ATTACHMENT 1

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ATTACHMENT 2

DEFINITION OF TERMS

Virtually all the safety assessment and compliance analysis tools used in the Office of Nuclear Material Safety and Safeguards (NMSS) are a variety of systematic safety assessment methods. A subset of these systematic safety assessment methods are Probabilistic Safety Assessment (PSA) methods. Because the terminology is not standardized and because each group of users of such methods tends to use terms to stress a particular aspect of the methodology or its application, a variety of terms have been developed and employed in various applications. The following definitions are provided for clarification:

System Analysis - System analysis is a directed process for the orderly and timely acquisition and investigation of specific system information pertinent to a given decision. (Fault Tree Handbook, 1981)

Probabilistic Safety Assessment (PSA) - A wide class of probabilistic methods used to assess safety; this includes probabilistic risk assessment (PRA), risk assessment, failure mode and effects analysis, and performance assessment (PA).

Risk - The risk triplet is the set, $<s_i, f_i, x_i>$, in which s_i represents the ith scenario (sequence or progression); f_i is the associated frequency; and x_i is the resulting consequence. (S. Kaplan and B. J. Garrick, "On the Quantitative Definition of Risk")

Risk Assessment (RA) - "Risk Assessment refers to the technical assessment of the nature and magnitude of risk." (from: “Risk Analysis: A guide to principles and methods for analyzing health and environmental risks.” J.J. Cohrssen and V.T. Covello, CEQ, 1989)

Probabilistic Risk Assessment - "Probabilistic Risk Assessment is an analytical technique for integrating diverse aspects of design and operation in order to assess the risk of a particular nuclear power plant [facility] and to develop an information base for analyzing plant-specific [facility-specific] and generic issues. In achieving these objectives, probabilistic risk assessments serve many purposes." (from PRA Procedures Guide, 1982.) Note, this is a definition of PRA focused on U.S. Nuclear Regulatory Commission (NRC) reactor activities and is used as a term of art, within NRC, to denote analyses of reactor safety, usually with considerable detail regarding the component and system failures that lead to an accident. In some cases the plant systems analysis (Level I PRA) is expanded to include an analysis of accident progression and source term (Level II PRA) and further expanded to include consequence analysis and risk integration (Level III PRA) A broader community uses PRA to mean a broader variety of analyses devoted to other systems and with a wider range of complexity and detail.

Performance Assessment (PA) - PA, a type of systematic safety analysis, is a method: (1) to estimate the potential health, safety, and environmental effects of creating and using a nuclear waste facility; (2) to characterize these effects in terms of their magnitude and likelihood; (3) to compare the characterization of these effects with acceptability standards; and (4) to present the results of these analyses in a format useful to regulators, scientists, and the public. (Adapted from N. A. Eisenberg, et al., “A proposed validation strategy for the U.S. DOE Office of Civilian Radioactive Waste Management geologic repository program,” GEOVAL 1987) PA, as used programmatically in NMSS, includes any quantitative assessment or modeling

performed to evaluate a waste facility or part thereof, regardless of the degree to which the analysis is probabilistic.

Total System Performance Assessment (TSPA) -"Performance assessment is a method of forecasting how a system or parts of a system designed to contain radioactive waste will behave over time. Its goal is to aid in determining whether the system can meet established performance requirements. A TSPA is the subset of performance assessment analyses in which all of the components of a system are linked into a single analysis." (U.S. Department of Energy (DOE), "Viability Assessment of a Repository at Yucca Mountain, Total System Performance Assessment." 1998) This is clearly a term of art used by DOE to emphasize the complete nature of the analysis. It should be noted that although a TSPA must calculate some measure of total system performance, it may also calculate (most analyses do calculate) the performance of subsystems or provide intermediate results.

Integrated Safety Analysis (ISA) - An ISA is a systematic analysis to identify plant and external hazards and their potential for initiating accident sequences; the potential accident sequences and their likelihood and consequences; and the items (i.e., site, structures, systems, equipment, components, and activities of personnel) that are relied on for safety. This methodology, adapted from the chemical process industry, provides for flexibility in the scope and detail of the analysis, depending on the magnitude of the hazards and the nature of the system. This method has been used in NMSS to address the safety in fuel fabrication facilities and in spent fuel storage facilities.

