Details of Technical Options for Revision
of
10 CFR Part 50 and Appendix I
Regulations and Regulatory Guidance
for
Light Water-Cooled Nuclear Power Reactors

A. Introduction

For power reactors, radioactive liquid and gaseous effluents are controlled under Part 20, Part 50.34a and 50.36a, and Appendix I to Part 50. Appendix I contains provisions to ensure that gaseous and liquid radioactive effluents released in unrestricted areas and doses to members of the public are As Low As Is Reasonably Achievable (ALARA). These requirements were first published in 1975. The concern with existing regulations and guidance is that they are based on dosimetry concepts issued in 1959 under the recommendations of the International Commission on Radiological Protection (ICRP) in ICRP 2. This approach was consistent with the prior version of Part 20, but is no longer consistent with current Part 20. As revised in 1991, Part 20 changed the methodology by implementing dosimetry concepts of ICRP 26 and ICRP 30. However, Appendix I and guidance documents (e.g., Regulatory Guide 1.109 and others) were not changed, and therefore are still based on ICRP 2 dosimetry concepts.

B. Background

In 1975, the NRC adopted the ALARA principle in regulating radioactive gaseous and liquid effluents from nuclear power plants. The requirements and numerical guidance, respectively, are contained in Part 50 and its Appendix I. The dose criteria are based on ICRP 2 dosimetry (i.e., whole body and critical organ dose concepts and models). This approach was consistent with that used in the prior version of Part 20, Standards for Protection Against Radiation. The current Part 20, promulgated in 1991 and implemented in 1994, applies the dosimetry concepts and dose calculation methodology of ICRP 26 and ICRP 30 in deriving doses to individuals. At that time, Appendix I was not changed and it still incorporates all of the ICRP 2 concepts. In Part 20, dose is expressed as total effective dose equivalent (TEDE), which incorporates a risk-based weighed dose by tissues or organs. Under this risk-based approach, the dose to the body is expressed in a single value instead of the old method of expressing separate doses for the whole body and critical organs. Other differences exist, such as the use of non-stochastic effects in limiting doses to specific organs. The ICRP 2 approach does not make such distinctions among organs.

In practice, the Appendix I design objectives are far more restrictive than Part 20 allowable dose limits or effluent concentration levels. However, Appendix I design objectives are not a radiation protection standard under 10 CFR Part 50.34a. Releases of radioactive effluents from nuclear power plants are controlled by plant specific technical specifications to ensure that releases are maintained (i) ALARA using Appendix I design objectives and guidelines, (ii) to a small fraction of Part 20 dose and concentration limits, and (iii) within the Environmental Protection Agency (40 CFR Part 190) environmental dose standards for facilities that are part of the fuel cycle. As a result**,** Part 20 criteria and limits are rarely controlling in limiting radioactive effluents from nuclear power plants.

The U.S. Environmental Protection Agency (EPA) standards are endorsed in Part 20.1301(e). Inasmuch as the regulatory purpose of Part 20 is not the same as Part 50, Appendix I, the difference in dosimetry concepts between Part 20 and Part 50, Appendix I is not irreconcilable. However, there are regulatory, practical, and public confidence considerations that should be considered by the NRC in determining whether to transition to a common concept in dosimetry for both Part 20 and Part 50, Appendix I. These considerations are discussed below.

