UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
COMMONWEALTH EDISON COMPANY	)	Docket Nos. 50-454
	)	50-455
(Byron Station, Units 1 and 2)	)	

TESTIMONY OF MICHAEL A. LAMASTRA, EDWARD F. BRANAGAN, JR., JOHN J. HAYES, JR., AND ROBERT F. SKELTON ON LEAGUE CONTENTIONS 42, 111 AND 112

SUMMARY

The following testimony addresses League Contention 42, 111 and 112 which relate generally to the subject of ALARA and onsite radiation monitoring. The principal points made in this testimony are as follows:

1. Appropriate steps have or will be taken in accordance with NRC regulations and regulatory guidance to control radiation doses to transient workers and to keep occupational expcsures ALARA.

2. Appropriate and conservative risk estimators have been used in estimating health effects which may occur as a result of occupational exposure at Byron.

3. Applicant's design, record-keeping, training and education programs meet NRC regulatory requirements relating to radiation exposure.

4. Applicant has established adequate monitoring of radioactive emissions to keep radiation levels ALARA and in conference with 10 CFR Part 50, Appendix I.

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COMMONWEALTH EDISON COMPANY	)	Docket Nos. 50-454
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NRC STAFF TESTIMONY OF MICHAEL A. LAMASTRA, EDWARD F. BRANAGAN, JR., JOHN J. HAYES, JR., AND ROBERT F. SKELTON ON LEAGUE CONTENTIONS 42, 111 AND 112

Q.1. Please state your names and positions with the NRC?

A.1. (Panel)

I, Michael A. Lamastra, am a Health Physicist in the Radiation Protection Section of the Radiological Assessment Branch. A copy of my professional qualifications is attached.

I, Edward F. Branagan, Jr., am a Health Physicist in the Radiological Impact Section of the Radiological Assessment Branch. A copy of my professional qualifications is attached.

I, John J. Hayes, Jr., am a Nuclear Engineer in the Meteorology and Effluent Treatment Branch. A copy of my professional qualifications is attached.

I, Robert F. Skelton, am a Plant Protection Analyst in the Power Reactor Safeguards Licensing Branch, Division of Safeguards. A copy of my professonal qualifications is attached.

Q.2. What is the purpose of your testimony?

A.2. (Panel)

The purpose of our testimony is to provide the Staff position in response to League Contentions 42, 111 and 112 relating generally to ALARA and radiation monitoring onsite. Copies of these contentions are attached to this testimony. (Attachment A).

Q.3. With respect to League Contention 42, what consideration, if any, has been given by the Staff to the use of temporary, transient workers by the Applicant in order to reduce overall worker doses?

A.3. (Lamastra)

During shutdown for refueling and/or special maintenance work, the Applicant may obtain the temporary services of transient workers. The Applicant will be required to control the quarterly doses to these transient workers in accordance with the provision of 10 CFR § 20.102. Pursuant to 10 CFR § 20.102, a licensee shall require any individual, prior to first entry into a restricted area under circumstances in which that individual could receive, in any period of one calendar quarter an occupational dose in excess of 25 percent of the applicable standards specified in 10 CFR 20.101 and 20.104, to disclose in a written signed statement either that the individual had no prior occupational dose during the current calendar quarter or the nature and amount of such exposure. 10 CFR 20.101 provides that, before permitting any individual in a restricted area to receive a whole body occupational dose in excess of the standard specified in 10 CFR 20.101(a) but within the limits of 10 CFR 20.101(b), a licensee shall obtain a certification on Form NRC-4 (Attachment B) or signed statement from the individual containing all the information required in Form NRC-4.

Q.4. What is the annual onsite design dose for the Byron station?

A.4. (Lamastra)

In section 12.4 of the FSAR for Byron (prior to Amendment #40), the applicant estimated a design dose of 500 person-rems per unit. In section 12.4 of NUREG-0876, "Safety Evaluation Report Related to the Operation of Byron Station Unit 1 and 2" ("SER"), the Staff found the Applicant's estimated design dose acceptable. I prepared that SER section and adopt it a part of my testimony in this proceeding. In Amendment No. 40 of the FSAR, dated November 1982 the Applicant revised its estimate for Byron's design dose to 400 person-rems per unit. I have reviewed the Applicant's revised dose assessment and conclude that it meets the intent of the Standard Review Plan, is equivalent to the dose estimate of currently operating PWRs, and is acceptable.

Q.5. What provides the Staff with reasonable assurance that the Byron design will provide safe operation with respect to low-level radiation hazards?

A.5. (Lamastra)

The applicant has provided a commitment in the FSAR to ensure that Byron will be designed and operated in a manner consistent with the guidance of Regulatory Guide 8.8, "Information Relevant to Ensuring That Occupational Radiation Exposure At Nuclear Power Stations Will Be As Low As Is Reasonably Achievable" (Attachment C) and the Regulatory Guide 8.10, "Operating Philosophy for Maintaining Occupational Radiation Exposures As Low As Is Reasonably Achievable" (Attachment D). The Byron plant has been designed using the ALARA policy and the Applicant and architect-engineer have continued to review, update, and modify the plant design during plant construction using ALARA guidelines. The applicant's ALARA design procedure is described in its response to NRC Question 331.3 (Attachment E).

Q.6. What health effects might occur as a result of occupational exposure at Byron?

A.6. (Branagan)

A discussion of potential health effects to occupationally exposed persons is presented in section 5.9.3.1 of the Byron FES (NUREG-0848). I, Edward F. Branagan, Jr., have reviewed that portion of the FES concerning occupational exposure (i.e., pp. 5-22 to 5-25) and adopt it as part of my testimony.

The following risk estimators were used to estimate health effects: 135 potential deaths from cancer per million person-rems and 258 potential cases of all forms of genetic disorders per million person-rems.

The risk of potential fatal cancers in the exposed work-force population at the Byron facility and the risk of potential genetic disorders in all future generations of this work-force population, is estimated as follows: multiplying the annual plant-worker-population dose (about 440 person-rems per reactor unit) by the risk estimators, the staff estimates that about 0.06 cancer deaths may occur in the total exposed population and about 0.11 genetic disorders may occur in all future generations of the same exposed population. The value of 0.06 cancer deaths means that the probability of one cancer death over the life-time of the entire work-force as a result of one year of reactor operation is about 6 chances in 100. The value of 0.11 genetic disorders in all future generations of the entire work-force as a result of one year of reactor operation is about 11 chances in 100.

Q.7. What is the basis for the risk estimators used in the FES and in this testimony?

A.7. (Branagan)

The Staff's estimates are based on information compiled by the National Academy of Science's Advisory Committee on the Biological Effects of Ionizing Radiation (BEIR I). (Ref. 1). The estimates of the risks to workers and the general public are based on conservative assumptions (that is, the estimates are probably higher than the actual number).

The cancer-mortality risk estimates are based on the "absolute risk" model described in BEIR I. Higher estimates can be developed by use of the "relative risk" model along with the assumption that risk prevails for the duration of life. Use of the "relative risk" model would produce risk values up to about four times greater than those used in this testimony. The Staff regards the use of the "relative risk" model values as a reasonable upper limit of the range of uncertainty. The lower limit of the range would be zero because health effects have not been detected at doses in this dose-rate range. The number of potential non-fatal cancers would be approximately 1.5 to 2 times the number of potential fatal cancers. Values for genetic risk estimators range from 60 to 1500 potential cases of all forms of genetic disorders over all future generations per million person-rems (derived from BEIR I).

Q.8. Are the risk estimators that were used in the FES consistent with the values recommended by the major radiation protection organizations?

A.8. (Branagan)

Yes. The somatic risk estimator for exposure of the whole body that were used in the FES are compared with risk estimators from other sources of information in Table 1 of this testimony. (Attachment F). The risk estimators that are compared in Table 1 include values from the BEIR I Report, the National Academy of Sciences BEIR III Report which was published in 1980, the International Commission on Radiological Protection (ICRP), the National Council on Radiation Protection and Measurements (NCRP), and the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). (Refs. 2-7). These organizations represent the views of the overwhelming majority of the members of the scientific community. The risk estimators used in the FES are consistent with the values from these other sources of information.

Q.9. Does the available evidence indicate that the use of temporary workers for compliance with NRC regulations increases the risk of health effects by spreading a given quantity of dose over a larger number of workers?

A.9. (Branagan)

No. The Staff's position is that conservative values of health risk estimators are obtained for low-LET (linear energy transfer) radiation at low doses and low dose rates by a linear extrapolation from measured values at intermediate-to-high doses and dose rates down to the naturally-occurring spontaneous incidence (i.e., at zero dose). This position is consistent with the recommendations of the major radiation protection organizations. Based on the use of the linear non-threshold model, the spreading of a given quantity of dose over a larger number of workers would not increase the overall risk of health effects.

Q.10. Is the linear non-threshold model a conservative model to use for evaluating potential health impacts from radiation associated with the Byron facility?

A.10. (Branagan)

Yes. In regard to the use of the linear non-threshold model, the National Council on Radiation Protection and Measurements (NCRP) cautions that:

> [L]inear interpolation between the naturally occurring spontaneous incidence and the incidence observed following exposure at intermediate-to-high doses and dose rates generally overestimates the risk of low-LET radiation at low doses and low dose rates. This observation has also been incorporated in reports by the ICRP (1977), NCRP (1975), and UNSCEAR (1977). (Ref. 7).

Essentially all of the whole body doses to plant workers are due to low-LET radiation.

Q.11. Do the best current estimates concerning the health effects of low level radiation indicate that the risk is as high as one lethal cancer per 1000 person-rems?

A.11. (Branagan)

No. The Staff has estimated that a reasonable upper limit to the range of uncertainty in the cancer-mortality risk estimator is about 0.5 potential fatal cancers per 1000 person-rems. A value of 1 potential fatal cancer per 1000 person-rems is very unlikely.

Q.12. Why is the routine person-rem per year estimate for Byron acceptable under ALARA criteria?

A.12. (Lamastra)

The Staff has reviewed Byron's radiation protection/ALARA program using the acceptance criteria stated in the Standard Review Plan (NUREG-0800), section 12. Specifically, the Staff assured that occupational radiation doses will be maintained ALARA by evaluating the Applicant's conformance with the provisions of Regulatory Guide 8.8. Special attention was given in our licensing review to:

1. management policy and organization;
2. personnel qualifications and training;
3. design of facilities and equipment;
4. radiation control program, plans, and prodedures; and

5. availability of supporting equipment, instrumentation, and facilities.

It is the Staff's conclusion as documented in Section 12 of the SER that Byron's radiation protection/ALARA program meets the acceptance criteria stated in section 12 of NUREG-0800.

Q.13. Has a design dose been considered for the inspection and replacement of steam generators?

A.13. (Lamastra)

No. The Applicant has not specifically estimated a design dose for the inspection and replacement of steam generators. The expected dose to plant workers performing steam generator inspections would be included in the routine inspection dose estimate of 300 person-rems listed in Table 12.4-3 of the FSAR for both units. The dose for steam generator replacement, if required, would be considered special maintenance. In Table 12.4-3 of the FSAR, the Applicant using historical data estimates that there will be 300 person-rems per year os special maintenance for both units. The Staff finds the Applicant's use of historical data for estimating special maintenance doses reasonable. However, as noted in section 5.9.3.1 of Byron's FES, some plants require a higher than average amount of special maintenance (including replacement of steam generators), and may experience annual average lifetime doses as high as 1300 person-rems.

Q.14. Is the Staff satisfied that the applicant will have an adequate health physics staff in place to provide necessary radiation protection services? Explain.

A.14. (Lamastra)

Yes. The Staff has reviewed the qualifications of the Radiation/Chemical Supervisor and found him to meet the criteria for a Radiation Protection Manager as listed in Regulatory Guide 1.8, "Personnel Selection and Training." The Applicant has also proposed implementing a training and qualification program for health physics technicians that meets the criteria of ANSI 18.1, "Selection and Training of Nuclear Power Plant Personnel." As stated in Section 12.5 of the SER, the Staff finds this commitment acceptable.

Q.15. Is there an increased risk of sabotage by allowing additional personnel on the site?

A.15. (Skelton)

While there is a potential increase in risk of sabotage associated with the additional personnel allowed on site, the Staff believes the overall risk is still small provided appropriate regulatory requirements are satisfied. In this regard, we have reviewed the Byron Nuclear Power Station's Physical Security Plan (Rev. 6, dated April, 1982) and determined that the licensee has committed to implement the prescriptive requirements of 10 CFR 73.55(b) through (h). These include among other things:

- Access Controls
  - identification & picture badge system
  - search of individuals for firearms & explosives
  - vehicle searches
  - delivered package & material identification and search
  - escort of visitors
  - pre-employment screening for all employees who have unescorted access
  - screening for contractor employees who have unescorted access

- Protection of Vital Equipment
  - located behind a second barrier
  - access further limited to performance of duties
  - locking and alarming areas that contain vital equipment
  - special controls for containment during refueling and maintenance

Also, the Physical Security Plan contains a specific chapter which deals with "Security Measures During Maintenance, Refueling and Major Modifications." This chapter contains additional commitments to specifically deal with activities which require additional personnel. Because of these commitments, it has been determined that the security plan provides the necessary measures to protect against any potential increased risks caused by these additional persons.

It is the Staff's position that a Security Plan that satisfies the specific requirements of 73.55(b)-(h) also satisfies the General Performance Objective of providing high assurance that operation of the reactor would not constitute an unreasonable risk to public safety. The Staff is satisfied that the Applicant's Security Plans are adequate to minimize any potential increase in the risk of sabotage associated with the use of temporary workers onsite at the Byron Station.

Q.16. Can you summarize the NRC Staff conclusion regarding Contention 42?

A.16. (Lamastra)

Yes. As stated in Section 12.5 of the SER, the Staff finds that the radiation protection design and program described in the FSAR for Byron are in accordance with the criteria of the Standard Review Plan and Regulatory Guides 8.8 and 8.10 and are acceptable.

Q.17. With respect to League Contention 112, do NRC regulations require occupational doses to workers to be as low as achievable?

A.17. (Lamastra)

No. 10 CFR Part 20 allows a career average of 5 rem per year (under certain circumstances, the provisions of 10 CFR Part 20 would permit an individual to receive up to 12 rem in a given year). However, 10 CFR 20.1(c) specifies that radiation exposures should be "As Low As Reasonably Achievable" (ALARA).

Q.18. What consideration has been given by the Staff to the adequacy of the Applicant's worker ALARA program?

A.18. (Lamastra)

The Staff evaluated the Applicant's radiation safety/ALARA program contained in their FSAR using the criteria of Standard Review Plan Section 12. The results of this evaluation are presented in Section 12 of the SER. It is the Staff's conclusion that the radiation protection measures incorporated into the plant design will provide reasonable assurance that occupational doses will be maintained ALARA and below the limits of 10 CFR 20.

Q.19. Have appropriate preventive measures been taken to reduce doses? Explain.

A.19. (Lamastra)

Yes, as explained in the Answer to Question 5 above. As part of the Applicant's commitment to implement Regulatory Guide 8.8, the Byron plant design has been continually reviewed during the construction phase to ensure that occupational radiation doses will be ALARA. This design review was performed by Westinghouse and the architect-engineer, Sargent and Lundy. The ALARA design review included access control, radiation shielding, and control of airborne contamination. A description of the Applicant ALARA design procedure is present in the Applicant's response to NRC Question 331.3 (Attachment E).

Q.20. With respect to Contention 112(a), has the design of Byron been modified in any way to respond to "new evidence on low levels of radiation"?

A.20. (Lamastra)

The Staff is not aware of any plant design changes proposed by the applicant to respond to alleged "new evidence on low levels of radiation."

Q.21. With respect to Contention 112(b), is Edison's record-keeping adequate to evaluate cumulative worker exposures from Byron and other area nuclear facilities?

A.21. (Lamastra)

Yes. In order to meet the requirements of 10 CFR § 20.401, which requires all the information listed on Form NRC-5 (Attachment G) to be recorded, the Applicant has committed to follow the guidance of Regulatory Guide 8.7, "Occupational Radiation Exposure Records System" in developing its occupational records system and to record doses by tasks to provide feedback information for ALARA reviews. Regulatory Guide 8.7 endorses, as modified, ANSI 13.6-1966 (R 1972), "American National Standard Practice for Occupational Radiation Exposure Records System" ANSI 13.6 requires, in part, the following:

1. positive identification of individuals;
2. a summary of prior radiation exposure received by an individual;
3. radiation exposure received by individuals at other installations during current employment;
4. identification of the type of dosimeters used;
5. radiation exposure received by individuals at the facilities (x-ray, gamma, beta, and neutron);
6. a record of bioassay data; and
7. a record of bioassay data interpretation.