ASSOCIATION OF RISK ASSESSMENT METHODS WITH REGULATED USES OF NUCLEAR MATERIALS

Group	Description	Regulated Activities	Risk Assessment Method
1	Activities that involve long-term commitment of a site or facility to the presence of nuclear material at a planned, acceptable level	-High level waste (HLW) disposal -Low level waste (LLW) disposal -Decommissioning (residual contamination) -Mill tailings reclamation	Performance Assessment
2	Activities that involve the use of engineered casks to isolate nuclear material under various normal and off-normal conditions	-Transportation -Dry cask storage	Probabilistic Risk Assessment or Integrated Safety Analysis (ISA)
3	Activities that involve chemical and physical processing of nuclear material at a large-scale facility	-Mining and milling of source material -Uranium hexaflouride conversion -Enrichment -Fuel fabrication -Pre-closure activities related to HLW and LLW disposal -Waste treatment facility (vitrification)	ISA
4	Activities that involve the use of either sealed or unsealed byproduct material in industrial and medical applications	-Irradiators -Radiography -Medical Uses -Well Logging -Laboratory Use -Manufacturing and Distribution -Gauges -measuring Systems -Waste Disposal (incineration, packaging processing)	Hazard/Barrier Analysis (Nuclear Byproduct Material Risk Review assessment methodology)

ATTACHMENT 3

POTENTIAL REGULATORY USE OF RISK ASSESSMENT METHODS

Group	Activity	Regulatory Manifestation of Risk Insights	Licensee Use of Risk Assessment	Staff Use of Risk Assessment
1	High-level waste (HLW) disposal	Probabilistic dose standard codified by rule	Performance assessment (PA) to show compliance with standard	PA to develop risk insights in support of rulemaking and development of guidance. PA to support independent review of licensee's analysis
1	Low-level waste (LLW) disposal	Dose standard, for reasonable scenarios, codified by rule	PA to show compliance with standard	PA to develop risk insights in support of development of guidance. PA to support independent review of licensee's analysis
1	Decommissioning (residual contamination)	Dose standard, for reasonable scenarios, codified by rule	PA to show compliance with standard. Guidance will permit simplified analysis in most cases.	PA to develop risk insights in support of development of guidance. PA to support independent review of licensee's analysis
1	Mill tailings reclamation	Uranium Mill Tailings Radiation Control Act and associated Environmental Protection Agency standards establish an immutable basis	None	None
2	Transportation	Performance-based criteria and guidance and risk-informed regulatory decisions (e.g., Trojan vessel) derived from risk insights	Applicant/licensee may perform risk assessment to support regulatory actions (e.g., Trojan reactor vessel).	Probabilistic risk assessment (PRA) or Integrated Safety Analysis (ISA) to develop risk insights that underpin regulations and guidance
2	Dry cask storage	Performance-based criteria and guidance and risk-informed regulatory decisions derived from risk insights	Applicant/licensee may perform risk assessment to support regulatory actions.	PRA or ISA to develop risk insights that underpin regulations and guidance
3	Mining of source material	Prescriptive criteria and guidance derived from risk insights	None	ISA to develop risk insights that underpin regulations and guidance
3	Milling of source material	Prescriptive criteria and guidance derived from risk insights	None	ISA to develop risk insights that underpin regulations and guidance
3	UF-6 conversion	Performance requirements comprised of radiological consequences, given the likelihood of occurrence	ISA summary to demonstrate compliance with performance requirements	ISA summary forms the basis for regulatory activities.
3	Enrichment	Performance requirements comprised of radiological consequences, given the likelihood of occurrence	ISA summary to demonstrate compliance with performance requirements	ISA summary forms the basis for regulatory activities.
3	Fuel fabrication	Performance requirements comprised of radiological consequences given the likelihood of occurrence.	ISA summary to demonstrate compliance with performance requirements.	ISA summary forms the basis for regulatory activities.
3	Pre-closure activities for HLW disposal	Dose standard for normal operations and a spectrum of likely scenarios	ISA to show compliance with dose standards	ISA to support independent review of any licensee analyses that may bear significantly on post-closure repository performance
3	Pre-closure activity for LLW disposal	Dose standard for normal operation and prescriptive requirements for off-normal conditions	None	None