In implementing ALARA requirements of Appendix I, the U.S. Nuclear Regulatory Commission (NRC) published a series of regulatory guides to provide guidance on how to demonstrate compliance with design objectives. The regulatory guides address methods for estimating gaseous and liquid effluent releases, dispersion of effluents in the atmosphere and water bodies, and calculating potential radiation doses to offsite members of the public. The main guidance document is Regulatory Guide 1.109. This guide contains the mathematical models and assumptions in estimating radiation doses to members of the public from radioactive effluents during plant operation. Regulatory Guide 1.109 is supported by a series of related documents, including Regulatory Guide 1.111, which describes mathematical models and assumptions for estimating atmospheric transport, dispersion, and deposition of airborne effluents during routine operation. Another document, Regulatory Guide 1.112, describes methods for calculating radioactive source terms for evaluating radioactive waste treatment systems. Regulatory Guide 1.113 provides mathematical models and methods in estimating aquatic dispersion of both routine and accidental releases. Regulatory Guide 1.110 provides methods to conduct cost-benefit analyses in evaluating the performance of radwaste systems used in light water reactors. Regulatory Guide 4.15 addresses quality assurance for maintaining radiological effluent monitoring programs at reactors, including in nearby environments. Regulatory Guide 1.21 provides guidance on how to compile this information and conduct assessments in demonstrating compliance with Appendix I design objectives. It also contains guidance on the submission of periodic reports to the NRC. Finally, the NRC has issued several other documents (as NUREGs) that support the implementation of Appendix I. Enclosure 4 of this Commission paper presents a more detailed listing of NRC guidance.

Over the past decade there have been discussions with stakeholders about updating the basis of Appendix I design objectives and its supporting guidance documents to be consistent with the TEDE dose methodology used in Part 20. Currently, the implementation of Part 50 Appendix I design objectives is not an issue for power reactors because their use is well established and the industry has extensive operational experience in demonstrating compliance. The concern is that the use of an outdated dose calculation methodology, in expressing separate doses for the whole body and critical organs, is inefficient for both licensees and NRC. Specifically, the concerns are:

- the basis of Appendix I design objectives and associated dose calculation methodology are outdated given that its underlying basis has been revised twice since 1959;
- the basis of Appendix I design objectives should be updated to reflect current principle and scientific knowledge underlying radiation protection principles;
- the basis of Appendix I design objectives should be consistent with all other Title 10 regulatory programs;
- radiation protection principles based on ICRP 2 recommendations are no longer taught in current health physics university curriculum. As a result, the staff needs

to instruct new employees about the implementation of ICRP 2 in reviewing reactor license applications using current guidance and dose computer codes;

- the scientific and technical bases of Appendix I design objectives are outdated compared to those used in current international standards and global approach currently being used in siting, designing, and building new reactors under Part 52;
- the results of traditional cost-benefit analyses cannot be justified in maintaining an outdated radiation protection principle on a major segment of NRC licensees; and
- the use of a dual system of radiation protection principles and dose calculation methods may be difficult to defend with stakeholders and may undermine public confidence on how the NRC manages its regulatory programs and during licensing hearings of new reactors.

Together, these concerns present potential impediments in light of new reactor applications. If these requirements and regulatory guides were to remain unchanged, the United States would remain alone in its use of ICRP 2 dose concepts because of a world-wide approach in using current dosimetry methods to design and operate new power reactors. NRC is supporting the review of one early site permit, four design certifications, and seventeen combined licensed applications.

Given this wave of new power reactor licensing, the removal of inconsistencies between Part 20 and the basis of Part 50 Appendix I design objectives would be important to the regulatory process and eliminate confusion in current dual regulatory requirements in calculating doses for demonstrating compliance with Appendix I design objectives using ICRP 2 and ICRP 26 and 30 for Part 20. Applicants would have the option of voluntarily complying with the revised Part 50, Appendix I regulations for efficiency. However, applications for early site permits, reactor certifications, and construction/operating license (COL) applications submitted after the effective date of the rulemaking, would be required to comply with the revised basis of Appendix I dose criteria and supporting guidance. The staff proposes to address the implementation of revised Part 50 and Appendix I requirements in the rule in a manner similar to that incorporated in Sections I and V of Appendix I when these regulations were implemented in 1975. The staff recognizes that the ongoing licensing of new reactors will use the existing 10 CFR Part 50 and Part 50 Appendix I until such time as revisions are made. A key issue in discussions with licensees will be the desirability and impact of implementing a new set of requirements as the new reactors commence operation.