The Applicant's exposure tracking by task system is described in their response to NRC Question 331.32 (Attachment H). This commitment is sufficient to meet the requirements of 10 CFR Part 20 and is acceptable to the NRC Staff.

Q.22. With respect to Contention 112(c), is Edison's training program adequate to minimize radiation doses, particularly as it relates to transient or temporary workers?

A.22. (Lamastra)

Yes. The Applicant intends to meet the requirement of 10 CFR § 19.12 and Regulatory Guide 8.8 by providing training to each individual so that he is capable of carrying out his responsibility for maintaining his own dose ALARA. The Applicant has commited that plant personnel, including contract personnel, will receive general employee radiation protection training and other specific radiation protection training depending on his assigned duties within the plant.

Regulatory Guide 8.13, "Instruction Concerning Prenatal Radiation Exposure," Regulatory Guide 8.27, "Radiation Protection Training for Personnel at Light-Water-Cooled Nuclear Plants," and Regulatory Guide 8.29, "Instruction Cocnerning Risks for Occupational Radiation Exposure" describe radiation protection and biological risk training programs acceptable to the Staff to meet the requirements of 10 CFR § 19.12. The Applicant's training program will be routinely evaluated by NRC inspection personnel against the Staff criteria to ensure compliance with 10 CFR § 19.12.

Q.23. With respect to contention 112(d), is there any program at Edison to limit higher doses only to volunteers or older workers? Is such a program advisable?

A.23. (Lamastra)

The Staff is not aware of any program at Edison to limit higher doses to volunteers or older workers during normal operations of the Byron plant. It is the NRC Staff position that current NRC occupational dose and ALARA criteria listed in 10 CFR Part 20 and Regulatory Guide 8.8, together with worker training requirements in 10 CFR § 19.12, are adequate to reduce the risk to workers' health and safety.

Q.24. With respect to Contention 112(e), is the Applicant's education program for workers adequate to ensure their cooperation in reducing doses?

A.24. (Lamastra)

The Applicant's training program is sufficient to meet NRC regulatory requirements and should ensure that workers understand the potential risk of radiation exposure.

Q.25. Can you summarize the NRC Staff conclusion regarding Contention 112?

A.25. (Lamastra)

The Staff finds that the Applicant has designed and intends to operate the Byron nuclear power station in a manner that will keep plant personnel doses ALARA.

Q.26. With respect to League Contention 111, do 10 CFR Sections 50.34a or 50.36a require that the levels of radioactive materials in effluents be as low as is achievable?

A.26. (Hayes)

No. Neither Section 50.34a nor Section 36a require that levels of radioactive materials in effluents be as low as is achievable. Rather, both sections refer to effluents being "as low as is reasonably achievable (ALARA)." Section 50.34a specifically states that the term "as low as is reasonably achievable" in 10 CFR Part 50 means as low as is reasonably achievable taking into account the state of the technology and the economics of improvements in relation to the benefits to the public health and safety, and other societal and socio-economic considerations, and in relation to the utilization of atomic energy in the public interest. This provision also states that the dose rates set out in Appendix I to 10 CFR Part 50 provide numerical guidance on the design objectives for light-water-cooled nuclear power reactors to meet the requirements that radioactive materials in effluents released to unrestricted areas be kept ALARA and that compliance with these release levels constitutes compliance with the ALARA requirement itself. These numerical guides are design dose objectives and not to be construed as radiation protection standards.

The regulations are quite specific in stating the the effluents must be controlled to meet the ALARA requirement. There are no regulatory requirements to control effluents to a degree which is "as low as achievable."

Q.27. Has the Staff evaluated the Byron Station with respect to 10 CFR § 50.34a and with respect to Appendix I to 10 CFR Part 50?

A.27. (Hayes)

Yes. The Staff has independently evaluated the Byron Station with respect to 10 CFR § 50.34a and has determined that the station conforms to the requirements of this paragraph and that the station effluents would be in conformance with Appendix I to 10 CFR Part 50. This conclusion is presented in Sections 11.2.2 and 11.3.2 of the Byron SER (NUREG-0876). I hereby adopt those sections as part of my testimony in this case.

Q.28. Will the Applicant be required to have technical specifications on effluents which require compliance with 10 CFR § 20.106, will the Applicant be required to develop and follow operating procedures pursuant to 10 CFR 50.34a, and will equipment installed in the radioactive waste system pursuant to 10 CFR Section 50.34a be required to be maintained and used?

A.28. (Hayes)

Prior to issuance of an operating license for Byron, the Applicant will be required to have technical specifications on effluents which, in addition to requiring compliance with the applicable provisions of 10 CFR § 20.106, will also require that operating procedures be developed, pursuant to 10 CFR § 50.34a(c) for the control of radioactive effluents, be established and followed and that equipment installed, in the radioactive waste system pursuant to 10 CFR § 50.34a be maintained and used. The Staff will review the Applicant's proposed radiological effluent technical specifications (RETS) when submitted. No operating license will be issued for Byron Unit 1 until the Applicant's technical specifications conform to the Staff requirements.

Q.29. Will the minimum number of effluent monitor channels that must be operable be specified in addition to the effluent monitors?

A.29. (Hayes)

Yes. The radiological effluent technical specifications will require that radioactive gaseous and liquid effluent monitoring instrumentation be specified along with the minimum number of channels that must be operable. In addition, the surveillance requirements for these instruments, which include channel checks, source checks, channel calibration, and channel functional test (see Table 2 at Attachment I) will also be required to be specified in the RETS. The sampling frequency, the minimum frequency of analysis, and the type of activity to be analyzed will be specified in the RETS for both liquid and gaseous effluents. The RETS will also require that effluents from the site be in compliance with 10 CFR 20.106 and that the design dose objectives of 10 CFR Part 50, Appendix I are not exceeded. It is the Staff position that these technical specifications will ensure that the requirements of 10 CFR § 50.36a will be met.

Q.30. Should the Byron Station utilize additional monitors?

A.30. (Hayes)

No. The Staff has reviewed the effluent process and monitoring system with respect to Standard Review Plan (SRP) Section 11.5, as noted in Section 11.5 of the Byron SER. I adopt that SER section as part of my testimony. The Staff determined that all normal and potential pathways for the release of radioactive materials to the environment are monitored. Byron Station contains a number of process monitors in addition to the effluent monitors. The Staff has found that the location and the number of effluent monitors at the Byron Station are sufficient.

Q.31. Is there a requirement for the effluents from the Byron Station to be monitored by an independent party?

A.31. (Hayes)

No. There is no requirement in the regulations for effluent monitors to be read by an independent analyst. The Applicant will be required to participate in a program to confirm the accuracy of its analysis program. Further, the Applicant is subject to review and inspection by the NRC regional office to ensure that the monitoring program is adequate.

In any event, the State of Illinois is planning a monitoring system which will have the effect of verifying the Applicant's analyses. Specifically, the State of Illinois is planning to install a system at the Byron Station during state fiscal year 1984 (July 1, 1983-July 1, 1984) which will provide real-time isotopic data on the airborne release of radioiodine, particulates, and noble gases. This information will be fed to a central computer in Springfield, Illinois. The State of Illinois computer will also receive the signal from the Byron Station effluent monitors operated by Commonwealth Edison, which will be utilized by the State as a cross-check. Thus, this state system will provide an independent analysis of the Byron airborne releases.

Q.32. Will local authorities be notified when discharge emissions exceed certain limits?

A.32. (Hayes)

Yes. The State of Illinois' effluent monitoring system will alarm in Springfield at the main computer when the airborne effluents reach a predetermined level. In addition, onsite emergency plans specify the conditions under which state and local officials must be notified when certain conditions occur at the station. Some of the initiating conditions which require notification include those in which gaseous and liquid effluents exceed certain specified levels (e.g., RETS limits). State and local authorities will be notified when these events occur and appropriate protective measures will be initiated.

Q.33. Would more adequate monitoring of radioactive effluents occur if monitoring devices that measured the differences in alpha, beta, and gamma dose levels were utilized?

A.33. (Hayes)

No. The Applicant will utilize beta scintillation detectors to detect noble gas effluents and particulates emitted as airborne effluents. It will utilize gamma scintillation detectors to monitor airborne radioiodine releases. For liquid effluents, the monitors are gamma scintillator detectors which provide maximum sensitivity in analyzing a water medium. Since beta and gamma monitors are being utilized to monitor radioiodines and particulates and noble gases, the assertion in contention 112 regarding beta and gamma monitors is inapplicable.

Monitoring for alpha is not done because of the very small quantity of alpha-emitting radionuclides released from a nuclear power plant. However, the technical specifications at Byron will require that the airborne effluent release points be continually sampled and that a gross alpha analysis be performed on a monthly basis on a composite of these samples. The collection of alpha emitting radionuclides will occur on the same filters which will collect particulates.

For liquid effluents, the most sensitive means of detecting effluents is with a gamma detector. This is the most practicable and "state of the art" means for monitoring liquid effluents. Use of alpha and beta detectors is not practicable for liquid effluents. As with the gaseous samples, a gross alpha analysis will be performed on the monthly composite of effluents.

Q.34. Will I-129 and plutonium be monitored for in the effluents from the Byron Station?

A.34. (Hayes)

As stated in response to Question 33 above, a gross alpha analysis for alpha emitting radionuclides, which include plutonium, is performed on a monthly composite sample of all releases, liquid and airborne. A specific analysis for plutonium will not be performed. The RETS require that the principal gamma emitters and those radionuclides with identifiable gamma peaks in both liquid and airborne effluents be identified. Therefore, the release of radionuclides such as I-129 if any significant consequence would be identified.

The quantities of plutonium and I-129 released from a nuclear power plant are of such levels that the releases are below the lower limit of detection of the instrumentation. Releases of plutonium and I-129 are typically of concern for reprocessing plants and not for nuclear power plants.

History has shown that such releases from nuclear power plants are usually below the lower limits of detection by present instrumentation. Furthermore, the dose consequences associated with releases at these lower limits of detection are inconsequential.

A.35. Can you summarize the Staff's conclusion with respect to Contention 111?

A.35. The Staff concludes that Applicant has established adequate monitoring of radioactive emissions to keep radiation levels as low as reasonably achievable and in conformance with Appendix I to 10 CFR Part 50.

References

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3. UNSCEAR (1977). United Nations Scientific Committee on the Effects of Atomic Radiation, "Sources and Effects of Ionizing Radiation," Report to the General Assembly, Publ. E77IX1, (United Nations, New York).

4. UNSCEAR (1982). United Nations Scientific Committee on the Effects of Atomic Radiation, "Sources and Effects of Ionizing Radiation."

5. NAS (1980). National Academy of Sciences-National Research Council. "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation: 1980," Committee on the Biological Effects of Ionizing Radiation (National Academy of Sciences-National Research Council, Washington).

6. NCRP (1975). National Council on Radiation Protection and Measurements. "Review of the Current State of Radiation Protection Philosophy," NCRP Report No. 43 (National Council on Radiation Protection and Measurements, Washington).

7. "Influence of Dose and Its Distribution in Time on Dose-Response Relationships for Low-LET Radiations," National Council on Radiation Protection and Measurements. NCRP Report No. 64 (1980)

Michael A. Lamastra
Professional Qualifications
Radiological Assessment Branch
Division of Systems Integration

I am a Health Physicist in the Radiological Assessment Branch, Division of Systems Integration, Office of Nuclear Reactor Regulation.

My formal education consists of an A.A. degree in Radiation Science from Montgomery Community College in 1972, a B.S. degree in Physics from Towson State College in 1974, and an M.S. degree in Radiological Health from the University of Pittsburgh in 1975.

Before joining NRC, I served three years as a partime employee of the Radiation Protection Department of the National Institutes of Health in Bethesda, Maryland. My duties included collecting air samples to determine the level of radioactivity for specific isotopes, radiation contamination surveys of research labs, and advising research personnel in safety procedures involving the use of radioactive isotopes.

I joined the NRC in June 1976 as a Health Physicist in the Radioisotopes Licensing Branch, Office of Nuclear Material Safety and Safeguards. My principal function was to review applications from medical and academic institutions for byproduct, source, and special nuclear material to determine the adequacy of their proposed radiation safety program and the related efforts proposed to assure that occupational radiation exposure and release of radioactive material to the general public are as low as is reasonably achievable.

Since February 1981, I have served as a Health Physicist in the Radiation Protection Section of the Radiological Assessment Branch. My principal function is the review of power reactor applications, both at the construction permit and operating license state, to determine the adequacy of proposed occupational radiation protection programs and the related efforts proposed to assure that occupational radiation exposures will be maintained as low as is reasonably achievable.

I am a member of the health Physics Society and the Baltimore-Washington Local Chapter of the Health Physics Society.

EDWARD F. BRANAGAN, JR.
OFFICE OF NUCLEAR REACTOR REGULATION

PROFESSIONAL QUALIFICATIONS

From April 1979 to the present, I have been employed in the Radiological Assessment Branch in the Office of Nuclear Reactor Regulation of the U.S. Nuclear Regulatory Commission (NRC). As a Health Physicist with the Radiological Assessment Branch, I am responsible for evaluating the environmental radiological impacts resulting from the operation of nuclear power reactors. In particular, I am responsible for evaluating radioecological models and health effect models for use in reactor licensing.

In addition to my duties involving the evaluation of radiological impacts from nuclear reactors, my duties in the Radiological Assessment Branch have included the following: (1) I managed and was the principal author of a report entitled "Staff Review of 'Radioecological Assessment of the Wyhl Nuclear Power Plant'" (NUREG-0668); (2) I served as a technical contact on an NRC contract with Argonne National Laboratory involving development of a computer program to calculate health effects from radiation; (3) I served as the project manager on an NRC contract with Idaho National Engineering Laboratory involving estimated and measured concentrations of radionuclides in the environment; (4) I served as the project manager on an NRC contract with Lawrence Livermore Laboratory concerning a literature review of values for parameters in terrestrial radionuclide transport models; and (5) I served as the project manager on an NRC contract with Oak Ridge National Laboratory concerning a statistical analysis of dose estimates via food pathways.

From 1976 to April 1979, I was employed by the NRC's Office of Nuclear Materials Safety and Safeguards, where I was involved in project management and technical work. I served as the project manager for the NRC in connection with the NRC's estimation of radiation doses from radon-222 and radium-226 releases from uranium mills, in coordination with Oak Ridge National Laboratory which served as the NRC contractor. As part of my work on NRC's Generic Environmental Impact Statement on Uranium Milling (GEIS), I estimated health effects from uranium mill tailings. Upon publication of the GEIS, I presented a paper entitled "Health Effects of Uranium Mining and Milling for Commercial Nuclear Power" at a Conference on Health Implications of New Energy Technologies.

I received a B.A. in Physics from Catholic University in 1969, a M.A. in Science Teaching from Catholic University in 1970, and a Ph.D. in Radiation Biophysics from Kansas University in 1976. While completing my course work for my Ph.D., I was an instructor of Radiation Technology at Haskell Junior College in Lawrence, Kansas. My doctoral research work was in the area of DNA base damage, and was supported by a U.S. Public Health Service traineeship; my doctoral dissertation was entitled "Nuclear Magnetic Resonance Spectroscopy of Gamma-Irradiated DNA Bases."

I am a member of the Health Physics Society.

John J. Hayes, Jr.
Professional Qualifications
Effluent Treatment Systems Branch
Division of Systems Integration

My name is John J. Hayes Jr. I am a senior nuclear engineer in the Effluent Treatment Systems Branch in the Office of Nuclear Reactor Regulation, I am responsible for technical reviews, analyses, and evaluations of reactor plant systems and equipment for fission product removal and treatment of radioactive wastes, as to their adequacy in meeting the applicable regulations. I am also responsible for the derivation of models used in the calculation of source terms to estimate the radiological impact on the environment, the adequacy of the instrumentation provided for maintaining radioactive discharges from nuclear power plants and for providing technical bases for guides and standards.

I received a Bachelor of Science degree in Chemical Engineering from Purdue University in 1970 and a Master of Science degree in Nuclear Engineering also from Purdue University in 1976.

My professional experience totals approximately 11 years of central station nuclear power plants.

From 1971 to 1974 I was employed as a chemical engineer by Carolina Power and Light Company. In this position I was responsible for obtaining all permits, including air and water quality permits, for all power plants from the appropriate federal agencies and from regulatory agencies in the States of North Carolina and South Carolina.