3	Waste treatment facility (vitrification)	Performance requirements comprised of radiological consequences, given the likelihood of occurrence.	ISA summary to demonstrate compliance with performance requirements	ISA summary forms the basis for regulatory activities.
4	Sealed Sources	Regulatory requirements ranging from exemption to specific licensing criteria	None	Ongoing refinement to develop risk insights that underpin regulations, licensing and inspection practices, and guidance
4	Unsealed Byproduct Material	Regulatory requirements ranging from exemption to specific licensing criteria	None	Ongoing refinement to develop risk insights that underpin regulations, licensing and inspection practices, and guidance

ATTACHMENT 4

A FRAMEWORK FOR APPLYING RISK ASSESSMENT TO REGULATING NUCLEAR MATERIAL USES AND DISPOSAL

1. THE REACTOR FRAMEWORK OF SECY-95-280

As described in SECY-95-280, the reactor framework is a general structure to ensure consistent and appropriate application of probabilistic risk assessment (PRA) methods. It has four parts. The first defines regulatory application areas (e.g., graded quality assurance) in which PRA can play a role in the U.S. Nuclear Regulatory Commission's (NRC's) decision-making process. The areas are grouped by the expected sophistication of the PRA required (ranging from PRAs based on generic data to state-of-the-art PRAs using plant-specific data). The second part entails an evaluation of the deterministic engineering considerations underlying the application area to ensure that the existing deterministic engineering approach is altered only after careful consideration. Factors to be considered include: defense-in-depth, the single-failure criterion, and appropriate codes and standards. The third part of the framework is an evaluation of risk issues in support of the proposed regulatory action. Elements of this evaluation include: scope and level of detail of the PRA, human and equipment reliability, sensitivity and uncertainty analyses, and assurance of technical quality. The final part integrates the deterministic and risk considerations to ensure a consistent and scrutable decision-making process and to ensure that the underlying bases for rules, regulations, regulatory guides, and staff review guidance are maintained or modified to the extent supported by the risk and engineering conclusions of parts two and three.

This framework is implemented through a six-step process. The first step is to identify the specific regulatory applications that are amenable to expanded use of PRA information and to identify responsible staff organizations and pilot plants. The second is to conduct pilot programs for selected regulatory application areas. These projects provide insight into the treatment of issues, the selection of risk metrics, and the development of standards and guidance. The third step of the implementation process is to develop and document the acceptance process and criteria. The fourth step is to make near-term regulatory decisions in response to industry requests and initiatives. The fifth is to develop formal PRA standards, working with appropriate professional societies and industry groups. Finally, the sixth step is to make long-term modifications to the regulations, if necessary.

2. RISK ASSESSMENT IN MATERIALS REGULATION--COMPARISON WITH REACTORS

SECY-98-138 discussed the following differences between the nuclear materials and reactor programs in terms of developing a framework for using risk-assessment in nuclear materials regulation:

1. PRA may be applicable only for a few nuclear material uses; other risk assessment methods may be needed for most such uses;

2. Integrating probabilistic and deterministic considerations is not as important in regulating nuclear material uses as it is in reactor regulation;

3. Relating analytical methods to specific applications is much more important for

materials applications;