C. Proposed Approach

A review of current rules and requirements indicates that there are a number of regulatory and technical overarching issues that would need to be considered in defining a successful course of action. Some of the overarching issues involve deciding on whether to revise the guidance at all, determining the scope of a rulemaking if a revision were chosen, whether the regulatory guidance could be revised without first considering updating Part 20 to ICRP 103 recommendations, and addressing any constraints associated with the Part 52 design certification rule. In broad terms, the following arguments could be made on whether to revise the basis of the Appendix I design objectives and its related guidance:

a. Do not revise the basis of Appendix I design objectives and related guidance

Leave the basis of Appendix I design objectives and related guidance as they are. This argument makes the case that there is no necessary connection between Appendix I design objectives and Part 20 dose limits to the public, given that Appendix I is not a radiation protection standard. The Appendix I design objectives are an "ALARA design basis" requirement. If the design objectives of Appendix I are met, it constitutes a demonstration that effluents and doses to the public are ALARA and no additional efforts are required to reduce effluent release rates. As a result, there is no need to link the two, as Part 20 and Appendix I address different regulatory objectives. However, the staff has been drawn into discussions and conclusions that compliance with Part 50 Appendix I numerical guides also demonstrates compliance with the dose and effluent concentrate limits of Part 20 given that Appendix criteria are more restrictive. This rational is scientifically and technically incorrect because of the recognized differences in underlying dosimetry concepts and dose calculation methodologies.

b. Integrate the revision of the basis of the Appendix I design objectives and its related guidance with that of Part 20

Integrate the revision with upcoming considerations that will address the update of Part 20 using current ICRP 103 recommendations. This approach would combine both efforts into one coherent rulemaking that would ensure that the revision to Part 20 and basis of Appendix I design objectives and regulatory guidance are implemented using a systematic approach. This course of action would ensure a consistent application of regulatory criteria between Parts 20 and Part 50 and 52. In turn, this option offers several alternatives on how to implement the revision. One approach would be initiate the revisions of Part 20 and Part 50 as two parallel rulemaking efforts with the implementation of the revised rules synchronized to a common implementation date.

In light of the above, the staff proposes the revision to the basis of Appendix I design objectives and regulatory guidance in making them consistent with other NRC regulatory programs using current scientific dosimetry concepts. The revised guidance would retain the current numerical design criteria of Appendix I, but would redefine the dose criteria as Effective Dose (ED) or Total Effective Dose (TED). The approach identifies regulatory programs and requirements for reactor licensing, associated regulatory guidance, and describe the advantages, limitations, and constraints to both NRC and licensees in revising regulations and regulatory guidance. Specifically, the following identifies specific elements of Part 20 and Appendix I to Part 50 regulations requiring update:

1. If Part 20 is revised, align dose definitions and quantities under Part 50.2 and Appendix I criteria with proposed Part 20 revision under the framework of ICPR 103 recommendations.

2. If Part 20 is not revised, align dose definitions and quantities under Part 50.2 and Appendix I criteria with the current framework of Part 20.

3. Align Part 50, Appendix I Sections II.A to II.C design objective dose criteria with proposed Part 20 revision or current Part 20 if it is not revised, specifically:

   (a) retain the 3 and 5 mrem (0.03 and 0.05 mSv, respectively) annual dose criteria of Appendix I for liquid and gaseous effluents, respectively, and report dose results as ED;

   (b) assess whether to omit reporting requirements of Appendix I for organ doses, e.g., skin and thyroid;

   (c) assess whether organ dose results of Appendix I be available for inspection, beyond that submitted yearly;

   (d) assess whether the gamma and beta air dose criteria should remain in Section II.B.1 of Appendix I;

   (e) update definitions of dose receptors in Section III and IV of Appendix I;