From 1974 to 1980 I was employed as a principal engineer with the NUS Corporation. In this position I was responsible for the review of radwaste systems of nuclear power plants, generation of effluent source terms resulting from operation of such systems, and calculation of doses to members of the general public from these effluents. I was also responsible for the evaluation of various accidents for the preparation of inputs to Chapter 15 of Final and Preliminary Safety Analysis Reports. I was also responsible for training individuals from Brazil, Yugoslavia, and Tawian in the generation of effluent source terms and calculation of doses resulting from these effluents.

In 1980, I accepted the position of senior engineer with the U. S. Nuclear Regulatory Commission.

EDUCATIONAL AND PROFESSIONAL QUALIFICATIONS

Robert F. Skelton
Division of Safeguards
U.S. Nuclear Regulatory Commission

My name is Robert F. Skelton. I am a Plant Protection Analyst with fifty-nine months experience in the Division of Safeguards, U.S. Nuclear Regulatory Commission. I am responsible for the review, assessment, and approval of physical security plans and site specific measures employed by licensees to protect power reactor facilities. I have also participated in the review of security contingency plans and guard training and qualification plans for reactor and fuel cycle facilities as well as physical security plans for the protection of special nuclear material. I have evaluated the effectiveness of installed security systems in connection with the NRC safeguards assessment activities.

After receiving a Bachelor of Arts Degree from Parsons College in 1968, I served as a Police Officer/Radio Operator (summer, 1968) and for four years as a Counterintelligence Special Agent and Intelligence Photographer with the U.S. Army. My assignments included conducting personnel security investigations, physical security surveys, classified document inspections, counter-sabotage/espionage investigations, and intelligence photographic duties. For thirteen months I was involved in a number of sensitive assignments in these areas in Korea.

From 1972 to 1977, I was employed as a Senior Security Specialist, with the U.S. Secret Service at The White House. During that time, I provided worldwide, advance security operations for the President and other protectees of the Secret Service, assuming responsibility for all aspects of their technical security. A portion of those technical security duties involved audio and explosives countermeasures; the installation and maintenance of locking mechanisms, protective lighting, and alarm systems.

I am also currently serving in a volunteer capacity as a sworn Deputy Sheriff in Arlington County, Virginia.

ATTACHMENT A

League Contention 42

As the Staff has recognized in NUREG-0410 and in the Black Fox testimony previously cited, occupational radiation exposure to station and contractor personnel has generally been increasing in recent years, and violation of the limits of 10 CFR Part 20 has been avoided by C.E., as by other licensees, by obtaining the temporary services of transient workmen rather than by devoting adequate effort to reducing exposures. Among other things, this practice results in using larger numbers of people and thereby increasing the risk of sabotage, operator error and similar safety-related hazards. Furthermore, new information on low-level radiation effects indicates that the Byron design basis will not provide safe operation. Accordingly, both because of the lack of assurance of the practices of using transient workers, as a result of this serious and unresolved problem the findings required by 10 CFR § 50.57(a)(3)(8) and 50.57(a)(b) cannot be made.

League Contention 11

C.E. has not met the requirements of NEPA and the Regs, including but not limited to 10 C.F.R. §§ 50.34(a) and 50.36(a) because C.E. has not adequately monitored and provided a design base for the Byron plant which will keep radiation levels as low as achievable as required for operation of the plant to protect the health and safety of the public. To keep radiation levels as low as achievable, C.E. should provide and utilize:

A. More adequate environmental and discharge montoring of radioactive emissions from the Pyron plant, which include:

(1) Monitoring devices at more locations within and without the plant site.

(2) Provisions for more frequent reading of monitors by independent analysts.

(3) Better monitoring devices which include:

(a) An automatic system of monitoring that notifies local authorities by an alarm when discharge emission exceed design limits;

(b) Monitoring devices that measure differences in alpha, beta and gamma dose levels, which presently are not proposed to be considered and measured;

(c) Monitoring and recording of emissions of all dangerous long lived radionuclides, including especially I-129 and Plutonium;

(d) Bioaccumulative testing in a tiered system to assess the uptake of radioactive and chemical polutants from bottom sediments or soil to lower organisms and to contamination of the food chain of man and other life.

League Contention 112

C.E. has not met the requirements of NEPA and 10 CFR Part 20 because it has not adequately assessed the effect of radiation on plant workers and provided a design base for the Byron plant which will provide radiation levels as low as achievable. To keep radiation levels as low as achievable there is a need for better use preventive measures to reduce radiation, including neutron, exposure levels to regular plant personnel and transient workers. These include but are not limited to:

(a) Plant designs for reducing amount of radiation exposure which take into account new evidence on low levels of radiation which were not considered in design of the plant.

(b) Improved record keeping of radiation exposures, including cumulative exposures both at the plant site and at other facilities.

(c) Better training of personnel to prevent radiation exposures, including more use of regular trained personnel rather than transient or temporary workers with little experience and training.

(d) Limiting exposure to high levels of radiation to volunteers and/or only older workers beyond the child bearing age or others incapable of biological reproduction.

(e) Better education about radiation dangers to ensure cooperation of workers in keeping radiation exposures to a minimum.

As a result, the applicable findings required by the Act, NEPA, and the Regs, cannot be made herein.

Form NRC-4
(6-77)
10 CFR 20

U. S. NUCLEAR REGULATORY COMMISSION

Approved by GAO
B-180225 (R0043)
Expires - 4-30-83

OCCUPATIONAL EXTERNAL RADIATION EXPOSURE HISTORY

See Instructions on the Back

IDENTIFICATION

1. NAME (PRINT – LAST, FIRST, AND MIDDLE)	2. SOCIAL SECURITY NO.
3. DATE OF BIRTH (MONTH, DAY, YEAR)	4. AGE IN FULL YEARS (N)

OCCUPATIONAL EXPOSURE – PREVIOUS HISTORY

5. PREVIOUS EMPLOYMENTS INVOLVING RADIATION EXPOSURE–LIST NAME AND ADDRESS OF EMPLOYER	6. DATES OF EMPLOYMENT (FROM–TO)	7. PERIODS OF EXPOSURE	8. WHOLE BODY (REM)	9. RECORD OR CALCULATED (INSERT ONE)
10. REMARKS	11. ACCUMULATED OCCUPATIONAL DOSE – TOTAL			

13. CALCULATIONS – PERMISSIBLE DOSE WHOLE BODY:

(A) PERMISSIBLE ACCUMULATED DOSE = 5(N–18) = ________ REM

(B) TOTAL EXPOSURE TO DATE (FROM ITEM 11) = ________ REM

(C) UNUSED PART OF PERMISSIBLE ACCUMULATED DOSE (A–B) = ________ REM

12. CERTIFICATION: I CERTIFY THAT THE EXPOSURE HISTORY LISTED IN COLUMNS 5, 6, AND 7 IS CORRECT AND COMPLETE TO THE BEST OF MY KNOWLEDGE AND BELIEF.

EMPLOYEE'S SIGNATURE　　　DATE

14. NAME OF LICENSEE

ATTACHMENT B

INSTRUCTIONS FOR PREPARATION OF NRC FORM 4

This form or a clear and legible record containing all the information required on this form must be prepared by each licensee of the Nuclear Regulatory Commission who, pursuant to Section 20.101, proposes to expose an individual to a radiation dose in excess of the amounts specified in Paragraph 20.101(a) of the regulations in Part 20, "Standards for Protection Against Radiation," 10 CFR. The requirement for completion of this form is contained in Section 20.102 of that regulation. The information contained in this form is used for estimating the external accumulated occupational dose of the individual for whom the form is completed. A separate Form NRC-4 shall be completed for each individual to be exposed to a radiation dose in excess of the limits specified in Paragraph 20.101(a) of Part 20 of the Commission's regulations.* Listed below by item are instructions and additional information directly pertinent to completing this form:

Identification

Item 1. Self-explanatory.

Item 2. Self-explanatory except that, if individual has no social security number, the word "none" shall be inserted.

Item 3. Self-explanatory.

Item 4. Enter the age in full years. This is called "N" when used in calculating the Permissible Dose. N is equal to the number of years of age of the individual on his last birthday.

Occupational Exposure

Item 5. List the name and address of each previous employer and the address of employment. Start with the most recent employer and work back.

Include only those periods of employment since the eighteenth birthday involving occupational exposure to radiation. For periods of self-employment, insert the word "self-employed."

Item 6. Give the dates of each employment listed in Item 5.

Item 7. List periods during which occupational exposure to radiation occurred.

Item 8. List the dose recorded for each period of exposure from the records of previous occupational exposure of the individual as calculated under Section 20.102. Dose is to be given in rem.

"Dose to the whole body" shall be deemed to include any dose to the whole body, gonads, active blood-forming organs, head and trunk, or lens of eye.

Item 9. After each entry in Item 8 indicate in Item 9 whether dose is obtained from records or calculated in accordance with Section 20.102.

Item. 10. Self-explanatory.

Total Accumulated Occupational Dose (Whole Body)

Item 11. The total for the whole body is obtained by summation of all values in Item 8.

Certification

Item 12. Upon completion of the report, the employee must certify that the information in Columns 5, 6, and 7 is accurate and complete to the best of his knowledge. The date is the date of his signature.

Calculations

Item 13. The lifetime accumulated occupational dose for each individual and the permissible dose under Paragraph 20.101(b) are obtained by carrying out the following steps: The value for N should be taken from Item 4. Subtract 18 from N and multiply the difference by 5 rem. (For example, John Smith, age 32; N = 32, PAD = 5(32-18) = 70 rem.) Enter total exposure to date from Item 11. Subtract (b) from (a) and enter the difference under (c). The value in (c) represents the unused part of the permissible accumulated dose. This value for permissible dose is to be carried forward to Form NRC-5, "Current Occupational External Radiation Exposure (Whole Body)."

Item 14. Self-explanatory.

*This form requires the signature of the employee concerned.

PRIVACY ACT STATEMENT

Pursuant to 5 U.S.C. 552a(e) (3), enacted into law by section 3 of the Privacy Act of 1974 (Public Law 93-579), the following statement is furnished to individuals who supply information to the Nuclear Regulatory Commission on Form NRC-4. This information is maintained in a system of records designated as NRC-27 and described at 40 Federal Register 45344 (October 1, 1975).

1. AUTHORITY Sections 53, 63, 65, 81, 103, 104, 161(b), and 161(o) of the Atomic Energy Act of 1954, as amended (42 U.S.C. 2073, 2093, 2095, 2111, 2133, 2134, 2201(b), and 2201(o)). The authority for soliciting the social security number is 10 CFR Part 20.
2. PRINCIPAL PURPOSE(S) The information is used by the NRC in its evaluation of the risk of radiation exposure associated with the licensed activity and in exercising its statutory responsibility to monitor and regulate the safety and health practices of its licensees. The data permits a meaningful comparison of both current and long term exposure experience among types of licensees and among licensees within each type. Data on your exposure to radiation is available to you upon request.
3. ROUTINE USES The information may be used to provide data to other Federal and State agencies involved in monitoring and/or evaluating radiation exposure received by individuals employed as radiation workers on a permanent or temporary basis and exposure received by monitored visitors. The information may also be disclosed to an appropriate Federal, State, or local agency in the event the information indicates a violation or potential violation of law and in the course of an administrative or judicial proceeding.
4. WHETHER DISCLOSURE IS MANDATORY OR VOLUNTARY AND EFFECT ON INDIVIDUAL OF NOT PROVIDING INFORMATION It is voluntary that you furnish the requested information, including social security number; however, the licensee must have a completed Form NRC-4 on each individual whom the licensee proposes to expose to a radiation dose in excess of the amounts specified in 10 CFR 20.101(a). Failure to obtain the requested information before permitting such exposure may subject the licensee to enforcement action in accordance with 10 CFR 20.601. The social security number is used to assure that NRC has an accurate identifier not subject to the coincidence of similar names or birthdates among the large number of persons on whom data is maintained.
5. SYSTEM MANAGER(S) AND ADDRESS Director, Office of Management Information and Program Control
U.S. Nuclear Regulatory Commission, Washington, D.C. 20555

GPO 887-281

U.S. NUCLEAR REGULATORY COMMISSION

Revision 3
June 1978

REGULATORY GUIDE

OFFICE OF STANDARDS DEVELOPMENT

REGULATORY GUIDE 8.8

INFORMATION RELEVANT TO ENSURING THAT OCCUPATIONAL RADIATION EXPOSURES AT NUCLEAR POWER STATIONS WILL BE AS LOW AS IS REASONABLY ACHIEVABLE

A. INTRODUCTION

Paragraph 20.1(c) of 10 CFR Part 20, "Standards for Protection Against Radiation," states that licensees should make every reasonable effort to maintain exposures to radiation as far below the limits specified in Part 20 as is reasonably achievable. This guide provides information relevant to attaining goals and objectives for planning, designing, constructing, operating, and decommissioning a light-water reactor (LWR) nuclear power station to meet the criterion that exposures of station personnel[1] to radiation during routine operation of the station will be "as low as is reasonably achievable" (ALARA). This guide is also responsive to the admonition of the Federal Radiation Council (now EPA) that occupational radiation exposures be maintained ALARA. Major accident situations and emergency procedures are not within the scope of this guide.

Much of the information presented in this guide also is applicable to nuclear power stations other than those cooled with light water. The applicable goals and objectives should be used for all nuclear power stations until more specific goals and objectives are available for other types of power reactors.

B. DISCUSSION

The relationship between radiation dose and biological effects is reasonably well known only for doses that are high compared with current annual dose limits and only when such doses are delivered at high dose rates.[2] An ad hoc committee of the National Council on Radiation Protection and Measurements (NCRP) (Ref. 1) chose in 1959 to make the cautious assumptions that a proportional relationship exists between dose and biological effects and that the effect is not dependent on dose rate. Essentially, this amounts to assumptions of a nonthreshold, "linear" (straight line) dose-effect relationship.

The International Commission on Radiological Protection ICRP), the Federal Radiation Council (FRC) whose functions now reside in the Environmental Protection Agency (EPA), and committees of the National Academy of Sciences/National Research Council (NAS/NRC) have used this hypothesis to estimate conservatively the number of possible biological effects that statistically may be associated with exposures to radiation.

The NAS/NRC Biological Effects of Ionizing Radiation (BEIR) Committee (Ref. 2) reiterated that the assumptions of a nonthreshold linear relationship between dose and biological effects independent of the dose rate should be applied for radiation protection purposes. This recommendation has been adopted by EPA (41 FR 28409) for the purpose of estimating the potential human health impact of low levels of ionizing radiation. The radiation protection goal is to reduce doses wherever and whenever reasonably achievable, thereby reducing the risk that is assumed (for radiation protection purposes) to be proportional to the dose.

In 1973, the ICRP (Ref. 3) stated:

"Whilst the values proposed for maximum permis-

* Lines indicate substantive changes from previous issue.

[1] "Station personnel," as used in this guide, includes all persons working at the station, whether full-time or part-time and whether employed by the licensee or by a contractor for the licensee.

[2] Throughout this guide the word "dose" will allude to "dose equivalent," the term used for radiation protection purposes, with the unit expressed in "rems."

C

sible doses are such as to involve a risk which is small compared to the other hazards of life, nevertheless, in view of the incomplete evidence on which the values are based, coupled with the knowledge that certain radiation effects are irreversible and cumulative, it is strongly recommended that every effort be made to reduce exposure to all types of ionizing radiation to the lowest possible level."

Merely controlling the maximum dose to individuals is not sufficient; the collective dose to the group (measured in man-rems) also must be kept as low as is reasonably achievable. "Reasonably achievable" is judged by considering the state of technology and the economics of improvements in relation to all the benefits from these improvements. (However, a comprehensive consideration of risks and benefits will include risks from nonradiological hazards. An action taken to reduce radiation risks should not result in a significantly larger risk from other hazards.)

Under the linear nonthreshold concept, restricting the doses to individuals at a fraction of the applicable limit would be inappropriate if such action would result in the exposure of more persons to radiation and would increase the total man-rem dose. The radiation protection[3] community has recognized for many years that it is prudent to avoid unnecessary exposure to radiation and to maintain doses ALARA. In addition to reduced biological risks, the benefits of such practices may include avoidance of costs for extra personnel to perform maintenance activities and avoidance of nonproductive station shutdown time caused by restrictions on station personnel working in radiation areas.

Annual collective radiation dose equivalents received by personnel working at an LWR nuclear power station have ranged from less than 100 man-rems to over 5,000 man-rems (Refs. 4 and 5). Typically, annual collective dose equivalents range from 400 to 1,000 man-rems at LWR stations that have been in operation from 2 to 14 years and have generating capacities ranging from less than 100 MWe to 800 MWe. In view of the anticipated growth of nuclear power stations over the next few decades and the radiation exposure experience to date, additional efforts to reduce radiation doses to nuclear power station personnel are warranted.

