexposure should consider use of the planned special exposure (§ 20.206) to permit continued employment.

Final Rule. The allowance of an additional 1 rem per quarter following an exposure in excess of the limits has been deleted.

Section 20.202 Compliance with Requirements for Summation of Internal and External Doses.

Comment: Implementation burden. Many commenters felt that the burden of adding external and internal doses was substantial, particularly as most licensees would be faced with either external exposure situations or internal dose situations, but not both.

Response: The NRC staff disagrees that there will be a substantial recordkeeping burden because this summation will be required only if both the internal dose and the external dose are each likely to exceed 10 percent of the dose

limit. Thus, in most situations, as noted in the comments, only one component will be required to be measured and, consequently, summation of internal and external doses will not be required.

Final Rule. The requirement remains that the committed effective dose equivalent and the deep-dose equivalent should be summed to give the total effective dose equivalent. However, this summation need only be performed if both components are required to be monitored (i.e., exceed 10% of an applicable dose limit). If the summation of doses is not required, then the limit applies to the component (internal or external) that is measured. The NRC is planning to issue additional guidance in the form of a regulatory guide before the effective date of the revised Part 20. This guide will be on procedures to be used in estimating committed effective dose equivalents and deep-dose equivalents and guidance on when internal and external doses have to be summed.

Comment: Use of individual metabolic or dosimetric data. Several commenters thought that the proposed rule required the use of specific metabolic and dosimetric parameters for the exposed individual. One commenter also thought that the use of such parameters would "invalidate the stochastic approach of the regulation, which presumes that the effects of radiation exposure at these levels are statistical in nature."

Response: It was not intended that licensees would be required to collect and use specific metabolic or dosimetric information on exposed individuals for use in dose assessments. The intent was to permit the use of personal data for dose assessment when such data were available. The use of parameters that are more appropriate for a particular exposed individual than those assumed for the "Reference Man" should improve the accuracy of the dose estimate for that individual. This is unrelated to the concept of stochastic health effects.

The statistical nature of the potential stochastic effects of low doses of ionizing radiation does not require that the associated dose estimates be based on Reference Man doses. However, it is necessary to resort to population-averaged dose-to-risk conversion factors as there are no health risk coefficients available for specific individuals.

[Monitoring thresholds and thresholds for summation of internal and external dose -- see discussion under § 20.502]

Note: Section 20.202(c) states that: "The assigned deep-dose equivalent and shallow-dose equivalent must be for the part of the body receiving the highest exposure." This requirement is intended to apply primarily to situations where there are steep gradients in the radiation dose rate, depending upon location within the facility and spatial orientation of the worker's body. For example, good practice for a worker in a nuclear power plant who is reaching up into a radioactive steam generator would be to wear at least two personnel dosimeters: one to monitor the extremity dose (worn on the finger or wrist) and one to monitor the whole-body dose (worn on the upper arm). For routine monitoring in relatively homogeneous radiation fields, special consideration to identify the actual "highest" exposed area would not be required.

267
#3

Section 20.203 Determination of External Dose from Airborne Radioactive Material.

Comment: This could be read to require that the air concentration be measured at two locations. This section appears to require that the air concentration be measured at the location of the individual and at the point of maximum concentration in the cloud. The regulation should emphasize the reliance on personnel dosimeters or other monitoring devices.

Response and Final Rule. Section 20.203 has been shortened considerably. The revised section emphasizes the use of survey instruments and personnel monitoring devices to evaluate the external dose. The remaining technical guidance from this section in the proposed rule will be incorporated into a regulatory guide.

Section 20.204 Determination of Internal Exposure.

Comment: Interim dose calculation factors and parameters. Because the existing Part 20 is based on ICRP-2[17] dosimetry and metabolic models and the revised Part 20 employs the ICRP-30[18] dose parameters, there was concern regarding whether the more recent ICRP-30 parameters should be used, particularly when the value is to be compared with the intake limits in the present Part 20.

Response: The NRC is planning to issue a regulatory guide that will address the use of bioassay measurements for determining compliance with Part 20. Appropriate parameters for calculating organ doses from radionuclide intakes can be found in ICRP-30 and its supplements. Dose factors in Federal Guidance Report #11[19] are also acceptable for use in calculating occupational exposures. However, the effective dose equivalent factors in Federal Guidance Report #11 do not employ a rounding method suggested in ICRP-30. For this reason, the dose factors in Report #11 may be be slightly higher (10-20 percent) than the effective dose factors which correspond to the ALIs and DACs in both the revised Part 20 and Report #11. These dose factors would be more restrictive (give slightly higher doses for the same intake) than dose factors computed using the ICRP-30 roundoff procedure, but they can be used for evaluating compliance with Part 20.

[Section on Implementation Deleted per discussion in this paper]

Section 20.205 [deleted] Further Provisions -- Internal Exposure Involving Radionuclides with Very Long Effective Half-Lives.

Comment: Exemption for long-lived radionuclides and the use of the committed dose equivalent concept. The use of the concept of a "committed dose equi-

17 International Commission on Radiological Protection, "Report of Committee II on Permissible Dose for Internal Radiation," ICRP Publication No. 2 (1959). (Available for sale from Pergamon Press, Elmsford, N.Y. 10523.)

18 International Commission on Radiological Protection, "Limits for Intakes of Radionuclides by Workers," ICRP Publication No. 30. (Available for sale from Pergamon Press, Elmsford, N.Y. 10523.)

19 Environmental Protection Agency, Federal Guidance Report No. 11, "Limiting Values of Radionuclide Intake and Air Concentration, and Dose Conversion Factors for Inhalation, Submersion and Ingestion." USEPA Report EPA-520/1-88-020 (September 1988). (Available from the USEPA, Office of Radiation Programs, 401 M Street, S.W., Washington, DC 20460.)

valent" drew numerous comments. This approach entails assigning to the year of intake the future internal dose (the "committed dose equivalent" over 50 years) from radionuclides taken into the body during that year. The proposed rule (in § 20.205) allowed an exemption from the use of committed dose equivalents for several long-lived radionuclides.

Many of the commenters objected to having to assign the future 50-year dose to a single year. Others suggested that variable integration periods be allowed instead of one fixed 50-year value. One argument offered in support of either of these positions is that many adult workers would not normally be expected to live long enough to accrue the full 50-year committed dose equivalent.

Commenters pointed out that while pre-exposure controls (such as the annual limits on intake and the derived air concentrations) should be based upon the committed dose equivalent concept for planning and control, the use of controls based upon limiting the annual effective dose equivalent rate (rather than using the committed dose equivalent) might be preferable for post-exposure management following actual radionuclide intakes.

It was also noted that there were several additional nuclides that had similar half-lives and retention characteristics but were not included in the proposed exception. Among these were cobalt, strontium, and americium. The approach in the proposed rule was characterized as appearing to place almost complete emphasis on the control of the work environment rather than on the assessment and control of the individual worker.

Response: The concept of dose commitment is not new; this concept has been used as the basis for controlling internal doses since the late 1950s when ICRP Publication No. 2[17] and the present 10 CFR Part 20 were published. However, the term "committed dose equivalent" applied to future doses from internal emitters initially appeared in 1977 in ICRP Publication No. 26.[1]

The concentration limits for air and water in Appendix B to the existing Part 20 were based upon concentrations which, if continually inhaled (for air)

or ingested (for water) over a 50-year period, would produce a dose rate in the "critical organ" in the 50th year that was numerically equal to the annual organ dose limit. For certain radionuclides that slowly approached a constant body burden, primarily those radionuclides that have both long radiological half-lives and long biological clearance half-times, the limiting organ dose rate is not reached by the 50th year. For shorter-lived radionuclides and those that are rapidly removed from the body, equilibrium may be attained more rapidly and the limiting annual organ dose rate could persist over many years.

The limiting dose rate in the 50th year from a constant intake of a radionuclide each year over a 50-year period is numerically equal to the total dose integrated over the 50-year period from a single year's intake of the same magnitude. Therefore, controlling the integrated future ("committed") dose for each year's radionuclide intake also controls the annual dose rate in the 50th year to be within the dose limit.

It was noted that use of limits to annual doses in some cases would not ensure that doses in future years would be within limits. The example of the ingrowth of americium-241 from plutonium-241 was cited in which, even if the initial annual dose from plutonium-241 were within the limit, the ingrowth of the radiologically more significant americium-241 would lead to doses higher than the limits in subsequent years.

There are only a few radionuclides that would not attain an equilibrium level (and a constant annual organ dose rate) within time periods of less than 50 years. The use of the committed dose equivalent, rather than controlling internal dose on the basis of annual dose, substantially overestimates annual doses only for those radionuclides that do not reach an equilibrium level in the body early in the working lifetime. These radionuclides are primarily the long-lived radionuclides for which the exemptions of § 20.205 in the proposed rule were intended. Radionuclides (such as cobalt-60, strontium-90, and americium-241) that were easily measured at airborne concentrations or body burdens below the DAC and ALI values were not included in the list of exempted radionuclides because an exemption was not believed to be necessary for them.

The annual limits on intake and derived air concentrations are used mainly for pre-exposure control rather than post-exposure dose assessment so that fine-tuning these values to specific ages or adjusting them for factors such as the length of the period over which the committed dose is evaluated or to differences in individual organ sizes (as were suggested) is not warranted for occupational dose assessment. The use of age-dependent committed dose factors as suggested by some commenters would add needless complexity to the assessment of internal doses and cannot be justified on the basis of the availability of information on either age-dependent metabolic parameters or age-dependent radiobiological risk information.

267 p2

The use of an annual dose limitation system, even with a reduction in the allowable dose limit from 5 rems to 3 rems such as in the proposed § 20.205, does not provide a limitation on the lifetime radiation dose or risk equivalent to that provided by the committed dose limitation system of this final rule for all classes of workers. Although long-term workers would be protected to the same degree under either the annual or committed dose systems, short-term or temporary workers could get somewhat higher lifetime doses under a dose limitation system based on limiting only individual annual dose. Furthermore, it is neither reasonable nor practical to expect future employers to take special measures to control radiation dose to workers who transfer because a previous employer, working under annual organ dose limits, permitted intakes that would result in future dose rates that are appreciable fractions of the allowable dose limits. Such a practice would not be fair to workers whose future employability may be limited because of the additional restrictions a new employer would have to put on their exposure, or to future employers of these workers who may have to assess internal doses from residual body burdens of internal radionuclides in order to show compliance. The annual dose system also requires a complex bookkeeping effort because the annual dose limit for each worker depends upon the worker's pre-existing body burden of radioactive materials.

added explanation

Final Rule. For the reasons discussed above, the Commission has decided not to adopt proposed § 20.205 and the exemptions for certain long-lived radionuclides for the final rule. The use of the committed dose equivalent will be applied uniformly to all radionuclides, regardless of half-life. The Commission

recognizes that the removal of this exemption, combined with the lowering of the airborne concentration limits for several radionuclides (notably thorium and uranium), could impact on the current and future facilities that use these materials. Licensees that are affected by these changes may request an extension of the implementation time in order to make the necessary modifications to comply with the revised limits as they relate to long-lived radionuclides identified in the proposed § 20.205. In addition, licensees should note the flexibility provided in the revised rule for more accurate dose assessments to be made that might show that additional controls were not required in order to meet the dose limits. Specifically, § 20.204 allows the use of actual particle-size distributions and physiochemical characteristics of airborne particulates to define a site-specific derived air concentration to be used in lieu of the generic values in Appendix B. Such adjustments result in the use of more precise dose estimates because of a better characterization of the actual exposure conditions. Although these adjustments might permit higher airborne radionuclide concentration limits to be used, the same degree of health protection would exist because the radiation dose (and risk) would remain the same. This section also allows for whole-body counting or bioassay measurements to determine the behavior of radioactive materials in the individual and the use of these data to calculate internal doses. A 7-month delay between a bioassay or retention measurement and recording of the associated dose is also permitted in order to make confirmatory measurements.

SRM1#2 + RoVS p1

267 p2-3

The Commission recognizes that alternative methods may be identified in the future that might achieve the same degree of lifetime risk limitation for both short-term and long-term workers as the dose system recommended by the ICRP, the Radiation Protection Guidance to Federal Agencies for Occupational Exposure, and adopted in the current and revised 10 CFR Part 20. The Commission further believes that, to be acceptable, such alternatives should not result in an adverse impact on worker employability or result in undue recordkeeping or excessive monitoring requirements for the future employers of transferring workers.

Section 20.206 Planned Special Exposures.

Comment: The use of planned special exposures could result in lifetime cumulative doses greater than those doses formerly permitted under the 5(N - 18) formula. One commenter noted that the new regulatory scheme, including planned special exposures, allowed a higher total lifetime dose than was permitted using the 5(N - 18) formula. The calculation presumes a working lifetime of 47 years (starting at age 18 and ending at age 65). Under the revised Part 20, the lifetime limiting dose would be 260 rems (5 rems per year)(47years) + 5(5 rems) (planned special exposures) = 235 + 25 = 260 rems). Under the 5(N - 18) formula, at age 65 (N = 65), the cumulative dose would be 5(47) = 235 rems. The comment further noted that the NCRP recommended [in NCRP Report No. 91] a cumulative dose limit of 1 rem x age; the Department of Energy has proposed a 100-rem lifetime dose limit, and the ICRP at its 1984 Stockholm meeting inferred a goal of 1 rem per year. Other commenters noted that, because of the potential lifetime dose including the planned special exposure, the claim on page 51, FR 1121 (Table 5), of the proposed rule that "Individuals receiving highest exposure will be reduced" is unjustified and incorrect.

Response: The analysis of maximum doses discussed above is overly simplified because it assumes that there are individuals who will be exposed at the allowable dose limit every year of their working lifetime. Under the old 5(N - 18) formula, the unused portion of the dose limit (the difference between the actual dose received and 5 rems) became part of a "dose bank" that could be drawn on in later years (at a rate up to 3 rems per quarter or 12 rems per year). This "dose bank," which is inherent in the age-prorated formula of 5(N - 18), does not exist with the straight annual dose limit. If the worker's exposure is under the 5-rem annual dose limit, there is no way to recapture the difference for use in future years. Consequently, the average annual dose (for the more highly exposed workers) associated with new Part 20 is expected to be less than under the former rule.

As noted above (see Response under § 20.201 Occupational Dose Limits), the Commission considered the use of a lifetime dose limit but rejected it.

Comment: Planned special exposures should not be limited to external exposures but should also be permitted for internal exposures. Several commenters noted that it was inconsistent to treat internal and external doses as equivalent by summing them and then restricting planned special exposures to only external doses. Commenters also pointed out that the total effective dose equivalent (TEDE) could be minimized in some cases if some external doses were reduced at the expense of incurring some internal doses.

Response: The Commission agrees that restricting the use of planned special exposures to only external doses would be inconsistent with the ALARA principle and the presumed equivalence of internal and external doses inherent in the revised Part 20. Consequently, the requirements have been modified so internal doses may be included in planned special exposures in order that the total dose (TEDE) can be controlled in keeping with ALARA.

Comment: The annual dose allowed in a planned special exposure does not agree with the recommendations of the ICRP. A few commenters thought that the allowable annual dose from planned special exposures should be 10 rems as stated in the ICRP recommendations. Other commenters agreed with the NRC's modification to reduce the annual dose for planned special exposures to 5 rems.

Response: The NRC has intentionally reduced the dose allowed in any year from a planned special exposure from the 10-rem value proposed by the ICRP to 5 rems. The lifetime total limit from planned special exposures of 25 rems remains the same as the ICRP recommendation. The Commission believes that it would be better to distribute the dose over the lifetime more evenly than to permit a large portion of the cumulative dose to be received within a small period of time. In this sense it should be recalled that the planned special exposure is in addition to the normal dose limits. Under the Part 20 condition, it would be theoretically possible to get a 10-rem dose in 1 year, 5 rems from a planned special exposure and 5 rems from routine operation. This is roughly equivalent to the 12 rems (3 rems/quarter) that could be received under the present Part 20 limitations using the 5(N - 18) formula. The initial ICRP proposal would have permitted a 15-rem dose in 1 year, 10 rems from planned special exposures and 5 rems from routine operation.

Comment: Subtraction of emergency doses. Some commenters suggested that doses received under emergency conditions, up to a lifetime total of 25 rems, not be subtracted from the lifetime allowance for planned special exposures. It was also suggested that the employability of the individual might be jeopardized if the dose "bank" were depleted.

Response: The NRC has not officially sanctioned the 25-rem "forgivable" emergency dose that has been recommended by some organizations for a once-in-a-lifetime dose that would not be counted against an individual's lifetime dose. Consequently, all doses received as a result of occupational exposure must be recorded in an individual worker's record.

The Commission believes that planned special exposures will be used infrequently so that the lack of a dose bank for some individuals would not be a major drawback to their employability.

Comment: The time period for notifying exposed individuals of their dose is too short. A number of commenters thought that the 15-day period for notifying exposed individuals of their exposure from a planned special exposure was too short. Some commenters noted that most NRC reporting requirements provide a 30-day, not a 15-day, period. Other commenters suggested that the 15-day period could give the impression [to the worker] that an inordinate risk was involved when that was not the case.

Response: The 15-day period for notification was intended to be unique and to further emphasize that "planned special exposures" were indeed "special." However, the Commission has extended the time period for notification of the individual from 15 days to 30 days to allow licensees additional time to estimate internal exposures that are now permitted in the revised rule to be part of a planned special exposure. The requirement to notify the NRC (see § 20.1204) that a planned special exposure has taken place is also 30 days.

Comment: Doses received during a planned special exposure that do not exceed the dose limits for normal operation should not have to be recorded as planned special exposures or be subtracted from the lifetime planned special exposure limit. A few commenters expressed concern that exposures during planned special exposures that did not result in doses to an individual in excess of the occupational annual dose limits would nevertheless have to be reported separately and subtracted from the individual's lifetime allotment for planned special exposures.

Response: The intent of the planned special exposure was that it would be used infrequently in circumstances where the elimination of the 5(N - 18) lifetime cumulative limit might create a severe handicap to the licensee's operations. Being able to switch doses between planned special exposures and routine dose limits would tend to encourage the use of planned special exposures as the licensee would have nothing to lose by using the planned special exposure. This is contrary to the Commission's intent that the planned special exposures be restricted to "special" situations. Once a licensee decides to conduct a planned special exposure, all of the unique limitations, reporting, and recordkeeping requirements are to apply, even if the doses actually received fall within the dose limits for routine operations.

Final Rule. The provisions of planned special exposures have been extended to include internal exposures, and the reporting time to the individuals involved has been changed to 30 days to allow sufficient time for analysis of internal dose.

NCAA P41

Section 20.207 Occupational Dose Limits for Minors.

Comment: Exposure of Minors. One commenter stated that minors should not be exposed to radiation because they do not meet the criteria for occupational radiation exposure. The commenter argued that minors are not trained regarding radiation protection, do not derive a benefit from employment, and would require the preparation of an NRC Form 4 if they were workers.

Response: Allowing minors to be occupationally exposed to radiation was permitted in the present Part 20 (§ 20.104). All individuals, including minors, who enter a restricted area are required (10 CFR 19.12) to be instructed as to the risks involved. Minors who are employed receive salaries and other associated benefits of employment so that there does not appear to be a major difference in this respect from other workers. Furthermore, licensees are required under the existing and revised Part 20 rules to maintain the same exposure records for minors as for adults.

An alternative to this procedure would be to exclude minors completely from radiation-related work. This does not appear to be desirable as the monetary, experience, and educational benefits that may accrue to the minor appear to outweigh the small incremental risk involved (particularly considering the reduced dose limits applied to minors). Consequently, no change has been made from the proposed rule.

Section 20.208 Dose to an Embryo/Fetus.

Comment: Biological basis for lower dose limits for pregnant women. There were comments that cited older studies and recommendations for dose limits for the embryo/fetus that are considerably higher than 0.5 rem. These comments questioned the biological basis for the 0.5 rem dose limit for the embryo/fetus in the proposed rule.

Response: The biological effects of ionizing radiation upon the embryo/fetus are summarized in Regulatory Guide 8.13[20] More detailed information can

20 U.S. Nuclear Regulatory Commission, "Instructions Concerning Prenatal Radiation Exposure," Regulatory Guide 8.13, Rev. 2, December 1987.

be found in publications of the NCRP,[21] ICRP,[22] UNSCEAR,[23] and the OECD/NEA.[24]

The limit of 0.5 rem during the entire gestation period is based upon a recommendation by the NCRP in 1977 (see Reference 21). The International Commission on Radiological Protection (ICRP-26) recommended 0.3 times the annual dose limit or 15 mSv (1.5 rems) over the full gestation period and 5 mSv (0.5 rem) in the first 2 months of pregnancy.

Final Rule. The limit for the embryo/fetus of a declared pregnant woman is 0.5 rem over the entire gestation period. There is also an admonition that the licensee avoid substantial variation above the average monthly exposure rate that would comply with the 0.5-rem limit. These conditions are consistent with the Federal guidance on occupational radiation exposure and with the recommendations of the NCRP in NCRP Report No. 91.[6]

Comment: Licensee's Responsibilities to Protect the Embryo/Fetus of an Undeclared Pregnant Woman. Several commenters raised the question of whether the licensee had any responsibility for protecting the embryo/fetus of an obviously pregnant female employee who had not formally declared her pregnancy to the employer.

Response: It is the fundamental responsibility of the pregnant worker to decide when or whether she will formally declare her condition to her employer. This position is derived from court rulings concerning a pregnant woman's rights regarding termination of the pregnancy. Having a woman formally declaring her

---

21 National Council on Radiation Protection and Measurements, "Review of Radiation Dose Limit for Embryo and Fetus in Occupationally Exposed Women," NCRP Report No. 53 (1971). (Available for sale from the NCRP, 7910 Woodmont Avenue, Suite 800, Bethesda, MD 20814-3095.)

22 International Commission on Radiological Protection, "Developmental Effects of Irradiation on the Brain of the Embryo and Fetus," Annals of the ICRP 16 4) (1986). (Available for sale from Pergamon Press, Elmsford, NY 10523.)

23 United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), Genetic and Somatic Effects of Ionizing Radiation Sales Section, United Nations, NY 1986, particularly Chapter III, Biological Effects of Pre-natal Irradiation."

24 Organization for Economic Cooperation and Development/Nuclear Energy Agency, "The Biological Basis for the Control of Prenatal Irradiation," OECD/NEA, Paris, France (1988).

pregnancy to her employer derives from legal, not health protection, considerations. If she chooses not to declare her pregnancy, the licensee will not be required under the Commission's regulations to limit her dose to the 0.5-rem limit.

Undeclared pregnant women are protected under the NRC regulations for all workers. The normal occupational dose limits would still be in effect and would have to be complied with, and the dose would also have to be kept "as low as is reasonably achievable." In addition, as part of her initial employment, the woman should have received instructions in radiation protection (10 CFR 19.12), and she should have been provided with a copy of Regulatory Guide 8.13.

It might be prudent for a licensee to remind a pregnant, but undeclared, worker of the special limit for protection of the embryo/fetus of a declared pregnant woman and to provide another copy of Regulatory Guide 8.13 to her. However, if the licensee has previously provided this information to the employee, it is not a Commission requirement that it be done again. If the requirements referred to in the previous paragraph have been fulfilled, the licensee will not be cited for a violation of the Commission's regulations if the estimated dose to the embryo/fetus of an undeclared pregnant woman exceeds the 0.5-rem limit, even if the worker's pregnant state seems obvious.

Comment: Requirements on the worker to declare pregnancy information on child-bearing capacity. Some commenters called for a requirement that the employee declare the pregnancy to the employer as soon as it is known to the pregnant woman. Another commenter suggested that two classes of women, "fertile" and "nonfertile," be established with separate dose limits for each class.

Response: Section 161c. of the Atomic Energy Act gives NRC the authority to require such information to be provided by the worker. However, such a requirement could be considered to be discriminatory and an invasion of personal privacy. It would also be unenforceable because the woman and her physician know when she knew of the pregnancy and patient-doctor communications are privileged. Infringement on personal privacy is also a drawback that applies to

requiring the female worker to supply information concerning her "fertility" or "infertility."

Comment: Estimation of Dose to the Embryo/Fetus. The assignment to the embryo/fetus of a dose equal to the dose to the declared pregnant woman was questioned. For example, would it be reasonable to assign to the embryo/fetus a dose based upon the dose received by the woman's shoulder or head?

Commenters also indicated that licensees should be permitted to employ factors other than a factor of 2 and take into account shielding of the embryo/fetus by maternal organs and the placenta in evaluating the external dose component of the embryo/fetus.

Response: The concept used in the proposed rule of relating the dose to the embryo/fetus to the dose received by the mother has been modified. The final rule permits direct calculation of the dose to the embryo/fetus. This was done so that the use of more accurate dose assessments would not be precluded by the rule. The internal dose to the embryo/fetus may or may not be directly proportional to the dose received by the mother.

267 p3

A forthcoming regulatory guide will provide guidance on methods for calculating the dose to the embryo/fetus. For interim assessments of the dose to the embryo/fetus, it may be assumed that the dose to the embryo/fetus from external radiation and from radionuclides in the body that are relatively uniformly distributed, such as cesium-137 and compounds of tritium and carbon-14 that are not organically bound, is the same as the dose to the mother since under these circumstances the same energy would be deposited per gram of tissue in both the mother and the fetus. For external gamma irradiation, the assumption that the dose to the fetus is the same as to the mother should be conservative (yield calculated doses that are somewhat higher than the actual doses determined by more precise evaluations).

Permitting calculations of the embryo/fetal dose using reduction factors for attenuation within the body of the mother would entail knowledge of the

energy spectra of the incident radiation. As noted previously (Response for § 20.201), photon spectral measurements, although technically feasible, are not currently required by the Commission and are considered to be beyond the scope of routine radiation protection survey measurements. The small amount of reduction in the calculated dose afforded by such attenuation corrections would be secondary in importance compared to uncertainties due to body orientation, partial-body exposure from collimated beams of radiation, and the radiobiological sensitivity of the embryo/fetus.

In situations where the use of a single dose measurement would be inappropriate for both the woman and the embryo/fetus, a solution would be to monitor the two doses separately.

Comment: Additional Dose Increment Allowed to Pregnant Women Beyond the Dose Limits. The rationale was requested by a few commenters for permitting an extra 0.05 rem (0.5 millisievert) beyond the 0.5-rem (5 millisieverts) dose limit to an embryo/fetus.

Response: The small additional dose is intended to apply in situations where the embryo/fetus has accumulated a substantial fraction of the dose limit or has already exceeded the limit before the woman formally declares herself to be a "declared pregnant woman." If the incremental 0.05-rem dose were not available, a woman having already received a dose in excess of the 0.5-rem limit might not be able to be further employed in a radiation-related job. The licensee could be in "instant noncompliance" as the embryo/fetus dose limit could have been exceeded before the licensee was aware that it was applicable (i.e., before the woman declared her pregnancy). Thus, the small incremental 0.05-rem dose provides a means of ensuring continued employment for the woman and also removes the threat of inadvertent noncompliance on the part of the licensee. The additional risk posed by this incremental dose to the embryo/fetus is small compared to the potential risk from the overall 0.5-rem dose limit.

Final Rule. The final rule corrects an anomaly in the proposed rule regarding the application of the additional 0.05-rem incremental dose. In the proposed rule, the additional 0.05-rem dose was available if the embryo/fetal dose limit had been exceeded prior to the woman's declaration of pregnancy (even if the dose were 0.501 rem). However, the additional 0.05-rem dose increment would not have been available if the embryo/fetal dose were less than the 0.5-rem limit (even if the dose were as much as 0.499 rem). There is no significant difference in risk between 0.551 (0.501 + 0.05) rem and 0.549 (0.499 + 0.05) rem. This provision would have resulted in unnecessary penalties to both the licensee and the declared pregnant woman. In the final rule, the 0.05-rem dose increment is available as an additional dose if the embryo/fetal dose at the time of declaration is greater than 0.45 rem (0.45 = 0.5 - 0.05).

Subpart D--Radiation Dose Limits for Individual Members of the Public

Section 20.301 Dose Limits for Individual Members of the Public.

Comment: NRC should defer changes to limits for the general public until the EPA issues revised Federal guidance. The EPA suggested that NRC not modify its radiation limits for protection of the general public until EPA prepares revised Federal guidance on dose limits applicable to the general public (the recently issued Federal guidance applied only to occupational radiation protection).

[ ]

KCMU p 48

Response: Although it would be desirable to use Federal guidance as a basis for the revision of the limits for the public, the Commission believes that Part 20 needs to be based on a consistent set of principles and concepts rather than having its standards for workers using one dose limitation system and its standards for the general public using an entirely different (and outmoded) system. The latest Federal guidance does not address radiation exposure of the general public and, although the NRC staff is represented on an EPA Task Group which is developing draft Federal guidance on doses to members of the general public, the Commission has chosen not to defer these limits until this

update KCMU p 48

Task Group has completed drafting the guidance and EPA makes recommendations to the President for its issuance. The Commission's intent to address these limits was noted explictly in the statement of considerations that accompanied the proposed rule (51 FR 1118, Section XXVIII).

Comment: Facilities that are subject to other lower standards should not have to demonstrate compliance with the 0.1-rem limit ["reference level"]. Several commenters expressed concern that additional efforts would be required to demonstrate compliance with the proposed 0.1-rem "reference level." For licensees that were already subject to the 0.025-rem (25-millirem) limits of EPA's 40 CFR Part 190, this appeared to be an unnecessary burden.

Response: The concept that 0.1 rem represents a "Reference Level" has been eliminated. The 0.1-rem value in the final rule represents the primary dose limit for protection of the public. This change from the proposed rule reflects the clarifications by the ICRP (see Section II.A.) regarding the usage of the 0.1-rem and 0.5-rem recommended dose levels. This change does not represent a major change from the proposed rule. Many commenters had indicated a belief that, because of the reporting and control requirements associated with the 0.1-rem reference level, it already represented a de facto limit.

Demonstration of compliance with the limits in 40 CFR Part 190 or with the design objectives of Appendix I to 10 CFR Part 50 will be deemed to demonstrate compliance with the 0.1-rem dose limit for most licensed facilities. [2] Power reactor licensees that comply with Appendix I may also have to demonstrate that they are within the 0.025-rem limit in 40 CFR Part 190. [3] Demonstration of compliance with the limits of 40 CFR Part 190 will be considered to demonstrate compliance with the 0.1-rem limit. For uranium mills, it will be necessary to show that the dose from radon and its daughters, when added to the dose calculated for 40 CFR Part 190 compliance, does not exceed 0.1 rem.

The dose rate limit of 2 millirems in any 1 hour from § 20.105(b)(1) of the present Part 20 was omitted in the proposed rule but has been reinstated in the revised rule. The reason for this is that this limit provides a more readily

measurable quantity than the 100 millirem per year value and can be more easily verified by short-term measurements.

Comment: Inclusion of doses from other licensed or unlicensed radiation sources. Many commenters expressed an opinion that the dose should not be all-inclusive and should not include fallout from nuclear weapons tests, transportation of radioactive material, or other sources of radiation not under the control of the licensee.

Response: The new lower dose limit for members of the general public (which was described as a "reference level" in the proposed rule) applies only to doses from radiation and radioactive materials under the licensee's control. The EPA's generally applicable environmental radiation limit for nuclear power operations (40 CFR Part 190) does apply to the total dose from all sources within the uranium fuel cycle. However, in its practical implementation, the sources would have to be located within a few miles of each other for the combined dose contributions to be significantly different from the dose from either facility alone.

The definition of "natural background" has been replaced by "background radiation," which includes natural background, global fallout, and radon not associated with licensed material. This clarifies sources of radiation and radionuclides that can be excluded from evaluations of the dose from licensed activities.

SOPA I #6

Comment: Differentiation of limits for long-term operation and for shorter-term transient operation. A number of commenters noted that ICRP-26 described the 0.1 rem (1 mSv) per year value was intended to be an average goal for long-term operation but that 0.5 rem (5 mSv) was intended as the primary annual dose limit for members of the public. Some commenters suggested that a lifetime dose limit be established for members of the public.

Response: As noted above in Section II.A., the ICRP has modified its interpretation in the ICRP statement issued following their 1985 Paris meeting,[2] so that the primary standard is 1 mSv (0.1 rem) per year. This clarification of ICRP philosophy is reflected in Part 20 by the change of the 0.1 rem per year value from a "reference level" in the proposed rule to a primary limit in the final rule.

Final Rule. It should be emphasized that the 0.1 rem per year limit in Part 20 is not intended to be applied as a long-term average goal: it is an annual limit. As a matter of practicality, long-term (or lifetime) dose limits for members of the public cannot be implemented unless each year's dose is kept within the long-term goal. Doses to individuals in the general public are not usually monitored directly (locations rather than individuals in the offsite environment are monitored). As individuals may change residency and there is no reporting or tracking system, lifetime doses to specific individuals in the general population are very difficult to determine.

The 0.5 rem per year limit is available only upon specific application to and approval by the Commission (see § 20.301(c)). A 0.5-rem value has been retained in order to apply to transient situations and to alleviate the immediate need to redesign or reshield existing facilities that were designed to meet the former 0.5-rem limit. The 0.5-rem limit is intended to be applied primarily to temporary situations where operation of a facility or the person's exposure to radiation and radioactive emissions is not expected to result in doses above 0.1 rem over long periods of time. For design of new installations, the 0.1-rem limit should be used. However, existing facilities may apply for NRC approval to use the 0.5-rem limit while more complete evaluation of the need for any additional modifications is performed.

The Commission is aware that some categories of licensees, such as uranium mills and in situ uranium mining facilities, may experience difficulties in determining compliance with the revised values in Appendix B, Table 2, for radionuclides such as radon-222. Provision has been made for licensees to use air and water concentration limits for protection of members of the general public that are different from those in Appendix B, Table 2, if the licensee

can demonstrate that the physicochemical properties of the effluent justify such modification and the revised value is approved by the NRC. For example, uranium mill licensees could, under this provision, adjust the Table 2 value for radon (with daughters) to take into account the actual degree of equilibrium present in the environment. This provision permits (upon NRC approval) the use of concentration limits for members of the general public that better represent actual exposure conditions. This is similar to the allowance for use of modified derived air concentrations (with Commission approval) in § 20.204(c)(3). In both situations, licensees would be permitted to propose radionuclide concentration limits for their facility that reflect actual properties of the effluents rather than using the generic concentration-to-dose assumptions associated with Appendix B values. These adjustments tailor the concentration limits to specific conditions, provide the same limitation of dose, and do not permit any greater risk even though the adjusted concentration limits (for members of the general public or for workers) may be higher than the Appendix B generic values.

Use of this provision, applied to the percentage of radionuclide equilibrium existing in radioactive decay chains, could provide a factor of 2 or 3 upward change in the appropriate air concentration limit. In addition, the licensee can demonstrate compliance by calculating the dose to the nearest resident rather than meeting the air concentration limit at the site boundary. This should provide an additional factor of 2 or 3 allowance. Lastly, if the 0.1-rem effective dose limit still cannot be met, the licensee can apply to NRC under § 20.301(c) for permission to use a temporary 0.5 rem per year limit rather than the 0.1 rem per year limit. Section 20.301(c) of the revised rule requires that, in order to receive permission for use of this higher dose limit, the licensee has to specify (1) the need for and expected duration of the higher value, (2) their program to assess and control doses, and (3) procedures to control doses to be ALARA. These options used singularly or in combination coupled with process or operational modifications of these facilities is expected to provide sufficient flexibility to enable most uranium recovery facilities to comply with the provisions of the revised 10 CFR Part 20.

Section 20.303 [Reserved].

The former 0.1-rem "Reference Level" and the EPA Standard for Nuclear Power Operations that were in this section in the proposed rule are included as primary limits for members of the public in § 20.301 of the final rule.

Section 20.304 [Deleted] De Minimis Level and Collective Dose Evaluations.

Comment: Adoption of a threshold for calculating collective (population) doses. The proposed § 20.304 would have allowed licensees to disregard doses to individuals that were less than 1 millirem per year when evaluating collective (population or "person-rem") doses. A major criticism of this section was the narrowness of its scope. The section pertained only to a change in the calculational methodology for estimating collective doses and would not have permitted unrestricted release of any materials or equipment.

Most comments from people and organizations within the nuclear power and radiation applications industry favored this measure as an initial step toward developing more general "below regulatory concern" (BRC) levels. Several commenters thought that NRC acknowledgment of the concept of a "BRC" level was more important than the specific proposal to truncate collective dose calculations. Many commenters thought that a generic BRC level would limit unnecessary expenditure of resources that would otherwise have to be spent to control inconsequential risks.

There were also a number of comments that were not in favor of either the proposed collective dose cutoff or the more general application of the concept of "below regulatory concern." A few commenters expressed opinions that it did not appear feasible to arrive at a universal de minimis level, because the level that would appear to be truly insignificant to most people would be too low to result in any appreciable saving to the industry. There also were comments that noted that the proposed collective dose cutoff could cause large numbers of potential adverse health effects to be overlooked if they resulted from small radiation doses delivered to very large numbers of people. Many commen-

ters, both pro and con regarding the adoption of a BRC level, thought that a threshold value for collective dose should also be developed. A few commenters noted that the focus of the more generic BRC concept tended to be for single licensees and that it might be necessary to consider the impacts from multiple licensees.

Many of the commenters who supported a generic BRC concept did not agree with the numerical value (0.001 rem per year) proposed for the cutoff, believing it to be too low. An explanation for this opinion was that if 0.001 rem represented an insignificant level of risk, then all larger doses might be perceived as representing "significant" levels of risk. A value of 0.010 rem was noted by several commenters as being a more suitable value and still represented an inconsequential risk.

Response: The Commission agrees that "Below Regulatory Concern" levels would be useful and has issued policy statements on the application of the concept of "below regulatory concern" with regard to waste disposal ("Radioactive Waste Below Regulatory Concern," Federal Register of August 29, 1986 (51 FR 30839)) and a general policy statement on "Below Regulatory Concern" was announced on June 27, 1990, and was subsequently published in the Federal Register on July 3, 1990 (55 FR 27522). The general policy statement establishes the framework for the Commission to formulate rules and licensing decisions to exempt certain practices involving small quantities of radioactive materials from some or all regulatory controls. The BRC policy statement sets forth criteria for protection of both individuals (individual dose criteria) and population groups (a collective dose criterion).

SRM 1 #5

In order to ensure that any computational changes reflect the policy that evolves from the effort to develop generic BRC policy, the Commission removed the threshold for truncating collective doses (§ 20.304) from Part 20 and has included such a threshold in the generic BRC policy statement. This deletion is also consistent with comments that noted that this section described a method for calculating a quantity (collective dose) that was not required to be calculated by Part 20 and comments that such details of calculations would be better in a regulatory guide rather than in a regulation.

Comment: The accreditation requirement requires the use of a commercial dosimetry service.

Response: This is an incorrect interpretation of the dosimetry accreditation rule (52 FR 4601). That rule, which is incorporated into the revised Part 20, states that the dosimetry processor must be accredited. It is possible for licensees that provide their own dosimetry services to be accredited.

Comment: Lack of specificity in monitoring requirements. Commenters noted that the monitoring requirements, both in the present Part 20 and in the proposed rule, were general and imprecise.

Response: Many portions of Part 20 are not very specific and detailed because Part 20 contains the NRC's general radiation protection requirements and applies to all classes of licensees, including large power reactors, universities, and medical institutions as well as small radionuclide and sealed source users. Because of this breadth of application, the requirements in Part 20 cannot be very detailed for any one type of facility. However, the requirements in Part 20 are designed to provide the framework for all licensees and to establish provisions that the NRC considers to be fundamental to basic radiation protection.

Section 20.502 Conditions Requiring Individual Monitoring of External and Internal Occupational Dose.

Comment: Monitoring Thresholds. A number of commenters questioned the rationale for the lack of agreement of the thresholds in the proposed rule for monitoring external doses (10 percent of the annual limits) and for requiring monitoring of internal doses (30 percent of the annual limit). It was frequently mentioned that starting to require monitoring at 30 percent of the dose limit could result in overlooking doses of 1.5 rems (30 percent of 5 rems). The 1.5-rem value would have been above the limits for minors and for the embryo/fetus (0.5 rem) and was characterized as being a rather substantial fraction of the

deep-dose equivalent limit. In this connection, it was also noted that the possibility existed, when large external doses were expected, of exceeding a total effective dose equivalent limit of 5 rems because the licensee was not aware of the internal dose contribution.

Some commenters thought that the monitoring thresholds would be understood more easily if they were expressed as doses instead of percentages.

Response: The unequal thresholds for requiring monitoring of internal doses (30 percent of the dose limit) and external doses (10 percent of the dose limit) were originally set because of the difficulties in performing low-level bioassay analyses of alpha-emitting radionuclides at fuel fabrication and other facilities where actinides may be prevalent. (Bioassays for the radionuclides most commonly found at nuclear power reactors were viewed as generally being able to meet the 10 percent threshold set for external doses.) In situations such as bioassay for alpha-emitting radionuclides, it may be difficult to detect 10 percent of the ALI or 10 percent of the dose limit by bioassay measurements on excreta.

The monitoring threshold is a predetermined level of anticipated dose for carrying out bioassay procedures and does not represent a required level of detection sensitivity. If, by a reasonable analysis of the working environment, it appears that a worker is likely to inhale radioactive materials at concentrations that could produce an annual committed effective dose equivalent of 0.5 rem (10 percent of the 5-rem limit) or more, then that worker's intake should be monitored using measurements of exposure (e.g., estimates of DAC-hours based upon measured air concentrations) or intake (such as by whole-body counting or other bioassay technique) or by measurements of both exposure and intake. Whether the actual doses received were in excess of 10 percent of the limits could only be determined from these subsequent measurements.

The monitoring thresholds are specified as percentages of the dose limits rather than as doses because the thresholds apply to several different dose limits: the total effective dose equivalent, the eye dose equivalent, and the shallow-dose equivalent.

Final Rule. The threshold for monitoring internal doses has been dropped from 30 percent of the dose limit to 10 percent of the limit. This provides consistency in the internal and external monitoring requirements. The Commission acknowledges that, in some cases, particularly bioassay measurements of transuranic elements, it may not be feasible to actually confirm such levels by bioassay. However, the monitoring threshold is not a requirement on the capability of the measurement. Average airborne radionuclide concentrations and the expected time of exposure can be used to estimate radionuclide intakes and the need for bioassay or other monitoring methods.

The Commission intends to issue a regulatory guide on the procedures to be used in estimating committed effective dose equivalents and deep-dose equivalents and guidance on when they have to be summed.

Comment: Evaluation of radionuclide intakes for respirator wearers. Several commenters mentioned that internal dose monitoring, such as bioassays, should not be required solely because respiratory protection devices were used. The rationale given by the commenters was that the requirement provides a negative incentive for using respirators and is, therefore, counter to ALARA operating practices.

NCRP 157

Response: The requirement (in § 20.502(b)(3)of the proposed rule) for bioassays for anyone using respiratory protection has been dropped. The Commission agrees that such a requirement might be a disincentive for using respirators as part of an ALARA effort. There is, however, a requirement (in § 20.703) for bioassays to be conducted, as appropriate, as part of a respiratory protection program. Whether bioassays are necessary for a particular individual will depend on whether that individual could have exceeded 10 percent of the annual limit on intake (ALI) or was exposed to airborne radionuclide concentrations in excess of the monitoring threshold. An evaluation of internal dose would be required if there were a potential for exceeding 10 percent of an annual limit on intake (0.1 ALI), whether or not a respirator is worn.

[Note: Because the requirement for performing bioassays for a particular individual has been separated from the wearing of a respirator, the concentrations to be used for evaluating monitoring thresholds are those of the ambient atmosphere before credit is taken for respiratory protective factors. One of the purposes of such bioassays is to confirm the effectiveness of the respiratory protection being provided. If bioassay were made dependent upon the corrected air concentration (after dividing by the protection factor), it would be equivalent to assuming that the intended protection factor was correct without further verification.]

Subpart G--Control of Exposure from External Sources in Restricted Areas

Sections 20.601, 20.602, and 20.603 Control of Access to High and Very High Radiation Areas.

Comment: Inapplicability of requirements to nuclear power reactors. Many commenters indicated that the proposed requirements for control of entry into very high radiation areas could not be applied to nuclear power reactors because of the number and size of potential "very high radiation areas" and the physical inability to restrict access to these areas. Similarly, interlocks that can result in the withdrawal or cessation of the radiation source may be unworkable in nuclear power reactors. Several commenters proposed incorporating requirements for power reactors that are similar to reactor license conditions in reactor technical specifications.

Response: The Commission recognizes that the detailed requirements applicable to large irradiators that were formerly in § 20.203(c)(6) should be in a specific regulation dealing with these facilities rather than in Part 20. For this reason, these detailed requirements will be placed in a future Part 36 of Title 10 which is being issued for public comment and applies specifically to irradiators. At the time that that rule is made effective, the Commission will transfer these requirements from Part 20 to Part 36. In the meantime, the NRC staff will issue a regulatory guide that provides more specific detailed guidance for nuclear power reactors on high and very high radiation areas.

Comment: Choice of Dose Rate Defining a "Very High Radiation Area." Several commenters believed that the 500 rads per hour dose rate that defines a "very high radiation area" was too high, noting the proximity of this value to the median lethal dose (LD_{50} for acute radiation exposures. Alternative values, such as 1 rem per hour at 30 centimeters, were proposed.

Response: The seriousness of this dose rate was a factor in its adoption. The 500 rads per hour value appears in the previous 10 CFR 20.203(c)(6) as a criterion for additional access controls for irradiators (similar in scope to the requirements of § 20.603 in the final rule). However, the previous Part 20 did not use a unique designation such as the "very high radiation area" designation used in the proposed and revised Part 20 rules. The difference between the 1 rem per hour definition of a "very-high" radiation area used in reactor technical specifications and the 500 rads per hour definition used in the revised Part 20 is discussed in a regulatory guide currently being prepared.

Comment: Meaning of "direct surveillance." Several commenters thought that the term "direct surveillance" used in the proposed § 20.601 could be interpreted to require stationing an observer at the entrance to the "high" or "very high" radiation areas.

Response: The final rule permits "...continuous direct or electronic surveillance over a high radiation area that is capable of preventing unauthorized entry..." This removes the burden of having to station a person in or near a "radiation area," but requires interlocks or electronic locks so that the remotely located observer may prevent entry into the area when necessary.

Final Rule. The section on very high radiation areas has been divided into two sections. Section 20.602 provides a general requirement for restricting access to such areas. This general requirement applies to all very high radiation areas, regardless of the type of licensed operation, including those at nuclear power reactors. A second, more detailed, set of requirements applies only to large gamma irradiators. This section, § 20.603, restates requirements for irradiators that are in § 20.203(c)(6) of the present 10 CFR Part 20.

Subpart H -- Respiratory Protection and Controls Restrict Internal Exposure in Restricted Areas

Sections 20.701 and 20.702 Use of Process or Other Engineering Controls and Use of Other Controls.

Comment: "Use of other controls." Commenters suggested that, if workers could be exposed to concentrations of radioactive materials greater than 1 derived air concentration, ALARA should be applied to the total of internal and external doses (to the total effective dose equivalent). It was noted that this condition was included in the Federal Guidance on Occupational Radiation Exposure.

Response: Modifications have been made in the final rule to permit ALARA considerations to apply to the total effective dose equivalent rather than just the internal dose portion.

Comment: Some commenters indicated that the use of respirators should be permitted even if their use would not be able to reduce airborne concentrations below 1 DAC. They noted that this would be consistent with the ALARA philosophy.

Response: Section 20.702 has been rewritten to clarify the intent that the concentration of 1 DAC is not a cutoff on the voluntary use of respirators but is intended to be the point where some corrective action (including, but not limited to, the use of respirators) by the licensee would be required when the use of ventilation and process controls cannot further reduce the airborne concentrations of radioactive materials.

Section 20.703 Use of Individual Respiratory Protection Equipment.

Comment: The proposed rule permits low estimates but not high estimates of intake to be corrected. Commenters noted that the the proposed rule

(§ 20.703(a)(1)) was not balanced as correction of intake estimates based upon dividing DAC-hours by the respirator protection factor and was only permitted if the initial estimate was later shown (by bioassay results) to have been low.

Response: The rule has been modified so that corrected estimates of actual intake can be used in records in place of earlier estimated intakes, regardless of whether the change would result in an increase or in a decrease in the intake estimate.

Comment: NRC should provide a recommended minimum acceptable standard for determining an individual's physical fitness for respirator use. Part 20 requires that a physician determine that an individual worker is physically able to wear a respirator. NRC should, therefore, provide guidance to the physician on minimum standards for wearing respirators.

Response: The NRC policy is that the decision as to medical fitness has been, and continues to be, left to the physician; i.e., the medical doctor should decide what constitutes minimum health standards for respirator wearers. Furthermore, the requirements may vary, depending on the respirator used and physical situations, such as the type of work to be performed, which are outside the scope of Part 20. Licensees desiring more guidance should obtain ANSI Standard Z88.6(1984), "For Respiratory Protection -- Respirator Use - Physical Qualifications For Personnel," which was developed as an industry consensus standard that provides definitive guidance to "identify the responsibilities of the physician, the employee, and management in determining the employee's ability to use a respirator."

Comment: NRC should permit a health professional to certify physical capability to use a respirator rather than requiring a physician to perform each required certification. The proposed rule requires that a physician annually certify a worker's physical suitability for using a respirator. This should be broadened to permit any qualified health professional, acting under a physician's orders, to perform the actual certification rather than requiring a doctor to do this.

Response: As noted in the previous response, the decision on the physical ability of an individual to wear a respirator is a subjective judgment that, in the Commission's opinion, requires the decisionmaker to have a medical degree. The Commission notes that this annual certification could easily be included in an annual physical checkup.

Comment: The selection of respirator protection factors based upon "average concentrations" and not "peak airborne concentrations" is an improvement. The proposed rule, unlike the previous Part 20, permitted protection factors to be applied to the time-averaged air concentration rather than the peak air concentration.

Response: Despite some favorable comments on this change, the Commission has determined that the use of the average airborne concentration may not provide an adequate margin for health protection and, in the final rule, has reverted to the use of the anticipated peak concentration.

Final Rule. The proposed rule has been modified to require a respiratory protection program when respiratory protection devices are being used to limit intakes, whether or not credit is taken for respiratory protection factors. Allowance has been made for use of respirators that do not provide protection factors that would keep exposures below the derived air concentrations if (and only if) such use would keep the total effective dose equivalent ALARA.

267
P5

Section 20.704 Further Restrictions on the Use of Respiratory Protection Equipment.

Comment: Section 20.704 should be deleted. This section, which states that the Commission may impose additional conditions on respirator use, is not necessary because § 20.1302 permits the NRC to place additional requirements on a licensee.

Response: Although the comments are correct that § 20.1302 gives the Commission general authority to impose additional requirements on licensees, the Commission believes that the restatement of this policy in a section pertaining specifically to respiratory protection is desirable. As noted by the comments, this section does not create any additional requirement not otherwise contained in the regulations. [ ]

Final Rule. The requirements contained in the proposed rule are retained.

Subpart I--Storage and Control of Licensed Material

Sections 20.801 and 20.802 Security of Stored Material and Control of Material not in Storage.

Comment: Definition of "secure." Several commenters requested a definition of the term "secure," which they felt was vague and did not provide an indication of the required licensee action.

Response: The phrase has been rearranged and now reads "secure from unauthorized removal or access" similar to the wording in the previous Part 20. This should provide sufficient clarification of what was intended by "secure."

Comment: Unnecessary restrictions on research. One commenter thought that the requirement to secure small quantities of radioactive materials when they are not in use would interfere with university research.

Response: The Commission believes that locking radiotracer laboratories when they are not being used is a small nuisance compared to the consequences of unauthorized access to or theft of the radioactive materials, which could result in contamination of unrestricted areas or exposure of individuals, as well as having to report a loss of licensed material to the NRC.

Subpart J--Precautionary Procedures

Section 20.901 Caution Signs.

Comment: Black should be permitted as an acceptable color for the radiation warning symbol. Several commenters requested that the color black should also be allowed to be used on signs and for stenciling on packages. The fading of magenta inks in sunlight and the use of black for marking international shipments were cited as supporting this position. 237 #1

Response: The Commission believes that, although the 'magenta-on-yellow" color scheme has provided a unique warning of possible radiation hazards, black-on-yellow would also be acceptable. The fading of the magenta color as cited above may reduce the visibility of the sign with time. Because of the cost impacts if existing warning signs had to be replaced, the Commission is permitting the use of black in addition to continued approval of magenta and purple, rather than as a required replacement.

Final Rule. This section has been modified to add black as an acceptable color for the radiation warning symbol.

Section 20.902 Posting Requirements.

Comment: The terms "Caution" and "Danger" are not used consistently. Commenters noted that "Caution" or "Danger" could be used on signs for "Radiation Areas," "High Radiation Areas," and "Very High Radiation Areas" despite the considerable variation in the hazards that might exist in these different areas.

Response and Final Rule: The Commission agrees that the terms "Caution" and "Danger" should be used in a more consistent manner. The final rule permits only the term "Caution" to be used in "Radiation Areas." "Caution" or "Danger" may be used in "High Radiation Areas," since it covers a considerable range from KCMU #65

0.1 rem per hour to over 500 rads per hour. Only "Grave Danger" may be used in "Very High Radiation Areas." This should provide more emphasis on the use of "Danger," the importance of which might have been diminished by its prior applicability to the lower hazard "Radiation Area." "Caution" is inappropriate for use in "very high radiation areas" because of the potential hazard.

Comment: There should be a requirement to post all "restricted areas" whether or not it is a radiation or an airborne radioactivity area.

Response: The objective of posting is to warn personnel of a potential hazard. A "restricted area," per se, does not warrant such a warning. There is nothing to prevent a licensee from posting a notice designating a "restricted area," but such action is not required.

Comment: The definition of "airborne radioactivity area" would require tracking of employee "stay times" (time spent in the area). The second option to the definition of "airborne radioactivity area" would require performing surveys of airborne activity and tracking the time spent by workers in the area. The present rule would have only necessitated the survey.

Response: There are two alternative definitions of an "airborne radioactivity area"; only the second one would require consideration of stay times. This second option does not require posting in areas that have low occupancy times and airborne radioactivity concentrations between 0.3 and 1.0 times the applicable DACs.

Comment: Areas containing only noble gases should not require posting as "airborne radioactivity areas." The hazard associated with such areas is primarily from external radiation.

Response: The DACs in Appendix B that apply to noble gases (and define an "airborne radioactivity area") are based upon submersion doses; therefore,

the relationship remains valid. It should be noted that, because some short-lived noble gases have particulate daughters (such as ^{88}Rb and ^{138}Cs), the warning denoted by posting as an "airborne radioactivity area" may still be required.

Comment: There is no evident need to post all rooms containing 10 times the Appendix C levels. The requirement to post a caution sign in rooms that store ten times the Appendix C concentrations is unwarranted. There was some concern noted that such posting could deter firefighters or other emergency workers from entering an otherwise safe area, and increased damages could result.

Response: Complete dispersion of ten times the Appendix C activities could produce air concentrations for some radionuclides in excess of the occupational DACs. For example, if ten times the Appendix C quantities were dispersed in a 1,000 cubic foot (10 ft. x 10 ft. x 10 ft.) room, the resulting concentrations would be 35 times the DAC for organic carbon-14, 58 times the DAC for cesium-137, about 18 times the DACs for iodine-131 and tritium (water vapor), and approximately 6 times the DAC for technetium-99m. These appear to be sufficiently large to justify a posting requirement, particularly to caution firefighters in case of a fire.

Comment: The posting requirement should not be applied to sealed sources, such as gauges. Posting the entrances to areas having radioisotopic gauges could require multiple postings in large buildings.

Response: Posting is only required at entrances to the room containing the source and only when the dose rate at 30 centimeters would exceed 0.005 rem (0.05 mSv) in any hour (§ 20.903(c)) unless areas outside the room warrant posting as "radiation areas" and are already posted.

Section 20.903 Exceptions to Posting Requirements.

Comment: The proposed rule omits the past exemption for posting rooms containing only packages prepared for transportation.

Response and Final Rule: The Commission believes that there should be posting of these areas because there is no restriction on the length of time that packages may remain in a room. If the packages contain only small quantities of radioactive materials, then posting of the room would still be exempted under the remaining exemptions. The term "prepared for transportation" does include packages that are intended to be carried in a "sole use" vehicle. Such packages are permitted to have higher allowable dose rates than those specified in DOT (or NRC) limits for general shipment.

Final Rule. The exception for posting areas containing packages prepared for transportation has not been reinstated.

Comment: The requirement for a person in attendance would be unworkable in a hospital. The requirement (in lieu of posting the room containing a radiotherapy patient) for a person in attendance in order to prevent entry was interpreted as requiring a 24-hour escort for each radiotherapy patient.

Response: The intent was to generally require posting of therapy patients' rooms. (As noted in one of the comments, the dose rate from patients even with diagnostic nuclear medicine treatments might exceed dose rates of 0.002 rem per hour.) The intent of "in attendance" would be satisfied by a duty nurse at a nursing station, providing that the station was in sight of the entrance to the patient's room.

Section 20.904 Labeling Containers.

Comment: There is no way to meet the requirement to label containers in some nuclear power plants or in hot cells. It is difficult to mark the detailed information on a container in some areas of a plant or in hot cells.

Response: Section 20.905 contains exceptions to the labeling requirements that take care of the problem noted by the commenter.

[Note: For the purpose of this section, "Mixed Fission Products" and "Fission and Activation Products" may be regarded as radionuclides, provided that the total activity is also specified. Designations as to the process stream or location sampled or type of sample (e.g., "primary coolant") may also be helpful as an additional designation of the potential hazard.]

Section 20.905 Exemptions to Labeling Requirements.

Comment: The proposed rule omits existing exemptions for packages containing only exempt quantities and those containing less than 10 mCi or less of tritium, iodine-125, carbon-14, and sulfur-35.

Response: While these sources pose little external hazard from gamma radiation, the quantities could be a potential internal hazard if the package were ruptured and the contents were released. Consequently, some warning remains appropriate.

Comment: The proposed rule omitted the existing exemption from labeling for packages labeled for shipment in accordance with DOT requirements.

KCmm p70

Response and Final Rule: The exemption for DOT-labeled packages has been restored because the Commission agrees that the DOT labeling is sufficient to denote the presence of radioactive materials and provide an indication of any potential hazard. Quantities and concentrations not requiring DOT labels would not warrant an NRC labeling requirement. (See § 20.905(d).)

Section 20.906 Procedures for Handling Packages.

Comment: The requirement to monitor all packages is unnecessary. The requirement to monitor all incoming packages containing radioactive materials is unnecessary and in large installations creates a substantial monitoring burden.

Response: This requirement has been reevaluated and modified in order to reduce the burden.

Final Rule. Section 20.906 in the final rule requires incoming packages to be monitored when: (1) they are labeled as containing radioactive materials according to DOT regulations, or (2) when a package is damaged or leaking. The first provision would reinstate the exemption from monitoring for shipments of small quantities of radioactive materials that would not require DOT labeling.

Comment: The requirement to survey external surfaces of packages is unnecessary. Several commenters with extensive experience in monitoring packages noted that external contamination was rarely if ever present and that wipe tests are time-consuming both to make the smears and to count them.

Response: Experience in the shipment of thousands of packages each year has been very good. However, potential problems with leaking packages during transit warrant continued monitoring upon receipt to ensure that leaking packages are found and reported. Appropriate action can then be taken to determine the extent of contamination in transport vehicles and storage areas in order to limit the consequences and avoid recurrence. However, an exemption from the contamination survey requirement has been provided for special form (sealed) sources that are being moved to and from work sites in licensee owned or operated vehicles. This partially restores an exemption from the package survey requirements in the existing Part 20 (§ 20.205(b)(iii)) for all special form sources.

237 #4

The Commission believes that restoring this exemption will not result in any additional hazard. An external radiation survey of the package is still required. The primary purpose of this external survey of sealed sources is to ensure that the source is still properly secured and shielded after transporting it.

Final Rule: The requirement to monitor external surfaces of packages has been retained and applies to the two classes of packages for which surveys are required (labeled "radioactive" and damaged or leaking). A partial exemption to sealed sources transported for field use has been reinstated because of the difficulty in making field measurements of surface contamination and because the transporting vehicle is not in general commerce.

KCMH #71

237 #4

Comment: The requirement to monitor packages within 3 hours is unwarranted. This requirement would be difficult to meet for several types of licensees, some of which do not have a full-time health physics staff person.

Response: Licensees receiving labeled packages of radioactive materials to which this requirement applies are expected to have available persons who are qualified to perform such monitoring. However, the person monitoring the package need not be a board-certified health physicist.

Final Rule. The 3-hour period in the current Part 20 (§ 20.205(b)(1)(5)) has been retained except if the package is received after normal working hours.

Subpart K--Waste Disposal

Section 20.1001 General Requirements.

Comment: Decay in storage as a disposal option. Many commenters noted favorably the addition of "decay in storage" as an allowed waste disposal option. Several commenters, however, did not believe that the option, as expressed in the proposed rule, was particularly helpful.

Response: Technically, the "decay in storage" option has always been available to a licensee since the license permitted possession of the radioactive materials and these materials naturally underwent radioactive decay. The option was formally included in the proposed and final rules because the list of disposal options is exclusive and there have been questions as to whether this was allowed under the previous Part 20. It should be noted that this option does not allow material that has "decayed in storage" to be released to unrestricted areas unless it meets the requirements of one of the other allowed forms of waste disposal in Part 20, or the requirements of § 35.92, "Decay-in-Storage," of 10 CFR Part 35, or the specific requirements given in any NRC or Agreement State license conditions.

The NRC staff considered adding a separate "Disposal by Decay in Storage" option with specific criteria for unrestricted release of material after decay. These criteria are commonly included in source and byproduct material licenses. However, the provisions included in 10 CFR 35.92 and certain specific license conditions pertain to relatively short-lived radionuclides and are neither appropriate nor applicable to other classes of licenses, such as those issued under Part 50. Also, when evaluated for a specific licensed activity, it is possible to consider existing pathways of exposure and to establish specific criteria for decay.

SECY-89-26 267 P5

General criteria in a rule would need to be sufficiently conservative to take into account all reasonably conceivable pathways, thereby reducing the applicable level from what would be permitted in a case-by-case evaluation.

NCRP 72

Final Rule. The Final Rule has been modified to explicitly list "decay-in-storage" as an authorized form of disposal. Section 20.1001 has been modified to incorporate the requirements that were in § 20.1002(b) of the proposed rule. These provisions require NRC licenses for persons who receive wastes containing licensed radioactive materials for treatment, for treatment or disposal by incineration, decay-in-storage, or disposal in facilities licensed under Part 60 or Part 61.

267 P5

Section 20.1003 Disposal by Release into Sanitary Sewerage.

Comment: Removal of allowance for dispusal of "dispersible wastes." A number of commenters felt that the restriction of wastes released to sanitary sewers to soluble wastes would have an adverse impact on certain licensees that, under the previous rule, had disposed of "dispersible" but insoluble radioactive materials. In particular, the practice was mentioned of grinding up animal carcasses with subsequent sewer disposal of the ground residue. This practice is permitted by the previous Part 20 but would not have been permitted under the proposed rule.

Response: In the final rule, the Commission has modified the conditions in the proposed rule for disposal of radioactive wastes into sanitary sewer systems so that "dispersible biological materials" may continue to be disposed of by release to sanitary sewers. This means of disposal is advantageous compared with other alternatives for disposal of this type of biological material.

The prohibition on disposal of insoluble materials via the sanitary sewer was intended to prevent disposal via sanitary sewers of material in which the radioactive material is primarily in an insoluble form. Such materials may accumulate in the sewer system, in the sewer treatment plants, and in the sewer sludge.

Final Rule: The final rule permits disposal into sanitary sewers of: (1) radionuclides in soluble form or (2) radionuclides in readily dispersible biological material, provided that the limits in Appendix B, Table 3, on the average monthly concentrations and the limits in § 20.1003(a)(4) on the total activity released annually are met. The revised rule no longer permits the disposal of nonbiological insoluble materials because of potential reconcentration of these materials in the sanitary sewer system, sewage treatment plants, and sewage sludge. This prohibition for insoluble materials is the reason why there are no values listed in Table 3 of Appendix B for insoluble materials.

Comment: The rationale for the reduction in the limits for sewer disposal is not explained. The concentration limits for radionuclides released to sanitary sewer systems in the proposed rule have been reduced by a factor of 10 from the former rule. This reduction did not appear to take into account the dilution afforded from multiple users of the sewer system. Commenters indicated that they thought that this reduction would increase the amount of material that would have to be disposed of via a low-level radioactive waste burial site and could result in increased radiation doses to workers having to package this material.

Response: The assumption noted by many commenters that radionuclides discharged into sanitary sewer systems are not ingested is not necessarily true because water in large lake or river systems may be recycled. The dilution afforded by having multiple users of a sewer system can be offset in part because there can also be several users that discharge radioactive wastes into the same sewer system. The revised Part 20 rule permits a higher concentration limit for discharges into sanitary sewers than for other liquid effluent releases of radioactive materials, but has lower concentration limits than were formerly allowed for sewage. In view of past contamination incidents (involving cobalt-60 and americium-241) and the reduction in the dose limit for members of the public, the Commission believes that continuation of the higher limits is no longer desirable.

KCMH p73

The NRC has under way a study of the dose pathways associated with disposal of radioactive materials via sanitary sewers. This study will help clarify the potential for human exposure.

Comment: The exemption on disposal of human excreta should be removed. Hospitals should have to comply with the same regulations as other licensees.

Response: Disposal into a sanitary sewer system (which was designed specifically to handle this type of waste) is the preferred method of disposal because of the other health considerations in handling human excreta in addition to radiation protection. This exemption is in the current Part 20.

Section 20.1004 Treatment or Disposal by Incineration.

Comment: Relaxation of specific NRC authorization for incineration. A number of comments questioned the need for the existing requirement that incineration of radioactive materials requires specific prior NRC approval (except for small quantities of tritium and carbon-14, which are specifically exempted). These commenters noted that the source of the released material (from an incinerator stack or from a fume hood vent) should not be the basis of requiring specific prior NRC approval of incineration while permitting general effluent releases.

Response: Relaxation of the prior approval requirement for incineration was considered in connection with the revision of Part 20. The requirement for prior NRC approval of incineration remains in the revised Part 20 because the acceptability of incineration as a disposal option, except for exempted quantities of radioactive materials, must be determined on a site-specific basis considering: (1) incinerator design to safely dispose of hazardous materials, (2) the variable nature of the material to be burned both in terms of isotopic composition and activity, and (3) because many of these incinerators can be located in urban areas, special calculational methods may be required to assess doses to people located near these facilities.

KCRY4 p74

change from KCRY4 not made. Emphasis on difficult meteorology not population distribution

Final Rule: Disposal by incineration still requires specific approval by the Commission (or Agreement State) whether done only for wastes from the licensed facility or whether done for wastes received from other licensees.

Section 20.1005 Disposal of Specific Wastes.

Comment: There should be a definition of ALARA for solid wastes. Many commenters suggested the need for ALARA or exempt quantities of radioactive material in solid wastes so that very low-level solid wastes could be disposed of without regard to their radioactivity.

Response: The Commission agrees that such levels would be useful and has developed a policy statement regarding levels of dose and risk that can be used to determine that specific practices involve radiation hazards that are Below Regulatory Concern (BRC). This policy statement was published in the Federal Register on July 3, 1990 (55 FR 27522). The BRC Policy Statement provides a comprehensive policy that will establish a disciplined and consistent framework for all future Commission exemption decisions. This includes potential application to rulemaking or licensing actions for disposal of slightly contaminated solid radioactive wastes. The Commission is developing a program for implementing the BRC policy separate from this Part 20 rulemaking.

267 p6 rewrite of suggested version in KCMH p75

Section 20.1006 Transfer for disposal and manifests.

Comment: This section should not be in Part 20.

Response and Final Rule: This section is in Part 20 because it relates to the radiation protection aspects of low-level waste shipments.

Section 20.1007 Compliance with Environmental and Health Protection Regulations.