   (f) update Appendix I Section II.D cost-benefit analysis criteria from $1000 per man total body/thyroid rem to $2000 per man-rem (NUREG-1530 & NUREG/BR-0058), or current criteria using new information (e.g., 2007 dollars);

   (g) determine whether the provisions of Sections I and V of Appendix I need qualifiers addressing implementation of revised regulations for the existing fleet of operating reactors vs. Part 52 for newly licensed reactors before fuel load; and

   (h) revise the introduction of Appendix I requirements and their applicability to light-water-cooled and water-moderated power reactors in differentiating these requirements against those applicable to the next generation of nuclear plants with designs other than light water-cooled and water-moderated.

4. Redefine compliance requirements for “licensed operation” to consider sites with two or more licensees contributing radiation exposures to a single offsite dose receptor under Part 20.1301.

5. Given item 4 above, assess whether compliance with 40 CFR Part 190 [in Part 20.1301(e)] needs more elaboration in Part 20, Part 50 Appendix I, or in a regulatory guide.

6. Review and update all related conforming references: Regulatory Guides (Divisions 1, 4 and 8), Standard Review Plan (SRP, NUREG-0800, Sections 11 and 12), Branch Technical Positions of SRP Section 11, Generic Letter 89-01, NUREGs, and computer codes. Enclosure 4 of this Commission paper presents a listing of such guidance documents.

D. Implications

The proposed revision would consider updating key regulatory guides and determine whether other supporting documents need to be revised as well. The revised guidance would retain the current numerical dose criteria of Appendix I, but would redefine the dose criteria as ED or TED.

Also, the adjustments made to the dose calculation methodology would be consistent with the dosimetry concepts of ICRP 103 recommendations, as adopted in the revision to Part 20. For the purpose of this discussion, the focus is on Regulatory Guide 1.109, but it should be recognized that the revision would require, by necessity, the review of other regulatory guides, supporting NUREGs, computer codes, etc., given their complex interlocking relationships in supporting the implementation of Appendix I.

The proposed approach offers several advantages as it provides an opportunity to revise and integrate regulatory and technical issues associated with Part 50 Appendix I requirements with that of Part 20. This approach would result in the use of a consistent concept in regulating other NRC programs. It provides the opportunity to address the implications of the revision on Part 50 licensees, Part 52 early site permit, design certification, and COL applications. Together, these considerations are expected to simplify the regulatory burden for the NRC and licensees.

Conceptually, the proposed revision would result in two sets of regulatory guides, supporting NUREGs, and computer codes. The revised guidance would address the licensing and operation of new reactors, while the current guidance would remain unchanged for the existing fleet of operating reactors. Also, utilities would have the option of adopting the revised guidance for procedural efficiency and consistency in reporting doses to members of the public among multiple reactor sites, e.g., one site with an existing reactor and another with a newly licensed reactor. However, it is recognized that some aspects of the current guidance might be equally applicable to both categories of reactors and would not be revised or duplicated. Finally, a revision to the current guidance, based on new data, operational experience, and technological advances in radiological assessment, would provide an opportunity for introducing a more realistically conservative (risk-informed and performance-based) approach in licensing Appendix I requirements for new power reactors.

In considering the scope of the revision, the update would apply a tiered approach, reflecting varying levels of complexity. The approach and the scope of the revision ultimately implemented would depend on the chosen option. It is envisioned that the revision process might consider:

a. Limited Scope Revision - Target only those elements of the guidance dealing with dose conversion factors and, if necessary, directly supporting radiological parameters, such as specific adjustments to the basis of dose conversion factors. The balance of the technical guidance and default values of all other parameters would remain as stated in current regulatory guides. Also, the revision would address whether changes are needed in computer codes used to calculate doses or dose conversion factors.

b. Expanded Scope Revision - In addition to the above, the basis and values of specific parameters that affect dose results would be evaluated, and an assessment would identify the need to update or retain some or all default values. Such parameters, for example, would include human food or animal consumption rates, bio-accumulation factors, shore-line width factors, agricultural productivity, etc.

c. Full Scope Revision - This approach would consider a full revision of the guidance, including a top-down review and update of conceptual models

addressing effluent source term development, atmospheric and aquatic dispersion, and environmental transport based on an evaluation of the current literature and industry standards; dosimetry concepts and dose calculation methods based on ICRP 103 recommendations; and a review of all model assumptions, parameters, and their default values.