The wide range in collective radiation doses to station personnel among the various stations appears to be primarily a function of doses received in maintenance operations in radiation areas. Some data are available to permit estimates of the distribution of doses among broad job categories and among the equipment systems or components that represent substantial sources of exposures. Doses to station personnel are influenced by many variables, including the ability of fuel elements to retain fission products, the extent of deposition of activated corrosion products throughout the primary and auxiliary coolant systems, the reliability of other specific equipment, the station layout, and radiation protection programs.

If design reviews or inspections had revealed that radiation exposures at nuclear power stations were unavoidable or that the cost of reducing the exposures would be unreasonable, the exposures might be considered ALARA by definition. However, this has not always been the case, and this guide is intended to assist in achieving a status wherein exposures are considered to be ALARA.

A major portion of the radiation exposure of station personnel is received during maintenance, radwaste handling, inservice inspection, refueling, and nonroutine operations (Ref. 6). The decommissioning process also has a potential for substantial exposures to personnel. Effective design of facilities and selection of equipment for systems that contain, collect, store, process, or transport radioactive material in any form will contribute to the effort to maintain radiation doses to station personnel ALARA.

Products of erosion or corrosion (i.e., "crud"[4]) that become mobile and are activated constitute an important (perhaps principal) source of radiation with respect to the exposure of station personnel. (Crud is accumulated in and transported by the coolant. Some components of the crud become radioactive when passing through the reactor core. Migration of crud to other systems occurs with coolant or steam. Specific radionuclides that have been identified in crud and that can contribute substantially to the radiation source are Co-58, Co-60, Mn-54, Zn-65, and Zr-95.)

Exposures of station personnel who service equipment contaminated by crud can generally be reduced substantially by minimizing the formation of crud and by designing or modifying equipment to minimize locations where crud can deposit and accumulate. Provisions for isolating components and flushing with crud-removing fluid such as demineralized water can often reduce accumulations prior to activities such as maintenance or equipment replacement.

Station and equipment layout also can affect the potential for radiation exposures. Exposures at sites where multiple radiation sources exist sometimes can be reduced by additional separation of individual sources. Adequate space for ease of maintenance and other operations can permit the tasks to be completed more quickly, thereby reducing the length of expo-

[3] The term "radiation protection," as used in this guide, is considered to be synonymous with the term "applied health physics"; i.e., the development and implementation of methods and procedures necessary to evaluate radiation hazards and to provide protection to man and his environment from unwarranted exposure.

[4] "Crud" is corrosion and erosion products and other solids that are formed by chemical and physical reaction between the reactor coolant and structural materials.

sures. Shielding by structural materials, equipment, and auxiliary or permanent shields can reduce exposures by isolating radiation sources. Where equipment components constitute a substantial radiation source that cannot be effectively reduced in place, features that permit the removal of such components for maintenance at remote locations often can be effective in reducing exposures. The use of remote-handling features also can reduce exposures of station personnel in certain instances.

Station technical and supervisory personnel, working closely with radiation protection personnel, can reduce exposures by planning activities of personnel who must enter radiation areas, by studying the actions and procedures of individuals working in such areas, and by conducting postoperation debriefings on projects resulting in substantial exposures to identify how procedures might be modified to reduce exposures on subsequent similar tasks. Training programs for all station personnel can establish and reinforce the principles of radiation protection as applied to specific job functions. By making personnel aware of the methods and the special equipment and protective equipment available to them, potential radiation doses can be reduced.

The concept of maintaining occupational radiation exposures ALARA does not embody a specific numerical guideline value at the present time. Rather, it is a philosophy that reflects specific objectives for radiation dose management in:

1. Establishing a program to maintain occupational radiation exposures ALARA;
2. Designing facilities and selecting equipment;
3. Establishing a radiation control program, plans, and procedures; and
4. Making supporting equipment, instrumentation, and facilities available.

When an adequate data base, including economic information, is available, the criteria for keeping annual collective doses to station personnel ALARA might be derived or selected in numerical terms. However, a data base of operating experience and cost information to provide quantitative guidance for establishing such criteria is not available at this time, and the criteria for meeting the provision of paragraph 20.1(c) of 10 CFR Part 20 must therefore take the form of qualitative guidance (e.g., goals, objectives, and statements of good practice).

The NRC staff has not performed a cost-benefit analysis for each of the considerations discussed or presented in Section C of this guide. This guide presents goals and objectives that were selected to satisfy the principles, philosophy, and criteria for maintaining occupational radiation exposures ALARA. Attaining these goals and objectives will require good engineering judgment on a case-by-case basis. A cost-benefit analysis may be helpful in arriving at the judgment, but it should not be the decisive factor in all cases.

The nuclear steam supply system (NSSS) vendor, the designer, the architect-engineer (A/E), the constructor, and the operator of the nuclear power facility each have responsibilities related to the effort of maintaining occupational radiation exposures ALARA. Thus, coordination and cooperation are essential to achieving these goals and objectives of maintaining occupational radiation exposures ALARA.

This guide is written primarily for the applicant or licensee. However, the designer, the A/E, and the constructor will find many of the guide's considerations helpful in the design and construction process to ensure that their efforts are consistent with the needs of the applicant or licensee to maintain radiation exposures ALARA.

Specific design or operational objectives for maintaining radiation exposures ALARA are suggested by the parameters that determine the magnitude of doses to station personnel, both as individuals and as a group. Doses to personnel in nuclear power stations are predominantly from external exposure, i.e., from radiation sources external to the body. However, there also exists a potential for doses from internal exposures, i.e., from radioactive materials taken into the body.

Important parameters in determining doses from external exposures are (1) the length of time that the receptor remains in the radiation field and (2) the intensity of the radiation field. Some degree of exposure of station personnel cannot be avoided during the operation and maintenance of nuclear power stations. However, there are many ways by which the exposures and resultant doses can be lowered by reducing the time interval of the exposure and the intensity of the radiation field. The intensity of the radiation field is determined by (1) the quantity of radioactive material, (2) the nature (i.e., characteristics) of the emitted radiation, (3) the nature of the shielding between the radiation source and the receptor, and (4) geometry (e.g., distances and dimensions).

Parameters important in determining doses from internal exposures are (1) the quantity of radioactive material taken into the body, (2) the nature (isotopical and body deposition characteristics) of the material, and (3) the time interval over which the material is retained by the body. The principal modes by which radioactive material can be taken into the body are (1) inhalation, (2) ingestion, (3) skin absorption, and (4) injection through wounds. At nuclear power stations, radioactive materials are generally confined, but some dispersion within the station is unavoidable and constitutes the source of (1) contaminated air and liquids that present the potential for intake by inhalation and absorption and (2) contaminated surfaces that present the potential for intake by ingestion and through cuts or abrasions in the skin. Absorption generally is not an important intake mode at nuclear power stations except for tritium, which can be absorbed through the skin.

Consequently, the basic variables that can be controlled to limit doses from internal exposures are those that limit (1) the amount of contamination, (2) the disposal of the contamination, and (3) the length of time that personnel must spend in contaminated areas. Protective equipment can keep the intake of the contaminant to a minimum. Physical and chemical methods can be used to hasten the elimination of radioactive material taken into the body; however, because of the risks associated with the use of these methods, they are reserved for very serious cases where the probability of experiencing biological effects is quite substantial, e.g., large intakes such as those that might occur in serious accident situations.

Objectives stated in this guide for maintaining occupational radiation exposures ALARA are derived by considering the parameters that affect dose, the variables that exist in the station design features, and the variables that can be provided by station administrative actions. Section C, Regulatory Position, states objectives in a manner that encourages innovation by permitting considerable flexibility on the part of the utility, the NSSS vendor, the designer, the constructor, and the A/E. However the regulatory position also describes a large number of specific concerns that should be addressed in meeting the goals and objectives.

C. REGULATORY POSITION

The goals of the effort to maintain occupational radiation exposures ALARA are (1) to maintain the annual dose to individual station personnel as low as is reasonably achievable and (2) to keep the annual integrated (collective) dose to station personnel (i.e., the sum of annual doses (expressed in man-rems) to all station personnel) as low as is reasonably achievable.

The NRC staff believes that the stated objectives are attainable with current technology and with good operating practices. The costs for attaining these objectives have not been established and are expected to vary widely depending on the features of the specific power reactor facility and the method selected to accomplish the objectives. The favorable cost-benefit ratio for achieving some of these objectives may be obvious without a detailed study. For other objectives, however, a cost-benefit study might be required to determine whether the objectives are reasonably achievable. Doses to station personnel can affect station availability, and this factor should be considered in assessing the cost-benefit ratio.

Attaining the following objectives to the extent practicable throughout the planning, designing, constructing, operating, maintenance, and decommissioning of an LWR station will be considered to provide reasonable assurance that exposures of station personnel to radiation will be ALARA. The methods are deliberately stated such that considerable flexibility can be used in the manner by which the objectives can be achieved. Differences among stations might necessitate further innovation in methods used to achieve the objectives.

1. Program for Maintaining Station Personnel Radiation Doses ALARA

To attain the integrated effort needed to keep exposures of station personnel ALARA, each applicant and licensee should develop an ALARA program that reflects the efforts to be taken by the utility, nuclear steam supply system vendor, and architect-engineer to maintain radiation exposure ALARA in all phases of a station's life. This program should be in written form and should contain sections that cover the generally applicable guidance presented in this guide, as a minimum, and more specific guidance as required to address the particular LWR that is the subject of the licensing action. This program may be combined with the station's radiation protection manual, safety analysis report, or other documents or submittals. It need not be an independent document.

a. Establishment of a Program To Maintain Occupational Radiation Doses ALARA

(1) A management policy for, and commitment to, ensuring that the exposure of station personnel to radiation will be ALARA should be established.

(2) The policy and commitment should be reflected in written administrative procedures and instructions for operations involving potential exposures of personnel to radiation and should be reflected in station design features. Instructions to designers, constructors, vendors, and station personnel specifying or reviewing station features, systems, or equipment should reflect the goals and objectives to maintain occupational radiation exposures ALARA. (Few utilities design or build their nuclear power stations; but as *customers* of designers and builders, utilities should expect the designers and builders to be responsive to their needs and instructions.)

b. Organization, Personnel, and Responsibilities

(1) In view of the need for upper-level management support, responsibility and authority for implementing the program to maintain occupational radiation exposures ALARA should be assigned to an individual (or committee) with organizational freedom to ensure development and implementation. Responsibilities and authorities should include:

(a) Ensuring that a corporate program that integrates management philosophy and regulatory requirements is established, with specific goals and objectives for implementation included;

(b) Ensuring that an effective measurement system is established and used to determine the degree of success achieved by station operations with regard to the program goals and specific objectives;

(c) Ensuring that the measurement system results are reviewed on a periodic basis and that corrective actions are taken when attainment of the specific objectives appears to be jeopardized;

(d) Ensuring that the authority for providing procedures and practices by which the specific goals and objectives will be achieved is delegated; and

(e) Ensuring that the resources needed to achieve goals and objectives to maintain occupational radiation exposures ALARA are made available.

In view of the responsibilities required to implement a program to maintain occupational radiation exposures ALARA, the individual (or committee) selected for this function might also be chosen to coordinate the effort among the several corporate functional groups (such as the operations, maintenance, technical support, engineering, safety, and radiation protection groups) and to represent the corporate interests in dealing with the NSSS designer, vendor, A/E, and builder during the design and construction phases. If the expertise for performing this function is not within the corporation when the station is in the design stage, consultants who possess the required expertise should be used. The utility should obtain assurance that available data and experience obtained from similar nuclear power stations are considered and reflected in the work of the NSSS designer, vendor, A/E, and builder so as to provide features in the new station that permit an effective ALARA program.

(2) The Plant Manager (Superintendent or equivalent) is responsible for all aspects of station operation, including the onsite radiation protection program.

Responsibilities of the Plant Manager with respect to a program to maintain occupational radiation exposures ALARA should include:

(a) Ensuring support from all station personnel;

(b) Participating in the selection of specific goals and objectives for the station;

(c) Supporting the onsite Radiation Protection Manager (RPM) in formulating and implementing a station program in maintaining occupational radiation exposures ALARA; and

(d) Expediting the collection and dissemination of data and information concerning the program to the corporate management.

(3) The Radiation Protection Manager (RPM) (onsite) has a safety function and responsibility to both employees and management that can be best fulfilled if the individual is independent of station divisions, such as operations, maintenance, or technical support, whose prime responsibility is continuity or improvement of station operability. The RPM should have direct recourse to responsible management personnel in order to resolve questions related to the conduct of the radiation protection program.

(The specific responsibilities given here for the RPM are illustrative and not intended to be all-inclusive with respect to the ALARA program or effort. They do not include any of the responsibilities in areas other than ALARA efforts.)

Responsibilities of the RPM with respect to a program to maintain occupational radiation exposures ALARA should include:

(a) Participating in design reviews for facilities and equipment that can affect potential radiation exposures;

(b) Identifying locations, operations, and conditions that have the potential for causing significant exposures to radiation;

(c) Initiating and implementing an exposure control program;

(d) Developing plans, procedures, and methods for keeping radiation exposures of station personnel ALARA;

(e) Reviewing, commenting on, and recommending changes in job procedures to maintain exposures ALARA;

(f) Participating in the development and approval of training programs related to work in radiation areas or involving radioactive materials;

(g) Supervising the radiation surveillance program to maintain data on exposures of and doses to station personnel, by specific job functions and type of work;

(h) Supervising the collection, analysis, and evaluation of data and information attained from radiological surveys and monitoring activities;[5]

(i) Supervising, training, and qualifying the radiation protection staff of the station; and

(j) Ensuring that adequate radiation protection coverage is provided for station personnel during all working hours.

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[5] Data collected during outages can indicate trends of radiation buildup in equipment that can permit estimates of probable radiation levels to be encountered during subsequent outages.

Qualifications[6] needed for the RPM job, as well as those needed for other positions in organizations operating nuclear power stations, are presented in Regulatory Guide 1.8, "Personnel Selection and Training."

c. Training and Instruction

A training program in the fundamentals of radiation protection and in station exposure control procedures should be established. It should include instructing all personnel whose duties require (1) working with radioactive materials, (2) entering radiation areas, or (3) directing the activities of others who work with radioactive materials or enter radiation areas. The training program also should include sufficient instruction in the biological effects of exposures to radiation to permit the individuals receiving the instruction to understand and evaluate the significance of radiation doses in terms of the potential risks.

The training should be commensurate with the duties and responsibilities of those receiving the instructions, as well as with the magnitude of the potential doses and dose rates that can be anticipated. Personnel (including contractor personnel) who direct the activities of others should be familiar with the licensee's radiation control program and should have the authority to implement the licensee's commitment to ensure the radiation exposures of station personnel will be ALARA.

The training program should include instruction on (1) radiation protection rules for the station and (2) the applicable Federal regulations. Copies of these rules and regulations should be made available to those receiving the instructions. The training program should be approved by the RPM and presented by competent instructors. The information presented in the training program should be reviewed periodically and modified, where necessary, to reflect contemporary techniques and adjustments based on experience in station operations. Instruction of station personnel should stress the importance of exposure-reduction efforts by every individual and should emphasize the need for feedback of information obtained when similar tasks were performed previously.

Station personnel should receive instruction at periodic intervals to reinforce their knowledge and keep it current. Station personnel whose duties do not require entering radiation areas or working with radioactive materials should receive sufficient instruction in radiation protection and station rules and regulations to understand why they should not enter such areas.

Training programs that have as their goal an increase in craft skills provide a broader base of knowledgeable station personnel available to service equipment in radiation areas and permit the services to be performed more reliably and more efficiently. This can promote lower individual and collective dose levels.

d. Review of New or Modified Designs and Equipment Selection

(1) Since several groups within a utility (e.g., maintenance, operations, radiation protection, technical support, engineering, and safety groups) are interested in station design and equipment selection, the utility should ensure that these groups are adequately represented in the review of the design of the facility and the selection of equipment. A coordinated effort by the several functional groups within the utility is required to ensure that station features will permit the goals and objectives of the ALARA program to be achieved. Although the A/E and designers greatly influence station design features, utilities should not delegate all responsibilities for station design review and equipment selection to the NSSS designer, vendor, or A/E.