Final Rule. This section has a counterpart in the present Part 20 and in the proposed rule (§ 20.1005) stating that meeting Part 20 requirements does not remove the responsibility of licensees, when disposing of licensed radioactive materials, from meeting the requirements of other applicable Federal, State, and local regulations applicable to toxic or hazardous wastes. [ ]

KCMH p75 example omitted as redundant

The advisory statement in the final rule has been expanded to cover all methods of waste disposal. This section of the rule is advisory and is not intended to imply that NRC will take enforcement action for violations of other environmental protection regulations issued under statutes other than the Atomic Energy Act. [deletion omitted]

Subpart L--Records

Standardization of Record Retention Requirements.

Final Rule. Records directly pertaining to effluents released to the general environment, waste disposal, and doses received by individuals are to be kept until the "Commission terminates each pertinent license requiring the record." Other record retention requirements in this subpart generally have been modified to be for 3 years after the record is made. This change is in conformance with the final rule published in the Federal Register of May 27, 1988 (53 FR 19240) on record retention requirements for other parts of the NRC regulations. This change provides for consistent record retention requirements throughout the NRC regulations in Title 10 of the Code of Federal Regulations.

Section 20.1101 General Requirements.

Comment: The units used in records should be limited to those commonly in use: the rad, the rem, and the curie. Some commenters thought that the use of SI units (gray, sievert, and becquerel) should not be allowed.

Response and Final Rule: The Commission agrees that the use of "special units," the rad, the rem, and the curie, is preferable at this time. This will avoid any difficulties arising from trying to implement both a new regulation and new units. This will reduce potential problems in records and reports that could result from some licensees using the "SI units" and some using the older "special units." The final rule requires the use of the "special units" instead of the "SI units." See the discussion of this topic under § 20.4 Units.

Section 20.1102 Records of Radiation Protection Programs.

Comment: Added implementation burden associated with requirements for formal radiation programs. A number of commenters thought that the require-

ment to have a formal ALARA program would result in substantial increased costs due to additional recordkeeping, procedural requirements, and quality assurance requirements.

Response: As discussed under § 20.101 these provisions have been modified to require ALARA as one part of a licensee's radiation protection program. The adoption of requirements for licensees to have a formal radiation protection program was not intended to cause large implementation costs. Much of the cost associated with the recordkeeping requirements in the proposed rule was a result of the ALARA documentation requirements. These recordkeeping requirements have been reduced in the final rule by deleting specific reference to documenting ALARA actions. Specific types of records will be developed by each licensee as part of their radiation protection program. Therefore, this section contains general recordkeeping requirements associated with the radiation protection program.

Comment: The recordkeeping burden for small licensees requires a commitment of resources that is not commensurate with the risk. (In Section XXXVI of the proposed rule (51 FR 1121-1122), NRC specifically requested comments on the magnitude of the impact of the proposed rule on small licensees and requested suggestions on how these impacts could be reduced.) Quite a few commenters expressed their belief that the proposed rule will require more extensive monitoring and recordkeeping efforts than were required by the existing Part 20. Several commenters suggested that the NRC explore possible exemptions or exclusions for academic licensees and other users of small quantities of licensed material. Other commenters expressed the view that the protection of public health for both the worker and the general public should be the same regardless of the size or economic resources of the licensee.

Response: Because of the changes to reduce the recordkeeping burden discussed in response to the preceding comment and because the basic requirement in § 20.101 calls for effort "... commensurate with the scope and extent of licensed activities ...," the Commission has not made further exemptions or exclusions from the recordkeeping requirements in this section for certain types of licensees.

Section 20.1104 Determination of Prior Occupational Dose.

Comment: Medical and academic licensees would have difficulty in complying with the requirement to determine prior exposures. The transitory nature of personnel in these facilities would make meeting these requirements very costly. Doses to employees are small fractions of the limits so that such costs would be difficult to justify.

Response: The requirement to determine dose received in the current year implements the annual dose limits. The requirement to attempt to obtain records of lifetime cumulative doses follows one of the provisions of the guidance to Federal agencies on occupational radiation protection. Efforts to obtain prior exposure histories are only required for workers who are required to be monitored under § 20.502. Determination of prior doses received during planned special exposures or doses in excess of the annual limits are required only for workers who will be used in planned special exposures.

Comment: The recording of "fictitious" radiation doses should be avoided. The present and proposed rules state that, when information is not available regarding the dose received for a specific period, the licensee should assume that the dose received was at the dose limit. Several commenters thought that this was inappropriate. Some commenters mentioned that this practice might be nonconservative as it would tend to overestimate the dose used in any epidemiological studies of radiation effects, thereby resulting in an underestimate of the risk associated with a unit radiation dose.

Response and Final Rule: The final rule has been modified so that it does not require any assumed dose value to be recorded in case of incomplete prior dose histories. Only the lack of data must be recorded for periods where there is no information. However, for the current year, where there are missing data, an assumption is to be made for establishing administrative controls: the portion of the dose limit remaining for the current year is reduced by 1.25 rems for each calendar quarter for which information is missing. (The values for other limits, such as the shallow dose equivalent or eye dose equivalent

should be reduced by a one-quarter of their annual limit for each unreported quarter.) The licensee must note the absence of this information on the employee's record but should not enter the assumed dose value as part of the employee's permanent dose record. For example, an employee who had prior radiation working experience joins Company X on July 1st but does not have the prior radiation records. This employee's dose should be limited to 2.5 rems (5 rems - 2(1.25) = 2.5 rems) until such time as the records are obtained.

Comment: There should be a quarterly dose limit to cover workers whose records have not been received from a former employer. A 0.5-rem dose might be appropriate for this purpose.

include KCMU p 78

Response: If data were missing for all four quarters (employment commenced late in the fourth calendar quarter), then the employee could not be exposed to radiation above the level for a member of the general public. However, this limit is 0.1 rem per year not 0.5 rem.

Section 20.1105 Records of Planned Special Exposures.

See discussion under § 20.1204.

Section 10.1106 Records of Individual Monitoring Results.

Comment: NRC should not require reporting or recording of cumulative dose. A number of commenters noted that the ICRP system of dose limitation is based [as one of the principles] on controlling annual doses. Consequently, they questioned the need for recording cumulative doses.

Response: Although the commenters are correct that there is no longer a cumulative dose restriction in Part 20 (such as the former 5(N - 18) formula), the Federal Guidance on Occupational Exposure (see Section II.D.) contains a recommendation that cumulative dose records be maintained and provided to the worker. [ ]

KCMU p 80

Comment: The proposed rule does not require recording annual doses as listed in the 1987 Federal occupational guidance.

Response: "Annual dose" is specified in the guidance and is the same as the annual deep dose equivalent for external doses. However, "annual dose" is not required to be recorded by the revised Part 20 for internal doses. This is consistent with an exception noted in footnote 5 to the Federal guidance (Federal Register of January 27, 1977; 52 FR 2832):

> "When these conditions on intake of radioactive materials have been satisfied [i.e., meeting the committed dose limits], it is not necessary to assess contributions from such intakes to annual doses in future years, and, as an operational procedure, such doses may be assigned to the year of intake for the purpose of assessing compliance."

p267 p6

Paragraph 20.1106(b) -- See discussion under § 20.1204.

Comment: The recordkeeping requirement in the proposed § 20.1106(d)(2) would require that all records begin at the beginning of a calendar year. This would create an unnecessary hardship on dosimeter processors since they could not stagger the dosimeter changeover schedules to provide a more uniform workload distribution.

Response and Final Rule: The term "year" replaces the term "calendar year" in § 20.3 and permits the licensee to define the year to begin anytime in January. A licensee may change the starting date, provided that the change is made at the beginning of the year and provided that no day is omitted and no day is included twice in consecutive years.

Comment: The requirement in § 20.1106(e) for each licensee to keep a copy of the dosimeter processor's accreditation certificate creates an undue burden

on commercial processors. Commercial dosimeter processors would have to print and distribute thousands of their certificates so that each user had a copy.

Response: The proposed rule contained a requirement for the licensee to maintain a copy of the dosimetry processing accreditation certificate issued to the processor providing dosimetry services to the licensee. This requirement, which was in the proposed dosimetry accreditation rule, was considered unnecessary and was dropped as a requirement in the final version of that rule. Consequently, it has been deleted from revised Part 20. Licensees who provide their own dosimeter processing services do have to maintain a copy of their NVLAP accreditation certificate for inspection.

Comment: The NRC should consider a "traveling dose history" that can move with the worker. This was suggested, particularly for transient workers and for workers employed concurrently by two employers. The master record will reside with the current employer and would have to be transmitted by the worker to a new employer.

Response: Because the NRC can only regulate its licensees and has no authority over individual workers, the recordkeeping and transmittal requirements for dose histories are placed on the licensee and not on the worker. The concept of a "passport" incorporating security and dosimetry data has been used successfully in Japan and elsewhere. The requirements for determination of prior exposures that are in § 20.1104 provide a similar record to a "moving history," but this would have to be updated by each new employer.

Concurrent employment with two (or more) employers requires special attention so that the combined doses from both employers would not exceed the dose limits. When two employers are aware of such concurrent employment, the simplest expedient to achieve this goal is for them to agree that the dose limit they will use for this employee in the individual programs is less than one-half of the NRC dose limits (the fraction of the dose limit allocated to each employer might also be determined on the basis of the relative amount of time worked at each location).

The problem of dual employment is more of a problem when the employee has not confided in the employer. The licensee is required to ascertain the employment and dose record for the current year for new employees (§ 20.1104). If the employee deliberately falsifies this information, the licensee would not know of concurrent employment and the licensee would not be penalized for combined doses from both employers that exceeded the dose limits. If a current employee takes on additional outside radiation work without informing the employer, the employer should not be penalized. It should be noted that, under the new reporting requirements in § 20.1206, individual dose records will be required to be submitted to the NRC for all workers for those categories of licensees formerly subject to § 20.407, including nuclear power reactor licensees. [ ] per KCMU p82

Final Rule. Section 20.1106 has been modified in order to separate the requirement for keeping a record from the format of the record. A clarification has been added that the dose information on an embryo/fetus be kept with the mother's dose record. [ ] per KCMU p82

Section 20.1107 Records of Dose to Individual Members of the Public.

Comment: Reporting requirements for exceeding "reference levels." The proposed rule contained requirements for reporting exposures in excess of the "reference levels" for doses to members of the general public. Many commenters thought that this was excessive because this was not an actual regulatory limit.

Response: The 100 millirems per year "reference level" for doses to members of the general public in the proposed rule has been incorporated as the dose limit in the final rule for members of the general public so that the associated recording and reporting requirements now pertain to a regulatory limit.

Final Rule. Section 20.1107 has been broadened in scope from "effluents" to pertain to records of all estimates of doses received by individual members of the public. [ ] Doses to members of the public are calculated from measurements of direct radiation, and radionuclides in effluents, and the environment rather ED replaces KCMU p83 comment

than as measurements pertaining to a a particular individual. This difference in method of dose assessment from the more direct measurements used for occupational exposure does not imply any lessening of requirements for keeping adequate records of effluents released to unrestricted areas.

Section 20.1108 Records of Waste Disposal.

Final Rule. Section 20.1108 is unchanged from the proposed rule.

Section 20.1109 Records of Testing Entry Control Devices for Very High Radiation Areas.

Final Rule. Section 20.1109 contains an addition to the proposed rule for keeping records of tests of entry control devices for very high radiation areas. This addition is based upon a requirement in § 20.203(c)(6) of the present Part 20.

Section 20.1110 Form of Records.

Comment: NRC should allow computerized recordkeeping systems to handle records. A few licensees suggested that NRC allow "electronic" recordkeeping systems and provide guidance for their use.

Response: The Commission agrees that there is great value in the use of "electronic media." There are a growing number of licensees that are using computer information networks for retaining and transmitting radiation dose histories and other worker-related information among different facilities.

Final Rule. The final Part 20 expands the definition of "record" to include "electronic media." The use of electronic media requires authentication and the prevention of alteration or loss of the records. As with existing requirements for paper records, the electronic media must be capable of producing a legible copy of the record.

Subpart M--Reports

Section 20.1201 Reports of Theft or Loss of Licensed Material.

Comment: The term "substantial exposure" in § 20.1201(a) should be defined. The requirement to report the loss of radiation sources capable of producing "substantial exposure" needs to be more precise.

Response: The term "substantial exposure" has been replaced by a specific designation of the activity of lost source that requires immediate reporting to the Commission. This quantity is 1,000 times the Appendix C activity levels. For sealed sources of cobalt-60, cesium-137, or iridium-192, this activity would produce a dose of around 25 rems at 1 foot over a 30-day period (25 rems is the worker dose that requires immediate Commission notification). Although somewhat similar doses may be projected from inhalation of dispersible material, the exact exposure conditions would have to be known in order to make a valid activity-to-dose relationship.

Final Rule. The final rule now contains specific activity criteria for immediate reporting rather than the vague term, "substantial exposure."

Comment: The quantity for reporting the loss of a source is too low (too high). The reportable quantity of ten times the Appendix C activity values appeared to some commenters to be overly restrictive; others thought that all lost or missing radiation sources should be reported.

Response: The specified 30-day reporting level is a compromise between having higher reporting levels and having a requirement that all lost or missing sources be reported. Further, the report permits review of the circumstances involved including any lack of security of materials or weakness in the licensee's control program that may be unrelated to the sources being stolen or lost, but may be pertinent in avoiding recurrent theft or loss.

Final Rule. The activity levels in Appendix C for some long-lived radionuclides have been increased from those specified in the proposed rule. This increase means that the loss of milligram quantities of natural uranium will no longer have to be reported.

Comment: A 30-day telephone report should not be required concomitant with a written report. Sections 20.1201(a)(1)(ii) and 20.1201(b) both call for a 30-day report; the first requires a telephone report and the latter section requires a written report.

Response and Final Rule. The rule has been revised to clarify that the written reports required by § 20.1201(b) are to be submitted within 30 days of the telephone notification required by § 20.1201(a), rather than both being within 30 days of learning of the theft or loss.

Comment: The rule should provide for a "grace period" before having to report a lost source to NRC. Commenters noted that, in many instances, a source "lost" in transit eventually turns up. Some specified period, such as 7 days, should be permitted before a "lost" source would have to be reported to the NRC.

Response: The rule contains two notification requirements: the one for immediate notification only pertains to those sources that exceed 1,000 times the Appendix C activity levels. The second notification requirement pertains to sources that exceed ten times the activity levels in Appendix C and that are still missing after 30 days. This provides a grace period of 30 days for reporting the loss of most sources.

Section 20.1202 Notification of Incidents.

Comment: The requirements for immediate notification of NRC are too low. Some commenters thought that the doses associated with the requirements for

immediate reporting to NRC (five times the respective annual limits) would not produce any discernible harmful effects to the individual to warrant immediate reporting.

Response: Doses of the order of 25 rems (5 times the 5-rem annual dose limit) can produce discernible biological effects in the body in the form of chromosome aberrations and changes in the white blood cell populations. Although the majority of these effects are temporary, they could be discerned. However, irrespective of the potential for discernible effects, doses at these levels represent a major breakdown in the licensee's control over the radioactive material, and the Commission believes that it is important that NRC be promptly notified so that it can take actions, if necessary, to limit further consequences.

KCMH p 86

Final Rule. The final rule retains the previous reporting requirement.

KCMH p86

Comment: Immediate reporting should be required if there is any potential for dose reduction. The Environmental Protection Agency (EPA) suggested that incidents always be reported if there is the potential for significantly reducing public doses through protective actions. It is believed by the EPA that this would occur at doses significantly less than those of the proposed reporting criteria.

Response: The incident reporting levels and response times have been selected to limit attention to the more potentially serious events without the entire NRC emergency response network being activated unduly for events involving only small quantities of radioactive materials. For most cases, it is expected that the licensee would have initiated any necessary remedial measures.

Comment: Immediate and 24-hour notification requirements should be suspended in the case of a declared emergency at a nuclear power plant. Commenters felt that any emergency at a nuclear power plant will involve onsite NRC staff and that stopping emergency activities to make the Part 20 incident reports could be a burden on the licensee.

Response and Final Rule. These reports are particularly easy to make for nuclear power reactors (the reactor operator merely has to pick up the dedicated NRC telephone line to get the NRC Operations Center). There are certain functions of the NRC (such as activating the NRC Incident Response Plan) that require that NRC be notified; therefore, this notification requirement has been retained.

Section 20.1203 Reports of Exposures, Radiation Levels, and Concentrations.

Comment: There is no requirement for reporting doses that exceed the limit for protection of the embryo/fetus in § 20.208.

Response and Final Rule: A requirement has been added to the final rule in § 20.1203(a)(2)(iii).

NCMH
p88

Comment: The identifiers required in § 20.1203(b)(2) for the embryo/fetus should be those of the mother. As the fetus has no date of birth and no Social Security account number, those of the mother should be used.

Response and Final Rule. A footnote to this effect has been added to § 20.1203.

Comment: Reports of exceeding the 0.1-rem reference level should not be required. A number of commenters noted that the 0.1-rem "reference level" was not a limit and, therefore, exceeding it should not necessitate a report to the NRC.

Response: As a result of changes in the ICRP interpretation of the 0.1-rem level and the former 0.5-rem dose limit, the 0.1-rem level is now the recommended limit. Consequently, 0.1 rem is the primary limit applicable to members of the general public and reports are justified when it is exceeded.

Comment: Smaller licensees, such as nuclear medicine facilities, should be exempted from the reporting requirements of § 20.1203. Licensees are required to report concentrations in unrestricted areas that exceed ten times any applicable limit in the license. Because some nuclear medicine units use the room air volume for dilution, calculated concentrations exceeding ten times the Appendix B limits might frequently occur. This would require either more frequent reporting to NRC or use of more sophisticated atmospheric dispersion models.

Response: The reporting requirements are very similar to those in the previous Part 20. Part 35 of the Commission's regulations, which deals with medical applications, covers the medical use of noble gases and in § 35.205(a) limits airborne concentrations to the 10 CFR Part 20 Appendix B concentrations. Experience has not indicated large numbers of reports of such limits being exceeded.

Section 20.1204 Reports of Planned Special Exposures.

Comment: The NRC should have to pre-approve planned special exposures.

Response and Final Rule: The Commission has decided not to require pre-approval of planned special exposures. This is, in the Commission's view, consistent with the 1987 Federal Radiation Guidance for Occupational Exposures because detailed requirements are prescribed in Part 20 for the use of planned special exposures.

Comment: The licensee should not have to file a separate report to NRC for planned special exposures. Several commenters objected to having to file these separate reports each time a planned special exposure is carried out. This was viewed as representing a reporting requirement for operating within the NRC regulations. It was suggested that this information be included in the employee's records without reporting to NRC.

Response: Because of the newness of the concept, the NRC wishes to monitor carefully the use of the planned special exposures. Further, while the planned special exposures are included in the final rule, the use of this concept does represent a situation in which the licensee is operating outside the normal dose limits and of which the Commission should be aware.

Comment: Period for reporting planned special exposures. Several commenters noted that the 15-day period for reporting planned special exposures is shorter than the 30-day period usually allowed for similar reports.

Response: The reporting period of a planned special exposure has been increased from 15 days to 30 days to be more consistent with other reporting requirements.

Section 20.1206 Reports of Individual Monitoring.

Comment: Could the requirement for the reporting of individual exposures be construed as an invasion of privacy? Some commenters believed that requiring the reporting of individual doses rather than a statistical summary might constitute an invasion of personal privacy.

Response: The Commission does not believe that submission of individual dose data constitutes an invasion of privacy. Such data have been reported to the NRC routinely in the termination reports for some time. Such information will be protected in accordance with the Privacy Act and will be restricted, as it has been in the past, to use by NRC officials, NRC contractors, or qualified scientific investigators. Instructions on protecting this information appear in § 20.1106(d).

Comment: If the radiation exposure data are collected into a central repository, would the NRC be the proper place for it? One commenter felt that the radiation exposure data might be better maintained by an agency whose charter encompasses the analysis of the data for estimates of risk.

Response: Arguments might be made for other agencies having the lead role in the storage and analysis of those data; however, it is the NRC that has the statutory authority to require that these data be collected. Although the Part 20 recordkeeping requirements are intended primarily to fulfill NRC's information needs for regulation, the NRC has continuing contacts with agencies that have expertise in conducting epidemiological studies (such as the National Cancer Institute of the National Institutes of Health and the Office of Health and Safety of the Department of Energy) to ensure that the Part 20 reporting and recordkeeping requirements do not lose information that would be vital to carrying out studies of this type.

Comment: The total collective (person-rem) dose should be reported. It was felt by one commenter that NRC should require the total collective dose to be reported so that the numbers used in NUREG-0473 (NRC's annual summary of occupational radiation doses) will be the same as those calculated by the licensee.

Response: The reason for a possible discrepancy between a licensee's estimate of the collective dose to workers and the estimate published by the NRC has been that the licensee may sum the actual individual doses and the NRC estimate is based upon the statistical summary rather than the actual individual dose reports. Such differences should be reduced in the future because NRC will be also be using dose information for individuals. The final rule requires licensees who previously submitted the dose summaries to report the individual dose data to NRC. Both collective dose calculations should then be using the same data base.

Comment: The termination report required in § 20.1207 should (or should not) be replaced with an annual report for all personnel monitored. Some commenters felt that an annual report just to the NRC should replace the present requirement for a termination report. Other commenters felt that annual reports to the NRC of doses to individuals constituted a considerably larger burden than did a statistical summary. Some commenters, who disagree with filing an annual

report to the NRC, were in favor of giving such an annual dose summary to the worker. Other commenters suggested that all licensees be required to submit an annual report to NRC on each monitored individual.

Response: The reporting of individual monitoring data will help track doses to individuals who are exposed at several facilities during any given year and whose total dose would be underreported by statistical reports prepared at each work site. Such information is shown at the present time only by analysis of the termination reports.

Licensees who were previously required to file both annual statistical summaries and termination reports with the NRC will, instead, submit annual dose reports to NRC for all workers for whom monitoring was required under § 20.502. A copy of the annual report to NRC could also be given to the individual worker in order to satisfy the revised reporting requirement in § 19.13 of 10 CFR Part 19. Although this may entail some additional burden to licensees, the use of "electronic media" for recordkeeping might in fact reduce overall costs. It is intended that large employers (such as nuclear power reactor licensees) would submit an electronic copy of their dose reports in a prescribed format to the NRC in lieu of paper copies of individual records.

Section 20.1301 Applications for Exemptions.

Comment: NRC should make the issuance of exemptions a matter of public record. Several commenters felt that the issuance of any exemptions under this section should require public notice and comment. The EPA stated that exemptions could adversely affect its ability to control radionuclides under the Safe Drinking Water Act.

Response: The NRC has issued few exemptions under this longstanding provision and has not exempted anyone from the dose limits for a worker or for a member of the public. The Safe Drinking Water Act was not intended to control effluents and, although radionuclide concentrations at downstream water supplies are routinely calculated as part of licensing evaluations, the licensee must

KCMU p93 (top)

meet the Part 20 concentration limits at the effluent release point, not at the drinking water intake after dilution occurs.

Appendix A

Comment: The protection factor for air-purifying respirators with particulate elements is too low. The listed protection factor for air-purifying respirators with particulate filters is 50, whereas both ANSI Z88.2 and the OSHA regulations in 29 CFR 134 use 100.

Response: The NRC never endorsed ANSI Z88.2-1980, whereas the OSHA regulations generally follow ANSI standards. The current NRC-allowed protection factors (PFs) are based upon research conducted by the Los Alamos National Laboratory (LANL). These recommendations included a PF of 50 for full face respirators, based on experimental data on actual testing of personnel using respirators under carefully controlled conditions. In actual use, there is essentially no difference between a PF of 50 versus a PF of 100, so that there should be little or no real impact on field use of respirators or on operations at nuclear facilities that would result from using the higher protection factor.

Comment: Several respiratory equipment specifications in Appendix A should be applicable only for areas that are "immediately dangerous to life and health." Footnotes "h" and "i" contain specifications for air flow rates and flow calibration and a requirement for standby rescuers to be available when using supplied-air suits. These were felt to be unneeded considering that if the air flow failed, the person could withstand a small exposure to the airborne radionuclides while exiting the area after removing the protective hood.

Response: The supposition that conditions "immediately dangerous to life and health" do not exist is not always correct. Failure of an airline in supplied-air suits may be considered as "immediately dangerous to life and health" because there is an acute danger of suffocation if the air supply is interrupted

and the hood cannot be removed by the wearer. Rapid recovery of and assistance to the individual in the supplied-air suit necessitates the presence of a pre-equipped rescuer.

Appendix B

General comments. Most of the comments from radiation protection professionals favored the adoption of the ICRP-26/ICRP-30 annual limits on intake and the derived air concentrations. Comments from private citizens were against adoption of the ICRP values because the majority of the values would increase (as stated in Section XXIX of the proposed rule, 51 FR 1120).

Response: From an occupational protection standpoint, the changes that result from adoption of the ICRP risk-based approach lead to higher limiting intake values than in the previous Part 20. These increases result from the increase in the allowable ceiling for organ doses. The values that served as the basis for calculating the concentration limits used in the former Part 20 were organ dose limits of 5, 15, and 30 rems. The new concentration limits are based upon the effective (weighted) organ dose or upon the nonstochastic limit that forms an organ dose ceiling when the stochastic risk is not limiting. These changes increase the limiting annual organ doses (when only one organ is irradiated) for those doses that are limited by the stochastic (effective dose) limit from 5 rems to 20 rems for the gonads, from 15 rems to 32 rems per year for the breast, and from 15 rems to 42 rems for the lung. Limiting doses to other organs increase from the former 15- and 30-rem values to the 50-rem nonstochastic limit.

The former ICRP-2 "critical organ" concept based the limiting intake upon controlling the dose rate to the organ receiving the highest dose rate (the "critical organ"). The doses to organs other than the critical organ did not have to be evaluated, even if these doses were close to the estimated dose to the critical organ. The new ICRP-26/30 system evaluates the doses to the major organs and the six remaining organs that receive the next highest doses. These doses are then multiplied by the appropriate weighting factors (w_T) and are sum-

med to give a risk-weighted "effective dose." The concentration limits that are based upon this newer ICRP approach reflect the doses to all principal organs that are irradiated, not just the one organ that receives the highest dose as was done in the former Part 20.

Many of the comments from private citizens do not appear to reflect the proposed rule because many of the comments objected to raising the limits for radionuclide concentrations applicable to the general public. As noted in the discussion of Appendix B in the notice of proposed rulemaking (Section XXIX, 51 FR 1119-1120), the concentration limits for members of the public were based upon a "reference level" dose (now the dose limit for members of the general public) of 0.1 rem per year and incorporated an additional factor of 2 reduction (Proposed Appendix B; 51 FR 1145) for age-dependency and combined air and water intakes. Thus the concentration limits for the public reflect a reduction in their basis from a whole-body annual dose of 0.5 rem in the former Part 20 to 0.05 rem in the proposed and final rules.

The concentration limits for individual radionuclides may be higher or lower for members of the general public in unrestricted areas in the final Appendix B than in the former tables because of changes that occurred in the intervening 25 years in the metabolic and other parameters used to calculate internal doses. These changes are reflected in ICRP Publication 30 and its supplements and amendments. However, these changes are a result of changes in the scientific techniques and parameters used in calculating doses and do not reflect an increase in the allowable dose limits, which, in reality, have been decreased in the revised Part 20.

Comment: NRC should consider deleting Table 2 from Appendix B. The concentration limits in Appendix B do not provide adequate protection of children and infants because they do not take into account age-dependency in a proper manner. Compliance with the dose limits, rather than with these concentration limits, should be required.

Response: The use of the effective dose equivalent concept reduces the importance of age-dependent intake-to-dose factors. Age-dependency is of primary importance in calculating organ doses. Those organs for which age-dependency is important, such as the thyroid gland, are of lesser importance because of lower w_T values (for the thyroid, for example, $w_T = 0.03$) used to calculate the effective dose. A factor of 2 is included in the calculation of concentration limits for release to air and water, which, in part, accounts for age-dependency. In addition, the Commission believes that there is a lack of detailed age-dependent metabolic data for all but the most common radionuclides that will inhibit such attempts to increase the precision of the dose estimates.

Many smaller licensees routinely use concentrations and the Appendix B tables in order to demonstrate compliance. The use of concentration limits for determining compliance is a well-established practice that is economical for many of the smaller licensees. Despite the growing availability of simplified dose assessment models, the Commission is continuing to accept the use of concentrations to demonstrate compliance with the dose limits.

Comment: The Appendix B tables fail to account for the chemical toxicity of natural and low-enriched uranium. This fails to take into account the possible kidney (renal) damage associated with the chemical toxicity.

Response: There is a separate limit for uranium intake that is based upon the chemical toxicity. This limit was expressed as footnote 3 to Appendix B, page 1199 of the January 9, 1986 notice of proposed rulemaking and also as § 20.204(i) on page 1131. In the revised rule, it still appears as footnote 3 in Appendix B, but the limit also has been moved up in the text to the section on dose limits and now appears as § 20.201(e).

Comment: The limits for occupational and nonoccupational exposure to radon-222 and its particulate daughters do not appear to be consistent with the airborne concentration limits for other radionuclides in terms of risk.

Response: The occupational concentration limits for radon-222 are based on the existing Federal guidance, which is 4 WLM (4 Working-Level Months) per year. The annual limit on intake (ALI) is stated as 100 μCi or 4 working-level months. The derived air concentration (DAC) in Part 20 for occupational exposure to radon-222 of 3 x 10 s is equivalent to 0.33 working levels (this equivalence is also given in the Appendix B table). The concentration limit for members of the general public is a factor of 300 lower and, like the other airborne concentration limits, represents an effective dose of 0.05 rem per year.

Comment: Concentration limits for tritium omit chemical forms other than for tritiated water vapor.

Response: As there is expected to be no occupational intake via oral ingestion, and most of the commonly-used organic tritiated compounds are not volatile, inhalation and transpiration through the skin are the principal pathways of exposure. Different intake limits would apply to hydrogen gas (HT or T_2) and tritiated water vapor, HTO. The HT or T_2 gas is rapidly converted to HTO by isotopic exchange and oxidation (both in air and in the body) so that specifying a submersion dose limit for HT would understate the actual radiological impact. Comparison with other derived limits for other chemical forms shows that the use of the concentration limits for HTO provides an adequate level of protection for most of the other chemical forms.

Comment: No concentration limits are listed for natural thorium. There are limits for natural uranium, but corresponding concentration limits for natural thorium are not given. The isotopic composition of thorium can vary somewhat with different ores and with different times after chemical separation.

Response: A licensee should use the thorium-232 value or if a more precise value is desired, use the procedure for mixtures in Appendix B applied to the actual isotopic concentrations present. RCMH p98

Comment: The derived air concentrations for the general public are not always 0.1 times the occupational values.

Response: The limits for the general public are calculated solely from the stochastic risks. This differs from ICRP, which would use a "capping" organ dose limit of 5 rems (0.1 x the nonstochastic limit of 50 rems) in deriving the organ dose limit for organs that are limited by the nonstochastic risk. If there is a threshold for nonstochastic effects for the worker at 50 rems, it would also apply to a member of the public. Rather than applying a factor of 10 reduction to a nonstochastic value, the limiting stochastic (effective) dose was used to calculate the concentration limits for the general public. Values are not based on the nonstochastic risk for members of the public, even if they were the basis for the calculation of the DACs and ALIs for the worker. This difference in method of calculation accounts for the lack of a consistent ratio between worker DACs and effluent limits for the public.

Appendix C

symbol corrected

Comment: The reduction from 100 μCi to 0.001 μCi for thorium values will require posting of areas where thoriated-nickel machine parts are used.

Response: On the basis of specific activity considerations, the existing 100 μCi limit has been retained for long-lived radionuclides (half-lives longer than 10^8 years) such as thorium-232, which would require several grams of material to produce the stated activity level. Because this is based on half-life, two isotopes may be treated differently, e.g., uranium-235 which does not meet the half-life criterion has an Apperdix C value of 0.001 μCi, and uranium -238 which does meet the criterion has a value of 100 μCi.

Appendix D Contains the NRC Regional Office addresses and telephone numbers.

Appendix E [Reserved]

Final Rule. The calculational guidelines and equations that appeared in Appendix E are being incorporated into a regulatory guide on summation of internal and external doses. This will make it easier to revise and clarify the calculational methods without having to resort to formal rulemaking. (Note: NRC routinely issues regulatory guides for public comment before making them final.)

Appendix F

[Note: Appendix F is derived directly from requirements inserted by the Part 61 rulemaking proceeding on low-level radioactive waste disposal sites. These requirements were in § 20.311 of the existing 10 CFR Part 20. Because these requirements are relatively recent, they were not modified in the Part 20 revision. The Commission is considering revisions to the manifest requirements in a rulemaking separate from the Part 20 rulemaking.]

RCMM p 100

Appendix G

No comments on Appendix G were received.

VII. Conforming Amendments

Accompanying the revised rule are amendments to other parts of Chapter I that update citations to 10 CFR Part 20 that are found in these other regulations. Two amendments are particularly important as they go beyond updating cross-reference citations. One amendment to Appendix C of 10 CFR Part 2 updates and modifies the examples of the severity levels associated with violations of 10 CFR Part 20. Because Appendix C relates to administrative policy of the Commission and because the listed violations are used as examples of

different severity levels and are not all inclusive, the Commission does not believe that solicitation of public comment is required before these are issued in final form.

The second major change to other parts is the requirement to provide all workers with information on their radiation doses. This modification was made to conform to the 1987 Federal guidance on occupational radiation exposure. Formerly, Part 19 required licensees to furnish such a report at least annually upon the request of the worker. The change deletes the words "upon request." Public comment is not being solicited on this change as the comments were requested in the proposed rule (Section XXVII, 51 FR 1118) on the option of requiring reports to individual workers. (These comments are discussed with regard to § 20.1106.) Part 19 has been revised to require licensees to advise each worker at least annually of the worker's dose recorded pursuant to § 20.1106.

VIII. Finding of No Significant Environmental Impact: Availability

The Commission has determined under the National Environmental Policy Act of 1969, as amended and the Commission's regulations in Subpart A of 10 CFR Part 51 that this rule is not a major Federal action significantly affecting the quality of the human environment and therefore an environmental impact statement is not required. The revised 10 CFR Part 20 changes the level for protection of the general public from an implicit limit of 0.5 rems per year to an explicit limit of 0.1 rem per year. There are also numerous changes in airborne and water radionuclide concentration limits. These changes result from changes in the models and parameters used to estimate the radiation dose associated with intake of a radionuclide. Some of the concentration limits for the general public in this revision are higher or lower than present concentration limits; and some are similar to the present limits.

Despite the changes in the dose and concentration limits, the Commission believes that issuance of the final Part 20 rule will not have a major impact on the environment. The primary basis for this conclusion is that, in addition

to 10 CFR Part 20, there are other regulations that govern allowable doses to members of the public and that remain unchanged by the changes to Part 20. These other regulations include Appendix I to 10 CFR Part 50, 10 CFR Part 60, and 10 CFR Part 61, the EPA's generally applicable environmental standards in 40 CFR Part 190 and the National Emission Standards for Hazardous Air Pollutants (NESHAP) in 40 CFR Part 61 Subpart I. These standards set limits or design objectives (Appendix I) for releases of radioactive material to the general environment that are generally more restrictive than the dose limits in Part 20. Consequently, since these more restrictive standards remained essentially unchanged by the Part 20 revision, the level of public protection and the associated environmental impact are not changed appreciably from those associated with the current rule and the aforenamed regulations.

The environmental assessment and finding of no significant impact on which this determination is based are available for inspection at the NRC Public Document Room 2120, L Street NW (Lower-Level), Washington, DC 20555. Single copies of the environmental assessment and finding of no significant impact are available from Harold T. Peterson, Jr., Nuclear Regulatory Commission, NL/S-139, Washington, DC 20555, Telephone: (301) 492-3640.

IX. Paperwork Reduction Act Statement

This final rule amends information collection requirements that are subject to the Paperwork Reduction Act of 1980 (44 U.S.C. 3501, et seq.). These information collection requirements have been submitted for approval by the Office of Management and Budget (OMB). These information collection requirements will not become effective until approved by OMB. The OMB approval will be published in the Federal Register.

Public reporting burden for this collection of information is estimated to average 33 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to the Information and Records

Management Branch (MNBB 7714), U.S. Nuclear Regulatory Commission, Washington, DC 20555, and to the Desk Officer, Office of Information and Regulatory Affairs, NEOB-3019 (3150-0014, 3150-0044, 3150-0005, and 3150-0006), Office of Management and Budget, Washington, DC 20503.

X. Revised Regulatory Analysis

The Commission has issued a final regulatory analysis for this regulation. This revised analysis was based on the draft regulatory analysis as modified to account for the changes from the proposed rule resulting from public comments on both the proposed rule and the staff's revised rule in SECY-88-315 and supplemental papers. Copies of both the draft and final regulatory analysis are available for inspection and copying for a fee in the NRC Public Document Room. (See Address.)

XI. Final Regulatory Flexibility Analysis

In accordance with the Regulatory Flexibility Act of 1980, 5 U.S.C. 605(b), the Commission has prepared a regulatory flexibility analysis that indicated the revised rule will apply to all NRC licensees. The NRC has approximately 7,500 licensees, approximately one-quarter of which are classified as small entities. (Note: Agreement States, which implement comparable regulations under Section 274 of the Atomic Energy Act of 1954, as amended, have about 16,000 licensees of which a comparable number are assumed to be small entities.) The types of small entities that would be affected by this rule include physicians, small hospitals, small laboratories, industrial applications in small industries, radiographers, and well loggers.

Copies of the draft and final regulatory analysis are available for inspection and copying, for a fee, in the NRC Public Document Room. (See Address.)

XII. Backfit Analysis

A final backfit analysis has been prepared for this rule and may be examined and copied for a fee in the Commission's Public Document Room (see "Address"). For the reasons stated in this backfit analysis, the Commission believes that the reductions in allowable dose limits that are embodied in the revised Part 20 constitute substantial increases in the protection of public health and safety. Although current practice, including the philosophy of keeping radiation exposures as low as is reasonably achievable (ALARA), generally has kept radiation exposures well below the existing limits, the reductions in the allowable dose limits ensure that such doses will also remain low in the future.

In addition to the quantifiable safety benefits accruing from dose reductions and other improvements in the revised Part 20, there are several qualitative factors that support issuing the Part 20 revision. One of the main qualitative factors is that it is necessary to revise the 30-year-old existing Part 20 to ensure that the NRC regulations reflect the current state of radiation protection science. Any future revisions in dose limits recommended by ICRP or NCRP would undoubtedly be based upon the 1977 ICRP and 1987 NCRP recommendations and, therefore, would be more easily incorporated into the framework of the revised Part 20 than in the framework of the current Part 20. Other qualitative factors include: maintaining consistency with international radiation protection factors, keeping the radiation protection requirements consistent with current risk assessment methodologies, and having the NRC's standards conform to Federal radiation protection guidance.

Based on the conclusions in the final backfit analysis, the revised Part 20 provides substantial increase in public health and safety compared to current regulations, including a determination that, when the quantitative and qualitative benefits of the revision are considered, the costs of implementing the revised Part 20 are justified, the Commission finds that the requirements of the "Backfit Rule" (§ 50.109) are satisfied and that the Part 20 revision should be issued as final rule.

The Commission is adopting the final rule based on the conclusions of this analysis that the rule provides for a substantial increase in the overall protection of the public health and safety and that the direct and indirect costs of its implementation are justified in terms of the quantitative and qualitative benefits associated with the rule. The Commission would note, however, that, even had the analysis not concluded that the revised Part 20 provides a substantial increase in the overall public health and safety, it could have gone forward with the rule because the changes made to Part 20 also amount to a redefinition of the level of adequate protection and the backfit rule's cost justification standards do not apply to a redefinition of adequate protection.

XIII. Additional Views of Commissioner Curtiss

I approve the revisions to 10 CFR Part 20 and related changes to other regulations as outlined in SECY-88-315 and SECY-89-267, subject to the modifications discussed below.

Backfit: I have examined the proposed Part 20 amendments from the standpoint of whether and, if so, how the backfit rule should apply to this particular rulemaking. The nature and effects of the proposed changes to Part 20 lead me to the conclusion that the proposed amendments, in essence, would redefine what is necessary for adequate protection of the public health and safety in the radiation protection area. Thus, while I believe that we should apply the backfit rule to this Part 20 rulemaking effort, I also believe that this rulemaking constitutes a redefinition of adequate protection as described in 10 CFR § 50.109(a)(4)(iii) and that the usual backfit analysis and cost-benefit balancing are therefore not required in this instance.

On the question of whether such an approach would require this rule to be renoticed for further public comment, I have concluded that there was ample indication in the notice of proposed rulemaking that the Commission is rethinking its radiation protection standards across-the-board in this Part 20 rulemaking. Moreover, this initiative was explained in a manner that could logically be construed to encompass the approach to backfitting described above. Of partic-

ular importance, the notice of proposed rulemaking itself seems to indicate that the Commission is contemplating an action that would redefine what is necessary for adequate protection in the radiation protection area. For example, the notice states that:

SRM #1

JCAK

> [T]he Nuclear Regulatory Commission (NRC) is proposing a major revision of its regulations in 10 CFR Part 20 which provide the requirements for the protection of individuals who are exposed . . . to ionizing radiation from routine activities . . . which are licensed by the NRC. . . . The intent of the revision is to improve NRC radiation protection standards by reflecting developments in the principles that underlie radiation protection and advances in related sciences that have occurred since the promulgation of 10 CFR part 20 nearly thirty years ago. . . . The expected result of promulgating and implementing the proposed revised rule is an improved rule that provides better assurance of protection; establishes a clear health protection basis for limits and other regulatory actions taken to protect public health; applies to all licensees in a consistent manner; and reflects current information on health risk, dosimetry, and radiation protection practices and experiences.
>
> 51 Fed. Reg. 1092 (January 9, 1986).

With regard to existing Part 20 standards, the Commission noted that:

> [i]n promulgating these standards, the AEC emphasized "that the standards are subject to change with the development of new knowledge, with significant increase in the average exposure of the whole population to radiation and with further experience in the administration of the Commission's regulatory program." Consistent with this emphasis, the proposed revision reflects new knowledge, increased uses of radiation and generation of radiation sources,

SRM2#
5CAC

> and experience gained during the past twenty years. . . . [Earlier] revisions [to the existing Part 20] have not kept the regulations in accord with more recent recommendations of scientific organizations . . to improve overall protection and establish a clear health risk rationale. . . . [T]he central thrust of the revision [is] to ensure that radiation protection is adequate and defendable when judged by good protection practices and contemporary standards.

51 Fed. Reg. 1093, 1094 (citations omitted).

In discussing the benefits of the proposed rulemaking, the Commission indicated that:

> [t]he proposed revision to Part 20 includes numerous changes required to bring the radiation protections standards into accord with current defendable [sic] scientific knowledge, and to reflect contemporary scientific and philosophical approaches to protection against radiation. . . . The Commission anticipates that promulgating and implementing the proposed rule will result in a regulation that provides better assurance of protection, establishes a clear health protection basis for limits, applies to all licensees, including small entities, in a consistent manner, and reflects current information on health risk, dosimetry, and radiation protection practices and experiences.

51 Fed. Reg. 1120, 1122.

Consistent with all of these statements on the nature of the proposed changes to Part 20, a supplemental notice of proposed rulemaking that requested comments on a proposed backfit analysis indicated that:

SR:71 #1
JCAC

[T]his is the first complete revision of these regulations in over 25 years. This revision will bring the Commission's radiation protection standards into accord with current recommendations of the International Commission on Radiological Protection (ICRP).

The proposed revision to 10 CFR Part 20 [is] intended to:

a. Update the quarter-century-old 10 CFR Part 20 to incorporate advances in science and new concepts of radiation protection methodology and philosophy;

b. Implement pending Federal radiation guidance on occupational radiation protection;

c. Implement the principal current dose-limiting recommendations of the ICRP;

d. Incorporate the ICRP "effective dose equivalent" concept;

e. Update the limits on airborne radionuclide intakes, effluent releases and doses from inhaled or ingested radionuclides using up-to-date metabolic models and dose factors; and

f. Require that licensees have programs for keeping radiation exposures "as low as is reasonably achievable" (ALARA).

51 Fed. Reg. 30870, 30871 (August 29, 1986).

Overall, these various characteristics of the purpose, intent, and nature of the proposed changes to Part 20 lead to the conclusion that the Commission is, in fact, rethinking its radiation protection standards. For these reasons, I believe that the notice adequately describes the nature and substance of the proposed rule changes and that renoticing to further reflect a Commission judgment that the proposed changes constitute a redefinition of adequate protection is not necessary.

JCDC
SRM2
#1

XIV. List of Subjects

Part 20 - Byproduct material, licensed material, nuclear materials, nuclear power plants and reactors, occupational safety and health, packaging and containers, penalty, radiation protection, reporting and recordkeeping requirements, special nuclear material, source material, waste treatment and disposal.

Parts 2, 19, 20, 31, 32, 34, 35, 39, 40, 50, and 61 - Radiation protection.

Under the authority of the Atomic Energy Act of 1954, as amended, the Energy Reorganization Act of 1974, as amended, and 5 U.S.C. 552 and 553, the following amendments to 10 CFR Parts 2, 19, 20, 31, 32, 34, 35, 39, 40, 50, and 61 are published as a document subject to codification.

Regulatory language necessary

1. 10 CFR Part 20 is revised to read as follows:

PART 20 - STANDARDS FOR PROTECTION AGAINST RADIATION

SUBPART A--GENERAL PROVISIONS

Section

20.1 Purpose.
20.2 Scope.
20.3 Definitions.
20.4 Units of radiation dose.

20.5 Units of radioactivity.
20.6 Interpretations.
20.7 Communications.
20.8 Implementation.
20.9 Reporting, recording, and application requirements: OMB approval

SUBPART B--RADIATION PROTECTION PROGRAMS

20.101 Radiation protection programs.

SUBPART C--OCCUPATIONAL DOSE LIMITS

20.201 Occupational dose limits for adults.
20.202 Compliance with requirements for summation of external and internal doses.
20.203 Determination of external dose from airborne radioactive material.
20.204 Determination of internal exposure.
20.205 [Reserved]
20.206 Planned special exposures.
20.207 Occupational dose limits for minors.
20.208 Dose to an embryo/fetus.

SUBPART D--RADIATION DOSE LIMITS FOR INDIVIDUAL MEMBERS OF THE PUBLIC

20.301 Dose limits for individual members of the public.
20.302 Compliance with dose limits for individual members of the public.

SUBPART E--[RESERVED]

SUBPART F--SURVEYS AND MONITORING

20.501 General.
20.502 Conditions requiring individual monitoring of external and internal occupational dose.

SUBPART G--CONTROL OF EXPOSURE FROM EXTERNAL SOURCES IN RESTRICTED AREAS

20.601 Control of access to high radiation areas.
20.602 Control of access to very high radiation areas.
20.603 Control of access to very high radiation areas - irradiators.

SUBPART H--RESPIRATORY PROTECTION AND CONTROLS TO RESTRICT INTERNAL EXPOSURE IN RESTRICTED AREAS

20.701 Use of process or other engineering controls.
20.702 Use of other controls.
20.703 Use of individual respiratory protection equipment.
20.704 Further restrictions on the use of respiratory protection equipment.

SUBPART I--STORAGE AND CONTROL OF LICENSED MATERIAL

20.801 Security of stored material.
20.802 Control of material not in storage.

SUBPART J--PRECAUTIONARY PROCEDURES

20.901 Caution signs.
20.902 Posting requirements.

20.903 Exceptions to posting requirements.
20.904 Labeling containers.
20.905 Exemptions to labeling requirements.
20.906 Procedures for receiving and opening packages.

SUBPART K--WASTE DISPOSAL

20.1001 General requirements.
20.1002 Method for obtaining approval of proposed disposal procedures.
20.1003 Disposal by release into sanitary sewerage.
20.1004 Treatment or disposal by incineration.
20.1005 Disposal of specific wastes.
20.1006 Transfer for disposal and manifests.
20.1007 Compliance with environmental and health protection regulations.

SUBPART L--RECORDS

20.1101 General provisions.
20.1102 Records of radiation protection programs.
20.1103 Records of surveys.
20.1104 Determination of prior occupational dose.
20.1105 Records of planned special exposures.
20.1106 Records of individual monitoring results.
20.1107 Records of dose to individual members of the public.
20.1108 Records of waste disposal.
20.1109 Records of testing entry control devices for very high radiation areas.
20.1110 Form of records.

SUBPART M--REPORTS

20.1201 Reports of theft or loss of licensed material.
20.1202 Notification of incidents.

20.1203 Reports of exposures, radiation levels, and concentrations of radioactive material exceeding the limits.
20.1204 Reports of planned special exposures.
20.1205 [Reserved]
20.1206 Reports of individual monitoring.

SUBPART N--EXEMPTIONS AND ADDITIONAL REQUIREMENTS

20.1301 Applications for exemptions.
20.1302 Additional requirements.

SUBPART O--ENFORCEMENT

20.1401 Violations.

APPENDICES

Appendix A Protection factors for respirators.

Appendix B Annual limits on intake (ALIs) and derived air concentrations (DACs) of radionuclides for occupational exposure; effluent concentrations; concentrations for release to sewerage.

Appendix C Quantities of licensed material requiring labeling.

Appendix D United States Nuclear Regulatory Commission Regional Offices.

Appendix E [Reserved]

Appendix F Requirements for low-level waste transfer for disposal at land disposal facilities and manifests.

AUTHORITY: Secs. 53, 63, 65, 81, 103, 104, 161, 182, 186, 68 Stat. 930, 933, 935, 936, 937, 948, 953, 955, as amended (42 U.S.C. 2073, 2093, 2095, 2111, 2133, 2134, 2201, 2232, 2236): secs. 201, as amended, 202, 206, 88 Stat. 1242, as amended, 1244, 1246 (42 U.S.C. 5841, 5842, 5846). For the purposes of sec. 223, 68 Stat. 958, as amended (42 U.S.C. 2273), §§ 20.102, 20.201 - 20.204, 20.206, 20.207, 20.208, 20.301, 20.302, 20.501, 20.502, 20.601(a) and (d), 20.602, 20.603, 20.701, 20.704, 20.801, 20.802, 20.901(a), 20.902, 20.904, 20.906, 20.1001, 20.1002, 20.1003, 20.1004, 20.1005(b) - (d), 20.1006, 20.1101 - 20.1110, 20.1201 - 20.1206, and 20.1301 are issued under sec. 161b., 68 Stat. 948 (42 U.S.C. 2201(b)) and § 20.1106(d) is issued under the Privacy Act of 1974, Pub.L. 93-579, 5 U.S.C. 552a: and §§ 20.102(a)(2) and (4), 20.204(c), 20.206(g) and (h), 20.904(c)(4), 20.905(c) and (d), 20.1005(c), 20.1006(b) - (d), 20.1101 - 20.1103, 20.1104(b) - (d), 20.1105 - 20.1108, and 20.1201 - 20.1207 are issued under sec. 161o, 68 Stat. 950, as amended (42 U.S.C. 2201(o)).

SUBPART A--GENERAL PROVISIONS

§ 20.1 Purpose.

(a) The regulations in this part establish standards for protection against ionizing radiation resulting from activities conducted under licenses issued by the Nuclear Regulatory Commission. These regulations are issued under the Atomic Energy Act of 1954, as amended, and the Energy Reorganization Act of 1974, as amended.

(b) It is the purpose of the regulations in this part to control the receipt, possession, use, transfer, and disposal of licensed material by any licensee in such a manner that the total dose to an individual (including doses resulting from licensed and unlicensed radioactive material and from radiation sources other than background radiation) does not exceed the standards for protection against radiation prescribed in the regulations in this part. However, nothing in this part shall be construed as limiting actions that may be necessary to protect health and safety.

§ 20.2 Scope.

The regulations in this part apply to persons licensed by the Commission to receive, possess, use, transfer, or dispose of byproduct, source, or special nuclear material or to operate a production or utilization facility under Parts 30 through 35, 39, 40, 50, 60, 61, 70, or 72 of this chapter. The limits in this part do not apply to doses due to background radiation, to exposure of patients to radiation for the purpose of medical diagnosis or therapy, or to voluntary participation in medical research programs.

§ 20.3 Definitions.

As used in this part:

"Absorbed dose" means the energy imparted by ionizing radiation per unit mass of irradiated material. The units of absorbed dose are the rad and the gray (Gy).

"Act" means the Atomic Energy Act of 1954 (42 U.S.C. 2011 et seq.), as amended.

"Activity" is the rate of disintegration (transformation) or decay of radioactive material. The units of activity are the curie (Ci) and the becquerel (Bq).

"Adult" means an individual 18 or more years of age.

"Airborne radioactive material" means radioactive material dispersed in the air in the form of dusts, fumes, particulates, mists, vapors, or gases.

"Airborne radioactivity area" means a room, enclosure, or area in which airborne radioactive materials, composed wholly or partly of licensed material, exist in concentrations--

(1) In excess of the derived air concentrations (DACs) specified in Appendix B, or

(2) To such a degree that an individual present in the area without respiratory protective equipment could exceed, during the hours an individual is present in a week, an intake of 0.6 percent of the annual limit on intake (ALI) or 12 DAC-hours.

"Annual limit on intake" (ALI) means the derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year by the reference man that would result in a committed effective dose equivalent of 5 rems (0.05 Sv) or a committed dose equivalent of 50 rems (0.5 Sv) to any individual organ or tissue. (ALI values for intake by ingestion and by inhalation of selected radionuclides are given in Table 1, Columns 1 and 2, of Appendix B.)

"ALARA" (acronym for "as low as is reasonably achievable") means making every reasonable effort to maintain exposures to radiation as far below the dose limits in this part as is practical consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest.

"Background radiation" means radiation from cosmic sources; naturally occurring radioactive materials, including radon in concentrations or levels commonly found in structures or the environment; and global fallout as it commonly exists in the environment from the testing of nuclear explosive devices. "Background radiation" does not include radiation from source, byproduct, or special nuclear materials regulated by the Commission.

SRM #6

"Bioassay" (radiobioassay) means the determination of kinds, quantities or concentrations, and, in some cases, the locations of radioactive material in the human body, whether by direct measurement (in vivo counting) or by analysis and evaluation of materials excreted or removed from the human body.

"Byproduct material" means -

(1) Any radioactive material (except special nuclear material) yielded in, or made radioactive by, exposure to the radiation incident to the process of producing or utilizing special nuclear material; and

(2) The tailings or wastes produced by the extraction or concentration of uranium or thorium from ore processed primarily for its source material content, including discrete surface wastes resulting from uranium solution extraction processes. Underground ore bodies depleted by these solution extraction operations do not constitute "byproduct material" within this definition.

"Class" (or "lung class" or "inhalation class") means a classification scheme for inhaled material according to its rate of clearance from the pulmonary region of the lung. Materials are classified as D, W, or Y, which applies to a range of clearance half-times: for Class D (Days) of less than 10 days, for Class W (Weeks) from 10 to 100 days, and for Class Y (Years) of greater than 100 days.

"Collective dose" is the sum of the individual doses received in a given period of time by a specified population from exposure to a specified source of radiation.

"Commission" means the Nuclear Regulatory Commission or its duly authorized representatives.

267
p6

"Committed dose equivalent" ($H_{T,50}$) means the dose equivalent to organs or tissues of reference (T) that w be received from an intake of radioactive material by an individual during the 50-year period following the intake.

"Committed effective dose equivalent" ($H_{E,50}$) is the sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to these organs or tissues

$(H_{E,50} = \sum_{T} w_T H_{T,50})$.

"Controlled area" means an area, outside of a restricted area but inside the site boundary, access to which can be limited by the licensee for any reason.

"Declared pregnant woman" means a woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception.

"Deep-dose equivalent" (H_d which applies to external whole-body exposure, is the dose equivalent at a tissue depth of 1 cm (1000 mg/cm^2).

"Department" means the Department of Energy established by the Department of Energy Organization Act (Pub. L. 95-91, 91 Stat. 565, 42 U.S.C. 7101 et seq.) to the extent that the Department, or its duly authorized representatives, exercises functions formerly vested in the U.S. Atomic Energy Commission, its Chairman, members, officers, and components and transferred to the U.S. Energy Research and Development Administration and to the Administrator thereof pursuant to sections 104 (b), (c), and (d) of the Energy Reorganization Act of 1974 (Pub. L. 93-438, 88 Stat. 1233 at 1237, 42 U.S.C. 5814) and retransferred to the Secretary of Energy pursuant to section 301(a) of the Department of Energy Organization Act (Pub. L. 95-91, 91 Stat. 565 at 577-578, 42 U.S.C. 7151).

"Derived air concentration" (DAC) means the concentration of a given radionuclide in air which, if breathed by the reference man for a working year of 2,000 hours under conditions of light work (inhalation rate 1.2 cubic meters of air per hour), results in an intake of one ALI. DAC values are given in Table 1, Column 3, of Appendix B.

"Derived air concentration-hour" (DAC-hour) is the product of the concentration of radioactive material in air (expressed as a fraction or multiple of the derived air concentration for each radionuclide) and the time of exposure to that radionuclide, in hours. A licensee may take 2,000 DAC-hours to represent one ALI, equivalent to a committed effective dose equivalent of 5 rems (0.05 Sv).

"Dose" or "radiation dose" is a generic term that means absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, committed effective dose equivalent, or total effective dose equivalent, as defined in other paragraphs of this section.

"Dose equivalent" (H_T) means the product of the absorbed dose in tissue, quality factor, and all other necessary modifying factors at the location of interest. The units of dose equivalent are the rem and sievert (Sv).

"Dosimetry processor" means an individual or an organization that processes and evaluates individual monitoring equipment in order to determine the radiation dose delivered to the equipment.

"Effective dose equivalent" (H_E) is the sum of the products of the dose equivalent to the organ or tissue (H_T) and the weighting factors (w_T) applicable to each of the body organs or tissues that are irradiated ($H_E = \sum_T w_T H_T$).

"Embryo/fetus" means the developing human organism from conception until the time of birth.

"Entrance or access point" means any location through which an individual could gain access to radiation areas or to radioactive materials. This includes entry or exit portals of sufficient size to permit human entry, irrespective of their intended use.

"Exposure" means being exposed to ionizing radiation or to radioactive material.

"External dose" means that portion of the dose equivalent received from radiation sources outside the body.

"Extremities" means hand, elbow, arm below the elbow, foot, knee, and leg below the knee.

"Eye dose equivalent" applies to the external exposure of the lens of the eye and is taken as the dose equivalent at a tissue depth of 0.3 centimeter (300 mg/cm2).

"Generally applicable environmental radiation standards" means standards issued by the Environmental Protection Agency (EPA) under the authority of the Atomic Energy Act of 1954, as amended, that impose limits on radiation exposures or levels, or concentrations or quantities of radioactive material, in the general environment outside the boundaries of locations under the control of persons possessing or using radioactive material. [267 p 6]

"Government agency" means any executive department, commission, independent establishment, corporation wholly or partly owned by the United States of America, which is an instrumentality of the United States, or any board, bureau, division, service, office, officer, authority, administration, or other establishment in the executive branch of the Government.

"Gray" [See § 20.4]

"High radiation area" means an area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.1 rem (1 mSv) in § hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

"Individual" means any human being.

"Individual monitoring" means:

(1) The assessment of dose equivalent by the use of devices designed to be worn by an individual;

(2) The assessment of committed effective dose equivalent by bioassay (see Bioassay) or by determination of the time-weighted air concentrations to which an individual has been exposed, i.e., DAC-hours; or

(3) The assessment of dose equivalent by the use of survey data.

"Individual Monitoring Devices" ("individual monitoring equipment") means devices designed to be worn by a single individual for the assessment of dose equivalent such as film badges, thermoluminescent dosimeters (TLDs), pocket ionization chambers, and personal ("lapel") air sampling devices.

"Internal dose" means that portion of the dose equivalent received from radioactive material taken into the body.

"License" means a license issued under the regulations in Parts 30 through 35, 39, 40, 50, 60, 61, 70, or 72 of this chapter.

"Licensee" means the holder of a license.

"Licensed material" means source material, special nuclear material, or byproduct material received, possessed, used, transferred or disposed of under a general or specific license issued by the Commission.

"Limits" (dose limits) means the permissible upper bounds of radiation doses.

"Lost or missing licensed material" means licensed material whose location is unknown. It includes material that has been shipped but has not reached its destination and whose location cannot be readily traced in the transportation system.

"Member of the public" means an individual in a controlled or unrestricted area. However, an individual is not a member of the public during any period in which the individual receives an occupational dose.

"Minor" means an individual less than 18 years of age.

"Monitoring" (radiation monitoring, radiation protection monitoring) means the measurement of radiation levels, concentrations, surface area concentrations or quantities of radioactive material and the use of the results of these measurements to evaluate potential exposures and doses.

"Nonstochastic effect" means health effects, the severity of which varies with the dose and for which a threshold is believed to exist. Radiation-induced cataract formation is an example of a nonstochastic effect.

"NRC" means the Nuclear Regulatory Commission or its duly authorized representatives.

"Occupational dose" means the dose received by an individual in a restricted area or in the course of employment in which the individual's assigned duties involve exposure to radiation and to radioactive material from licensed and unlicensed sources of radiation, whether in the possession of the licensee or other person. Occupational dose does not include dose received from background radiation, as a patient from medical practices, from voluntary participation in medical research programs, or as a member of the general public.

"Person" means:

(1) Any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, Government agency other than the Commission or the Department of Energy (except that the Department shall be considered a person within the meaning of the regulations in 10 CFR Chapter I to the extent that its facilities and activities are subject to the licensing and related regulatory authority of the Commission under Section 202 of the Energy Reorganization Act of 1974 (88 Stat. 1244), the Uranium Mill Tailings Radiation Control Act of 1978 (92 Stat. 3021), the Nuclear Waste Policy Act of 1982 (96 Stat. 2201), and Section 3(b)(2) of the Low-Level Radioactive Waste Policy Amendments Act of 1985 (99 Stat. 1842)), any State or any political subdivision of or any political entity within a State, any foreign government or nation or any political subdivision of any such government or nation, or other entity; and

(2) Any legal successor, representative, agent, or agency of the foregoing.

"Planned special exposure" means an infrequent exposure to radiation, separate from and in addition to the annual dose limits.

"Public dose" means the dose received by a member of the public from exposure to radiation and to radioactive material released by a licensee, or to another source of radiation either within a licensee's controlled area or in unrestricted areas. It does not include occupational dose or doses received from background radiation, as a patient from medical practices, or from voluntary participation in medical research programs.

"Quality Factor" (Q) means the modifying factor (listed in Tables 1 and 2 of § 20.4) that is used to derive dose equivalent from absorbed dose.

"Quarter" means a period of time equal to one-fourth of the year observed by the licensee (approximately 13 consecutive weeks), providing that the beginning of the first quarter in a year coincides with the starting date of the year and that no day is omitted or duplicated in consecutive quarters.

"Rad" [See § 20.4].

"Radiation" (ionizing radiation) means alpha particles, beta particles, gamma rays, x-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions. Radiation, as used in this part, does not include non-ionizing radiation, such as radio- or microwaves, or visible, infrared, or ultraviolet light.

"Radiation area" means an area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.005 rem (0.05 mSv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

"Reference man" means a hypothetical aggregation of human physical and physiological characteristics arrived at by international consensus. These characteristics may be used by researchers and public health workers to standardize results of experiments and to relate biological insult to a common base.

"Rem" [See § 20.4].

"Respiratory protective device" means an apparatus, such as a respirator, used to reduce the individual's intake of airborne radioactive materials.

"Restricted area" means an area, access to which is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials. Restricted area does not include areas used as residential quarters, but separate rooms in a residential building may be set apart as a restricted area.

"Sanitary sewerage" means a system of public sewers for carrying off waste water and refuse, but excluding sewage treatment facilities, septic tanks, and leach fields owned or operated by the licensee.

"Shallow-dose equivalent" (H_s), which applies to the external exposure of the skin or an extremity, is taken as the dose equivalent at a tissue depth of 0.007 centimeter (7 mg/cm^2) averaged over an area of 1 square centimeter.

"Sievert" [See § 20.4].

"Site boundary" means that line beyond which the land or property is not owned, leased, or otherwise controlled by the licensee.

"Source material" means-

(1) Uranium or thorium or any combination of uranium and thorium in any physical or chemical form; or

(2) Ores that contain, by weight, one-twentieth of 1 percent (0.05 percent), or more, of uranium, thorium, or any combination of uranium and thorium. Source material does not include special nuclear material.

"Special nuclear material" means-

(1) Plutonium, uranium-233, uranium enriched in the isotope 233 or in the isotope 235, and any other material that the Commission, pursuant to the provisions of section 51 of the Act, determines to be special nuclear material, but does not include source material; or

(2) Any material artificially enriched by any of the foregoing but does not include source material.

"Stochastic effects" means health effects that occur randomly and for which the probability of the effect occurring, rather than its severity, is assumed to be a linear function of dose without threshold. Hereditary effects and cancer incidence are examples of stochastic effects.

"Survey" means an evaluation of the radiological conditions and potential hazards incident to the production, use, transfer, release, disposal, or presence of radioactive material or other sources of radiation. When appropriate,

such an evaluation includes a physical survey of the location of radioactive material and measurements or calculations of levels of radiation, or concentrations or quantities of radioactive material present.

"Total Effective Dose Equivalent" (TEDE) means the sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

"Unrestricted area" means an area, access to which is neither limited nor controlled by the licensee.

"Uranium fuel cycle" means the operations of milling of uranium ore, chemical conversion of uranium, isotopic enrichment of uranium, fabrication of uranium fuel, generation of electricity by a light-water-cooled nuclear power plant using uranium fuel, and reprocessing of spent uranium fuel, to the extent that these activities directly support the production of electrical power for public use. Uranium fuel cycle does not include mining operations, operations at waste disposal sites, transportation of radioactive material in support of these operations, and the reuse of recovered non-uranium special nuclear and byproduct materials from the cycle.

"Very high radiation area" means an area, accessible to individuals, in which radiation levels could result in an individual receiving an absorbed dose in excess of 500 rads (5 grays) in 1 hour at 1 meter from a radiation source or from any surface which the radiation penetrates. [Note: At very high doses received at high dose rates, units of absorbed dose (e.g., rads and grays) are appropriate, rather than units of dose equivalent (e.g., rems and sieverts).]

"Week" means 7 consecutive days starting on Sunday.

"Weighting factor", w_T, for an organ or tissue (T) is the proportion of the risk of stochastic effects resulting from irradiation of that organ or tissue to the total risk of stochastic effects when the whole body is irradiated uniformly. For calculating the effective dose equivalent, the values of w_T are:

ED

ORGAN DOSE WEIGHTING FACTORS

Organ or Tissue	w_T
Gonads	0.25
Breast	0.15
Red bone marrow	0.12
Lung	0.12
Thyroid	0.03
Bone surfaces	0.03
Remainder	0.30[a]
Whole Body	1.00[b]

[a] 0.30 results from 0.06 for each of 5 "reminder" organs (excluding the skin and the lens of the eye) that receive the highest doses.

[b] For the purpose of weighting the external whole body dose (for adding it to the internal dose), a single weighting factor, $w_T = 1.0$, has been specified. The use of other weighting factors for external exposure will be approved on a case-by-case basis until such time as specific guidance is issued.

"Whole body" means, for purposes of external exposure, head, trunk (including male gonads), arms above the elbow, or legs above the knee.

"Working level" (WL) is any combination of short-lived radon daughters (for radon-222: polonium-218, lead-214, bismuth-214, and polonium-214; and for radon-220: polonium-216, lead-212, bismuth-212, and polonium-212) in 1 liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha particle energy.

"Working level month" (WLM) means an exposure to 1 working level for 170 hours (2,000 working hours per year/12 months per year = approximately 170 hours per month).

"Year" means the period of time beginning in January used to determine compliance with the provisions of this part. The licensee may change the starting date of the year used to determine compliance by the licensee provided that the change is made at the beginning of the year and that no day is omitted or duplicated in consecutive years.

§ 20.4 Units of radiation dose.

(a) As used in this part, the units of radiation dose are:

"Gray" (Gy) is the SI unit of absorbed dose. One gray is equal to an absorbed dose of 1 Joule/kilogram (100 rads).

"Rad" is the special unit of absorbed dose. One rad is equal to an absorbed dose of 100 ergs/gram or 0.01 joule/kilogram (0.01 gray).