4. A broad range of licensee and regulator circumstances will need to be considered.

3. A FRAMEWORK FOR NUCLEAR MATERIAL USES AND DISPOSAL

These differences are addressed by a framework that is quite similar to the reactor framework of SECY-95-280. It too has four parts. Like the reactor framework, the first part defines regulatory application areas in which risk assessment methods can play a role in NRC's decision-making process. The areas are grouped by regulated use (e.g., fuel fabrication) and within each use by regulatory application (e.g., graded quality assurance). The second part entails an evaluation of the current considerations underlying the application area to ensure that the existing approach is altered only after careful consideration. Factors to be considered include: deterministic considerations [hazard, relative importance of human vs. equipment error, defense-in-depth (where applicable), codes and standards];, current risk considerations (e.g., use of performance assessment in geologic repository licensing); and institutional considerations (existing statutory requirements, Agreement State issues, and licensee circumstances). The third part of the framework is an evaluation of new risk considerations in support of the proposed regulatory action. Elements of this evaluation include: scope and level of detail of the risk assessment, sensitivity and uncertainty analyses, and assurance of technical quality. The final part integrates the current considerations and new risk considerations to ensure a consistent and scrutable decision-making process and to ensure that the underlying bases for rules, regulations, regulatory guides, and staff review guidance are maintained or modified to the extent supported by the conclusions of parts two and three.

This framework will be implemented through a five-step process. The first step is to identify the specific regulatory applications that are amenable to expanded use of risk assessment information and to identify responsible staff organizations. This step would be accomplished by identifying a full set of regulatory application areas as defined above and then screening them to establish a set of applications that would be amenable to risk-informed (RI) regulatory approaches. The staff would intend to systematically evaluate all of its regulatory applications in this manner, but external considerations would be used to prioritize which would be treated first. For example, the staff is currently working with an RI approach for total system performance of a geologic repository for high-level radioactive waste (HLW) because of external considerations regarding the national HLW program. Because of limited resources, the staff is proposing this step-by-step approach, rather than a comprehensive reevaluation in all areas simultaneously. On this prioritized basis, the technical and programmatic factors affecting the choice of risk metrics and goals in each regulatory application area would be systematically evaluated. Consideration would be given to: (1) the costs, both to the staff and licensees, of implementing a new approach; and (2) the benefits, in terms of risk reduction and/or elimination of unnecessary regulatory burdens. This evaluation would use predictive or actuarial risk studies, as appropriate. Given these considerations, the staff would decide whether it seems appropriate to change the existing regulatory framework and, if so, propose risk metrics and goals as a basis for interaction with stakeholders. Such interaction would include stakeholder workshops, Internet postings, and possibly pilot projects.

The second step is to decide how to modify the current approach of the regulatory application

areas that are determined to be amenable to RI approaches. Stakeholder workshops, Internet postings, and pilot projects will be used as an important source of information to address the following considerations: (1) what specific use is the staff expected to make of risk insights and risk assessment in development of regulations and guidance, licensing, inspection, assessment, and enforcement? and (2) what specific use is the licensee expected to make of risk insights and risk assessment in planning and conducting its operations? The third step is to make the appropriate changes to the rules and regulations, staff review plans, and Regulatory Guides. Where feasible, the staff would encourage industry development of voluntary standards. The fourth step is staff training to assure consistent and knowledgeable implementation of the new RI approaches, and the fifth step is to develop or adapt needed tools (e.g., risk assessment methods or computer codes). This five-step implementation process is shown in Figure 1.