(2) Design concepts and station features should reflect consideration of the activities of station personnel (such as maintenance, refueling, inservice inspections, processing of radioactive wastes, decontamination, and decommissioning) that might be anticipated and that might lead to personnel exposure to substantial sources of radiation. Radiation protection aspects of decommissioning should be factored into planning, designing, construction, and modification activities. Station design features should be provided to reduce the anticipated exposures of station personnel to these sources of radiation to the extent practicable.

(3) Specifications for equipment should reflect the objectives of the ALARA program, including considerations of reliability, serviceability, limitations of internal accumulations of radioactive material, and other features addressed in this guide. Specifications for replacement equipment also should reflect modifications based on experience gained from using the original equipment.

2. Facility and Equipment Design Features

Radiation sources within a nuclear power station differ appreciably with respect to location, intensity, and characteristics. The magnitude of the dose rates that results from these sources is dependent on many

[6] Consideration has been given to peer group certification, i.e., certification of health physicists by the American Board of Health Physics (ABHP), as representing evidence of adequate qualifications for RPM candidates. While the staff believes that peer group certification is desirable, the present ABHP certification is not necessarily specifically applicable to applied health physics or radiation protection needs in nuclear power stations. However, the staff is discussing with the ABHP the prospects for a special certification program specifically directed toward the needs of radiation protection personnel at nuclear power stations.

factors, including the facility and equipment design, layout, mode and length of operation, and radiation source strength and characteristics.

To provide a basis for design, the quantity and isotopic composition of the radioactive material that can be anticipated to be contained, deposited, or accumulated in the station equipment should be estimated. Fission product source terms should be estimated using these bases: (1) an offgas rate of 100,000 μCi/sec after 30 minutes delay for BWRs and (2) 0.25% fuel cladding defects for PWRs. Activation source terms, including activated corrosion products, should be based on measurements and experience gained from operating stations of similar design. ANSI N237-1976 (Ref. 7) is based on such experience and provides information that can be used as a basis for estimating activation source terms. When operating measurements are used, extrapolation of data to equilibrium conditions may be needed to estimate ultimate activation source terms. Neutron and prompt gamma source terms should be based on applicable operating experience and reactor core physics calculations.

ALARA program objectives are presented below for each of several station features or functions. Each statement of objective is followed by a number of specific concerns or suggestions that should be addressed.

a. Access Control of Radiation Areas

To avoid unnecessary and inadvertent exposures of personnel to radiation, the magnitude of the potential dose rates at all locations within the station should be estimated during station design. Actual dose rates should be measured periodically during operation to determine current exposure potentials. Zones associated with the higher dose rates should be kept as small as reasonably achievable consistent with accessibility for accomplishing the services that must be performed in those zones, including equipment laydown requirements. Radiation zones where station personnel spend substantial time should be designed to the lowest practical dose rates.

(It is common practice to identify "radiation zones" within a nuclear power station. The zone designations are established to reflect the design maximum dose rates that may exist in areas within the station where station personnel must have access to perform required services. Several systems for designating "radiation zones" currently exist among the utilities, and ANSI Committee 6.7 is developing a standard that should prove useful in attaining common designations and terminology in this matter. To avoid ambiguity, no reference to radiation zone numbers is made in this guide at this time.)

A system should be established to permit effective control over personnel access to the radiation areas and control over the movement of sources of radiation within the station. Where high radiation areas (>100 mrem/h) exist, § 20.203 of 10 CFR Part 20 requires that station design features and administrative controls provide effective ingress control, ease of egress, and appropriate warning devices and notices. Access control of radiation areas also should reflect the following considerations:

(1) Extraordinary design features are warranted to avoid any potential dose to personnel that is large enough to cause acute biological effects and that could be received in a short period of time. Positive control of ingress to such areas, permanent shielding, source removal, or combinations of these alternatives can reduce the dose potential.

(2) Administrative controls such as standard operating procedures can be effective in preventing inadvertent exposures of personnel and the spread of contamination when radioactive material or contaminated equipment must be transported from one station location to another and when the route of transport through lower radiation zones or "clean" areas cannot be avoided.

(3) Station features such as platforms or walkways, stairs, or ladders that permit prompt accessibility for servicing or inspection of components located in higher radiation zones can reduce exposure of personnel who must perform these services.

b. Radiation Shields and Geometry

Radiation shields should be designed using the design basis assumptions explained in regulatory position 2 and conservative assumptions for geometries. Calculational methods known to provide reliable and accurate results (i.e., methods and modeling techniques that have been demonstrated to give acceptable accuracy in analyses similar to the problem of concern) should be used to determine appropriate shield thicknesses. Shield design features should reflect the following considerations to maintain occupational radiation exposures ALARA:

(1) Exposure of personnel servicing a specific component (such as a pump, filter, or valve) to radiation from other components containing radioactive material can be reduced by providing shielding between the individual components that constitute substantial radiation sources and the receptor.

(2) Where it is impracticable to provide permanent shielding for individual components that constitute substantial radiation sources, the exposure of personnel maintaining such components can be reduced (a) by providing as much distance as practicable between the serviceable components and the substantial radiation sources in the area and (b) by providing temporary shields around components that contribute substantially to the dose rate.

(3) Potential exposure of station personnel to radiation from certain systems containing radiation sources can be reduced by means of a station layout that permits the use of distance and shielding between the sources and work locations. These systems include (but are not limited to) the NSSS and the reactor water cleanup, offgas treatment, solid waste treatment, and storage systems, as well as systems infrequently containing radiation sources such as the standby gas treatment and residual heat removal systems.

Radiation from an operating BWR turbine can constitute a substantial source of exposure for construction personnel or others who have access to the site for extended periods of time if insufficient shielding is provided.

(4) Streaming or scattering of radiation from locally shielded components (such as cubicles) can be reduced by providing labyrinths for access. However, such labyrinths or other design features of the cubicle should permit the components to be removed readily from the cubicle for repair or replacement where such work is expected or anticipated. Single-scatter labyrinths may be inadequate if the cubicle contains a substantial radiation source.

(5) Streaming of radiation into accessible areas through penetrations for pipes, ducts, and other shield discontinuities can be reduced (a) by means of layouts that prevent substantial radiation sources within the shield from being aligned with the penetrations or (b) by using "shadow" shields such as shields of limited size that attenuate the direct radiation component. Streaming also can occur through roofs or floors unless adequate shielding encloses the source from all directions.

(6) The exposure of station personnel to radiation from pipes carrying radioactive material can be reduced by means of shielded chases.

(7) Design features that permit the rapid removal and reassembly of shielding, insulation, and other material from equipment that must be inspected or serviced periodically can reduce the exposure of station personnel performing these activities.

(8) Space within cubicles and other shielding to provide laydown space for special tools and ease of servicing activities can reduce potential doses by permitting the services to be accomplished expeditiously, thus reducing exposure time.

(9) The exposure of personnel who service components that constitute substantial radiation sources or are located in high radiation fields can be minimized by removing the components and transporting them to low radiation zones where shielding and special tools are available. Design features that permit the prompt removal and installation of these components can reduce the exposure time

(10) Floor and equipment drains, piping, and sumps that are provided to collect and route any contaminated liquids that might leak or be spilled from process equipment or sampling stations can become substantial radiation sources. The drain lines can be located in concrete floors, concrete ducts, columns, or radwaste pipe chases to provide shielding. These systems can also become a source of airborne contamination because of the potential for gases to form in, and be released by, such systems (see regulatory position 2.d(6)).

c. Process Instrumentation and Controls

Appropriate station layout and design features should be provided to reduce the potential doses to personnel who must operate, service, or inspect station instrumentation and controls. The following considerations should be reflected in selecting the station features:

(1) The exposure of personnel who must manually operate valves or controls can be reduced through the use of "reach rods" or remotely operated valves or controls. However, these devices can require lubrication and maintenance that can be the source of additional exposures, and these factors should be taken into consideration.

(2) The exposure of personnel who must view or operate instrumentation, monitors, and controls can be reduced by locating the readouts or control points in low radiation zones.

(3) Instrumentation must satisfy functional requirements, but the exposure of personnel can be reduced if the instruments are designed, selected, specified, and located with consideration for long service life, ease and low frequency of maintenance and calibration, and low crud accumulation. Operating experience should be recorded, evaluated, and reflected in the selection of replacement instrumentation.

(4) The use of instrumentation that contains minimal quantities of contaminated working fluid (e.g., pressure transducers rather than bellows-type pressure gauges) can reduce the potential for exposure at the readout locations.

d. Control of Airborne Contaminants and Gaseous Radiation Sources

Station design features should be provided in all station work areas to limit the average concentrations of radioactive material in air to levels well below the values listed in Appendix B, Table 1, Column 1 of 10 CFR Part 20. Effective design features can minimize the occurrence of occasional increases in air contamination and the concentrations and amounts of contaminants associated with any such occasional increases. Designs that permit repeated, identified releases of large amounts of radioactive materials into the air spaces occupied by personnel are contrary to a program to maintain occupational radiation exposures ALARA.

Station design features should provide for protection against airborne radioactive material by means of engineering controls such as process, containment, and ventilation equipment. The routine provision of respiratory protection by use of individually worn respirators rather than engineered design features is generally unacceptable. The use of respirators, however, might be appropriate in certain nonroutine or emergency operations when the application of engineering controls is not feasible or while such controls are being installed.

The approved use of respirators is subject to the requirements of § 20.103, "Exposure of Individuals to Concentrations of Radioactive Materials in Air in Restricted Areas," of 10 CFR Part 20 and to regulatory guidance on acceptable use. (See Regulatory Guide 8.15, "Acceptable Programs for Respiratory Protection," and NUREG-0041, "Manual of Respiratory Protection Against Airborne Radioactive Materials" (Ref. 8).) Design features of the station ventilation system and gaseous radwaste processing systems should reflect the following considerations:

(1) The spread of airborne contamination within the station can be limited by maintaining air pressure gradients and airflows from areas of low potential airborne contamination to areas of higher potential contamination. Periodic checks would ensure that the design pressure differentials are being maintained.

(2) Effectively designed ventilation systems and gaseous radwaste treatment systems will contain radioactive material that has been deposited, collected, stored, or transported within or by the systems. Exposures of station personnel to radiation and to contamination from ventilation or gaseous radwaste treatment components occur as a result of the need to service, test, inspect, decontaminate, and replace components of the systems or perform other duties near these systems. Potential doses from these systems can be minimized by providing ready access to the systems, by providing space to permit the activities to be accomplished expeditiously, by separating filter banks and components to reduce exposures to radiation from adjacent banks and components, and by providing sufficient space to accomodate auxiliary ventilation or shielding of components.

(3) Auxiliary ventilation systems that augment the permanent system can provide local control of airborne contaminants when equipment containing potential airborne sources is opened to the atmosphere. Two types of auxiliary ventilation systems have proved to be effective. In areas where contaminated equipment must be opened frequently, dampers and fittings can be provided in ventilation ducts to permit the attachment of flexible tubing or "elephant trunks" without imbalancing the ventilation system. In areas where contaminated equipment must be opened infrequently, portable auxiliary ventilation systems featuring blowers, HEPA filters, and activated charcoal filters (where radioiodine might be anticipated) on carts can be used effectively. Portable auxiliary ventilation systems should be tested frequently to verify the efficiency of the filter elements in their mountings. When the efficiency has been verified, the system may be exhausted to the room or the ventilation exhaust duct without further treatment and thus imbalance of the permanent ventilation system can be avoided.

(4) Machining of contaminated surfaces (e.g., welding, grinding, sanding, or scaling) or "plugging" of leaking steam generator or condenser tubes can be substantial sources of airborne contamination. These sources can be controlled by using auxiliary ventilation systems.

(5) Sampling stations for primary coolant or other fluids containing high levels of radioactive material can constitute substantial sources of airborne contamination. Such sources can be controlled by using auxiliary ventilation systems.

(6) Wet transfer or storage of potentially contaminated components will minimize air contamination. This can be accomplished by keeping contaminated surfaces wet, by spraying, or, preferably, by keeping such surfaces under water.

e. Crud Control

Design features of the primary coolant system, the selection of construction materials that will be in contact with the primary coolant, and features of equipment that treat primary coolant should reflect considerations that will reduce the production and accumulation of crud in stations where it can cause high exposure levels. The following items should be considered in the crud control effort:

(1) Production of Co-58 and Co-60, which constitute substantial radiation sources in crud, can be reduced by specifying, to the extent practicable, low-nickel and low-cobalt bearing materials for primary coolant pipe, tubing, vessel internal surfaces, heat exchangers, wear materials, and other components that are in contact with primary coolant. Alternative materials for hard facings of wear materials of high-cobalt content should be considered where it is shown that these high-cobalt materials contribute to the overall exposure levels. Such consideration should also take into account potential increased service/repair requirements and overall reliability of the new material in relation to the old. Alternative materials for high-nickel alloy materials (e.g., Inconel 600) should be considered where it is shown that these materials contribute to overall exposure levels. Such consideration should also take into account potential increased

service/repair requirements and overall reliability of the new materials in relation to the old.

(2) Loss of material by erosion of load-bearing hard facings can be reduced by using favorable geometrics and lubricants, where practicable, and by using controlled leakage purge across journal sleeves to avoid entry of particles into the primary coolant.

(3) Loss of material by corrosion can be reduced by continuously monitoring and adjusting oxygen concentration and pH in primary coolant above 250°F and by using bright hydrogen-annealed tubing and piping in the primary coolant and feedwater systems.

(4) Consideration should be given to cleanup systems (e.g., using graphite or magnetic filters) for removal of crud from the primary coolant during operation.

(5) Deposition of crud within the primary coolant system can be reduced by providing laminar flow and smooth surfaces for coolant and by minimizing crud traps in the system to the extent practicable.

f. Isolation and Decontamination

Potential doses to station personnel who must service equipment containing radioactive sources can be reduced by removing such sources from the equipment (decontamination), to the extent practicable, prior to servicing. Serviceable systems and components that constitute a substantial radiation source should be designed, to the extent practicable, with features that permit isolation and decontamination. Station design features should consider, to the extent practicable, the ultimate decommissioning of the facility and the following concerns:

(1) The necessity for decontamination can be reduced by limiting, to the extent practicable, the deposition of radioactive material within the processing equipment—particularly in the "dead spaces" or "traps" in components where substantial accumulations can occur. The deposition of radioactive material in piping can be reduced and decontamination efforts enhanced by avoiding stagnant legs, by locating connections above the pipe centerline, by using sloping rather than horizontal runs, and by providing drains at low points in the system.

(2) The need to decontaminate equipment and station areas can be reduced by taking measures that will reduce the probability of release, reduce the amount released, and reduce the spread of the contaminant from the source (e.g., from systems or components that must be opened for service or replacement). Such measures can include auxiliary ventilation systems (see regulatory position 4.b), treatment of the exhaust from vents and overflows (see regulatory position 2.h(8)), drainage control such as curbing and floors sloping to local drains, or sumps to limit the spread of contamination from leakage of liquid systems.

(3) Accumulations of crud or other radioactive material that cannot be avoided within components or systems can be reduced by providing features that will permit the recirculation or flushing of fluids with the capacity to remove the radioactive material through chemical or physical action. The fluids containing the contaminants will require treatment, and this source should be considered in sizing station radwaste treatment systems.

(4) Continuity in the functioning of processing or ventilation systems that are important for controlling potential doses to station personnel can be provided during servicing of the systems if redundant components or systems are available so that the component (with associated piping) being serviced can be isolated.

(5) The potential for contamination of "clean services" (such as station service air, nitrogen, or water supply) from leakage from adjacent systems containing contaminants can be reduced by separating piping for these services from piping that contains radioactive sources. Piping that carries radioactive sources can be designed for the lifetime of the station, thus avoiding the necessity for replacement (and attendant exposures) and lessening the potential for contamination of clean services if it is impracticable to provide isolation through separate chases.

(6) Surfaces can be decontaminated more expeditiously if they are smooth, nonporous, and free of cracks, crevices, and sharp corners. These desirable features can be realized by specifying appropriate design instructions, by giving attention to finishing work during construction or manufacture, and by using sealers (such as special paints) on surfaces where contamination can be anticipated. (ANSI N101.2 provides helpful guidance on this matter (Ref. 9).)

(7) Where successful decontamination of important systems could be prevented by an anticipated failure of a critical component or feature, additional features that permit alternative decontamination actions can be provided.