As an approach, the staff recommends the "Expanded Scope Revision" option as it focuses on an alignment with ICRP 103 recommendations and leaves intact all other aspects of current NRC guidance. For example, a top-down review and update of conceptual models addressing atmospheric and aquatic dispersion, and environmental transport is expected to be a resource and time intensive effort. The proposed approach would ensure that only essential regulatory guides and guidance documents would be revised and available in time by the implementation date specified in the final rule for Part 50 and Appendix I. In support of the implementation of the revised regulations, the staff proposes to prioritize the revisions of supporting regulatory guides, computer codes, and other guidance documents because of resource considerations. The revision of the balance of the guidance would be effected in defined subsequent stages.

E. Impact on NRC Regulations

The following presents discussions on potential impacts on the Reactor Oversight Program, nuclear utilities, and public confidence; considers ALARA, backfit, and cost-benefit analyses; and covers technical considerations in comparing impacts between ICRP 2 and methods based on ICRP 103.

Impacts on Reactor Oversight Program

The proposed revision of the basis of Appendix I design objectives and guidance supporting the implementation of Appendix I to Part 50 would have no impacts on current licensee programs and NRC activities. Thus, such a revision should not pose any backfitting considerations under the Backfit Rule, 10 CFR 50.109 - see separate discussion. The staff's evaluation would need to address any potential impacts on the Reactor Oversight Process (ROP). The specific elements of the ROP are those that address the public safety corner stone, cross-cutting issues, impacts on the baseline inspection program, preserving the effectiveness of the significance determination process, and upholding the usefulness of current performance indicators. Other aspects that would need to be evaluated are performance issues associated with reactor license renewals and extensions, and extended power up rates in maintaining safety. The revised guidance would address the licensing of new reactors, while the current guidance would remain unchanged for the existing fleet of operating reactors. The proposed revision would result in two sets of regulatory guides and updated documents. However, it is recognized that some aspects of the current guidance might be equally applicable to both categories of reactors and would need not be revised or duplicated. As part of the rulemaking, the NRC would need to assess regulatory and cost-benefit impacts on NRC programs and licensees, including a provision offering voluntary implementation for utilities operating existing and new reactors.

Impacts on Licensees

Regarding the scope of the proposed revision, it is expected that the industry would take a specific position on the issues and provide recommendations to the NRC. At this time, it is expected that, among others, some of the arguments may include:

- Regulations used to protect workers and the public, which are based on different dose concepts and models, are confusing to the industry and public.
- With new reactor applications, an update of the basis of Appendix I design objectives is appropriate and timely.
- There is an advantage in combining an update of Part 20 with a revision to the basis of Appendix I design objectives in the same rulemaking; thereby, ensuring consistency on the scientific and regulatory basis of how doses are defined and calculated in demonstrating compliance.
- NRC regulations and guidance should reflect current science, taking into account relevant recommendations issued by standards setting radiation protection organizations.
- The use of current science in setting the basis of dose limits would help with public confidence, ensure consistency among regulatory programs, and offers a benefit to the regulated community, assuming that the revision is not backfitted on the industry.
- On the other hand, significant changes to Appendix I might damage the reputation of the public radiation safety cornerstone, given the history of routine compliance with Appendix I design objectives.
- Similarly, the proposed revision should assess whether there are possible ramifications on current or pending applications for plant life extensions, extended power uprates, and licensing of new reactors at sites with existing plants.
- The implementation of revised Appendix I guidance should be optional for currently operating nuclear power plants.
- The NRC should assess potential impacts on different types of utilities, e.g., small utilities as single plant operators vs. utilities owning fleets of reactors.
- Nuclear Energy Institute, American Nuclear Industries, and utilities (large and small) will need to assess whether there are any potential liabilities in instances when plants are operated under different regulatory regimes, e.g., a single utility operating one plant under existing Appendix I regulatory guidance and another using revised Appendix I regulatory guidance.
- The revision of the basis to Appendix I design objectives and its guidance should offer flexibility on how the requirements are implemented in the context of performance-based and risk-informed regulations.