"Rem" is the special unit of any of the quantities expressed as dose equivalent. The dose equivalent in rems is equal to the absorbed dose in rads multiplied by the quality factor (1 rem = 0.01 sievert). 267 p6

"Sievert" is the SI unit of any of the quantities expressed as dose equivalent. The dose equivalent in sieverts is equal to the absorbed dose in grays multiplied by the quality factor (1 Sv = 100 rems). 267 p6

(b) As used in this part, the quality factors for converting absorbed dose to dose equivalent are shown in Table 1.

TABLE 1
QUALITY FACTORS AND ABSORBED DOSE EQUIVALENCIES

TYPE OF RADIATION	Quality Factor (Q)	Absorbed Dose Equal to a Unit Dose Equivalent[a]
X-, gamma, or beta radiation	1	1
Alpha particles, multiple-charged particles, fission fragments and heavy particles of unknown charge	20	0.05
Neutrons of unknown energy	10	0.1
High-energy protons	10	0.1

[a]Absorbed dose in rad equal to 1 rem or the absorbed dose in gray equal to 1 sievert.

(C) If it is more convenient to measure the neutron fluence rate than to determine the neutron dose equivalent rate in rems per hour or sieverts per hour, as provided in paragraph (b) of this section, 1 rem (0.01 Sv) of neutron radiation of unknown energies may, for purposes of the regulations in this part, be assumed to result from a total fluence of 25 million neutrons per square centimeter incident upon the body. If sufficient information exists to estimate the approximate energy distribution of the neutrons, the licensee may use the fluence rate per unit dose equivalent or the appropriate Q value from Table 2 to convert a measured tissue dose in rads to dose equivalent in rems.

TABLE 2

MEAN QUALITY FACTORS, Q, AND FLUENCE PER UNIT DOSE EQUIVALENT FOR MONOENERGETIC NEUTRONS

	Neutron Energy (MeV)	Quality Factor[a] (Q)	Fluence per Unit Dose Equivalent[b] (neutrons cm^{-2} rem^{-1})
(thermal)	2.5×10^{-8}	2	980×10^6
	1×10^{-7}	2	980×10^6
	1×10^{-6}	2	810×10^6
	1×10^{-5}	2	810×10^6
	1×10^{-4}	2	840×10^6
	1×10^{-3}	2	980×10^6
	1×10^{-2}	2.5	1010×10^6
	1×10^{-1}	7.5	170×10^6
	5×10^{-1}	11	39×10^6
	1	11	27×10^6
	2.5	9	29×10^6
	5	8	23×10^6
	7	7	24×10^6
	10	6.5	24×10^6
	14	7.5	17×10^6
	20	8	16×10^6
	40	7	14×10^6
	60	5.5	16×10^6
	1×10^2	4	20×10^6
	2×10^2	3.5	19×10^6
	3×10^2	3.5	16×10^6
	4×10^2	3.5	14×10^6

[a]Value of quality factor (Q) at the point where the dose equivalent is maximum in a 30-cm diameter cylinder tissue-equivalent phantom.

[b]Monoenergetic neutrons incident normally on a 30-cm diameter cylinder tissue-equivalent phantom.

§ 20.5 Units of radioactivity.

For the purposes of this part, activity is expressed in the special unit of curies (Ci) or in the SI unit of becquerels (Bq), or their multiples, or disintegrations (transformations) per unit of time.

(a) One becquerel = 1 disintegration per second (s^{-1}).

(b) One curie = 3.7×10^{10} disintegrations per second = 3.7×10^{10} becquerels = 2.22×10^{12} disintegrations per minute.

§ 20.6 Interpretations.

Except as specifically authorized by the Commission in writing, no interpretation of the meaning of the regulations in this part by an officer or employee of the Commission other than a written interpretation by the General Counsel will be recognized to be binding upon the Commission.

§ 20.7 Communications.

Unless otherwise specified, communications or reports concerning the regulations in this part should be addressed to the Executive Director for Operations, U.S. Nuclear Regulatory Commission, Washington, DC 20555. A communication, report, or application may be delivered in person to the Commission's offices at 2120 L Street, NW. (Lower Level), Washington, DC 20037, or 11555 Rockville Pike, Rockville, MD 20852.

§ 20.8 Implementation.

(a) Licensees shall implement the provisions of this part on or before January 1, 1993. If a licensee chooses to implement the provisions of this part prior to January 1, 1993, the licensee shall implement all provisions of this part not otherwise exempted by paragraph (d) of this section, and shall provide written notification to either the Director of the Office of Nuclear Materials Safety and Safeguards or the Director of the Office of Nuclear Reactor Regulation, as appropriate, that the licensee is adopting early implementation of this part. Until January 1, 1993, or until the licensee notifies the Commission of early implementation of the provisions of this part, compliance will be required with the version of 10 CFR Part 20 codified in the Code of Federal Regulations on January 1, 1991.

SRM: #9 SRM.

(b) After the time the licensee implements this part, the applicable section of this part shall be used in lieu of any section of this part in effect on or before January 1, 1991 that is cited in license conditions or technical specifications, except as specified in paragraphs (c), (d) and (e) of this section. If the requirements of this part are more restrictive than the existing license condition, then the licensee shall comply with this part unless exempted by paragraph (d) of this section.

GR1 1 #1 SRM

(c) Any existing license condition or technical specification that is more restrictive than this part remains in force until there is a technical specification change, license amendment, or license renewal.

(d) If a license condition or technical specification exempts a licensee from a provision of the version of Part 20 in effect on or before January 1, 1991, it also exempts the licensee from the corresponding provision of this part.

(e) If no section in this part corresponds to the provisions of Part 20 in effect prior to January 1, 1991 cited in a license condition, a license condition based on the version of Part 20 in effect on or before January 1, 1991 remains in force until either there is a technical specification change, license amendment, or license renewal that modifies or removes this condition.

§ 20.9 Reporting, recording, and application requirements: OMB approval.

(a) The Nuclear Regulatory Commission will submit the information collection requirements contained in this part to the Office of Management and Budget for approval as required by the Paperwork Reduction Act of 1980 (44 U.S.C. 3501 et seq.). OMB clearance will be obtained prior to January 1, 1993.

(b) The approved information collection requirements contained in this part appear in §§ 20.101, 20.202, 20.204, 20.206, 20.301, 20.501, 20.601, 20.603, 20.703, 20.901, 20.902, 20.904, 20.906, 20.1002, 20.1004, 20.1006, 20.1102, 20.1103, 20.1104, 20.1105, 20.1106, 20.1107, 20.1108, 20.1109, 20.1110, 20.1201, 20.1202, 20.1203, 20.1204, 20.1206, and Appendix F.

SUBPART B--RADIATION PROTECTION PROGRAMS

§ 20.101 Radiation protection programs.

(a) Each licensee shall develop, document, and implement a radiation protection program commensurate with the scope and extent of licensed activities

and sufficient to ensure compliance with the provisions of this part. (See § 20.1102 for recordkeeping requirements relating to these programs.)

(b) The licensee shall use, to the extent practicable, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses and doses to members of the public that are as low as is reasonably achievable (ALARA).

(c) The licensee shall periodically (at least annually) review the radiation protection program content and implementation.

SUBPART C--OCCUPATIONAL DOSE LIMITS

§ 20.201 Occupational dose limits for adults.

(a) The licensee shall control the occupational dose to individual adults, except for planned special exposures under § 20.206, to the following dose limits.

(1) An annual limit, which is the more limiting of--

(i) The total effective dose equivalent being equal to 5 rems (0.05 Sv); or

(ii) The sum of the deep-dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 50 rems (0.5 Sv).

(2) The annual limits to the lens of the eye, to the skin, and to the extremities which are:

(i) An eye dose equivalent of 15 rems (0.15 Sv), and

(ii) A shallow-dose equivalent of 50 rems (0.50 Sv) to the skin or to each of the extremities.

(b) Doses received in excess of the annual limits, including doses received during accidents, emergencies, and planned special exposures, must be subtracted from the limits for planned special exposures that the individual may receive during the current year (see § 20.206(e)(1)) and during the individual's lifetime (see § 20.206(e)(2)).

(c) The assigned deep-dose equivalent and shallow-dose equivalent must be for the part of the body receiving the highest exposure. The deep-dose equivalent, eye dose equivalent and shallow-dose equivalent may be assessed from surveys or other radiation measurements for the purpose of demonstrating compliance with the occupational dose limits, if the individual monitoring device was not in the region of highest potential exposure, or the results of individual monitoring are unavailable.

(d) Derived air concentration (DAC) and annual limit on intake (ALI) values are presented in Table 1 of Appendix B and may be used to determine the individual's dose (see § 20.1106) and to demonstrate compliance with the occupational dose limits.

(e) In addition to the annual dose limits, the licensee shall limit the soluble uranium intake by an individual to 10 milligrams in a week in consideration of chemical toxicity (see footnote 3 of Appendix B).

(f) The licensee shall reduce the dose that an individual may be allowed to receive in the current year by the amount of occupational dose received while employed by any other person (see § 20.1104(e)).

§ 20.202 Compliance with requirements for summation of external and internal doses.

(a) If the licensee is required to monitor under both §§ 20.502(a) and (b), the licensee shall demonstrate compliance with the dose limits by summing external and internal doses. If the licensee is required to monitor only under § 20.502(a) or only under § 20.502(b), then summation is not required to demonstrate compliance with the dose limits. The licensee may demonstrate compliance with the requirements for summation of external and internal doses by meeting one of the conditions specified in paragraph (b) of the section, and the conditions in paragraphs (c) and (d) of this section.

(NOTE: The dose equivalents for the lens of the eye, the skin, and the extremities are not included in the summation, but are subject to separate limits.)

(b) Intake by inhalation. If the only intake of radionuclides is by inhalation, the total effective dose equivalent limit is not exceeded if the sum of the deep-dose equivalent divided by the total effective dose equivalent limit, and one of the following, does not exceed unity:

(1) The sum of the fractions of the inhalation ALI for each radionuclide, or

(2) The total number of derived air concentration-hours (DAC-hours) for all radionuclides divided by 2,000, or

(3) The sum of the calculated committed effective dose equivalents to all significantly irradiated[1] organs or tissues (T) calculated from bioassay data using appropriate biological models and expressed as a fraction of the annual limit.

(c) Intake by oral ingestion. If the occupationally exposed individual also receives an intake of radionuclides by oral ingestion greater than 10 percent of the applicable oral ALI, the licensee shall account for this intake and include it in demonstrating compliance with the limits.

(d) Intake through wounds or absorption through skin. The licensee shall evaluate and, to the extent practical, account for intakes through wounds or skin absorption. (NOTE: The intake through intact skin has been included in the calculation of DAC for hydrogen-3 and does not need to be further evaluated.)

§ 20.203 Determination of external dose from airborne radioactive material.

Licensees shall, when determining the dose from airborne radioactive material, include the contribution to the deep-dose equivalent, eye dose equivalent, and shallow-dose equivalent from external exposure to the radioactive cloud (see Appendix B, footnotes 1 and 2).

---

1 An organ or tissue is deemed to be significantly irradiated if, for that organ or tissue, the product of the weighting factors, w_T, and the committed dose equivalent, H_{50}, per unit intake is greater than 10 percent of the maximum weighted value of H_{50} (i.e., $w_T H_{50,T}$) per unit intake for any organ or tissue.

Note. Airborne radioactivity measurements and DAC values should not be used as the primary means to assess the deep-dose equivalent when the airborne radioactive material includes radionuclides other than noble gases or if the cloud of airborne radioactive material is not relatively uniform. The determination of the deep-dose equivalent to an individual should be based upon measurements using instruments or individual monitoring devices.

§ 20.204 Determination of internal exposure .

(a) For purposes of assessing dose used to determine compliance with occupational dose equivalent limits, the licensee shall, when required under § 20.502, take suitable and timely measurements of--

(1) Concentrations of radioactive materials in air in work areas; or

(2) Quantities of radionuclides in the body; or

(3) Quantities of radionuclides excreted from the body; or

(4) Combinations of these measurements.

(b) Unless respiratory protective equipment is used, as provided in § 20.703, or the assessment of intake is based in bioassays, the licensee shall assume that an individual inhales radioactive material at the airborne concentration in which the individual is present.

(c) When specific information on the physical and biochemical properties of the radionuclides taken into the body or the behavior or the material in an individual is known, the licensee may--

(1) Use that information to calculate the committed effective dose equivalent, and, if used, the licensee shall document that information in the individual's record; and

(2) Upon prior approval of the Commission, adjust the DAC or ALI values to reflect the actual physical and chemical characteristics of airborne radioactive material (e.g., aerosol size distribution or density); and

(3) Separately assess the contribution of fractional intakes of Class D, W, or Y compounds of given radionuclide (see Appendix B) to the committed effective dose equivalent.

(d) If the licensee chooses to assess intakes of Class Y material using the measurements given in § 20.204(a)(2) or (3), the licensee may delay the recording and reporting of the assessments for periods up to 7 months, unless otherwise required by §§ 20.1202 or 20.1203, in order to permit the licensee to make additional measurements basic to the assessments.

(e) If the identity and concentration of each radionuclide in a mixture are known, the fraction of the DAC applicable to the mixture for use in calculating DAC-hours must be either--

(1) The sum of the ratios of the concentration to the appropriate DAC value (e.g., D, W, Y) from Appendix B for each radionuclide in the mixture; or

(2) The ratio of the total concentration for all radionuclides in the mixture to the most restrictive DAC value for any radionuclide in the mixture. 267

(f) If the identity of each radionuclide in a mixture is known, but the concentration of one or more of the radionuclides in the mixture is not known, the DAC for the mixture must be the most restrictive DAC of any radionuclide in the mixture. 7

(g) When a mixture of radionuclides in air exists, licensees may disregard certain radionuclides in the mixture if--

(1) The licensee uses the total activity of the mixture in demonstrating compliance with the dose limits in § 20.201 and in complying with the monitoring requirements in § 20.502(b), and

(2) The concentration of any radionuclide disregarded is less than 10 percent of its DAC, and

(3) The sum of these percentages for all of the radionuclides disregarded in the mixture does not exceed 30 percent.

(h)(1) In order to calculate the committed effective dose equivalent, the licensee may assume that the inhalation of one ALI, or an exposure of 2,000 DAC-hours, results in a committed effective dose equivalent of 5 rems (0.05 Sv) for radionuclides that have their ALIs or DACs based on the committed effective dose equivalent.

(2) When the ALI (and the associated DAC) is determined by the nonstochastic organ dose limit of 50 rems (0.5 Sv), the intake of radionuclides that would result in a committed effective dose equivalent of 5 rems (0.05 Sv) (the stochastic ALI) is listed in parentheses in Table 1 of Appendix B. In this

case, the licensee may, as a simplifying assumption, use the stochastic ALIs to determine committed effective dose equivalent. However, if the licensee uses the stochastic ALIs, the licensee must also demonstrate that the limit in § 20.201(a)(1)(ii) is met.

§ 20.205 [Reserved]

§ 20.206 Planned special exposures.

A licensee may authorize an adult worker to receive doses in addition to and accounted for separately from the doses received under the limits specified in § 20.201 provided that each of the following conditions is satisfied--

(a) The licensee authorizes a planned special exposure only in an exceptional situation when alternatives that might avoid the higher exposure are unavailable or impractical.

(b) The licensee (and employer if the employer is not the licensee) specifically authorizes the planned special exposure, in writing, before the exposure occurs.

(c) Before a planned special exposure, the licensee ensures that the individuals involved are--

(1) Informed of the purpose of the planned operation;

(2) Informed of the estimated doses and associated potential risks and specific radiation levels or other conditions that might be involved in performing the task; and

(3) Instructed in the measures to be taken to keep the dose ALARA considering other risks that may be present.

(d) Prior to permitting an individual to participate in a planned special exposure, the licensee ascertains prior doses as required by § 20.1104(b) during the lifetime of the individual for each individual involved.

(e) Subject to § 20.201(b), the licensee does not authorize a planned special exposure that would cause an individual to receive a dose from all planned special exposures and all doses in excess of the limits to exceed--

(1) The numerical values of any of the dose limits in § 20.201(a) in any year; and

(2) Five times the annual dose limits in § 20.201(a) during the individual's lifetime.

(f) The licensee maintains records of the conduct of a planned special exposure in accordance with § 20.1105 and submits a written report in accordance with § 20.1204.

(g) The licensee records the best estimate of the dose resulting from the planned special exposure in the individua. s record and informs the individual, in writing, of the dose within 30 days from the date of the planned special exposure. The dose from planned special exposures is not to be considered in controlling future occupational dose of the individual under § 20.201(a) but is to be included in evaluations required by § 20.206(d) and (e).

§ 20.207 Occupational dose limits for minors.

The annual occupational dose limits for minors are 10 percent of the annual dose limits specified for adult workers in § 20.201.

§ 20.208 Dose to an embryo/fetus.

(a) The licensee shall ensure that the dose to an embryo/fetus during the entire pregnancy, due to occupational exposure of a declared pregnant woman, does not exceed 0.5 rem (5 mSv). (For recordkeeping requirements, see § 20.1106.)

(b) The licensee shall make efforts to avoid substantial variation above a uniform monthly exposure rate to a declared pregnant woman so as to satisfy the limit in paragraph (a) of this section.

(c) The dose to an embryo/fetus shall be taken as the sum of--

(1) The deep-dose equivalent to the declared pregnant woman; and

(2) The dose to the embryo/fetus from radionuclides in the embryo/fetus and radionuclides in the declared pregnant woman.

267
p 8

(d) If the dose to the embryo/fetus is found to have exceeded 0.5 rem (5 mSv), or is within 0.05 rem (0.5 mSv) of this dose, by the time the woman

declares the pregnancy to the licensee, the licensee shall be deemed to be in compliance with paragraph (a) of this section if the additional dose to the embryo/fetus does not exceed 0.05 rem (0.5 mSv) during the remainder of the pregnancy.

SUBPART D--RADIATION DOSE LIMITS FOR INDIVIDUAL MEMBERS OF THE PUBLIC

§ 20.301 Dose limits for individual members of the public.

(a) Each licensee shall conduct operations so that--

(1) The total effective dose equivalent to individual members of the public from the licensed operation does not exceed 0.1 rem (1 mSv) in a year, exclusive of the dose contribution from the licensee's disposal of radioactive material into sanitary sewerage in accordance with § 20.1003, and

(2) The dose in any unrestricted area from external sources does not exceed 0.002 rem (0.02 mSv) in any one hour.

267 p8

(b) If the licensee permits members of the public to have access to controlled areas, the limits for members of the public continue to apply to those individuals.

(c) A licensee or license applicant may apply for prior NRC authorization to operate up to an annual dose limit for an individual member of the public of 0.5 rem (5 mSv). The licensee or license applicant shall include the following information in this application:

(1) Demonstration of the need for and the expected duration of operations in excess of the limit in paragraph (a) of this section.,

(2) The licensee's program to assess and control dose within the 0.5 rem (5 mSv) annual limit., and

(3) The procedures to be followed to maintain the dose as low as is reasonably achievable.

(d) In addition to the requirements of this part, a licensee subject to the provisions of EPA's generally applicable environmental radiation standards in 40 CFR Part 190 shall comply with those standards.

JCVS 237#3

(e) The Commission may impose additional restrictions on radiation levels in unrestricted areas and on the total quantity of radionuclides that a licensee may release in effluents in order to restrict the collective dose.

§ 20.302 Compliance with dose limits for individual members of the public.

(a) The licensee shall make or cause to be made, as appropriate, surveys of radiation levels in unrestricted and controlled areas and radioactive materials in effluents released to unrestricted and controlled areas to demonstrate compliance with the dose limits for individual members of the public in § 20.301.

(b) A licensee shall show compliance with the annual dose limit in § 20.301 by--

(1) Demonstrating by measurement or calculation that the total effective dose equivalent to the individual likely to receive the highest dose from the licensed operation does not exceed the annual dose limit., or

(2) Demonstrating that-

(i) The annual average concentrations of radioactive material released in gaseous and liquid effluents at the boundary of the unrestricted area do not exceed the values specified in Table 2 of Appendix B; and

(ii) If an individual were continually present in an unrestricted area, the dose from external sources would not exceed 0.002 rem (0.02 mSv) in an hour and 0.05 rem (0.5 mSv) in a year.

(c) Upon approval from the Commission, the licensee may adjust the effluent concentration values in Appendix B, Table 2, for members of the public, to take into account the actual physical and chemical characteristics of the effluents (e.g., aerosol size distribution, solubility, density, radioactive decay equilibrium, chemical form). [ ]

267
P8

SUBPART E--[RESERVED]

SUBPART F--SURVEYS AND MONITORING

§ 20.501 General.

(a) Each licensee shall make or cause to be made, surveys that--

(1) May be necessary for the licensee to comply with the regulations in this part; and

(2) Are reasonable under the circumstances to evaluate:

(i) The extent of radiation levels; and

(ii) Concentrations or quantities of radioactive material; and

(iii) The potential radiological hazards that could be present.

(b) The licensee shall ensure that instruments and equipment used for quantitative radiation measurements (e.g., dose rate and effluent monitoring) are calibrated periodically for the radiation measured.

(c) All personnel dosimeters (except for direct and indirect reading pocket ionization chambers and those dosimeters used to measure the dose to the extremities) that require processing to determine the radiation dose and that are used by licensees to comply with § 20.201, with other applicable provisions of this chapter, or with conditions specified in a license must be processed and evaluated by a dosimetry processor--

(1) Holding current personnel dosimetry accreditation from the National Voluntary Laboratory Accreditation Program (NVLAP) of the National Institute of Standards and Technology; and 267 09

(2) Approved in this accreditation process for the type of radiation or radiations included in the NVLAP program that most closely approximates the type of radiation or radiations for which the individual wearing the dosimeter is monitored.

§ 20.502 Conditions requiring individual monitoring of external and internal occupational dose .

Each licensee shall monitor exposures to radiation and radioactive material at levels sufficient to demonstrate compliance with the occupational dose limits of this part. As a minimum--

(a) Each licensee shall monitor occupational exposure to radiation and shall supply and require the use of individual monitoring devices by--

(1) Adults likely to receive, in 1 year from sources external to the body, a dose in excess of 10 percent of the limits in § 20.201(a),

(2) Minors and declared pregnant women likely to receive, in 1 year from sources external to the body, a dose in excess of 10 percent of any of the applicable limits in §§ 20.207 or 20.208, and

(3) Individuals entering a high or very high radiation area.

(b) Each licensee shall monitor (see § 20.204) the occupational intake of radioactive material by and assess the committed effective dose equivalent to--

(1) Adults likely to receive, in 1 year, an intake in excess of 10 percent of the applicable ALI(s) in Table 1, Columns 1 and 2, of Appendix B; and

(2) Minors and declared pregnant women likely to receive, in 1 year, a committed effective dose equivalent in excess of 0.05 rem (0.5 mSv).

SUBPART G--CONTROL OF EXPOSURE FROM EXTERNAL SOURCES IN RESTRICTED AREAS

§ 20.601 Control of access to high radiation areas.

(a) The licensee shall ensure that each entrance or access point to a high radiation area has one or more of the following features--

(1) A control device which, upon entry into the area, causes the level of radiation to be reduced below that level at which an individual might receive a deep-dose equivalent of 0.1 rem (1 mSv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates; 26709

(2) A control device that energizes a conspicuous visible or audible alarm signal so that the individual entering the high radiation area and the supervisor of the activity are made aware of the entry; or

(3) Entryways that are locked, except during periods when access to the areas is required, with positive control over each individual entry.

(b) In place of the controls required by paragraph (a) of this section for a high radiation area, the licensee may substitute continuous direct or electronic surveillance that is capable of preventing unauthorized entry.

(c) A licensee may apply to the Commission for approval of alternative methods for controlling access to high radiation areas.

(d) The licensee shall establish the controls required by paragraphs (a) and (c) of this section in a way that does not prevent individuals from leaving a high radiation area.

(e) Control is not required for each entrance or access point to a room or other area that is a high radiation area solely because of the presence of radioactive materials prepared for transport and packaged and labeled in accordance with the regulations of the Department of Transportation provided that--

(1) The packages do not remain in the area longer than 3 days; and

(2) The dose rate at 1 meter from the external surface of any package does not exceed 0.01 rem (0.1 mSv) per hour.

(f) Control of entrance or access to rooms or other areas in hospitals is not required solely because of the presence of patients containing radioactive material, provided that there are personnel in attendance who will take the necessary precautions to prevent the exposure of individuals to radiation or radioactive material in excess of the limits established in this part and to operate within the ALARA provisions of the licensee's radiation protection program.

§ 20.602 Control of access to very high radiation areas .

In addition to the requirements in § 20.601, the licensee shall institute additional measures to ensure that an individual is not able to gain unauthorized or inadvertent access to areas in which radiation levels could be encountered at 500 rads (5 grays) or more in 1 hour at 1 meter from a radiation source or any surface through which the radiation penetrates.

space intentionally blank as long footnote would not fit with headings and other text

§ 20.603 Control of access to very high radiation areas - irradiators.

(a) Each area in which there may exist radiation levels in excess of 500 rads (5 grays) in 1 hour at 1 meter from a sealed radioactive source[2] that is used to irradiate materials must meet the following requirements.

(1) Each entrance or access point must be equipped with entry control devices which--

(i) Function automatically to prevent any individual from inadvertently entering the area when very high radiation levels exist,

(ii) Permit deliberate entry into the area only after a control device is actuated that causes the radiation level within the area, from the sealed source, to be reduced below that at which it would be possible for an individual to receive a deep-dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour; and

(iii) Prevent operation of the source if the source would produce radiation levels in the area that could result in a deep-dose equivalent to an individual in excess of 0.1 rem (1 mSv) in 1 hour.

(2) Additional control devices must be provided so that, upon failure of the entry control devices to function as required by paragraph (a)(1) of this section--

(i) The radiation level within the area, from the sealed source, is reduced below that at which it would be possible for an individual to receive a deep-dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour; and

(ii) Conspicuous visible and audible alarm signals are generated to make an individual attempting to enter the area aware of the hazard and at least one other authorized individual, who is physically present, familiar with the

---

2 This section applies to radiation from byproduct, source, or special nuclear materials that are used in sealed sources in non-self-shielded irradiators. This section does not apply to radioactive sources that are used in teletherapy, in radiography, or in completely self-shielded irradiators in which the source is both stored and operated within the same shielding radiation barrier and, in the designed configuration of the irradiator, is always physically inaccessible to any individual and cannot create high levels of radiation in an area that is accessible to any individual. This section also does not apply to sources from which the radiation is incidental to some other use or to nuclear reactor-generated radiation.

activity, and prepared to render or summon assistance, aware of the failure of the entry control devicea.

(3) The licensee shall provide control devices so that, upon failure or removal of physical radiation barriers other than the source's shielded storage container--

(i) The radiation level from the source is reduced below that at which it would be possible for an individual to receive a deep-dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour; and 267 #4

(ii) Conspicuous visible and audible alarm signals are generated to make potentially affected individuals aware of the hazard and the licensee or at least one other individual, who is familiar with the activity and prepared to render or summon assistance, aware of the failure or removal of the physical barrier.

(4) When the shield for the stored source is a liquid, the licensee shall provide means to monitor the integrity of the shield and to signal, automatically, loss of adequate shielding.

(5) Physical radiation barriers that comprise permanent structural components, such as walls, that have no credible probability of failure or removal in ordinary circumstances need not meet the requirements of paragraphs (a)(3) and (4) of this section.

(6) Each area must be equipped with devices that will automatically generate conspicuous visible and audible alarm signals to alert personnel in the area before the source can be put into operation and in sufficient time for any individual in the area to operate a clearly identified control device, which must be installed in the area and which can prevent the source from being put into operation.

(7) Each area must be controlled by use of such administrative procedures and such devices as are necessary to ensure that the area is cleared of personnel prior to each use of the source.

(8) Each area must be checked by a radiation measurement to ensure that, prior to the first individual's entry into the area after any use of the source, the radiation level from the source in the area is below that at which it would be possible for an individual to receive a deep-dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour. 267 #9

(9) The entry control devices required in paragraph (a)(1) of this section must have been tested for proper functioning (see § 20.1109 for recordkeeping requirements).

(i) Testing must be conducted prior to initial operation with the source of radiation on any day (unless operations were continued uninterrupted from the previous day), and

(ii) Testing must be conducted prior to resumption of operation of the source of radiation after any unintended interruption; and

(iii) The licensee shall submit and adhere to a schedule for periodic tests of the entry control and warning systems.

(10) The licensee may not conduct operations, other than those necessary to place the source in safe condition or to effect repairs on controls, unless control devices are functioning properly.

(11) Entry and exit portals that are used in transporting materials to and from the irradiation area, and that are not intended for use by individuals, must be controlled by such devices and administrative procedures as are necessary to physically protect and warn against inadvertent entry by any individual through these portals. Exit portals for processed materials must be equipped to detect and signal the presence of any loose radiation sources that are carried toward such an exit and to automatically prevent loose radiation sources from being carried out of the area.

(b) Persons holding licenses or applicants for licenses for radiation sources that are within the purview of paragraph (a) of this section and that will be used in a variety of positions or in locations, such as open fields or forests, that make it impracticable to comply with certain requirements of paragraph (a) of this section, such as those for the automatic control of radiation levels, may apply to the Director, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC 20555, for approval of the use of alternative safety measures. Any alternative safety measures must provide a degree of personnel protection at least equivalent to those specified in paragraph (a) of this section. At least one of the alternative measures must include an entry-preventing interlock control based on a measurement of the radiation that ensures the absence of high radiation levels before an individual can gain access to the area where such radiation sources are used.

(c) The entry control devices required by paragraphs (a) and (b) of this section must be established in such a way that no individual will be prevented from leaving the area.

SUBPART H--RESPIRATORY PROTECTION AND CONTROLS TO RESTRICT INTERNAL EXPOSURE IN RESTRICTED AREAS

§ 20.701 Use of process or other engineering controls.

The licensee shall use, to the extent practicable, process or other engineering controls (e.g., containment or ventilation) to control the concentrations of radioactive material in air.

§ 20.702 Use of other controls.

When it is not practicable to apply process or other engineering controls to control the concentrations of radioactive material in air to values below those which define an airborne radioactivity area, the licensee shall, consistent with maintaining the total effective dose equivalent ALARA, increase monitoring, and limit intakes by one or more of the following means:

(a) Control of access;

(b) Limitation of exposure times;

(c) Use of respiratory protection equipment; or

(d) Other controls.

§ 20.703 Use of individual respiratory protection equipment.

(a) If the licensee uses respiratory protection equipment to limit intakes pursuant to § 20.702--

(1) The licensee shall use only respiratory protection equipment that is tested and certified or had certification extended by the National Institute for Occupational Safety and Health/Mine Safety and Health Administration (NIOSH/MSHA).

(2) If the licensee wishes to use equipment that has not been tested or certified by NIOSH/MSHA, has not had certification extended by NIOSH/MSHA, or for which there is no schedule for testing or certification, the licensee shall submit an application for authorized

use of that equipment, including a demonstration by testing, or a demonstration on the basis of reliable test information, that the material and performance characteristics of the equipment are capable of providing the proposed degree of protection under anticipated conditions of use.

(3) The licensee shall implement and maintain a respiratory protection program that includes--

(i) Air sampling sufficient to identify the potential hazard, permit proper equipment selection, and estimate exposures;

(ii) Surveys and bioassays, as appropriate, to evaluate actual intakes;

(iii) Testing of respirators for operability immediately prior to each use;

(iv) Written procedures regarding selection, fitting, issuance, maintenance, and testing of respirators, including testing for operability immediately prior to each use; supervision and training of personnel; monitoring, including air sampling and bioassays; and recordkeeping; and

(v) Determination by a physician prior to initial fitting of respirators, and at least every 12 months thereafter, that the individual user is physically able to use the respiratory protection equipment.

(4) The licensee shall issue a written policy statement on respirator usage covering--

(i) The use of process or other engineering controls, instead of respirators;

(ii) The routine, nonroutine, and emergency use of respirators; and

(iii) The periods of respirator use and relief from respirator use.

(5) The licensee shall advise each respirator user that the user may leave the area at any time for relief from respirator use in the event of equipment malfunction, physical or psychological distress, procedural or communication failure, significant deterioration of operating conditions, or any other conditions that might require such relief.

(6) The licensee shall use equipment within limitations for type and mode of use and shall provide proper visual, communication, and other special capabilities (such as adequate skin protection) when needed.

(b) In estimating exposure of individuals to airborne radioactive materials, the licensee may make allowance for respiratory protection equipment used to limit intakes pursuant to § 20.702, provided that the following conditions, in addition to those in § 20.703(a), are satisfied:

(1) The licensee selects respiratory protection equipment that provides a protection factor (see Appendix A) greater than the multiple by which peak concentrations of airborne radioactive materials in the working area are expected to exceed the values specified in Appendix B, Table 1, Column 3. If the selection of a respiratory protection device with a protection factor greater than the peak concentration is inconsistent with the goal specified in § 20.702 of keeping the total effective dose equivalent ALARA, the licensee may select respiratory protection equipment with a lower protection factor only if such a selection would result in keeping the total effective dose equivalent ALARA. The concentration of radioactive material in the air that is inhaled when respirators are worn may be initially estimated by dividing the average concentration in air, during each period of uninterrupted use, by the protection factor. If the exposure is later found to be greater than estimated, the corrected value must be used; if the exposure is later found to be less than estimated, the corrected value may be used.

267 p 9

267 p 10

(2) The licensee shall obtain authorization from the Commission before assigning respiratory protection factors in excess of those specified in Appendix A. The Commission may authorize a licensee to use higher protection factors on receipt of an application that--

(i) Describes the situation for which a need exists for higher protection factors, and

(ii) Demonstrates that the respiratory protection equipment provides these higher protection factors under the proposed conditions of use.

(c) The licensee shall use as emergency devices only respiratory protection equipment that has been specifically certified or had certification extended for emergency use by NIOSH/MSHA.

(d) The licensee shall notify, in writing, the Director of the appropriate NRC Regional Office listed in Appendix D at least 30 days before the date that respiratory protection equipment is first used under the provisions of either § 20.703(a) or (b).

§ 20.704 Further restrictions on the use of respiratory protection equipment.

[a] deleted

237 #2

[b] The Commission may impose restrictions in addition to those in §§ 20.702, 20.703, and Appendix A to--

[1] (a) Ensure that the respiratory protection program of the licensee is adequate to limit exposures of individuals to airborne radioactive materials; and

[2] (b) Limit the extent to which a licensee may use respiratory protection equipment instead of process or other engineering controls.

SUBPART I--STORAGE AND CONTROL OF LICENSED MATERIAL

§ 20.801 Security of stored material.

The licensee shall secure from unauthorized removal or access licensed materials that are stored in controlled or unrestricted areas.

§ 20.802 Control of material not in storage.

The licensee shall control and maintain constant surveillance of licensed material that is in a controlled or unrestricted area and that is not in storage.

SUBPART J--PRECAUTIONARY PROCEDURES

§ 20.901 Caution signs.

(a) Standard radiation symbol. Unless otherwise authorized by the Commission, the symbol prescribed by this part shall use the colors magenta, or purple, or black on yellow background. The symbol prescribed by this part is the three-bladed design: 237 #1

RADIATION SYMBOL

(1) Cross-hatched area is to be magenta, or purple, or black, and
(2) The background is to be yellow. 237 #1

(b) Exception to color requirements for standard radiation symbol. Notwithstanding the requirements of paragraph (a) of this section, licensees are authorized to label sources, source holders, or device components containing sources of licensed materials that are subjected to high temperatures, with conspicuously etched or stamped radiation caution symbols and without a color requirement.

(c) Additional information on signs and labels. In addition to the contents of signs and labels prescribed in this part, the licensee may provide, on or near the required signs and labels, additional information, as appropriate, to make individuals aware of potential radiation exposures and to minimize the exposures.

§ 20.902 Posting requirements.

(a) Posting of radiation areas. The licensee shall post each radiation area with a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION, RADIATION AREA."

(b) Posting of high radiation areas. The licensee shall post each high radiation area with a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION, HIGH RADIATION AREA" or "DANGER, HIGH RADIATION AREA."

(c) Posting of very high radiation areas. The licensee shall post each very high radiation area with a conspicuous sign or signs bearing the radiation symbol and words "GRAVE DANGER, VERY HIGH RADIATION AREA."

(d) Posting of airborne radioactivity areas. The licensee shall post each airborne radioactivity area with a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION, AIRBORNE RADIOACTIVITY AREA" or "DANGER, AIRBORNE RADIOACTIVITY AREA."

(e) Posting of areas or rooms in which licensed material is used or stored. The licensee shall post each area or room in which there is used or stored an amount of licensed material exceeding 10 times the quantity of such material specified in Appendix C with a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION, RADIOACTIVE MATERIAL(S)", or "DANGER, RADIOACTIVE MATERIAL(S)."

§ 20.903 Exceptions to posting requirements.

(a) A licensee is not required to post caution signs in areas or rooms containing radioactive materials for periods of less than 8 hours, if each of the following conditions is met:

(1) The materials are constantly attended during these periods by an individual who takes the precautions necessary to prevent the exposure of individuals to radiation or radioactive materials in excess of the limits established in this part; and

(2) The area or room is subject to the licensee's control.

(b) Rooms or other areas in hospitals that are occupied by patients are not required to be posted with caution signs pursuant to § 20.902 provided that--

(1) The patient is being treated with sealed sources or has been treated with unsealed radioactive material in quantities less than 30 millicuries, or the measured dose rate at 1 meter from the patient is less than 0.005 rem (0.05 mSv) per hour; and

(2) There are personnel in attendance who will take the necessary precautions to prevent the exposure of individuals to radiation or radioactive material in excess of the limits established in this part and to operate within the ALARA provisions of the licensee's radiation protection program.

(c) A room or area is not required to be posted with a caution sign because of the presence of a sealed source provided the radiation level at 30 centimeters from the surface of the source container or housing does not exceed 0.005 rem (0.05 mSv) per hour.

§ 20.904 Labeling containers.

(a) The licensee shall ensure that each container of licensed material bears a durable, clearly visible label bearing the radiation symbol and the words "CAUTION, RADIOACTIVE MATERIAL" or "DANGER, RADIOACTIVE MATERIAL." The label must also provide sufficient information (such as the radionuclide(s) present, an estimate of the

quantity of radioactivity, the date for which the activity is estimated, radiation levels, kinds of materials, and mass enrichment) to permit individuals handling or using the containers, or working in the vicinity of the containers, to take precautions to avoid or minimize exposures.

(b) Each licensee shall, prior to removal or disposal of empty uncontaminated containers to unrestricted areas, remove or deface the radioactive material label or otherwise clearly indicate that the container no longer contains radioactive materials.

§ 20.905 Exemptions to labeling requirements.

A licensee is not required to label--

(a) Containers holding licensed material in quantities less than the quantities listed in Appendix C; or

(b) Containers holding licensed material in concentrations less than those specified in Table 3 of Appendix B; or

(c) Containers attended by an individual who takes the precautions necessary to prevent the exposure of individuals in excess of the limits established by this part; or

(d) Containers when they are in transport and packaged and labeled in accordance with the regulations of the Department of Transportation,[3] or

(e) Containers that are accessible only to individuals authorized to handle or use them, or to work in the vicinity of the containers, if the contents are identified to these individuals by a readily available written record (examples of containers of this type are containers in locations such as water-filled canals, storage vaults, or hot cells). The record must be retained as long as the containers are in use for the purpose indicated on the record; or

---

3 Labeling of packages containing radioactive materials is required by the Department of Transportation (DOT) if the amount and type of radioactive material exceeds the limits for an excepted quantity or article as defined and limited by DOT regulations 49 CFR 173.403(m) and (w), and 173.421-424.

(f) Installed manufacturing or process equipment, such as reactor components, piping, and tanks.

§ 20.906 Procedures for receiving and opening packages.

(a) Each licensee who expects to receive a package containing quantities of radioactive material in excess of a Type A quantity, as defined in § 71.4 and Appendix A to Part 71 of this chapter, shall make arrangements to receive--

(1) The package when the carrier offers it for delivery; or

(2) Notification of the arrival of the package at the carrier's terminal and to take possession of the package expeditiously.

(b) Each licensee shall monitor the external surfaces of a package known to contain radioactive material for radicactive contamination and radiation levels if the package--

(1) Is labeled as containing radioactive material; or

(2) Has evidence of potential contamination, such as packages that are crushed, wet, or damaged.

(c) The licensee shall perform the monitoring required by paragraph (b) of this section as soon as practicable after receipt of the package, but not later than 3 hours after the package is received at the licensee's facility if it is received during the licensee's normal working hours, or not later than 3 hours from the beginning of the next working day if it is received after working hours.

(d) The licensee shall immediately notify the final delivery carrier and, by telephone and telegram, mailgram, or facsimile, the Administrator of the appropriate NRC Regional Office listed in Appendix D when--

(1) Removable radioactive surface contamination exceeds the limits of § 71.87(i) of this chapter; or

(2) External radiation levels exceed the limits of § 71.47 of this chapter.

(e) Each licensee shall--

(1) Establish, maintain, and retain written procedures for safely opening packages in which radioactive material is received; and

(2) Ensure that the procedures are followed and that due consideration is given to special instructions for the type of package being opened.

(f) Licensees transferring special form sources in licensee-owned or licensee-operated vehicles to and from a work site are exempt from the contamination monitoring requirements of (b), but are not exempt from the survey requirement in (b) for measuring radiation levels which is required to ensure that the source is still properly lodged in its shield.

237
#4

SUBPART K--WASTE DISPOSAL

§ 20.1001 General requirements.

(a) A licensee shall dispose of licensed material only--

(1) By transfer to an authorized recipient as provided in § 20.1006 or in the regulations in Parts 30, 40, 60, 61, 70, or 72 of this chapter; or

(2) By decay in storage; or

(3) By release in effluents within the limits in § 20.301; or

(4) As authorized under §§ 20.1002, 20.1003, 20.1004, or 20.1005.

(b) A person must be specifically licensed to receive waste containing licensed material from other persons for:

(1) Treatment prior to disposal; or

(2) Treatment or disposal by incineration; or

(3) Decay in storage; or

(4) Disposal at a land disposal facility licensed under Part 61 of this chapter; or

(5) Disposal at a geologic repository under Part 60 of this chapter.

§ 20.1002 Method for obtaining approval of proposed disposal procedures.

A licensee or applicant for a license may apply to the Commission for approval of proposed procedures, not otherwise authorized in the regulations in this chapter, to dispose of licensed material generated in the licensee's activities. Each application shall include:

(a) A description of the waste containing licensed material to be disposed of, including the physical and chemical properties important to risk

evaluation, and the proposed manner and conditions of waste disposal; and

(b) An analysis and evaluation of pertinent information on the nature of the environment; and

(c) The nature and location of other potentially affected licensed and unlicensed facilities., and

(d) Analyses and procedures to ensure that doses are maintained ALARA and within the dose limits in this part.

§ 20.1003 Disposal by release into sanitary sewerage.

(a) A licensee may discharge licensed material into sanitary sewerage if each of the following conditions is satisfied:

(1) The material is readily soluble (or is readily dispersible biological material) in water; and

(2) The quantity of licensed or other radioactive material that the licensee releases into the sewer in 1 month divided by the average monthly volume of water released into the sewer by the licensee does not exceed the concentration listed in Table 3 of Appendix B; and

(3) If more than one radionuclide is released, the following conditions must also be satisfied:

(i) The licensee shall determine the fraction of the limit in Table 3 of Appendix B represented by discharges into sanitary sewerage by dividing the actual monthly average concentration of each radionuclide released by the licensee into the sewer by the concentration of that radionuclide listed in Table 3 of Appendix B., and

237 #6

(ii) The sum of the fractions for each radionuclide required by paragraph (a)(3)(i) of this section does not exceed unity; and

(4) The total quantity of licensed and other radioactive material that the licensee releases into the sanitary sewerage system in a year does not exceed 5 curies (185 GBq) of hydrogen-3, 1 curie (37 GBq) of carbon-14, and 1 curie (37 GBq) of all other radioactive materials combined.

(b) Excreta from individuals undergoing medical diagnosis or therapy with radioactive material is not subject to the limitations contained in paragraph (a) of this section.

§ 20.1004 Treatment or disposal by incineration.

A licensee may treat or dispose of licensed material by incineration only in the amounts and forms specified in § 20.1005 or as specifically approved by the Commission pursuant to § 20.1002.

§ 20.1005 Disposal of specific wastes.

(a) A licensee may dispose of the following licensed material as if it were not radioactive:

(1) 0.05 microcurie (1.85 kBq), or less, of hydrogen-3 or carbon-14 per gram of medium used for liquid scintillation counting.

(2) 0.05 microcurie (1.85 kBq), or less, of hydrogen-3 or carbon-14 per gram of animal tissue, averaged over the weight of the entire animal.

(b) A licensee may not dispose of tissue under paragraph (a)(2) of this section in a manner that would permit its use either as food for humans or as animal feed.

(c) The licensee shall maintain records in accordance with § 20.1108.

§ 20.1006 Transfer for disposal and manifests.

(a) The requirements of this section and Appendix F are designed to control transfers of low-level radioactive waste intended for disposal at a land disposal facility (as defined in Part 61 of this chapter), establish a manifest tracking system, and supplement existing requirements concerning transfers and recordkeeping for those wastes.

(b) Each shipment of radioactive waste intended for disposal at a licensed land disposal facility must be accompanied by a shipment manifest as specified in Section I of Appendix F.

(c) Each shipment manifest must include a certification by the waste generator as specified in Section II of Appendix F.

(d) Each person involved in the transfer for disposal and disposal of waste, including the waste generator, waste collector, waste processor, and

disposal facility operator, shall comply with the requirements specified in Section III of Appendix F.

§ 20.1007 Compliance with environmental and health protection regulations

Nothing in this subpart relieves the licensee from complying with other applicable Federal, State, and local regulations governing any other toxic or hazardous properties of materials that may be disposed of under this subpart.

SUBPART L--RECORDS

§ 20.1101 General provisions.

(a) Each licensee shall use the units: curie, rad, rem, including multiples and subdivisions, and shall clearly indicate the units of all quantities on records required by this part.

(b) The licensee shall make a clear distinction among the quantities entered on the records required by this part (e.g., total effective dose equivalent, shallow-dose equivalent, eye dose equivalent, deep-dose equivalent, committed effective dose equivalent).

§ 20.1102 Records of radiation protection programs.

(a) Each licensee shall maintain records of the radiation protection program, including:

(1) The provisions of the program; and

(2) Audits and other reviews of program content and implementation.

(b) The licensee shall retain the records required by paragraph (a)(1) of this section until the Commission terminates each pertinent license requiring the record. The licensee shall retain the records required by paragraph (a)(2) of this section for 3 years after the record is made.

§ 20.1103 Records of surveys.

(a) Each licensee shall maintain records showing the results of surveys and calibrations required by §§ 20.501 and 20.906(b). The licensee shall retain these records for 3 years after the record is made.

(b) The licensee shall retain each of the following records until the Commission terminates each pertinent license requiring the record:

(1) Records of the results of surveys to determine the dose from external sources and used, in the absence of or in combination with individual monitoring data, in the assessment of individual dose equivalents; and

(2) Records of the results of measurements and calculations used to determine individual intakes of radioactive material and used in the assessment of internal dose; and

(3) Records showing the results of air sampling, surveys, and bioassays required pursuant to § 20.703(a)(3)(i) and (ii); and

(4) Records of the results of measurements and calculations used to evaluate the release of radioactive effluents to the environment.

§ 20.1104 Determination of prior occupational dose.

(a) For each individual who may enter the licensee's restricted or controlled area and is likely to receive, in a year, an occupational dose requiring monitoring pursuant to § 20.502, the licensee shall--

(1) Determine the occupational radiation dose received during the current year; and

(2) Attempt to obtain the records of lifetime cumulative occupational radiation dose.

(b) Prior to permitting an individual to participate in a planned special exposure, the licensee shall determine--

(1) The internal and external doses from all previous planned special exposures; and

(2) All doses in excess of the [ ] limits (including doses received during accidents and emergencies) received during the lifetime of the individual.

267 p10

(c) In complying with the requirements of paragraph (a) of this section, a licensee may--

(1) Accept, as a record of the occupational dose that the individual received during the current year, a written signed statement from the individual, or from the individual's most recent employer for work involving radiation exposure, that discloses the nature and the amount of any occupational dose that the individual may have received during the current year;

(2) Accept, as the record of lifetime cumulative radiation dose, an up-to-date NRC Form 4, or equivalent, signed by the individual and countersigned by an appropriate official of the most recent employer for work involving radiation exposure, or the individual's current employer (if the individual is not employed by the licensee); and

(3) Obtain reports of the individual's dose equivalent(s) from the most recent employer for work involving radiation exposure, or the individual's current employer (if the individual is not employed by the licensee) by telephone, telegram, electronic media, or letter. The licensee shall request a written verification of the dose data if the authenticity of the transmitted report cannot be established.

(d) The licensee shall record the exposure history, as required by paragraph (a) of this section, on NRC Form 4, or other clear and legible record, of all the information required on that form.[4] The form or record must show each period in which the individual received occupational exposure to radiation or radioactive material and must be signed by the individual who received the exposure. For each period for which the licensee obtains reports, the licensee shall use the dose shown in the report in preparing NRC Form 4. For any period in which the licensee does not obtain a report, the licensee shall place a notation on NRC Form 4 indicating the periods of time for which data are not available.

---

4 Licensees are not required to reevaluate the separate external dose equivalents and internal committed dose equivalents or intakes of radionuclides assessed under the regulations in this part in effect before January 1, 1993. Further, occupational exposure histories obtained and recorded on NRC Form 4 before January 1, 1993, would not have included effective dose equivalent, but may be used in the absence of specific information on the intake of radionuclides by the individual.

(e) If the licensee is unable to obtain a complete record of an individual's current and previously accumulated occupational dose, the licensee shall assume--

(1) In establishing administrative controls under § 20.201(f) for the current year, that the allowable dose limit for the individual is reduced by 1.25 rems (12.5 mSv) for each quarter for which records were unavailable and the individual was engaged in activities that could have resulted in occupational radiation exposure; and

(2) That the individual is not available for planned special exposures.

(f) The licensee shall retain the records on NRC Form 4 or equivalent until the Commission terminates each pertinent license requiring this record. The licensee shall retain records used in preparing NRC Form 4 for 3 years after the record is made.

§ 20.1105 Records of planned special exposures.

(a) For each use of the provisions of § 20.206 for planned special exposures, the licensee shall maintain records that describe--

(1) The exceptional circumstances requiring the use of a planned special exposure; and

2.67 p10

(2) The name of the management official who authorized the planned special exposure and a copy of the signed authorization, and

(3) What actions were necessary; and

(4) Why. the actions were necessary; and

(5) How doses were maintained ALARA, and

(6) What individual and collective doses were expected to result, and the doses actually received in the planned special exposure.

(b) The licensee shall retain the records until the Commission terminates each pertinent license requiring these records.

§ 20.1106 Records of individual monitoring results.

(a) Recordkeeping requirement. Each licensee shall maintain records of doses received by all individuals for whom monitoring was required pursuant to

§ 20.502, and records of doses received during planned special exposures, accidents, and emergency conditions. These records[5] must include, when applicable--

(1) The deep-dose equivalent to the whole body, eye dose equivalent, shallow-dose equivalent to the skin, and shallow-dose equivalent to the extremities, and

(2) The estimated intake or body burden of radionuclides (see § 20.202), and

(3) The committed effective dose equivalent assigned to the intake or body burden of radionuclides, and

(4) The specific information used to calculate the committed effective dose equivalent pursuant to § 20.204(c); and

(5) The total effective dose equivalent when required by § 20.202; and

(6) The total of the deep-dose equivalent and the committed dose to the organ receiving the highest total dose.

(b) Recordkeeping frequency. The licensee shall make entries of the records specified in paragraph (a) of this section at least annually.

(c) Recordkeeping format. The licensee shall maintain the records specified in paragraph (a) of this section on NRC Form 5, in accordance with the instructions for NRC Form 5, or in clear and legible records containing all the information required by NRC Form 5.

(d) Privacy protection. The records required under this section should be protected from public disclosure because of their personal privacy nature. These records are protected by most State privacy laws and, when transferred to the NRC, are protected by the Privacy Act of 1974, Pub.L. 93-579, 5 U.S.C. 552a, and the Commission's regulations in 10 CFR Part 9.

(e) The licensee shall maintain the records of dose to an embryo/fetus with the records of dose to the declared pregnant woman. The declaration of pregnancy shall also be kept on file, but may be maintained separately from the dose records.

267 p 20

---

5 Assessments of dose equivalent and records made using units in effect before January 1, 1993, need not be changed.

(f) The licensee shall retain each required form or record until the Commission terminates each pertinent license requiring the record.

§ 20.1107 Records of dose to individual members of the public.

(a) Each licensee shall maintain records sufficient to demonstrate compliance with the dose limit for individual members of the public (see § 20.301).

(b) The licensee shall retain the records required by paragraph (a) of this section until the Commission terminates each pertinent license requiring the record.

§ 20.1108 Records of waste disposal.

(a) Each licensee shall maintain records of the disposal of licensed materials made under §§ 20.1002, 20.1003, 20.1004, 20.1005, Part 61, and disposal by burial in soil, including burials authorized before January 28, 1981.[6]

(b) The licensee shall retain the records required by paragraph (a) of this section until the Commission terminates each pertinent license requiring the record.

§ 20.1109 Records of testing entry control devices for very high radiation areas.

(a) Each licensee shall maintain records of tests made under

---

6 A previous § 20.304 permitted burial of small quantities of licensed materials in soil before January 28, 1981, without specific Commission authorization.

§ 20.603(a)(9) on entry control devices for very high radiation areas. These records must include the date, time, and results of each such test of function.

(b) The licensee shall retain the records required by paragraph (a) of this section for 3 years after the record is made.

§ 20.1110 Form of records.

Each record required by this part must be legible throughout the specified retention period. The record may be the original or a reproduced copy or a microform provided that the copy or microform is authenticated by authorized personnel and that the microform is capable of producing a clear copy throughout the required retention period. The record may also be stored in electronic media with the capability for producing legible, accurate, and complete records during the required retention period. Records, such as letters, drawings, and specifications, must include all pertinent information, such as stamps, initials, and signatures. The licensee shall maintain adequate safeguards against tampering with and loss of records.

SUBPART M--REPORTS

§ 20.1201 Reports of theft or loss of licensed material.

(a) Telephone reports.

(1) Each licensee shall report by telephone as follows:

(i) Immediately after its occurrence becomes known to the licensee, any lost, stolen, or missing licensed material in an aggregate quantity equal to or greater than 1,000 times the quantity specified in Appendix C under such circumstances that it appears to the licensee that an exposure could result to persons in unrestricted areas; or

(ii) Within 30 days after the occurrence of any lost, stolen, or missing licensed material becomes known to the licensee, all licensed material in a quantity greater than 10 times the quantity specified in Appendix C that is still missing at this time.

(2) Reports must be made as follows:

(i) Licensees having an installed Emergency Notification System shall make the reports to the NRC Operations Center in accordance with § 50.72 of this chapter, and

(ii) All other licensees shall make reports to the NRC Operations Center.

(b) Written reports.

(1) Each licensee required to make a report under paragraph (a) of this section shall, within 30 days after making the telephone report, make a written report setting forth the following information:

(i) A description of the licensed material involved, including kind, quantity, and chemical and physical form; and

(ii) A description of the circumstances under which the loss or theft occurred; and

(iii) A statement of disposition, or probable disposition, of the licensed material involved; and

(iv) Exposures of individuals to radiation, circumstances under which the exposures occurred, and the possible effective dose equivalent to persons in unrestricted areas; and

(v) Actions that have been taken, or will be taken, to recover the material; and

(vi) Procedures or measures that have been, or will be, adopted to ensure against a recurrence of the loss or theft of licensed material.

(2) Reports must be made as follows:

(i) For holders of an operating license for a nuclear power plant, the events included in paragraph (b) of this section must be reported in accordance with the procedures described in § 50.73(b), (c), (d), (e), and (g) of this chapter and must include the information required in paragraph (b)(1) of this section, and

(ii) All other licensees shall make reports to the Administrator of the appropriate NRC Regional Office listed in Appendix D.

(c) A duplicate report is not required under (b) if the licensee is also required to submit a report pursuant to §§ 30.55(c), 40.64(c), 50.72, 50.73, 70.52, 73.27(b), 73.67(e)(3)(vi), 73.67(g)(3)(iii), 73.71, or 150.19(c) of this chapter.

(d) Subsequent to filing the written report, the licensee shall also report any additional substantive information on the loss or theft within 30 days after the licensee learns of such information.

(e) The licensee shall prepare any report filed with the Commission pursuant to this section so that names of individuals who may have received exposure to radiation are stated in a separate and detachable part of the report.

§ 20.1202 Notification of incidents.

(a) Immediate notification. Notwithstanding any other requirements for notification, each licensee shall immediately report any event involving byproduct, source, or special nuclear material possessed by the licensee that may have caused or threatens to cause any of the following conditions--

(1) An individual to receive--

(i) A total effective dose equivalent of 25 rems (0.25 Sv) or more; or

(ii) An eye dose equivalent of 75 rems (0.75 Sv) or more; or

(iii) A shallow-dose equivalent to the skin or extremities of 250 rads (2.5 Gy) or more; or

(2) The release of radioactive material, inside or outside of a restricted area, so that, had an individual been present for 24 hours, the individual could have received an intake five times the occupational annual limit on intake (the provisions of this paragraph do not apply to locations where personnel are not normally stationed during routine operations, such as hot-cells or process enclosures), or

(3) A loss of 1 working week or more of the operation of any facilities affected; or

(4) Damage to property in excess of $200,000.

(b) Twenty-four hour notification. Each licensee shall, within 24 hours of discovery of the event, report any event involving loss of control of licensed material possessed by the licensee that may have caused, or threatens to cause, any of the following conditions:

(1) An individual to receive, in a period of 24 hours--

(i) A total effective dose equivalent exceeding 5 rems (0.05 Sv), or

(ii) An eye dose equivalent exceeding 15 rems (0.15 Sv); or

(iii) A shallow-dose equivalent to the skin or extremities exceeding 50 rems (0.5 Sv); or

(2) The release of radioactive material, inside or outside of a restricted area, so that, had an individual been present for 24 hours, the individual could have received an intake in excess of one occupational annual limit on intake (the provisions of this paragraph do not apply to locations where personnel are not normally stationed during routine operations, such as hot-cells or process enclosures), or

(3) A loss of 1 day or more of the operation of any facilities affected; or

(4) Damage to property in excess of $2,000.

(c) The licensee shall prepare any report filed with the Commission pursuant to this section so that names of individuals who have received exposure to radiation or radioactive material are stated in a separate and detachable part of the report.

(d) Reports made by licensees in response to the requirements of this section must be made as follows:

(1) Licensees having an installed Emergency Notification System shall make the reports required by paragraphs (a) and (b) of this section to the NRC Operations Center in accordance with § 50.72; and

(2) All other licensees shall make the reports required by paragraphs (a) and (b) of this section by telephone to the NRC Operations Center and by telegram, mailgram, or facsimile to the Administrator of the appropriate NRC Regional Office listed in Appendix D.

(e) The provisions of this section do not include doses that result from planned special exposures, that are within the limits for planned special exposures, and that are reported under § 20.1204.

§ 20.1203 Reports of exposures, radiation levels, and concentrations of radioactive material exceeding the limits.

(a) Reportable events. In addition to the notification required by § 20.1202, each licensee shall submit a written report within 30 days after learning of any of the following occurrences:

(1) Any incident for which notification is required by § 20.1202; or

(2) Doses in excess of any of the following:

(i) The occupational dose limits for adults in § 20.201; or

(ii) The occupational dose limits for a minor in § 20.207; or

(iii) The limits for an embryo/fetus of a declared pregnant woman in § 20.208; or

(iv) The limits for an individual member of the public in § 20.301; or

(v) Any applicable limit in the license; or

(3) Levels of radiation or concentrations of radioactive material in--

(i) A restricted area in excess of any applicable limit in the license, or

(ii) An unrestricted area in excess of 10 times any applicable limit set forth in this part or in the license (whether or not involving exposure of any individual in excess of the limits in § 20.301), or

(4) For licensees subject to the provisions of EPA's generally applicable environmental radiation standards, levels of radiation or releases of radioactive material in excess of those standards, or of license conditions related to those standards.

(b) Contents of reports.

(1) Each report required by paragraph (a) of this section must describe the extent of exposure of individuals to radiation and radioactive material, including, as appropriate:

(i) Estimates of each individual's dose; and

(ii) The levels of radiation and concentrations of radioactive material involved; and

(iii) The cause of the elevated exposures, dose rates, or concentrations; and

(iv) Corrective steps taken or planned to ensure against a recurrence, including the schedule for achieving conformance with applicable limits, generally applicable environmental standards, and associated license conditions.

(2) Each report filed pursuant to paragraph (a) of this section must include for each individual[7] exposed: the name, Social Security account number, and date of birth. The report must be prepared so that this information is stated in a separate and detachable part of the report.

---

7 With respect to the limit for the embryo/fetus (§ 20.208), the identifiers should be those of the declared pregnant woman.

(c) For holders of an operating license for a nuclear power plant, the occurrences included in paragraph (a) of this section must be reported in accordance with the procedures described in § 50.73(b), (c), (d), (e), and (g) of this chapter and must also include the information required by paragraph (b) of this section. Occurrences reported in accordance with § 50.73 of this chapter need not be reported by a duplicate report under paragraph (a) of this section.

(d) All licensees, other than those holding an operating license for a nuclear power plant, who make reports under paragraph (a) of this section shall submit the report in writing to the U.S. Nuclear Regulatory Commission, Document Control Desk, Washington, DC 20555, with a copy to the appropriate NRC Regional Office listed in Appendix D.

§ 20.1204 Reports of planned special exposures.

The licensee shall submit a written report to the Administrator of the appropriate NRC Regional Office listed in Appendix D within 30 days following any planned special exposure conducted in accordance with § 20.206, informing the Commission that a planned special exposure was conducted and indicating the date the planned special exposure occurred and the information required by § 20.1105.

§ 20.1205 [Reserved].

§ 20.1206 Reports of individual monitoring.

(a) This section applies to each person licensed by the Commission to--

(1) Operate a nuclear reactor designed to produce electrical or heat energy pursuant to § 50.21(b) or § 50.22 of this chapter or a testing facility as defined in § 50.2 of this chapter; or

(2) Possess or use byproduct material for purposes of radiography pursuant to Parts 30 and 34 of this chapter; or

(3) Possess or use at any one time, for purposes of fuel processing, fabricating, or reprocessing, special nuclear material in a quantity exceeding 5,000 grams of contained uranium-235, uranium-233, or plutonium, or any combination thereof pursuant to Part 70 of this chapter; or

(4) Possess high-level radioactive waste at a geologic repository operations area pursuant to Part 60 of this chapter; or

(5) Possess spent fuel in an independent spent fuel storage installation (ISFSI) pursuant to Part 72 of this chapter; or

(6) Receive radioactive waste from other persons for disposal under Part 61 of this chapter; or

(7) Possess or use at any time, for processing or manufacturing for distribution pursuant to Parts 30, 32, 33 or 35 of this chapter, byproduct material in quantities exceeding any one of the following quantities:

	Quantity of Radionuclide[a] in curies
Cesium-137	1
Cobalt-60	1
Gold-198	100
Iodine-131	1
Iridium-192	10
Krypton-85	1,000
Promethium-147	10
Technetium-99m	1,000

[a]The Commission may require as a license condition, or by rule, regulation, or order pursuant to § 20.1302, reports from licensees who are licensed to use radionuclides not on this list, in quantities sufficient to cause comparable radiation levels.

(b) Each licensee in a category listed in paragraph (a) of this section shall submit an annual report of the results of individual monitoring carried out by the licensee for each individual for whom monitoring was required by § 20.502 during that year. The licensee may include additional data for individuals for whom monitoring was provided but not required. The licensee shall use Form NRC 5 or electronic media containing all the information required by Form NRC 5.

(c) The licensee shall file the report required by § 20.1206(b), covering the preceding year, on or before April 30 of each year. The licensee shall

submit the report to the Director, Office of Nuclear Regulatory Research, Nuclear Regulatory Commission, Washington, DC 20555.

SUBPART N--EXEMPTIONS AND ADDITIONAL REQUIREMENTS

§ 20.1301 Applications for exemptions.

The Commission may, upon application by a licensee or upon its own initiative, grant an exemption from the requirements of the regulations in this part if it determines the exemption is authorized by law and would not result in undue hazard to life or property.

§ 20.1302 Additional requirements.

The Commission may, by rule, regulation, or order, impose requirements on a licensee, in addition to those established in the regulations in this part, as it deems appropriate or necessary to protect health or to minimize danger to life or property.

SUBPART O--ENFORCEMENT

§ 20.1401 Violations.

(a) The Commission may obtain an injunction or other court order to prevent a violation of the provisions of--

(1) The Atomic Energy Act of 1954, as amended;

(2) Title II of the Energy Reorganization Act of 1974, as amended; or

(3) A regulation or order issued pursuant to those Acts.

(b) The Commission may obtain a court order for the payment of a civil penalty imposed under Section 234 of the Atomic Energy Act:

(1) For violations of--

(i) Sections 53, 57, 62, 63, 81, 82, 101, 103, 104, 107, or 109 of the Atomic Energy Act of 1954, as amended;

(ii) Section 206 of the Energy Reorganization Act;

(iii) Any rule, regulation, or order issued pursuant to the sections specified in paragraph (b)(1)(i) of this section.

(iv) Any term, condition, or limitation of any license issued under the sections specified in paragraph (b)(1)(i) of this section.

(2) For any violation for which a license may be revoked under Section 186 of the Atomic Energy Act of 1954, as amended.

(c) Any. person who willfully violates a provision of the Atomic Energy Act or regulation or order issued under the requirements of that Act may be guilty of a crime and, upon conviction, be punished by fine or imprisonment or both, as provided by law.

APPENDIX A

PROTECTION FACTORS FOR RESPIRATORS[a]

Description[b]	Modes[c]	Protection Factors[d] Particulates only	Protection Factors[d] Particulates, gases, & vapors[e]	Tested & Certified Equipment: National Institute for Occupational Safety and Health / Mine Safety and Health Administration tests for permissibility
I. AIR-PURIFYING RESPIRATORS[f]				
Facepiece, half-mask[g]	NP	10		30 CFR Part 11, Subpart K.
Facepiece, full	NP	50		
Facepiece, half-mask full, or hood	PP	1000		
II. ATMOSPHERE-SUPPLYING RESPIRATORS				
1. Air-line respirator				
Facepiece, half-mask	CF		1000	30 CFR Part 11, Subpart J.
Facepiece, half-mask	D		5	
Facepiece, full	CF		2000	
Facepiece, full	D		5	
Facepiece, full	PD		2000	
Hood	CF		h	
Suit	CF		i	J
2. Self-contained breathing apparatus (SCBA)				
Facepiece, full	D		50	30 CFR Part 11, Subpart H.
Facepiece, full	PD		10,000[k]	
Facepiece, full	RD		50	
Facepiece, full	RP		5,000[l]	
III. COMBINATION RESPIRATORS				
Any combination of air-purifying and atmosphere-supplying respirators		Protection factor for type and mode of operation as listed above		30 CFR Part 11, §11.63(b).

FOOTNOTES

a. For use in the selection of respiratory protective devices to be used only where the contaminants have been identified and the concentrations (or possible concentrations) are known.

b. Only for shaven faces and where nothing interferes with the seal of tight-fitting facepieces against the skin. (Hoods and suits are excepted.)

c. The mode symbols are defined as follows:

CF = continucus flow

D = demand

NP = negative pressure (i.e., negative phase during inhalation)

PD = pressure demand (i.e., always positive pressure)

PP = positive pressure

RD = demand, recirculating (closed circuit)

RP = pressure demand, recirculating (closed circuit)

d.1. The protection factor is a measure of the degree of protection afforded by a respirator, defined as the ratio of the concentration of airborne radioactive material outside the respiratory protective equipment to that inside the equipment (usually inside the facepiece) under conditions of use. It is applied to the ambient airborne concentration to estimate the concentrations inhaled by the wearer according to the following formula:

$$\text{Concentration inhaled} = \frac{\text{Ambient airborne concentration}}{\text{Protection factor}}$$

2. The protection factors apply:

(a) Only for individuals trained in using respirators and wearing properly fitted respirators that are used and maintained under supervision in a well-planned respiratory protective program.