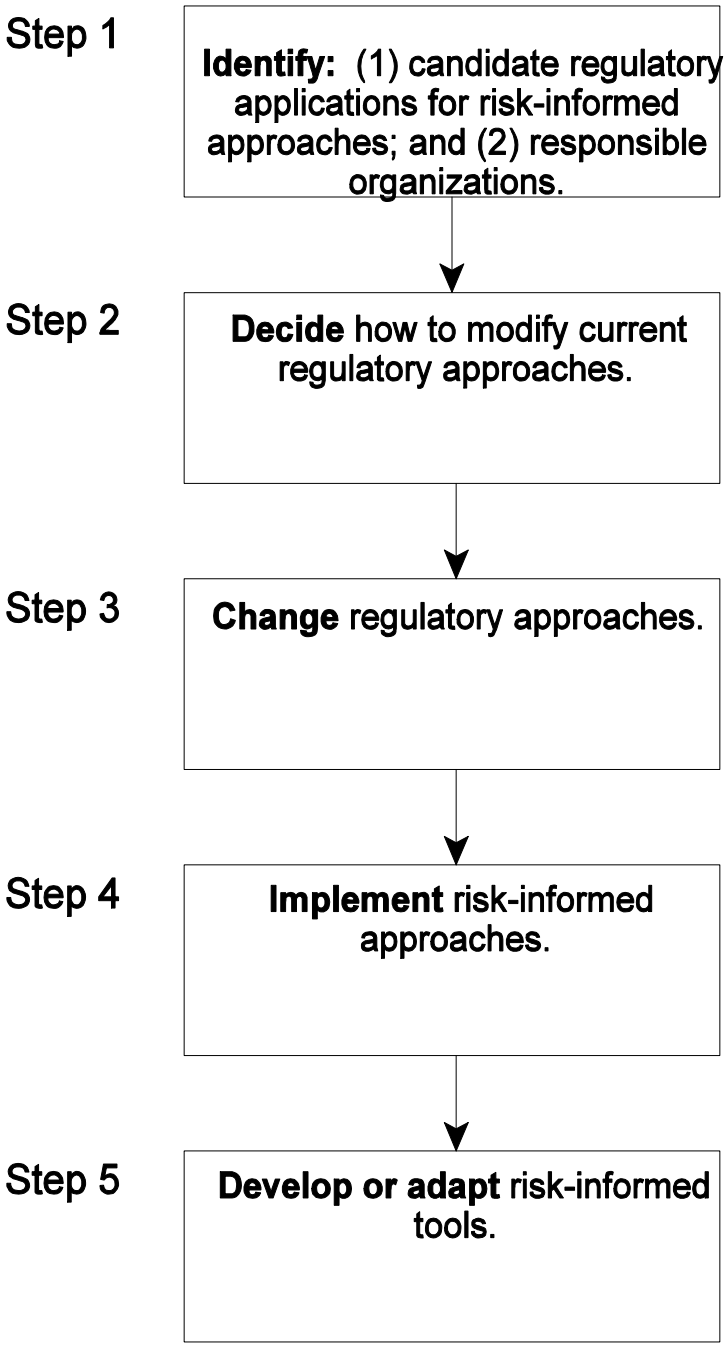

Figure 1. Five-step implementation process.

ATTACHMENT 5

Summary of dose limits & target populations

Dose or Dose Limit	Regulatory Basis	Target Population	Reference
500 rem	ICRP & NCRP recommendation	Max equivalent dose to the skin of an occupational workers for emergency life-saving efforts	NCRP #116 (p. 44)
400 rem	NCRP Recommendation	Career Male astronaut whole body dose equivalent limit[1]	NCRP #98 (p. 7)
300 rem	NCRP Recommendation	Career Female astronaut whole body dose equivalent limit[1]	NCRP #98 (p. 7)
300 rem	10 CFR 100	Max total radiation dose for a 2 hour period to the thyroid from a postulated fission product release if an individual were present at any point of a nuclear reactor's exclusion area boundary	10 CFR 100.11(a)(1)
250 rem	NCRP Recommendation	Theoretical occupational Lifetime dose	NCRP #98 (p. 7)
100 rem	NCRP Recommendation	Whole body dose for life-saving actions (valid until 1986)	NCRP #39[2] (p. 100)
50 rem	ICRP & NCRP Recommendation	Max effective dose to an occupational worker for emergency life-saving efforts	NCRP #116 ICRP 60
50 rem	10 CFR 20	Annual organ or tissue dose other than lens of the eye; Shallow dose equivalent to the skin or any extremity	10 CFR 20.1201
>25 rem	EPA Protective Action Guides	Voluntary Whole body dose for life-saving actions & protection of large populations	EPA-400-R-92-001 (May 1992)
25 rem	10 CFR 100	Max total radiation dose for a 2 hour period to the whole body from a postulated fission product release if an individual were present at any point of a nuclear reactor's exclusion area boundary	10 CFR 100.11(a)(1)
25 rem	EPA Protective Action Guides & USNRC RG 8.29	Whole body dose for life-saving actions & protection of large populations	EPA-400-R-92-001 (May 1992); RG 8.29 (p.13)
25 rem	10 CFR 20 & 10 CFR 835	Lifetime dose limit for individuals participating in planned special exposures	10 CFR 20.1206(e)(2) & 10 CFR 835.204

[1] Career whole body dose equivalent limit at age 55 based on a lifetime excess risk of cancer mortality of 3×10^{-4} per rad.