It is recognized that recommendations from utilities operating nuclear power plants would be expressed during public meetings and joint NRC and industry workshops.

Impacts on Public Confidence

The proposed revision might be perceived by the public as a relaxation of NRC requirements, e.g., allowing the use of dose models that might result in higher releases of radioactivity in the environment for the same dose limits. It is expected that, among others, issues raised by stakeholders may include:

- The underlying basis of NRC regulations should be updated in light of scientific findings presented in the Biological Effects of Ionizing Radiation (BEIR) VII report.
- Any revision to Appendix I and its guidance should weigh ICRP 103 recommendations and BEIR VII Committee findings.
- The revision to the basis of Appendix I design objectives and its guidance may not be favored pending an evaluation of the findings of the BEIR VII report on low-dose hypersensitivity, bystander effects, and genomic instability.
- If revised guidance is deemed to provide better protection to public health and safety, all power plants should be required to comply with them, regardless of any backfitting costs.
- Methodologies that result in the maximum health and safety protection should be the NRC's first approach, and any revision should aim for more restrictive standards since more nuclear power plants are expected to be built in the near future.
- The NRC should move away from performance-based regulations, because it is a relaxation to regulatory requirements. NRC should continue to use the more conservative and safer defense in depth strategy.

As part of NRC strategic goals, the process supporting the revision to the basis of Appendix I design objectives and guidance will be transacted openly and offer opportunities for public and stakeholder participation in the regulatory process.

ALARA Considerations

The requirements of Part 50 Appendix I define ALARA dose levels associated with radioactive materials present in liquid and gaseous effluents from light water reactors. If the design objectives of Appendix I are met, it constitutes a demonstration that effluents are ALARA and no additional efforts are required to reduce effluent release rates. Compliance with Appendix I is typically judged on whether the licensee has incorporated appropriate measures to track and, if necessary, reduce effluent releases as an operational principle, and not whether exposures and doses have been reduced to an absolute minimum. In this context, the proposed revision to the basis of the Appendix I design objectives will not change the premise of the ALARA dose-based standard and, consequently, the implementation and demonstration of compliance with a revised basis of Appendix I design objectives is not expected to require the expenditure of additional efforts on the part of licensees and NRC staff.

The proposed revision to the basis of Appendix I design objectives will not change the requirements of the EPA standards under 40 CFR Part 190 standards, consequently, the implementation and demonstration of compliance is not expected to require additional efforts by licensees and NRC staff. In order for light water reactors to demonstrate that doses from

effluents and direct radiation are ALARA, it is necessary to confirm that effluents meet the design objectives of Appendix I, that direct radiation from onsite radioactive sources (e.g., from radioactive waste storage buildings, turbine shine, storage tanks, etc.) is also ALARA, and that the total dose to any members of the public at the nearest location is within the EPA dose standards. Meeting these conditions is evidence that offsite doses are ALARA and in conformance with both Appendix I and 40 CFR Part 190. The potential impacts of the proposed revision on ALARA objectives and compliance with EPA standards will be evaluated in ensuring that operational flexibility is maintained and that no new constraints are imposed inadvertently.