(b) For air-purifying respirators only when high efficiency particulate filters (above 99.97% removal efficiency by thermally generated 0.3 μm dioctyl phthalate (DOP) test or equivalent) are used in atmospheres not deficient in oxygen and not containing radioactive gas or vapor respiratory hazards.

(c) No adjustment is to be made for the use of sorbents against radioactive material in the form of gases or vapors.

(d) For atmosphere-supplying respirators only when supplied with adequate respirable air. Respirable air shall be provided of the quality and quantity required in accordance with NIOSH/MSHA certification (described in 30 CFR Part 11). Oxygen and air shall not be used in the same apparatus.

e. Excluding radioactive contaminants that present an absorption or submersion hazard. For tritium oxide, approximately one-third of the intake occurs by absorption through the skin so that an overall protection factor of less than 2 is appropriate when atmosphere-supplying respirators are used to protect against tritium oxide. If the protection factor for a device is 5 the effective protection factor for tritium is about 1.4; for devices with protection factors of 10 the effective factor for tritium oxide is about 1.7, and for devices with protection factors of 100 or more the effective factor for tritium oxide is about 1.9. Air-purifying respirators are not suitable for protection against tritium oxide. See also footnote i concerning supplied-air suits.

f. Canisters and cartridges shall not be used beyond service-life limitations.

g. Under-chin type only. This type of respirator is not satisfactory for use where it might be possible (e.g., if an accident or emergency were to occur) for the ambient airborne concentrations to reach instantaneous values greater than 10 times the pertinent values in Table 1, Column 3 of Appendix B of this part. This type of respirator is not suitable for protection against plutonium or other high-toxicity materials. The mask is to be tested for fit prior to use, each time it is donned.

h.1. Equipment shall be operated in a manner that ensures that proper air flow-rates are maintained. A protection factor of no more than 1000 may be utilized for tested-and-certified supplied-air hoods when a minimum air flow of 6 cubic feet (0.17 cubic meters) per minute is maintained and calibrated airline pressure gauges or flow measuring devices are used. A protection factor of up to 2000 may be used for tested and certified hoods only when the air flow is maintained at the manufacturer's recommended maximum rate for the equipment, this rate is greater than 6 cubic feet (0.17 cubic meters) per minute, and calibrated airline pressure gauges or flow measuring devices are used.

2. The design of the supplied-air hood or helmet (with a minimum flow of 6 cfm (0.17 m^3 per minute) of air) may determine its overall efficiency and the protection it provides. For example, some hoods aspirate contaminated air into the breathing zone when the wearer works with hands-over-head. This aspiration may be overcome if a short cape-like extension to the hood is worn under a coat or overalls. Other limitations specified by the approval agency shall be considered before using a hood in certain types of atmospheres (see footnote i).

i. Appropriate protection factors shall be determined, taking into account the design of the suit and its permeability to the contaminant under conditions of use. There shall be a standby rescue person equipped with a respirator or other apparatus appropriate for the potential hazards and communications equipment whenever supplied-air suits are used.

j. No approval schedules are currently available for this equipment. Equipment is to be evaluated by testing or on the basis of reliable test information.

k. This type of respirator may provide greater protection and be used as an emergency device in unknown concentrations for protection against inhalation hazards. External radiation hazards and other limitations to permitted exposure, such as skin absorption, must be taken into account in such circumstances.

l. Quantitative fit testing shall be performed on each individual and no more than 0.02% leakage is allowed with this type of apparatus. Perceptible outward leakage of gas from this or any positive pressure self-contained breathing apparatus is unacceptable because service life will be reduced substantially. Special training in the use of this type of apparatus shall be provided to the wearer.

Note 1: Protection factors for respirators as may be approved by the U.S. Bureau of Mines/National Institute for Occupational Safety and Health (NIOSH), according to applicable approvals for respirators for type and mode of use to protect against airborne radionuclides, may be used to the extent that they do not exceed the protection factors listed in this table. The protection factors listed in this table may not be appropriate to circumstances where chemical or other respiratory hazards exist in addition to radioactive hazards. The selection and use of respirators for such circumstances should take into account applicable approvals of the U.S. Bureau of Mines/NIOSH.

Note 2: Radioactive contaminants for which the concentration values in Table 1, Column 3 of Appendix B of this part are based on internal dose due to inhalation may, in addition, present external exposure hazards at higher concentrations. Under these circumstances, limitations on occupancy may have to be governed by external dose limits.

APPENDIX B

ANNUAL LIMITS ON INTAKE (ALIs) AND DERIVED AIR CONCENTRATIONS (DACs) OF RADIONUCLIDES FOR OCCUPATIONAL EXPOSURE; EFFLUENT CONCENTRATIONS; CONCENTRATIONS FOR RELEASE TO SEWERAGE

Introduction

For each radionuclide Table 1 indicates the chemical form which is to be used for selecting the appropriate ALI or DAC value. The ALIs and DACs for inhalation are given for an aerosol with an activity median aerodynamic diameter (AMAD) of 1 μm and for three classes (D,W,Y) of radioactive material, which refer to their retention (approximately days, weeks or years) in the pulmonary region of the lung. This classification applies to a range of clearance half-times for D of less than 10 days, for W from 10 to 100 days, and for Y greater than 100 days. Table 2 provides concentration limits for airborne and liquid effluents released to the general environment. Table 3 provides concentration limits for discharges to sanitary sewer systems.

ED to list other tables

Notation

The values in Tables 1, 2, and 3 are presented in the computer "E" notation. In this notation a value of 6E-02 represents a value of 6×10^{-2} or 0.06, 6E+2 represents 6×10^{2} or 600, and 6E+0 represents 6×10^{0} or 6.

Table 1 "Occupational"

Note that the columns in Table 1 of this appendix captioned "Oral Ingestion ALI," "Inhalation ALI," and "DAC," are applicable to occupational exposure to radioactive material.

The ALIs in this appendix are the annual intakes of given radionuclide by "Reference Man" which would result in either (1) a committed effective dose equivalent of 5 rems (stochastic ALI) or (2) a committed dose equivalent of 50 rems to an organ or tissue (non-stochastic ALI). The stochastic ALIs were derived to result in a risk, due to irradiation of organs and tissues, comparable to the risk associated with deep dose equivalent to the whole body of 5 rems. The derivation includes multiplying the committed dose equivalent to an organ or tissue by a weighting factor, w_T. This weighting factor is the

proportion of the risk of stochastic effects resulting from irradiation of the organ or tissue, T, to the total risk of stochastic effects when the whole body is irradiated uniformly. The values of w_T are listed under the definition of weighting factor in § 20.3. The non-stochastic ALIs were derived to avoid non-stochastic effects, such as prompt damage to tissue or reduction in organ function.

A value of $w_T = 0.06$ is applicable to each of the five organs or tissues in the "remainder" category receiving the highest dose equivalents, and the dose equivalents of all other remaining tissues may be disregarded. The following parts of the GI tract -- stomach, small intestine, upper large intestine, and lower large intestine -- are to be treated as four separate organs.

moved from p 181

Note that the dose equivalents for extremities (hands and forearms, feet and lower legs), skin, and lens of the eye are not considered in computing the committed effective dose equivalent, but are subject to limits that must be met separately.

moved from p 181

When an ALI is defined by the stochastic dose limit, this value alone, is given. When an ALI is determined by the non-stochastic dose limit to an organ, the organ or tissue to which the limit applies is shown, and the ALI for the stochastic limit is shown in parentheses. (Abbreviated organ or tissue designations are used:

LLI wall = lower large intestine wall;
St. wall = stomach wall;
Blad wall = bladder wall; and
Bone surf = bone surface.)

The use of the ALIs listed first, the more limiting of the stochastic and non-stochastic ALIs, will ensure that non-stochastic effects are avoided and that the risk of stochastic effects is limited to an acceptably low value. If, in a particular situation involving a radionuclide for which the non-stochastic ALI is limiting, use of that non-stochastic ALI is considered unduly

conservative, the licensee may use the stochastic ALI to determine the committed effective dose equivalent. However, the licensee shall also ensure that the 50-rem dose equivalent limit for any organ or tissue is not exceeded by the sum of the external deep dose equivalent plus the internal committed dose to that organ (not the effective dose). For the case where there is no external dose contribution, this would be demonstrated if the sum of the fractions of the nonstochastic ALIs (ALI_{ns}) that contribute to the committed dose equivalent to the organ receiving the highest dose does not exceed unity (i.e., Σ (intake (in μCi) of each radionuclide/ALI_{ns}) $\leq$ 1.0). If there is an external deep dose equivalent contribution of H_d then this sum must be less than 1 - (H_d/50) instead of being $\leq$ 1.0.

clarification

> Note that the dose equivalents for extremities (hand and forearms, feet and lower legs), skin, and lens of the are are not considered in computing the committed effective dose equivalent, but are subject to limits that must be met separately.

The derived air concentration (DAC) values are derived limits intended to control chronic occupational exposures. The relationship between the DAC and the ALI is given by:

$$DAC = ALI(\text{in } \mu Ci)/(2000 \text{ hours per working year} \times 60 \text{ minutes/hour} \times 2 \times 10^4 \text{ ml per minute}) = [ALI/2.4 \times 10^9] \mu Ci/ml,$$

where 2×10^4 ml per minute is the volume of air breathed per minute at work by "Reference Man" under working conditions of "light work."

The DAC values relate to one of two modes of exposure: either external submersion or the internal committed dose equivalents resulting from inhalation of radioactive materials. Derived air concentrations based upon submersion are for immersion in a semi-infinite cloud of uniform concentration and apply to each radionuclide separately.

The ALI and DAC values relate to exposure to the single radionuclide named, but also include contributions from the in-growth of any daughter radionuclide produced in the body by the decay of the parent. However, intakes that include both the parent and daughter radionuclides should be treated by the general method appropriate for mixtures.

The value of ALI and DAC do not apply directly when the individual both ingests and inhales a radionuclide, when the individual is exposed to a mixture of radionuclides by either inhalation or ingestion or both, or when the individual is exposed to both internal and external irradiation (see § 20.202). When an individual is exposed to radioactive materials which fall under several of the translocation classifications (i.e., Class D, Class W, or Class Y) of the same radionuclide, the exposure may be evaluated as if it were a mixture of different radionuclides.

It should be noted that the classification of a compound as Class D, W, or Y is based on the chemical form of the compound and does not take into account the radiological half-life of different radioisotopes. For this reason, values are given for Class D, W, and Y compounds, even for very short-lived radionuclides.

Table 2

The columns in Table 2 of this appendix captioned "Effluents," "Air," and "Water," are applicable to the assessment and control of dose to the public, particularly in the implementation of the provisions of § 20.302. The concentration values given in Columns 1 and 2 of Table 2 are equivalent to the radionuclide concentrations which, if inhaled or ingested continuously over the course of a year, would produce a total effective dose equivalent of 0.05 rem (50 millirem or 0.5 millisieverts)

Consideration of non-stochastic limits has not been included in deriving the air and water effluent concentration limits because non-stochastic effects are presumed not to occur at the dose levels established for individual members of the public. For radionuclides, where the non-stochastic limit was governing in deriving the occupational DAC, the stochastic ALI was used in deriving the corresponding airborne effluent limit in Table 2. For this reason, the DAC and airborne effluent limits are not always proportional as they were the previous Appendix B.

added explanatory text

The air concentration values listed in Table 2, Column 1, were derived by one of two methods. For those radionuclides for which the stochastic limit is governing, the occupational stochastic inhalation ALI was divided by 2.4 x 10^9, relating the inhalation ALI to the DAC, as explained above, and then divided by a factor of 300. The factor of 300 includes the following components: a factor of 50 to relate the 5-rem annual occupational dose limit to the 0.1-rem limit for members of the public, a factor of 3 to adjust for the difference in exposure time and the inhalation rate for a worker and that for members of the public., and a factor of 2 to adjust the occupational values (derived for adults) so that they are applicable to other age groups.

For those radionuclides for which submersion (external dose) is limiting, the occupational DAC in Table 1, Column 3, was divided by 219. The factor of 219 is composed of a factor of 50, as described above, and a factor of 4.38 relating occupational exposure for 2,000 hours per year to full-time exposure (8,760 hours per year). Note that an additional factor of 2 for age considerations is not warranted in the submersion case.

The water concentrations were derived by taking the most restrictive occupational stochastic oral ingestion ALI and dividing by 7.3 x 10^7. The factor of 7.3 x 10^7 (ml) includes the following components: the factors of 50 and 2 described above and a factor of 7.3 x 10^5 (ml) which is the annual water intake of "Reference Man."

Note 2 of this appendix provides groupings of radionuclides which are applicable to unknown mixtures of radionuclides. These groupings (including occupational inhalation ALIs and DACs, air and water effluent concentrations and sewerage) require demonstrating that the most limiting radionuclides in successive classes are absent. The limit for the unknown mixture is defined when the presence of the one of the listed radionuclides cannot be definitely excluded as being present either from knowledge of the radionuclide composition of the source or from actual measurements.

added explanatory language

Table 3 "Sewer Disposal"

The monthly average concentrations for release to sanitary sewers are applicable to the provisions in § 20.1003. The concentration values were derived by taking the most restrictive occupational stochastic oral ingestion ALI and dividing by 7.3×10^6(ml). The factor of 7.3×10^6(ml) is composed of a factor of 7.3×10^6(ml), the annual water intake by "Reference Man," and a factor of 10, such that the concentrations, if the sewage released by the licensee were the only source of water ingested by a reference man during a year, would result in a committed effective dose equivalent of 0.5 rem.

LIST OF ELEMENTS

Name	Symbol	Atomic Number	Name	Symbol	Atomic Number
Actinium	Ac	89	Mercury	Hg	80
Aluminum	Al	13	Molybdenum	Mo	42
Americium	Am	95	Neodymium	Nd	60
Antimony	Sb	51	Neptunium	Np	93
Argon	Ar	18	Nickel	Ni	28
Arsenic	As	33	Niobium	Nb	41
Astatine	At	85	Osmium	Os	76
Barium	Ba	56	Palladium	Pd	46
Berkelium	Bk	97	Phosphorus	P	15
Beryllium	Be	4	Platinum	Pt	78
Bismuth	Bi	83	Plutonium	Pu	94
Bromine	Br	35	Polonium	Po	84
Cadmium	Cd	48	Potassium	K	19
Calcium	Ca	20	Praseodymium	Pr	59
Californium	Cf	98	Promethium	Pm	61
Carbon	C	6	Protactinium	Pa	91
Cerium	Ce	58	Radium	Ra	88
Cesium	Cs	55	Radon	Rn	86
Chlorine	Cl	17	Rhenium	Re	75
Chromium	Cr	24	Rhodium	Rh	45
Cobalt	Co	27	Rubidium	Rb	37
Copper	Cu	29	Ruthenium	Ru	44
Curium	Cm	96	Samarium	Sm	62
Dysprosium	Dy	66	Scandium	Sc	21
Einsteinium	Es	99	Selenium	Se	34
Erbium	Er	68	Silicon	Si	14
Europium	Eu	63	Silver	Ag	47
Fermium	Fm	100	Sodium	Na	11
Fluorine	F	9	Strontium	Sr	38
Francium	Fr	87	Sulfur	S	16
Gadolinium	Gd	64	Tantalum	Ta	73
Gallium	Ga	31	Technetium	Tc	43
Germanium	Ge	32	Tellurium	Te	52
Gold	Au	79	Terbium	Tb	65
Hafnium	Hf	72	Thallium	Tl	81
Holmium	Ho	67	Thorium	Th	90
Hydrogen	H	1	Thulium	Tm	69
Indium	In	49	Tin	Sn	50
Iodine	I	53	Titanium	Ti	22
Iridium	Ir	77	Tungsten	W	74
Iron	Fe	26	Uranium	U	92
Krypton	Kr	36	Vanadium	V	23
Lanthanum	La	57	Xenon	Xe	54
Lead	Pb	82	Ytterbium	Yb	70
Lutetium	Lu	71	Yttrium	Y	39
Magnesium	Mg	12	Zinc	Zn	30
Manganese	Mn	25	Zirconium	Zr	40
Mendelevium	Md	101			

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Release to Sewers
			Col. 1- Oral Ingestion ALI (μCi)	Col. 2- Inhalation ALI (μCi)	Col. 3 DAC (μCi/ml)	Col. 1- Air (μCi/ml)	Col. 2- Water (μCi/ml)	Monthly Average (μCi/ml)
1	Hydrogen-3	Water, DAC includes skin absorption	8E+4	8E+4	2E-5	1E-7	1E-3	1E-2
4	Beryllium-7	W, all compounds except those given for Y	4E+4	2E+4	9E-6	3E-8	6E-4	6E-3
		Y, oxides, halides, and nitrates	-	2E+4	8E-6	3E-8	-	-
4	Beryllium-10	W, see ^{7}Be	1E+3 LLI wall (1E+3)	2E+2	6E-8	2E-10	-	-
		Y, see ^{7}Be	-	1E+1	6E-9	2E-11	2E-5	2E-4
6	Carbon-11[2]	Monoxide	-	1E+6	5E-4	2E-6	-	-
		Dioxide	-	6E+5	3E-4	9E-7	-	-
		Compounds	4E+5	4E+5	2E-4	6E-7	6E-3	6E-2
6	Carbon-14	Monoxide	-	2E+6	7E-4	2E-6	-	-
		Dioxide	-	2E+5	9E-5	3E-7	-	-
		Compounds	2E+3	2E+3	1E-6	3E-9	3E-5	3E-4

APPENDIX D

UNITED STATES NUCLEAR REGULATORY COMMISSION REGIONAL OFFICES

	Address	Telephone (24 hours)
Region I: Connecticut, Deleware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont.	USNRC, Region I 475 Allendale Road King of Prussia, PA 19406	(215) 337-5000, (FTS) 346-5000.
Region II: Alabama, Florida, Georgia Kentucky, Mississippi, North Carolina, Puerto Rico, South Carolina, Tennessee, Virginia, Virgin Islands, and West Virginia.	USNRC, Region II 101 Marietta Street, NW Suite 2900 Atlanta, GA 30323	(404) 331-4503, (FTS) 841-4503.
Region III: Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, and Wisconsin.	USNRC, Region III 799 Roosevelt Road Glen Ellyn, IL 60137	(708) 790-5500, (FTS) 388-5500.
Region IV: Arkansas, Colorado, Idaho, Kansas, Louisiana, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, Utah, and Wyoming.	USNRC, Region IV 611 Ryan Plaza Drive Suite 1000 Arlington, TX 76011	(817) 860-8100 (FTS) 728-8100.
Region IV: Field Office	USNRC, Region IV Uranium Recovery Field Office 730 Simms Street, Suite 100a Golden, CO 80401 Mail: P.O. Box 25325 Denver, CO 80225	(303) 236-2805, (FTS) 776-2805.
Region V: Alaska, Arizona, California, Hawaii, Neveda, Oregon, Washington, and U.S. territories and possessions in the Pacific.	USNRC, Region V 1450 Maria Lane Suite 210 Walnut Creek, CA 94596	(415) 943-3700, (FTS) 463-3700.

APPENDIX E [RESERVED]

APPENDIX F

REQUIREMENTS FOR LOW LEVEL-WASTE TRANSFER FOR
DISPOSAL AT LAND DISPOSAL FACILITIES AND MANIFESTS

I. MANIFEST

The shipment manifest shall contain the name, address, and telephone number of the person generating the waste. The manifest shall also include the name, address, and telephone number or the name and EPA hazardous waste identification number of the person transporting the waste to the land disposal facility. The manifest must also indicate as completely as practicable: a physical description of the waste, the volume, radionuclide identity and quantity, the total radioactivity, and the principal chemical form. The solidification agent must be specified. Waste containing more than 0.1% chelating agents by weight must be identified and the weight percentage of the chelating agent estimated. Wastes classified as Class A, Class B, or Class C in § 61.55 of this chapter must be clearly identified as such in the manifest. The total quantity of the radionuclides H-3, C-14, Tc-99, and I-129 must be shown. The manifest required by this paragraph may be shipping papers used to meet Department of Transportation or Environmental Protection Agency regulations or requirements of the receiver, provided all the required information is included. Copies of manifests required by this section may be legible carbon copies or legible photocopies.

II. CERTIFICATION

The waste generator shall include in the shipment manifest a certification that the transported materials are properly classified, described, packaged, marked, and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation and the

Commission. An authorized representative of the waste generator shall sign and date the manifest.

III. CONTROL AND TRACKING

A. Any generating licensee who transfers radioactive waste to a land disposal facility or a licensed waste collector shall comply with the requirements in paragraphs A.1 through 8 of this section. Any generating licensee who transfers waste to a licensed waste processor who treats or repackages waste shall comply with the requirements of paragraphs A.4 through 8 of this section. A licensee shall:

Prepare all wastes so that the waste is classified according to § 61.55 of this chapter and meets the waste characteristics requirements in § 61.56 of this chapter.,

2. Label each package of waste to identify whether it is Class A waste, Class B waste, or Class C waste, in accordance with § 61.55 of this chapter;

3. Conduct a quality control program to ensure compliance with §§ 61.55 and 61.56 of this chapter; the program must include management evaluation of audits;

4. Prepare shipping manifests to meet the requirements of section I and II of this appendix;

5. Forward a copy of the manifest to the intended recipient, at the time of shipment, or deliver to a collector at the time the waste is collected, obtaining acknowledgment of receipt in the form of a signed copy of the manifest or equivalent documentation from the collector;

6. Include one copy of the manifest with the shipment;

7. Retain a copy of the manifest and documentation of acknowledgment of receipt as the record of transfer of licensed material as required by Parts 30, 40, and 70 of this chapter; and

8. For any shipments or any part of a shipment for which acknowledgment of receipt has not been received within the times set forth in this section, conduct an investigation in accordance with paragraph E of this appendix.

B. Any waste collector licensee who handles only prepackaged waste shall:

1. Acknowledge receipt of the waste from the generator within 1 week of receipt by returning a signed copy of the manifest or equivalent documentation.,

2. Prepare a new manifest to reflect consolidated shipments; the new manifest shall serve as a listing or index for the detailed generator manifests. Copies of the generator manifests shall be a part of the new manifest. The waste collector may prepare a new manifest without attaching the generator manifests, provided the new manifest contains for each package the information specified in section I of this appendix. The collector licensee shall certify that nothing has been done to the waste that would invalidate the generator's certification; 267 p10

3. Forward a copy of the new manifest to the land disposal facility operator at the time of shipment;

4. Include the new manifest with the shipment to the disposal site.,

5. Retain a copy of the manifest and documentation of acknowledgment of receipt as the record of transfer of licensed material as required by Parts 30, 40, and 70 of this chapter, and retain information from generator manifest until disposition is authorized by the Commission; and

6. For any shipments or any part of a shipment for which acknowledgment of receipt is not received within the times set forth in this section, conduct an investigation in accordance with paragraph E of this section.

C. Any licensed waste processor who treats or repackages wastes shall:

1. Acknowledge receipt of the waste from the generator within 1 week of receipt by returning a signed copy of the manifest or equivalent documentation,

2. Prepare a new manifest that meets the requirements of sections I and II of this appendix. Preparation of the new manifest reflects that the processor is responsible for the waste; 267 p10

3. Prepare all wastes so that the waste is classified according to § 61.55 of this chapter and meets the waste characteristics requirements in § 61.56 of this chapter;

4. Label each package of waste to identify whether it is Class A waste, Class B waste, or Class C waste, in accordance with §§ 61.55 and 61.57 of this chapter;

5. Conduct a quality control program to ensure compliance with §§ 61.55 and 61.56 of this chapter. The program shall include management evaluation of audits,

6. Forward a copy of the new manifest to the disposal site operator or waste collector at the time of shipment, or deliver to a collector at the time the waste is collected obtaining acknowledgment of receipt in the form of a signed copy of the manifest or equivalent documentation by the collector.,

7. Include the new manifest with the shipment;

8. Retain copies of original manifests and new manifests and documentation of acknowledgment of receipt as the record of transfer of licensed material required by Parts 30, 40, and 70 of this chapter; and

9. For any shipment or part of a shipment for which acknowledgment is not received within the times set forth in this section, conduct an investigation in accordance with paragraph E of this section.

D. The land disposal facility operator shall:

1. Acknowledge receipt of the waste within 1 week of receipt by returning a signed copy of the manifest or equivalent documentation to the shipper. The shipper to be notified is the licensee who last possessed the waste and transferred the waste to the operator. The returned copy of the manifest or equivalent documentation shall indicate any discrepancies between materials listed on the manifest and materials received.

2. Maintain copies of all completed manifests or equivalent documentation until the Commission authorizes their disposition., and

3. Notify the shipper (i.e., the generator, the collector, or processor) and the Administrator of the nearest Commission Regional Office listed in Appendix D to this part when any shipment or part of a shipment has not arrived within 60 days after the advance manifest was received.

E. Any shipment or part of a shipment for which acknowledgment is not received within the times set forth in this section must:

1. Be investigated by the shipper if the shipper has not received notification or receipt within 20 days after transfer; and

2. Be traced and reported. The investigation shall include tracing the shipment and filing a report with the nearest Commission Regional Office listed

in Appendix D to this part. Each licensee who conducts a trace investigation shall file a written report with the appropriate NRC Regional Office within 2 weeks of completion of the investigation.

CONFORMING AMENDMENTS

The following amendments to other parts of Chapter I of Title 10 generally update citations to 10 CFR Part 20 that are found in these other parts of the NRC regulations. Two amendments are particularly important as they go beyond updating cross-reference citations. The amendment to 10 CFR Part 2 Appendix C updates and modifies the examples of the severity levels associated with violations of 10 CFR Part 20. Because Appendix C relates to administrative policy of the Commission and because the listed violations are used as examples of different severity levels and are not all-inclusive, the Commission is issuing these Part 2 amendments in final form without public comment. [?]

PART 2- RULES OF PRACTICE

2. The authority citation for Part 2 continues to read in part as follows:

Authority: Sec. 161, 68 Stat. 948, as amended (42 U.S.C. 2201); sec. 201, 88 Stat. 1242, as amended (42 U.S.C.5841).

3. Supplement IV -- Severity Categories of Appendix C to 10 CFR Part 2 is amended to read as follows:

Appendix C--General Statement of Policy and Procedures for NRC Enforcement Actions

* * * * *

E

A. Severity I -- Violations involving for example:

1. Single radiation exposure of a worker in excess of 25 rems total effective dose equivalent, 75 rems to the lens of the eye, or 250 rads to the skin of the whole body, or to the feet, ankles, hands or forearms, or to any other organ or tissue.,

2. Single radiation exposure of the embryo/fetus of a declared pregnant woman in excess of 2.5 rems total effective dose equivalent.,

3. Single radiation exposure of a minor in excess of 2.5 rems total effective dose equivalent, 7.5 rems to the lens of the eye, or 25 rems to the skin of the whole body, or to the feet, ankles, hands or forearms, or to any other organ or tissue;

4. Annual exposure of a member of the public in excess of 2.5 rems total effective dose equivalent;

5. Release of radioactive material to an unrestricted area at concentrations in excess of 50 times the limits for members of the public in Appendix B, Table 2 of 10 CFR Part 20; or

6. Disposal of licensed material in quantities or concentrations in excess of 10 times the limits of 10 CFR 20.1003.

B. Severity II -- Violations involving for example:

1. Single radiation exposure of a worker in excess of 10 rems total effective dose equivalent, 30 rems to the lens of the eye, or 100 rems to the skin of the whole body, or to the feet, ankles, hands or forearms, or to any other organ or tissue.,

[15] Personnel overexposures and associated violations, incurred during a life-saving effort, will be treated on a case-by-case basis.

2. Single radiation exposure of the embryo/fetus of a declared pregnant woman in excess of 1.0 rem total effective dose equivalent;

3. Single radiation exposure of a minor in excess of 1 rem total effective dose equivalent; 3.0 rems to the lens of the eye, or 10 rems to the skin of the whole body, or to the feet, ankles, hands or forearms, or to any other organ or tissue.,

4. Annual exposure of a member of the public in excess of 0.5 rem total effective dose equivalent;

5. Release of radioactive material to an unrestricted area at concentrations in excess of 10 times the limits for members of the public in Appendix B, Table 2 of 10 CFR Part 20;

6. Disposal of licensed material in quantities or concentrations in excess of five times the limits of 10 CFR 20.1003., or

7. Failure to make an immediate notification as required by 10 CFR 20.1202(a)(1) or (a)(2).

C. Severity III -- Violations involving for example:

1. Single radiation exposure of a worker in excess of 5 rems total effective dose equivalent, 15 rems to the lens of the eye, or 50 rems to the skin of the whole body or to the feet, ankles, hands or forearms, or to any other organ or tissue;

2. Single radiation exposure of the embryo/fetus of a declared pregnant woman in excess of 0.5 rem total effective dose equivalent;

3. Single radiation exposure of a minor in excess of 0.5 rem total effective dose equivalent; 1.5 rems to the lens of the eye, or 5 rems to the skin of the whole body, or to the feet, ankles, hands or forearms, or to any other organ or tissue;

4. Worker exposure above regulatory limits when such exposure reflects a programmatic (rather than an isolated) weakness in the radiation control program;

5. Annual exposure of a member of the public in excess of 0.1 rem total effective dose equivalent (except when operation up to 0.5 rem a year has been approved by the Commission under § 20.301(c));

6. Release of radioactive material to an unrestricted area at concentrations in excess of two times the limits for members of the public in Appendix B to 10 CFR Part 20 (except when operation up to 0.5 rem a year has been approved by the Commission under § 20.301(c)),

7. Failure to make a 24-hour notification required by 10 CFR 20.1202(b) or an immediate notification required by 10 CFR 20.1201(a)(1)(i);

8. Substantial potential for exposures or releases in excess of the applicable limits in 10 CFR Part 20 whether or not such exposure or release occurs (e.g., operation of a radiation facility with a nonfunctioning interlock system or entry into high radiation areas, such as under reactor vessels or in the vicinity of exposed radiographic sources, without having performed an adequate survey),

9. Improper disposal of licensed material not covered in Severity Levels I or II;

10. Release for unrestricted use of contaminated or radioactive material or equipment that poses a realistic potential for exposure of the public to levels or doses exceeding the annual dose limits for member of the public, or that reflects a programmatic (rather than an isolated) weakness in the radiation control program;

11. Conduct of licensee activities by a technically unqualified person; or

12. Significant failure to control licensed material.

D. Severity IV -- Violations involving for example:

1. Exposures in excess of the limits of 10 CFR 20.201, 20.207 or 20.208 not constituting Severity Level I, II or III violations;

2. Release of radioactive material to an unrestricted area at concentrations in excess of the limits for members of the public in Appendix B to 10 CFR Part 20 (except when operation up to 0.5 rem a year has been approved by the Commission under § 20.301(c)),

3. A radiation dose rate in an unrestricted or controlled area in excess of 0.002 rem in any 1 hour (2 millirem/hour) or 50 millirems in a year;

4. Failure to maintain and implement radiation programs to keep radiation exposures as low as is reasonably achievable;

5. Doses to a member of the public in excess of any EPA generally applicable environmental radiation standards, such as 40 CFR Part 190.,

6. Failure to make the 30-day notification required by 10 CFR 20.1201(a)(1)(ii) or 20.1203(a),

7. Failure to make a timely written report as required by 10 CFR 20.1201(b), 20.1204, or 20.1206; or

8. Any other matter that has more than a minor safety, health, or environmental significance.

E. Severity V -- Violations that are of a minor safety, health, or environmental significance.

PART 19 - NOTICES, INSTRUCTIONS, AND REPORTS TO WORKERS; INSPECTIONS

5. The authority citation for Part 19 continues to read in part as follows:

Authority: Sec. 161, 68 Stat. 948, as amended (42 U.S.C. 2201); sec. 201, 88 Stat. 1242, as amended (42 U.S.C.5841).

6. Section 19.3 is amended by revising paragraph (e) to read as follows:

§ 19.3 Definitions.

* * * * *

(e) "Restricted area" means an area, access to which is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials. Restricted area does not include areas used as residential quarters, but separate rooms in a residential building may be set apart as a restricted area.

7. In § 19.13, paragraph (d) is amended by changing the reference to "§20.405 and § 20.408" to read "§§20.1202, 20.1203, 20.1204 or 20.1206" and by revising paragraphs (b), (c), and (e) to read as follows:

§ 19.13 Notifications and reports to individuals.

* * * * *

(b) Each licensee shall advise each worker annually of the worker's dose as shown in records maintained by the licensee pursuant to § 20.1106.

(c) At the request of a worker formerly engaged in licensed activities controlled by the licensee, each licensee shall furnish to the worker a report of the worker's exposure to radiation or radioactive material for each year the worker was required to be monitored under § 20.502. Such report shall be furnished within 30 days from the time the request is made, or within 30 days after the exposure of the individual has been determined by the licensee, whichever is later. This report shall cover the period of time that the worker's activities involved exposure to radiation from radioactive materials

licensed by the Commission and shall include the dates and locations of licensed activities in which the worker participated during this period.

* * * * *

(e) At the request of a worker who is terminating employment with the licensee that involved exposure to radiation or radioactive materials, during the current year, each licensee shall provide at termination to each such worker, or to the worker's designee, a written report regarding the radiation dose received by that worker from operations of the licensee during the current year or fraction thereof. If the most recent individual monitoring results are not available at that time, a written estimate of the dose shall be provided together with a clear indication that this is an estimate.

PART 30 - RULES OF GENERAL APPLICABILITY TO DOMESTIC LICENSING OF BYPRODUCT MATERIAL

8. The authority citation for Part 30 continues to read in part as follows:

Authority: Sec. 161, 68 Stat. 948, as amended (42 U.S.C. 2201); sec. 201, 88 Stat. 1242, as amended (42 U.S.C.5841).

§ 30.51 [Amended].

9. In § 30.51(c)(4), the reference to "§ 20.401(c)" is changed to read "§ 20.1108."

PART 31 - GENERAL DOMESTIC LICENSES FOR BYPRODUCT MATERIAL

10. The authority citation for Part 31 continues to read in part as follows:

Authority: Sec. 161, 68 Stat. 948, as amended (42 U.S.C. 2201), sec. 201, 88 Stat. 1242, as amended (42 U.S.C.5841).

§ 31.5 [Amended].

In § 31.5(c)(10), the reference to "§§ 20.402 and 20.403" is changed to read "§§ 20.1201 and 20.1202."

§ 31.7 [Amended.].

12. In § 31.7(b), the reference to "§§ 20.402 and 20.403" is changed to read "§§ 20.1201 and 20.1202."

§ 31.10 [Amended].

13. In § 31.10(b)(1) the reference to "§ 20.301" is changed to read "§ 20.1001."

14. In § 31.10(b)(3) the reference to "§§ 20.301, 20.402, and 20.403" is changed to read "§§ 20.1001, 20.1201, and 20.1202."

§ 31.11 Amended]

15. In § 31.11(c)(5), the reference to "§ 20.301" is changed to read "§ 20.1001."

16. In § 31.11(f), the reference to "§§ 20.301, 20.402, and 20.403" is changed to read "§§ 20.1001, 20.1201, and 20.1202."

PART 32 - SPECIFIC DOMESTIC LICENSES TO MANUFACTURE OR TRANSFER CERTAIN ITEMS CONTAINING BYPRODUCT MATERIAL

17. The authority citation for Part 32 continues to read in part as follows:

Authority: Sec. 161, 68 Stat. 948, as amended (42 U.S.C. 2201), Sec. 201, 88 Stat. 1242, as amended (42 U.S.C.5841).

18. Section 32.51 is amended by revising paragraphs (a)(2)(ii) and (c) to read as follow:

§ 32.51 Byproduct material contained in devices for use under § 31.5; requirements for license to manufacture or initially transfer.

(a) * * *

(2) * * *

(ii) Under ordinary conditions of handling, storage, and use of the device, the byproduct material contained in the device will not be released or inadvertently removed from the device, and it is unlikely that any person will receive in any period of 1 year a dose in excess of 10 percent of the annual limits specified in § 20.201(a) of this chapter., and

* * * * *

(c) In the event the applicant desires that the general licensee under § 31.5 of this chapter, or under equivalent regulations of an Agreement State, be authorized to install the device, collect the sample to be analyzed by a specific licensee for leakage of radioactive material, service the device, test the on-off mechanism and indicator, or remove the device from installation, the applicant shall include in the application written instructions to be followed by the general licensee, estimated calendar quarter doses associated with such activity or activities, and the bases for these estimates. The submitted information must demonstrate that performance of this activity or activities by an individual untrained in radiological protection, in addition to other handling, storage, and use of devices under the general license, is unlikely to cause that individual to receive in a year a dose in excess of 10 percent of the annual limits specified in § 20.201(a) of this chapter.

§ 32.61 [Amended].

19. In § 32.61(d), the reference to "§ 20.203(a)" is changed to read "§ 20.901(a)."

§ 32.71 [Amended].

20. In § 32.71(c)(2), the reference to "§ 20.203(a)(1)" is changed to read "§ 20.901(a)."

21. In § 32.71(e), the reference to "§ 20.301" is changed to read "§ 20.1001."

PART 34 - LICENSES FOR RADIOGRAPHY AND RADIATION SAFETY REQUIREMENTS FOR RADIOGRAPHIC OPERATIONS

22. The authority citation for Part 34 continues to read in part as follows:

Authority : Sec. 161, 68 Stat. 948, as amended (42 U.S.C. 2201); Sec. 201, 88 Stat. 1242, as amended (42 U.S.C.5841).

§ 34:29 Amended

1

23. In § 34.29(a), the reference to "§ 20.203(c)(2)(ii), (2)(iii), or (4)" is changed to read "§ 20.601(a)(2), (a)(3), or (b)."

§ 34.41 [Amended].

24. In § 34.41(a), the reference to "§ 20.203(c)(2)" is changed to read "§ 20.601(a)(1), (a)(2), or (a)(3)."

§ 34.42 [Amended].

25. In § 34.42, the reference to "§ 20.204(c)" is changed to read "§ 20.903" and the reference to "§ 20.203(b) and (c)(1)" is changed to read "§ 20.902(a) and (b)."

PART 35 - MEDICAL USE OF BYPRODUCT MATERIAL

26. The authority citation for Part 35 continues to read as follows:

Authority: Sec. 161, 68 Stat. 948, as amended (42 U.S.C. 2201), Sec. 201, 88 Stat. 1242, as amended (42 U.S.C.5841).

267
p11

§ 35.92(a).

27. Change reference to "§ 20.301" to "§ 20.1001."

§ 35.315(a)(8)

28. Change reference to "§ 20.401(c)(1)" to "§ 20.1106(a)."

§ 35.415.

29. Change reference to "§ 20.105(b)" to "§ 20.301(a)."

§ 35.630(a)(1).

30. Change reference to "National Bureau of Standards" to "National Institute of Standards and Technology."

§ 35.630(a)(2).

31. Change reference to "National Bureau of Standards" to "National Institute of Standards and Technology."

§ 35.641(a)(2)(i).

32. Change reference to "§ 20.101" to "§ 20.201."

267
p 11

§ 35.641(a)(2)(ii).

33. Change reference to "§ 20.105(b)" to "§ 20.301."

§ 35.641(b)(2).

34. Change reference to "§ 20.501" to "§ 20.1301."

§ 35.643 (a).

35. Change reference to "§ 20.105(b)" to "§ 20.301."

§ 35.643(a)(1).

36. Change reference to "§ 20.105(b)" to "§ 20.301."

§ 35.630(a)(2).

37. Change reference to "§ 20.105(a)" to "§ 20.301(c)."

38. Change reference to "§ 20.105(b)" to "§ 20.301(a)."

267 p 11

PART 39 - LICENSES AND RADIATION SAFETY REQUIREMENTS FOR WELL-LOGGING

39. The authority citation for Part 39 continues to read in part as follows:

Authority: Sec. 161, 68 Stat. 948, as amended (42 U.S.C. 2201), Sec. 201, 88 Stat. 1242, as amended (42 U.S.C.5841).

40. In § 39.15(a)(5)(iii)(B), the reference to "§ 20.203" is changed to read ""§ 20.901(a)."

41. In § 39.31(a)(1), the reference to "§ 20.203" is changed to read "§ 20.901(a).

42. In § 39.31(a)(2), the reference to "§ 20.203" is changed to read "§ 20.901(a)."

43. In § 39.77(b), the reference to "§§ 20.402, 20.403, and 20.405" is changed to read "§§ 20.1201 and 20.1203."

PART 40 - DOMESTIC LICENSING OF SOURCE MATERIAL

44. The authority citation for Part 40 continues to read in part as follows:

Authority: Sec. 161, 68 Stat. 948 as amended (42 U.S.C. 2201), Sec. 201, 88 Stat. 1242, as amended (42 U.S.C. 5841).

45. Section § 40.34 is amended by revising paragraph (a)(2) to read as follows:

§ 40.34 Special requirements for issuance of specific licenses.

(a) * * *

(2) The applicant submits sufficient information relating to the design, manufacture, prototype testing, quality control procedures, labeling or marking, proposed uses, and potential hazards of the industrial product or device to provide reasonable assurance that possession, use, or transfer of the depleted uranium in the product or device is not likely to cause any individual to receive in any period of 1 year a radiation dose in excess of 10 percent of the annual limits specified in § 20.201(a) of this chapter; and

* * * * *

§ 40.61 [Amended].

46. In § 40.61(c)(4), the reference to "§ 20.401(c)" is changed to read "§ 20.1108."

Appendix A to Part 40.

47. In the Introduction to Appendix A, the reference to "§ 20.1(c)" is changed to read "§ 20.3."

PART 50 - DOMESTIC LICENSING OF PRODUCTION AND UTILIZATION FACILITIES

48. The authority citation for Part 50 continues to read in part as follows:

Authority: Sec. 161, 68 Stat. 948, as amended (42 U.S.C. 2201); Sec. 201, 88 Stat. 1242, as amended (42 U.S.C.5841).

49. Section 50.34 is amended by revising paragraph (f)(2)(viii) to read as follows:

§ 50.34 Contents of applications; technical information.

* * * * *

(f) * * *

(2) * * *

(viii) Provide a capability to promptly obtain and analyze samples from the reactor coolant system and containment that may contain TID-14844 source term radioactive materials without radiation exposures to any individual exceeding 5 rems to the whole body or 50 rems to the extremities. Materials to be analyzed and quantified include certain radionuclides that are indicators of the degree of core damage (e.g., noble gases, iodines and cesiums, and nonvolatile isotopes), hydrogen in the containment atmosphere, dissolved gases, chloride, and boron concentrations. (II.B.3)

* * * * *

50. In § 50.36a(a), the reference to "§ 20.106" is changed to read "§ 20.301" and paragraph (b) is revised to read as follows:

§ 50.36a Technical specifications on effluents from nuclear power reactors.

* * * *

(b) In establishing and implementing the operating procedures described in paragraph (a) of this section, the licensee shall be guided by the following considerations: Experience with the design, construction, and operation of nuclear power reactors indicates that compliance with the technical specifications described in this section will keep average annual releases of radioactive material in effluents and their resultant committed effective dose equivalents at small percentages of the values specified in § 20.301 of this chapter and in the operating license. At the same time, the licensee is permitted the flexibility of operation, compatible with considerations of health and safety, to assure that the public is provided a dependable source of power even under unusual operating conditions which may temporarily result in releases higher than such small percentages, but still within the dose values specified in § 20.301 of this chapter and in the operating license. It is expected that in using this operational flexibility under unusual operating conditions, the licensee will exert its best efforts to keep levels of radioactive material in

effluents as low as is reasonably achievable. The guides set out in Appendix I provide numerical guidance on limiting conditions for operation for light-water-cooled nuclear power reactors to meet the requirement that radioactive materials in effluents released to unrestricted areas be kept as low as is reasonably achievable.

51. In § 50.72 in paragraph (a), Footnote 1, the reference to "§ 20.205, § 20.403" is changed to read "§ 20.906, § 20.1202," and paragraphs (b)(2)(iv)(A) and (B) are revised to read as follows:

§ 50.72 Immediate notification requirements for operating nuclear power reactors.

* * * * *

(b) * * *

(2) * * *

(iv) (A) Any airborne radioactive release that results in concentrations in unrestricted areas that exceed 20 times the applicable concentration specified in Appendix B, Table 2, Column 1, of Part 20 of this chapter, when averaged over a time period of 1 hour.

(B) Any liquid effluent release that exceeds 20 times the applicable concentration specified in Appendix B, Table 2, Column 2, of Part 20 of this chapter at the point of entry into the receiving waters (i.e., unrestricted area) for all radionuclides except tritium and dissolved noble gases, when averaged over a time period of 1 hour. (Immediate notifications made under this paragraph also satisfy the requirements of paragraphs (a)(2) and (b)(2) of § 20.1202 of this chapter).

52. Section 50.73 is amended by revising paragraphs (a)(2)(viii)(A) and (B) and (ix) to read as follows:

§ 50.73 Licensee event report system.

(a) * * *

(2) * * *

(viii)(A) Any airborne radioactivity release that exceeded 20 times the applicable concentrations specified in Appendix B, Table 2, Column 1, of Part

20 of this chapter in unrestricted areas, when averaged over a time period of 1 hour.

(B) Any liquid effluent release that exceeded 20 times the applicable concentrations specified in Appendix B, Table 2, Column 2, of Part 20 of this chapter at the point of entry into the receiving water (i.e., unrestricted area) for all radionuclides except tritium and dissolved noble gases, when averaged over a time period of 1 hour.

(ix) Reports submitted to the Commission in accordance with paragraph (a)(2)(viii) of this section also meet the effluent release reporting requirements of § 20.1203(a)(3) of this chapter.

* * * * *

PART 61 - LICENSING REQUIREMENTS FOR LAND DISPOSAL OF RADIOACTIVE WASTE

53. The authority citation for Part 61 continues to read in part as follows:

Authority: Sec. 161, 68 Stat. 948, as amended (42 U.S.C. 2201); Sec. 201, 88 Stat. 1242, as amended (42 U.S.C.5841).

§ 61.52 [Amended].

54. In § 61.52(a)(6), the reference to "§ 20.105" is changed to read "§§ 20.301 and 20.302."

PART 70 - DOMESTIC LICENSING OF SPECIAL NUCLEAR MATERIAL

55. The authority citation for Part 70 continues to read in part as follows:

Authority: Sec. 161, 68 Stat. 948, as amended (42 U.S.C. 2201), Sec. 201, 88 Stat. 1242, as amended (42 U.S.C.5841).

§ 70.51 Amended].

56. In § 70.51(b)(6), the reference to "§ 20.401(c)" is changed to read "§ 20.1108."

Dated at Rockville, Maryland, this _____ day of _____ 1990.

For the Nuclear Regulatory Commission.

_____

Samuel J. Chilk,

Secretary of the Commission.

ENCLOSURE C

FINAL REGULATORY ANALYSIS

PNL-6712

Technical Evaluation Report

Regulatory Analysis for the Revision of 10 CFR Part 20

S. E. Merwin
J. A. MacLellan
M. F. Mullen
K. L. Swinth
J. J. Tawil
R. J. Traub
M. G. Woodruff

November 1988

Prepared for
Division of Regulatory Applications
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
under Contract DE-AC06-76RLO 1830
NRC FIN B2918

Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
by Battelle Memorial Institute

Battelle

PNL-6712

PNL-6712

TECHNICAL EVALUATION REPORT

REGULATORY ANALYSIS FOR THE REVISION OF 10 CFR PART 20

S. E. Merwin
J. A. MacLellan
M. F. Mullen
K. L. Swinth
J. J. Tawil
R. J. Traub
M. G. Woodruff

November 1988

Prepared for
Division of Regulatory Applications
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
under Contract DE-AC06-76RLO 1830
NRC FIN B2918

Pacific Northwest Laboratory
Richland, Washington

ABSTRACT

The revised 10 CFR Part 20, "Standards for Protection Against Radiation," would have substantial impacts on both U.S. Nuclear Regulatory Commission (NRC) and Agreement State licensees. It is estimated that the revision will cost licensees over $170 million (present value); more than half of these costs are related to the new requirement to sum external and internal doses to demonstrate compliance with the annual whole-body effective dose equivalent limit of 5 rem. Fuel fabrication and processing facilities will incur significant costs to reduce levels of airborne uranium to below the applicable derived air concentrations (DACs). The revision would also have substantial benefits, most notably by reducing doses to both workers and the unborn. Of the $44 million (present value) in benefits identified in this analysis, over 80% are related to dose reductions. There were large uncertainties in these estimates, however, and the actual value of the benefit from the reduced doses could be much lower. Although the quantified benefits from the revision do not appear to outweigh the costs, many benefits identified in this analysis were not quantified and their consideration could favor revising 10 CFR Part 20 as planned.

EXECUTIVE SUMMARY

STATEMENT OF THE PROBLEM

The basic philosophy and scientific basis for the present 10 CFR Part 20 is over 30 years old. Newer concepts of radiation protection and updated biological data have rendered the present Part 20 outdated and inconsistent with current recommendations of national and international radiation protection organizations. Both the National Council on Radiation Protection and Measurements (NCRP) and the International Commission on Radiological Protection (ICRP) have published recommendations on limits for exposure to ionizing radiation that are in some ways significantly different from the limits promulgated in the present Part 20. In addition, the Environmental Protection Agency (EPA) has published in the Federal Register (1987) "Radiation Protection Guidance to Federal Agencies for Occupational Exposure," (referred to hereafter as Federal Guidance) signed by the President. This Federal Guidance incorporates the basic elements of both the ICRP and NCRP recommendations. In the past, it has been the Nuclear Regulatory Commission's (NRC's) policy to comply with Federal Guidance promulgated by the EPA.

The present Part 20 is in need of revision in six principal areas to become consistent with the Federal Guidance, ICRP recommendations, and/or NCRP recommendations:

1. Use of the current 3 rem/quarter limit on whole-body exposures allows some (usually older) workers to receive doses greater than 5 rem/yr. The Federal Guidance includes an annual whole-body effective dose equivalent limit of 5 rem.

2. Under the current Part 20, internal doses are not included in the assessment of whole-body dose. It is possible for a worker to legally receive internal doses from some radionuclides that are equivalent to whole-body doses of 10 rem or more (using the newer ICRP method for risk assessment) in addition to annual external doses of 12 rem. Because the effective whole-body dose limit of 5 rem, as stated in the Federal Guidance, includes the sum of internal and external doses, under the current Part 20 a worker can legally receive an effective whole-body dose equivalent that is four or more times higher than the limit recommended in the Federal Guidance.

3. The current Part 20 limits on intake for some radionuclides do not reflect recent biological information or models of radionuclide retention and consequent risk. As a result, the current limits are too high for most alpha-emitting radionuclides and too low for most other radionuclides. The associated errors approach or exceed one order of magnitude in many cases.

4. The current Part 20 dose limits for specific organs and parts of the body are not consistent with recent recommendations of the ICRP and NCRP.

5. The current Part 20 does not promulgate a dose limit for the embryo/fetus, even though such a limit is addressed in both an NRC Regulatory Guide and staff position paper. Recent studies suggest that the embryo/fetus is more biologically sensitive to radiation-induced damage from ionizing radiation, and the current dose limits for adults may not ensure adequate protection of the unborn. The Federal Guidance includes a dose limit of 0.5 rem to the embryo/fetus.

6. For licensees not covered by the Uranium Fuel Cycle Standard (40 CFR 190) or the Clean Air Act Standard (40 CFR 61), there is no explicitly stated annual dose limit for individual members of the public in the current Part 20. Although the Federal Guidance does not include such a limit, the NCRP recommends an annual dose limit of 100 mrem for continuing long term exposures.

OBJECTIVES

The principal objective of revising Part 20 is to make the NRC's "Standards for Protection Against Radiation" consistent with the recommendations of national (NCRP and EPA) and international (ICRP) organizations responsible for providing radiation protection standards. The ICRP and NCRP recommendations serve as the primary scientific basis for federal standards for protection against radiation. Also, as a matter of policy, the former Atomic Energy Commission (AEC) and the NRC have considered past Federal Radiation Council (FRC) and EPA federal guidance as binding and have implemented the guidance in their regulations.

The revision of Part 20 was also prepared to satisfy other objectives of the NRC. The revision would resolve several petitions for rulemaking and rulemaking proceedings that are still pending. These include limitation of dose to the embryo/fetus (NPRM, 1-3-75), deletion of the 5(N-18) dose-averaging formula (NPRM, 2-20-79) and petitions to lower dose limits (PRM-20-6 and PRM-20-6A). The revision would also correct some errors and inconsistencies in the current Part 20.

ALTERNATIVES

This regulatory analysis focused on the consequences of the planned revision of Part 20. This alternative and others available to the NRC are described below.

Alternative 1: Revise Part 20 as Planned

Adoption of this alternative would result in a comprehensive revision of 10 CFR Part 20. This would be the final step in a process initiated by the NRC almost 10 years ago to incorporate the recommendations of the ICRP into the rule. The revision would also incorporate many of the recent recommendations of the NCRP and would be consistent with the recent Federal Guidance.

Alternative 2: No Action

Under this alternative, the NRC would terminate the existing rulemaking, publish a notice to this effect in the Federal Register, and initiate individual rulemaking actions as the situation demands. This would leave the principles underlying the current Part 20 in place and the rule would be inconsistent with ICRP and NCRP recommendations as well as the Federal Guidance.

Alternative 3: Modify the Revision and Proceed with the Rulemaking

Under this alterative, the NRC would modify the current revision to reduce the costs identified in this regulatory analysis. Several provisions of the revision could be modified to lessen the impact on licensees; however, some of these modifications would compromise the primary benefits of the revision.

Alternative 4: Incorporate Only Those Provisions Necessary for Compliance with the Federal Guidance

Adoption of this alternative would require an extensive modification of the revision. The modified revision would be consistent with the Federal Guidance but would not contain some of the changes present in the currently planned revision.

CONSEQUENCES

Alternative 1: Revise Part 20 as Planned

This alternative was the basis for the analysis provided in this report. The present value of the costs of the revision of Part 20 was estimated to be $170,000,000, based on 1989 dollars, a discount rate of 10%, and a 30-year period. This estimate includes all costs that will be incurred in response to the promulgation of Part 20. If only those costs thought to be necessary for compliance are included in the cost estimate, this value would be reduced by about $50 million.

Approximately 70% of the estimated costs of the revision are related to the revised provisions for monitoring, evaluating and recording internal doses. Table S.1 provides a breakdown of the costs by section of the rule.

The greatest impact of the revision is expected to be sustained by fuel fabrication facilities, where both the new Derived Air Concentration (DAC) values for uranium and the requirement to control intakes based on DACs and Annual Limits on Intakes (ALIs) will necessitate engineering modifications to reduce airborne uranium levels. It is estimated that 44% of the costs of the revision of Part 20 will be incurred by fuel fabrication facilities. Commercial nuclear power plants, medical facilities, academic/research institutions, and manufacturing and distribution facilities will incur an estimated 36%, 13%, 3%, and 2% of the costs of the revision, respectively. Other facilities would incur relatively insignificant costs. The costs to

TABLE 5.1. Costs Incurred by Section of the Final Rule

Section	Description	Present Value, $ Millions
§20.201	Occupational Dose Limits	12[a]
§20.202, 20.204	Summation of Internal/External Dose	96[a]
§20.208	Dose Limit for the Embryo/Fetus	5.2[a]
§20.502	Conditions Requiring Individual Monitoring	1.4
§20.1106	Records of Individual Monitoring	20[a]
§20.1107	Records of Doses to the Public	3.9
§20.1206	Reports of Personnel Monitoring	11[a]
----	Personnel Training	10
----	Revision of Procedures	10
----	NRC Inspector Training/Procedures	1.1
		170

(a) These costs are directly related to specific recommendations in the Federal Guidance. A total of $144 million, or 85% of the quantified costs of the revision are directly related to those recommendations.

the NRC were estimated to be $2,900,000, or about 2% of the total cost of the revision. Tables S.2 and S.3 provide a summary of the quantified costs by facility type.

The benefits of revising Part 20 include both quantifiable and unquantifiable components. One of the principal benefits of the revision is that it would make NRC regulations consistent with ICRP and NCRP recommendations and the recent Federal Radiation Protection Guidance. This benefit is significant but cannot be measured in dollars. Other benefits of revising Part 20 are more readily quantified. These quantified benefits included an annual savings of $880,000 in operating costs and reduced annual doses of 1200 rem and 300 rem to adult workers and the unborn, respectively. The present value of the quantified benefits was estimated to be $44,000,000, over 80% of which was related to dose savings. The present value of the estimated dose savings was highly dependent on several assumptions, including the value of both avoiding a rem to an adult worker and avoiding a rem to a fetus ($1000 and $10,000, respectively).

One section of the revision was identified to have benefits that greatly exceeded the associated costs. It was estimated that Section 20.208, "Dose to an Embryo/Fetus," will result in costs of $5,200,000 (present value) to licensees and reduced doses of 300 rem/yr to the unborn. In view of the perceived risk associated with dose to the embryo/fetus, this section of the rule is anticipated to provide a significant net benefit. The anticipated net benefit does not include consideration of the ramifications of the limits with regard to civil rights of female workers.

There were many uncertainties in the cost estimates provided in this report. A sensitivity analysis of the assumptions used to determine the net benefit of the revision suggested that the present value of the net benefit ranges from -$40 million to -$170 million. Based on this quantitative analysis, it appears that the revision of Part 20 does not have a favorable benefit/cost ratio. However, many of the benefits of the revision were not quantified in this analysis, and consideration of these benefits could justify the revision of Part 20 as planned.

Alternative 2: No Action

The primary consequence of this alternative would be that the NRC would not implement the Federal Radiation Protection Guidance. Licensees would be free to voluntarily implement some or all of the recommendations; however, they would not be required to do so by 10 CFR Part 20. Development costs already incurred by the NRC should not be considered as a consequence of this alternative.

Alternative 3: Modify the Revision and Proceed with the Rulemaking

The primary consequences of this alternative would be twofold. First, the modifications would reduce the cost impact on licensees. Second, the modifications would lessen the consistency of the revision with the Federal Guidance. Three potential modifications to the rule are presented.

TABLE S.2. Implementation Costs of the Part 20 Revision by Facility Type

Facility Category	Cost, $ Millions (1989 Dollars) Initial Cost	Annual Cost	Present Value of Costs	Total Licensee Costs, %	
Fuel Fabrication and Processing	33	5.3	75	44.7	(44.7)[a]
Commercial Power Reactors	30	4.0	61	36.4	(81.1)
Medical	7.4	1.8	22	13.1	(94.2)
Academic/Research Institutions	1.8	0.34	4.5	2.7	(96.9)
Manufacturing and Distribution	0.53	0.24	2.6	1.6	(98.5)
Other Measuring Systems	0.31	0.043	0.65	0.4	(98.9)
Research and Test Reactors	0.65	0.004	0.62	0.4	(99.3)
Industrial Radiography	0.29	0.022	0.45	0.3	(99.6)
Well Logging	0.012	0.044	0.39	0.2	(99.8)
All Others	0.081	0.049	0.50	0.3	(100.0)
Total Licensee Costs	74.1	11.8	167.7	100%	
NRC Costs	1.4	0.21	2.9		
Total Costs	75.5	12.0	170.6		

(a) Numbers in parentheses refer to cumulative percentages.

TABLE 5.3. Cost Per Facility and Annualized Cost to Implement the Part 20 Revision

Facility Category	Number	Present Value of Costs, $ Millions	Present Value of Cost Per Facility, $ Thousands	Annualized Cost Per Facility, $ Thousands/yr(a)
Fuel Fabrication and Processing	14	75	5,400	570
Commercial Power Reactors	109	61	560	59
Medical	6,506	22	3.4	0.36
Academic/Research Institutions	1,556	4.5	2.9	0.31
Manufacturing and Distribution	965	2.6	2.7	0.29
Other Measuring Systems	5,060	0.65	0.13	0.014
Research and Test Reactors	80	0.62	7.8	0.82
Industrial Radiography	851	0.45	0.53	0.056
Well Logging	454	0.39	0.86	0.091
All Others	1,752	0.50	0.29	0.030
All Facilities	17,347	168	9.68	1.03

(a) Annualized cost factor (capital recovery factor) for 30 years at a discount rate of 10% = 0.106.

Reintroduce the provision for long-lived radionuclides. It has previously been reported that the provision present in the proposed rule would eliminate the need for facility modifications at fuel fabrication facilities. In short, this provision allowed some licensees to calculate effective dose equivalent based on annual effective dose equivalent rather than committed effective dose equivalent for intakes of radionuclides having long effective half-lives.

However, it appears that this provision would not eliminate the need for facility modifications even if they were required without the provision. That is because the provision specifically stated that a licensee must operate the facility such that "any individual is unlikely to have an intake from occupational exposure in one year in excess of the ALI value." In effect, the provision would allow licensees to calculate doses differently but not operate the facilities differently.

Another important factor is that it is likely that major facility modifications will not be required in all cases. Currently, most fuel fabrication facilities operate with airborne uranium concentrations at 10% to 25% of current Maximum Permissible Concentration (MPC) values; under the revision, licensees would be operating at about 50% to 125% of the DAC values. Apparently, licensees feel that this would be unacceptable. Based on the analysis in this report, however, very few workers would exceed the annual whole-body effective dose equivalent limit at these levels. For those who would, an increased use of respirators or appropriate job rotations would eliminate overexposures. Individuals approaching the dose limits would be identified well in advance through air monitoring.

The reason that licensees would likely be unwilling to operate at air concentrations near 1 DAC is that under the present system of limitation, MPCs are often considered as limits and it is likely that the DACs will be incorrectly considered as limits as well. However, ALIs are the principal concern, and if particle size studies, studies on worker stay times in high-concentration areas, or solubility studies would show that workers can work safely under existing conditions, then proper use of the ALARA principle mandates that these studies be done. It is concluded that the provision is inconsistent with the Federal Guidance and would not result in major cost reductions in any case. Costs could be more effectively reduced through promotion of the concept that DACs need not be considered limits in all cases.

Remove the requirement to provide individual dose records to individuals. This modification would reduce the costs of the revision by an estimated $9.1 million (present value). Because no significant quantifiable benefits were identified from this requirement, this modification would be cost-beneficial; however, it would be inconsistent with the Federal Guidance.

Revise Section 20.1106, "Records of Individual Monitoring Results." Approximately 12% of the costs of the revision will be related to this requirement. Licensees will be required to revise recordkeeping procedures to allow the proper assessment and recording of internal doses. Because few workers receive significant internal doses, these costs appear to be excessive. Some

of these costs could be alleviated by relaxing the requirements for documenting internal exposures on NRC Form 5. However, this would be inconsistent with the recordkeeping requirements in the Federal Guidance.

Alternative 4: Incorporate Only Those Provisions Necessary for Compliance with the Federal Guidance

This alternative would result in a complete overhaul of the current Part 20 revision. The revision would be rewritten to include only those provisions necessary for compliance with the Federal Guidance. The consequences would essentially be the same as the consequences of Alternative 1 because most of the costs and benefits of the planned revision are associated with provisions necessary for compliance with the Federal Guidance. Considering the costs of the revision that were unquantified, however, especially the costs associated with the revised limits for disposal to sewers, significant cost savings could be realized through this alternative.

DECISION RATIONALE

Of the four alternatives, only Alternative 2 (no action) appears to be nonviable. Adoption of this alternative would allow the NRC's "Standards for Protection Against Radiation" (10 CFR Part 20) to remain inconsistent with the Federal Radiation Protection Guidance. This would disregard NRC policy and would contradict previous Commission comments to the EPA supporting development of the Federal Guidance.

Alternative 1 (revise Part 20 as planned) would incorporate both the Federal Radiation Protection Guidance and the ICRP and NCRP recommendations on limiting exposure to ionizing radiation. The cost of this alternative to licensees and regulatory agencies is estimated to be approximately $170 million (present value). However, adoption of the alternative would benefit society by reducing occupational exposures to both adult workers and the unborn being carried by pregnant workers. It was estimated that this alternative would result in reduced doses to workers of 1200 rem/yr and reduced doses to embryos/fetuses of 300 rem/yr. The present value of the benefits of the revision depends on the dollar values assigned to both adult and fetal doses and whether health effects were discounted; based on the assumptions used in this report, the present value was estimated to be $44 million. Although the quantified benefits from this alternative do not appear to outweigh the costs, many benefits identified in this analysis were not quantified and their consideration could favor the adoption of this alternative. Also, note that relatively large uncertainties may be associated with the estimates provided in this analysis.

Alternative 3 (modify the revision and proceed with the rulemaking) is viable, provided that the modifications do not compromise the benefits from the revision. Each potential modification identified in the previous section would result in cost savings but would lessen the consistency of the revision with the Federal Guidance. Whether the individual modifications should be adopted depends primarily on subjective considerations of these competing factors.

Alternative 4 (incorporate only those provisions necessary for compliance with the Federal Guidance) may be desirable depending on whether the associated delay would be acceptable in view of the reduced costs. Of the costs identified in the analysis of Alternative 1, only a small fraction could be avoided by adoption of this alternative. However, this alternative would avoid many of the potential costs that were not quantified. Essentially all of the primary benefits associated with Alternative 1 would also be realized by adoption of Alternative 4.

IMPLEMENTATION

Alternative 1: Revise Part 20 as Planned

Considering that NRC planning has been based on adoption of this alternative, Alternative 1, if implemented, would probably result in publication of the final rule by December 31, 1988. The NRC would also allow a 5-year implementation period retroactive to the date that the proposed rule was published (January 9, 1986). This would effectively allow licensees until January 9, 1991, to implement the provisions of the revision. Granting a longer period of implementation, e.g., 5 years from the date the final rule is published, would allow licensees to defer the costs of implementation. A longer period of implementation would also provide the NRC with more time to develop and publish regulatory guides in support of the revised rule.

Alternative 3: Modify the Revision and Proceed with the Rulemaking

If implemented, the preferred approach would be to identify the potential modifications and perform a separate cost-benefit analysis for each one. Favorable modifications would be introduced into the revision and unfavorable modifications would be dropped from consideration. Because most of the modifications would result in both reduced costs and reduced consistency with the Federal Guidance, the decisions to include each modification would require a comparison of the cost savings to the perceived importance of consistency with the Federal Guidance. Upon final modification of the rule, the rulemaking would proceed and the final rule would be published. An appropriate implementation period would be granted to licensees, and the NRC would develop and/or revise the regulatory guides required to support the revised rule.

Alternative 4: Incorporate Only Those Provisions Necessary for Compliance with the Federal Guidance

If implemented, this alternative would result in a major interruption to the current schedule for revising Part 20. The preferred approach would be to carefully examine the current revision and eliminate or rewrite the provisions that are not necessary for compliance with the Federal Guidance. Those provisions identified as cost-beneficial but not necessary for compliance with the Federal Guidance should remain in the revision. Once the appropriate changes are made, the revision could be published in the Federal Register. During this period, the NRC could develop and/or revise the regulatory guides required to support the revised rule.

ACKNOWLEDGMENTS

The authors would like to thank the following: Jerry B. Martin, Matthew P. Moeller, and Michael J. Scott for their technical contributions; Jim Weber for editing the report; and Claudia H. Burk, Lisa M. Stoetzel, and Marianna Cross for typing the report. The authors would also like to acknowledge the contributions by Darrell R. Fisher and John P. Corley (retired), who provided thorough technical reviews of the report and made many valuable suggestions.