(8) Contaminated water and deposited residues in spent fuel storage pools contribute to the exposure at accessible locations in the area. Treatment systems that remove contaminants from the water can perform more efficiently (a) if intake and discharge points for the treatment systems are located to provide enhanced mixing and to avoid stagnation areas in the pool and (b) if pool water overflows and skimmer tanks are provided. Fluid jet or vacuum-cleaner-type agitators can help reduce the settling of crud on surfaces of the pool system.

g. Radiation Monitoring Systems

Central or "built-in" monitoring systems that give information on the dose rate and concentration of airborne radioactive material in selected station areas can reduce the exposure of station personnel who would be required to enter the areas to obtain the data if such systems were not provided. These systems also can provide timely information regarding changes in the dose rate or concentrations of airborne radioactive material in the areas. (The installation of a central monitoring system is easier and less expensive if it is a part of the original station design.) The selection or design and installation of a central monitoring system should include consideration of the following desirable features:

(1) Readout capability at the main radiation protection access control point;

(2) Placement of detectors for optimum coverage of areas (Ref. 10);

(3) Circuitry that indicates component failure;

(4) Local alarm and readout;

(5) Clear and unambiguous readout;

(6) Ranges adequate to ensure readout of the highest anticipated radiation levels and to ensure positive readout at the lowest anticipated levels; and

(7) Capability to record the readout of all systems.

h. Resin and Sludge Treatment Systems

Systems used to transport, store, or process resins or slurries of filter sludge present a special hazard because of the concentrated nature of the radioactive material. Design features for resin- and sludge-handling systems should reflect this concern and the following specific considerations:

(1) The accumulation of radioactive material in components of systems used to process resin and sludges can be reduced by:

(a) Reducing the length of piping runs;

(b) Using larger diameter piping (to minimize plugging);

(c) Reducing the number of pipe fittings;

(d) Avoiding low points and dead legs in piping;

(e) Using gravitational flow to the extent practicable; and

(f) Minimizing flow restrictions of processed material.

(2) The need for maintenance and the presence of intense local radiation sources can be reduced by:

(a) Using full-ported valves constructed such that the slurry will not interfere with the opening or closing of the valve and

(b) Avoiding cavities in valves.

(3) The deposition of resin and sludge that would occur if elbow fittings were used can be reduced by using pipe bends of at least five pipe diameters in radius. Where pipe bends cannot be used, long radius elbows are preferred.

(4) Smoother interior pipe surfaces at connections (with attendant reductions in friction losses, deposition of material, and tendencies to "plug") can be achieved by using butt welds rather than socket welds and by using consumable inserts rather than backing rings.

(5) Where the use of tees cannot be avoided, line losses can be reduced if the flow is through the run (straight section) of the tee, and accumulations of material in the branch of the tee can be reduced by orienting the branch horizontally or (preferably) above the run.

(6) Slurry piping is subject to plugging that may require backflushing from the tank and equipment isolation valves and pressurizing with water, nitrogen, or air to "blow out" plugged lines. However, the use of pressurized gas for blowing out lines can present a potential contamination source and may not be effective in relieving plugged lines.

(7) Water, air, or nitrogen for sparging can be used to fluidize resins or sludges in storage tanks, The use of gases, however, presents a potential source of airborne contamination and tank rupture from overpressures.

(8) The spread of contamination by the loss of resin or sludge through overflows and vents can be reduced by using screens, filters, or other features that will collect and retain solids. However, such features generally require cleaning by remote flushing, by rapid replacement, or by other means to reduce exposures during servicing.

Consideration should be given to ANS N197, "Design and Performance of BWR Liquid Radioactive Waste Processing Systems (N18)" (Ref. 11); ANS 55.1, "Design Criteria for the Solid Radwaste Processing System of BWR, PWR, and HTGR" (Ref. 12); and ANS N199, "PWR Liquid Waste System Design (N18)" (Ref. 13). These standards cover some aspects of slurry systems.

i. Other Features

Station layout and station tasks should be reviewed to identify and provide special features that complement the ALARA program. Station design should reflect consideration of the following concerns:

(1) The selection of radiation-damage-resistant materials for use in high radiation areas can reduce the need for frequent replacement and can reduce the probability of contamination from leakage.

(2) The use of stainless steel for constructing or lining components, where it is compatible with the process, can reduce corrosion and can provide options for decontamination methods.

(3) Field-run piping that carries radioactive material can cause unnecessary exposures unless due consideration is given to the routing. Such unnecessary exposures can be avoided if the routing is accomplished under the cognizance of an individual familiar with the principles of radiation protection or if a detailed piping layout is provided, i.e., if the piping is not field-run.

(4) Where filters or other serviceable components can constitute substantial radiation sources, exposures can be reduced by providing features that permit operators to avoid the direct radiation beam and that provide remote removal, installation, or servicing. Standardization of filters should be considered.

(5) The servicing of valves can be a substantial source of doses to station personnel. These doses can be reduced by providing adequate working space for easy accessibility and by locating the valves in areas that are not in high radiation fields.

(6) Leakage of contaminated coolant from the primary system can be reduced by using live-loaded valve packings and bellow seals.

(7) Potential doses from servicing valves and from leakage can be reduced by specifying and installing reliable valves for the required service, by using radiation-damage-resistant seals and gaskets, and by using valve back seats. The use of straight-through valve configurations can avoid the buildup of accumulations in internal crevices and the discontinuities that exist in valves of other configurations. In most cases, valves can be installed in the "stem-up" orientation to facilitate maintenance and to minimize crud traps. The desired features are reliability, good performance, and the ability to be maintained infrequently and rapidly.

(8) Leaks from pumps can be reduced by using canned pumps where they are compatible with the service needs, provided that lower personnel exposures can be achieved thereby. If mechanical seals are used on a pump in a slurry service, features that permit the use of flush water to clean pump seals can reduce the accumulation of radioactive material in the seals. Drains on pump housings can reduce the radiation field from this source during servicing. Provision for the collection of such leakage or disposal to a drain sump is appropriate.

(9) The sources of radiation such as sedimentation that occurs in tanks used to process liquids containing radioactive material and residual liquids can be reduced when servicing by draining the tanks. The design can include sloping the tank bottoms toward outlets leading to other reprocessing equipment and, where practicable, providing built-in spray or surge features.

(10) Spare connections on tanks or other components located in higher radiation zones may be desirable to provide flexibility in operations. Exposures of personnel can be avoided if these connections are provided as a part of the original equipment rather than by subsequent modification of the equipment in the presence of radiation.

(11) Inspections to satisfy the ASME Code (Ref. 14) and regulatory requirements can result in exposures of station personnel to radiation. Many of the objectives presented above will aid in reducing potential exposures to personnel who perform the required inspections. Station features and design should, to the extent practicable, permit inspections to be accomplished expeditiously and with minimal exposure of personnel. The effort to maintain occupational radiation exposures ALARA can also be aided by prompt accessibility, shielding and insulation that can be quickly removed and reinstalled, and special tools and instruments that reduce exposure time or permit remote inspection of components or equipment containing potential radiation sources.

(12) Components can be removed from processing systems more expeditiously if adequate space is provided in the layout of the system and if the interconnections permit prompt disconnects.

(13) Station features that provide a favorable working environment such as adequate lighting, ventilation, working space, and accessibility (via such means as working platforms, cat walks, and fixed ladders) can promote work efficiency.

(14) The exposure of station personnel who must replace lamps in high radiation areas can be reduced by using extended service lamps and by providing design features that permit the servicing of the lamps from lower radiation areas.

(15) An adequate emergency lighting system can reduce potential exposures of station personnel by permitting prompt egress from high radiation areas if the station lighting system fails.

3. Radiation Protection Program

A substantial portion of the radiation dose to station personnel is received while they are performing services such as maintenance, refueling, and inspection in high radiation areas. The objectives that were presented in regulatory position 2 can provide station design features conducive to an effective program to maintain occupational radiation exposures ALARA. However, an effective program also requires station operational considerations in terms of procedures, job planning, recordkeeping, special equipment, operating philosophy, and other support. This section deals with the manner in which the station administrative efforts can influence the variables of (1) the number of persons who must enter high radiation areas or contaminated areas, (2) the period of time the persons must remain in these areas, and (3) the magnitude of the potential dose.

a. Preparation and Planning

Before entering radiation areas where significant doses could be received, station personnel should have the benefit of preparations and plans that can ensure the exposures are ALARA while the personnel are performing the services. Preparations and plans should reflect the following considerations:

(1) A staff member who is a specialist in radiation protection can be assigned the responsibility for contributing to and coordinating ALARA efforts in support of operations that could result in substantial individual and collective dose levels.

(2) To provide the bases for planning the activity, surveys can be performed to ascertain information with respect to radiation, contamination, airborne radioactive material, and mechanical difficulties that might be encountered while performing services.

(3) Radiation surveys provided in conjunction with inspections or other activities can define the nature of the radiation fields and identify favorable locations where personnel may take advantage of available shielding, distance, geometry, and other factors that affect the magnitude of the dose rate or the portions of the body exposed to the radiation.

(4) Photographs of "as installed" equipment or components can be valuable for planning purposes and can be augmented by additional photos taken during the surveys. The use of portable TV cameras with taping features has considerable merit as both an operational aid and a teaching aid.

(5) The existing radiation levels frequently can be reduced by draining, flushing, or other decontamination methods or by removing and transporting the component to a lower radiation zone. An estimate of the potential doses to station personnel expected to result from these procedures is germane in selecting among alternative actions.

(6) A preoperational briefing for personnel who will perform services in a high radiation area can ensure that service personnel understand the tasks about to be performed, the information to be disseminated, and the special instructions to be presented.

(7) A program can be implemented to provide access control and to limit exposures to those persons needed to perform the required services in the radiation areas. Such a program would address conditions that require a special work permit or other special procedures.

(8) A work permit form with an appropriate format can be useful for recording pertinent information concerning tasks to be performed in high radiation areas so that the information is amenable to cross-referencing and statistical analysis. Information of interest would include the following items:

(a) Designation of services to be performed on specific components, equipment, or systems;

(b) Number and identification of personnel working on the tasks;

(c) Anticipated radiation, airborne radioactive material, and contamination levels, based on current surveys of the work areas, and date of survey;

(d) Monitoring requirements such as continuous air monitoring or sampling equipment;

(e) Estimated exposure time required to complete the tasks and the estimated doses anticipated from the exposure;

(f) Special instructions and equipment to minimize the exposures of personnel to radiation and contamination;

(g) Protective clothing and equipment requirements;

(h) Personnel dosimetry requirements;

(i) Authorization to perform the tasks; and

(j) Actual exposure time, doses, and other information obtained during the operation.

(9) Consideration of potential accident situations or unusual occurrences (such as gross contamination leakage, pressure surges, fires, cuts, punctures, or wounds) and contingency planning can reduce the potential for such occurrences and enhance the capability for coping with the situations expeditiously if they occur.

(10) Portable or temporary shielding can reduce dose rate levels near "hot spots" and in the general area where the work is to be performed.

(11) Portable or temporary ventilation systems or contamination enclosures and expendable floor coverings can control the spread of contamination and limit the intake by workers through inhalation.

(12) "Dry runs" on mockup equipment can be useful for training personnel, identifying problems that can be encountered in the actual task situation, and selecting and qualifying special tools and procedures to reduce potential exposures of station personnel.

(13) Adequate auxiliary lighting and a comfortable environment (e.g., vortex tube coolers for supplied air suits) can increase the efficiency of the work and thus reduce the time spent in the higher radiation zones.

(14) Radiation monitoring instruments selected and made available in adequate quantities can permit accurate measurements and rapid evaluations of the radiation and contamination levels and changes in levels when they occur. Routine calibration of instruments with appropriate sources and testing can ensure operability and accuracy of measurements.

(15) Performing work on some components inside disposable tents or, for less complicated jobs, inside commercially available disposable clear plastic glove bags can limit the spread of contamination. Such measures can also avoid unnecessary doses resulting from the need to decontaminate areas to permit personnel access or to allow for entry with less restrictive protective clothing and equipment requirements.

(16) Careful scheduling of inspections and other tasks in high radiation areas can reduce exposures by permitting decay of radiation sources during the reactor shutdown period and by eliminating some repetitive surveys. Data from surveys and experience attained in previous operations and current survey data can be factored into the scheduling of specific tasks.

b. Operations

During operations in radiation areas, adequate supervision and radiation protection surveillance should be provided to ensure that the appropriate procedures are followed, that planned precautions are observed, and that all potential radiation hazards that might develop or that might be recognized during the operation are addressed in a timely and appropriate manner.

(1) Assigning a health physics (i.e., radiation safety or radiation protection) technician the responsibility for providing radiation protection surveillance for each shift operating crew can help ensure adequate radiation protection surveillance.

(2) Personnel monitoring equipment such as direct-reading dosimeters, alarming dosimeters, and personal dose rate meters can be used to provide early evaluation of doses to individuals and the assignment of those doses to specific operations (see Regulatory Guides 1.16, "Reporting of Operating Information—Appendix A Technical Specifications," and 8.4, "Direct-Reading and Indirect-Reading Pocket Dosimeters").

(3) Communication systems between personnel in high radiation zones and personnel who are monitoring the operation in other locations can permit timely exchanges of information and avoid unnecessary exposures to monitoring personnel.

c. Postoperations

Observations, experience, and data obtained during nonroutine operations in high radiation zones should be ascertained, recorded, and analyzed to identify deficiencies in the program and to provide the bases for revising procedures, modifying features, or making other adjustments that may reduce exposures during subsequent similar operations.

(1) Formal or informal postoperation debriefings of station personnel performing the services can provide valuable information concerning shortcomings in preoperational briefings, planning, procedures, special tools, and other factors that contributed to the cause of doses received during the operation.

(2) Dose data obtained during or subsequent to an operation can be recorded in a preselected manner as part of a "Radiation Work Permit" or similar program [see regulatory position 3.a(8)] so that the data are amenable to statistical analyses.

(3) Information concerning the cause of component failures that resulted in the need for servicing in high radiation areas can provide a basis for revising specifications on replacement equipment or for other modifications that can improve the component reliability. Such improvements can reduce the frequency of servicing and thus reduce attendant exposures.

(4) Information gained in operations can provide a basis for modifying equipment selection and design features of new facilities.

(5) Summaries of doses received by each category of maintenance activity can be reviewed periodically by upper management to compare the incremental reduction of doses with the cost of station modifications that could be made.

4. Radiation Protection Facilities, Instrumentation, and Equipment

A radiation protection staff with facilities, instrumentation, and protective equipment adequate to permit the staff to function efficiently is an important element in achieving an effective program to maintain occupational radiation exposures ALARA. The selection of instrumentation and other equipment and the quantities of such equipment provided for normal station operations should be adequate to meet the anticipated needs of the station during normal operations and during major outages that may require supplemental workers and extensive work in high radiation areas. (Accident situations are not considered in this guide.) Station design features and provisions should reflect the following considerations:

a. Counting Room

A low-radiation background counting room is needed to perform routine analyses on station samples containing radioactive material collected from air, water, surfaces, and other sources. An adequately equipped counting room would include:

(1) Multichannel gamma pulse height analyzer (Regulatory Guide 5.9, "Specifications for Ge(Li) Spectroscopy Systems for Material Protection Measurements—Part 1: Data Acquisition Systems," provides guidance for selecting Ge(Li) spectroscopy systems);

(2) Low-background alpha-beta radiation proportional counter(s) or scintillation counter(s);

(3) End-window Geiger-Muller (G-M) counter(s); and

(4) A liquid scintillation counter for tritium analyses. Analyses of bioassay and environmental samples and whole-body counting (see Regulatory Guide 8.9, "Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program") call for additional equipment and laboratory space if the analyses are performed by station personnel rather than by other specialists through contractual arrangements.

b. Portable Instruments

Portable instruments needed for measuring dose rates and radiation characteristics would include:

(1) Low-range (nominally 0 to 5 R per hour) ion chambers or G-M rate meters;

(2) High-range (0.1 to at least 500 R per hour) ion chambers;[7]

(3) Alpha scintillation or proportional count rate meters;

(4) Neutron dose equivalent rate meters;

(5) Air samplers for short-term use with particulate filters and iodine collection devices (such as activated charcoal cartridges); and

(6) Air monitors with continuous readout features.[7]

c. Personnel Monitoring Instrumentation

Personnel monitoring instrumentation selection should include consideration of:

(1) G-M "Friskers" for detecting low levels of radioactive material;

(2) Direct-reading low-range (0 to 200 mR) and intermediate-range (0 to 1000 mR) pocket dosimeters (see Regulatory Guide 8.4);

(3) Alarm dosimeters;

(4) Film badges and/or thermoluminescent dosimeters (TLD);

(5) Hand and foot monitors; and

(6) Portal monitors.

d. Protective Equipment

Utility-supplied protective equipment selection should include consideration of :

(1) Anticontamination clothing and equipment that meet the requirements of ANSI Z-88.2 (Ref. 15) for use in atmospheres containing radioactive materials or the National Institute of Occupational Safety and Health's (NIOSH) "Certified Personal Protective Equipment List," and current supplements from DHEW/PHS (Ref. 16).