Part 50, Appendix I Section II.D Cost-Benefit Ratio

The staff also proposes an update of Appendix I, Section II.D cost-benefit analysis criteria of $1000 per man total body/thyroid rem. Under current policy, the cost-benefit ratio for NRC regulatory analysis has been revised to $2000 per man-rem; see NUREG-1530 & NUREG/BR-0058, Rev. 4. The staff recommends that the cost-benefit ratio in Appendix I be updated using most current information (e.g., based on post-2007 dollars). The staff would address the revision of the supporting guidance, Regulatory Guide 1.110 as well. Specifically, the staff would assess whether liquid and gaseous effluent treatment system efficiencies have been maximized in the design of new reactors, and, if so, determine if there is still a need to evaluate system augmentation in order of diminishing cost-benefit returns, as is currently specified by Appendix I. Given these observations, there might be a need to determine if the NRC needs to redefine “items of reasonably demonstrated technology” for effluent treatment systems. Other aspects of the revision of Regulatory Guide 1.110 would include updating the listings of effluent treatment systems; revise associated maintenance, operating, and other costs of treatment systems; and assess whether a 30-year life cycle is still appropriate for new effluent treatment systems proposed in new reactor designs given the increasing application of modular treatment subsystems. The staff’s understanding of current industry practices is that modular or skid-mounted treatment subsystems are replaced more frequently, on about a 10-year operational cycle.

Backfit Considerations

In assessing the merits of updating the basis of Part 50 Appendix I design objectives, the staff will evaluate the impacts on licensee programs under the provisions of 10 CFR 50.109 – the Backfit Rule. The backfitting issues apply to four different classes of affected entities: (i) currently-operating reactors; (ii) existing design certifications, currently-docketed design certification applications and combined license applications; (iii) future design certifications and combined license applications which have not yet been filed, but will be filed prior to the effective date of any final rule amending Part 20 and Part 50, Appendix I; and (iv) future design certifications and combined license applications filed after the effective date of any final rule amending Part 20 and Part 50, Appendix I. Backfitting considerations and policy implications are expected to differ among these four classes of entities, and the staff will develop its position on backfitting for each affected class. The staff proposes to develop its position on backfitting for each affected class as part of the development of the proposed rule, with input from all affected stakeholders.

Cost-Benefit Considerations

The concern is that the use of an outdated dose calculation methodology is inefficient for both

licensees and NRC since dose calculations have to be done using two different methods, ICRP 2 for demonstrating compliance with Appendix I design objectives and ICRP 26 and 30 in demonstrating compliance with Part 20. The use of the current dose calculation methodology is outdated given that its underlying basis has been revised twice since 1959. The implementation of Appendix I design objectives is not a significant issue for existing power reactors because their use is well established and the industry has extensive operational experience in demonstrating compliance. Over the recent past, there have been discussions about updating the basis of Appendix I design objectives to be consistent with the dose methodology applied in Part 20. However, questions have been raised as to whether changes to the basis of Appendix I design objectives would still qualify for revision if appraised against criteria used in a traditional cost-benefit analysis. Given that the numerical dose criteria would not be changed by the revision, the impact on licensees would be associated with updating procedures, developing new calculation tools, and reformatting required reports to the NRC. Such changes would be implemented as a one time initial effort, followed by gains in administrative and procedural efficiencies and reductions in operating costs accruing over the life of the operational program. On the other hand, cost alone may not be a justifiable reason for imposing outdated radiation protection principles on a major segment of NRC licensees.

Arguments could be made that the basis of Appendix I design objectives should be updated to reflect current scientific knowledge about radiation protection principles. For example, the National Technology Transfer and Advancement Act of 1995 (Public Law 104-113) and Office of Management and Budget Circular A-119 (Federal Participation in the Development and Use of Voluntary Standards, February 10, 1998) encourage Federal Agencies to adopt recognized and applicable standards, harmonize the use of standards as opposed to developing unique government standards, and reduce or eliminate the burden in complying with NRC regulations. Moreover, the use of a dual system of radiation protection principles and dual dose calculation methods may be difficult to defend with stakeholders and may undermine public confidence on how the NRC manages its regulatory programs. The proposed revision to the basis of Appendix I objectives will be evaluated in assessing cost and benefits and qualitative factors in ensuring that all important particulars are considered in the decision making process.