CONTENTS

ABSTRACT iii

EXECUTIVE SUMMARY v

ACKNOWLEDGMENTS xv

1.0 INTRODUCTION 1.1

1.1 BACKGROUND 1.1

1.2 HISTORY OF PART 20 REVISIONS 1.1

1.3 PURPOSE OF REVISION 1.2

1.4 TECHNICAL APPROACH 1.3

1.5 CONTENTS OF THIS REPORT 1.4

2.0 COMPARISON OF PRESENT PART 20 WITH PART 20 REVISION 2.1

2.1 SUMMARY OF SIGNIFICANT CHANGES REGARDING INTERNAL DOSE ASSESSMENT 2.1

2.1.1 Section 20.202: Compliance with Requirements for Summation of Internal and External Exposures ... 2.1

2.1.2 Section 20.204: Determination of Internal Exposure 2.1

2.1.3 Section 20.502: Conditions Requiring Individual Monitoring of External and Internal Occupational Dose 2.2

2.2 SUMMARY OF SIGNIFICANT CHANGES REGARDING OCCUPATIONAL DOSE LIMITS 2.2

2.2.1 Section 20.201: Occupational Dose Limits for Adults 2.2

2.2.2 Section 20.206: Planned Special Exposures 2.2

2.2.3 Section 20.208: Dose to an Embryo/Fetus 2.3

2.3 SUMMARY OF SIGNIFICANT CHANGES REGARDING LIMITATION OF DOSE TO THE PUBLIC 2.3

2.3.1 Section 20.301: Dose Limits for Individual Members of the Public 2.3

2.3.2 Section 20.302: Compliance with Dose Limits for Individual Members of the Public 2.3

2.4 SUMMARY OF SIGNIFICANT CHANGES REGARDING RECORDKEEPING AND REPORTING REQUIREMENTS 2.3

2.4.1 Section 20.1106: Records of Individual Monitoring Results 2.4

2.4.2 Section 20.1107: Records of Dose to Individual Members of the Public 2.4

2.4.3 Section 20.1206: Reports of Personnel Monitoring .. 2.4

2.5 SUMMARY OF OTHER CHANGES 2.4

2.5.1 Changes Regarding Control of Internal Exposure in Restricted Areas 2.4

2.5.2 Changes Regarding Precautionary Procedures 2.4

2.5.3 Changes Regarding Waste Disposal 2.5

2.5.4 Changes Regarding Recordkeeping Requirements 2.5

2.5.5 Changes Regarding Reporting Requirements 2.5

3.0 CONSEQUENCES OF REVISED DOSE EVALUATION REQUIREMENTS 3.1

3.1 EXTERNAL DOSE EVALUATIONS 3.1

3.2 INTERNAL DOSE EVALUATIONS 3.3

3.2.1 Bioassay 3.4

3.2.2 Air Monitoring 3.4

3.3 DOSE EVALUATION COSTS 3.8

3.4 DISTRIBUTION OF OCCUPATIONAL DOSES 3.13

3.4.1 Fuel Fabrication Facilities 3.13

3.4.2 Other Facilities 3.14

3.5 RECORDKEEPING 3.15

3.6 SUMMARY OF CONSEQUENCES 3.18

4.0 CONSEQUENCES OF REVISED LIMITS 4.1
4.1 OCCUPATIONAL DOSE LIMITS FOR ADULTS 4.1
4.1.1 Whole-Body Dose Equivalent Limits 4.1
4.1.2 Other Limits and Their Consequences 4.8
4.2 PLANNED SPECIAL EXPOSURES 4.9
4.2.1 Use of the Planned Special Exposure Provision 4.9
4.2.2 Effect on Distribution of Doses 4.10
4.2.3 Cost Implications 4.10
4.3 DOSE TO AN EMBRYO/FETUS 4.10
4.3.1 Effect on Distribution of Doses 4.11
4.3.2 Cost Implications 4.12
4.3.3 Other Considerations 4.12
4.4 DOSE LIMIT FOR INDIVIDUAL MEMBERS OF THE PUBLIC 4.13
4.4.1 Effect on Distribution of Doses 4.13
4.4.2 Cost Implications 4.14
4.5 SUMMARY OF CONSEQUENCES 4.14
5.0 CONSEQUENCES OF OTHER CHANGES 5.1
5.1 CONTROL OF INTERNAL EXPOSURE IN RESTRICTED AREAS 5.1
5.2 PRECAUTIONARY PROCEDURES 5.3
5.2.1 Labeling Requirements 5.3
5.2.2 Posting Requirements 5.4
5.2.3 Package Handling Requirements 5.4
5.3 WASTE DISPOSAL 5.4
5.4 RECORDKEEPING REQUIREMENTS 5.5
5.5 REPORTING REQUIREMENTS 5.8
5.5.1 Incident Reports 5.8

5.5.2 Reports of Personnel Monitoring 5.8

5.5.3 Reports to Individuals 5.9

5.6 OTHER CHANGES 5.11

5.6.1 Units of Radiation Dose 5.11

5.6.2 Radiation Protection Programs 5.11

5.6.3 Control of Access to High Radiation Areas 5.12

5.7 SUMMARY OF CONSEQUENCES 5.12

6.0 OTHER CONSEQUENCES OF THE REVISION 6.1

6.1 PERSONNEL TRAINING 6.1

6.2 PROCEDURE REVISIONS 6.3

6.3 NRC COSTS 6.6

6.3.1 Development 6.7

6.3.2 Implementation 6.7

6.3.3 Operation 6.8

6.4 EFFECTS ON SMALL BUSINESSES 6.9

6.5 SUMMARY OF CONSEQUENCES 6.12

7.0 QUALITATIVE BENEFITS FROM REVISING PART 20 ..... 7.1

7.1 POTENTIAL BENEFITS FROM CONSISTENCY WITH NATIONAL AND INTERNATIONAL RECOMMENDATIONS 7.1

7.2 POTENTIAL BENEFITS FROM REVISED MONITORING REQUIREMENTS ... 7.5

7.3 POTENTIAL BENEFITS FROM REVISED RECORDKEEPING/REPORTING REQUIREMENTS 7.6

7.4 POTENTIAL BENEFITS FROM ADDITIONS/REVISIONS TO CURRENT DOSE LIMITS 7.8

7.5 POTENTIAL BENEFITS FROM SUPPLIED GUIDANCE FOR COMPLYING WITH THE REVISION 7.9

7.6 POTENTIAL BENEFITS FROM DOSE LIMITS FOR PREGNANT WOMEN AND EMBRYOS/FETUSES 7.10

7.7 POTENTIAL BENEFITS FROM REVISED LABELING REQUIREMENTS 7.10

8.0 SUMMARY OF COSTS AND BENEFITS 8.1

8.1 COMPENDIUM OF NRC AND AGREEMENT STATE LICENSEES 8.1

8.2 SUMMARY OF COSTS 8.4

8.2.1 Summary by Facility Type 8.6

8.2.2 Summary by Part 20 Section 8.6

8.2.3 Discussion of Uncertainties 8.6

8.3 SUMMARY OF BENEFITS 8.9

8.3.1 Summary by Part 20 Section 8.9

8.3.2 Discussion of Uncertainties 8.9

8.4 SENSITIVITY ANALYSIS 8.10

8.5 CONCLUSIONS 8.11

9.0 REFERENCES 9.1

TABLES

S.1 Costs Incurred by Section of the Final Rule viii

S.2 Implementation Costs of the Part 20 Revision by Facility Type .. x

S.3 Cost Per Facility and Annualized Cost to Implement the Part 20 Revision xi

3.1 Occupational Dose Limits Specified in the Present and Revised Part 20 ..... 3.1

3.2 Annual Limits on Intake of Common Radionuclides Compared to Detection Capabilities for Urinalysis and In Vivo Counting ..... 3.

3.3 Comparison of Part 20 Current and Revised Air Concentration Limits for Certain Radionuclides .....

3.4 Estimated Costs of Increased Recordkeeping Requirements Resulting from the Revised Dose Evaluation Requirements 3.17

3.5 Summary of Consequences of the Revised Dose Evaluation Requirements 3.18

4.1 Doses Received by Licensee Employees in 1984 ..... 4.2

4.2 Number of Licensee Employees Reported to Have Received Doses Approaching or Exceeding 5 rem in 1979 ..... 4.3

4.3 Adjusted Number of Employees Who Received Doses >5 rem in 1979 and 1984 ..... 4.5

4.4 Number of Women Reported to Have Received Doses >0.5 rem in 1980 ..... 4.12

4.5 Summary of Consequences of the Revised Limits 4.15

5.1 Estimated Collective Dose Equivalent Savings During an Outage Through Reduced Respiratory Usage for Selected Tasks 5.2

5.2 Current and Revised Average Concentration Limits for Releases into Sanitary Sewerage 5.6

5.3 Cost of Providing Reports to Individuals by Facility Category .. 5.10

5.4 Summary of Marginal Cost Increases from Other Changes in the Revised Part 20 ..... 5.13

6.1 Fraction of Licensees That May Be Classified as Small Businesses 6.10

6.2 Per-facility Costs from the 10 CFR Part 20 Revision 6.10

6.3 Estimated Total Cost to Small Businesses from the 10 CFR Part 20 Revision 6.11

6.4 Summary of Marginal Cost Increases from Other Consequences of the 10 CFR Part 20 Revision 6.12

7.1 Comparison of the Revision of Part 20 with National and International Recommendations 7.3

8.1 Categories of Licensees 8.3

8.2 Number of NRC and Agreement State Licensees in 1985 ..... 8.4

8.3 Employee Data for NRC and Agreement State Licensees in 1985 .... 8.5

8.4 Quantified Costs Incurred from the Revision of Part 20 by Facility Category 8.7

8.5 Quantified Costs Incurred from the Revision of Part 20 by Section of the Rule 8.8

8.6 Benefits of the Revision of Part 20 by Section of the Rule 8.10

8.7 Sensitivity of Net Benefits to Variations in Basic Assumptions . 8.12

8.8 Estimated Net Impact (Present Value) of the Revision of Part 20 ..... 8.13

1.0 INTRODUCTION

The U.S. Nuclear Regulatory Commission (NRC) plans to promulgate a complete revision of Title 10, Part 20, Code of Federal Regulations, "Standards for Protection Against Radiation." This report presents a cost-benefit analysis of the revision which can be used by regulatory authorities to assess the impact of the revision on society. Groups affected by the revision will be NRC licensees, Agreement State licensees, NRC and Agreement State agencies, the general public, and businesses directly or indirectly related to the nuclear industry. The following four sections provide a historical perspective of Part 20 and describe the methodology used in this report to assess the impact of the revision.

1.1 BACKGROUND

Code of Federal Regulations Title 10, Part 20 provides standards for protection of workers and the public against radiation hazards arising out of activities under licenses issued by the NRC. In addition, these standards are used as the basis for the regulations promulgated by the 28 Agreement States.

The current standards are based primarily on the recommendations of the International Commission on Radiological Protection (ICRP) published in 1959 (ICRP 1959). Since that time, 10 CFR Part 20 has undergone numerous minor revisions, but most of the principles underlying the protection standards remain as they were three decades ago. In 1977, the ICRP published a new set of recommendations (ICRP 1977). These recommendations were based on a revised concept of total risk limitation and provided methods for normalizing risks from doses received by different parts of the body. This concept was adopted by both the National Council on Radiation Protection and Measurements (NCRP) (NCRP 1987) and the Environmental Protection Agency (EPA) (FR 1987; EPA 1983a; EPA 1983b). If promulgated, the revision of Part 20 would incorporate the ICRP system of dose limitation.

1.2 HISTORY OF PART 20 REVISIONS

The NRC's standards for protection against radiation are basically unchanged from those first developed by the Atomic Energy Commission (AEC) approximately 30 years ago. These standards were based on ICRP recommendations (ICRP 1959) and reflected the scientific understanding of the effects of radiation at that time. Since then, Part 20 has undergone numerous minor revisions, but the basic principles underlying the system of dose limitation have not changed.

Soon after the publication of the ICRP recommendations in ICRP Publication 26 (ICRP 1977), the NRC initiated a rulemaking activity to incorporate these recommendations into 10 CFR Part 20. On March 20, 1980, an "Advance Notice of Proposed Rulemaking" was published in the Federal Register.

In 1982, the NRC prepared a Regulatory Analysis for the most recent version of the planned revision of Part 20. Subsequently, the revision underwent several iterations until a proposed revision was published in the Federal Register on January 9, 1986 (FR 1986). This was a corrected version of the proposed revision first published on December 20, 1985. Announcement of a 120-day comment period coincided with publication of the proposed revision.

Upon publication of the proposed revision, a draft backfit analysis to comply with Section 50.109 of 10 CFR 50 was requested by the Commission. This analysis was developed and published for public comment on August 29, 1986. Coincident with publication of the backfit analysis, the public comment period on the proposed revision was extended to October 31, 1986. This provided a 250-day comment period on the proposed revision, including a 60-day joint comment period on the proposed revision and the backfit analysis. A total of 813 comments were received during the 250-day comment period.

Based primarily on analysis of the comments on the proposed rule, the NRC performed further iterations of the revision until December 4, 1987, when the final rule language was approved by an NRC Steering Committee. Several changes to the rule were made after that date. The analysis provided in this report is based on the May 19, 1988, wording of the rule. Although further changes to the wording might occur before the Commission decides whether to promulgate the revised rule, any such changes should not affect the conclusions of this report.

1.3 PURPOSE OF REVISION

The primary purpose of revising Part 20 is to incorporate the basic principles of ICRP Publication 26, which were endorsed by the EPA in its Federal Radiation Protection Guidance (FR 1987). Under the current Part 20, the quarterly whole-body dose limit applies only to external doses. Internal doses are subject to separate limits based on the dose to critical organs. Under the revised Part 20, external doses and internal doses would be summed to demonstrate compliance with the annual whole-body dose limit. This system of dose limitation is consistent with current ICRP and NCRP recommendations on protection of both workers and the public from ionizing radiation (ICRP 1977; NCRP 1987), and is also consistent with the Radiation Protection Guidance to Federal Agencies for Occupational Exposure, signed by the President (FR 1987).

The revised Part 20 would also incorporate other recommendations of the ICRP, NCRP, and EPA. Under the current Part 20, workers are allowed to receive an external whole-body dose of 3 rem per quarter, provided that their average annual dose after the age of 18 does not exceed 5 rem. Considering that internal doses are not considered in this limit, the potential exists for some workers under the current rule to receive doses significantly more than 12 rem per year. Under the revised Part 20, workers would be limited to 5 rem per year, except under special circumstances when a limit of 10 rem could be applied.

The revised Part 20 would include, for the first time, a dose limit to the embryo/fetus of pregnant workers. The ICRP, NCRP, and EPA all recommended a limit to the embryo/fetus that is separate and lower than the whole-body dose limit to adult workers. This provision in the revised Part 20 would introduce a limit that is already being applied to most radiation workers in the United States.

The revised Part 20 would correct outdated individual radionuclide intake limits in the current rule. Because the fundamental principles of the current rule are 30 years old, some of the intake limits are no longer consistent with current scientific knowledge and understanding of the behavior of radionuclides in the body. Inconsistencies associated with application of the limits would be corrected by the revision, as well.

In general, the revision of Part 20 represents a complete overhaul of the current rule. The revision would reflect current scientific knowledge of radiation protection principles and would provide a sound technical basis for the dose limits.

1.4 TECHNICAL APPROACH

This report documents a regulatory analysis of the impacts of the revision of Part 20. The methods and format of the analysis are consistent with both the regulatory analysis guidelines of the NRC (USNRC 1984) and accepted methods for performing value-impact assessments (Heaberlin et al. 1983). Although this analysis does not provide a backfit analysis consistent with 10 CFR 50.109, the information provided in this report is sufficient for the development of such an analysis.

The analysis provided in this report is a cost-benefit analysis of the revision of Part 20. Only the marginal costs and benefits are identified; that is, only those costs and benefits that represent additions or reductions compared to those currently being incurred under the present Part 20 are considered. The analysis is based on many sources of information, including a previous regulatory analysis of an earlier version of the revision (USNRC 1982), public comments on the regulatory analysis, public comments on the proposed rule and backfit analysis, and numerous publications relevant to specific provisions of the revision.

The current plan for implementing the revision is to allow a 5-year implementation period beginning the day the proposed rule was published (January 9, 1986). Because the final revision is not expected to be published until the end of 1988, licensees will have approximately 2 years after publication of the rule to fully implement its provisions. In this report, all quantified costs and benefits are normalized to January 1, 1989. For cost estimates obtained from cost information provided in the literature, a 5% per year increase was applied to account for inflation.

Because publication of the proposed rule in 1986 prompted many licensees to begin "gearing up" for publication of the final rule, implementation costs will be distributed over the 5-year implementation period. In many cases,

licensees will defer implementation of the rule as long as possible. For this analysis, present value calculations are based on the assumption that 5%, 5%, 10%, 40%, and 40% of the implementation costs were or will be incurred in 1986, 1987, 1988, 1989, and 1990, respectively.

To be consistent with accepted guidance on performing value-impact assessments (Heaberlin et al. 1983), the resources spent to quantify the costs and benefits identified in this report were commensurate with their expected magnitude. As a result, many of the identified impacts have been labeled "negligible." This is not intended to imply that the impacts are nonexistent or unimportant to individual licensees; rather, impacts labeled "negligible" are assumed to have no significant impact on the results of this analysis.

1.5 CONTENTS OF THIS REPORT

The Executive Summary summarizes the analysis in a format consistent with the regulatory analysis guidelines of the NRC (USNRC 1984). Section 2.0 compares the current Part 20 with the Part 20 revision to briefly familiarize the reader with the important changes introduced in the revision. Section 3.0 presents the consequences of the revised dose evaluation requirements, including both external and internal dose evaluation. Section 4.0 presents the consequences of the revised dose limits, and Section 5.0 presents the consequences of other changes to Part 20. In Section 6.0, consequences of the revision that are not related to specific provisions are described, including the costs associated with personnel training and procedure revisions, the costs that will be incurred by NRC to implement and enforce the revision, and the impact of the revision on small businesses. Section 7.0 discusses the important benefits from revising Part 20. Although most of these benefits cannot be quantified, they are presented in sufficient detail in this report so that the appropriate authorities can evaluate their significance with respect to the associated costs of the revision. Finally, Section 8.0 summarizes the costs and benefits associated with the revision.

As discussed in Section 1.2, the revision of Part 20 has undergone numerous iterations. In this report, the following definitions apply. The proposed rule is defined as the rule published for public comment on January 9, 1986 (FR 1986). It may also be referred to as "the proposed revision" or "the proposed Part 20." The current rule is defined as the rule present in the Code of Federal Regulations as of January 1, 1988. The current rule may also be referred to as "the present rule", "the current (or present) Part 20", or "the current (or present) regulations." The revised rule is defined as the current version of the planned revision, as of May 19, 1988. The revised rule may also be referred to as "the revised Part 20", "the revision of Part 20", or simply "the revision."

2.0 COMPARISON OF PRESENT PART 20 WITH PART 20 REVISION

The revision of Part 20 will involve changes to most sections of the present rule. Also, the revision will result in either the addition or deletion of certain sections. Some of the changes are major and are expected to impact licensees significantly. Other changes, however, are relatively minor and are expected to have little or no impact. Sections 2.1 through 2.4 below describe changes to the rule that are likely to have significant impacts. Section 2.5, however, describes changes that are expected to have less significant impacts. Changes expected to have little or no impact are not discussed.

2.1 SUMMARY OF SIGNIFICANT CHANGES REGARDING INTERNAL DOSE ASSESSMENT

The primary purpose for revising Part 20 is to incorporate the current ICRP system of dose limitation (ICRP 1977) as adopted by the EPA (FR 1987). Basic to this system is the concept that both internal and external doses should be summed to determine relative risk. As a result, the revised Part 20 requires assessment of internal doses and summation of internal and external doses to determine the total effective dose equivalents, a measure of total health risk, to individuals. The present Part 20 does not require summation of internal and external doses.

An important consideration for this analysis is that under the revised Part 20, the summation requirement might result in increased whole-body dose equivalents being recorded compared to the external whole-body doses currently being recorded even though the actual dose (risk) to the worker remains the same. Because this increase in recorded dose would be a result of changing terminology rather than an actual increase in risk, no impact regarding health effects is associated with this change.

2.1.1 Section 20.202: Compliance with Requirements for Summation of Internal and External Exposures

The present Part 20 does not require summation of external and internal doses. In the revised rule, Section 20.202 specifies when and how a licensee must consider intakes of radionuclides in determination of total effective dose equivalent.

2.1.2 Section 20.204: Determination of Internal Exposure

This section defines acceptable procedures for determining internal exposures based on air sampling or bioassay measurements. The revised section is more detailed than the analogous section in the present Part 20 because the revised Part 20 requires summation of internal and external doses.

2.1.3 Section 20.502: Conditions Requiring Individual Monitoring of External and Internal Occupational Dose

The present Part 20 requires monitoring at 25% of the quarterly limits. However, Section 20.502 of the revised rule requires individual monitoring for workers who are likely to receive doses in excess of 10% of the occupational dose limits. This section mandates, in accordance with Section 20.202, that suitable measurements be performed to allow summation of internal and external doses. Summation is required when internal doses exceed 10% of the applicable annual limits.

2.2 SUMMARY OF SIGNIFICANT CHANGES REGARDING OCCUPATIONAL DOSE LIMITS

This section describes the significant changes in occupational dose limits in the revised Part 20.

2.2.1 Section 20.201: Occupational Dose Limits for Adults

The present Part 20 specifies a 1.25 rem/quarter limit to the whole body, head and trunk, active blood-forming organs, lens of eyes, or gonads. If the licensee has a record of a worker's exposure history, the worker may receive up to 3 rem/quarter, provided the worker's lifetime dose does not exceed 5(N-18) rem, where N is the worker's age in years. The revised occupational dose limits for adults specify a total effective dose equivalent per year of 5 rem and a limit of 50 rem (sum of deep and committed dose equivalents) for organs or tissues other than the lens of the eye.

The present Part 20 specifies limits of 1.25 rem/quarter to the lens of the eye, 7.5 rem/quarter to the skin, and 18.75 rem/quarter to each of the extremities. The revised annual limits are 15 rem to the lens of the eye, 50 rem to the skin, and 50 rem to each of the extremities. The definition of "extremities" in the revision is slightly different than the definition in the present Part 20.

The present Part 20 also specifies limits for exposure of individuals to concentrations of radioactive materials in air. The limit can be calculated from air concentrations listed by radionuclide in Appendix B. The revision, on the other hand, does not specify such limits because the total effective dose equivalent limit includes intakes of radionuclides. However, the revision does specify a 10 mg/week limit for intake of soluble uranium because of its chemical toxicity. Limits on intake of other radioactive materials are implied by the 5 rem/yr limit on total effective dose equivalent for radiation workers.

2.2.2 Section 20.206: Planned Special Exposures

This section in the revised rule allows licensees to authorize adult workers to receive doses in excess of the occupational dose limits provided that certain conditions are met. Although there is no analogous provision in the present Part 20, planned special exposures would be similar to the 5(N-18) rule in that workers would be allowed to exceed the annual

occupational dose limits under certain conditions. If the provision is used, individual workers could receive double the annual occupational dose limits for a maximum of 5 years during the worker's lifetime.

2.2.3 Section 20.208: Dose to an Embryo/Fetus

A limit to the embryo/fetus is not addressed in the present Part 20. Under this section in the revised rule, however, the dose to an embryo/fetus is limited to 0.5 rem. The new rule effectively limits the total effective dose equivalent of a declared pregnant woman to 0.5 rem during the pregnancy. Most licensees currently practice this limit because it is addressed in both a NRC Regulatory Guide (USNRC 1987a) and a staff position paper.

2.3 SUMMARY OF SIGNIFICANT CHANGES REGARDING LIMITATION OF DOSE TO THE PUBLIC

Although the present rule only implies limits on dose to the public, the revised Part 20 would contain explicit limitations on such dose. This section describes the new requirements.

2.3.1 Section 20.301: Dose Limits for Individual Members of the Public

In the present Part 20, a whole-body limit of 0.5 rem/yr for each member of the public is implied but is not explicitly stated. This revised section, however, limits the total effective dose equivalent to individual members of the public to 0.1 rem/yr. The limit includes doses from all operations by a licensee, excluding disposal of radioactive material into sanitary sewerage. The revision allows licensees to apply for authorization to operate up to an annual effective dose equivalent of 0.5 rem/yr for individual members of the public.

2.3.2 Section 20.302: Compliance with Dose Limits for Individual Members of the Public

Although the present Part 20 does not include this provision, this section in the revised rule requires licensees to make measurements, as appropriate, to demonstrate compliance with the limits specified in Section 20.301.

2.4 SUMMARY OF SIGNIFICANT CHANGES REGARDING RECORDKEEPING AND REPORTING REQUIREMENTS

Because the revision to Part 20 includes a revised system of dose limitation, the information collected by licensees to assess doses will be more detailed than the information presently collected. As a result, recording and reporting of this information is expected to be more extensive than under the present rule.

2.4.1 Section 20.1106: Records of Individual Monitoring Results

This section specifies the information that will be required on NRC Form 5. Although the present Part 20 also requires individual monitoring results to be recorded on NRC Form 5, more information will be required under the revised rule to demonstrate compliance with occupational dose limits.

2.4.2 Section 20.1107: Records of Dose to Individual Members of the Public

Although not required in the present Part 20, the revised rule requires that records shall be maintained to demonstrate compliance with dose limits for individual members of the public.

2.4.3 Section 20.1206: Reports of Personnel Monitoring

The present Part 20 does not require that individual monitoring reports be submitted for each individual for whom monitoring was required, but does require certain licensees to submit an annual statistical summary report. Under Section 20.1206 of the revised rule, however, the same licensees are required to submit an annual report of the results of individual monitoring for each individual for whom monitoring was required. In addition, the revised 10 CFR Part 19 requires that all licensees submit, at least annually, reports to those individuals describing the doses that they received. Currently, licensees are required to submit reports to individuals only upon request.

2.5 SUMMARY OF OTHER CHANGES

2.5.1 Changes Regarding Control of Internal Exposure in Restricted Areas

Subpart H of the revision contains requirements pertaining to respiratory protection controls to restrict internal exposure in restricted areas Most of the changes that appear in the revision are either editorial or are insignificant with respect to cost. One exception is Section 20.702, which states that the licensee shall limit intakes so that the total effective dose equivalent is maintained ALARA. The present Part 20 discourages deliberate internal exposures that are a significant fraction of the dose limits and does not require that the total effective dose equivalent be maintained as low as reasonably achievable (ALARA).

2.5.2 Changes Regarding Precautionary Procedures

Most of the changes regarding precautionary procedures are expected to have insignificant impacts on licensees with the exception of labeling requirements. In the revised Appendix C, quantities of most radioactive materials that will require labeling are higher than the values provided in Appendix C of the present Part 20.

2.5.3 Changes Regarding Waste Disposal

Most of the changes regarding waste disposal requirements are expected to have insignificant impacts on licensees. One exception is that the amounts of specific radionuclides that can be released into sanitary sewerage have been changed. In most cases, the revised limits are 10-100 times more restrictive than the present limits.

2.5.4 Changes Regarding Recordkeeping Requirements

Subpart L of the revision contains sections that describe recordkeeping requirements. The requirements include records of radiation protection programs, records of surveys, records of prior occupational dose, records of planned special exposures, records of doses to both individual workers and individual members of the public, records of waste disposal, and records of testing entry control devices. Except for the sections that require records of doses to individual workers and individual members of the public (discussed in Section 2.4), the changes to the present rule are expected to have only minor impacts on licensees. In several cases, the sections in the revision contain more detail than the relevant sections in the present rule. The impacts of these revised requirements are expected to be minor because most licensees currently keep records that fulfill the requirements of the revision. In two other cases (records of radiation protection programs and records of testing entry control devices), the requirements are new but are not expected to have a significant cost impact on licensees.

2.5.5 Changes Regarding Reporting Requirements

Subpart M of the revision describes reporting requirements. Except for Section 20.1206, which was discussed in Section 2.4 of this report, the reporting requirements pertain to unusual situations such as thefts and over-exposures. In these cases, the requirements in the revision are similar to the requirements in the present Part 20 except for minor changes that either involve editorial changes or revised definitions of reportable events. Because reporting of incidents is very infrequent, these changes are expected to have minimal cost impacts.

3.0 CONSEQUENCES OF REVISED DOSE EVALUATION REQUIREMENTS

The present and proposed dose limits specified in 10 CFR Part 20 are summarized in Table 3.1. In addition to the changes to the limits, the fraction of the annual limit at which monitoring is required was effectively lowered from 25% to 10% for both internal and external doses. Also, the revised annual total dose equivalent limit is based on a weighted fraction concept designed to normalize the risk of adverse health effects from a dose delivered nonuniformly to the body to the risk from a uniform whole body dose. The total effective dose equivalent includes the sum of both external doses and weighted internal doses when both individually exceed 10% of the annual limit. The anticipated impacts of these changes are evaluated in the following sections.

TABLE 3.1. Occupational Dose Limits Specified in the Present and Revised Part 20

Present Exposure Category	Present Dose Limit, rem	Revised Exposure Category	Revised Annual Dose Limit, rem
Whole Body (head and trunk, active blood forming organs, or gonads)	3/quarter 5/yr (avg.)	Total effective dose equivalent	5
Lens of eyes	5/yr	Lens of eyes	15
Hands, forearms, feet and ankles	75/yr	Extremities	50
Skin of the whole body	30/yr	Skin	50
Internal Dose	520 MPC-h /quarter		
Committed Dose Equivalents Whole Body Most Organs Thyroid	 5/yr 15/yr 30/yr	Committed dose equivalent (organs)	50

3.1 EXTERNAL DOSE EVALUATIONS

The present Part 20 limits external whole-body doses to 3 rem/quarter and to a lifetime average that is less than 5 rem/yr after the age of 18. Doses to individual organs are not considered in calculations for compliance with this limit. The revised annual limit of 5 rem includes the summation of external and internal doses if the latter exceed 10% of the annual effective dose equivalent limit. The annual limit for extremities was lowered from 75 to 50 rem and the limit for the skin was raised from 30 to 50 rem.

One potential cost associated with reduced external dose limits is the cost associated with improvements in personnel dosimeters. The most restrictive exposure limit regarding the sensitivity of personnel dosimeters is the annual whole body limit of 5 rem/yr. Assuming a 1-month exchange period, the minimum sensitivity for the dosimeter must be about 40 mrem (0.1 x 5000 mrem/12 months per year). Under both the current Part 20 and the revised Part 20, NRC licensees are required to obtain personnel dosimetry from a processor holding accreditation from the National Voluntary Laboratory Accreditation Program (NVLAP). Although NVLAP does not have a provision for lower limit of detection, dosimeters used currently can detect a 40 mrem dose. Therefore, no costs are anticipated regarding improvements in dosimetry methods.

Another potential cost is the cost associated with increased monitoring of workers. Because external doses must be monitored for workers likely to receive 10% of the revised dose limits in contrast to 25% of the current limits, it is possible that increased monitoring will be required at some facilities. However, essentially all facilities currently monitor whole-body doses to workers who receive significantly less than 500 mrem/yr. The primary reason for monitoring relatively low doses is not to meet applicable state and federal regulations, but to both detect unsafe working conditions and protect the facility from litigation by documenting individual doses (Kelsey, Lane and Mettler 1984). Therefore, no increased monitoring of whole-body doses is anticipated from the revised monitoring requirements. However, extremity doses are not currently monitored at 10% of the revised extremity limits in all cases.

At nuclear power plants, extremity dose monitoring is not normally performed on a routine basis because extremity doses received during routine operations are generally well below 25% of the current limits (Huggins and Watson 1984). However, considering that the revised monitoring requirement is 10% of the revised extremity limits, and that the revised extremity limits are 50 rem/yr as opposed to 18.75 rem/quarter, some workers who are not currently monitored will be monitored under the revised requirements. Based on a study of hand doses received during 4 months of routine operations at a typical nuclear power plant (Huggins and Watson 1984), it is estimated that additional extremity monitoring will be required for an average of 60 person-months during routine operations per nuclear power plant per year. An additional 120 person-months/yr during outages is also anticipated.

Increases in extremity monitoring are expected for some other facilities, as well. Procedures such as implantation of radiotherapy needles at hospitals, elution and activity measurements at nuclear pharmacies, and glove box operations at fuel fabrication facilities could result in doses to workers that may require increased extremity monitoring under the revised Part 20 (Thind 1987; Harty, Reece and MacLellan 1986). It is estimated that for 10% of medical facilities, average additional extremity monitoring of 12 person-months will be required. The remaining 90% of medical facilities are anticipated to incur no increased extremity monitoring costs. Additional extremity monitoring of 24 person-months per nuclear pharmacy and 60 person-months per fuel fabrication facility are also estimated. For

other facilities, increases in extremity monitoring are expected to be relatively insignificant.

Based on the estimates provided above and the data presented in Section 8.1, increased extremity monitoring equivalent to 33,600 person-months/yr is anticipated in order to comply with the revised requirements. Assuming a monthly exchange period (Huggins and Watson 1984) and two dosimeters per person (one on a finger of each hand), 67,200 additional dosimeters per year will be processed. Based on an estimated cost of $5 per dosimeter, which includes both the cost of evaluation and the cost of recording the evaluated dose information, the impact on NRC and Agreement State licensees is estimated to be $340,000 per year. The present value of these costs is included in the summaries presented in Sections 3.6 and 8.2.

3.2 INTERNAL DOSE EVALUATIONS

Section 20.103 of the current Part 20 promulgates limits for exposure to concentrations of radioactive materials in air in restricted areas. Internal dose is limited by compliance with maximum permissible concentrations (MPC) of radionuclides in air. These MPC values were established using empirically derived biokinetic models and the calculated dose to critical organs per unit of radioactivity inhaled. The critical organs were defined as those receiving the greatest dose and were specific for each radionuclide.

Compliance with the regulations is currently demonstrated by comparison of the exposure limit with the actual 13-week average air concentration and by appropriate bioassay techniques. Doses do not need to be calculated for time-weighted exposures less than 2 MPC-h/d or 10 MPC-h/wk. The required sensitivity level for monitoring potential internal exposures is, therefore, 25% of the average weekly intake that would occur during exposure to an air concentration of one MPC.

The revised Part 20 requires licensees to monitor intakes of radioactive material for adults likely to receive, in 1 year, an intake in excess of 10% of the applicable Annual Limits on Intake (ALIs). Intakes through wounds or oral ingestion will be significant for only a small percentage of the worker population and will almost always be the result of accidents (unplanned exposures). The only mode of entry for which monitoring will be routinely affected by the changes in the revision is intake by inhalation.

In accordance with the revised Part 20, compliance with the limit on intake by inhalation may be demonstrated in any of three ways: 1) limiting the sum of the quotients of intakes divided by ALIs to unity, 2) limiting the DAC-hours of exposure to 2000, or 3) based on calculations from bioassay data, limiting the committed effective dose equivalents to all organs or tissues to the annual limit. Determination of internal exposure, therefore, requires either bioassay measurements to determine the uptake of radionuclides, or air monitoring to determine air concentrations to which workers may be exposed.

3.2.1 Bioassay

Bioassay techniques may be separated into two categories, in vitro and in vivo. In vitro techniques estimate uptakes or intakes through analysis of excreta from potentially exposed individuals and application of biokinetic models to represent the behavior of radionuclides in the body. In vivo techniques estimate uptakes or intakes by direct measurement of photons emitted from radioactive material present in the body. The measurement data are then extrapolated to uptakes using biokinetic models. Because intakes as small as 10% of an ALI must be included in the total effective dose equivalent under the revised Part 20 requirements, the bioassay technique used to assess internal uptakes must have a minimum detectable activity (MDA) at least as small as the uptake assumed to follow an intake of 10% of an ALI.

Using published data (Lessard et al. 1987) for excretion and lung retention fractions, the MDA necessary for detecting an intake of one-tenth of an ALI 30 days following the intake was calculated for a number of commonly-used radionuclides (Table 3.2). Thirty days was assumed to be the minimum measurement interval for a routine program, even though longer intervals are typical for many radionuclides. The calculated MDAs were then compared to acceptable MDAs (AMDAs) listed in draft ANSI Standard N13.30 Performance Criteria for Radiobioassay (see note "b" to Table 3.2). The AMDAs were established as the level expected to be obtainable by a competent counting laboratory and are not necessarily "acceptable" to meet health physics needs in all situations.

Table 3.2 indicates that for most radionuclides, an intake of 10% of an ALI is detectable 30 days following the intake by either in vitro or in vivo techniques. However, detection at this level may not be possible at current levels of sensitivity for a few radionuclides (e.g., ^{90}Sr and Pu isotopes). If the nuclide-specific MDAs are within the present capabilities of a bioassay laboratory, implementation of the proposed regulations will incur no additional costs due to sensitivity requirements. If the required MDA is below the present sensitivity of the bioassay system, costs will be incurred either to improve the system sensitivity, increase the frequency of bioassay measurements, or implement an alternate monitoring system for internal exposure (air monitoring).

3.2.2 Air Monitoring

Airborne radioactive material can be measured by air sampling and analysis. A volume of air is drawn through a detection device that measures the radioactivity directly, or through a collection device such as a filter or impactor, which removes the radioactive material from the air for counting.

Two general types of air samples can be collected: breathing zone and general area. Breathing zone samplers provide a relatively representative sample of the concentration of radioactive material in air breathed by an individual, but suffer from limitations regarding sampling rate. Although

TABLE 3.2. Annual Limits on Intake of Common Radionuclides Compared to Detection Capabilities for Urinalysis and In Vivo Counting

Nuclide	Class	ALI, μCi	MDA(a) Required To Detect A 10% ALI Intake 30 Days Post Exposure		Required MDA<AMDA(b)	
			Urine	In Vivo	Urine	In Vivo
^{3}H	Vapor	8E4	2.5E4	-(c)	No	-
^{14}C	D	2E5	1.4E6	-	No	-
^{32}P	D	9E2	4.2E1	-	No	-
	W	1E2	1.9E1	-	No	-
^{35}S	D	2E4	1.2E3	-	No	-
	W	2E3	1.8E2	-	No	-
^{45}Ca	W	8E2	3.0E4	-	No	-
^{51}Cr	D	5E4	2.8E6	-	No	-
	W	2E4	5.1E5	9.7E4	No	No
	Y	2E4	1.4E5	1.4E5	No	No
^{54}Mn	D	9E2	2.0E2	<1E-3	No	Yes
	W	8E2	2.0E1	7.6E3	No	No
^{59}Fe	D	3E2	2.3E3	-	No	-
	W	5E2	1.0E3	3.2E3	No	No
^{60}Co	W	2E2	-	2.0E3	-	No
	Y	3E1	-	4.3E2	-	No
^{65}Zn	Y	3E2	5.3E3	4.0E3	No	No
^{86}Rb	D	8E2	9.1E3	-	No	-
^{90}Sr	D	2E1	9.0E-1	-	No	-
	Y	4E0	6.6E-3	-	Yes	-
^{99}Mo	D	3E3	1.1E6	-	No	-
	Y	1E3	1.8E4	1.5E4	No	No
^{99m}Tc	D	2E5	-	-	-	-
^{125}I	D	6E1	2.6E3	1.1E3	No	No
^{129}I	D	9E0	5.5E2	2.2E2	No	No
^{131}I	D	5E1	2.7E-1	2.4E1	No	No
^{137}Cs	D	2E2	-	4.8E1	-	No

TABLE 3.2 (contd)

Nuclide	Class	ALI, μCi	MDA(a) Required To Detect A 10% ALI Intake 30 Days Post Exposure: Urine	MDA(a) Required To Detect A 10% ALI Intake 30 Days Post Exposure: In Vivo	Required MDA<AMDA(b): Urine	Required MDA<AMDA(b): In Vivo
^{144}Ce	W	3E1	-(c)	2.9E2	-	No
	Y	1E1	-	6.7E1	-	No
^{235}U	D	1E0	1.0E1	<1E-3	No	Yes
	W	8E-1	5.0E0	8.2E0	No	No
	Y	4E-2	2.5E-1	5.8E-1	No	No
Nat U(by ^{234}Th)	D	1E0	1.0E1	1.5E1	No	No
	W	8E-1	5.0E0	8.2E0	No	No
	Y	5E-2	2.5E-1	7.2E-1	No	Yes
^{238}Pu	W	6E-3	8.0E-6	6.1E-2	Yes	Yes
	Y	2E-2	1.0E-6	2.9E-1	Yes	Yes
^{241}Am	W	5E-3	5.0E0	5.1E-2	No	No

(a) Units are nCi for in vivo bioassay and nCi/L for all urinalyses except natural uranium urinalyses (μg/L).
(b) AMDAs specified in draft ANSI Standard N13.30, Performance Criteria for Radiobioassay. Draft ANSI Standard N13.30 is available from the Executive Secretary, Health Physics Society, 8000 Westpark Drive, Suite 400, McLean, VA 22102.
(c) Not applicable.

area air samplers can collect larger air samples, general area air concentrations may differ appreciably from the concentration in the breathing zone of the individual. Uptakes estimated from air samples have an estimated total uncertainty factor of 5 or more for breathing zone samplers and 20 or more for area air samplers (Booth, Bronson and Groth 1985).

Table 3.3 summarizes the revised changes in air concentration limits for a number of common radionuclides. For those radionuclides not detectable with current bioassay technology, increased sensitivity is most easily obtainable through air monitoring. The costs of implementing the revised limits will, therefore, involve procuring and maintaining additional air monitoring equipment, increasing labor costs for collecting and analyzing air samples, and establishing an appropriate personnel monitoring records system. These costs are detailed in Sections 3.3, 3.4, and 3.5.

TABLE 3.3. Comparison of Part 20 Current and Revised Air Concentration Limits for Certain Radionuclides

Nuclide	Class	DAC, μCi/mL	MPC(air), μCi/mL(a)	DAC/MPC(air)
^{3}H	Vapor	2E-5	5E-6(S)	4
^{14}C	D	1E-6	4E-6(S)	0.3
^{32}P	D	4E-7	7E-8(S)	6
	W	2E-7	8E-8(I)	3
^{35}S	D	7E-6	3E-7(S)	20
	W	9E-7	3E-7(I)	3
^{45}Ca	W	4E-7	1E-7(I)	4
^{51}Cr	D	2E-5	1E-5(S)	2
	W	1E-5	1E-5(S)	1
	Y	8E-6	2E-6(I)	4
^{54}Mn	D	4E-7	4E-7(S)	1
	W	3E-7	4E-8(I)	8
^{59}Fe	D	1E-7	1E-7(S)	1
	W	2E-7	5E-8(I)	4
^{60}Co	W	7E-8	3E-7(S)	0.2
	Y	1E-8	9E-9(I)	1
^{65}Zn	Y	1E-7	6E-8(I)	2
^{86}Rb	D	3E-7	3E-7(S)	1
^{90}Sr	D	8E-9	1E-9(S)	8
	Y	2E-9	5E-9(I)	0.4
^{99}Mo	D	1E-6	7E-7(S)	1
	Y	6E-7	2E-7(I)	3
^{99m}Tc	D	6E-5	4E-5(S)	2
^{125}I	D	3E-8	5E-9(S)	6
^{129}I	D	4E-9	2E-9(S)	2
^{131}I	D	2E-8	9E-9(S)	2
^{137}Cs	D	6E-8	6E-8(S)	1

TABLE 3.3 (contd)

Nuclide	Class	DAC, μCi/mL	MPC(air), μCi/mL(a)	DAC/MPC(air)
^{144}Ce	W	1E-8	1E-8(S)	1
	Y	6E-9	1E-9(I)	6
^{235}U	D	6E-10	5E-10(S)	1
	W	3E-10	5E-10(S)	0.6
	Y	2E-11	1E-10(I)	0.2
Natural Uranium	D	5E-10	1E-10(S)	5
	W	3E-10	1E-10(S)	3
	Y	2E-11	1E-10(I)	0.2
^{238}Pu	W	3E-12	2E-12(S)	2
	Y	7E-12	4E-11(I)	0.2
^{241}Am	W	2E-12	6E-12(S)	0.3

(a) S = soluble, I = insoluble

3.3 DOSE EVALUATION COSTS

The principal components of cost-benefit evaluations (value-impact assessments) of proposed regulatory actions are the attributes that are used to characterize the consequences of the proposed action. There are twelve attributes normally used for NRC value impact assessments (Heaberlin et al. 1983). These attributes may be categorized as factors affecting public health, accidental occupational exposure, routine occupational exposure, offsite property, onsite property, regulatory efficiency, improvements in knowledge, industry implementation, industry operations, NRC development, NRC implementation, and NRC operations.

Changes in dose evaluation requirements will not affect actual doses received by the public, nor the frequency of accidents which could affect occupational exposure, nor property damage. The effect of the revised dose evaluation requirements on routine occupational exposures will be discussed in Section 3.4. Changes in dose evaluation requirements may affect regulatory efficiency through changes in reporting requirements. This is discussed in Section 7.3. The changes will not improve knowledge of accident probabilities or consequences. The NRC development costs are sunken costs and are not considered in the regulatory analysis. The NRC implementation and operations costs will not be specific for dose evaluation requirements and are discussed in Section 6.3. Discussions in this section will therefore be limited to the effect of the revised dose evaluation requirements on industry implementation and operations costs.

In this section, costs are summarized by facility type according to the facility categories listed in Table 8.1 of this report. For each affected facility type, the industry implementation and operations costs expected to be incurred from the revised dose evaluation requirements are estimated. Costs associated with recordkeeping are discussed separately in Section 3.5. Cost estimates are not provided for five facility categories (well logging, industrial radiography, other measuring systems, research and test reactors, and other facilities) because the associated costs are anticipated to be either zero or insignificant. Costs for these five facility types will be minimal because significant internal doses are rare and it is not anticipated that changes to existing procedures will be required from the revised dose evaluation requirements.

Medical Facilities. Potential internal exposures to workers in a hospital are primarily limited to the nuclear medicine department. By far the most common radionuclide used in nuclear medicine is ^{99m}Tc. In one study it was estimated that 80% of the patient procedures involve ^{99m}Tc (Wiatrowski et al. 1984).

The radiopharmaceuticals of ^{99m}Tc are stable in solution and are non-volatile. If there are 30 mCi per patient and 8 patients per day per room of 10 X 15 X 8 feet with one air change per hour, 18% of the total dose could be volatilized without exceeding 10% of the DAC value. With no air changes (total recirculation), 0.8% of the total dose could be volatilized without exceeding 10% of the DAC value. The intakes of these radiopharmaceuticals by workers, therefore, are expected to be less than the 10% threshold for monitoring.

Radioiodine compounds comprise most of the remaining radionuclides that are potentially inhaled at nuclear medicine departments. For all of these compounds, the DAC values in the revision are at least two times higher than the current MPC values. Therefore, monitoring will not be required at lower levels of intake than are currently required even though monitoring will be required if intakes are likely to exceed 10% of the applicable ALIs. It is anticipated, however, that some of these licensees will respond to the revised Part 20 by performing additional monitoring for 1 year to demonstrate compliance. This monitoring will consist of a self-monitoring program by researchers who handle iodine (USNRC 1982). Associated cost estimates for one-third of the approximately 4800 nuclear medicine departments (i.e., 1600 departments) are $400 each for instrument calibration services and $550 each for equipment purchases, for a total one-time cost of $1,500,000 (USNRC 1982). The remaining two-thirds of the facilities are not anticipated to incur costs because they currently do not have quantitative internal exposure monitoring programs and are not expected to require one based on the revised regulations.

A similar response is anticipated from the research hospitals possessing a broad license. There are approximately 200 broad-scope research hospitals with 52,000 potentially exposed employees, two-thirds of whom are monitored for internal exposures (USNRC 1982). Assuming a 1-year program of quarterly internal monitoring to demonstrate that intakes are less than 10% of the applicable ALIs, that most researchers handle H-3 or P-32 which can be

evaluated using urinalysis, and that 20% of the researchers would be sampled at a cost of $18 per urinalysis (USNRC 1982), the one-time cost would be 52,000 X 0.67 X 0.2 X $18 X 4, or $500,000. One whole-body count is also expected to be needed for 10% of the researchers who received urinalysis in order to evaluate internal deposition of gamma-emitters. The associated cost estimate, assuming $200 per whole-body count, is $140,000 (that is, 52,000 X 0.67 X 0.2 X 0.1 X $200).

The costs to private practitioners of nuclear medicine will be similar to those of nonresearch hospitals. Of the approximately 1000 private practice licensees, one-third were assumed to have quantitative internal exposure monitoring programs (USNRC 1982). If these 330 facilities undergo a self-monitoring program for 1 year at a cost of $1000 each, the total cost estimate is $330,000.

The current level of monitoring in nuclear pharmacies is sufficient to satisfy the provisions of the revised regulation. The only additional efforts would be the conversion of organ burden to dose, which falls under the category of recordkeeping (see Section 3.5).

Manufacturing and Distribution Facilities. It was assumed that the facilities involved in the manufacture and distribution of large sources currently have limited routine monitoring programs for internal exposures. Although exposures are probably less than 10% of the limits, monitoring would have to be performed for a year to demonstrate this to the inspectors (USNRC 1982). It is estimated that 100 workers in the industry would have to be monitored at a cost estimated to be $200 per whole-body count. With an initial count and four quarterly counts the cost for the demonstration program would be about $100,000.

Facilities involved in the manufacture and distribution of small sources utilize extensive routine bioassay and air monitoring at numerous locations. The programs are considerably more extensive than those expected to be required under the provisions of the revised Part 20 and should not need to be upgraded in response to the revision.

Academic/Research Institutions. There are currently about 1500 academic and research institutions employing 692,000 workers, 14% of whom are monitored for ionizing radiation (Table 3.3). The radionuclides commonly used at these institutions are ^{3}H, ^{14}C, ^{32}P, ^{36}Cl, ^{45}Ca, ^{59}Fe, ^{60}Co, ^{125}I, ^{131}I, and ^{137}Cs, among others. The DAC values in the revision for these radionuclides are an average of 2.4 times higher than the current MPC values. Considering that the revised requirement for monitoring intakes is effectively lower by a factor of 2.5 than the current requirement, no significant changes in long-term monitoring practices are expected to be necessary at these facilities.

Even though long-term changes are not anticipated, it is expected that some of these licensees will incur initial costs required to demonstrate compliance to inspectors (USNRC 1982). Although these costs may not be necessary based on strict interpretation of the revision, they are included in this analysis because they are based on anticipated actual responses by licensees regardless of the necessity of their responses. Based on similar

assumptions used to estimate these costs for broad-scope medical facilities, the total initial costs for academic/research institutions are estimated to be $940,000 for urinalysis (i.e., 692,000 X 0.14 X 0.67 X 0.2 X $18 X 4) and $250,000 for whole-body counts (i.e., 692,000 X 0.14 X 0.67 X 0.2 X 0.1 X $200). Increases in long-term operation costs are estimated to be negligible.

Fuel Fabrication and Processing Facilities. As will be discussed in Section 3.4.1, the effective dose equivalent to workers at fuel fabrication facilities from radioactive material deposited in the body may currently equal or, at least at one facility, exceed the effective dose equivalent from external radiation. The internal exposures at these facilities are thought to be chronic exposures to Class Y materials.

If the proposed DACs are implemented, if chronic exposures continue to exist at fuel fabrication plants, and, if the margin between the DACs and actual plant air concentrations will be equal to the present margin between MPCs and plant conditions, then it may be assumed that the chronic lung burdens of the average worker will decrease by a factor of 5, which is the difference between the revised DAC and current MPC for insoluble (Class Y) uranium. Since the lung burdens at one facility are near the detection limits of currently available lung counting equipment, a reduction of the lung burdens by a factor of 5 would result in lung burdens that are below the detection limits of currently available lung counting equipment (Booth, Bronson and Groth 1985; Palmer et al. 1987; Robinson et al. 1986). Booth, Bronson and Groth (1985) concluded that adequate estimates of intake can be accomplished with currently available air monitoring equipment, much of which should be already in place. They also concluded that procedural changes would be required for changing the method of compliance from one based on lung counting to one based on air monitoring, and estimated these costs to be about $24,000 per facility (in 1989 dollars). Based on recent information on operating fuel fabrication facilities, these costs are anticipated to be incurred by five facilities in this category for a total of $120,000. Although other facilities in this category may incur related costs, they are assumed to be relatively insignificant for this analysis. Annual operation costs of $43,000 per facility (Booth, Bronson and Groth 1985) for a total of $215,000 are also anticipated for additional air sampling equipment.

The primary costs in these facilities will involve facility modifications to reduce existing airborne levels to below the applicable DACs for uranium. Booth, Bronson and Groth (1985) stated that fuel fabrication facilities may have areas where airborne activities are routinely 25% to 50% of current MPCs. More recently, it appears that existing fuel fabrication facilities operate with airborne levels that range from 10% to 25% of the MPCs. Considering that the revised DAC value for Class Y uranium is one-fifth of the current MPC value, facility modifications might be necessary to provide adequate safety margins.

Two courses of action are being considered by these facilities: ventilation changes and extensive use of glove boxes. One facility has estimated these costs to be $11.5 million for the ventilation change option and $42 million for the glove box option; the ventilation change option will also

require an annual maintenance cost of $2 million. Nilson and Malody (1982) did not quantify the costs but did estimate that it would be millions of dollars. Although apparently not yet evaluated, it might be possible to collect air samples to determine the actual particle size distribution at these facilities; the observed particle size distributions may allow operation at current activity levels. There is evidence that such studies would show that some engineering modifications may not be necessary (West, Scott and Schultz 1979). Licensees may choose not to exercise such an option even if it is offered due to the difficulties in explaining to the public why air activity concentrations above those published in Part 20 do not pose a hazard to the workers. In consideration of these factors and assuming that five facilities will be most affected, the total cost estimate is $30,000,000 initially ($6 million per facility) and $5,000,000 in annual operation costs ($1 million per facility). These estimates are based on the assumption that particle size studies will render some modifications unnecessary.

It may be asked whether reductions in air concentration levels would be required at fuel fabrication plants if permissible to base dose equivalent limits for long-lived radionuclides on the annual effective dose equivalent rather than the committed effective dose equivalent. Even with the exemption described in Section 20.205 of the proposed revision, it appears that the facilities would be required to maintain the average air concentration less than the DAC [see 20.205(b)(2)]. Since the external contribution to the committed effective dose equivalent is small, on the average, and even the maximum external dose equivalents do not exceed approximately 1 rem (which would decrease the allowable air concentration by ~20%), it seems that fuel fabrication plants will be required to reduce their uranium air concentrations irrespective of whether the dose equivalent is based on annual effective dose equivalent or committed effective dose equivalent. The major question seems to be how much below the DAC the licensee would be required to maintain air concentrations. If the average air concentration is 1 DAC and a worker were to inhale 1 ALI (the apparent maximum in either case), the committed effective dose equivalent received is 5 rem, which does not allow for external doses to be accrued. If external doses were received by the worker, then air concentrations would need to be reduced below the DAC by corresponding amounts. In the case of fuel fabrication plants, it appears that 99% of the workers would not exceed the revised total effective dose equivalent limit if they inhaled 0.8 ALI. For those few who would, procedures such as increased local ventilation or the use of respirators would serve as sufficient countermeasures.

Commercial Power Reactors. Revised internal exposure provisions are not expected to alter internal monitoring programs already in existence at these plants. These programs greatly exceed the requirements of both the current and revised Part 20. Those utilities that use air monitoring as the surrogate for internal dose will continue to do so, and the calculated doses are so low that it is unlikely that any utility will refine their methods by measuring particle size, solubility fraction, etc. The few facilities that use bioassay data for compliance will probably not alter their procedures. Less than 0.03% of the individuals counted at nuclear power plants between 1978 and 1983 had measured body burdens in excess of 10% of the relevant ALIs (Booth, Bronson and Groth 1985) and it is unlikely that any utility will

discontinue its existing monitoring program. The revised regulation does not require breathing zone monitoring for intake monitoring and allows general area sampling. The significant costs associated with the revised dose evaluation requirements are related to recordkeeping (see Section 3.5).

3.4 DISTRIBUTION OF OCCUPATIONAL DOSES

The revised dose evaluation requirements will result in internal and external doses being summed to demonstrate compliance with the dose limits. An important distinction between the current and revised rule is that the latter requires control of internal exposures as long as the controls are consistent with maintaining the total effective dose equivalent ALARA. In contrast, the current rule strongly discourages intakes of radioactive material by mandating both quarterly and weekly control measures. As a result, intakes of radioactive material are currently rare at most facilities. For those facilities where internal doses are significant compared to the revised annual dose limit, e.g., fuel fabrication facilities, added control measures should result in decreased internal doses.

3.4.1 Fuel Fabrication Facilities

In 1984, there were 9379 workers at 11 uranium fuel fabrication plants, 5947 of whom received measurable external radiation doses. In 1984, the average measurable dose was about 140 mrem; in 1983 and 1982, the average measurable radiation doses were 160 mrem and 140 mrem, respectively (Brooks 1986). These numbers agree well with the measurable average of 170 mrem for 1980 that was reported by Kumazawa, Nelson and Richardson (1984), and the average annual dose equivalent reported by Booth, Bronson and Groth (1985) at a single facility. Brooks (1986) reported that for fuel fabrication plants, 99% of the external dose equivalents were less than 1.5 rem in 1982 and 1983, and that 99% were less than 0.95 rem in 1984.

Regarding internal doses, the workers at the facility studied by Booth, Bronson and Groth (1985) were found to have measurable lung burdens ranging from 60 to 200 μg ^{235}U. The average of all workers (including those with burdens less than measurable) was found to be 47 μg. The average body burden of 47 μg of ^{235}U will result in an annual effective dose equivalent of 460 mrem and an estimated annual lung dose equivalent of 3900 mrem, based on the assumption that the body burdens resulted from chronic exposures to Class Y aerosols. The maximum observed lung burdens (200 μg ^{235}U) result in annual lung dose equivalents of approximately 17 rem/yr and annual effective dose equivalents of about 2 rem/yr. Thus, for at least one facility, the average annual effective dose equivalent from internal radiation exceeded that from external radiation. Because these are values for only one facility, extrapolation to the entire industry is tenuous.

Lessard et al. (1987) have published tables that indicate the lung burden at various times after inhalation of uranium. These tables can be combined with a continuous inhalation model in order to compute the cumulative lung burden following chronic inhalation of uranium. Calculations indicate that during chronic inhalation, the lung burden quickly builds and

essentially levels off at about 15 years, the lung burden increases at a rate of only about 1% per year at 15 years.

Kumazawa, Nelson and Richardson (1984) found that the median age of a nuclear fuel cycle worker was 35 years. For purposes of this analysis it was assumed that the average worker began work at 25 years of age, which results in a total work time of about 10 years. The average lung burden of 47 μg ^{236}U found by Booth, Bronson and Groth (1985) will be achieved in 10 years if the chronic inhalation rate is about 102 μg (^{236}U) per year. This annual intake will result in a committed dose equivalent to the lung of about 5.5 rem and a committed effective dose equivalent of 0.65 rem. This indicates that the average worker at fuel fabrication facilities receives committed effective dose equivalents well below 5 rem/yr.

Considering external doses, it appears that the average worker receives about 0.8 rem combined external and committed effective dose equivalent; the internal component is about four times the external component. The only instance in which fuel fabrication facilities appear not to be already in compliance with the revised requirements is for those individuals who receive the maximal doses, and even then it appears to be a problem only if the individuals who have the largest lung burdens have been exposed for less than 5 years. For a chronic exposure over 5 years, 99% of the workers would have a total of external radiation dose equivalent and committed effective dose equivalent that is <5 rem. For those 1% who currently receive doses that would be unacceptable under the revised Part 20, steps would need to be taken to reduce intakes, e.g., through the use of respirators.

Although the air concentrations in certain areas of fuel fabrication facilities exceed the revised DACs, it appears that few individuals would exceed the revised dose limits. Thus, it appears that one or more of the following may be true: 1) workers do not spend all of their time in the high air concentration areas of the facility, 2) the particle size distribution of the dust precludes lung deposition of much of the material, or 3) some of the material is more soluble than anticipated and is removed from the lung with a biological half-life less than 500 days.

Calculations based on the data presented above indicate that a reduction in airborne levels in all areas of a facility by a factor of 5 would result in a decreased effective dose equivalent of 520 mrem (650 mrem X 0.8) for an average worker. Based on five facilities and assuming that 414 workers receive measurable doses at each of these facilities (see Section 8.1), the annual reduction in effective dose equivalent would be 1080 rem. However, in Section 3.3 as well as in this section it was determined that airborne levels in some areas of these facilities need not be reduced by a factor of five. It is assumed that an average reduction of 2.5 will be observed, for a total effective dose equivalent savings of 540 rem/yr.

3.4.2 Other Facilities

Significant internal doses are rare at facilities other than fuel fabrication facilities. For nuclear power plant workers, average annual internal doses are negligible and maximum annual internal doses are a small

fraction of the revised annual total dose equivalent limit (Booth, Bronson and Groth 1985). As a result, it is not expected that summation of internal and external doses will result in added control measures to ensure that workers do not exceed the revised total effective dose equivalent limit or corresponding administrative limits. This assumption is thought to be valid for all facilities (except fuel fabrication facilities) because currently most of the significant intakes of radioactive material result from accidental, not planned, exposures.

Under the current Part 20, most licensees attempt to avoid intakes of radionuclides by workers. The current rule emphasizes the limitation of internal exposures and many licensees feel that compliance is assured if intakes are avoided altogether. Unfortunately, the avoidance of intakes of radionuclides often leads to increased external doses that exceed the internal doses avoided. This practice may or may not be consistent with the ALARA principle, depending on both the magnitude of the increase in total collective dose equivalent and the costs saved by avoiding the assessment and recording of intakes of radioactive material (Merwin, Brown and Martin 1987).

It is likely that the revised dose evaluation requirements will affect the distribution of doses to some workers who currently receive negligible internal doses. Because the DACs for most radionuclides are higher than the corresponding MPCs, it is anticipated that intakes of radionuclides will generally be more common under the revised Part 20 than under the current Part 20. This increase will result from both decreased controls on airborne activity and more consistent use of the ALARA philosophy regarding tradeoffs between internal and external doses.

In summary, the revised dose evaluation requirements may result in increased internal doses for some workers at facilities other than fuel fabrication facilities. However, these doses would be justified by a concomitant decrease in external doses and/or a cost savings, e.g., a reduction in the use of respirators. In other words, the fact that the revised requirements will likely result in improved implementation of the ALARA principle virtually assures a positive impact. Otherwise, licensees could not justify allowing increased internal doses. This potential impact is discussed further in Section 5.1.

3.5 RECORDKEEPING

The revised dose evaluation requirements, in combination with the revised recordkeeping requirements, will result in substantial costs to licensees who have extensive internal dosimetry programs. These costs are estimated in this section. Recordkeeping costs not associated with the revised dose evaluation requirements are estimated in Section 5.4.

The current Part 20 requires that individual dose records be kept for all personnel for whom monitoring is required. The records are required to be kept on NRC Form 5 (or equivalent) and at least four separate entries per

year are required because the current rule promulgates quarterly dose limits. Records of surveys and individual monitoring are also required to be maintained.

The revision of Part 20 also requires that individual dose records be kept for all personnel for whom monitoring was required. However, because individual doses will include internal doses when intakes greater than 10% of applicable ALIs occurred, more information will be required to evaluate doses. Thus, NRC Form 5 will require more information under the revised rule. For facilities with comprehensive internal dosimetry programs, such as nuclear power plants and fuel fabrication facilities, extensive modifications to existing dose evaluation procedures will be required. For facilities where internal doses are normally insignificant, increased effort to complete NRC Form 5 should not be required (USNRC 1982).

An extensive study on the dosimetry and recordkeeping implications of the revision of Part 20 was performed by the Atomic Industrial Forum (AIF) (Booth, Bronson and Groth 1985). Additional information on recordkeeping costs anticipated from the revised dose evaluation requirements were available from public comments on the proposed revision and a report prepared for the NRC (SEA 1986).

Costs are anticipated to be incurred by some licensees to develop revised recordkeeping procedures and to implement and operate revised recordkeeping programs. Development costs may include development and approval of revised procedures. Implementation costs may include modification of computer programs and data bases and acquisition of additional computer-related equipment. Operation costs may include equipment replacement and maintenance, labor, and data review (Booth, Bronson and Groth 1985). These costs are expected to be incurred at some facilities even though there exists an extremely low frequency of significant internal exposures at the facilities. Some of the costs, therefore, will not be necessary for compliance with the revised Part 20; rather, the costs will be incurred voluntarily as options for demonstrating compliance.

An extensive study of these costs for nuclear power plants and fuel fabrication facilities was performed (Booth, Bronson and Groth 1985). Upon review of this study and other applicable information, the cost estimates from this study were adopted for this analysis. Table 3.4 lists the appropriate cost estimates in 1989 dollars.

Assuming that 109 nuclear power plants will be operating in the beginning of 1989 (ANS 1988), the total development and implementation costs incurred by nuclear power plant facilities is estimated to be $2,700,000 and $9,900,000, respectively. The annual operation costs are estimated to be $2,300,000. It was assumed for this analysis that the number of nuclear power plants operating after January 1, 1989, would remain constant at 109.

TABLE 3.4. Estimated Costs of Increased Recordkeeping Requirements Resulting From the Revised Dose Evaluation Requirements

Cost Category	Cost per Facility (1989 dollars) Nuclear Power Plants	Fuel Fabrication
Development (initial cost)	25,000	13,900
Implementation (initial cost)	91,000	67,200
Operation (annual cost)	21,000	9,700
Present Value[(a)]	290,000	157,000

(a) Calculated using methods described in Section 8.2 of this report.

Based on five fuel fabrication facilities that will incur most of the costs of the revision, the total costs for development and implementation are estimated to be $70,000 and $336,000, respectively. Total annual operation costs for these facilities are estimated to be $49,000.

Although significant internal doses are relatively rare at other facilities, they do exist and health physicists at these facilities will be required to evaluate and record the appropriate committed and total dose equivalents. Because these instances will be rare, it is assumed that internal doses will be recorded manually at these facilities when appropriate. It is estimated that at academic and research facilities and at medical facilities, responsible personnel will spend an average of 8 person-hours developing and implementing revised recordkeeping procedures that pertain to dose evaluation. Average operation costs of 4 person-hours/yr are anticipated for manual evaluation and recording of information on NRC Form 5. Based on an hourly rate of $25 per health physicist in 1989 dollars (SEA 1986), the development costs per facility are expected to be $200. Annual operation costs are expected to be $100 per facility. Based on the number of academic/research and medical facilities estimated in Section 8.1, academic/research facilities are anticipated to incur $310,000 in development costs and $160,000 in annual operation costs. Medical facilities are anticipated to incur development costs of $1,300,000 and annual operation costs of $650,000. These estimates include both NRC and Agreement State licensees.

Most other licensees have limited or nonexistent internal dosimetry programs. Internal doses at these facilities will rarely exceed levels that must be included in the evaluation of total effective dose equivalent. Thus, no significant recordkeeping costs related to the revised dose evaluation requirements are anticipated for these facilities.

Because licensees will be required to monitor both external doses and intakes of radioactive material likely to exceed 10% of the applicable annual limits under the revised monitoring requirements, licensees that currently do not record doses over 10% of the current limits will have to record external doses under the revised requirements and might have to record internal doses

depending on the radionuclide. Because the applicable DACs are higher for most radionuclides than the current MPCs, and considering that most licensees currently record all measured external and internal doses, the impact on recordkeeping with regard to an increased number of workers for whom records will be kept is considered to be negligible for this analysis.

3.6 SUMMARY OF CONSEQUENCES

This section summarizes the consequences of the revised dose evaluation requirements described in Sections 3.1-3.5. In Table 3.5, the costs are summarized by facility category in terms of both initial and annual costs. Initial costs include development and implementation costs; annual costs consist of operational costs. Table 3.5 also summarizes the annual benefits (reduced doses) from the revised dose evaluation requirements. The impacts from the revised dose evaluation requirements are anticipated to be negligible for facility categories not listed in Table 3.5.

TABLE 3.5. Summary of Consequences of the Revised Dose Evaluation Requirements

Facility Category	Initial Cost, $	Annual Cost, $	Value of Annual Dose Savings, $(a)	Net Present Value of Costs and Benefits, $(b)
Medical	3,800,000	730,000	negligible	- 9,700,000
Manufacturing and Distribution	100,000	54,000	negligible	- 560,000
Academic/Research Institutions	1,500,000	160,000	negligible	- 2,700,000
Fuel Fabrication and Processing	31,000,000	5,300,000	540,000	- 69,000,000
Commercial Power Reactors	13,000,000	2,500,000	negligible	- 33,000,000
Total(c)	49,000,000	8,700,000	540,000	-115,000,000

(a) Based on a value of $1000/person-rem.
(b) Calculated using methods described in Sections 8.2 and 8.3 of this report. The present values are based on 1989 dollars, a discount rate of 10% (applied to all costs and benefits), and a 30-year period. A negative sign indicates a negative impact.
(c) Throughout this report there may be minor variations in summed values because of rounding.

It is probable that some of the costs that will be incurred by licensees in response to the promulgation of 10 CFR Part 20 will not be necessary for compliance with the revision. For example, because few workers at nuclear power plants currently receive doses greater than 10% of the applicable DACs, summation of external and internal doses will be required in only a small number of cases. It follows that some of the estimated costs of increased recordkeeping requirements resulting from the revised dose evaluation requirements (see Table 3.4) could be avoided if optimal compliance with the revision is achieved. An estimate of the costs of the revision based on optimal compliance is included in the sensitivity analysis provided in Section 8.4.