(2) Respiratory protective equipment, including a respirator fitting program that satisfies the guidance of Regulatory Guide 8.15 and NUREG-0041 (Ref. 8).

e. Support Facilities

Design features of radiation protection support facilities should include consideration of:

(1) A portable-instrument calibration area designed and located such that radiation in the calibration area will not interfere with low-level monitoring or counting systems;

(2) Personnel decontamination area (this facility should be located and designed to expedite rapid cleanup of personnel and should not be used as a multiple-purpose area or share ventilation with food-handling areas) with showers, basins, and installed "frisker" equipment;

(3) Facilities and equipment to clean, repair, and decontaminate personnel protective equipment, monitoring instruments, hand tools, electromechanical parts, or other material (highly contaminated tools or other equipment should not be decontaminated in the area used to clean respiratory equipment);

(4) Change rooms that (preferably) connect with the personnel decontamination area and a control station area equipped with sufficient lockers to accommodate permanent and contract maintenance workers who may be required during major outages;

(5) Control stations for entrance or exit of personnel into radiation- and contamination-controlled access areas of the station such as the personnel entrance to the containment buildings and the main entrance to the radwaste processing areas; these control stations also may be used as the control point for radioactive material movements throughout the station and for the storage of portable radiation survey equipment, signs, ropes, and respiratory protective equipment;

(6) Equipment to facilitate communication between all areas throughout the station; and

(7) Sufficient office space to accommodate the temporary and permanent radiation protection staff, permanent records, and technical literature.

[7] Variable alarm setpoint features on these instruments can be valuable in providing a warning when unexpected substantial changes in dose rate or air concentration occur.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC staff's plans for using this regulatory guide.

This guide reflects current NRC staff practice in license application reviews. Therefore, except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the methods described herein are being and will continue to be used in the evaluation of submittals for construction permits and operating license applications until this guide is revised as a result of suggestions from the public or additional staff review.

At the operating license review stage, the radiation protection design presented in the applicant's final safety analysis report will be reviewed against regulatory position 2 of this guide and differences from the recommendations of the guide will be identified (particularly for plants designed before Regulatory Guide 8.8 was issued). However, no substantive design changes will be required at the operating license stage unless the design change can prevent substantial man-rem exposures that cannot be prevented by procedural measures and the design change is consistent with the cost-effectiveness principle of maintaining occupational radiation exposures ALARA.

Methods other than those set forth in this guide may be substituted for those stated herein, provided they satisfy the criterion "as low as is reasonably achievable" of paragraph 20.1(c) of 10 CFR Part 20.

REFERENCES

1. Ad Hoc Committee of the National Council on Radiation Protection and Measurements, "Somatic Radiation Dose for the General Population," Science 131, 482 (1960).

2. "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation," National Academy of Sciences/National Research Council, DHEW Contract PH-43-64-44, November 1972.

3. International Commission on Radiological Protection (ICRP), "Implications of Commission Recommendations That Doses Be Kept As Low As Readily Achievable," ICRP Publication 22, Pergamon Press, 1973. Copies may be obtained from Pergamon Press, Maxwell House, Fairview Park, Elmsford, New York 10523.

4. C. A. Pelletier et al., "Compilation and Analysis of Data on Occupational Radiation Exposure Experienced at Operating Nuclear Power Plants," Atomic Industrial Forum, 1974.

5. T. D. Murphy, N. J. Dayem, J. Stewart Bland, and W. J. Pasciak, "Occupational Radiation Exposure at Light-Water-Cooled Power Reactors, 1969-1975," NUREG-0109, U.S. Nuclear Regulatory Commission, August 1976. Copies may be obtained from the National Technical Information Service, Springfield, Va. 22161.

6. NUREG-0322, "Ninth Annual Occupational Radiation Exposure Report, 1976." Copies may be obtained from the National Technical Information Service, Springfield, Va. 22161.

7. ANSI N237, "Source Term Specification." Copies may be obtained from the American Nuclear Society, 555 North Kensington Avenue, La Grange Park, Illinois 60525.

8. Copies of NUREG-0041 may be obtained from the National Technical Information Service, Springfield, Va. 22161.

9. ANSI N101.2, "Protective Coatings (Paints) for Light Water Nuclear Reactor Containment Facilities." Copies may be obtained from the American National Standards Institute, 1430 Broadway, New York, N.Y. 10018.

10. ANS/HPS 56.8, "Location and Design Criteria for Area Radiation Monitoring Systems for LWRs," (draft).

11. ANS N197, "Design and Performance of BWR Liquid Radioactive Waste Processing Systems (N18)." Copies may be obtained from the American Nuclear Society, 555 North Kensington Avenue, La Grange Park, Illinois 60525.

12. ANS 55.1, "Design Criteria for the Solid Radwaste Processing System of BWR, PWR, and HTGR." Copies may be obtained from the American Nuclear Society, 555 North Kensington Avenue, La Grange Park, Illinois 60525.

13. ANS N199, "PWR Liquid Waste System Design (N18)." Copies may be obtained from the American Nuclear Society, 555 North Kensington Avenue, La Grange Park, Illinois 60525.

14. Section XI, ASME Boiler and Pressure Vessel Code and Addenda. Copies may be obtained from the American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, N.Y. 10017.

15. ANSI Z-88.2, "Practices for Respiratory Protection." Copies may be obtained from the American National Standards Institute, 1430 Broadway, New York, N.Y. 10018.

16. NIOSH, "Certified Personal Protective Equipment List," July 1974, and supplements by DHEW/PHS. Published by U.S. Department of Health, Education, and Welfare, Public Health Service, Center of Disease Control, National Institute of Occupational Safety and Health. Copies are available from the Office of Technical Publications, National Institute of Occupational Safety and Health, Post Office Building, Cincinnati, Ohio 45202.

U.S. NUCLEAR REGULATORY COMMISSION

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September 1975

REGULATORY GUIDE

OFFICE OF STANDARDS DEVELOPMENT

(This page reissued May 1977)

REGULATORY GUIDE 8.10

OPERATING PHILOSOPHY FOR MAINTAINING OCCUPATIONAL RADIATION EXPOSURES AS LOW AS IS REASONABLY ACHIEVABLE

A. INTRODUCTION

Paragraph 20.1(c) of 10 CFR Part 20, "Standards for Protection Against Radiation," states, in part, that licensees should make every reasonable effort to maintain radiation exposures as far below the limits specified in that part as practicable. This guide describes to licensees a general operating philosophy acceptable to the NRC staff as a necessary basis for a program of maintaining occupational exposures to radiation as low as is reasonably achievable.

Both this guide and Regulatory Guide 8.8, "Information Relevant to Maintaining Occupational Radiation Exposure as Low as is Reasonably Achievable (Nuclear Power Reactors)," deal with the concept of "as low as is reasonably achievable" occupational exposures to radiation. The main difference between the two guides, aside from the fact that Regulatory Guide 8.8 applies only to nuclear power reactors and this guide applies to all specific licensees, is that Regulatory Guide 8.8 is addressed to applicants for a license and tells them what information relevant to "as low as is reasonably achievable" should be included in their license applications. This guide, on the other hand, describes an operating philosophy that the NRC staff believes all specific licensees should follow to keep occupational exposures to radiation as low as is reasonably achievable.

B. DISCUSSION

Even though current occupational exposure limits provide a very low risk of injury, it is prudent to avoid unnecessary exposure to radiation. The objective is thus to reduce occupational exposures as far below the specified limits as is reasonably achievable by means of good radiation protection planning and practice, as well as by management commitment to policies that foster vigilance against departures from good practice.

In addition to maintaining doses to individuals as far below the limits as is reasonably achievable, the sum of the doses received by all exposed individuals should also be maintained at the lowest practicable level. It would not be desirable, for example, to hold the highest doses to individuals to some fraction of the applicable limit if this involved exposing additional people and significantly increasing the sum of radiation doses received by all involved individuals.

C. REGULATORY POSITION

Two basic conditions are considered necessary in any program for keeping occupational exposures as far below the specified limits as is reasonably achievable. The management of the licensed facility should be committed to maintaining exposures as low as is reasonably achievable, and the personnel responsible for radiation protection should be continually vigilant for means to reduce exposures.

1. Management Commitment

The commitment made by licensee management to minimize exposures should provide clearly defined radiation protection responsibilities and an environment in which the radiation protection staff can do its job properly. There are several aspects to this commitment:

a. Plant personnel should be made aware of management's commitment to keep occupational exposures as low as is reasonably achievable. The commitment should appear in policy statements, instructions to personnel, and similar documents. As a minimum, workers should be sufficiently familiar with this commitment that they can explain what the management commitment is, what "as low as is reasonably achievable exposure to radiation" means, why it is recommended, and how they have been advised to implement it on their jobs.

V

The first page of this guide is being reissued with the words "For Comment" deleted. The staff's consideration of comments received during the initial public comment period has resulted in the determination that there is no need for a revision at this time.

It is suggested that you attach this page to the first page of the complete guide. No changes have been made to the text of either this page or the remainder of the guide.

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a. **Plant personnel should be made aware of management's commitment to keep occupational exposures as low as is reasonably achievable.** The commitment should appear in policy statements, instructions to personnel, and similar documents. As a minimum, workers should be sufficiently familiar with this commitment that they can explain what the management commitment is, what "as low as is reasonably achievable exposure to radiation" means, why it is recommended, and how they have been advised to implement it on their jobs.

b. **Management should periodically perform a formal audit to determine how exposures might be lowered.** This should include reviews of operating procedures and past exposure records, plant inspections, and consultations with the radiation protection staff or outside consultants. As a minimum, management should be able to discuss which operating procedures were reviewed, in which locations most exposures are being received, what groups of workers are receiving the highest exposures, what discussions they have had with the radiation protection staff or outside consultants, and what steps they have taken to reduce exposures.

* c. **The management should ensure that there is a well-supervised radiation protection capability with well-defined responsibilities.** The qualifications for the Radiation Protection Manager for a nuclear power reactor facility are presented in Regulatory Guides 1.8 and 8.8. Applicants submitting applications for any specific license other than a nuclear power reactor license should select and state the qualifications for the lead individual who will be responsible for implementing the radiation protection program for the facility, i.e., the Radiation Safety Officer (RSO).[1] The qualifications selected should be commensurate with the potential problems anticipated to be encountered in a facility of the type subject to the license.

d. **The management should see that plant workers receive sufficient training.** Section 19.12 of 10 CFR Part 19 requires instruction of personnel on radiation protection. The radiation worker should understand how radiation protection relates to his job and should be tested on this understanding at least once per year. He should have frequent opportunities to discuss radiation safety with the radiation protection staff whenever the need arises. Management should be committed to a review of radiation protection at least once every three years. Training should be sufficient to ensure that the workers can correctly answer questions on radiation protection as it relates to their jobs.

e. **The RSO should be given sufficient authority to enforce safe plant operation.** The RSO should have the authority to prevent unsafe practices and to communicate promptly with an appropriate level of management about halting an operation he deems unsafe. Operating procedures related to radiation safety should be reviewed and approved by radiation protection personnel. This authority should be demonstrable by written policy statements.

f. **Modifications to operating and maintenance procedures and to plant equipment and facilities should be made where they will substantially reduce exposures at a reasonable cost.** The management should be able to demonstrate that improvements have been *sought*, that modifications have been considered, and that they have been implemented where practicable. Where modifications have been considered but not implemented, the licensee should be prepared to describe the reasons for not implementing them.

2. Vigilance by the RSO and the Radiation Protection Staff

It should be the responsibility of the RSO and the radiation protection staff to conduct surveillance programs and investigations to ensure that occupational exposures are as far below the specified limits as is reasonably achievable. Additionally, they should be vigilant in searching out new and better ways to perform all radiation jobs with less exposure. There are several aspects to this responsibility.

a. **The RSO and the radiation protection staff should know the origins of radiation exposures in the plant.** They should know these by location, operation, and job category and should be aware of trends in exposures. Where radiation work permits are used, exposures received should be recorded on the permits. The RSO and the radiation protection staff should be able to describe which locations, operations, and jobs are associated with the highest exposures and why exposures are increasing or decreasing.

b. **The RSO and the radiation protection staff should look for ways to reduce exposures.** When unusual exposures have occurred, the radiation protection staff should direct and participate in an investigation of the circumstances of such exposures to determine the causes and take steps to reduce the likelihood of similar future occurrences. For each such occurrence, the RSO should be able to demonstrate that such an investigation has been carried out, that conclusions were reached as a result of the investigation, and that corrective action was taken, as appropriate.

The RSO and the radiation protection staff should periodically review operating procedures that may affect radiation safety and survey plant operations to identify situations in which exposures can be reduced. Indicated changes should be promptly implemented. Procedures for receiving and evaluating suggestions relating to radiation protection from employees should be established. Workers should be knowledgeable of the procedures for making suggestions on radiation protection.

c. **Adequate equipment and supplies for radiation protection work should be provided.** The RSO should be responsible for ensuring that proper equipment and supplies are available, are maintained in good working order, and are used properly. Written procedures for the use of the equipment should be available and followed.

*Lines indicate substantive changes from previous issue.

[1] The term "Radiation Safety Officer" is used by many licensees; other terms are equally acceptable.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC staff's plans for utilizing this regulatory guide.

Except in those cases in which the applicant or licensee proposes an alternative method for complying with the specified portions of the Commission's regulations, the methods described herein will be used in the evaluation of submittals in connection with applications for a specific license.

Regulatory Guides 1.8 and 8.8 address nuclear power reactor facilities specifically and will be used by the NRC staff in evaluating submittals in connection with licensing actions for nuclear power reactors.

QUESTION 331.3

"With regard to the review of changes made during the plant design process in order to maintain occupational radiation exposures ALARA:

a. Identify by title the individual who has been responsible for this radiation protection design review, and describe how she or he relates to the individual responsible for the overall design.

b. Provide a breakdown by title of radiation protection personnel who have been participating in such reviews, tabulating the health physics education and experience required of each.

c. Describe formal arrangements and procedures for assuring that adequate radiation protection reviews are performed throughout the design and construction processes and adequate records are kept to document the completion of each such reviews."

RESPONSE

a. Balance of Plant

The station owner has the responsibility for the radiation protection design review on the Byron and Braidwood nuclear power stations. Commonwealth Edison utilized Westinghouse and S&L to review the Byron/Braidwood station radiation protection design.

Westinghouse employs system analysis engineers, competent in the area of health physics and radiation protection, to work with system design engineers. Although many groups within the Westinghouse Pressurized Water Reactor Systems Division (PWRSD) are available when required, the two major sections responsible for radiation protection review are Energy and Environmental Analysis, within the Nuclear Safety Department, and Radiation and Systems Analysis within the Engineering Department. The managers of these two sections report thorugh the maangement of their respective departments to the PWRSD General Manager, who is responsible for the overall design of RESAR-414 plants.

The A-E, Sargent & [illegible]ndy, performs ALARA Radiation Protection Design Reviews at [illegible]y points in the balance of plant design.

ATTACHMENT E

These reviews are independent of the owner's reviews and incorporate the instructions of the owner. The radiation protection design reviews conducted by Sargent & Lundy, cover access control, radiation shielding, radiation monitoring, radiation protection facilities, and control of airborne contamination in accordance with the ALARA concepts in Sections C.2 and C.4 of Regulatory Guide 8.8. The Sargent & Lundy ALARA review is conducted according to written procedures which establish a Review Committee and a committee chairperson. The chairperson is an experienced Radiation Protection Specialist and is responsible for the design review; he assigns committee members and additional reviewers as necessary to review tasks in their area of expertise. The Review Committee issues a report summarizing its review and its conclusions. A summary of the qualifications of the personnel who participated in the most recent Sargent & Lundy ALARA Radiation Protection Design Review are given in Table Q331.3-2. The review team consisted of the committee chairman, at least three committee members and two additional reviewers.

b. Types of personnel that have been involved in the radiation protection review are given in Tables Q331.3-1 and Q331.3-2.

c. Balance of Plant

Design information is logged and sent to the owner for comments. Portions of the design information involve radiation shielding, monitoring, laboratory facilities and other radiation considerations. These items are directed to the responsible radiation protection reviewer. Comments are sent through both Project Manager's Divisions (owner and designer). Radiation protection comments and requested changes are forwarded to the engineer responsible for the radiation protection (RP) design. The RP designer responds to the comments and requests. He then files the comments, requests, and the response. The RP designer makes the required design changes. The Project Management divisions coordinate and document the changes.