[2] NCRP Report No. 39 (1971) has been superseded by NCRP report No. 116 (1993)

Dose or Dose Limit	Regulatory Basis	Target Population	Reference
18.75 rem	29 CFR 1910	Max quarterly dose for hands and forearms; feet and ankles (osha-regulated activities)[3]	29 CFR 1910.96 (b)
15 rem	10 CFR 20	Annual eye dose equivalent (lens of the eye)	10 CFR 20.1201
10 rem	USNRC RG 8.29	Acute emergency exposure for protecting valuable property	RG 8.29 (1996) (p. 8.29-13)
10 rem	NCRP Recommendation	Acute emergency exposure for life-saving actions	NRCP # 91 (p. 36)
7.5 rem	29 CFR 1910	Max quarterly dose to skin of whole body of occupational workers (osha-regulated activities)	29 CFR 1910.96 (b)
5 rem	10 CFR 20 & 10 CFR 835	Annual Exposure Limit for Occupational Workers (NRC, DOE & States)	10 CFR 20.1201 & 10 CFR 835.202
5 rem	10 CFR 72	Max whole body dose to any individual located on or beyond the nearest boundary of the controlled area of an ISFSI or MRS[4]	10 CFR 72.106
5 rem	10 CFR 35	Notification limits for medical misadministrations involving members of the public	60 FR 48623 (Oct 1995)
3 rem	29 CFR 1910	Max quarterly dose to the whole body (OSHA-regulated activities)	29 CFR 1910.96
2 rem	EPA	Remedial annual action level for naturally occurring radiation (radon) for members of the public (corresponds to 2 WLM[5])	NCRP #116 (p. 49)
1.875 rem	OSHA	Max quarterly hand or forearm dose to a minor (under age 18)	29 CFR 1910.96(b)(3)
1.5 rem	IAEA Recommendation	Threshold for conducting environmental monitoring and assessments of radiation exposure levels in work areas due to the transport of radioactive material	IAEA Safety Series #6 (1985)
1.25 rem	49 CFR 172	Max quarterly EDE for occupational radiation exposure resulting from transportation activities	49 CFR 172.803 (b)(1)
1 rem	---	Avg astronaut Exposure per Flight Mission	NCRP #94

[3] OSHA-Regulated activities include occupational exposure from facilities other than those regulated by nrc or an agreement state. These may include radiation exposures from x-rays or linear accelerators operated by non-agreement states.

[4] ISFSI = Independent Spent Fuel Storage Installation; MRS = Monitored retrievable storage installation

[5] One working level month (WLM) is approximately equal to an annual exposure to an average of 4 pCi per liter of radon if the radon products are in 50% equilibrium with the radon. One WLM exposure would result from being exposed to 1 working level (WL) for a period of 1 working month (i.e. 170 hrs)

Dose or Dose Limit	Regulatory Basis	Target Population	Reference
1 rem	EPA	EPA public protection action guide limit for evacuation & shelter	EPA 400-R-92-001 (pp. 2-6)
750 mrem	OSHA	Max quarterly skin of whole body dose to a minor (under age 18)	29 CFR 1910.96(b)(3)
650 mrem	---	Avg ede[6] per diagnostic Nuclear brain scan	NCRP #93 (p 46)
540 mrem	10 CFR 20[7]	Avg annual measurable dose per radiographer (1993)[8]	NUREG-0713 Vol 15 (p. 4-6)
500 mrem	10 CFR 35	Proposed patient release criteria	SECY-96-100 & NUREG-1492
500 mrem	10 CFR 20, 10 CFR 835 & 49 CFR 172	Max dose equivalent limit to the embryo/fetus (entire gestation period)	10 CFR 20.1208, 10 CFR 835.206 & 49 CFR 172.803 (b)(3)
500 mrem	ANSI, Non-agreement State regs	Design criteria for shielding for radiation-producing machines (i.e., teletherapy, x-ray machines, irradiators)	ANSI N433.1 & NCRP #49
500 mrem	NCRP Recommendation	Max annual effective dose limit for infrequent annual exposures to members of the public	NCRP #116 (p. 46)
500 mrem	NCRP Recommendation	remedial annual action limit recommended for continuous exposures from natural sources (excluding radon)	NCRP #116 (p. 50)
500 mrem	49 CFR 172 & EPA FRC Guidance[9]	Max annual radiation exposure to members of the general public from transporting radioactive material	49 CFR 172.803 (b)(2) IAEA Safety Series #6
360 mrem	---	Annual TEDE for public (including annual medical exposure)	NCRP #101 (p. 73)
300 mrem	---	Annual TEDE for public (Excluding annual medical exposure)	NCRP #94