4.0 CONSEQUENCES OF REVISED LIMITS

The revision of Part 20 contains changes to most of the current dose limits. These include occupational whole-body dose limits and separate limits for the eyes, extremities, skin, and individual organs. In addition, the revised Part 20 contains dose limits for the embryo/fetus and for individual members of the public; neither of these limits exists in the current Part 20. The consequences of the revised limits are presented below.

4.1 OCCUPATIONAL DOSE LIMITS FOR ADULTS

The present occupational dose limits for adults are 1.25 rem/quarter to the whole-body, head and trunk, active blood-forming organs, lens of eyes, or gonads; 18.75 rem/quarter for hands and forearms or feet and ankles; and 7.5 rem/quarter for skin of the whole body. A licensee may, however, permit a worker to receive whole-body doses up to 3 rem/quarter, provided that the worker's average dose to the whole body after the age of eighteen does not exceed 5 rem/yr. Inhalations of radioactive material per quarter are limited to the amount that would be inhaled by a worker present for 520 hours at the air concentrations listed in Appendix B, Table 1.

The revised occupational dose limits are a total effective dose equivalent of 5 rem/yr, a dose to any organ or tissue other than the lens of the eye of 50 rem/yr, an eye dose equivalent of 15 rem/yr, and a shallow dose equivalent of 50 rem/yr to each of the extremities and to the skin. Planned special exposures exceeding the annual limits are allowed, providing there is justification (see Section 4.2). A comparison of the current and revised limits was presented in Table 3.1.

4.1.1 Whole-Body Dose Equivalent Limits

As discussed in Section 3.0, there are significant differences in the dosimetric principles that form the basis for the two sets of limits. Under the present Part 20, whole-body dose limits are based only on external doses. Internal doses are subject to separate controls on intake. Under the revised limits, however, external and internal doses are summed to determine the total effective dose equivalent. Weighting factors are applied to internal doses depending on the critical organ(s) for the radionuclides of concern to equate the risk to that from a whole-body exposure.

In this section, the costs and benefits associated with revising the whole-body dose limits are presented. Although it is difficult to compare the two dose limits because they are based on different methodologies for evaluating doses, very few workers currently receive both internal and external doses that approach the separate limits under the current Part 20. (It is assumed in this section that workers who were reported to receive whole-body doses approaching or exceeding 5 rem did not receive significant internal doses. The few cases where this assumption does not apply were discussed in Section 3.4).

Number of Workers Who Receive High Doses

Certain licensees are currently required under Part 20.407 to submit an annual statistical summary report of whole-body doses received by individuals for whom monitoring was required. The reports list the number of individuals who received doses in any of eighteen dose ranges. The data in these reports are periodically compiled and analyzed by the NRC. To assess the impact of the revision, summary information on the relatively high doses received by individuals at NRC-licensed facilities was reviewed. Table 4.1 lists selected data for the year 1984 for the seven categories of licensees required to submit annual summary reports (Brooks 1986).

TABLE 4.1. Doses Received by Licensee Employees in 1984

Facility Type	No. of Licensees	No. of Employees Monitored	Average Dose Equivalent per Employee Monitored, rem	No. of Employees Receiving Doses 4 rem or Greater	
				4-5 rem	>5 rem
Industrial Radiography	361	8,458	0.30	24	13
Manufacturing and Distribution	38	5,009	0.13	1	0
High-Level Waste Repository	0	0	----	0	0
Low-Level Waste Disposal	2	925	0.08	0	0
Independent Fuel Storage	1	32	0.41	0	0
Fuel Fabrication and Processing	14	9,488	0.09	0	0
Commercial Power Reactors	88	170,928	0.32	380	11
Total	504	194,840	0.30	405	24

Similar data for licensee categories other than the seven presented in Table 4.1 were not available for the year 1984 because licensees in other categories were not required to submit annual reports of occupational exposures. However, data for other categories of licensees were compiled for exposures occurring in 1979 (Brooks, McDonald and Richardson 1982). Selected data from that report are presented in Table 4.2.

TABLE 4.2. Number of Licensee Employees Reported to Have Received Doses Approaching or Exceeding 5 rem in 1979

Facility Category	No. of Employees Monitored	No. of Employees Receiving Doses of 4 rem or Greater	
		4-5 rem	>5 rem
Academic	24,639	1	1
Medical	64,057	21	29
Marketing	11,037	31	21
Industrial Radiography	11,969	34	24
Research and Development	18,663	4	1
Other Byproduct Material[a]	27,335	9	22
Uranium Milling/Production	3,508	0	0
Fuel Fabrication and Processing	9,946	0	0
Other Special Nuclear Material	7,562	0	0
Research and Test Reactors	3,003	0	0
Power Reactors	106,445	477	130
Total	288,164	577	228

(a) Includes well logging.

Although in some cases the facility categories are not consistent between Tables 4.1 to 4.2, analysis of the data from which the tables were derived provides an indication of trends in dose distributions. Of the 577 individuals reported to have received occupational doses between 4 and 5 rem in 1979, only 35 (6%) were not employed by licensees categorized as facilities belonging to one of the seven types listed in Table 4.1. Of these 35 individuals, 30 were employed at either a medical facility or a well logging facility. The remaining 5 individuals were employed at other types of facilities. Similarly, of the 228 individuals reported to have received occupational doses greater than 5 rem in 1979, 53 (23%) were not employed by licensees categorized as facilities belonging to one of the types listed in Table 4.1. Of these 53 individuals, 46 were employed at either a medical facility or a well logging facility. The remaining 7 individuals were employed at other types of facilities.

The number of workers reported by licensees to have received doses in the various dose ranges does not reflect the actual distribution of doses received because of multiple reporting of transient (temporary) workers who worked at more than one facility during a year. Transient workers are often employed at nuclear power facilities for relatively brief periods, principally during plant outages or during special maintenance activities (Lawrence et al. 1984). Because a facility is required to report only those doses

received at that facility, a summation of these reports results in transient workers being counted two or more times in relatively low dose ranges; such a practice does not reflect the doses actually received by these individuals during the year. However, their actual annual doses can be determined by compiling termination reports. When a transient worker terminates employment at a facility, a termination report indicating the dose received by that worker during employment at that facility is reported to the NRC as required under the present Part 20. Although termination reports are required to be submitted by all seven categories of licensees listed in Table 4.1, more than 95% of termination reports are filed by commercial nuclear power facilities (Brooks 1986).

Analysis of the termination reports submitted by nuclear power facilities indicates that from 1977 through 1984, multiple reporting of transient workers accounted for an underestimate of the number of workers who were reported to have received annual doses greater than 5 rem. The actual total was from 50 to 80 workers per year higher (Brooks 1986). Although this number applies only to transient workers employed at nuclear power plants, it was assumed that relatively few transient workers at other facilities received doses >5 rem during this period because more than 95% of transient worker reports were filed by nuclear power plants. In addition, the nature of the work performed during outages at nuclear power plants suggests that doses >5 rem/yr are most likely to be incurred by transient workers employed at nuclear power plants rather than transient workers employed elsewhere.

Using these adjusted dose estimates for transient workers at commercial power reactors, the actual number of workers who received annual doses >5 rem was derived for the years 1979 and 1984. The results are presented in Table 4.3. For 1984, the data for well logging, medical, and other facilities were extrapolated from the 1979 data assuming a reduction in numbers consistent with the reduction observed for industrial radiography facilities. Extrapolation was necessary because 1979 was the last year that data were compiled for facilities other than those required to submit annual summary reports.

The data in Table 4.3 suggest that the number of licensee workers who received annual doses >5 rem dropped significantly from 1979 to 1984. In 1979, 180 nuclear power plant workers received doses >5 rem, 130 (72%) of whom were reported by facilities on the annual statistical summary report form. The remaining 28% were transient workers reported by two or more facilities during the year. In 1984, 110 workers received >5 rem, none of whom were reported on the annual statistical summary report forms, i.e., all of whom were transient workers.

Exposure data for the years 1985 and 1986 suggest that doses received by workers in the nuclear power plant industry dropped dramatically during those two years. In 1985, collective doses received by nuclear power plant workers were 20% lower than the collective doses received in 1984 (Ryan 1986). Compared to the reduction in collective doses observed in previous years, the 20% reduction in collective doses in 1985 was unprecedented. Since 1973, the greatest single-year reduction in collective dose equivalent received by

TABLE 4.3. Adjusted Number of Employees Who Received Doses >5 rem in 1979 and 1984

Facility Type	No. of Employees Who Received >5 rem	
	1979	1984
Industrial Radiography	24	13
Medical	29	16
Well Logging	17	9
Commercial Power Reactors	180	110(a)
All Others	7	5
Total	257	153

(a) Estimate based on discussions with firms providing contract personnel (Brooks 1986).

nuclear power plant employees had been 4%. As in 1984, no worker at any one nuclear power facility received >5 rem in 1985.

In 1986, the total collective dose equivalent was lower than the 1985 level. Also in 1986, the average dose per worker reached the lowest level ever reported for the U.S. nuclear power industry (USNRC 1987b). For the third consecutive year, no worker received a dose >5 rem while at any one facility.

The recent dramatic decreases in collective dose equivalents, average individual dose equivalents, and number of workers who received >5 rem per year is not likely to be a short-lived phenomenon. Some of this change is attributable to an increased emphasis by the Institute of Nuclear Power Operations (INPO) on keeping doses low (Ryan 1985). INPO, an organization established in 1979 to promote the highest levels of safety and excellence in the nuclear industry, has recognized low personnel radiation exposures as one indicator of high plant performance (Pate 1986). Combined with NRC efforts to promote the ALARA concept, efforts by INPO to reduce individual and collective radiation doses throughout the nuclear industry have been successful.

Several other factors may have contributed to the recent reduction in doses to workers at both nuclear power plants and other NRC-licensed facilities. First, for most of this decade, NRC has been moving toward a revision of Part 20 that includes a 5-rem annual limit. Second, the concept of ALARA has been emphasized by essentially all influential organizations, including the NRC. Many facilities have responded by both reducing the collective doses incurred at the facilities and by reducing the number of workers to zero who are receiving an annual dose >5 rem. These two factors have contributed to the practice by all nuclear power plants to establish administrative

limits that are <5 rem/yr. Finally, post-Three Mile Island modifications that involved high doses have now been completed (Ryan 1985).

Direct Implications of Revised Occupational Limits

It is evident from the data presented in the preceding section that the number of licensee workers who receive annual doses >5 rem is small and is continually decreasing. Based on the trends indicated by recent exposure data, it is estimated that the revised whole-body dose limit will reduce from 50 to zero the number of workers at nuclear power plants who will receive planned annual doses >5 rem. This estimate does not consider the use of the planned special exposure provision, which is discussed in Section 4.2; nor does it consider gradual implementation of the revision.

Because the workers affected by the revised limits will primarily be temporary workers, licensees will selectively hire temporary workers whose total annual doses from all employers are not approaching the dose limits. This is not expected to result in a change in the total collective dose equivalents received at the facilities, nor is it expected that significant costs will be incurred by licensees, because only 50 workers per year would be expected to receive annual doses >5 rem if the revised Part 20 were not promulgated. This is a very small percentage of the contractor work force, and licensees are not anticipated to experience a shortage of qualified workers in the foreseeable future (NESP 1980). The only significant cost associated with nuclear power plant facilities is that some workers will not be eligible for some jobs within the nuclear industry for portions of a year because their total annual doses from all employers will be near administrative or NRC dose limits. No attempt was made in this analysis to quantify these costs.

No impact from the revised limit is anticipated with regard to reducing annual doses below 5 rem to workers at facilities other than nuclear power plants. Table 4.3 indicated that in 1984, 43 non-power-plant workers were exposed to doses >5 rem. Of these, 16 were employed at medical facilities (hospitals) and it is likely that similar exposures in 1989 would not be planned, with or without promulgation of the revised Part 20. Twenty-two of the 43 workers were employed by either well logging or industrial radiography facilities. It is estimated that by 1989, only a few such workers per year would receive annual doses >5 rem if the revised Part 20 were not promulgated. This estimate considers the continuing overall reduction in relatively high doses throughout the nuclear industry as a result of emphasis on ALARA practices. For similar reasons, the five individual doses >5 rem in 1984 that were reported by other facilities would not be expected to occur in 1989.

Indirect Implications of Revised Occupational Limits

An important effect of the revised occupational whole-body dose limit will be to reduce the administrative limits at some facilities. An administrative limit is a self-imposed limit set by a facility to provide a safety margin to ensure that the NRC limits are not exceeded. As stated previously in this section, nuclear power plants currently do not intentionally allow

workers to receive whole-body doses greater than 5 rem/yr. To assure this, the administrative limits at the plants are set lower than 5 rem/yr. Annual administrative limits are common at many plants, as are quarterly and/or weekly administrative limits (either in addition to or instead of annual administrative limits) (Pelletier and Voilleque 1979). It is expected that a minor reduction in administrative limits will occur at some nuclear power plants in response to the revision of Part 20, resulting in hiring about 20 permanent workers for radiation areas who will lessen the burden on similar workers approaching the plant administrative limits. Although this will likely result in a decrease in efficiency for performance of some work, the anticipated slight increase in collective dose equivalent is considered negligible for this analysis.

It is likely that other facilities will reduce their administrative dose limits in response to the revised whole-body dose limits in Part 20. However, Table 4.1 indicated that few employees other than those at nuclear power plants receive doses >4 rem. Therefore, the impact of the revised whole-body dose limit with regard to lowered administrative limits is estimated to be negligible for facilities other than nuclear power plants.

Before the estimated impact of the revised whole-body dose limits can be quantified, two important factors must be considered. First, as stated previously, the number of workers who have received doses approaching or exceeding 5 rem/yr has decreased dramatically in recent years. It is likely that this trend will continue regardless of the limits specified in Part 20. However, because of the difficulty in estimating the rate of decrease, it is estimated that the work force in the nuclear industry will be permanently increased by 20 workers to ensure that administrative dose limits are not exceeded. This consideration partially accounts for the probability that some of the decrease in individual doses already observed may be directly attributable to licensee pre-planning in anticipation of the revised limits.

The second important consideration in assessing the impact of the revised limits is that the implementation period for the revision is 5 years from the date the proposed revision was published (January 9, 1986). If licensees make use of this implementation period, costs could be deferred, resulting in a reduced present value of the costs of the revision. The method used in this report for calculating present values is described in Section 8.2.

Statement of Impact

The estimated impact of the revised whole-body occupational dose limit on NRC licensees is expected to be limited to the costs associated with hiring additional permanent workers at nuclear power plants. These workers will be hired in order to reduce annual doses to members of the existing workforce who currently receive doses approaching or exceeding 5 rem/yr. Based on data presented in this report and an annual cost of $60,000/worker (SEA 1986), which includes all costs (labor and overhead) associated with the employment of the worker, the estimated annual impact of the revised whole-body dose limits is $1,200,000 in 1989 dollars. A one-time marginal cost of $280,000 is also estimated for hiring 20 workers at a cost of $14,000/worker in 1989

dollars (Vallario et al. 1985). No other attributes are expected to be significantly affected by the revised whole-body dose limit.

4.1.2 Other Limits and Their Consequences

In addition to the revised whole-body dose limit, the revision of Part 20 includes revised dose limits for the eyes, extremities, skin, and individual organs. The revised limits for the eyes and skin allow higher annual doses than are allowed by the present limits. The revised limit for the extremities is lower than the present limit; however, the revised rule clearly states that the limit is applicable to individual extremities. In contrast, the current rule does not specify that the limit is applicable to individual extremities. Finally, the dose limit to individual organs is essentially unchanged. However, the use of DACs and ALIs to limit the doses to individual organs will indirectly change the limit on intake of certain radionuclides. This consequence of the revised dose evaluation requirements was discussed in Section 3.4.

Dose limits for the eyes, skin and extremities are intended to prevent nonstochastic effects to those parts of the body (ICRP 1977, NCRP 1987). When the dose limit to an individual organ is not determined by the 5-rem annual limit for the whole-body, the limit to that organ (50 rem/yr) is also intended to prevent nonstochastic effects.

Because nonstochastic effects have a dose threshold, workers should not suffer from these effects, providing that their doses are kept below the limits. Under the current dose limits, no nonstochastic effects have been observed except when doses much greater than the limits were received from accidental overexposures. Assuming that the revised dose limits will not affect the probability of an accidental overexposure, no impact regarding occupational health is anticipated from the revised limits.

The revised limits could result in slight impacts on operations costs. For example, an increased annual eye dose limit could result in a decreased use of protective goggles (McGuire, Baker and Vandergrift 1983). Also, a decreased extremity limit could result in an increased use of shielding and gloves. Depending on the current interpretation of the dose limit to the skin, however, some individual licensees currently choose to adopt the limit to the skin for limiting dose to the extremities. Although the most recent guidance by NRC states that the dose limit to the skin of the whole body does not apply to the skin of the hand and forearm (USNRC 1983), licensees do not use consistent methods to determine doses to the skin. Therefore, an increased dose limit for skin could result in increased extremity doses.

Although there will likely be slight impacts on operations costs from the revised limits, the net impact is estimated to be negligible. Because the revised limits to the eyes and skin are less restrictive than the current limits, the costs saved are expected to approximately offset the costs incurred from the more restrictive extremity limits. In addition, previous case studies have indicated that, except for a few workers, eye, skin, and extremity doses have been maintained well below both the current and revised limits (USNRC 1982). Increased costs for extremity monitoring, which will

result from both reduced limits and reduced doses that require monitoring, were discussed in Section 3.1.

4.2 PLANNED SPECIAL EXPOSURES

Under the planned special exposure provision in the revised Part 20, a licensee may authorize an adult worker under certain conditions to receive doses in excess of the prescribed annual limits. This provision may only be used in an exceptional situation, and the dose received by an individual from all planned special exposures in a year must not exceed one times the annual limit. In order to authorize a planned special exposure, a licensee must first ascertain the doses received from all previous planned special exposures and unplanned exposures in excess of the annual limits for each individual involved. The total lifetime dose from all planned special exposures and all doses in excess of the annual limits must not exceed 5 times the annual limits.

Although the present Part 20 does not include a planned special exposure provision, the present "5(N-18)" rule is somewhat similar because, under the rule, annual doses >5 rem/yr are permitted. An important difference, however, is that planned special exposures are limited to "exceptional" situations, whereas the "5(N-18)" rule was essentially unconditional. As a result, it is expected that fewer individuals will receive annual doses >5 rem under the revised Part 20 than under the present Part 20.

4.2.1 Use of the Planned Special Exposure Provision

Use of the planned special exposure provision for whole-body doses will be limited primarily to commercial nuclear power facilities. This is because, as demonstrated in Section 4.1.1, temporary workers at nuclear power plants are the only workers at NRC-licensed facilities who currently receive planned annual doses >5 rem. It is assumed that this would continue in the future even without implementation of the revised Part 20. As a result, facilities other than nuclear power plants would have no reason or justification for using the planned special exposure provision for whole-body doses. The few exceptions that might occur were assumed for this analysis to be negligible.

It was estimated that reduced administrative limits based on the revised Part 20 would result in the hiring of 20 additional permanent workers at all nuclear power plants combined (Section 4.1.1). In addition, it was estimated that annual individual doses >5 rem would be reduced from 50 to zero once the revised Part 20 is implemented. This reduction would be realized primarily through selective hiring of temporary workers. These estimates were made without consideration of the planned special exposure provision.

Instead of reducing individual doses through increased or selective hiring, it is possible that licensees will use the planned special exposure provision to authorize annual doses >5 rem in order to reduce expenses. However, this possibility is remote because of the conditions of the provision. The condition likely to limit the use of the planned special

exposure provision is 20.206(a), which states that the provision can only be used when other alternatives are either "unavailable or impractical." Because the term "cost-effective" is not included in this condition, licensees will be likely to use the planned special exposure provision only when no other reasonable alternative exists.

It is estimated that an average of one nuclear power plant facility per year will use the planned special exposure provision. One reason for using the provision could be to avoid a safety hazard that may occur if repairs to a vital piece of equipment are delayed. Another reason could be to avoid substantial costs that would be incurred if vital work is delayed. In either case, the benefits would outweigh the costs. Otherwise, the licensee could not justify using the planned special exposure provision.

4.2.2 Effect on Distribution of Doses

Use of the planned special exposure provision should result in a decrease in collective dose equivalent because alternatives to use of the provision, such as performance of a job using more workers than are needed, would be less efficient. Therefore, use of the provision should partially offset the slight increase in collective dose equivalent anticipated from the revised whole-body dose equivalent limit. However, because the planned special exposure provision is anticipated to be used about once per year, the effect on doses to workers is assumed to be negligible.

4.2.3 Cost Implications

When the planned special exposure provision is used, a cost savings associated with its use is virtually assured because of the conditions that must be met before the rule can be implemented. Licensees will be unlikely to use the provision unless alternatives to its use are significantly less cost-effective. The associated cost savings could be significant if, for example, the down time at a nuclear power plant is reduced (the cost of replacement power averages $400,000 - $500,000 per day during a nuclear power plant outage). Because the planned special exposure provision is anticipated to be used infrequently, no attempt was made in this analysis to quantify the associated net cost savings. It is assumed, however, that these savings will partially offset the cost increases associated with the revised whole-body dose limit.

4.3 DOSE TO AN EMBRYO/FETUS

The current Part 20 does not provide a limit on dose to the embryo/fetus of a pregnant worker. Rather, pregnant workers are subject to the same occupational dose limits as all other adult workers. A 0.5-rem limit is practiced at many facilities because of a NRC Regulatory Guide (USNRC 1987a) and a staff position paper that address this subject. The revised Part 20 explicitly states that the dose to an embryo/fetus due to occupational exposure of a declared pregnant worker shall be limited to 0.5 rem during the entire pregnancy. The rule also states that efforts shall be made to avoid substantial variation above a uniform monthly rate that would satisfy

the 0.5-rem limit. By comparison, the NCRP recommends a limit of 0.5 rem to the fetus during the entire pregnancy, and also recommends a limit of 0.05 rem/month once a pregnancy becomes known (NCRP 1987). Essentially, the revised Part 20 rule is consistent with the NCRP recommendations; however, the rule is worded less strongly.

4.3.1 Effect on Distribution of Doses

Because licensees are currently not required to submit detailed annual reports of doses received by individuals, it is not possible to precisely determine the number of female workers at licensee facilities who currently receive doses >0.5 rem/yr. However, based on a comprehensive review of occupational exposure to ionizing radiation in the United States in the year 1980 (Kumazawa, Nelson and Richardson 1984), it is possible to estimate the effect of the embryo/fetus limit on occupational exposures. In 1980, an estimated 80% of female workers monitored for exposure to ionizing radiation were between the ages of 18 and 40. The median age of these women was 27, 28, and 32 for workers in medicine, the nuclear fuel cycle, and industry, respectively. Approximately 10,000 women were reported to have received doses >0.5 rem in 1980. A distribution of these women by dose range and industry is presented in Table 4.4, where the data indicate that approximately 90% of the women who received doses >0.5 rem were employed in medicine.

There is evidence, however, that the number of pregnant women who receive annual doses >0.5 rem is small and is decreasing (USNRC 1982). Several factors could account for this trend. First, the NRC published a revised regulatory guide on prenatal radiation exposure in 1975 (USNRC 1975) which specifies that women assigned to work in a restricted area should be given specific instruction regarding prenatal exposure risks to the developing embryo and fetus. Women were instructed that they could request reassignment to nonradiation work if they were pregnant or expected to be soon. Currently, most licensees either comply with or go beyond the recommendations in this regulatory guide. Two other factors that may contribute to this trend are the emphasis by ICRP (ICRP 1977) and NCRP (NCRP 1987) on limitation of dose to the unborn, and the trend toward reduced individual doses throughout the nuclear industry (see Section 4.1.1).

Although few pregnant women currently receive doses >0.5 rem, the embryo/fetus dose limit in the revised Part 20 and the recent revision of Regulatory Guide 8.13 (USNRC 1987a) will result in a further reduction in the number of pregnant women who receive doses >0.5 rem. For the reasons discussed in the paragraph above, it is assumed in this report that essentially all pregnant women who currently receive doses >0.5 rem do so voluntarily.

It was estimated that about 7% of female radiation workers in the U.S. become pregnant in a given year (NCRP 1977). Based on the data in Table 4.4 and the recent trend toward decreased individual doses, and assuming that declared pregnant women will not receive doses >0.5 rem under the new limit, it is estimated that the doses to 200 pregnant women per year will be reduced below 0.5 rem due to the embryo/fetus limit. It is also estimated that an additional 1000 pregnant women per year will receive reduced doses even

TABLE 4.4. Number of Women Reported to Have Received Doses >0.5 rem in 1980

Dose Range, rem	Number of Women Employed			
	Medicine	Nuclear Fuel Cycle	Other Industries	Total
0.5-1.0	5,902	82	560	6,544
1.0-2.0	2,191	111	236	2,538
2.0-3.0	587	33	68	688
3.0-4.0	188	19	0	207
4.0-5.0	100	0	0	100
Total	8,968	245	864	10,077

though they would not have received doses >0.5 rem had the limit not been promulgated. This estimate is based on the assumption that licensees will be more cautious regarding the exposure of pregnant women to ionizing radiation once the limit is promulgated. The total dose reduction for the 1200 pregnant women is estimated to be 300 rem. Because these doses will likely be distributed to nonpregnant replacement workers in most cases, the net savings in collective dose is anticipated to be insignificant for workers at licensee facilities. However, it is estimated that 300 rem/yr to fetuses will be saved by the dose limit. It is assumed that 90% of this dose reduction will occur at medical facilities and 10% will occur at nuclear power plants.

4.3.2 Cost Implications

Because most licensees voluntarily keep doses to pregnant women below the limit specified in the Part 20 revision, they have experience in ensuring that declared pregnant workers do not receive doses >0.5 rem. Most licensees simply remove pregnant workers from work involving high radiation doses (USNRC 1982). The costs, therefore, are expected to be administrative costs required to either hire a replacement worker or reassign a present worker to the job vacated by the pregnant woman. The average estimated cost per pregnant worker who is removed from her work is $500. Based on the estimates in Section 4.3.1, the total cost to licensees is expected to be $600,000 per year, 90% and 10% of which will be incurred by medical facilities and nuclear power plants, respectively.

4.3.3 Other Considerations

Because it will be difficult for licensees to determine in advance which women will become pregnant during their employment, it is possible that some licensees will selectively hire either men or older women for jobs that involve relatively high doses. This will limit the career opportunities for certain women. This phenomenon has already been observed at some facilities, especially nuclear power plants (USNRC 1982), and it is likely that promulgation of the limit will further affect the employment opportunities to some

degree for a small number of women. This topic is discussed further in Section 7.6.

4.4 DOSE LIMIT FOR INDIVIDUAL MEMBERS OF THE PUBLIC

The current Part 20 does not explicitly state a dose limit for individual members of the public, but does state limits of 2 mrem in 1 hour and 100 mrem in 7 days, based on continuous presence of an individual in an unrestricted area. An annual limit of 500 mrem is implied, however, by wording in the current rule regarding license applications. A limit of 500 mrem/yr is also implied by the limit on releases of radioactive material to unrestricted areas. The present Part 20 also refers to 40 CFR Part 190 (EPA 1986a), which specifies much lower dose limits to the public from nuclear fuel cycle operations. Even though a 500 mrem/yr limit is not explicitly stated in the present Part 20, the NRC would not allow licensees to operate such that this annual dose is exceeded.

The Part 20 revision explicitly states an annual dose limit of 0.1 rem to individual members of the public from continuing operations by a licensee. A licensee may apply for authorization to operate temporarily up to an annual limit of 0.5 rem. In addition to the annual limit, the dose in any unrestricted area is limited to 2 mrem/h (there is no 7-day limit). An additional rule requires demonstration of compliance with the dose limits by either measurement or calculation using approved methods.

4.4.1 Effect on Distribution of Doses

All licensees in the nuclear fuel cycle are constrained by 40 CFR Part 190 (EPA 1986a) to operate such that whole-body doses to individual members of the public are less than 25 mrem/yr; 40 CFR Part 61 (EPA 1986b) contains a similar limit for air emissions for most other NRC licensees. Nuclear power plants are subject to further release limits in 10 CFR Part 50, Appendix I. Because of the nature of operations of licensees not affected by 40 CFR Part 190 or 40 CFR Part 61, it is extremely unlikely that any licensee (NRC or Agreement State) currently exceeds the revised 100-mrem annual effective dose equivalent limit, except for some medical facilities (see below). For those licensees in the future who can justify exceeding this limit, the revised rule allows for application to operate up to 500 mrem/yr, which is the limit implied in the present Part 20.

It is possible that medical facilities where brachytherapy or radioimmunotherapy procedures are performed will be affected by the revised limits. Many hospitals performing brachytherapy have radiation levels outside a patient's room exceeding 2 mrem/h (Thomadsen et al. 1983). In some cases, these facilities must provide shielding or control patient admissions to ensure that dose rates to neighboring patients do not exceed the limits in Part 20. In many cases, the 100-mrem/7-day limit is the more restrictive limit because the wording of the rule requires limitation based on continuous presence of an individual in an unrestricted area (Thomadsen et al. 1983; Gitterman and Webster 1984).

The revised limits could be both costly and beneficial to these facilities. The 100-mrem annual limit could be restrictive for patients who would otherwise remain at the facility for an extended period near a brachytherapy room. Conversely, the absence of the 100-mrem/7-day limit could allow facilities to control dose rates based on the less-restrictive 2-mrem/h limit. Based on these opposing factors and detailed descriptions of the ramifications of the current dose limits (Gitterman and Webster 1984), the net impact from the revised limits is anticipated to be insignificant for this analysis.

4.4.2 Cost Implications

Because licensee operations are not expected to be impacted by the revised limit, no operations costs are anticipated. However, the rule requiring demonstration of compliance may involve some added costs. The magnitude of these costs depends on the interpretation of the rule, which does not provide detailed procedures for how compliance must be demonstrated, nor does it provide details on which licensees are affected by the rule. Discussions with NRC personnel indicate that the intent of the rule is not to require increased monitoring of the environment, but to require licensees to maintain records showing compliance. Therefore, no significant costs other than recordkeeping costs are anticipated from promulgation of both the revised limits and the requirement to demonstrate compliance. The associated recordkeeping costs are discussed in Section 5.4 of this report.

4.5 SUMMARY OF CONSEQUENCES

In this section, the consequences of the revised limits are summarized. Table 4.5 summarizes these consequences by facility category (as defined in Section 8.1) and is a compendium of the consequences identified in Sections 4.1 to 4.4 in this report. The impacts from the revised limits are anticipated to be negligible for facility categories not listed in Table 4.5. The positive present value of $10 million listed in the table indicates that the expected benefit from the dose savings to the embryo/fetus exceeds the costs that will be incurred by licensees to comply with the revised dose limits.

TABLE 4.5. Summary of Consequences of the Revised Limits

Facility Category	Initial Cost, $	Annual Cost, $	Value of Annual Dose Savings, $(a)	Net Present Value of Costs and Benefits, $(b)
Medical	0	540,000	2,700,000	+19,000,000
Commercial Power Reactors	280,000	1,300,000	300,000	- 9,000,000
Total	280,000	1,800,000	3,000,000	+10,000,000

(a) Based on a value of $10,000/fetus-rem.
(b) Calculated using methods described in Sections 8.2 and 8.3 of this report. The present values are based on 1989 dollars, a discount rate of 10% (applied to all costs and benefits), and a 30-year period. A positive sign indicates a positive impact and a negative sign indicates a negative impact.

5.0 CONSEQUENCES OF OTHER CHANGES

In this section, the consequences of other changes in the revision are discussed. These include changes regarding control of internal exposure in restricted areas, precautionary procedures, waste disposal, recordkeeping requirements not discussed in Section 3.5, reporting requirements, and others. These consequences are summarized in Section 5.7.

5.1 CONTROL OF INTERNAL EXPOSURE IN RESTRICTED AREAS

Under the present Part 20, in areas of airborne contamination, licensees are required to maintain intakes of radioactive material as low as is reasonably achievable without regard to external exposures. In many circumstances this mandates the use of respiratory protective equipment. Under the revised Part 20, internal exposures are considered a part of the worker's total radiation exposure and the licensee is required to keep the total effective dose equivalent ALARA. This permits the licensee to base ALARA decisions on both internal and external exposure rates, and could lead to a long-term net benefit in both collective dose and program costs.

Informal studies at Three Mile Island Unit 2 (TMI-2) indicated an overall dose savings of up to 50% (internal plus external dose) when the use of a respirator was discontinued (Cardarelli et al. 1986). The higher doses with a respirator were due to loss of productivity and consequent lengthened work times. It is well known that wearing respirators can lead to anxiety, which is associated with increased breathing resistance, increased body temperatures, decreased communication capabilities, limited vision, and general discomfort, all of which reduce work efficiency. A controlled experiment (Cardarelli et al. 1986) failed to show a statistically significant change in work time for a selected task with and without a respirator. It was observed that due to the discomfort of the respirator the workers operated faster, but this would probably not be true during longer, more complex tasks.

Information on accumulated doses is readily available for the various jobs involving respirator usage; however, information on present respirator usage, job frequency, and air concentrations by job is not readily available. Clearly, both cost savings and dose savings are likely, but the magnitude was difficult to assess accurately without additional information. If there were a 25% decrease in collective dose due to the greater efficiency from not using respirators in high-external, low-internal dose rate fields, this could result in an annual savings of over 600 person-rem during outages (Table 5.1). This is based on collective doses for selected jobs (Dionne and Baum 1985) and assumes a 25% decrease in collective doses for 10% of the outage tasks.

The costs associated with the use of respiratory protection equipment (i.e., costs of canisters and additional personnel to process respirators and track stay times in airborne radioactivity areas) were estimated at over $30,000 per outage week (Hendrixson, Wagner and Morris 1986). With a typical plant outage lasting 8 weeks (ANS 1988), the annual cost savings for the

TABLE 5.1. Estimated Collective Dose Equivalent Savings During an Outage Through Reduced Respiratory Usage for Selected Tasks[a]

Task	Typical Collective Dose Equivalent, person-rem[b]	Annual Frequency[c]	No. of Reactors Affected	Savings in Collective Dose Equivalent, person-rem[d]
Assembly/Disassembly Fuel Shuffle	56	0.67	107	100
Snubber Inspection and Repair	75	0.6	107	120
Torus Inspection/Modification Repair	280	0.6	36	151
In-Service Inspection	68	0.6	107	109
Steam Generator(Test/Plug)	76	0.5	71	67
Decontamination	33	0.5	107	44
Reactor Coolant/Circulation Pump Seal Repair	14	0.47	107	18
Total				609

(a) Data derived from Dionne and Baum (1985).

(b) Collective dose for typical plant based on $\frac{1}{N_T} (\Sigma N_i \times D)$

where N_i is the number of plants of Type i and D is the average collective dose for type i.

(c) (Estimated frequency of task per outage) X (annual frequency of outage [0.67]).

(d) Assumes a 25% reduction in collective dose due to efficiency increases through reduced respiratory usage for 10% of the outage tasks.

utility industry would be $1.75 million, counting 0.67 outages per reactor per year, 109 reactors (ANS 1988), and a 10% reduction in the overall use of respirators during outages. However, a decrease in the frequency of respirator use will likely result in increased costs for air monitoring, health physics support, and bioassay measurements (Merwin, Brown and Martin 1987). Therefore, the net annual cost savings are estimated to be one half of $1,750,000 or $880,000.

There are large uncertainties in these estimates, and benefits realized on other jobs or during routine operation were ignored. The impact on the non-power reactor segments of the industry were felt to be relatively insignificant and were not considered further.

5.2 PRECAUTIONARY PROCEDURES

Precautionary procedures are set forth in Subpart J of the Part 20 revision. These include procedures for labeling containers of radioactive material, posting caution signs, and handling packages containing radioactive material.

5.2.1 Labeling Requirements

The revised rules that address container labeling are essentially the same as the present rules. In both cases, containers of radioactive material must be labeled with caution signs, and the labels must provide information on the radioactive material present in the containers. Containers are exempt from the labeling requirement if they contain concentrations or quantities of radioactive material less than the values tabulated in Appendixes B and C.

The significant differences between the revised and present requirements are the exempt quantities provided in Appendix C. The present Appendix C lists the exempt quantities of 180 separate radionuclides, whereas the revised Appendix C lists the exempt quantities of 761 separate radionuclides. Of the 180 radionuclides listed in the revised Appendix C that are also listed in the present Appendix C, the exempt quantities in the revision are unchanged for 93 radionuclides, higher for 79 radionuclides, and lower for 8 radionuclides. Of the 87 exempt quantities that were changed, 76 were changed by a factor of ten and 11 were changed by a factor of 100.

The current exempt quantities of the radionuclides not listed in the present Appendix C are equal to one of two default values, depending on whether or not the radionuclide is an alpha emitter. Of the 581 radionuclides listed in the revised Appendix C that are not listed in the present Appendix C, 557 of the revised exempt quantities are equal to, or in most cases higher than the current default quantities. Only 24 revised quantities are lower than the relevant default values listed in the present Appendix C.

Because the Part 20 revision relaxes the requirement for labeling for most radionuclides, there could be a net cost savings from the revised labeling requirements. However, most of the radionuclides listed in the revised Appendix C are not commonly found in licensee facilities. For most

of the radionuclides that are common, the revised exempt quantities are only one order of magnitude higher than the present exempt quantities. Also, it is common practice to label containers of radioactive material with appropriate labels regardless of the quantity. The main exception to this practice occurs for packages containing naturally-occurring radionuclides, such as thorium and uranium, for which the exempt quantities in Appendix C are unchanged. As a result, the net benefit from the revised labeling requirements is anticipated to be positive but small. No attempt was made in this report to quantify the potential benefits nor the potential for increased doses to the public. However, a qualitative discussion of the potential benefits from the revised labeling requirements is presented in Section 7.7.

5.2.2 Posting Requirements

The revised posting requirements, which address the types of posting required for rooms containing radioactive material or having specified radiation dose rates, are essentially equivalent to the current requirements. The minor changes are not expected to result in significant cost impacts.

5.2.3 Package Handling Requirements

These requirements address the receiving, monitoring, and opening of packages containing radioactive material. The changes are relatively minor and no significant impacts from the revision are anticipated.

5.3 WASTE DISPOSAL

The revision of Part 20 explicitly permits onsite storage of radioactive wastes to allow the radioactivity to decay. The expense of radioactive waste disposal and the lack of facilities has forced licensees to segregate, recycle, and compact wastes in an attempt to reduce waste volume and, thus, costs (Bunker 1985). More significant than cost is the possible exclusion from commercial low-level waste disposal facilities which the Low-Level Radioactive Waste Policy Act of 1990 (P.L. 96-573) portends. This has led to the building of onsite radwaste storage facilities as an alternative to immediate disposal. The NRC issued a generic letter (USNRC 1981) that provides guidance for temporary (5-yr) onsite radwaste storage at power reactors. Temporary onsite storage is regarded as a contingency that would become legalized by the new Part 20. This change will have little impact on the industry since facilities are already being built at medical research institutions (Masse 1984) and nuclear power plants (Rutland and Tuohy 1984; Kemper, Kohlerand and Scholz 1984). The NRC encourages medical licensees to modify their license to store wastes with half-lives up to 100 days for decay and disposal by conventional means. The value of this change is already being realized and the cost impact is already being borne by NRC licensees.

The only changes regarding waste disposal requirements that are expected to have a significant impact are the revised requirements for disposal by release into sanitary sewerage. Although there are some changes in the wording of the rule, they are relatively insignificant compared to the

changes in the concentration limits listed in Appendix B. Under the current Part 20, releases to sewers must be in concentrations lower than the values listed in Appendix B, Table I, Column 2. The limiting concentrations in the revised Part 20 are listed in Appendix B, Table 3. A comparison of the current and revised average concentration limits for sewage disposal is presented in Table 5.2.

Table 5.2 indicates that for the radionuclides listed, the revised concentration limits are generally one to two orders of magnitude lower than the current values. For alpha emitters, the disparity is often greater than two orders of magnitude.

It is anticipated that some licensees will be required to take action to reduce the concentrations of radionuclides that are released to the sanitary sewerage system. Based on a review of published data on releases of radionuclides by licensees (Tichler and Norden 1986; Cook 1981) and on a review of numerous NRC inspection reports, it is concluded that some medical, academic/research, manufacturing and distribution, and nuclear laundry licensees could be affected by the revised release limits. Because of the large volumes of water released by most major medical and academic/research licensees, the impact on these licensees should be relatively small. It is likely, however, that some manufacturing and distribution and nuclear laundry licensees could be required to improve filtration systems, increase holdup times, and/or increase the amount of water released to sewers in order to comply with the revised limits. Nuclear power plants should not be affected because releases from these facilities are currently very low in accordance with the requirements in 10 CFR 50, Appendix I. Nilson and Malody (1982) suggested that some fuel fabrication facilities might be impacted by the revised limit for ^{236}U; however, the magnitude of this potential impact is uncertain, and may be smaller than originally anticipated. Because the available data are not sufficient for a complete evaluation of these potential impacts, the impact of the revised limits for releases into sanitary sewerage was not quantified in this analysis; however, the impact on some licensee operations could be significant.

5.4 RECORDKEEPING REQUIREMENTS

Subpart L of the revision describes the records required to be kept by licensees. As discussed in Section 3.5 of this report, the requirements for recording individual monitoring results will be costly to licensees because more information must be evaluated and recorded than under the present Part 20. The requirement to maintain records of radiation protection programs is included in the discussion presented in Section 5.6. Changes regarding other recordkeeping requirements will have relatively insignificant impacts, as described below:

Records of Surveys. Although the revised requirements are more detailed than the present requirements, essentially all licensees currently keep records required by the revised Part 20. Therefore, no significant impact is anticipated.

TABLE 5.2. Current and Revised Average Concentration Limits for Releases into Sanitary Sewerage

Radionuclide	Current Limit, μCi/mL	Revised Limit, μCi/mL	Reduction Factor, Current/Revised
^{3}H	1E-1	1E-2	10
^{14}C	2E-2	3E-4	70
^{32}P	5E-4	9E-5	60
^{35}S	2E-3	1E-3	2
^{45}Ca	3E-4	2E-4	2
^{51}Cr	5E-2	5E-3	10
^{54}Mn	4E-3	3E-4	10
^{59}Fe	2E-3	1E-4	20
^{60}Co	1E-3	3E-5	30
^{65}Zn	3E-3	5E-5	60
^{86}Rb	2E-3	7E-5	30
^{90}Sr	1E-5	4E-6	2
^{99}Mo	5E-3	1E-4	50
^{99m}Tc	2E-1	1E-2	20
^{125}I	4E-5	2E-5	2
^{129}I	1E-5	3E-6	3
^{131}I	6E-5	1E-5	6
^{137}Cs	4E-4	1E-5	40
^{144}Ce	3E-4	3E-5	10
^{235}U	8E-4	3E-6	300
^{238}Pu	1E-4	2E-6	50
^{241}Am	1E-4	3E-7	300

Determination of Prior Occupational Dose. The primary change regarding requirements for determining prior occupational dose is that licensees must "attempt" to obtain lifetime records of dose before permitting individuals who will require monitoring to enter the licensee's restricted or controlled areas. Under the current Part 20, licensees must obtain record of prior doses only for the current calendar quarter, unless they plan to use the 5(N-18) dose-averaging provision. Only then are licensees required to determine lifetime cumulative doses.

There could be both costs and benefits from the revised requirements. Because licensees will be required to determine lifetime cumulative doses for more workers, additional costs will be incurred. On the other hand, the revised requirements will result in better tracking of individual doses and licensees will expend less effort per worker to determine prior doses. The latter point is especially important for tracking transient worker doses, where under the current recordkeeping requirements time is often lost waiting for and verifying exposure histories (Hageman, Artz and Humphress 1982). Because the revised requirements will result in both costs and benefits that are difficult to quantify, the net impact was not estimated in this analysis.

Records of Planned Special Exposures. As discussed in Section 4.2, the planned special exposure provision will not be used frequently. Therefore, the associated recordkeeping costs are assumed to be insignificant for this analysis.

Records of Dose to Individual Members of the Public. Under this new requirement, licensees must maintain records sufficient to demonstrate compliance with the dose limit for individual members of the public. Although not explicitly required under the present Part 20, records currently being maintained by most licensees should be sufficient to demonstrate compliance. The only licensees that are likely to be affected by the new requirement are some medical facilities, academic/research institutions, and manufacturing and distribution facilities, where health physicists or radiation safety officers will maintain more detailed records of radioactive releases and inventories of radioactive materials. It is estimated that for facilities in these categories, a health physicist or other appropriate professional will devote an average of 2 hours per year to these tasks. Based on a cost of $25 per hour for health physicists (SEA 1986) and 9027 licensees in these categories (see Section 8.1), the estimated annual cost is $450,000.

Records of Waste Disposal. The changes that appear in the revised Part 20 are relatively minor and are expected to have an insignificant impact on licensees.

Records of Testing Entry Control Devices for Very High Radiation Areas. Although licensees are currently required to test entry control devices, they are not required to maintain test records. Although this requirement in the revision is new, most licensees voluntarily keep records to demonstrate compliance with the current testing requirements. Therefore, no significant impact is anticipated.

5.5 REPORTING REQUIREMENTS

The NRC currently requires that licensees report the theft or loss of licensed material and incidents involving radiation exposures that exceed the annual limits. Certain licensees are also required to submit an annual summary report of radiation exposures received by workers (Brooks 1986). However, the revision contains three significant changes regarding reporting requirements. First, planned special exposures must be reported to the NRC within 15 days after the exposure occurs. A similar requirement is not included in the current Part 20 because planned special exposures are not currently allowed. Second, licensees that are currently required to submit annual exposure data will be required to submit separate reports for each individual for whom monitoring was required rather than one report containing summarized information. Third, all licensees will be required to submit reports, at least annually, to all individuals for whom monitoring was required, indicating the doses that they received in the workplace. Although the latter requirement will actually be included in the revised 10 CFR Part 19, Section 19.13, it is included in the analysis provided in this report.

5.5.1 Incident Reports

Some incidents that are not reportable under the current requirements will be reportable under the revised requirements. Such incidents, including planned special exposures, are expected to be rare. Also, the cost of reporting an incident to the NRC is relatively insignificant. As a result, no significant impact is anticipated from the revised incident reporting requirements.

5.5.2 Reports of Personnel Monitoring

Under the current Part 20, certain licensees are required to submit an annual statistical summary report containing information on doses received by personnel. Under the revised requirements, individual reports rather than a summary report must be submitted. As a result, the affected licensees will annually submit one NRC Form 5 (or equivalent) for each individual for whom monitoring was required, rather than one report that summarizes all of the individual exposure information.

Because licensees are required to record individual dose information on NRC Form 5 (or equivalent) under a separate section of Part 20, the revised reporting requirement is not anticipated to result in significant costs regarding collection of information. The affected licensee will simply submit copies of forms they are required to maintain under the recordkeeping requirements. The amount of time required to assemble and submit these forms is anticipated to be equivalent to the amount of time expended under the current requirements to prepare a statistical summary report. Additional mailing costs will be incurred under the revised requirements, but these costs are assumed to be negligible for this analysis. Costs associated with updating computer programs and data bases so that licensees can process the reportable exposure information were included under the category of recordkeeping requirements (Section 3.5).

The significant costs from the revised requirements for reporting personnel exposures to the NRC will be incurred by the NRC itself. The NRC personnel responsible for processing licensee exposure data estimate that the marginal annual cost increase for processing exposure data could range from zero to $300,000 per year, depending on the format of the reports submitted by the licensees. If all licensees provide computer disks containing exposure information in NRC Form 5 format, no additional annual costs would be needed to process the data. However, the revised rule only requires that the reports contain all information required in NRC Form 5; the revised rule does not require that NRC Form 5 be used. Personnel at NRC estimate that approximately 30% of licensees will submit computer disks containing exposure information in NRC Form 5 format. Therefore, the estimated marginal cost increase is 70% of $300,000, or $210,000 per year. The NRC personnel also anticipate a one-time cost of $20,000 to upgrade software for processing the new data.

5.5.3 Reports to Individuals

Under the revised 10 CFR Part 19, all NRC licensees will be required to submit individual dose reports to all individuals for whom monitoring was required. As a minimum, licensees will be required to provide the reports at least annually. Three factors were considered in estimating the impact on licensees: 1) some licensees currently provide these reports voluntarily; 2) some licensees may choose to provide these reports more than once per year; and 3) under the current requirements, licensees must provide these reports to individuals who request them. Based on discussions with licensees and former licensee health physicists and radiation safety officers, it is assumed for this report that 1) 25% of licensees currently comply with the revised requirement, 2) licensees who choose to provide reports more frequently than once per year perceive a benefit from doing so (thus, the marginal cost can be estimated by assuming all licensees provide reports annually), and 3) the fraction of workers who currently request these reports is insignificant.

Based on the data provided in Section 8.1 and the assumptions listed above, it is estimated that an additional 583,000 reports per year (one each for 75% of monitored employees, see Table 8.3) will be submitted to individual workers. This estimate is also based on the assumption that for convenience, licensees will provide reports to all individuals actually monitored, not only to those individuals for whom monitoring is required.

Licensees will have three primary options for providing reports to individuals. First, larger facilities may maintain a database of personnel exposures and simply print the information on a form that is provided to the individuals. Second, smaller facilities that record personnel exposure data by hand will probably prepare annual individual reports by hand. Third, licensees who use the services of a dosimetry processor may pay the processor to prepare the annual summary reports.

It is estimated that no matter which of these three options is used, the cost per individual report will range from $1 to $2. For this analysis,

an average value of $1.50 per report is assumed. Based on 583,000 additional reports per year, the marginal annual cost would be $870,000. In addition, licensees that choose to maintain a database will be required to modify existing software. It is estimated that 25% of all medical, academic/research, and manufacturing and distribution licensees will select this option. This option will also be selected by an estimated 90% of all commercial power reactor and fuel fabrication facilities. A relatively insignificant fraction of other licensees will choose this option. A cost estimate for software modification is based on several factors: an estimated 1 person-week of effort by a computer programmer per licensee, as well as hourly costs of $33 for programmers at nuclear power plants (SEA 1986) and fuel fabrication facilities and $23 for programmers at other facilities. It is further assumed that 25% of the licensees currently provide reports voluntarily. Based on these factors, the estimated one-time cost for software modifications is $1,700,000. Table 5.3 presents the estimated costs by facility category. The present values provided in the table were calculated using methods described in Section 8.2 of this report.

TABLE 5.3. Cost of Providing Reports to Individuals by Facility Category

Facility Category	Initial Cost, $	Annual Cost, $/yr	Present Value of Costs, $
Medical	1,100,000	220,000	2,900,000
Well Logging	negligible	44,000	380,000
Industrial Radiography	negligible	22,000	190,000
Manufacturing and Distribution	170,000	140,000	1,400,000
Academic/Research Institutions	270,000	110,000	1,200,000
Other Measuring Systems	negligible	43,000	370,000
Fuel Fabrication and Processing	12,000	11,000	110,000
Research and Test Reactors	negligible	4,000	34,000
Commercial Power Reactors	97,000	240,000	2,100,000
All Others	negligible	49,000	420,000
Totals	1,700,000	880,000	9,100,000

5.6 OTHER CHANGES

Miscellaneous changes in the revision that do not fall under one of the categories discussed previously in this report are discussed in this section. In general, these changes are expected to have minimal impacts on licensees. Changes in the revision that are editorial changes only are not discussed in this report.

5.6.1 Units of Radiation Dose

Although the revision references the International System of Units (SI), it presents the conventional units found in the present Part 20. Thus, licensees will not be required to use the SI system for purposes of record-keeping or reporting. In addition, the default quality factor (Q) for neutrons remains at 10 and it is unlikely that licensees will be impacted by the slight changes in the table that presents factors for converting neutron fluence to dose.

5.6.2 Radiation Protection Programs

The revised Part 20 states that licensees must develop and document a radiation protection program that is "commensurate with the scope and extent of licensed activities...." In addition, licensees are required to use, "to the extent practicable," procedures and controls to maintain doses ALARA. In comparison, the present Part 20 does not specifically require a radiation protection program to be maintained, but does require that doses be maintained ALARA. An important point here is that the revision does not require a documented ALARA program, a requirement that was present in the proposed Part 20.

Although the new requirement to develop a radiation protection program may appear to place a substantial burden on some licensees, the marginal impact will not be severe because most licensees currently maintain a radiation protection program that is commensurate with the scope of their licensed activities. These programs are in place because of either license conditions, or regulatory guides, or both. For example, all nuclear power plants maintain both radiation protection programs and ALARA programs that greatly exceed the requirements in the revised Part 20. Also, most medical licensees maintain programs commensurate with Regulatory Guide 8.18 and a supporting publication (Brodsky 1982).

The only marginal costs anticipated from this requirement will be increased program documentation for a few licensees. For those licensees that have radiation protection manuals, the manuals should serve as acceptable documentation. (See Section 6.2 for cost estimates pertaining to revisions of these manuals.) For licensees that do not have radiation protection manuals, the limited scope of their activities should be sufficient to prevent the need for development of a program. Thus, for this analysis, it is assumed that the associated costs are negligible. However, the costs could be significant depending on the interpretation of the requirement by both licensees and the NRC. The NRC plans to publish several regulatory

guides that will provide information on acceptable radiation protection programs for specific categories of licensees.

5.6.3 Control of Access to High Radiation Areas

The revised Part 20 provides more detailed requirements than the present Part 20 for controlling access to high and very high radiation areas. Although the changes will affect some licensees, the associated costs are assumed to be negligible in this analysis.

5.7 SUMMARY OF CONSEQUENCES

In this section, the estimated impacts from other changes in the revised Part 20 are summarized. Table 5.4 summarizes these impacts by licensee facility category. It is a compendium of the costs and benefits identified in Sections 5.1 through 5.6 of this report.

TABLE 5.4. Summary of Marginal Cost Increases from Other Changes in the Revised Part 20

Facility Category	Initial Cost, $	Annual Cost, $	Value of Annual Dose Savings, $(a)	Net Present Value of Costs and Benefits, $(b)
Medical	1,100,000(c)	540,000(c)	negligible	-5,600,000(c)
Well Logging	negligible	44,000	negligible	-380,000
Industrial Radiography	negligible	22,000	negligible	-190,000
Manufacturing and Distribution	170,000(c)	190,000(c)	negligible	-1,800,000(c)
Academic/Research Institutions	270,000(c)	180,000(c)	negligible	-1,800,000(c)
Other Measuring Systems	negligible	43,000	negligible	-370,000
Fuel Fabrication and Processing	12,000(c)	11,000(c)	negligible	-110,000(c)
Research and Test Reactors	negligible	4,000	negligible	-34,000
Commercial Power Reactors	97,000	(640,000)(d)	610,000	+11,000,000
All Others	negligible(c)	50,000(c)	negligible	-430,000(c)
NRC	20,000	210,000	negligible	-1,800,000
Total	1,700,000(c)	650,000(c)	610,000	-2,000,000(c)

(a) Based on a value of $1000/person-rem.
(b) Calculated using methods described in Sections 8.2 and 8.3 of this report. The present values are based on 1989 dollars, a discount rate of 10% (applied to all costs and benefits), and a 30-year period. A positive sign indicates a positive impact and a negative sign indicates a negative impact.
(c) Not including potential costs from revised concentration limits for releases into sanitary sewerage.
(d) Number in parentheses indicates a cost savings.

6.0 OTHER CONSEQUENCES OF THE REVISION

Some of the costs associated with the revision of Part 20 cannot be attributed to specific sections of the rule. These costs include training of personnel and revision of procedures, and are discussed in Sections 6.1 and 6.2, respectively. Impacts on the NRC and small businesses are discussed in Sections 6.3 and 6.4, respectively. These consequences are summarized in Section 6.5.

Many of the costs identified in this section were calculated using published labor rates (including overhead costs) for nuclear power plant workers (SEA 1986). Because labor rates for non-power-reactor workers are generally lower, these costs were estimated by applying a factor of 0.7 to the rates for power reactor workers where applicable. All costs were adjusted to 1989 dollars.

6.1 PERSONNEL TRAINING

Some licensees will incur significant costs associated with training of personnel. Supervisory, health physics, and other professional personnel as well as general employees might require training depending on the facility. In the subsections below, cost estimates are provided for the ten categories of facilities defined in this report (see Section 8.1). In most cases, the costs per facility have a wide range within each category. Where appropriate, cost estimates are provided for separate classes of facilities within a category.

An important consideration in developing these cost estimates was that personnel training is performed routinely at most facilities. Personnel are often required to attend periodic training sessions conducted or sponsored by the licensees. The content and level of training with regard to radiation protection depends on the work performed by the employee.

To eliminate nonmarginal costs from this analysis, a factor of 0.75 has been applied to some of the cost estimates to account for the increased training or retraining in response to the revised Part 20 that can be incorporated into routine training programs. In addition, intensive training immediately following promulgation of the revision will result in a decreased need for training in the short term. In some cases, the marginal cost factor should be higher or lower than 0.75. Where applicable, the appropriate factor is provided in the sections below.

Some of the costs estimated in this section (and other sections) are considered to be marginal even though it is likely that in many cases, the costs will be absorbed during the normal daily activities of the relevant personnel. For radiation protection personnel whose primary function is to ensure that operations by the facility are in compliance with radiation protection regulations, part of their responsibility is to be familiar with the regulations and familiarization with new regulations would not result in increased actual costs to the facilities.

Medical. It is anticipated that nuclear physicians and nuclear medicine technologists would use their allotted time for continuing education to inform themselves of the content of the revised regulations and the ICRP Publication 26 recommendations (USNRC 1982). For this analysis, however, some of these costs are considered to be marginal and must be included in the assessment of the impact of the revision. It is estimated that 5% of the workers monitored for radiation exposure at three facilities will commit 2 hours each to studying the revised regulations and their implications. At a cost of $14 per technician hour (SEA 1986) and applying the data in Tables 8.2 and 8.3, the cost estimate for these workers is 193,000 X 0.05 X 2 X $14, or $270,000. Applying the marginal cost factor of 0.75, the marginal costs are estimated to be $200,000. Costs for professionals to study the regulations are included in the cost estimates provided in Section 6.2.

Well Logging. No significant retraining of workers or managers is anticipated for these facilities (USNRC 1982). All costs associated with studying the revision are accounted for in Section 6.2.

Industrial Radiography. In a survey of several of these facilities, none envisioned a need for retraining personnel (USNRC 1982). Thus, no significant costs are anticipated. All costs associated with studying the revision by responsible management are accounted for in Section 6.2.

Manufacturing and Distribution. It has been estimated that for facilities in this category, supervisors, health physicists, and other professionals will commit 250 person-hours, 200 person-hours, and 150 person-hours, respectively, to retraining (USNRC 1982). Other costs associated with retraining are assumed to be insignificant for this facility category. Assuming $31 per professional hour (SEA 1986), the total cost is estimated to be $19,000. The associated marginal cost estimate is $19,000 X 0.75, or $14,000.

Academic/Research Institutions. It is anticipated that users of radioactive material at these institutions will learn of the Part 20 revision and its implications through routine training and information programs. All of these costs are considered to be nonmarginal. Costs incurred by radiation safety officers to understand and implement the revised requirements are included in the cost estimates provided in Section 3.5.

Other Measuring Systems. No significant costs regarding personnel training will be required for these facilities. However, responsible personnel at most of the facilities will need to become familiar with the revision. An average of 2 person-hours for each facility is estimated. At a cost of $31 per professional hour (SEA 1986) and 5060 facilities (see Section 8.1), the marginal cost estimate is $310,000.

Fuel Fabrication and Processing. Booth, Bronson and Groth (1985) estimated that the revision would result in training costs of $145,000 (in 1989 dollars) at a typical fuel fabrication facility. For this analysis, it is estimated that of the 14 facilities in this category (see Section 8.1), five will incur marginal costs of $145,000 and nine will incur one-fourth of those

costs, or $36,000. The total cost estimate for fuel fabrication facilities is $1,000,000.

Research and Test Reactors. For these facilities, retraining of personnel will be absorbed in the normal training cycles (USNRC 1982). However, health physics personnel will need to become familiar with the revision. It is estimated that 8 hours will be committed per facility to become familiar with the revision and its ramifications. Assuming a cost of $31 per professional hour (SEA 1986) and 80 facilities (see Section 8.1), the total cost would be $20,000.

Commercial Power Reactors. Published cost estimates for training and retraining of personnel at commercial power reactors in response to the revision of 10 CFR 20 are available (Booth, Bronson, and Groth 1985; USNRC 1986) and are given in the public comments on the proposed revision. It appears that training for a new employee under the revised Part 20 will be comparable to current training for new employees. However, most employees will need to be retrained to become familiar with the revised regulations and the relevant revisions to plant procedures. In addition, health physics and dosimetry personnel will need to be retrained in the areas of their work affected by the revision.

It has been estimated that at a typical nuclear power plant, total costs associated with training are $175,000 (in 1989 dollars) (Booth, Bronson and Groth 1985). For this analysis, it is estimated that two-thirds of these costs are marginal. Further, a factor of 0.75 is applied to these costs to account for the fact that some nuclear power stations have multiple units, i.e., the training costs per unit at these sites will be less than at a typical one-unit station. For 109 nuclear power plants expected to be operating in 1989 (ANS 1988), the marginal cost estimate is $175,000 X 0.67 X 0.75 X 109, or $9,500,000.

All Others. In general, the licensees in this category do not have extensive radiation protection programs and general employee training will not be required. However, radiation protection personnel responsible for compliance with NRC regulations will probably read the revised Part 20 to become familiar with its provisions. It is estimated that an average of 2 hours per facility will be spent reading the revision and associated documents. Assuming a cost of $31 per professional hour (SEA 1986) and 1752 facilities in this category (see Section 8.1), the total cost would be $110,000. Applying the marginal cost factor of 0.75, the marginal cost estimate for this category of licensees is $81,000.

6.2 PROCEDURE REVISIONS

Some licensees will incur significant costs to incorporate the revised requirements into existing procedures and related documents. The magnitude of the impact on individual licensees is related to the magnitude of the licensee's radiation protection program. The affected documents could include operating procedures, radiation protection manuals, and policy statements (training manual revisions were included in the estimates provided in

Section 6.1). In this section, the costs associated with revising record-keeping procedures are not included because they were included in the record-keeping costs discussed in Section 3.5.

In the subsections below, cost estimates are provided for the ten categories of facilities defined for this analysis (see Section 8.1). In most cases, the costs per facility have a wide range within each category. Where appropriate, cost estimates are provided for separate classes of facilities within a category.

An important consideration in developing these cost estimates was that many procedures and related documents are routinely revised by licensees. Therefore, all of the costs associated with procedure revisions will not be marginal and should not be considered in this analysis. Several competing factors exist in separating the marginal costs from the nonmarginal costs: 1) considering the implementation period permitted by the NRC, some revisions can be incorporated without interrupting the usual schedule; 2) considering both the implementation period and the magnitude of the revised Part 20, some revisions cannot be incorporated without interrupting the usual schedule; 3) some revisions will be much more extensive than they would have been without a revised Part 20; and 4) extensive procedure revisions in response to the revised Part 20 will decrease the need for further revisions in the short term. In consideration of these factors, for this analysis the marginal costs of revising procedures are estimated to be 75% of the total costs, unless otherwise noted.

Medical. For these facilities, the cost of required procedure changes depends greatly on the type of facility. Of the 6506 facilities in this category (see Section 8.1), an estimated 4735 are classified as medical institutions (Hendrickson et al. 1987). The remaining facilities include private practice of nuclear medicine, in vitro labs, veterinary medicine, and others (see Table 8.1).

It is anticipated that a radiation protection manual at each medical institution will need to be revised. In addition to the procedure changes regarding recordkeeping that were estimated in Section 3.5, an estimated 8 person-hours will be committed to this task (USNRC 1982). At a cost of $31 per professional hour (SEA 1986), and assuming that $400 in printing and duplicating costs will be required per facility, the total cost estimate is $3,100,000.

It is expected that the costs of required procedure changes at other medical facilities will be limited to recordkeeping changes associated with the recording of infrequent internal exposures. (These costs were estimated in Section 3.5.) The marginal cost estimate for procedure revisions for all medical facilities is $3,100,000 X 0.75, or $2,300,000.

Well Logging. It is estimated that only five of the licensees in this category have radiation protection programs extensive enough to warrant procedure revisions in radiation protection manuals (USNRC 1982). It is estimated that for each of these firms, 80 person-hours of management time will be devoted to this work, and an additional $800 per firm will be spent to produce

revised manuals. At a [illegible] of $31 per hour for management personnel (SEA 1986), the total cost f[illegible] five firms is estimated to be $16,000. The other firms in the indus[illegible] are not expected to incur significant costs. Therefore, the marginal cost of procedure revisions is estimated to be $16,000 X 0.75, or $12,000.

Industrial Radiography. Most of the facilities in this industry have an in-house document that serves as a radiation protection manual (USNRC 1982). Because internal exposures are not a problem in this segment of the nuclear industry, it is not anticipated that extensive revisions to the existing manuals would be required in response to the revised Part 20. It is estimated that at a typical facility, one professional will spend 8 hours revising the radiation protection manual. Also, $200 will be spent to prepare and print the manual. At an hourly cost of $31 (SEA 1986) and assuming 851 industrial radiography facilities currently in operation (see Section 8.1), the total cost to these facilities would be $380,000. The marginal costs are estimated to be $380,000 x 0.75, or $290,000.

Manufacturing and Distribution. Of the facilities in these categories, required procedure revisions would be insignificant except for some source manufacturing firms and most nuclear pharmacies. It is anticipated that ten source manufacturing firms will require extensive procedure revisions, at a cost of 16 person-weeks of professional time per facility. At a cost of $31 per professional hour (SEA 1986) and $500 in printing and duplicating costs per facility, the total cost would be $200,000.

For nuclear pharmacies, it is expected that minor revisions of radiation safety manuals will be necessary, requiring 8 hours of professional time per facility. Printing costs of about $300 per facility will also be required. At a cost of $31 per professional hour and with 221 facilities in this category (Hendrickson et al. 1987), the total cost for these facilities would be $120,000.

Costs of required procedure changes at other facilities in this category are expected to be relatively insignificant. Therefore, the marginal cost estimate is ($200,000 + $120,000) X 0.75, or $240,000.

Academic/Research Institutions. Most of the facilities in this category have a radiation protection manual that provides guidance to users of radioactive material. In general, these manuals will not require revisions based on the revised Part 20.

As discussed in Section 3.5, radiation safety officers or other personnel at these facilities will be required to revise recordkeeping procedures to allow calculation of internal doses should significant intakes occur. No additional costs related to procedure revisions have been identified for these licensees.

Other Measuring Systems. Few of these licensees have radiation protection manuals or procedures that would require revisions based on the revised Part 20 (USNRC 1982). For those that do, the costs associated with the revisions are assumed to be insignificant for this analysis.

Fuel Fabrication and Processing. These facilities will require extensive revisions to air sampling and bioassay procedures in response to the revised dose evaluation requirements. Detailed cost estimates by Booth, Bronson, and Groth (1985) suggest that the associated costs at a typical facility are $86,000 (in 1989 dollars). For this analysis, it is estimated that of the 14 facilities in this category, five will incur marginal costs of $86,000 and nine will incur one-fourth of those costs, or $22,000. The total cost estimate for fuel fabrication facilities is $630,000.

Research and Test Reactors. It has been suggested that revisions will be required to safety guides for approximately 70% of the facilities in this category (USNRC 1982). The associated costs per facility will be 2 person-months of a professional, and $5000 in preparation, printing and duplicating costs (USNRC 1982). At a cost of $31 per professional hour (SEA 1986), the total cost based on 80 facilities in this category is $840,000. The marginal cost estimate is $840,000 X 0.75, or $630,000.