The personnel with expertise in radiation protection within the groups stated above participate in the design review process in a systematic manner. The procedures to assure radiation protection functions needed to prevent or mitigate consequences of postulated accidents that could cause undue risk to the health and safety of the public are formally documented.

The NRC has recently reviewed the Westinghouse policy, design, and operational considerations related to assuring that occupational radiation exposures are ALARA for the RESAR-3S and RESAR-414 designs. They have concluded that Westinghouse has shown sufficient concern and familiarity with the ALARA principles in the areas of design considerations such that this aspect of radiation protection is acceptable. There are no substantial differences between RESAR-414, RESAR-3S and the Byron/Braidwood design in those areas that affect ALARA.

d. The three examples which follow will result in a significant reduction in man-rem exposure.

1. The utilization of removable unmortared block wall sections (instead of mortared sections) for some equipment will significantly reduce the number of manhours spent in radiation areas.

2. Probe holes were placed in most removable hatches of filter and demineralizer cubicles. These holes allow radiation monitoring of the cubicles prior to removing its hatch. The radiation data from the monitor will allow radiation protection personnel better control of occupational exposure.

3. Area radiation monitors (ARMS) were placed in valve aisles which serve two or more highly radioactive systems. These ARMS will prevent high levels of unexpected exposure from the startup of an inactive system while performing maintenance on another system.

TABLE Q331.3-1

NSSS RADIATION PROTECTION PERSONNEL

JOB TITLES	RADIATION PROTECTION REVIEW RESPONSIBILITIES	EDUCATION	EXPERIENCE
Manager of Energy and Environmental Analysis	Interfaces between the Engineering Department and the NRC. He reviews, coordinates, and supplies input for hapters 1, 2, 11, 12, and 15 of the Safety Analysis Reports.	BS or higher in engineering or the physical sciences	5 years as a lead engineer or manager. Background in nuclear an chemical environmental engineering
Manager of Radiation and System Analysis	Provides radiation protection guidance. Analyzes plant radiation sources and exposure from and to components. Occupational radiation exposure design review.	MS or equivalent in mechanical, nuclear, or chemical engineering	6 years experience in nuclear plant system operation or design

TABLE Q331.3-2

RADIATION PROTECTION PERSONNEL PARTICIPATING IN THE

A-E's FSAR SUBMITTAL RADIATION PROTECTION DESIGN REVIEW

JOB TITLE	RESPONSIBILITIES	EDUCATION OF SPECIFIC REVIEWERS	EXPERIENCE OF* SPECIFIC REVIEWERS
Chairperson NSLD Radiation Protection Design Review Committee	Coordinate Review by the Committee. Assign Reviewers. Assign Review Tasks. Resolve Disputes. Approve Committee Conclusions. Terminate Review.	Chairperson: B.S. E.E. Certified Health Physicist Registered Professional Engineer	Over 25 Years Experience in the Nuclear Industry and With the AEC.
Committee Members	Assigned a Specific Area of Responsibility. Summarize Review Responses. Make Recommendations and Appraisals of Plant's RP Design.	Members: Ph D. N.E. Ph D. Health Physics M.S. N.E. Registered Professional Engineer	Over 7 Years in Nuclear Engineering and Radiation Engineering One Year in Health Physics Over 13 Years in Nuclear Engineering, Radiation Engineering, and Health Physics

*Experience at Time of Design Review.

TABLE Q331.3-2 (Cont'd)

JOB TITLE	RESPONSIBILITIES	EDUCATION OF SPECIFIC REVIEWERS	EXPERIENCE OF SPECIFIC REVIEWERS
Reviewers (In Addition to Committee Members)	Assigned a Specific Area of Responsibility. Review Completeness of Station's Radiation Protection Design. Identify Deficiencies. Make Recommendations.	Reviewers: Ph D. N.E. M.S. N.E.	4 Years in Nuclear Engineering and Radiation Engineering 3 Years in Nuclear Engineerign and Health Physics

Table 1 Comparison of FES Whole Body Cancer Mortality Risk Estimators (Per 10^6 person-rem) With Values From Other Sources of Estimates[a]

Source of Estimates	Dose-Response Models[b]	Projection Model Continuous Lifetime Exposure to 1 Rad/Yr (Low-LET)	
		Absolute	Relative
BEIR, 1980	LQ-L, $\overline{\text{LQ-L}}$	67	169
1972 BEIR[c]	Linear	115	568
UNSCEAR 1977	Linear	75-175	
ICRP[d]	Linear	100-125	
FES	Linear	135	500

[a] Except where noted all values are taken from Table V-4 of BEIR III.

[b] For BEIR 1980, the first model is used for leukemia, the second for other forms of cancer. The corresponding estimates when the other models are used (thereby providing an envelope of risk estimates) are:

L-L, $\overline{\text{L-L}}$	158	403

[c] Updated to 1970 U.S. population.

[d] The value for the ICRP is taken from ICRP (1977)

ATTACHMENT F

NRC Form 5
(10-81)
10 CFR 20

U. S. NUCLEAR REGULATORY COMMISSION

Approved by OMB
3150-0006
Expires 4-30-83

CURRENT OCCUPATIONAL EXTERNAL RADIATION EXPOSURE

See Instructions on Back

IDENTIFICATION

1. NAME (PRINT – Last, first, and middle)	2. SOCIAL SECURITY NO.
3. DATE OF BIRTH (Month, day, year)	4. NAME OF LICENSEE

5. DOSE RECORDED FOR (Specify: Whole body; skin of whole body; or hands and forearms, feet and ankles.)	6. WHOLE BODY DOSE STATUS (rem)	7. METHOD OF MONITORING (e.g., Film Badge – FB, Pocket Chamber – PC; Calculations – Calc.) X OR GAMMA ______ BETA ______ NEUTRONS ______

8. PERIOD OF EXPOSURE (From – To)	DOSE FOR THE PERIOD (rem)				13. RUNNING TOTAL FOR CALENDAR QUARTER (rem)
	9. X OR GAMMA	10. BETA	11. NEUTRON	12. TOTAL	

LIFETIME ACCUMULATED DOSE

14. PREVIOUS TOTAL (rem)	15. TOTAL QUARTERLY DOSE date rem	16. TOTAL ACCUMULATED DOSE (rem)	17. PERM. ACC. DOSE 5(N-18) (rem)	18. UNUSED PART OF PERMISSIBLE ACCUMULATED DOSE (rem)

ATTACHMENT G

INSTRUCTIONS FOR PREPARATION OF NRC FORM 5

The preparation and safekeeping of this form or a clear and legible record containing all the information required on this form is required pursuant to Section 20.401 of "Standards for Protection Against Radiation," 10 CFR 20, as a current record of occupational external radiation exposures. Such a record must be maintained for each individual for whom personnel monitoring is required under Section 20.202. Note that a separate NRC Form 5 is to be used for recording external exposure to (1) the whole body; (2) skin of whole body; (3) hands and forearms; or (4) feet and ankles, as provided by Item 5 below.

Listed below by item are instructions and additional information directly pertinent to completing this form.

Identification

Item 1. Self-explanatory.
Item 2. Self-explanatory except that, if individual has no social security number, the word "none" shall be inserted.
Item 3. Self-explanatory.
Item 4. Self-explanatory.

Occupational Exposure

Item 5. "Dose to the whole body" shall be deemed to include any dose to the whole body, gonads, active blood-forming organs, head and trunk, or lens of eye. Unless the lenses of the eyes are protected with eye shields, dose recorded as whole body dose should include the dose delivered through a tissue equivalent absorber having a thickness of 300 mg/cm^2 or less. When the lenses of the eyes are protected with eye shields having a tissue equivalent thickness of at least 700 mg/cm^2, dose recorded as whole body dose should include the dose delivered through a tissue equivalent absorber having a thickness of 1,000 mg/cm^2 or less.

Dose recorded as dose to the skin of the whole body, hands and forearms, or feet and ankles should include the dose delivered through a tissue equivalent absorber having a thickness of 7 mg/cm^2 or less. The dose to the skin of the whole body, hands and forearms, or feet and ankles should be recorded on separate forms unless the dose to those parts of the body has been included as dose to the whole body on a form maintained for recording whole body exposure.

Item 6. This item need be completed only when the sheet is used to record whole body exposures and the licensee is exposing the individual under the provisions of Paragraph 20.101(b) which allows up to 3 rems per quarter to the whole body. Enter in this item the unused part of permissible accumulated dose taken from previous records of exposure, i.e., Item 18 of the preceding NRC Form 5 or Item 13 of NRC Form 4 if the individual's exposure during employment with the licensee begins with this record.

Item 7. Indicate the method used for monitoring the individual's exposure to each type of radiation to which he is exposed in the course of his duties. Abbreviations may be used.

Item 8. Doses received over a period of less than a calendar quarter need not be separately entered on the form provided that the licensee maintains a current record of the doses received by the individual which have not as yet been entered on the form. The period of exposure should specify the day the measurement of that exposure was initiated and the day on which it was terminated. For example, if only quarterly doses are entered, the period of exposure for the first calendar quarter of 1962 might be taken as running from Monday, January 1, 1962, through Friday, March 30, 1962, and would be indicated in this item as Jan. 1, 1962-Mar. 30, 1962. If weekly doses are entered, a film badge issued Monday morning, January 1, 1962, and picked up Friday, January 5, 1962, would be indicated as Jan. 1, 1962-Jan. 5, 1962.

Items 9, 10 and 11. Self-explanatory. The values are to be given in rem. All measurements are to be interpreted in the best method known and in accordance with Paragraph 20.4(c). Where calculations are made to determine dose, a copy of such calculations is to be maintained in conjunction with this record. In any case where the dose for a calendar quarter is less than 10% of the value specified in Paragraph 20.101(a), the phrase "less than 10%" may be entered in lieu of a numerical value.

Item 12. Add the values under Items 9, 10 and 11 for each period of exposure and record the total. In calculating the "Total" any entry "less than 10%" may be disregarded.

Item 13. The running total is to be maintained on the basis of calendar quarters. Paragraph 20.3(a) (4) defines calendar quarter. No entry need be made in this item if only calendar quarter radiation doses are recorded in Items 9, 10, 11 and 12.

Lifetime Accumulated Dose (Whole Body)

NOTE: If the licensee chooses to keep the individual's exposure below that permitted in Paragraph 20.101(a), items 14 through 18 need not be completed. However, in that case the total whole body dose for each calendar quarter recorded in Item 13 (or Item 12 if quarterly doses are entered in Item 12) should not exceed 1 1/4 rem.

If an individual is exposed under the provisions of Paragraph 20.101 (b), complete Items 14 through 18 at the end of each calendar quarter and when the sheet is filled. Values in Item 13, when in the middle of a calendar quarter, and values in Item 18, must be brought forward to next sheet for each individual.

Item 14. Enter the previous total accumulated dose from previous dose records for the individual (e.g., from Item 16 of NRC Form 5 or Item 11 of NRC Form 4). The total occupational radiation dose received by the individual must be entered in this item, including any occupational dose received from sources of radiation not licensed by the Commission. If the individual was exposed to sources of radiation not licensed by the Commission during any calendar quarter after completing NRC Form 4 and personnel monitoring equipment was not worn by the individual, it should be assumed that the individual received a dose of 1 1/4 rems during each such calendar quarter.

Item 15. Enter the total calendar quarter dose from Item 13 (or from Item 12 if quarterly doses are entered in Item 12) and the date designating the end of the calendar quarter in which the dose was received (e.g., March 30, 1962).

Item 16. Add Item 14 and Item 15 and enter that sum.

Item 17. Obtain the Permissible Accumulated Dose (PAD) in rem for the WHOLE BODY. "N" is equal to the number of years of age of the individual on his last birthday. Subtract 18 from N and multiply the difference by 5 rem (e.g., John Smith, age 32; N = 32, PAD = 5(32-18) 70 rem.)

Item 18. Determine the unused part of the PAD by subtracting Item 16 from Item 17. The unused part of the PAD is that portion of the Lifetime Accumulated Dose for the individual remaining at the end of the period covered by this sheet.

PRIVACY ACT STATEMENT

Pursuant to 5 U.S.C. 552a(e) (3), enacted into law by section 3 of the Privacy Act of 1974 (Public Law 93-579), the following statement is furnished to individuals who supply information to the Nuclear Regulatory Commission on NRC Form 5. This information is maintained in a system of records designated as NRC-27 and described at 40 Federal Register 45344 (October 1, 1975).

1. AUTHORITY Sections 53, 63, 65, 81, 103, 104, 161(b), and 161(o) of the Atomic Energy Act of 1954, as amended (42 U.S.C. 2073, 2093, 2095, 2111, 2133, 2134, 2201(b), and 2201(o)). The authority for soliciting the social security number is 10 CFR Part 20.

2. PRINCIPAL PURPOSE(S) The information is used by the NRC in its evaluation of the risk of radiation exposure associated with the licensed activity and in exercising its statutory responsibility to monitor and regulate the safety and health practices of its licensees. The data permits a meaningful comparison of both current and long term exposure experience among types of licensees and among licensees within each type. Data on your exposure to radiation is available to you upon your request.

3. ROUTINE USES The information may be used to provide data to other Federal and State agencies involved in monitoring and/or evaluating radiation exposure received by individuals employed as radiation workers on a permanent or temporary basis and exposure received by monitored visitors. The information may also be disclosed to an appropriate Federal, State, or local agency in the event the information indicates a violation or potential violation of law and in the course of an administrative or judicial proceeding.

4. WHETHER DISCLOSURE IS MANDATORY OR VOLUNTARY AND EFFECT ON INDIVIDUAL OF NOT PROVIDING INFORMATION It is voluntary that you furnish the requested information including social security number; however, the licensee must complete NRC Form 5 on each individual for whom personnel monitoring is required under 10 CFR 20.202. Failure to do so may subject the licensee to enforcement action in accordance with 10 CFR 20.601. The social security number is used to assure that NRC has an accurate identifier not subject to the coincidence of similar names or birthdates among the large number of persons on whom data is maintained.

5. SYSTEM MANAGER(S) AND ADDRESS Director, Office of Management and Program Analysis, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555

QUESTION 331.32

"Provide additional information on how your exposure tracking and exposure reduction program, includes the elements of Regulatory Guide 1.70, Section 12.1.3 and 12.5.3, and Regulatory Guide 8.8, Section C.3.9(8)(j), C.3.8(2), and C.3.c(2)(5), including rem-tracking, self-reading pocket dosimeter use, post-maintenance, actual exposure, and how these results are used to make changes in future work. Verify that annual exposure reviews are performed by plant management and that these are used to identify groups with the highest exposure in order to assure that doses are ALARA."

RESPONSE

The Commonwealth Edison commitment to the ALARA principle is discussed in B/B-FSAR Subsection 12.1.1. The use of Radiation Work Permits is discussed in B/B-FSAR Subsection 12.1.1.3.

Pencil dosimeters will be used at Byron/Braidwood Stations to record estimates of daily exposures received by each individual worker. This information enables the Rad/Chem Department to spot significant individual exposures that may occur within the biweekly film badge monitoring period. Biweekly work group man-rem summaries are generated by the computer dosimetry program. The summaries serve to alert the station health physics staff and the corporate office of the trends in man-rem expenditures. Commonwealth Edison began a Radiation Evaluation Program (REP) in April of 1976. REP is a computer based occupational dose accounting system used to document, by work group, the dose expenditure resulting from work performed on various plant systems and components. In addition to each work group's dose and the plant component worked on, the program will document the total work effort in man-hours and include a brief description of the work performed.

The REP program applications are:

a. To provide timely radiological feedback information to our engineering and production departments and architect-engineer consultants for consideration in new plant design and to enable corrective action to be taken at existing stations.

b. To identify and compile dose histories on specific sources of occupational dose that might be reduced through improved station working and shielding procedures and training programs.

ATTACHMENT H

c. To provide data for comparison studies of specific sources of occupational exposure among similar CECo nuclear stations with relevant factors such as reactor equipment and plant layout, etc., taken into account.

d. To demonstrate an "active ALARA program."

The Station is also planning for an ALARA Review Committee. This committee is composed of the manager of each affected department, the Rad/Chem Supervisor, and an ALARA coordinator. The charter of the committee is to advise the Station Superintendent on ALARA matters. The committee reviews annual exposure reduction goals and provides direction for the ALARA coordinator. The committee meets at least quarterly. The chairman of the committee has decision making responsibility.