[6] EDE = Effective dose equivalent

[7] Resultant Average dose from the application of regulatory requirements in 10 CFR Part 20 (i.e., ALARA)

[8] Number of radiographers monitored for radiation exposure in 1993 was 4720.

[9] EPA's Federal Radiation Council (FRC) guidance was issued in 1960. EPA is currently developing guidance for regulatory agencies for limiting radiation exposures to members of the general public, and the anticipated annual limit is expected to be 100 mrem/yr. however, as of 1996, this new EPA guidance document has not been issued.

Dose or Dose Limit	Regulatory Basis	Target Population	Reference
270 mrem	10 CFR 20[10]	Avg annual measurable occupational dose per worker at LWRs (1993)[11]	10 CFR 20.1201
200 mrem	---	Avg annual dose to members of the public from radon	NCRP #93, #116 (p. 59; 45)
160 mrem	OSHA	Avg annual dose equivalent to Airplane Crew Members	NCRP #94 (p. 22)
125 mrem	OSHA	Max quarterly whole body dose to a minor (under age 18)	29 CFR 1910.96(b)(3)
100 mrem	10 CFR 20 & 10 CFR 835	Max annual Dose limits for members of the public	10 CFR 20.1301 & 10 CFR 835.208
100 mrem	IAEA B.S.S.[12]	Max annual dose equivalent for non-radiation workers (& shielding design specifications)	IAEA Safety Series 115-I
100 mR/wk	49 CFR 172	Max weekly radiation exposure to members of the public from transportation of radioactive material	49 CFR 172.803 (b)(2)
85 mrem	Proposed 40 CFR 196	Max dose "cap" to an individual for restricted use (EPA's proposed decommissioning std)	SECY-96-082 & Proposed 40 CFR 196.11 (d)(2)
75 mrem	10 CFR 72	Max annual dose equivalent to the thyroid of any real individual located beyond the controlled area resulting from radioactive materials in effluents and direct radiation from an ISFSI or MRS	10 CFR 72.104
50 mrem	10 CFR 20 App B, Tbl 2	Annual TEDE to members of the public resulting from the inhalation or ingestion of radionuclides continuously for a year	Part 20
50 mrem	29 CFR 1910	Max TEDE from inhalation or ingestion to a minor (under age 18) (Refs to 10 CFR 20)	29 CFR 1910.96(c)(2)
25 mrem	10 CFR 20	Licensees (i.e., fuel cycle facilities) subject to EPA's generally-applicable environmental radiation standards in 40 CFR 190	10 CFR 20.1301(d) & 40 CFR 190.10
25 mrem	10 CFR 40, App A	Max annual public dose equivalent cannot exceed 25 mrem whole body, 75 mrem thyroid, and 25 mrem to any other organ as a result of exposure to planned discharges of radioactive materials, Rn-220 and its daughters excepted to environment.	10 CFR Part 40, Criterion 8

[10] Resultant average dose in 1993 from the application of regulatory requirements in 10 CFR Part 20 (i.e., ALARA)

[11] Total number of commercial LWR workers monitored for radiation exposure in 1993 was 169,862. NUREG-0713, Vol 15, p.4-6.

[12] IAEA B.S.S. = International Basic safety standards for protection against ionizing radiation and for the safety of radiation sources, Safety Series No. 115-I (1994).