Commercial Power Reactors. Commercial power reactors have extensive radiation protection programs that include detailed procedures for external dosimetry, internal dosimetry, recordkeeping, contamination control, etc. Detailed cost estimates for revising these procedures based on the revised Part 20 are available in the literature (Booth, Bronson and Groth 1985). Other than recordkeeping procedures, which were discussed in Section 3.5, licensees will be required to revise procedures related to external and internal dosimetry. Because of the magnitude of the radiation protection programs at these facilities, much of the time associated with these revisions will be spent studying the impact of the revised regulations and designing programs and procedures to comply with the regulations. It is estimated that the associated development costs at a typical nuclear power plant will be $124,000 in 1989 dollars (Booth, Bronson and Groth 1985). For this analysis, a factor of 0.7 is applied to this estimate to account for the fact that multiple units at some sites share some of the procedure development activities, and as a result the costs of evaluating Part 20 and developing revised procedures will be smaller per facility than at a typical one-unit site. Assuming 109 operating units in 1989 (ANS 1988), the associated marginal cost estimate is $124,000 X 109 X 0.75 X 0.7, or $7,100,000.

All Others. In general, the licensees in this category do not have extensive radiation protection programs and do not have procedures that would require revisions based on the revised Part 20. Thus, the associated costs are assumed to be negligible for this analysis.

6.3 NRC COSTS

The NRC will incur costs related to the development, implementation, and operation of the revised rule. Development costs include the costs incurred by the NRC to prepare the revised rule for implementation. Implementation costs include the costs incurred to place the revised rule into operation. These costs include preparation and publication of the final rule. Costs associated with preparing and revising regulatory guides in support of the revised rule are also included in this category. Operation costs include

those costs incurred by the NRC after the proposed action takes effect. They primarily consist of the costs of enforcing the requirements.

Because this regulatory analysis pertains to both NRC licensees and Agreement State licensees, costs incurred by state regulatory agencies must also be considered. These cost estimates are included in the applicable sections below.

6.3.1 Development

The NRC has incurred substantial costs required to research and develop numerous versions of the revision of Part 20 over the past 7 years. More costs are anticipated for further reviews and revisions. However, because this analysis includes only those costs and benefits that will be incurred after the decision is made whether or not to publish the rule, the costs incurred by NRC before that date are not considered. In this report, the assumed decision date is October 1, 1988. No significant NRC development costs after that date are anticipated.

6.3.2 Implementation

The NRC has estimated that nine new regulatory guides will be necessary to support the revised Part 20. In addition, ten existing regulatory guides will require major revisions. It is estimated that 1.0 person-years per new guide and 0.5 person-year per revised guide will be committed. An additional 0.25 person-year is estimated to be required for minor revisions to a number of other existing regulatory guides. Based on a mean hourly rate of $51 per hour (SEA 1986) and 28,500 total hours of effort, the NRC is expected to incur implementation costs of $1,500,000 for developing and revising regulatory guides in support of the Part 20 revision.

Because only a few of the new and revised regulatory guides will be crucial to successful implementation of the revision by licensees, it is estimated that 30% of the costs estimated above will be incurred during the 2 years following publication of the revision (1989 and 1990). The remaining 70% of the costs are estimated to be distributed evenly over the following 5 years. In addition, only one-half of the latter are assumed to be marginal costs, because it is thought that the development and revision of similar regulatory guides would have occurred even without the revision of Part 20. As a result, the marginal costs associated with the development and revision of regulatory guides in response to the revision are estimated to be $220,000 per year in 1989 and 1990 and $100,000 per year from 1991 through 1995.

The NRC will also incur implementation costs related to the final preparation and publication of the rule. A total of 1 person-year of effort is anticipated to be required at a cost of $100,000. Finally, the NRC will be required to revise the various forms associated with Part 20, such as NRC Form 4 and NRC Form 5. The associated cost estimate for these revisions is $25,000.

6.3.3 Operation

Once the Part 20 revision is implemented, the NRC and Agreement States may incur costs related to additional inspection activities and additional training of inspectors. These cost estimates are provided below.

Additional Inspection Activities

Currently, power reactors are inspected an average of two or three times per year. Most other licensees are inspected anywhere from one to five times per year, depending on past performance and the type of license.

No increase in inspection activities at power reactors is anticipated from promulgation of the revision. Although inspectors will use the revision as the basis for the inspections, the frequency of inspections and the person-hours per inspection are not expected to change.

For other types of licensees, some may require additional inspections to ensure compliance with the revision. However, in consideration of the limited resources that will be available for carrying out additional inspections, it is anticipated that the NRC will reschedule inspections so that the problem facilities receive additional attention and the facilities with satisfactory performance will receive less attention than usual. Problem facilities will be identified through response to a letter-writing campaign. After several years, it is anticipated that inspection scheduling will be unaffected by the presence of the revised Part 20.

In summary, only those costs associated with communication with non-reactor licensees and analyzing the responses will be significant. It is estimated that an average of 0.2 person-hour per facility will be committed, which includes preparation of letters, response by the licensees, and evaluation of the responses by the NRC. (Although costs incurred by licensees are not the subject of this section, they are included here for convenience. Exclusion of these costs from the cost estimates for facility categories does not significantly affect those cost estimates.) Because it is not known how individual Agreement States will schedule inspections in response to the revised Part 20, costs per Agreement State licensee are estimated to be similar. For a total of 17,238 non-reactor licensees (see Section 8.1) and a cost per person-hour of $46 (SEA 1986), the associated cost estimate is $160,000.

Inspector Training

Because the Part 20 revision is extensive, additional inspector training will be required following publication of the revision. In the five NRC regions, there are approximately 110 inspectors who will need retraining. Each inspector will need to receive an estimated 3 days of retraining, for a total of 2600 person-hours. In addition, an estimated 80 person-hours per region will be needed to revise training procedures and conduct the retraining. This amounts to an additional 400 person-hours for a total of 3000 person-hours.

One benefit from the immediate retraining required for all inspectors is that routine training will be able to be curtailed for a few years thereafter. Currently, each inspector receives approximately 1 day of routine training per year. If each receives 3 days of training on the revised Part 20, future training in the short term will be less extensive than usual. This also applies to routine training instruction and training procedure revisions. It is estimated that the marginal inspector training costs associated with the revision are 50% of the 3000 person-hours estimated in the previous paragraph. The associated cost estimate, based on an hourly rate of $46 (SEA 1986), is $69,000. These costs are tripled to account for inspector training activities in Agreement States, for a total cost of $210,000.

6.4 EFFECTS ON SMALL BUSINESSES

The Regulatory Flexibility Act of 1980 (Public Law 96-354, 5 USC 601-612) requires that, when a rulemaking action is likely to have a significant impact on a substantial number of small entities, the impact must be addressed specifically. The NRC's Regulatory Analysis Guidelines (USNRC 1984) specify that this analysis should be incorporated into the regulatory analysis for the action.

The NRC specifies that entities are to be considered small businesses for the purposes of the Regulatory Flexibility Act if they meet the following requirements (Hendrickson et al. 1987):

- for most licensees, annual billings of $3.5 million or less
- for private practice physicians, annual billings of $1 million or less
- for state or public educational institutions, an institution supported by a jurisdiction with a population of 50,000 or less
- for other educational institutions, an institution having 500 or fewer employees.

Henderickson et al. (1987) analyzed data on NRC and Agreement State licensees based on the results of licensee surveys (see Section 8.1). These surveys were used to estimate the fraction of the licensees in various categories that could be considered small entities. While the estimates in Hendrickson et al. may overstate the number of small businesses in some cases and understate it in others, they are sufficient to provide an indication of the impact on small businesses that is commensurate with the level of effort and detail expended on other portions of this analysis.

Based on data in Hendrickson et al. (1987), estimates for the fraction of licensees in each facility category that could be classified as small businesses were obtained (see Table 6.1). These fractions are assumed to apply to the number of licensees tabulated in Section 8.1, although the absolute numbers differ from those in Hendrickson et al. (1987). The licensee

TABLE 6.1. Fraction of Licensees That May Be Classified as Small Businesses

Facility Category	Fraction
Medical	
Private Practice Physicians	93%
Other Facilities	21%
Well Logging	63%
Industrial Radiography	40%
Manufacturing and Distribution	32%
Academic/Research Institutions	29%
Other Measuring Systems	37%
All Others	25%

categories of commercial power reactors, research and test reactors, and fuel fabrication and processing facilities are assumed to contain no small entities.

Table 6.2, which is based on Tables 8.2 and 8.4, presents the average impact of the Part 20 revision per facility for each facility category that includes small businesses.

The monetary impact of the Part 20 revision, averaged over all facilities, is not expected to be substantial for most groups of licensees. The most substantial impacts will be borne by medical facilities. However, the average impact does not account for the fact that not all medical facilities (and private practice physicians) will incur these costs; rather, the costs will often be incurred only by those facilities that already have the most

TABLE 6.2. Per-Facility Costs from the 10 CFR Part 20 Revision

Facility Category	Development and Implementation Costs, $	Operation Costs, $/yr
Medical	1100	280
Well Logging	26	97
Industrial Radiography	340	26
Manufacturing and Distribution	550	250
Academic/Research Institutions	1200	220
Other Measuring Systems	61	8
All Others	46	28

extensive radiation protection programs. These facilities are usually the larger businesses that are not classified as "small entities."

Table 6.3 indicates the magnitude of the total cost to small entities of the Part 20 revision, should all such entities incur the average cost given in Table 6.2.

In addition to the above monetary impacts on small businesses, the Part 20 revision will have impacts that were not quantified. As discussed in Section 7.6, the embryo/fetus dose limit may significantly impact small businesses by causing the loss of a trained employee from certain jobs for a temporary period. A small firm usually does not have the ability to shift personnel around without a significant loss in productivity. Licensees may, therefore, be reluctant to employ women of childbearing age because of these costs.

Labeling requirements for products containing radioactive materials may also impact small businesses. As discussed in Sections 5.2 and 7.7, however, few changes with respect to container labeling are anticipated because most of the quantities of radioactive material that are exempt from labeling are either unchanged or less restrictive than under the current Part 20 quantities. Thus, costs incurred because of new labeling requirements are not expected to be substantial. As described in Section 5.2, a small positive net benefit is expected from the changes in labeling requirements. However, for those cases in which labeling requirements have become more stringent under the revised regulations, small businesses may bear a more significant impact than larger firms if the competitive positions of small businesses in both domestic and international markets are degraded when costs are passed along to customers.

TABLE 6.3. Estimated Total Cost to Small Businesses from the 10 CFR Part 20 Revision

Facility Category	Development and Implementation Costs, $	Operation Costs, $/yr
Medical		
Private Practice Physicians	1,000,000	260,000
Other Facilities	1,300,000	320,000
Well Logging	8,000	28,000
Industrial Radiography	120,000	9,000
Manufacturing and Distribution	170,000	80,000
Academic/Research Institutions	540,000	100,000
Other Measuring Systems	110,000	16,000
All Others	20,000	12,000
Total	3,300,000	830,000

6.5 SUMMARY OF CONSEQUENCES

In this section, the consequences of the revised Part 20 that are not associated with specific sections of the rule are summarized. Table 6.4 summarizes these consequences by licensee facility category and is a compendium of the costs identified in Sections 6.1 through 6.3 of this report.

TABLE 6.4. Summary of Marginal Cost Increases from Other Consequences of the 10 CFR Part 20 Revision

Facility Category	Initial Cost, $	Present Value of Costs, $(a)
Medical	2,500,000	-2,300,000
Well Logging	12,000	-11,000
Industrial Radiography	290,000	-260,000
Manufacturing and Distribution	260,000	-240,000
Academic/Research Institutions	negligible	negligible
Other Measuring Systems	310,000	-280,000
Fuel Fabrication and Processing	1,700,000	-1,500,000
Research and Test Reactors	650,000	-590,000
Commercial Power Reactors	17,000,000	-15,000,000
All Others	81,000	-73,000
NRC	1,400,000	-1,100,000
Total	24,000,000	-21,000,000

(a) Calculated using methods described in Section 8.2 of this report. The present values are based on 1989 dollars, a discount rate of 10%, and a 30-year period. A negative sign indicates a negative impact.

7.0 QUALITATIVE BENEFITS FROM REVISING PART 20

10 CFR Part 20 specifies the fundamental requirements for ensuring that workers and the public are protected from the hazards of ionizing radiation resulting from NRC-licensed activities. Consequently, Part 20 is the basic foundation for licensing, inspection, and enforcement activities relating to occupational and public health protection. Because the provisions of Part 20 are based primarily on recommendations by the ICRP and NCRP, recent changes in the basic radiation protection concepts promoted by these organizations have prompted the NRC to revise Part 20 to reflect these latest recommendations. The importance of revising Part 20 was reinforced when the EPA published its recent recommendations to Federal agencies, which essentially stressed that agencies incorporate the recent ICRP and NCRP recommendations in their conduct of programs for the protection of workers from ionizing radiation.

The previous four sections of this report presented a quantitative analysis, where possible, of the costs and benefits of the revision of Part 20. In most cases, quantitative estimates of the identified costs were possible. On the other hand, most of the potential benefits from revising Part 20 cannot be readily quantified. These potential benefits are discussed in this chapter.

Before describing these possible benefits, it is important to be clear about what is meant by a benefit. In social benefit/cost analysis, actions or projects are evaluated insofar as their effects increase or decrease the welfare of the individuals who are affected. Increases in welfare are associated with benefits, and decreases in welfare are associated with costs. A central theme in benefit/cost analysis is an individual's willingness to pay to receive benefits or accept compensation to bear costs. An effect is a benefit if one or more individuals can be identified who would be willing to pay for the effect from their own wealth.

7.1 POTENTIAL BENEFITS FROM CONSISTENCY WITH NATIONAL AND INTERNATIONAL RECOMMENDATIONS

The primary reason for completely revising Part 20 is that the current requirements are inconsistent with recent international and national recommendations (FR 1986). In 1977, the ICRP published a recommended system of dose limitation based on risk (ICRP 1977). Since that time, this system has been recognized as a major improvement over the old system of dose limitation by many, but not all health physicists (Skrable et al. 1985; Healy 1982). Also, some other countries have incorporated the recent ICRP recommendations into their radiation protection standards (Usui 1987). In 1987, the NCRP published its recommendations, which are essentially consistent with, but in some cases more restrictive than, the ICRP recommendations (NCRP 1987). Also in 1987, the EPA published its recommendations on occupational radiation protection (which were signed by the President) in the Federal Register (FR 1987). As a matter of policy, the NRC has considered past Federal Guidance as binding and has implemented the guidance in its regulations.

Unfortunately, the ICRP, NCRP, and EPA recommendations are not among themselves completely consistent. One reason for the inconsistencies is that the NCRP recommendations and the Federal Guidance (NCRP 1987; FR 1987) were published ten years after the relevant ICRP recommendations (ICRP 1977). Note that the proposed revision of Part 20 was published in 1986, before both the NCRP recommendations and the Federal Guidance were published. A comparison of the revision of Part 20 with these three sets of recommendations is presented in Table 7.1.

Table 7.1 indicates that, in general, the revision of Part 20 is either consistent with or more restrictive than the basic recommendations of ICRP 26 and 30, and is either consistent with or less restrictive than the basic recommendations of NCRP 91. The revision is also generally consistent with the Federal Radiation Protection Guidance. However, the revision provides detailed requirements in many cases where the Federal Guidance provides only general guidance.

Four potential benefits from consistency with national and international recommendations were identified and are discussed in this section:

- the knowledge that regulations are in agreement with currently accepted scientific concepts
- elimination of confusion caused by terminology that is based on inconsistent definitions and on inconsistent measurement concepts
- savings in teaching resources
- increasing the usefulness and applicability of dosimetry data collected under the provisions of Part 20.

Knowledge that Regulations are in Agreement with Currently Accepted Scientific Concepts. Individuals may benefit from the knowledge that federal regulations on radiation protection are based on currently accepted practice. According to the willingness-to-pay principle, the social benefit from this knowledge is calculated conceptually as the total dollars that the affected individuals would be willing to pay to possess this knowledge.

While no attempt is made here to place a monetary value on this possible benefit, some useful insights can be obtained by inquiring into the type of individual who might benefit from it. For this purpose two groups of individuals are considered: a) workers at risk of receiving occupational doses, and b) members of the general public.

Workers at risk from occupational exposure to ionizing radiation might be comforted by knowing that current regulations reflect the latest scientific information on radiological risk. If the regulations are outmoded, a worker may fear that he is not being afforded adequate protection. The benefit to him from revising the current Part 20 is the reduction in his uncertainty regarding the radiological risk. This benefit will occur even if the revision leads to no substantive change in the current provisions relating to workers.

TABLE 7.1. Comparison of the Revision of Part 20 with National and International Recommendations

Part 20 Section	Consistency with Recommendations of ICRP(a)	NCRP(a)	Federal Guidance
20.4: Units of Radiation Dose	C	I(b,c)	C
20.102: Radiation Protection Programs	C(d)	C(d)	C(d)
20.201: Occupational Dose Limits for Adults	C,I(e)	C	C
20.202: Compliance With Summation Requirements	C	C	G
20.203: External Dose From Airborne Material	I	N	N
20.204: Determination of Internal Exposure	C	G	G
20.206: Planned Special Exposures	C	I(b,c)	G
20.207: Occupational Dose Limits for Minors	I(e)	I(b)	C
20.208: Dose to an Embryo/Fetus	I(e)	I(c)	C
20.301: Dose Limits for Members of the Public	I(e)	C	N
20.302: Compliance with Public Dose Limits	C	N	N
20.502: Conditions Requiring Indiv. Monitoring	I(e)	N	G
20.601,2,3: Exposure Control in Restricted Areas	N	N	N
20.702,3,4: Respiratory Protection	N	N	G
20.901-6: Precautionary Procedures	N	N	N
20.1001-6: Waste Disposal	N	N	N
20.1102: Records of Radiation Protection Programs	N	N	G
20.1103: Records of Surveys	N	N	G
20.1104: Determination of Prior Occupational Dose	N	N	C
20.1105: Records of Planned Special Exposures	N	N	N
20.1106: Records of Individual Monitoring Results	N	N	C
20.1107: Records of Dose to the Public	N	N	N
20.1108: Records of Waste Disposal	N	N	N
20.1201,2,3: Incident Reporting Requirements	N	N	N
20.1204: Reports of Planned Special Exposures	N	N	G
20.1206: Reports of Personnel Monitoring	N	N	C

Codes: C - consistent with recommendations (Part 20 may be more detailed)
G - generally referred to in recommendations (Part 20 is more specific)
I - inconsistent with recommendations
N - not addressed in recommendations

(a) Consistency with ICRP 26 & 30 (ICRP 1977,ICRP 1979) and NCRP 91 (NCRP 1987). For those sections in Part 20 that are not applicable to the recommendations in these documents, they may be applicable to recommendations in other ICRP or NCRP documents.
(b) Revised Part 20 is less restrictive.
(c) The inconsistency is minor.
(d) NRC Regulatory Guides are expected to provide detailed guidance consistent with the recommendations.
(e) Revised Part 20 is more restrictive.

What can be said about the likely magnitude of this benefit? According to the willingness-to-pay principle, the benefit is equal to the total amount that workers would be willing to pay for the knowledge that, based on the latest scientific findings, the current provisions provide adequate worker protection. But workers who select risky occupations generally perceive their occupational risk to be lower than does the work force at large. Therefore, unless the reductions in uncertainty are relatively large, it seems unlikely that workers would be willing to pay very much to reduce this uncertainty.

There is an interesting sidelight to this effect. A number of studies indicate that occupational risks are reflected in wage levels, so that workers are compensated for the added risk (Low and McPheters 1983). This suggests that if perceptions of risk change, real wages should adjust accordingly. Furthermore, if the risk uncertainty is reduced equally on the upside and downside, then, because individuals tend to be risk-averse, the net benefit will be positive and real wages should adjust lower. It is important to realize, however, that this adjustment in real wages will occur only to the extent that workers are willing to give up real wages in exchange for less risk uncertainty.

Lastly, we inquire whether a regulatory review confers benefits on the general public. In more precise terms, would a regulatory review that led to no changes in public exposures provide a perceived benefit to members of the general public? In response, it is important to note that the provisions of Part 20 deal primarily with occupational dose, which is probably of relatively little concern to the general public; the focus of the general public seems to be on accidental releases. The provisions of the revised Part 20 that do address public dose are not expected to significantly impact the public. Therefore, benefits of the revision to the general public are deemed to be insignificant.

Elimination of Confusion Caused by Terminology that is Based on Inconsistent Definitions and on Inconsistent Measurement Concepts. Another possible benefit from updating present regulations is that the update may eliminate some confusion in terminology. For example, under a recent ICRP recommendation (ICRP 1977), total effective dose equivalent is defined as including both internal and external doses, with appropriate weighting factors applied. Under the current Part 20, however, external doses and internal doses are treated separately. In some situations it may not be clear which is the correct method for calculating whole-body dose and this could lead to faulty interpretations.

To demonstrate a real benefit from making definitions and concepts consistent with international practice, it is first necessary to show that the current situation does indeed lead to some confusion. At this time, no such situation has been identified.

Savings in Teaching Resources. The benefit in this category is that health physics students and professionals would not be required to understand two inconsistent systems of dose limitation. Currently, most health physics programs at universities teach both systems, but emphasize the newer system

because it represents a fundamental improvement over the old system. While older texts are used to teach the principles in the current Part 20, recent textbooks on health physics have all but abandoned the system of dose limitation on which the current Part 20 is based (Cember 1983).

Increasing the Usefulness and Applicability of Dosimetry Data Collected under the Provisions of Part 20. Another possible benefit from bringing current law into agreement with current international standards is the potential for increasing the value of future databases. For example, in meeting reporting requirements to the NRC, licensees do not currently add the risk from internal exposures to the risk from external exposures. Thus, in situations where internal exposures are present, valid measures of risk are not reported and, hence, are not readily available for further research.

In many research endeavors, analysts find occasion to combine data from different sources in order to reach useful conclusions. In combining data, it is important to ensure that the databases are commensurable. This might not be the case if data generated under requirements of the current Part 20 are combined with data generated under ICRP or NCRP recommendations. However, because internal doses are currently rare at most NRC-licensed facilities, and because the revision is based on combining the risks from internal and external doses, it is unlikely that the promulgation of the revision will result in a significant benefit in this area.

7.2 POTENTIAL BENEFITS FROM REVISED MONITORING REQUIREMENTS

Two possible benefits are identified in connection with the monitoring requirements imposed by the revised Part 20. These are benefits from 1) improving ALARA programs and 2) documenting individual doses that could later be used as supporting documents in litigation.

Improving ALARA Programs. Under the revised Part 20, monitoring will need to be upgraded to provide measurements of both internal and external individual doses that are likely to be in excess of 10 percent of the annual dose limits. By obtaining a more accurate record of the radiological environment within a facility, the facility operator may be able to discover relatively inexpensive (i.e., cost-effective) ways to reduce doses in accordance with ALARA. The extent to which such opportunities currently exist can only be conjectured.

Legal Defense by Documenting Individual Doses. The increased monitoring requirements will make it possible for a licensed firm to maintain better employee records of exposures. One function of an employee record is to reduce the uncertainty about whether a future adverse health effect is the result of past exposures. It may be argued, then, that increased monitoring requirements reduce litigation (a societal benefit) by reducing uncertainties about exposures. For instance, if the records show exposures high enough to produce a relatively high probability of causation (PC), then litigants will have an incentive to settle out of court, thus reducing litigation costs. Alternatively, if the records show that exposures were so low that the health effect was highly unlikely to have been caused by radiation exposures

received at the facility, then the would-be plaintiff has little incentive to pursue a lawsuit. In either case, litigation costs are reduced, and this represents a social benefit. The social benefit is measured as the present value savings in litigation costs (attorneys' fees, court costs, etc.) plus the amount of the judgment that compensates for actual harm done to the plaintiff. For example, punitive damages should not be included since they are not a social cost; rather, they are simply a transfer of monetary assets from one party to another.

Further analysis indicates, however, that a real societal benefit is not likely to be found here. The reason for this is that any financially responsible facility has a sufficient incentive to engage in monitoring for its own legal protection. Since the marginal benefits from increased monitoring will diminish at an increasing rate, there is an optimal level of monitoring which the firm will attempt to discover. The firm's optimizing (profit-maximizing) rule is to add monitoring protection until the marginal cost of the added protection just equals the expected marginal litigation costs. Since the facility is primarily concerned with the private costs rather than the social costs, it will include the cost of expected judgments in its calculation. This means that the marginal private costs will exceed the marginal social costs if the award is in excess of the actual harm sustained by the plaintiff, for example, because of punitive damages. In this case, the unregulated facility will tend to engage in more than the socially optimal level of monitoring, and monitoring requirements beyond this level will further exacerbate the resource misallocation, giving rise to even more excessive net societal costs. As discussed in Section 3.1, most licensees currently monitor occupational doses less than 500 mrem/yr, which is the required level of monitoring under the revised Part 20. Therefore, the potential benefit from reduced litigation is likely to be small.

7.3 POTENTIAL BENEFITS FROM REVISED RECORDKEEPING/REPORTING REQUIREMENTS

One of the proposed reporting requirements will require some facilities to provide to the NRC individual exposure reports for all individuals for whom monitoring was required. In addition, all licensees will be required to notify individuals of the doses that they receive. Two possible benefits have been identified as arising from this requirement: 1) developing a database containing records of individual exposures that are readily converted to risk measures, and 2) providing the basis for a registry under which the accumulated doses of transient workers could be routinely monitored.

Developing a Database of Individual Exposure Records. Whether or not an actual benefit exists here depends on what the NRC will do with the individual exposure records it collects from licensees. For a benefit to exist, the records after collection must 1) be beneficial to workers receiving an annual accounting of their dose for the previous calendar year, 2) be processed by the NRC to produce information beneficial to society, 3) be beneficial to NRC licensees, 4) be made available to researchers outside the NRC who will produce information beneficial to society, or 5) be maintained by the NRC in a repository for possible future retrieval for a socially beneficial purpose.

The first factor could give rise to a social benefit. Workers receiving notification of their prior year's dose might behave in either of two ways. Workers receiving relatively large doses might make an extra effort to avoid unnecessary exposures. On the other hand, workers receiving doses well below the publicized limit might adopt a cavalier attitude toward exposures.

Regarding the second factor (NRC-produced information), a significant benefit is unlikely because the current reporting requirements are virtually the same as the revised requirements except that individual rather than summarized information will be sent to the NRC. Although the summarized information leads to overestimates of collective doses (Brooks 1986), statistical corrections could be applied.

A possible benefit was identified with respect to the third factor, the benefits accruing to licensees. A dose history is required if a licensee needs to ensure that a new worker will not violate the 5(N-18) formula. Currently, it may be costly to recover the dose history because many licensees currently maintain worker dose records by year rather than by worker. However, the revised Part 20 excludes the 5(N-18) formula, thereby significantly reducing the need for a worker dose history more than 1 year in the past. If a worker changes jobs in the middle of a calendar year, he may need to produce his dose record for the new employer so that his dose for the remainder of the year can be planned. Since the revised Part 20 will result in better tracking of individual dose histories on NRC Form 4, providing the current year dose for transient workers will have very little cost. The benefit is expected to be small, though, because currently most employers experience little difficulty in obtaining a worker's current-year dose record from the worker's previous employer.

With regard to the fourth factor--making individual dose records available to others outside the NRC--the National Cancer Institute (NCI) has expressed interest in obtaining the individual dose records from the NRC to perform epidemiological studies. The records would be used to establish dose-response relationships from low levels of ionizing radiation. At least 10 years of data will be needed before statistically significant results can be expected from these studies. After the results of these studies are available, they may provide the basis for significant adjustments to dose limits. Of course, not all of the social benefits from more accurate dose limits can be attributed to the existence of the individual dose database; much of the benefit must be assigned to the epidemiological studies themselves.

There is a potential benefit from maintaining a historical database in a repository for future retrieval. Currently, little is known about the effect of dose incidence on an individual's accumulated lifetime risk. For example, we might learn that 2 successive years of 5 rem doses pose much greater risk than if a year of low exposure is interposed. Armed with such knowledge, one could then retrieve and review the lifetime histories of current workers in order to modulate their lifetime risk (Newcombe 1980).

Providing the Basis for a Registry to Monitor Transient Workers. As discussed in Section 4.1.1, transient workers at nuclear power plants

represent the majority of workers who currently receive doses greater than 5 rem/yr. Because workers will no longer be permitted to receive annual doses greater than 5 rem (except when the planned special exposure provision is used), some transient workers may falsify their accumulated dose to licensees so that they will be more likely to be hired.

Under the revised Part 20, both the revised requirements for determination of prior dose and the individual dose reporting requirements will provide for improved tracking of transient worker doses. This will reduce the likelihood that a worker will illegally receive doses greater than the limits. In terms of collective dose savings, however, no benefit is anticipated.

7.4 POTENTIAL BENEFITS FROM ADDITIONS/REVISIONS TO CURRENT DOSE LIMITS

The proposed revisions to Part 20 contain several adjustments to current dose limits. Some of the adjustments are more restrictive, and in other cases, the limits are less restrictive (see Section 4.0). Where limits have become stricter, nearly all tasks that are currently undertaken would continue to be undertaken under the stricter dose limits. In cases where the dose limits have been relaxed, one would expect that few new tasks would be added; rather, tasks would be performed by fewer workers.

Assuming that the risk from radiation dose is proportional to dose and has no threshold, no benefit in terms of risk would accrue from dose reallocation if the collective dose remains unchanged (Peterson 1984). However, from a social benefit/cost perspective, there may be social benefits and costs. These derive from the fact that spreading of risk is usually socially beneficial, as discussed below.

Benefits from Spreading of Risk. Studies that undertake to put a dollar figure on the value of a human life typically derive the value by taking the dollar amount that is expended to obtain a reduction in risk and multiplying this by the inverse of the risk reduction. For example, if individuals are willing to pay $10 to reduce a fatality risk from 1.0E-4 to 9.0E-5, then the imputed value of life is derived simply as $10/(1.0E-4 - 9.0E-5) = $10/1.0E-5 = $1.0E6, or one million dollars. The problem with this approach is that it assumes that an individual's willingness to pay to reduce a given increment of risk is independent of the level of risk. Were this independence valid, then we should expect this same individual to play a game of Russian roulette for a certain payment of $1E6/6 = $1.6E5. Yet, there is no reason why this individual should feel compelled to play for this amount. Russian roulette represents a much greater risk, and the individual might well require a larger amount, perhaps well in excess of a million dollars. Such behavior could not be termed inconsistent or irrational. It simply implies that risk-aversion is not a linear function of the risk level (Weinstein, Shepard and Pliskin 1980; Linnerooth 1979).

If risk aversion increases with the level of risk, then there will be a social benefit from spreading the risk over a greater number of individuals. In order to quantify the benefit, the following information is needed:

1) the level of risk to an individual before risk-spreading, 2) the level of risk to an individual after risk-spreading, and 3) for a representative individual, the functional relationship between willingness-to-pay to reduce risk and the level of risk.

The benefit from risk spreading may need to be adjusted for another effect. If risk is spread, then collective dose may not remain unchanged. To accomplish a task a manager will likely delegate it to the persons who can execute it at lowest cost. If additional workers must then be added (because of dose limitations), then the added workers generally will be less efficient than the original crew. As a result, collective dose may increase (Pelletier and Voilleque 1979). For example, four persons may be able to complete a task with a collective dose of 20 rem, but when five persons are assigned, the collective dose might increase to 23 rem. Collective dose increases although individual doses decrease.

In evaluating the net benefit from the revised dose limits, it is necessary to adjust the benefits from risk-spreading for the "less-efficient-worker" effect just described. Considering that the dose distributions to only a small number of workers will be affected by the revised limits and that the anticipated increase in collective dose is small (see Section 4.1.1), any potential net costs or benefits are likely to be small.

In a few instances, dose limits that have been revised do not affect current applications. For example, civilian activities involving Pu are essentially nonexistent at NRC-licensed facilities. In the future, an activity involving Pu might be discovered that is sufficiently valuable to warrant compliance with existing regulations. However, stricter provisions in the new Part 20 might prevent this activity from occurring. In those cases where the requirements have been relaxed, new activities may be viable immediately or some time in the future.

7.5 POTENTIAL BENEFITS FROM SUPPLIED GUIDANCE FOR COMPLYING WITH THE REVISION

The NRC plans to provide some detailed guidance in the form of regulatory guides on how licensees must meet the new Part 20 provisions (see Section 6.3.2). To the extent that the guidance is prescriptive, this will usually make licensee compliance more (socially) costly. It is easy to see why this is so. Consider, for example, a dose limitation with which licensees must comply. Let us assume that there are several different ways of complying with this limitation. Each profit-maximizing licensee will attempt to select the least costly compliance method. Because different licensees operate under different conditions, there is no reason why the least costly compliance method for one licensee will also be the least costly method for other licensees. Thus, a prescriptive approach to enforcement will generally impose higher social costs than necessary, even if the prescribed method is the method that most licensees deem to be the least costly. On the other hand, the absence of guidance often leads licensees to adopt methods that are unnecessarily costly to ensure compliance with possibly ambiguous regulations.

The benefit from the prescriptive approach is that it will generally make enforcement by the regulating agency easier (i.e., less costly). If compliance with the revision is ensured once well-defined procedures are followed, then the enforcement agency need only check that the licensees have carried out the prescribed steps. This can also improve the consistency with which inspectors enforce the requirements.

7.6 POTENTIAL BENEFITS FROM DOSE LIMITS FOR PREGNANT WOMEN AND EMBRYOS/FETUSES

To estimate the benefit from the dose limits for declared pregnant women, it is necessary to obtain an estimate of the number of pregnant women who currently receive doses in excess of the proposed limits. It is then simply a matter of computing the risk to each embryo/fetus to obtain a value for the benefit. This benefit was estimated in Section 4.3.

However, there may also be unintended costs. Licensees, particularly those with small operations, will be reluctant to employ women of child-bearing age. Loss of a trained employee for a temporary period could impose a substantial burden on a small firm, which usually does not have the ability to shift personnel around without a significant loss in productivity. However, because of potential legal liability, licensees may already be engaging in defensive hiring practices, in which case the new Part 20 would provide few added costs or benefits. The problems associated with a separate limit for the embryo/fetus are well documented (Taylor 1985) and are not discussed further in this report.

7.7 POTENTIAL BENEFITS FROM REVISED LABELING REQUIREMENTS

The proposed revision of Part 20 includes requirements that affect products containing radioactive materials. The levels of activity for which labeling will be required are lower for some radioactive materials and higher for others than under the current Part 20 (see Section 5.2.1). The main purpose of the proposed labeling requirements is to inform consumers of products posing health risks that exceed some determined level. It is noted that the health risk level at which labeling is required will be approximately the same for all radioactive materials because the exempt quantities are determined from occupational ALIs for each radionuclide.

Because most of the revised exempt quantities are either higher by one order of magnitude than the current exempt quantities or are unchanged, few changes with respect to container labeling are anticipated. For those cases where labeling of containers will no longer be required, there are obvious benefits from the reduced number of labels that must be purchased and affixed. An additional benefit is identified for firms that currently spend resources to ensure that containers do not contain enough radioactive material to require labeling. Because the revised exempt quantities are generally higher than the current values, fewer resources will be required to reduce amounts of radioactive material to exempt levels.

8.0 SUMMARY OF COSTS AND BENEFITS

Previous sections in this report included analyses of the costs and benefits of the revision of Part 20. Where possible, the costs and benefits were discussed with respect to the relevant sections of the rule and the types of licensees that would be affected. In addition, the costs and benefits that would be incurred once were delineated from those that would be incurred annually.

In the following sections, the costs and benefits are summarized so that meaningful evaluations of the impact of the revision of Part 20 can be made. In Section 8.1, the current number of NRC and Agreement State licensees are summarized by facility category. In Section 8.2, the costs of the revision are summarized by both facility type and Part 20 section. The uncertainties of the cost estimates are also discussed. In Section 8.3, the benefits of the revision are summarized by section of the revision, and the uncertainties and qualitative aspects of the benefits are discussed. In Section 8.4, a sensitivity analysis of the estimated net benefit is presented. Finally, the conclusions of this analysis are presented in Section 8.5.

8.1 COMPENDIUM OF NRC AND AGREEMENT STATE LICENSEES

In order to assess the impact of the revision of Part 20 on licensees, it was necessary to group the various types of licensees into categories that reflect the type of activities the licensees are involved in. Because both NRC and the Agreement States classify licensees under many categories, it was necessary to condense the number of categories of licensees for this analysis. The data presented below were derived primarily from a compilation of data presented in four references (Hendrickson et al. 1987; CRCPD 1987; Brooks 1986; Brooks, McDonald and Richardson 1982).

The Conference of Radiation Control Program Directors (CRCPD) periodically publishes a report of the number of Agreement State licenses by state and facility type. The most recent report (CRCPD 1987) was used to determine the number of Agreement State licensees in 1985. To determine this number from the data supplied in the report, several translations were necessary. First, the number of licenses issued by all States was determined for the various license categories listed in the CRCPD report. Second, the number of licenses issued by non-Agreement States was subtracted from the total number of licenses issued for each category of license. Finally, the total number of licensees was determined by dividing the number of licenses by 1.286, which is estimated to be the ratio of total licenses to licensees (Hendrickson et al. 1987). Although this ratio was derived from data on NRC licensees, the same ratio was assumed to apply to Agreement State licensees for this report.

The number of NRC licensees in 1986 was determined from several sources. For facilities other than power reactors, research and test reactors, and fuel fabrication and processing facilities, the number of licensees in each facility category was determined from a 1983 survey by the NRC's Division of

Rules and Records (DRR). The data from this survey was analyzed and published (Hendrickson et al. 1987). The number of power reactor and fuel fabrication facilities was determined from the annual radiation exposure summary reports submitted to NRC in 1984 (Brooks 1986). The number of research and test reactor licensees was determined from data submitted to NRC for the year 1979 (Brooks, McDonald and Richardson 1982). It was assumed in this report that these data for NRC licensees accurately represent the number of NRC licensees in 1985.

Because the categories of licensees listed in the various references were numerous and not always consistent, it was necessary for this analysis to condense the number of licensees into expressive categories. Ten general categories of licensees were identified based on the primary activities at the facilities. These categories and the associated categories used by NRC and CRCPD to classify licensees are listed in Table 8.1.

In 1985, there were 27 Agreement States. All licensees in Agreement States except power reactors, research and test reactors, and fuel fabrication and processing facilities are licensed by the States. All licensees not licensed by Agreement States are licensed by the NRC. Table 8.2 lists the number of NRC and Agreement State licensees in 1985 for each facility category. For this report, these data are assumed to represent accurately the number of licensees existing in 1989.

The data in Table 8.2 are generally consistent with the ratio of Agreement States to non-Agreement States. One inconsistency, however, is the number of licensees listed in the "Manufacturing and Distribution" facility category. For this category of licensees, NRC licensees outnumber Agreement State licensees by a factor of two. One reason for this apparent inconsistency is that the CRCPD data for Agreement States (CRCPD 1987) are not classified according to the NRC system of licensee classification. It is likely that some of the licensees listed in the "All Others" category for Agreement States would be listed in the "Manufacturing and Distribution" category under the NRC classification system.

Some of the costs of the revision of Part 20 identified in this analysis are directly related to the number of radiation workers at a facility. In order to assess these costs, it was necessary to estimate the number of employees, the number of employees monitored, and the number of employees reported to have measurable doses for each facility category. For facilities other than power reactors, research and test reactors, and fuel fabrication and processing facilities, the number of employees was determined by multiplying the average number of employees per licensee (Hendrickson et al. 1987) by the number of licensees listed in Table 8.2. The total number of employees monitored and the total number of employees having measurable doses were determined from data reported to NRC (Brooks 1986; Brooks, McDonald and Richardson 1982) indicating average numbers of these employees per licensee. The averages were multiplied by the number of licensees in each category listed in Table 8.2. It was assumed in this report that the most recent available data indicating both the average number of employees monitored per

TABLE 8.1. Categories of Licensees

Facility Category	Types of Licensees Included
Medical	Medical institutions (broad and other), medical private practice, teletherapy, cardiac pacemakers, eye applicators, nuclear medicine vans, veterinary, in vitro labs, and other medical
Well Logging	Well logging
Industrial Radiography	One location radiography, multilocation radiography, in-plant radiography, and field radiography
Manufacturing and Distribution	Manufacturing and distribution (broad and other), medical distribution, nuclear pharmacies, pacemaker manufacturing and distribution, other source material, source material shielding and source material general distribution
Academic/Research Institutions	Academic institutions (broad and other), and research and development institutions (broad and other)
Other Measuring Systems	Fixed gauge, portable gauge, and other measurement systems
Fuel Fabrication and Processing	Fuel fabrication and processing, UF_6 conversion and production, uranium mills, and uranium solution mining
Research and Test Reactors	Research reactors, test reactors, and critical experiment facilities
Commercial Power Reactors	Light water reactors, gas cooled reactors
All Others	All licensees licensed under 'Other Special Nuclear Material' codes (except pacemaker manufacturing and distribution), nuclear laundry, leak test service, irradiators, byproduct power sources, waste disposal, waste services, civil defense, and others

licensee and the average number of employees having measurable doses per licensee are applicable to the year 1985. Table 8.3 lists employee data for NRC and Agreement State licensees.

TABLE 8.2. Number of NRC and Agreement State Licensees in 1985

Facility Category	Number of Licensees		
	NRC	Agreement State	Total
Medical	2,432	4,074	6,506
Well Logging	130	324	454
Industrial Radiography	348	503	851
Manufacturing and Distribution	637	328	965
Academic/Research Institutions	769	787	1,556
Other Measuring Systems	[illegible]	2,824	5,060
Fuel Fabrication and Processing	14	0	14
Research and Test Reactors	80	0	80
Commercial Power Reactors	88(a)	0	88(a)
All Others	478	1,274	1,752
Total	7,212	10,114	17,326

(a) 109 reactors are assumed for the analysis in this report based on recent estimates for the year 1989 (ANS 1988).

8.2 SUMMARY OF COSTS

This section summarizes the costs identified in this report. The costs are summarized by facility type and Part 20 section, followed by a discussion of the uncertainties inherent in these estimates.

In this report, present values are calculated based on 1989 dollars, a discount rate of 10%, and a 30-year period. Because the NRC will grant a 5-year implementation period retroactive to January 9, 1986, development and implementation costs identified in this report will be distributed over the years 1986 to 1990. For this report, it was assumed that 5%, 5%, 10%, 40% and 40% of the development and implementation costs identified were or will be incurred in 1986, 1987, 1988, 1989 and 1990, respectively. In effect,

TABLE 8.3. Employee Data for NRC and Agreement State Licensees in 1985

Facility Category	Average No. Employees per Licensee	Total No. Employees	Total No. Employees Monitored	Total No. Employees Having Measurable Dose
Medical	460	3,000,000	193,000	109,000
Well Logging	170	77,100	39,300	37,000
Industrial Radiography	554	471,000	19,900	12,900
Manufacturing and Distribution	422	407,000	127,000	49,000
Academic/Research Institutions	445	692,000	93,700	27,900
Other Measuring Systems	292	1,480,000	38,000	13,700
Fuel Fabrication and Processing	679(a)	9,500(a)	9,500	5,800
Research and Test Reactors	45(a)	3,600(a)	3,500	1,000
Commercial Power Reactors	1,920(a)	169,000(a)	169,000(b)	95,000(b)
All Others	294	515,000	43,800	14,200
All Facilities	394	6,824,200	736,800	365,500

(a) Inferred from the number of workers monitored, assuming 100% of the workers at the facilities were monitored.
(b) A 24% increase in these numbers is assumed for the year 1989 based on recent estimates for the number of reactors operating in that year.

development and implementation costs were multiplied by 0.91(a) to determine their present value (Heaberlin et al. 1983). The one exception is NRC costs to develop regulatory guides because it is expected that some of the guides will be developed after 1990. Appropriate corrections to the present value calculations were made for those costs.

(a) $(0.05/1.1^{-2}) + (0.05/1.1^{-1}) + (0.1/1.1^{0}) + (0.4/1.1^{1}) + (0.4/1.1^{2}) = 0.91$.

Operation costs will be incurred annually once the revision is fully implemented. For this analysis, present values were calculated based on a 30-year period beginning in 1989. Present values of operation costs were calculated by multiplying the annual operation costs by 8.60 (Heaberlin et al. 1983). This multiplication factor includes consideration of partial realization of operation costs from 1986 to 1990 (see above paragraph).

8.2.1 Summary By Facility Type

In Section 8.1, ten categories of licensee facilities were defined for this analysis. In Table 8.4, the costs identified in this report are summarized by facility type. The costs incurred by NRC are also included in Table 8.4. All costs estimates are based on 1989 dollars.

8.2.2 Summary By Part 20 Section

In this section, the costs of the revision are summarized by section of the rule. In some cases, costs are attributable to two or more related sections. For example, costs related to increased extremity monitoring are attributable to both the reduced extremity limits and the reduced fraction of the dose limit that requires monitoring. In these cases, the costs were assumed to be evenly divided among the relevant sections.

Some costs are either not attributable to a specific section of the rule or are attributable to many sections. For example, costs related to personnel training cannot be readily associated with a specific section of the rule. In these cases, the costs are summarized by cost description.

Table 8.5 summarizes the costs of the revised rule (in 1989 dollars) by section of the rule. Sections not listed in the table were not identified to have significant associated costs.

8.2.3 Discussion of Uncertainties

Each of the individual estimates used to develop the overall estimates provided in Tables 8.4 and 8.5 have an associated uncertainty; therefore, the overall estimates have an associated uncertainty as well.

The single most important cost estimate for this analysis was the estimated cost of required modifications at fuel fabrication facilities. Costs of approximately $10 million initially and $2 million annually per facility have been estimated in the past. However, these estimates are thought to be maximum estimates, i.e., worst case scenarios. Consideration must be given to the possibility that particle size studies, use of respirators, etc., may be used in place of facility modifications. The $75 million cost estimate for fuel fabrication facilities could be a factor of five too high or a factor of two too low, depending on the steps that these facilities will actually take in response to the revised dose evaluation requirements.

Other assumptions necessary for this analysis were uncertain as well. For example, it was assumed throughout this report that Agreement State licensees will be subject to the same requirements as NRC licensees,

TABLE 8.4. Quantified Costs Incurred from the Revision of Part 20 by Facility Category

Facility Category	Development and Implementation Costs, $	Operation Costs, $/yr	Present Value of Costs, $(a)
Medical	7,400,000	1,800,000	-22,000,000
Well Logging	12,000	44,000	-390,000
Industrial Radiography	290,000	22,000	-450,000
Manufacturing and Distribution	530,000	240,000	-2,600,000
Academic/Research Institutions	1,800,000	340,000	-4,500,000
Other Measuring Systems	310,000	43,000	-650,000
Fuel Fabrication and Processing	33,000,000	5,300,000	-75,000,000
Research and Test Reactors	650,000	4,000	-620,000
Commercial Power Reactors	30,000,000	4,000,000	-61,000,000
All Others	81,000	49,000	-500,000
NRC	1,400,000	210,000	-2,900,000
Totals	75,000,000	12,000,000	-170,000,000

(a) The present values are based on 1989 dollars, a discount rate of 10%, and a 30-year period. A negative sign indicates a negative impact.

including the time allowed for implementation of the requirements. It is likely that Agreement State licensees will lag behind NRC licensees because Agreement State agencies will need time to evaluate the revised Part 20 and develop appropriate state regulations. If in fact Agreement State licensees take an average of 4 years longer to implement the provisions of the revised Part 20, the present value of the costs for Agreement State licensees would be about 30% lower than calculated in this report.

TABLE 8.5. Quantified Costs Incurred from the Revision of Part 20 by Section of the Rule

Section	Description	Present Value of Costs, $(a)
20.201	Occupational dose limits for adults	-12,000,000
20.202, 20.204	Summation of internal and external doses	-96,000,000
20.208	Dose limit for embryo/fetus	-5,200,000
20.502	Conditions requiring individual monitoring	-1,400,000
20.1106	Records of individual monitoring results	-20,000,000
20.1107	Records of dose to the public	-3,900,000
20.1206	Reports of personnel monitoring	-11,000,000(b)
NA(c)	Personnel training	-10,000,000
NA	Procedure revisions	-10,000,000
NA	NRC inspections/training	-1,100,000
Total		-170,000,000

(a) A negative sign indicates a negative impact.
(b) 84% of the costs are associated with the revised Part 19 requirements to provide reports to individuals of the doses they received.
(c) Not applicable.

Another assumption inherent in this analysis was that all identified costs must be considered as actual costs. Because many of the costs will not result in an increased use of resources, this assumption may overestimate the actual costs associated with the revision. For example, if a health physicist's hourly wage is $25 per hour (including overhead) and he must spend 8 hours revising procedures in response to the revised Part 20, he will most likely not work overtime to accomplish this task. Rather, he will likely omit performing another task of less importance. Because the most important tasks the health physicist performs would likely be worth more than $25 per hour and the least important tasks would be worth less than $25 per hour, the associated cost of revising the procedures would be less than 8 X $25. Because many of the costs identified in this report may fall under this category, the overall cost estimate may misrepresent the actual costs that will be incurred.

There was one major cost identified in this report that was not quantified: the cost associated with the revised concentration limits in Appendix B for releases into sewers. These costs could be significant with respect to the overall cost estimates provided in this report.

8.3 SUMMARY OF BENEFITS

In this section, the benefits of the revision of Part 20 are summarized. For those cases where the benefits were quantified in terms of cost savings, the present values were calculated using the same methods and assumptions used to calculate the present values of the annual costs (see Section 8,2). For those cases where the benefits were quantified in terms of dose reductions, present values were calculated based on a value of $1000 per person-rem (Heaberlin et al. 1983) and $10,000 per fetus-rem. The latter value was arbitrarily chosen based on the ratio of the embryo/fetus limit to the occupational dose limit for adults. Health effects were discounted in calculation of present values in consideration of the arguments that favor discounting of future radiation effects (Cohen 1983; Nieves et al. 1983). The dependence of the present value calculations on variations in these assumptions is discussed in Section 8.3.2.

8.3.1 Summary by Part 20 Section

In Table 8.6, the benefits of the revision are summarized by section of the rule. Some of the benefits are not attributable to a specific section of the rule and are therefore summarized by description only.

8.3.2 Discussion of Uncertainties

The estimated benefit of $44 million provided in Table 8.6 did not include consideration of many benefits that could not be quantified. It is likely that the actual value of the benefits of the revision, if such a value could be calculated, would be substantially higher than $44 million. The actual value depends primarily on the actual or perceived importance of consistency with ICRP/NCRP recommendations and the importance of complying with the Federal Guidance. Other benefits that were not quantified are thought to be of less importance.

On the other hand, the assumptions used to determine the present value of the benefits may have resulted in overestimates of the actual benefits. For example, the value assigned to a rem to the embryo/fetus ($10,000) was based on the assumption that a rem to the embryo/fetus is ten times as detrimental as a rem to an adult. If this assumption is valid, then it would be hard to justify any dose to pregnant women that could be avoided by job rotation practices; current practices in industry suggest that this may not be the case. Also, the value of $1000 assigned to a person-rem is probably too high based on the actual risk of harm from radiation as compared to the risk of harm from other hazards. However, some believe that health effects should not be discounted to determine present value; at $1000 per person-rem and $10,000 per fetus-rem, the annual dose reductions identified in this report would be valued at over $4 million dollars per year for 30 years, as opposed to a present value of $36 million as calculated in this report based on a 10% discount rate.

TABLE 8.6. Benefits of the Revision of Part 20 by Section of the Rule

Section	Description of Benefit	Annual Benefit	Present Value of Benefit, $(a)
20.202	Decreased collective doses	540 rem	+4,600,000
20.208	Reduced doses to the unborn	300 rem	+26,000,000
20.502	Increased knowledge of work environment	NQ(b)	NQ
	Reduced litigation costs	NQ	NQ
20.702	Decreased collective doses	610 rem	+5,300,000
	Reduced operating costs	$880,000	+7,600,000
20.905	Reduced operating costs	NQ	NQ
20.1206	More complete data base	NQ	NQ
NA(c)	Consistency with ICRP/NCRP Recommendations	NQ	NQ
NA	Consistency with Federal Guidance	NQ	NQ
Total			+44,000,000(d)

(a) A positive sign indicates a positive impact.
(b) Not quantified.
(c) Not applicable.
(d) Does not include unquantified benefits.

In consideration of the many uncertainties associated with the benefits from the revised Part 20, it is likely that the estimated $44 million (present value) is too low. The information provided in this report should be of help in determining the degree to which the quantified benefits underestimate the overall benefit from the revision.

8.4 SENSITIVITY ANALYSIS

Many of the estimates provided in this report were uncertain. In most cases, however, minor variations in the assumptions used to derive the estimates would not affect significantly the conclusions of this report. Probably the most important assumptions were those required to determine the present values of the costs and benefits. The following variations were used to determine the dependence of the calculated net benefits on the basic assumptions:

0) No variation from the basic assumptions (10% discount rate, all identified costs and benefits discounted, discount over a 30-year period, $1000/person-rem, $10,000/fetus-rem);

A) Health effects not discounted;

B) Health effects evaluated at $100/person-rem and $1000/fetus-rem;

C) 5% discount rate;

D) Lower-bound estimates of marginal costs incurred by licensees based on optimal compliance, i.e., only those costs thought to be necessary for compliance were included in the evaluation.

Table 8.7 lists the calculated net benefits for each facility category based on the variations listed above.

8.5 CONCLUSIONS

Perhaps the most useful method for presenting the costs and benefits identified in this report is to present the net impact per monitored worker by facility category (Table 8.8). This allows one to approximately determine the magnitude of the impacts versus the magnitude of a licensee's radiation protection program.

It is apparent that fuel fabrication facilities will incur by far the highest negative impact per employee monitored. The negative impact of $71 million listed in Table 8.8 includes about $76 million in costs and $5 million in dose savings (540 rem/yr at $1000 per person-rem, discounted at 10%). Of course, there are great uncertainties in these estimates, the greatest of which is the uncertainty whether massive engineering modifications will indeed be necessary at these facilities.

The overall impact on medical facilities was determined to be positive because the anticipated dose savings to the embryo/fetus was estimated to outweigh the costs, even though medical facilities will incur an estimated $22 million in costs. However, this conclusion relies heavily on both the estimated dose savings and the cost equated to a rem to the embryo/fetus; there were great uncertainties in both of these estimates.

Considering the best estimates of the quantified costs and benefits and the associated uncertainties, it is unlikely that the benefits associated with the revision of 10 CFR Part 20 will outweigh the costs. However, some of the costs and many of the benefits of the revision were not quantified; the unquantified benefits might have a high enough value to result in a favorable benefit/cost ratio. Because the most important unquantified benefit appears to be that the revision will be consistent with international (ICRP) and national (NCRP and EPA) recommendations, careful evaluation of this benefit is most important in determining whether the revision of Part 20 is acceptable from a benefit/cost standpoint.

TABLE 8.7. Sensitivity of Net Benefits to Variations in Basic Assumptions

Facility	Present Value of Net Benefit ($K) for Variation(a)				
	0	A	B	C	D
Medical	+1,400(b)	+58,000	-20,000	+5,800	+5,400
Well Logging	-390	-390	-390	-650	-390
Industrial Radiography	-450	-450	-450	-590	-390
Manufacturing and Distribution	-2,600	-2,600	-2,600	-4,000	-2,500
Academic/Research Institutions	-4,500	-4,500	-4,500	-6,600	-3,300
Other Measuring Systems	-650	-650	-650	-920	-580
Fuel Fabrication and Processing	-71,000	-59,000	-75,000	-100,000	-36,000
Research and Test Reactors	-620	-620	-620	-680	-470
Commercial Power Reactors	-46,000	-26,000	-53,000	-61,000	-34,000
All Others	-500	-500	-500	-800	-480
Total(c)	-125,000	-37,000	-158,000	-169,000	-73,000

(a) See text for explanation of variations.
(b) A positive sign indicates a positive impact and a negative sign indicates a negative impact.
(c) Does not include costs that will be incurred by the NRC.

TABLE 8.8. Estimated Net Impact (Present Value) of the Revision of Part 20

Facility Category	No. of Employees Monitored	Net Present Value of Impact, $(a)	Net Impact per Employee Monitored, $(a)
Medical	193,000	+1,400,000	+7.3
Well Logging	39,300	-390,000	-9.9
Industrial Radiography	19,900	-450,000	-23
Manufacturing and Distribution	127,000	-2,600,000	-20
Academic/Research Institutions	93,700	-4,500,000	-48
Other Measuring Systems	38,000	-650,000	-17
Fuel Fabrication and Processing	9,500	-71,000,000	-7,500
Research and Test Reactors	3,600	-620,000	-170
Commercial Power Reactors	209,000	-46,000,000	-220
All Others	43,800	-500,000	-11
Total	776,800	-125,000,000(b)	-161

(a) A positive sign indicates a positive impact and a negative sign indicates a negative impact.
(b) Does not include costs that will be incurred by the NRC.

9.0 REFERENCES

American Nuclear Society (ANS). 1988. "World List of Nuclear Power Plants." Nuclear News 31(2):63-82.

Booth, L. F., F. L. Bronson, and D. W. Groth. 1985. Dosimetry and Record-keeping Implications of the Proposed Revisions to 10 CFR 20. AIF/NESP-030, Atomic Industrial Forum, Bethesda, Maryland.

Brodsky, A. 1982. Principles and Practices for Keeping Occupational Radiation Exposures at Medical Institutions As Low As Reasonably Achievable. NUREG-0267, Rev. 1, U.S. Nuclear Regulatory Commission, Washington, D.C.

Brooks, B. G. 1986. Occupational Radiation Exposure at Commercial Nuclear Power Reactors And Other Facilities, 1984, Seventeenth Annual Report. NUREG-0713, Vol. 6, U.S. Nuclear Regulatory Commission, Washington, D.C.

Brooks, B., S. McDonald, and E. Richardson. 1982. Occupational Radiation Exposure, Twelfth Annual Report, 1979. NUREG-0714, Vol. 1, U.S. Nuclear Regulatory Commission, Washington, D.C.

Bunker, A. S. 1985. 'Dry Active Waste Management at Nuclear Power Stations." Radiation Protection Management 2(3):23-32.

Cardarelli, R., M. J. Slobodien, K. L. Mossman, A. Brodsky, and J. L. Telford. 1986. "The Effect of Respiratory Protection on Worker Efficiency - ALARA Considerations." Paper presented at the 31st Annual Meeting of the Health Physics Society, June 29-July 3, 1986, Pittsburgh Pennsylvania.

Cember, H. 1983. Introduction to Health Physics. 2nd ed. Pergamon Press, New York.

Cohen, B. L. 1983. "Discounting in Assessment of Future Radiation Effects." Health Physics 45:687-697.

Conference of Radiation Control Program Directors (CRCPD). 1987. "Profile of State and Local Radiation Control Programs in the United States for Fiscal Year 1985." Conference Publication 87-3, Conference of Radiation Control Program Directors, Inc., Frankfurt, Kentucky.

Cook, J. R. 1981. A Survey of Radioactive Effluent Releases from Byproduct Material Facilities. NUREG-0819, U.S. Nuclear Regulatory Commission, Washington, D.C.

Dionne, B. J., and J. W. Baum. 1985. Occupational Dose Reduction and ALARA at Nuclear Power Plants: Study on High-Dose Jobs, Radwaste Handling, and ALARA Incentives. NUREG/CR-4254, U.S. Nuclear Regulatory Commission, Washington, D.C.

Environmental Protection Agency (EPA). 1983a. Analysis of Costs for Compliance with Federal Radiation Protection Guidance for Occupational Exposure. Volume I: Cost of Compliance with Proposed Radiation Protection Guidance for Workers. EPA/520/1-83-013-1, U.S. Environmental Protection Agency, Washington, D.C.

Environmental Protection Agency (EPA). 1983b. Analysis of Costs for Compliance with Federal Radiation Protection Guidance for Occupational Exposure. Volume II: Case Study Analysis of the Impacts of Proposed Radiation Protection Guidance for Workers. EPA/520/1-83-013-2, U.S. Environmental Protection Agency, Washington, D.C.

Environmental Radiation Protection Standards for Nuclear Power Plant Operations, 40 C.F.R. Part 190, Section 190.1 (1986). (Cited in text as EPA 1986a).

Federal Register (FR). 1987. "Radiation Protection Guidance to Federal Agencies for Occupational Exposure. Recommendations Approved by the President." Vol. 52, No. 17, January 27, 1987, U.S. Environmental Protection Agency, Washington, D.C.

Federal Register (FR). 1986. "Part II - Nuclear Regulatory Commission. 10 CFR Parts 19 et al. Standards for Protection Against Radiation; Proposed Rule; Extension of Comment Period and Republication." Vol. 51, No. 6, January 9, 1986, U.S. Nuclear Regulatory Commission, Washington, D.C.

Gitterman, M., and E. W. Webster. 1984. "Shielding Hospital Rooms for Brachytherapy Patients: Design, Regulatory and Cost/Benefit Factors." Health Physics 46:617-625.

Hageman, J. P., J. M. Artz, and G. B. Humphress. 1982. Study of a Recordkeeping System for In-Processing of Transient Workers at Nuclear Power Plants. AIF/NESP-025, Atomic Industrial Forum, Bethesda, Maryland.

Harty, R., W. D. Reece, and J. A. MacLellan. 1986. Extremity Dosimetry at U.S. Department of Energy Facilities. PNL-5831, Pacific Northwest Laboratory, Richland, Washington.

Heaberlin, S. W., J. B. Burnham, R. H. V. Gallucci, M. F. Mullen, R. J. Nesse, L. A. Nieves, J. J. Tawil, M. B. Triplett, S. A. Weakley, and A. R. Wusterbarth. 1983. A Handbook for Value-Impact Assessment. NUREG/CR-3568, U.S. Nuclear Regulatory Commission, Washington, D.C.

Healy, J. W. 1982. "The ICRP Dose Limitation System - Solution or Problem?" Health Physics 42:407-413.

Hendrickson, P. L., M. J. Scott, M. F. Mullen, A. K. Nicholls, and S. A. Smith. 1987. Impact of Proposed Financial Assurance Requirements on Nuclear Materials Licensees. NUREG/CR-4958, U.S. Nuclear Regulatory Commission, Washington, D.C.

Hendrixson, E. S., D. C. Wagner, and L. Morris. 1986. "Containment Airborne I-131 Control Strategies." Radiation Protection Management 3(3):51-59.

Huggins, T. R., and J. [illegible]tson, Jr. 1984. "Routine Hand Doses vs. Monitoring Regulations at a Nuclear Power Plant." Health Physics 46:775-781.

International Commission on Radiological Protection (ICRP). 1959. Recommendations of the International Commission on Radiological Protection. ICRP Publication 2, Pergamon Press, Oxford.

International Commission on Radiological Protection (ICRP). 1977. Recommendations of the International Commission on Radiological Protection. ICRP Publication 26, Pergamon Press, Oxford.

International Commission on Radiological Protection (ICRP). 1979. Limits for Intakes of Radionuclides by Workers. ICRP Publication 30, Pergamon Press, Oxford.

International Commission on Radiological Protection (ICRP). 1982. General Principles of Monitoring for Radiation Protection of Workers. ICRP Publication 35, Pergamon Press, Oxford.

Kelsey, C. A., R. G. Lane, and F. A. Mettler. 1984. "Comments on 'Proposed Criteria for Issuing Personnel Dosimeters'." Health Physics 47:649-650.

Kemper, I. S., E. J. Kohlerand, and R. J. Scholz. 1984. "One Utility's Low-Level Waste Management Approach to Being in a Region Without a Burial Ground." ANS Transactions 47:76.

Kumazawa, S., D. R. Nelson, and A. C. B. Richardson. 1984. Occupational Exposure to Ionizing Radiation in the United States. A Comprehensive Review for the Year 1980 and a Summary of Trends for the Years 1960-1985. EPA 520/1-84-005, U.S. Environmental Protection Agency, Washington, D.C.

Lawrence, M. F., J. Skolnik, S. C. Cohen, and D. J. Goldin. 1984. Characterization of the Temporary Radiation Work Force at U.S. Nuclear Power Plants. AIF/NESP-028, Atomic Industrial Forum, Bethesda, Maryland.

Lessard, E. T., X. Yihua, K. W. Skrable, G. E. Chabot, C. S. French, T. R. Labone, J. R. Johnson, D. R. Fisher R. Belanger, and J. L. Lipsztein. 1987. Interpretation of Bioassay Measurements. NUREG/CR-4884, U.S. Nuclear Regulatory Commission, Washington, D.C.

Linnerooth, J. 1979. "The Value of Human Life: A Review of the Model." Economic Inquiry 17(1):52-74.

Low, S. A., and L. R. McPheters. 1983. "Wage Differentials and Risk of Death: An Empirical Analysis." Economic Inquiry 21(2):271-280.

Masse, F. 1984. "Low-Level Waste Management Practices in Academic and Medical Institutions." ANS Transactions 47:75.

McGuire, E. L., M. L. Baker, and J. F. Vandergrift. 1983. "Evaluation of Radiation Exposures to Personnel in Fluoroscopic X-ray Facilities." Health Physics 45:975-980.

Merwin, S. E., R. C. Brown, and J. B. Martin. 1987. "Optimization and ALARA Considerations in the Use of Respiratory Protection in Radiation Areas." Paper presented at the 32nd Annual Meeting of the Health Physics Society, July 5-10, 1987, Salt Lake City, Utah.

National Council on Radiation Protection and Measurements (NCRP). 1987. Recommendations on Limits for Exposure to Ionizing Radiation. NCRP Report No. 91, National Council on Radiation Protection and Measurements, Bethesda, Maryland.

National Council on Radiation Protection and Measurements (NCRP). 1977. Review of the NCRP Radiation Dose Limit for Embryo and Fetus in Occupationally Exposed Women. NCRP Report No. 53, National Council on Radiation Protection and Measurements, Bethesda, Maryland.

National Emission Standards for Hazardous Air Pollutants, 40 C.F.R. Part 61, Section 61.102 (1986). (Cited in text as EPA 1986b).

National Environmental Studies Project (NESP). 1980. Study of the Effects of Reduced Occupational Radiation Exposure Limits on the Nuclear Power Industry. AIF/NESP-017, Atomic Industrial Forum, Bethesda, Maryland.

Newcombe, H. B. 1980. "Design and Future Uses of National Dose Registers for Regulatory Control and Epidemiology." Health Physics 39:783-796.

Nieves L. A., J. W. Curry, L. J. Hood, and T. M. Tierney, Jr. 1983. Estimating the Economic Cost of Radiation-Induced Health Effects. PNL-4664, Pacific Northwest Laboratory, Richland, Washington.

Nilson, R., and C. W. Malody. 1982. "Radiation Protection Standards in Nuclear Fuel Manufacturing." Paper presented at the Conference on Radiation Issues for the Nuclear Industry, October 3-6, 1982, New Orleans, Louisiana.

Palmer, H. E., C. P. Brim, G. A. Rieksts, and M. C. Rhoads. 1987. Hanford Whole Body Counting Manual. PNL-6198, Pacific Northwest Laboratory, Richland, Washington.

Pa[illegible], Z. T. 1986. "INPO's Impact in the USA." International Atomic Energy Agency Bulletin 28(3).

Pelletier, C. A., and P. G. Voilleque. 1979. Potential Benefits of Reducing Occupational Radiation Exposure. AIF/NESP-010R, Atomic Industrial Forum, Bethesda, Maryland.

Peterson, Jr., H. T. 1984. "Regulatory Implications of Radiation Dose-Effect Relationships." Health Physics 47:345-359.

Robinson, A. V., D. R. Fisher, W. D. Reece, and J. A. MacLellan. 1986. Performance Testing of Radiobioassay Laboratories: In-Vivo Measurements, Pilot Study Report. PNL-5840, Pacific Northwest Laboratory, Richland, Washington.

Rutland, L., and J. M. Tuohy. 1984. "Some Effects of NRC Guidance on Design and Operation of an On-Site Radwaste Storage Facility." ANS Transactions 46:147.

Ryan, M. L. 1985. "Average Exposures for U.S. Nuclear Plant Workers Hit Record Low in 1984." Inside N.R.C. 7(14).

Ryan, M. L. 1986. "INPO Says Utility Worker Radiation Doses Cut 20% in 1985." Nucleonics Week 27(13).

Schlenker, R. A. 1986. "Comparison of Intake and Committed Dose Equivalent Permitted by Radiation Protection Systems Based on Annual Dose Equivalent and Committed Dose Equivalent for a Nuclide of Intermediate Effective Half-Life." Health Physics 51:207-213.