Technical Considerations in Comparing Doses Based on ICRP 2 Dosimetry Concepts Against Doses Derived Under the Proposed Revision of Appendix I Using ICRP 103 Concepts

The basis of the dose criteria of Appendix I are founded on ICRP 2 dosimetry (i.e., whole body and critical organ dose concepts and models). The Appendix I dose criteria are defined for the total body, any organ, skin, and also include absorbed dose limits in air. A summary of the Appendix I design objectives are summarized in Table 1. This approach was consistent with that used in the prior version of Part 20, Standards for Protection Against Radiation. The current Part 20 applies the dosimetry concepts and dose calculation methodology of ICRP 26 and ICRP 30 in deriving doses to individuals. In Part 20, dose is expressed as TEDE, which incorporates a risk-based weighed dose by tissues or organs. The dose to the body is expressed in a single value instead of the old method of expressing separate doses for the whole body and critical organs.

In implementation, the current ICRP dose conversion factors are different than that of ICRP 2. If the basis of Appendix I design objectives were changed to current ICRP recommendations, one would expect some differences in doses for the same unit intake of radioactivity. As a result, there would be a need to assess the impacts of using alternate exposure-to-dose conversion factors on allowable amounts of effluents, while still complying with current Appendix **I** design

objectives and dose criteria. Specifically, such assessments would involve modeling exposure pathways and calculating doses using revised dose conversion factors and performing the same analysis using the method of Regulatory Guide 1.109. The analysis would consider using actual effluent releases from operating power plants and model representative boiling water reactor (BWR) and pressurized water reactor (PWR) plants. The plant data would consider amounts of radioactive materials released in air and water, and would consider plants located at salt and fresh water sites. The analysis would consider pathways defined in Regulatory Guide 1.109, including drinking water, inhalation, and consumption of fish, invertebrates, fruits, vegetables, milk, and meat. Other pathways to be considered would include shoreline recreation, and gamma and beta air doses.

The results would be compared and differences in doses will be expressed as ratios by pathways, age groups and organs, and types of plants (PWR or BWR). For example, the ratio of doses for exposure to the whole body would be expressed as the dose based on ICRP 103 conversion factors to that of Regulatory Guide 1.109 dose conversion factors. Detailed comparisons would be developed to identify and group radionuclides and pathways by their relative differences. The evaluation of the results would be used to consider impacts, assess if ED could be simply substituted for total doses in Appendix I, address differences in age groups and organs and associated doses between ICRP 103 and ICRP 2 calculation methods, determine whether the gamma and beta air doses should be retained in the revised implementation of Appendix I design objectives, and assess the implication of the revised method in complying with the EPA dose standards of 40 CFR Part 190. Finally, the evaluation will consider changes that will need to be made by licensees in procedures and supporting documents, such as standard radiological effluent controls, offsite dose calculation manual, and annual radiological effluent reports.

Table 1 - Summary of Appendix I Design Objectives and Dose Criteria

Type of Effluent	Pathway	Organ	Dose Limit (per yr per unit)
Liquid	All	total body	3 mrem (0.03 mSv)
	All	any organ	10 mrem (0.1 mSv)
Gaseous	All	total body	5 mrem (0.05 mSv)
	All	skin	15 mrem (0.15 mSv)
Radioiodines & Particulates	All	any organ	15 mrem (0.15 mSv)
Gaseous	gamma air dose	n/a	10 mrad (0.10 mGy)*
	Beta air dose	n/a	20 mrad (0.20 mGy)*

Note: * Air doses are expressed in mrad.