Dose or Dose Limit	Regulatory Basis	Target Population	Reference
25 mrem	10 CFR 61	Max offsite releases to any member of the public for both operations and post-closure are limited to 25 mrem whole body, 75 mrem thyroid, & 25 mrem other organ	10 CFR 61.41
25 mrem	10 CFR 72	Max annual dose equivalent to the whole body or other organ of any real individual located beyond the controlled area resulting from radioactive materials in effluents and direct radiation from an ISFSI or MRS	10 CFR 72.104
25 mrem	40 CFR 190	Annual dose equivalent shall not exceed 25 mrem whole body, 75 mrem thyroid, & 25 mrem other organ as the result of planned discharges from uranium fuel cycle operations to the environment.	40 CFR 190.10
25 mrem	NCRP Recommendation	Max annual exposure to members of the public from a single source or set of sources under one control	NCRP #116 (p. 47)
20 mrem	---	Max individual public exposure due to transportation of radioactive material	NCRP #92 (p. 165)
20 mrad	10 CFR Part 50 Appendix I	Max annual beta air dose from gaseous effluents at any location near ground level from each LWR for any individual occupying an unrestricted area	10 CFR 50, App I Section II (B.1.)
15 mrem	Proposed 40 CFR 196	Annual EDE from all exposure pathways from a decommissioning site	40 CFR 196.11
15 mrem	10 CFR Part 50 Appendix I	Max annual organ dose or dose commitment from radioactive iodine or RAM in particulate form from effluents release from each LWR for any individual occupying an unrestricted area	10 CFR 50, App I, Section II (C.)
10 mrem	---	Avg annual effective dose equivalent to individuals in the U.S. from consumer products	NCRP #93 (p. 59)
10 mrad	10 CFR Part 50 Appendix I	Max annual gamma air dose from gaseous effluents at any location near ground level from each LWR for any individual occupying an unrestricted area	10 CFR 50, App I Section II (A)
10 mrem	EPA's clean air act	Max dose limit to members of the public from radioactive air effluents resulting from facilities regulated under this subpart	40 CFR Part 61, Subpart I
10 mrem	10 CFR Part 50 Appendix I	Max annual organ dose or dose commitment from liquid effluents from each LWR for any individual in an unrestricted area	10 CFR 50, App I Section II (A)

Dose or Dose Limit	Regulatory Basis	Target Population	Reference
4 mrem	Proposed 40 CFR 196	Max annual dose to any internal organ or the total body[13] corresponding to individual MCLs specified in 10 CFR 141 for protection of groundwater at a remediated site	40 CFR 196.23 (1) (See also 40 CFR 141.16)
3 mrem	10 CFR Part 50 Appendix I	Max annual total body dose or dose commitment from liquid effluents from each LWR for any individual in an unrestricted area	10 CFR 50, App I Section II (A)
2 mrem in any one hr	10 CFR 20	Max Dose Limit to members of the public in an unrestricted area from external sources[14]	10 CFR 20.1301 (a)(2)
2 mR/hr	10 CFR 71	Max external radiation level for packages in any normally occupied space (i.e., location of driver transporting radioactive material)	10 CFR 71.47 (b)(4)
2 mR/hr	49 CFR 172	Max radiation exposure to members of the general public from transportation of radioactive material	49 CFR 172.803 (b)(2)
1 mrem	IAEA Safety Series	Max annual individual dose equivalent per source or practice within the range of risks to be considered "Trivial." Also called "negligible individual dose (NID)"	IAEA Safety Series 89; IAEA-TECDOC-855 & NCRP #116 (p. 5)

[13] The 4 mrem/yr groundwater standard is derived from the average annual concentration of beta particle and photon radioactivity from man-made radionuclides in drinking water which would produce an annual dose equivalent of 4 mrem to the total body or any internal organ (see 40 CFR 141.16). NBS Handbook 69 (Aug 1963) is used as the basis for deriving these quantities, and each vary from the 4 mrem standard (For example., the MCL for Sr-90 = 0.07 mrem/yr; the MCL for uranium = 0.7 mrem/yr).

[14] In the statements of consideration for the revised 10 CFR Part 20 (see 56 FR 23374), the reason stated for the inclusion of the dose rate limit of 2 mrem in any one hour was that the limit "provides a more readily measurable quantity than the 100 mrem/yr value and can be more easily verified by short-term measurements."

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