Science and Engineering Associates, Inc. (SEA). 1986. Generic Cost Estimates. Abstracts From Generic Studies for Use in Preparing Regulatory Impact Analyses. NUREG/CR-4627, U.S Nuclear Regulatory Commission, Washington, D.C.

Skrable, K. W., G. E. Chabot, E. L. Alexander, and C. S. French. 1985. "Committed vs Annual Dose Limits for Internal Radiation Protection and Control." Health Physics 48:123.

Taylor, L. S. 1985. "The Problems of Radiation Double Standards: Exposure of Potentially Pregnant Persons." Health Physics 49:1043-1052.

Thind, K. S. 1987. "Extremity Dose: Its Definition, Standards and Regulatory Limits, Radiobiological Significance, Measurement and Practical Considerations." Health Physics 52:695-705.

Thomadson, B., J. van de Geijn, D. Buchler, and B. Paliwal. 1983. "Fortification of Existing Rooms Used for Brachytherapy Patients." Health Physics 45:607-615.

Tichler, J., and K. Norden. 1986. Radioactive Materials Released from Nuclear Power Plants. NUREG/CR-2907, U.S. Nuclear Regulatory Commission, Washington, D.C.

U.S. Nuclear Regulatory Commission (USNRC). 1975. "Instruction Concerning Prenatal Radiation Exposure." Regulatory Guide 8.13, Revision 1. U.S. Nuclear Regulatory Commission, Washington, D.C.

U.S. Nuclear Regulatory Commission (USNRC). 1981. "Storage of Low-Level Radioactive Wastes at Power Reactor Sites." Generic Letter 81-38, November 10, 1981, U.S. Nuclear Regulatory Commission, Washington, D.C.

U.S. Nuclear Regulatory Commission (USNRC). 1982. Enclosure 2 - Regulatory Analysis. U.S. Nuclear Regulatory Commission, Washington, D.C.

U.S. Nuclear Regulatory Commission (USNRC). 1983. "Dose Assignment for Workers in Non-Uniform Radiation Fields." Office of Inspection and Enforcement. I.E. Information Notice No. 83-59, U.S. Nuclear Regulatory Commission, Washington, D.C.

U.S. Nuclear Regulatory Commission (USNRC). 1984. Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission. NUREG/BR-0058, U.S. Nuclear Regulatory Commission, Washington, D.C.

U.S. Nuclear Regulatory Commission (USNRC). 1986. The Identification and Estimation of the Cost of Required Procedural Changes at Nuclear Power Plants. U.S. Nuclear Regulatory Commission, Washington, D.C.

U.S. Nuclear Regulatory Commission (USNRC). 1987a. "Instruction Concerning Prenatal Radiation Exposure." Regulatory Guide 8.13, Revision 2. U.S. Nuclear Regulatory Commission, Washington, D.C.

U.S. Nuclear Regulatory Commission (USNRC). 1987b. "Occupational Exposures at Power Reactors Reach All-Time Low in 1986." Highlights of Weekly Information Report, Week Ending July 31, 1987. U.S. Nuclear Regulatory Commission, Washington, D.C.

Usui, N. 1987. "Japan to Tighten Radiation Exposure Rules to Meet ICRP Standards." Nucleonics Week 28(50), December 10, 1987.

Vallario, R. W., P. M. Lewis, M. F. Mullen, and S. C. Vickroy. 1985. Regulatory Analysis of Recommendations for NRC Policy on Shift Scheduling and Overtime. PNL-5593, Pacific Northwest Laboratory, Richland, Washington.

Weinstein, M. C., D. S. Shepard, and J. S. Pliskin. 1980. "The Economic Value of Changing Mortality Probabilities: A Decision-Theoretic Approach." Quarterly Journal of Economics 94(2):373-396.

West, C. M., L. M. Scott, and N. B. Schultz. 1979. "Sixteen Years of Uranium Personnel Monitoring - in Retrospect." Health Physics 36:665-669.

Wiatrowski, W. A., E. P. Cooke, D. T. Kopp, and D. W. Jordan. 1984. "Radiocontamination in Medical Centers from Diagnostic Nuclear Medicine Procedures." Health Physics 47:297-298.

DISTRIBUTION

No. of Copies

OFFSITE

12 H. T. Peterson, Jr.
Radiation Protection and Health Effects Branch
Division of Regulatory Applications
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555

A. J. DiPalo
Regulation Development Branch
Division of Regulatory Applications
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555

B. J. Richter
Regulation Development Branch
Division of Regulatory Applications
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555

No. of Copies

ONSITE

50 Pacific Northwest Laboratory

R. C. Adams
W. J. Bair
L. G. Faust
D. R. Fisher
C. A. Geffen
J. R. Johnson
J. A. MacLellan
J. B. Martin
S. E. Merwin (24)
M. F. Mullen (5)
J. M. Selby
K. L. Soldat
K. L. Swinth
J. J. Tawil
R. J. Traub
M. G. Woodruff
Health Physics Department Library
Publishing Coordination
Technical Report Files (5)

ENCLOSURE D

FINAL ENVIRONMENTAL ASSESSMENT

ENVIRONMENTAL ASSESSMENT FOR THE REVISION OF 10 CFR PART 20 STANDARDS FOR PROTECTION AGAINST RADIATION

I. Introduction

The Nuclear Regulatory Commission (NRC) is revising its regulations in Part 20 of Title 10 of the Code of Federal Regulations (10 CFR Part 20). Because the regulations contain basic standards for protection against radiation, the proposed revision would affect all categories of NRC licensees. The intent of the revision is to improve NRC standards for protection against radiation by reflecting developments in the principles that underlie radiation protection and advances in related sciences that have occurred since the original promulgation of 10 CFR Part 20 over thirty years ago. The expected result of promulgating and implementing the revision is an improved rule that provides better assurance of protection of individuals, establishes a clear health protection basis for dose limits, applies to all licensees in a consistent manner, and reflects current information on health risk, dosimetry, and radiation protection practices and experiences.

The impact of this change in NRC's regulations on the environment could potentially arise in three areas, i.e., dose limits for members of the public, dose limits for radiation workers, and effluents from licensed facilities. The potential impact in each of these areas is discussed below.

II. The Need for the Proposed Action

The existing 10 CFR Part 20, "Standards for Protection Against Radiation," was developed and published in the late 1950s by the NRC's predecessor, the Atomic Energy Commission (AEC). These standards were based on

knowledge of radiation protection theory and practice developed through the 1950s. Since the initial publication of 10 CFR Part 20, there have been a number of revisions designed to bring the regulations into accordance with recommendations of scientific organizations having expertise in radiation protection and biological effects of ionizing radiation. However, the basic approach to radiation protection has been retained throughout these revisions--an approach which derives limits by implicit judgments on safety.

The principal concerns with the present 10 CFR Part 20 regulations and the benefits resulting from the revisions intended to address these concerns are outlined in Table 1.

III. Potential Environmental Impact

10 CFR Part 20 establishes requirements for the protection of individuals from ionizing radiation resulting from operations of NRC-licensed facilities. This overall goal is accomplished by regulations addressing three major topics, i.e., doses to members of the general public resulting from NRC licensed operations, controls on occupational exposure of radiation workers, and limits on the radionuclide concentrations in air and liquids discharged to the environment. This section addresses the potential impact on the environment of the revisions to 10 CFR Part 20 by reviewing the current status and likely impact of implementing the revisions in each of these three major topics of the regulation. For each subject area, the current status and likely effect of the revised regulation is quantified for the NRC licensed facilities with the largest potential for environmental impact, i.e. Part 50 licensees. Nuclear power reactors, in particular, have the potential for the most significant direct impact on the environment via plant effluents, as well as having the most significant impact on total occupational exposures.

TABLE 1. PRINCIPAL CONCERNS AND BENEFITS OF THE PROPOSED REVISION OF 10 CFR PART 20

CONCERN WITH PRESENT PART 20	PART 20 REVISION	BENEFITS OF REVISION
1. Many Values In Appendix B Do Not Reflect Current Knowledge.	o Revises and expands Appendix B to reflect contemporary knowledge of dosimetry and biology.	o Derived values will reflect ICRP risk based system and make use of contemporary knowledge.
o Present MPCs can cause underestimates of doses by a factor of 6 for most alpha emitters and 60 for thorium.		o Air concentrations are based on a lung model which permits adjustment for the particle sizes of aerosols.
o "Soluble" and "insoluble" designations in Part 20 and many other bases were abandoned by health physicists many years ago.		o Values are presented for various compounds. o Coverage of radionuclides has been increased from 260 to 757. o Of the radionuclides where comparisons can be made, about 65% of the new values are less restrictive, about 8% are unchanged, and about 27% are more restrictive.
2. 5(N-18) Dose-Averaging Formula Permits Workers to Receive up to 12 Rems Per Year from External Sources.	o Deletes 5(N-18) and adopts 5 rem (0.05 Sv) per year	o Annual and Lifetime doses to individuals receiving highest exposures will be reduced.
	o Provides "planned special exposures" for necessary and unavoidable activities.	o Risks to radiation workers receiving highest exposures will be more comparable to those in low risk industries.

TABLE 1. (Continued)

CONCERN WITH PRESENT PART 20	PART 20 REVISION	BENEFITS OF REVISION
o Potential. Total risk could be substantial (3-10%) from 50 years external exposures at 5 rems per year and additional from internal exposures.		o Provides substantial flexibility for licensee to manage justifiable exposures beyond selected annual dose limits. o Provides for readily monitored records.
3. Dose Limits for Internal and External Doses are Independent. o Risks from doses at the limits to various organs are unequal.	Requires summations of internal and external doses. o Adopts ICRP "effective dose equivalent" which adjusts doses to various organs to whole body dose equivalent based on risk.	o Effective dose equivalent limits from combined external and internal exposures are related to individual risk. o Limits for various organ doses reflect comparable risks. o Dose weighting factors based on Quantified risk of radiation-induced health effects are consistent with Commission policies on use of quantitative risk. o Workers and public can understand risk base which is more rational than present dose limit selection. o Adherence to stated limits of doses to workers subjected to both external and internal exposures will be ensured.
4. No Requirements for Formal Radiation Protection Program or for ALARA.	o Requires written radiation protection program with ALARA provisions.	o Ensures adequate radiation protection program and ALARA efforts by all licensees.

TABLE 1. (Continued)

CONCERN WITH PRESENT PART 20	PART 20 REVISION	BENEFITS OF REVISION
o Uneven requirements among types of licensees brought about mostly through licensing actions other than Part 20.	o Requires management commitment and participation. o Requires selection of investigation levels for doses to workers below dose limits.	o Provides basis for more effective ALARA efforts with reliance on licensee's judgment. o Provides requirements in Part 20 for enforcement actions.
5. <u>All Values Below the Limits are Treated as Equally Acceptable</u>. o De facto limits are established by licensing actions.	o Emphasizes ALARA.	o Actions are taken to reduce exposures before dose limits are exceeded. o Encourages reduction of doses to workers and public prior to reaching limits.
6. <u>Dose Data on Specific Workers Usually are not Available to Staff Until Workers Terminate Employment</u>. o Workers are not required to be informed of annual or accumulated doses without request.	o Requires use of effective dose equivalents.	o Reporting requirements result in greater awareness of current conditions. o Greater awareness of workers' accumulated doses is likely to increase their participation in dose reduction efforts.
7. <u>Presents No Clear Dose Limits for Members of the Public</u>.	o Establishes 100 mrem/yr (1 mSv/yr) effective dose equivalent (external and internal sources). Permits licensee to use 500 mrem/yr (5 mSv/yr) upon application to and approval by NRC.	o Dose limits for public would include possible multiple sources and multiple exposure modes.

The specific changes resulting from the revisions to 10 CFR Part 20 are itemized in Table 2. The potential environmental impact of these changes will be assessed by considering the current status and the expected impact of the Part 20 revisions for each of the three major subjects, i.e. dose limits to members of the public, occupational exposures, and concentration limits in plant effluents.

1. Dose Limits for Members of the Public

10 CFR Part 20 is not the only regulation which establishes limits for exposure to members of the general public, i.e., those people outside of restricted areas. Two other parts of the Code of Federal Regulations also govern these doses: 10 CFR Part 50 Appendix I Section II[1] which sets design objectives and operating criteria for effluents from nuclear power plants and 40 CFR Part 190 Subpart B[2] which sets dose limits for the uranium fuel cycle. The Appendix I design objectives are:

10 CFR Part 50 Appendix I Section II
3 mrems total body from liquid effluents
10 mrems any organ from liquid effluents
5 mrems total body from gaseous effluents
15 mrems to the skin from gaseous effluents
15 mrems to any organ from particulates and radioiodines in gaseous effluents

The EPA dose limits are:

40 CFR Part 190 Subpart B
25 mrems total body all effluents and direct radiation from uranium fuel cycle sources
75 mrems thyroid all effluents and direct radiation from uranium fuel cycle sources
25 mrems any other organ all effluents and direct radiation from uranium fuel cycle sources

TABLE 2. COMPARISON OF SALIENT ISSUES IN THE EXISTING 10 CFR 20 WITH THE REVISED VERSION

Issue	Existing Part 20		Revision	
OCCUPATIONAL Limits	External			
	Whole body, head and trunk, active blood-forming organs, lens of eye, or gonads	1.25 rems/qtr or 3 rems/qtr with lifetime occupational exposure history and within 5(N-18) dose-averaging formula.	Whole body, head, trunk, arm above elbow, and leg above knee	5 rems/year (0.05 Sv/year) - includes summation of (external) deep dose equivalent and (internal) committed* effective dose equivalent.
			Lens of eye	15 rems/year (0.15 Sv/year
	Hand and forearms; feet and ankles	18 3/4 rems/qtr (75 rems/yr)	Hand, elbow, arm below elbow, foot, knee, and leg below knee	50 rems/year (0.5 Sv/year)
	Skin of whole body	7 1/2 rems/qtr (30 rems/yr)	Skin (1 cm^2)	50 rems/year (0.5 Sv/year)
	No summation of internal (organ) doses.		Weighted organ doses for all organs are summed.	
	No summation of external and internal doses.		Doses from external and internal sources are summed.	

*Except for selected uranium and transuranic radionuclides for which the derived air concentrations (DACs) and annual limits of intake (ALIs) are hard to measure at levels found in the workplace. For these nuclides, the regulation may be based upon the effective dose equivalent received in the year rather than the committed effective dose equivalent.

TABLE 2. (Continued)

Issue	Existing Part 20	Revision
	Internal	
	Intake equivalent to 520 MPC-hours/qtr. (= 2080 MPC-hours/yr) Calculated to result in a 50-year committed dose of:	Annual limit of intake (ALI) equivalent to 2000 DAC-hours/year. Calculated DACs are based on the following: Organs are assigned weighting factors, based on the estimates of risk to that organ per unit of dose relative to the estimate of risk per unit of dose for uniform whole body exposure. "Capping" dose limit of 50 rems/year (0.5 Sv/year) used to avoid nonstochastic effects. For body parts other than those listed above:
	Whole body: 1.25 rems (5 rems/yr) Bone, thyroid, and skin: 7.5 rems (30 rems/yr) Other organs: (15 rems/yr)	

Tissue	w_T	Inferred Dose Limit (rems/year)	Actual Dose Limit (rems/year)
Gonads	0.25	20	20
Breast	0.15	33	33
Red bone marrow	0.12	42	42
Lung	0.12	42	42
Thyroid	0.03	167	50
Bone surfaces	0.03	167	50
Each of 5 remaining organs with the largest dose	0.06	83	50

Planned Special	5(N-13) dose averaging provided - with quarterly limits	Planned special exposures allowed in addition to the annual limits from routine exposures. Limits set at 1 x annual limits/year from all events in a year and 5 x annual limits/lifetime from all events. 5(N-18) dose averaging provision is eliminated. Planned special exposures may include internal as well as external doses.

TABLE 2. (Continued)

Issue	Existing Part 20	Revision
Embryo/Fetus	Not addressed.	0.5 rems (5 mSv) during the entire pregnancy due to occupational exposure of the "declared" pregnant woman.
ALARA	Recommended	ALARA program required.
BASIS FOR LIMITS	Biological damage or health effects would not be statistically observable.	"Acceptable risk (10^{-4} per year for workers, 10^{-6} to 10^{-5} per year for members of the public) based on estimated radiation-induced fatal cancers and serious hereditary disorders. Upper limit of organ dose set to avoid nonstochastic (threshold) effects, such as cataracts.
INTERNAL DOSIMETRIC METHODOLOGY		
Irradiation	Dose to the most irradiated organ, i.e., "critical organ", used to limit intake via "Maximum Permissible Concentrations" (MPC)	Dose to each organ is calculated, weighted by a factor representing the ratio of the risk dose to that organ to risk from 5 rems (0.05 Sv) of whole body irradiation, and then the products are summed. Values for ALIs and DACs have been calculated for each radionuclide.
	Doses from radionuclides deposited in non-critical organs are ignored.	Weighted doses to organs from radionuclides deposited anywhere in the body are summed.
Lung model	1959 ICRP-2 model used.	Improved 1966 model of ICRP Task Group on Lung Dynamics used.
Retention in lung	Aerosols ranked "Soluble" or "Insoluble".	Aerosols ranked by translation and elimination rates, i.e., D (days), W (weeks), and Y (years).

TABLE 2. (Continued)

Issue	Existing Part 20	Revision
	No consideration given for aerosol aerodynamic properties	Assumes 1um AMAD. Adjustments for other aerosol size distributions, and physical and chemical properties are possible.
Translocation	Based on 1959 biological data.	Based on 1978 biological data from ICRP-30.
PUBLIC		
Limit	Implied limit for individuals of 0.5 rems/ year to whole body, blood-forming organs, and gonads; 3 rems/year to bone and thyroid; and 1.5 rems/year to other organs. No summation of external and internal dose. No consideration of food pathways.	Explicit limit of 0.1 rem/year (1 mSv/year) for individuals from all sources. Includes summation of external and internal doses and food pathways. Licensee may apply for and with approval operate up to 500 millirems/year (5 mSv/yr). For members of the public, report required for exceeding 0.1-re (1mSv) level to members of public, unless licensee received prior approval for conducting operations at higher doses.
MONITORING		
Adult	Required at 25% of the basic quarterly limit (0.312 rems/quarter).	Required at 10% of the annual limit for deep dose equivalent (0.5 rem or 5 mSv).
		Required at 10% of the annual limit for eyes, skin, or extremities.
	Required for intakes greater than 25% of 520 MPC-hours in a quarter.	Required at 10% of the ALIs.
Minor	Required at 5% of the basic quarterly limit 0.0625 rems.	Required at 5% of the external annual limits for adults. Required at 5% of the ALIs for adults.

TABLE 2. (Continued)

Issue	Existing Part 20	Revision
SEWER DISPOSAL	Concentration limits equivalent to 5 rems/year by potential ingestion.	Concentration limits equivalent to 0.5 rem/year (5 mSv/year) by potential ingestion.
RECORDS		
Determination of prior dose	Occupational exposure history required as condition for allowing 3 rems per quarter and use of 5(N-18) dose-averaging formula. Signed statements of dose during last quarter required upon employment.	Occupational exposure history (effective dose equivalent received during the current year and, when appropriate, all planned special exposures and over-exposures received during the lifetime of the individual) required for all individuals requiring provision of individual monitoring devices or services.
Current exposure records	Form NRC-5 includes only external dose. Includes items for calculating status under 5(N-18).	Revised Form NRC-5 includes external dose, internal dose, summation, and dose received during planned special exposures and as overexposures.
Effluent releases	Implied under survey requirement.	Explicitly required.
Planned Special Exposures	No provision.	Records required.
REPORTS		
Criteria for immediate notification of incidents	20 times the basic quarterly dose limits	5 times the annual dose limits
	Property damage $200,000.	Same
Overexposures of public	Required if limits for short-term radiation levels or annual effluent releases to unrestricted areas are exceeded.	Required if any individual in an unrestricted area exceeds 0.1 rem (1 mSv) in one year.

TABLE 2. (Continued)

Issue	Existing Part 20	Revision
REPORTS (Continued)		
Planned special exposures	No provisions for planned special exposures.	Report required in all cases.
Individual monitoring reports	Annual statistical summary report required of 7 categories of licensees. Termination report required of same 7 categories of licensees.	Data for the same 7 categories of licensees on all individuals required to be monitored (or all all individuals actually monitored at licensee's option), in lieu of statistical summary and termination reports to NRC. For members of the public, report required for exceeding 0.1-rem (1mSv) level to members of public, unless licensee received prior approval for conducting operations at higher doses.
Reports to individuals	Required by 19.13(d) for any information reported to NRC. Applies only to overexposures and termination reports. Pursuant to 19.13, other reports on exposures are available to the individual on request.	Reports required to employee on annual basis. Doses reported will be effective dose equivalents. In addition, licensees would report to individuals any planned special exposures and estimates of both annual effective dose equivalent and 50-year committed effective dose equivalent to their employees.

Current Status

The existing regulation contains an implied whole body dose limit of 0.5 rems/y to an individual in an unrestricted area in 10 CFR Part 20.105.

The revised 10 CFR Part 20, Subpart D 20.301, explicitly states dose limits for members of the public. The limit is stated as the sum of external deep dose equivalents and internal committed effective dose equivalent to any individual.

The values identified in 10 CFR Part 50 Appendix I are objectives for the design, installation, and operation of equipment for the control of effluents. On the basis of this regulation, NRC has required licensees to develop radiological effluent technical specifications[3,4] which govern the operation of commercial light water reactors in the United States. Thus the design objectives are incorporated in the licenses of these facilities as operational limits. Compliance with the annual limits incorporated in the technical specifications of operating power reactors is demonstrated by calculation of individual doses, based on effluent and other measurements.

The calculated population dose commitment for 1984[b] was 280 person-rem. The range and geometric mean of the average total body doses for all light water reactors in the United States were 1.4×10^{-6} mrems (1.4×10^{-8}mSv) to 6.2×10^{-2} (6.2×10^{-4}mSv) and 4.5×10^{-4} (4.5×10^{-6}mSv) mrems respectively.

Impact From Part 20 Revisions

In contrast to the implied limit of the existing rule, the revised Part 20 includes an explicit limit of 100 mrem/yr (1mSv/yr) effective dose equivalent from external and internal exposures. Based on the statistics of currently incurred doses to the public from NRC

licensed facilities, and the current trend of declining exposures, it is concluded that the public dose limit of the revised Part 20 will not have any impact on members of the public. Instead, it is likely that public exposures will continue to be limited by other regulations, in particular, Appendix I of 10 CFR Part 50.

2. Occupational Doses

The major emphasis of the existing Part 20 regulation is on occupational doses. The following paragraphs address the current status and the likely effect of the modifications to Part 20 on this segment of the environmental impact of this regulation.

Current Status

Occupational dose is monitored by all licensees and reported to the NRC annually. Since 1973 these dose statistics have been compiled in annual reports. The latest report published covers calendar year 1985.[6] Table 3a lists worker doses from 1973 to 1987 for all light water reactors (boiling water reactors and pressurized water reactors). With a few exceptions, average worker dose has continued to decrease since 1977. Table 3b shows a breakdown of the average worker dose by reactor type. A declining trend is evident, from this data, for both reactor types.

Under the current regulations, an individual may receive up to 3 rem per quarter and 12 rems per year whole body dose provided an occupational exposure history (Form NRC-4) is on file with the licensee. Table 3 lists a summary of annual whole body exposures reported to the Commission from 1968 to 1984. The data show that since 1982 no individual has received greater than 12 rems/y whole body dose and a small fraction, 0.1%, of the total monitored workers received greater than 5 rems/y. Approximately 95% of all workers received less than 2 rems/y. These statistics indicate that the licensees have been successful in keeping worker dose below the

TABLE 3a. OCCUPATIONAL EXPOSURE AT LWRs

Year	Number of workers with measurable exposure	Total person rem	Average Dose rems
1973	14780	13963	0.94
1974	18466	13722	0.74
1975	25489	20879	0.82
1976	35447	26433	0.75
1977	38858	32511	0.84
1978	42674	31804	0.74
1979	60160	39981	0.66
1980	74503	53796	0.72
1981	76730	54142	0.71
1982	79224	52190	0.66
1983	80804	56471	0.70
1984	92918	55214	0.59
1985	92864	43042	0.46
1986*	103179	42725	0.41
1987*	-	40879	-

*Preliminary Data

TABLE 3b. OCCUPATIONAL EXPOSURE AT LWRs

Year	Average Worker Dose (mrems)		
	All LWRs	All BWRs	All PWRs
1973	0.94	0.85	1.0
1974	0.74	0.81	0.68
1975	0.82	0.86	0.76
1976	0.75	0.71	0.79
1977	0.74	0.89	0.65
1978	0.74	0.74	0.65
1979	0.66	0.73	0.56
1980	0.72	0.87	0.52
1981	0.71	0.73	0.61
1982	0.66	0.76	0.53
1983	0.70	0.82	0.56
1984	0.59	0.66	0.49
1985	0.46	0.54	0.41

current regulatory limits, and in most cases at least a factor of 2.5 below the new limit.

Impact of Part 20 Revisions on Occupational Doses

The revised 10 CFR Part 20.201 states a limit of 5 rems/y for adult occupational radiation dose. In the area of external deep dose equivalent the impact of this limit should be minimal if judged by the data in Table 4. This table shows that more than 95% of the radiation workers received doses of less than 2 rems/y for 1984. This leaves a 3 rems margin for most workers to address the new requirement that the external deep dose equivalent and the internal committed effective dose equivalent due to internal deposition of radionuclides, be additive. With the increased awareness of airborne contaminants and the improvement of the worker environment, it is reasonable to expect that this margin will not be exceeded except in very rare instances.

In the area of internal dose limits the current regulations limit exposure to contaminated air to 520 MPC-hours/qtr (hours at maximum permissible concentration per quarter) by an individual in a restricted area. This restriction on breathing contaminated air indirectly limits internal organ doses. The change in the revised Part 20 establishes a limit of 2000 DAC-hours/y (derived air concentration hours per year) or inhalation of one ALI (allowed annual limit of intake), and puts a capping dose limit of 50 rem/y to any organ to avoid non-stochastic effects. The major difference between the two approaches to limit exposure from ingested contaminants is in the calculation of MPCs and DACs. MPCs are calculated based on a single critical organ concept. DACs are calculated based on all organs receiving a dose both directly and/or indirectly from internally deposited radionuclides and weighting the estimate of risk to an organ relative to the risk for uniform whole body exposure.

TABLE 4. SUMMARY OF ANNUAL DOSE DISTRIBUTIONS
FOR CERTAIN NRC LICENSEES

1968 - 1984

Year	Total Number of Monitored Persons Compiled Number	(Adjusted* Number)	Percent of Individuals With Doses <2 rems	Percent of Individuals With Doses >5 rems	Number of Individuals With Doses >12 rems
1968	36,836		97.2%	0.5%	3
1969	31,176		96.5%	0.5%	7
1970	36,164		96.1%	0.6%	0
1971	36,311		95.3%	0.7%	1
1972	44,690		95.7%	0.5%	8
1973	67,862		95.0%	0.5%	1
1974	85,097		96.4%	0.3%	1
1975	78,713		94.8%	0.5%	1
1976	92,773		95.0%	0.4%	3
1977	98,212	(93,438)	93.8%*	0.4%	1
1978	105,893	(100,818)	94.6%*	0.2%*	3
1979	131,027	(125,316)	95.2%*	0.2%*	1
1980	159,177	(150,675)	94.6%*	0.3%*	0
1981	157,874	(149,314)	94.6%*	0.2%*	1
1982	162,456	(154,117)	94.9%*	0.1%	0
1983	172,927	(164,239)**	94.6%*	0.1%	0
1984	204,069	(194,840)**	95.9%*	0.1%	0

*Based on the distribution of individual doses after adjusting for the multiple counting of transient reactor workers (see Section 5).

**The termination data for about 15% of the individuals terminating during 1983 or 1984 have not been entered into the REIR System.

The regulations provide limits for planned special exposures. Under the current regulations a worker could exceed a 5 rems/y dose if an occupational exposure history was on file, in which case the worker could receive up to 12 rems/y. The revised regulation allows for planned special exposures exceeding the annual limits by an increment equal to the annual dose limit during any one year. No more than five times the annual limit may be permitted during a workers lifetime. These new criteria may have an affect on some licensee s operation, but the data in Table 4 indicates that the impact is not likely to be significant.

The revisions include an explicit requirement to include the "as low as reasonably achievable" (ALARA) concept in radiation protection programs. The ALARA concept is not new. Although not an explicit general regulatory requirement heretofore, the NRC's regulatory practice has included this basic concept in a number of regulatory programs (e.g., effluent technical specifications discussed previously). As a result, most, if not all, licensees currently have ALARA programs whose functions generally cover those listed in Section 20.102.

3. Concentration and Effluent Limits

A significant change occurs in the summation of both external and internal dose for a member of the public and the restriction of that dose to 0.1 rems/yr. The summation of the external and internal doses has required new derived limits in air and water to be calculated based on the 0.1 rem allowed dose. The revised effluent concentration limits are based upon an annual effective dose equivalent of 50 millirem in each release pathway (air and water).

The MPC changes, nevertheless, will have little environmental impact. This is a result of the defacto limitation on doses for members of the public arising from the more restrictive requirements in 10 CFR Part 50 Appendix I and 40 CFR Part 190.

In the areas of monitoring and record keeping, the revised regulations do not require anything different than what the licensees are presently required to do by license conditions or effluent technical specifications.

Liquid and gaseous effluents are an indicator of the facility's impact on the environment. Table 5 presents reported effluent release activities[6] for boiling water and pressurized water reactors for the years 1972 and 1984, and 1973 and 1984 respectively. There are significant differences between the two types of reactors but the important comparison is the historical trend for each type of facility. It is readily apparent that total radioactivity released in gaseous and liquid effluents have decreased during the span of years covered by the data. The decrease in noble gas releases was enhanced in boiling water reactors by the installation of augmented offgas systems in the late 1970s.

IV. Alternatives

The proposed revision of 10 CFR Part 20 reflects new scientific knowledge, increased uses of radiation and sources of radiation exposure, and experience gained during nearly thirty years. The proposed revision would adopt, in part, the approach to radiation protection and the system of dose limitations recommended by the ICRP. This revision would correct the deficiencies identified in the existing Part 20, and would also include a number of other changes required to make the regulations consistent with up-to-date principles that underlie radiation protection.

Alternative 1: No Action

To continue with the existing regulations would be to ignore recent scientific advancements. This alternative would result in a failure to implement the international system of dose limitations recommended

TABLE 5. RADIOACTIVE EFFLUENTS FROM LWRs
(curies/year)

Gaseous Effluents

	BWRs			PWRs		
Nuclide	Year	Range	Average	Year	Range	Average
Noble Gas	1972	1.8(4)-8.77(5)**	4.24(5)	1973	32-1.1(4)	2280
	1984	118-1.67(5)	5.22(4)	1984	28.4-4(4)	6300
Iodine	1972	0.15-5.89	1.69	1973	.01-1.61	0.41
	1984	1.86(-4)-2.92	0.22	1984	2.07(-4)-0.41	0.049

Liquid Effluents

	BWRs			PWRs		
Nuclide	Year	Range	Average	Year	Range	Average
^{3}H	1972	10.4-120	40.4	1973	154-3900	1196
	1984	1.1-125	28.3	1984	1.7-3660	589
MFP/AP*	1972	1.1-51.5	22	1973	0.1-27.8	6.1
	1984	.007-6.3	1.6	1984	0.019-13.0	2.6

*MFP/AP = Mixed Fission products and activation products

**8.77(5) = 8.77×10^{5}

by ICRP in Publications 26 and 30, the NCRP in Publication 91, and most importantly, in the 1987 Federal Guidance for occupational exposure. The inclusion of the (internal) committed dose equivalent estimates, which could be an important part of determining the risks, would continue to be omitted from the total dose equivalent. Furthermore, if the present 10 CFR Part 20 is not changed, the present lack of clarity and organization will continue to exist.

While it may be shown that present regulatory efforts have been effective in providing an adequate level of protection for occupational workers, the failure to reevaluate the regulatory limits in view of the new scientific information would leave the NRC open to criticism and make it difficult for NRC to respond to Congressional (including GAO) and public inquiries about the adequacy of present regulations for protection against radiation.

Alternative 2: Delay Action Awaiting Further Developments

Revision of Part 20 could be delayed pending revised Federal Guidance EPA Standards, or NCRP recommendations on public exposure limits.

Federal Guidance

The existing Part 20 is in accord with present Federal Guidance to agencies in the conduct of radiation protection activities published in 1960 and approved by President Eisenhower. This guidance applies both to exposures of workers and members of the public. EPA has issued revised occupational exposure guidance which is in line with ICRP recommendations but has not issued revised guidance for the public. It is not necessary that NRC await such guidance prior to publishing a revision of Part 20 because the NRC has independent statutory authority to set such limits. NRC, as a matter of policy, will generally implement any new Federal Guidance in the conduct of its regulatory programs.

EPA Standards

EPA has specific authority under the Atomic Energy Act, as amended, to establish "generally applicable environmental standards" for radiation and radioactive materials covered under the Act. This authority is limited to application at points beyond the site boundaries of NRC-licensed facilities. EPA has used this authority for control of effluents, from facilities in the uranium fuel cycle, in standards for high-level waste repositories, and in proposed low-level waste disposal standards. Since EPA is not immediately developing a generic standard for population exposure, no delay in Part 20 for this reason is justifiable.

EPA has issued final standards to control air emissions of radioactive materials which would apply to some NRC licensees, with exception for those NRC-licensed facilities already covered by EPA standards promulgated under the Atomic Energy Act. However, these standards have been remanded to EPA for revision by a Federal court. The details of implementation of the proposed standards by NRC have not been finally agreed to by NRC and EPA. Publication of the revised Part 20 is not likely to be affected by EPA's final standard, as the EPA standards did not require any modifications to the revised 10 CFR Part 20.

NCRP Recommendations

The National Council on Radiation Protection and Measurements (NCRP) has issued a major revision of its basic radiation protection criteria in NCRP Report 91. This report and its recommendations were considered in the preparation of the final Part 20 rule. The degree of protection recommended in NCRP Report No. 91 is not substantially different than that provided following the 1977 ICRP recommendations which form the basis of the current Part 20 revisions.

Alternative 3: Partial Updates of Part 20

3a. Update Only the Concentration Limits for Radionuclides in Air and Water.

If concentration limits were the only part of the regulations considered in the proposed revision, then the other shortcomings would still remain. The ALIs and DACs presented in ICRP Publications 30 and 32, and proposed for incorporation into Appendix B of the draft revision of Part 20, include weighting factors and consideration of committed effective dose equivalents that would not be appropriate for incorporation into the present Part 20. Development of replacements for these limits without the ICRP-recommended weighting factors, would involve extensive calculations. In addition, updating the concentration limits could constitute about 30% of the initial cost of the entire revision and about 50% of the annual cost. While updating the concentration limits would seem to be the most important of the proposed provisions, the other provisions are considered to be very necessary at this time and the benefits that would result from implementation are believed to outweigh the costs. While the concentration limit changes would have the greatest impact on the licensees who process uranium and thorium, the costs from the remaining limit revisions are more evenly spread over the entire nuclear industry and are less likely to impact heavily on a single type of licensee.

3b. Limit Revisions to those Necessary to Make 10 CFR Part 20 Consistent with the Major Recommendations of the Federal Guidance and ICRP-26 and ICRP-30.

This alternative involves making only those revisions that would bring Part 20 in line with the dose limits and the concept of "effective" whole-body dose recommended in ICRP Publication 26.

It would include incorporation of the dosimetric models and the biological information from ICRP. These changes would leave the other weakness noted above. This partial update, never-the-less, would entail most of the cost associated with the full revisions.

V. Summary and Conclusions

This revision of 10 CFR Part 20 was guided by (1) Federal Guidance issued by the President; (2) the recommendations of world-recognized authorities on radiation protection; (3) the most current national and international data on health effects and radiation dosimetry; (4) the advice of licensees, labor unions, health physics organizations, and other interested parties; and (5) public comments received on the proposed rule.

In drafting the Part 20 revision, references were consulted including the following:

International Commission on Radiological Protection publications:

- #? - "Report of Committee II on Permissible Dose for Internal Radiation" (1959)
- #23 - "Report of the Task Group on Reference Man" (1974)
- #26 - "Recommendations of the International Commission on Radiological Protection" (1977)
- #27 - "Problems Involved in Developing an Index of Harm" (1977)
- #30 - "Limits for Intakes of Radionuclides by Workers" (1978)
- #32 - "Limits for Inhalation of Radon Daughters by Workers" (1981)

International Commission on Radiation Units and Measurements reports:

- #33 - "Radiation Quantities and Units" (1980)

National Council on Radiation Protection and Measurements reports:

#38 - "Protection Against Neutron Radiation" (1971)

#39 - "Basic Radiation Protection Criteria" (1971)

#91 - "Recommendations on Limits for Exposure to Ionizing Radiation" (1987)

National Academy of Sciences Committee on the Biological Effects of Ionizing Radiations reports:

"The Effects on Populations of Exposure to Low Levels of Ionizing Radiation" (1972, 1980)

International Atomic Energy Agency Document:

"Basic Safety Standards for Radiation Protection" (1981 Rev.)

European Atomic Energy Communities directive:

Official Journal of the European Communities L246 (1980) "Basic Safety Standards for the Health Protection of the General Public and Workers Against the Dangers of Ionizing Radiation"

United Nations Scientific Committee on the Effects of Atomic Radiation reports:

"Sources and Effects of Ionizing Radiation" (1977)

"Ionizing Radiation: Sources and Biological Effects" (1982)

Section 3 discussed potential areas of environmental impact of the revised regulation. The revision will have little impact on doses to members of the public because more restrictive limits are found in 40 CFR Part 190, 10 CFR Part 50 Appendix I, and in some licensees' effluent technical specifications.

For those changes that affect the occupationally exposed individual there is a potential positive impact on health protection. In most

instances current practice of the licensees fits within the proposed changes, so that no major impact is anticipated for the majority of radiation workers as a result of reduced upper limits, or the combination of external and internal dose equivalents. For the very small fraction of the exposed work force with accumulated doses approaching the occupational dose limits, the determination of the total effective dose equivalent by combining both internal and external deep-dose equivalents provides a positive impact by ensuring appropriate limitation of the exposed individual's health risk.

In converting from concentration limits in the present Part 20 to the annual limits of intake (ALIs) and derived air concentrations (DACs) in the revision, many of the DACs are different from the limits currently listed in Appendix B, 10 CFR Part 20. Where comparison is possible, about 65% of the DAC listings are less restrictive, about 26% are more restrictive (in particular for radionuclides resulting in alpha particle emission), and the rest remain essentially unchanged.

The changes arise from a number of considerations that include:

(1) Dose contribution to all organs and tissues from radioactive material deposited in all organs and tissues, rather than dose to a critical organ from radioactive material deposited in that organ;

(2) Use of a quality factor (QF) of 1 for low-energy beta particles, and a QF of 20 for alpha particles, rather than 1.7 and 10, respectively;

(3) Updated biological models; and

(4) Application of the risk-based weighting factors within the ICRP system of dose limitation.

The current level of radiation protection is affected much more by consideration of what is ALARA than by specific dose limits. It is considered that a strong ALARA requirement will ensure that the level of radiation protection will remain high even though the limits for certain radionuclides might be increased. Furthermore, the proposed revision of Part 20 calls for the summation of external dose and internal committed effective dose equivalent, thereby providing an additional constraint on the amount of radioactive material that may be taken into the body.

While greater assurances would be provided for worker and public protection against radiation, the revision of Part 20 will not have a significant impact on the quality of the human environment. Changes in the limits for environmental releases will not usually be limiting as other existing standards already in practice will be governing.

VI. Environmental Assessment: Negative Declaration Finding

The Commission has determined under the National Environmental Policy Act of 1969, as amended, and the Commission's regulations in Subpart A of 10 CFR Part 51, not to prepare an environmental impact statement for this revision of 10 CFR Part 20 because the Commission has concluded, on the basis of an environmental assessment, that promulgations of this revision of 10 CFR Part 20 as a final rule would not be a major Federal action significantly affecting the quality of the human environment.

The revised 10 CFR Part 20 changes the level for protection of the general public from an implicit limit of 500 millirems (5mSv) per year to an explicit limit of 100 millirems (1mSv) per year. There are also numerous changes in airborne and water radionuclide concentration limits. These changes result from changes in the models and parameters used to estimate the radiation dose associate with intake of a radionuclide. Some of the concentration limits for the general

public in this revision are new; some limits are similar to the present limits, while other limits are changed upward or downward.

Despite the changes in the dose and concentration limits, the Commission believes that issuance of the final Part 20 rule will not have a major impact on the environment. The primary basis for this conclusion is that in addition to 10 CFR Part 20, there are other regulations that govern allowable doses to members of the public which remain unchanged by the revision to Part 20. These other regulations include Appendix I to 10 CFR Part 50, 10 CFR Parts 60 and 61 and the EPA's generally-applicable environmental standards in 40 CFR Parts 190, 191, 192 and (proposed 193), and the National Emission Standards for Hazardous Air Pollutants (NESHAPS) in 40 CFR Part 61 (radionuclides). These standards set limits or design objectives (Appendix I) for releases of radioactive material to the general environment which are generally more restrictive than the dose limits in Part 20. Consequently, since these more restrictive standards remained essentially unchanged by the Part 20 revision, the level of public protection and the associated environmental impact are not changed appreciable from those associated with the current rule and the aforementioned regulations.

VII. Availability of Documents

This environmental assessment may be examined and copied (for a fee) at the NRC Public Document Room. Single copies of this assessment may be obtained from the NRC project manager:

Harold T. Peterson, Jr.
Radiation Protection and Health Effects Branch
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatroy Commission
Washington, D.C. 20555
Telephone: (301) 492-3640

VIII. References

1. Title 10, Code of Federal Regulations, Part 50, Appendix I, "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion, 'As Low As Is Reasonably Achievable,' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents."

2. Title 40, Code of Federal Regulations, Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations."

3. "Radiological Effluent Technical Specifications for Boiling Water Reactors," Rev. 3, Draft 7," intended for contractor guidance in reviewing RETS proposals for operating reactors, NUREG-0473, September 1982.

4. "Radiological Effluent Technical Specifications for Pressurized Water Reactors," Rev. 3, Draft 7," intended for contractor guidance in reviewing RETS proposals for operating reactors, NUREG-0472, September 1982.

5. D. A. Baker, "Population Dose Commitments Due to Radioactive Releases from Nuclear Power Plant Sites in 1984," NUREG/CR-2850, Vol. 6 (PNL-4221) Vol. 6, January 1988.

6. J. Tichler, K. Norden, J. Congemi, "Radioactive Materials Released from Nuclear Power Plants, Annual Report 1985," NUREG/CR-2907, Vol. 5, BNL-NUREG-51581, Vol. 5, January 1988.

7. B. G. Brooks, "Occupational Radiation Exposure at Commercial Nuclear Power Reactors and other Facilities 1985," NRC Report NUREG-0713, Vol. 7, April 1988.

ENCLOSURE E

FINAL BACKFIT ANALYSIS

FINAL BACKFIT ANALYSIS FOR THE REVISION OF 10 CFR PART 20, "STANDARDS FOR PROTECTION AGAINST RADIATION"

August 1990

Division of Regulatory Applications
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555

FINAL BACKFIT ANALYSIS

FOR THE REVISION OF 10 CFR PART 20

A. Introduction

The comments of the NRC Commissioners in Section XXXVIII of the proposed rule indicated that the proposed rule was being published for public comment prior to a Commission decision on whether or not a backfit analysis should be prepared. Subsequently, at the direction of the Commission, the NRC staff prepared a draft backfit analysis for the Part 20 revision. This draft backfit analysis was published for public comment in the August 29, 1986 Federal Register (51 FR 30870). The public comment period on this analysis ran concurrently with the extended comment period on the proposed rule, both ending on October 31, 1986.

The Backfit Analysis was prepared to satisfy the requirements of § 50.109 of 10 CFR Part 50 (commonly called "The Backfit Rule") that:

(1) a systematic and documented analysis be prepared for any new requirements placed upon existing nuclear power reactor licensees;

(2) the analysis shows that the new requirement provides a substantial increase in the overall protection of public health and safety or in the common defense and security; and

(3) that the direct and indirect costs of implementation are justified in terms of the increased protection.

B. Draft Backfit Analysis and Public Comments

The Draft Backfit Analysis for the Part 20 rule concluded that: (1) the proposed Part 20 rule would provide improvements in health protection; (2) it could not be shown unequivocally that the direct and indirect costs of implementation would be justified in view of this increased protection; and (3) the continuation of the Part 20 rulemaking might be justified on the basis of qualitative as well as quantitative factors. The Draft Backfit Analysis also contained a request for public comment on these tentative conclusions, particularly on whether qualitative factors should be considered in evaluating costs and benefits.

There were 17 comments that responded specifically to the questions asked in the draft Backfit Analysis. Three of the 13 industry comments found the draft Backfit Analysis to be adequate, but only two commenters believed that it fully satisfied the backfit requirements in § 50.109. Seven commenters (all electric utilities) thought that the draft Backfit Analysis was inadequate. Some felt that a cost-benefit analysis should have been done for each of the major changes. [Note: The Regulatory Analysis contains estimates of the costs and benefits of each major change but does not perform a numerical balancing.]

One utility stated that the draft Backfit Analysis complies with § 50.109 when non-quantitative factors such as "contemporary scientific and philosophic approaches" are considered. Other comments state that non-quantitative factors should not be controlling, but could be considered in the analysis. There was no support from these comments for suspending

the application of the provisions of § 50.109 to the Part 20 rulemaking. Two commenters stated that the pertinent wording of § 50.109(c) would provide for Commission approval based on qualitative considerations. One of these commenters stated that: "...qualitative factors are of sufficient importance to establish compliance of the Part 20 backfit with [§] 50.109."

C. Final Backfit Analysis For The Part 20 Revision

The revision of 10 CFR Part 20 is not anticipated to require physical modification to nuclear power reactors. However, the definition of a "backfit" in § 50.109(a)(1) includes the modification of or addition to the procedures or organization required to design, construct or operate a nuclear power reactor facility. The Part 20 rule is applicable to all NRC licensees and, therefore, is broader in scope than the "Backfit Rule," which applies only to nuclear power reactors. However, the revision would result in the need for revisions in the operating procedures dealing with radiation protection at nuclear power reactor facilities licensed under 10 CFR Part 50 so the application of the backfit rule must be considered.

A separate Regulatory Analysis for the 10 CFR Part 20 revision describes the anticipated benefits and anticipated costs that could be associated with the implementation of the Part 20 revision, were it to be adopted. This Regulatory Analysis is the primary source of the estimates of the benefits and the impacts for nuclear power reactors described in this Final Backfit Analysis and is incorporated as part of it. The Regulatory Analysis also contains estimates of the costs and benefits from the Part 20 revision for classes of NRC-licensed activities other than power reactors.

As the provisions of § 50.109 for a backfit analysis apply only to nuclear power reactors, these other impacts are not discussed in this Backfit Analysis.

D. The Requirements of § 50.109(c)

Paragraph 50.109(c) of the backfit rule sets forth certain factors which, to the extent relevant information is available, are to be considered in a backfit analysis. These factors are:

1. Statement of Specific Objectives to be Achieved.

The revision of 10 CFR Part 20 is intended to:

a. Update the quarter-century-old 10 CFR Part 20 to incorporate advances in science and new concepts of radiation protection methodology and philosophy;

b. Implement the 1987 Federal Radiation Guidance on occupational radiation protection;

c. Implement the principal current dose-limiting recommendations of the International Commission on Radiological Protection (ICRP) and the National Council on Radiation Protection and Measurements (NCRP) for both workers and members of the general public;

d. Update the limits on airborne radionuclide intakes, effluent releases and doses from inhaled or ingested radionuclides using recent metabolic models and dose factors; and

e. Add requirements keeping radiation levels "as low as is reasonably achievable."

The principal benefits associated with the rule are primarily associated with changes to or new limits on doses to the embryo/fetus and to workers and to members of the public.

2. General Description of the Actions to be Required of the Licensee or Applicant.

The principal new or additional actions that would be required of licensees by the proposed 10 CFR Part 20 revisions are to:

a. Sum the dose from radiation external to the body and from radionuclides deposited in the body as appropriate based upon survey and monitoring requirements;

b. Provide increased protection for the embryo/fetus when female workers declare themselves pregnant;

c. Employ the latest ICRP limits on airborne radionuclide intakes, effluent releases and doses from inhaled or ingested radionuclides;

d. Modify training guides, operating procedures, and manuals to incorporate the new concepts and requirements and provide retraining of employees on these concepts and their implementation; and

e. Develop radiation protection programs.

3. Change in the Risk to the Public from Accidental Off-Site Release of Radioactive Material.

There is no direct impact on risks associated with accidental releases of radioactive materials because the principal thrust of the Part 20 applies to normal operation.

4. Potential Impact on Radiological Exposure of Facility Employees.

The principal impact of the revision would be to assure significantly better and more up-to-date worker protection. The added protection results from the following:

a. The limit for annual worker doses would be 5 rems total effective dose equivalent in a given year. This is the sum of the external deep dose equivalent and the internal committed effective dose equivalent. Currently, the limit for dose from external radiation workers is 3 rems per quarter (12 rems per year). An additional limit is 5 rems whole-body or higher organ doses from internal radionuclides inhaled or ingested. These dose limits are applied independently so that a worker could conceivably receive a total dose (external and internal) of 17 rems in a given year. However, the present Part 20 also provides that the worker's long-term average external dose does not exceed 5 rems per year (cumulative dose less than 5(N-18) where N = age).

b. The occupational dose limit for extremities would be reduced from 75 to 50 rems per year; however, the limits for the skin and the eye would be raised.

c. A limit of 0.5 rem would be placed on the dose to the embryo/fetus of a declared pregnant woman. There is currently no specific limit in the NRC regulations to protect the embryo/fetus. The exposure of the embryo-fetus constitutes not only a cancer risk, but also involves the possibility of producing mental retardation.

d. Allowable intakes of radionuclides would be based upon updated radiobiological, metabolic, and dosimetric data. For a number of radionuclides the intake limits would be lowered. However, for many radionuclides the allowable intake would be increased due to the new methods of dose evaluation. These increases are not expected to affect airborne concentration levels in current facilities which will probably continue to operate below the older lower limits.

e. The total effective dose equivalent would be the limiting quantity rather than separately limiting external or internal doses. In certain circumstances, internal and external radiation doses would be added together rather than evaluating them separately as required by the present rule.

f. Dose limits would be expressed as the sum of organ doses weighted by the comparative biological risk of cancer in the organ. This will provide a better characterization of the radiological risks to the body by taking into account radiations from radioactive material located in parts of the body other than the "critical organ."

5. Installation and Continuing Costs, Including the Cost of Facility Downtime or the Cost of Construction Delays

There should be no costs associated with reactor downtime or construction delays. The Part 20 changes apply primarily to operational procedures and should cause no modifications in facility design or in shielding. The initial and annual costs associated with various provisions in the revision are discussed and analyzed in the Regulatory Analysis. The total estimated costs for nuclear power reactor licensees are $30 million for initial procedure modification and new procedure implementation and $4 million in additional costs per year thereafter.

6. Potential Safety Impact of Changes in Plant or Operational Complexity, Including Relationships to Proposed and Existing Regulatory Requirements.

Any safety impacts and changes in plant complexity would be negligible, since the proposed rule should not entail changes in plant design. Some of the proposed changes could increase operational complexity. However, once the new procedures are fully implemented they are expected to become routine.

The impact of modifying operating procedures, manuals, and records would be minimized by a deferred implementation date that will provide a period during which licensees may develop the necessary new procedures, manuals, and records.

7. The Estimated Resource Burden on the NRC and the Availability of These Resources.

Costs to the NRC would primarily be associated with the preparation of new regulatory guides for implementing the new procedures and revising existing regulatory guides, branch technical positions, and inspection procedures to reflect the Part 20 revisions. This effort entails the preparation of 10 new regulatory guides requiring 0.2 man-year per guide or 2.0 person-years total and approximately $500K of technical support effort over a three-year period. Seven existing regulatory guides would require major revisions, resulting in an additional person-year of effort. This effort to develop the new regulatory guides necessary to implement the revised Part 20 was started in 1989.

It is estimated that approximately one staff-year would be required in the Office of Nuclear Reactor Regulation (NRR) to modify license conditions and technical specifications to comply with the proposed revision. The largest impact in NRC relevant to Part 50 licensees covered by § 50.109 would be in NRR and the Regional Offices to revise inspection procedures and to train inspectors on the new regulations and procedures. It is estimated that this would require about 2 person-years total (excluding materials licensees). These impacts would be spread over the implementation period. For this reason the Part 20 implementation should not have a major impact on NRC programs. Once the new procedures are in place, there should not be any significant resource expenditures above current levels.

8. Potential Impact of Differences in Facility Type, Design, or Age on the Relevancy and Practicality of the Proposed Action.

Since the proposed revisions principally affect operating procedures rather than facility physical design, there should be no significant impact due to differences in facility type, design or age.

9. Are the Proposed Revisions Interim or Final and if Interim, What is the Justification for Imposing Them on an Interim Basis?

This is a final rule.

10. Paragraph 50.109(c) requires consideration of the priority and scheduling of the action under consideration in light of other regulatory activities. Implementation of the proposed revision of 10 CFR Part 20 should not significantly affect any other backfits or safety-related activities. In order to minimize the impact of the retraining and revisions of procedures, the proposed implementation period of the Part 20 revision extends to 1992. The changes required to implement the Part 20 revision would not conflict with and do not need to be further prioritized with respect to other activities at nuclear power plants.

E. Providing a "Substantial" Increase in Public Health & Safety

For the reasons given below, the Commission has concluded that the revisions to Part 20 as applied to nuclear power reactors, provide a substantial increase in overall protection of public health and safety both for workers and for members of the general public. The Commission's conclusion rests on both quantitative and qualitative grounds. The quantitative grounds are discussed first.

(1). There is a requirement (§ 20.101) that licensees have a radiation protection program that describes measures to keep radiation exposures "as low as is reasonably achievable" or "ALARA," to the extent practicable. This makes the practice of ALARA mandatory for worker protection (consistent with the ALARA requirements for effluents in Appendix I to Part 50) rather than hortatory as in the present § 20.1(c).

(2). The new occupational dose limit for radiation workers (§ 20.201) is a "total effective dose equivalent" (TEDE) of 5 rems per year. This limit is placed upon the sum of the external dose (deep dose equivalent) and the committed effective dose resulting from internal retention of inhaled radionuclides. (Occupational radionuclide intakes from ingestion are not considered as there should not be intake of contaminated food or water on the job.)

The new annual limit supersedes dose limits that would have allowed up to 12 rems per year (3 rems per quarter) from external doses and an additional 5 rems internal dose for the whole-body or up to 30 rems for doses to individual organs. Under the existing Part 20, it would have been legally possible to receive 17 rems in 1 year from the combined 12-rem[1] external and 5-rem internal doses. This is limited in the revised Part 20 to a total (internal + external) effective dose equivalent of 5 rems per year.

In practice, industry's own efforts to ensure compliance with the dose limits and to keep radiation doses "as low as is reasonably achievable" results in actual worker exposures being much less than the legally allowable maximum. Industry also generally sets practical operating limits lower than NRC limits to ensure compliance with the latter. For nuclear power facilities, guidelines issued by the Institute for Nuclear Power Operations, which are generally a fraction of the NRC limits, provide additional incentives for power reactor licencees to keep exposures below the NRC limits. Most workers in nuclear power reactors receive doses that are only a fraction of the dose limits in 10 CFR Part 20. For example, the average dose to workers with measurable radiation exposure in nuclear power plants is about 0.4 rem, an order of magnitude below the 5-rem limit (1.25 rems per quarter), and about a factor of 25 below the 12-rem (3 rems per quarter) maximum dose limit.

(3). The new limit for doses to members of the public is an explicit 100 millirems per year. This is reduced from an implicit 500 millirems (and corresponding organ dose limits) per year found in the current Part 20 which formed the bases for the concentration limits in the existing Appendix B, Table 2. This change represents a substantial reduction in the numerical dose limit; however, most doses to the public from nuclear power reactors are only a very small fraction of Part 20 limits. This is due in part to ALARA design guidelines (e.g., Appendix I to 10 CFR Part 50) and ALARA-based operating limits (e.g., EPA's Uranium Fuel Cycle Standards in 40 CFR Part 190), and the licensee's own efforts to keep below the limits in order to assure compliance and maintain to releases "as low as is reasonable achievable." As was the case for occupational protection, the finding of a "substantial improvement in public health and safety" is based upon what would be legally permissible under the revised Part 20 as compared with the limits in the old Part 20.

(4). The revised Part 20 contains an explicit limit on the dose to the embryo/fetus of pregnant female workers in licensed facilities (§ 20.208). There is no corresponding limit in the present Part 20 specifically to protect the unborn. The explicit limitation of doses to a pregnant woman who formally declares her pregnancy to her employer (i.e., a "declared pregnant woman") represents the largest estimated health protection benefit from the revised Part 20. This benefit (protection of pregnant women at power reactors) is estimated to have an economic value of $2.6 million (Regulatory Analysis, page xv).

In addition to the quantifiable costs and safety benefits given above, the Commission has identified four qualitative arguments for the Commission's conclusion that the revisions to Part 20 provide a substantial increase in overall protection of public health and safety. These qualitative arguments are:

(1). The need for updating the principles and technical basis underlying the regulation. The system of protection presently used in 10 CFR Part 20 is based on the system of radioactive dose limitation and technical data in use over a quarter of a century ago. There have been broad revisions in the concepts and approaches for protection against radiation and numerous updates to the technical parameters used for estimating radionuclide metabolism and dose. A number of those changes result in more restrictive concentration limits as changes in the technical knowledge indicates that previous limits should be modified in order to provide the same margin of safety.

(2). Maintaining consistency with international radiation protection standards. The European Economic Community, the International Atomic Energy Agency, the International Labor Organization, the World Health Organization, and the OECD/Nuclear Energy Agency base their radiation protection codes on ICRP recommendations. If the U.S. does not implement the new standards, we would not be compatible with international organizations and a large segment of the nations with advanced nuclear technology. This could lead to inconsistent limits being applied in areas close to U.S. borders and confusion regarding the proper degree of safety protection that should be applied.

(3). Consistency of radiation protection requirements with current risk assessment methodologies. There is widespread and growing usage of the dose and risk-related assessment approach arising from the concepts in ICRP Publication No. 26 and the metabolic and dose parameters in ICRP-30 and its companion reports. This means that dose assessments as currently conducted in practice by the NRC staff are not consistent with the dose assessment models underlying the present Part 20. Agreement is desirable for the sake of internal consistency between the techniques used in risk and impact assessment and the methodology used to set standards against which the acceptability of these impacts is judged.

In addition, the new estimates of risk as documented in the 1988 report of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR, 1988) and the 1989 report of the National Research Council's Committee on the Biological Effects of Ionizing Radiation (BEIR V, 1989) cannot be readily adopted into the risk limitation procedures in the present Part 20 because they use the effective dose concept rather than the critical organ approach. (The revised Part 20 uses the effective dose approach for dose assessment.)

The reduction in the dose limits and the new embryo/fetus dose limit found in the revised Part 20 is in accord with the higher risks predicted by the BEIR V and UNSCEAR 88 reports. Continued use of the older values that no longer adequately reflect current scientific knowledge may not provide sufficient assurance that there is a consistent and defensible basis for health protection.

(4). The 1987 revised Federal radiation protection guidance on occupational protection. As provided for in Sec. 274(h) of the Atomic Energy Act, on January 20, 1987, the President approved revised guidance to Federal agencies on the formulation of standards for occupational radiation exposure. Members of the NRC staff participated in an interagency working group that developed the recommendations for the President. Although the Federal guidance does not have the force of a statutory requirement, the AEC and the NRC have, as a matter of policy, considered Federal guidance as binding and in the past have implemented prior guidance in their regulations. Not following the guidance would lead to inconsistent regulations among Federal agencies. This would be particularly confusing for the Federal agencies that are NRC licensees and would have to follow both the Federal guidance and the NRC regulations. Several DOD component agencies have already requested advice on implementing the 1987 Presidential guidance on occupational radiation exposure because of the differences between the guidance and the current Part 20. This confusion could have adverse impacts on safety.

F. Determination

For the reasons stated above, the Commission believes that the reductions in allowable dose limits that are embodied in the revised Part 20 constitute substantial increases in the protection of public health and safety. Although current practice, including the philosophy of keeping radiation exposures as low as is reasonably achievable (ALARA), generally has kept

radiation exposures well below the existing limits, the reductions in the allowable dose limits ensure that such doses will also remain low in the future.

In addition to the quantifiable safety benefits accruing from dose reductions and other improvements in the revised Part 20, there are several qualitative factors (described above) which support issuing the Part 20 revision. One of the main qualitative factors is that it is necessary to revise the 30-year-old existing Part 20 to ensure that the NRC regulations reflect the current state of radiation protection science. Any future revisions in dose limits recommended by ICRP or NCRP would undoubtedly be based upon the 1977 ICRP and 1987 NCRP recommendations and, therefore, would be more easily incorporated into the framework of the revised Part 20 than in the framework of the current Part 20.

Based upon the conclusions that the revised Part 20 provides: (1) a substantial increase in public health and safety and (2) that, when the quantitative and qualitative safety benefits of the revision are considered, the costs of implementing the revised Part 20 are justified, the Commission finds that the requirements of the "Backfit Rule" (§ 50.109) are satisfied and that the Part 20 revision should be issued as final rule.

The Commission is adopting the final rule based on the conclusion of this analysis that the rule provides for a substantial increase in the overall protection of the public health and safety and that the direct and indirect costs of its implementation are justified in terms of the quantitative and

qualitative benefits associated with the rule. The Commission would note, however, that, even had the analysis not concluded that the revised Part 20 provides a substantial increase in the overall public health and safety, it could have gone forward with the rule because the changes made to Part 20 also amount to a redefinition of the level of adequate protection and the backfit rule's substantial increase and cost justification standards do not apply to a redefinition of adequate protection.

ENCLOSURE F

LETTER TO CONGRESSIONAL COMMITTEES

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

The Honorable Bob Graham, Chairman
Subcommittee on Nuclear Regulation
Committee on Environment and Public Works
United States Senate
Washington, D.C. 20510

Dear Mr. Chairman:

Enclosed for the information of the Subcommittee are copies of a public announcement and a final rule revising the Commission's regulations for protection against radiation in 10 CFR Part 20. This rule implements the Federal radiation guidance issued by President Reagan in January 1987.

The rule will become effective 30 days after issuance in the Federal Register, but licensees will have until January 1, 1993 to come into compliance. The early implementation date will allow new licensees or license renewals to adopt the new regulation without having to adopt the current Part 20 for only a short time.

The rule has been modified from a proposed rule published for public comment in January 1986. Over 800 public comments were received and considered in preparing the final rule. The rule is consistent with the recommendations of both the National Council on Radiation Protection and Measurements and the International Commission on Radiological Protection.

Sincerely,

Eric S. Beckjord, Director
Office of Nuclear Regulatory Research

cc: Sen. Alan K. Simpson

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

The Honorable Morris K. Udall, Chairman
Subcommittee on Energy and the Environment
Committee on Interior and Insular Affairs
United States House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

Enclosed for the information of the Subcommittee are copies of a public announcement and a final rule revising the Commission's regulations for protection against radiation in 10 CFR Part 20. This rule implements the Federal radiation guidance issued by President Reagan in January 1987.

The rule will become effective 30 days after issuance in the Federal Register, but licensees will have until January 1, 1993 to come into compliance. The early implementation date will allow new licensees or license renewals to adopt the new regulation without having to adopt the current Part 20 for only a short time.

The rule has been modified from a proposed rule published for public comment in January 1986. Over 800 public comments were received and considered in preparing the final rule. The rule is consistent with the recommendations of both the National Council on Radiation Protection and Measurements and the International Commission on Radiological Protection.

Sincerely,

Eric S. Beckjord, Director
Office of Nuclear Regulatory Research

cc: Rep. James V. Hansen

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

The Honorable Philip R. Sharp, Chairman
Subcommittee on Energy and Power
Committee on Energy and Commerce
United States House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

Enclosed for the information of the Subcommittee are copies of a public announcement and a final rule revising the Commission's regulations for protection against radiation in 10 CFR Part 20. This rule implements the Federal radiation guidance issued by President Reagan in January 1987.

The rule will become effective 30 days after issuance in the Federal Register, but licensees will have until January 1, 1993 to come into compliance. The early implementation date will allow new licensees or license renewals to adopt the new regulation without having to adopt the current Part 20 for only a short time.

The rule has been modified from a proposed rule published for public comment in January 1986. Over 800 public comments were received and considered in preparing the final rule. The rule is consistent with the recommendations of both the National Council on Radiation Protection and Measurements and the International Commission on Radiological Protection.

Sincerely,

Eric S. Beckjord, Director
Office of Nuclear Regulatory Research

cc: Rep. Carlos J. Moorhead

ENCLOSURE G

PRESS RELEASE

DRAFT

NUCLEAR REGULATORY COMMISSION AMENDS RADIATION PROTECTION REQUIREMENTS

The Nuclear Regulatory Commission is amending its regulations governing protection against radiation to provide for a substantial increase in the overall protection of the public health and safety.

The new requirements are based on those that were proposed for public comment in January 1986. They incorporate Federal guidance for radiation protection of workers in the nuclear industry issued by the President in 1987 and recommendations of the International Commission on Radiological Protection (ICRP) and the National Council on Radiation Protection and Measurements (NCRP).

Highlights of the new requirements are:

-- Annual radiation exposures to individual members of the public from NRC-licensed activities are limited to an explicit 0.1 rem per year or 100 millirem compared with the previous implicit limit of 0.5 rem or 500 millirem;

-- The use of quarterly and cumulative radiation dose limits for nuclear industry workers are eliminated and provisions are added to control the sum of internal and external occupational dose limits while maintaining the annual dose limit for radiation workers at a level equivalent to the present five rem per year;

-- For the first time, a standard is established for protection of the embryo/fetus of women radiation workers which limits the exposure to 0.5 rem over the duration of the pregnancy, if the pregnancy has been made known to the employer;

-- The occupational radiation dose for minors (individuals under the age of 18) is limited to 10 percent of the annual dose limits specified for adult workers;

-- The annual average concentrations of radioactive material released in gaseous and liquid effluents at the boundary of an unrestricted area is revised to reflect up-to-date metabolic models and dose factors--some limits decrease, some increase and others remain the same; and

-- All NRC licensees are required to implement programs to assure that all radiation doses are kept as low as is reasonably achievable (ALARA).

The revised requirements reflect the first complete revision of the NRC's radiation protection requirements since they were first promulgated in 1957 and are based on three basic radiation protection principles:

-- That there is a potential health risk proportional to the radiation dose received and that there is an incremental health risk associated with even very small doses, even radiation doses much smaller than received from naturally occurring radiation sources;

DRAFT

-- That the severity of random health effects such as cancer and genetic effects is independent of dose and at low doses and dose rates there is considerable uncertainty about the risks of radiation exposure; and

-- That non-random occurrences of radiation-induced health effects such as radiation-induced cataracts can be prevented by limiting exposures to doses that are below the known thresholds for induction of such effects.

The revised Part 20 and conforming amendments to Parts 19, 32, 34, 39, 50 and 70 of the NRC regulations will become effective 30 days after issuance in the Federal Register. Licensees will not be required to implement the new regulations until January 1, 1993. Each implementation may be beneficial to applicants for new licenses or renewal of existing NRC licenses so that they will not have to commit to and implement the existing 10 CFR Part 20 for only a short period of time before the revised Part 20 would replace it. The NRC staff is developing guidance documents that will provide more details on the methods of implementing the new rule.

#

TRANSMITTAL TO: X Document Control Desk, P1-24

ADVANCE COPY TO: _____ Public Document Room*

DATE: 12/13/90

FROM: SECY, Operations Branch

Attached are copies of SECY papers and related documents. They are being forwarded for entry on the Daily Accession List and placement in the Public Document Room. No other distribution is requested or required.

1. SECY-90-387	11. _____
2. _____	12. _____
3. _____	13. _____
4. _____	14. _____
5. _____	15. _____
6. _____	16. _____
7. _____	17. _____
8. _____	18. _____
9. _____	19. _____
10. _____	20. _____

* PDR is advanced two copies of each SECY paper and one copy of each related document.

DF02
1/1