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Assessing the Radiological Consequences of Accidental Releases of Radioactive Materials from Liquid Waste Tanks for Combined License Applications

Interim Staff Guidance

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(Final)

INTERIM STAFF GUIDANCE

ASSESSING THE RADIOLOGICAL CONSEQUENCES OF ACCIDENTAL RELEASES OF RADIOACTIVE MATERIALS FROM LIQUID WASTE TANKS FOR COMBINED LICENSE APPLICATIONS

DC/COL-ISG-013

Purpose

The purpose of this Interim Staff Guidance (ISG) is to clarify previous U.S. Nuclear Regulatory Commission (NRC) guidance on reviewing the analysis of the radiological consequences of accidental releases of radioactive materials to groundwater and surface water. Such analyses are required as part of the licensing review of application for new nuclear power reactor applications under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50 and 10 CFR Part 52. Standard Review Plan (SRP), NUREG-0800, Sections 2.4.13 and 11.2, and Branch Technical Position (BTP) 11-6, describe acceptable guidance on how to assess the radiological consequences of such releases. However, at present, the two SRP sections [and BTP 11-6] are not internally consistent in identifying acceptable criteria for assessing the consequences of accidental releases of radioactive materials or in providing guidance to the staff and applicants for use in establishing conditions for such releases and in defining acceptable assumptions for describing exposure scenarios and pathways to members of the public.

Therefore, the primary focus of this ISG is to provide guidance defining the mechanism of the assumed tank failure, development of the radioactive source term, assumptions and level of conservatism used in the analysis, and approach applied in assessing the radiological impacts at the assumed location of the dose receptor. Because of the complexity of the issues related to the radiological consequences of groundwater contamination, guidance on this topic has been divided between this ISG and ISG-014[1]. These two ISGs are intended to be used together.

The primary focus of ISG-014 is to provide guidance on analyzing the subsurface transport of radioactivity in groundwater and surface water through the use of a structured hierarchical approach. ISG-014 emphasizes the consideration of hydrogeologic conditions that control the transport of radioactive materials considered in the analysis.

While this ISG is concerned with hydrogeologic conditions, its primary emphasis is on how radiological consequences are determined when considering various factors, such as the location and assumed failure mechanisms, types and concentrations of radioactive materials contained in accidental releases, the role of mitigating plant and system design features in reducing releases, the definition of the assumed exposure scenarios and dose receptors, and technical specifications in limiting the content of radioactive materials in tanks. This ISG

[1] ISG-014, Assessing the Radiological Consequences of Accidental Releases of Radioactive Materials from Liquid Waste Tanks in Ground and Surface Waters for Combined License Applications.

focuses on supplementing the guidance contained in, and resolving inconsistencies among, three existing guidance documents:

- SRP Section 2.4.13 “Accidental Releases of Radioactive Liquid Effluents in Ground and Surface Waters”;
- SRP Section 11.2 “Liquid Waste Management System”; and
- Branch Technical Position BTP 11-6 “Postulated Radioactive Releases Due to Liquid-Containing Tank Failures”

Background

This ISG is primarily concerned with clarifying the existing guidance contained in SRP Sections 2.4.13 and 11.2 and BTP 11-6. The focus and objective of each of these guidance documents, however, are different.

1. SRP Section 2.4.13

The focus of SRP Section 2.4.13 is on the characterization and identification of site properties that would affect the transport of radioactivity from accidental releases of radioactive liquid waste introduced in groundwater and surface water under most adverse accident conditions and natural phenomena. This section makes use of certain analyses covered by SRP Section 2.4.12, in particular analyses of groundwater flow systems and groundwater flow velocity. The staff uses the information obtained from such characterizations to develop site-specific hydrogeologic models, identify critical pathways, and identify site features that would be influential in the transport, dispersion, dilution and concentration of radioactive contaminants.

The requirements and acceptance criteria of SRP Section 2.4.13 include 10 CFR 100.10(c) and 10 CFR 100.20(c); General Design Criterion (GDC) 2 of 10 CFR Part 50, Appendix A; 10 CFR 52.17(a)(1)(vi) for early site permit (ESP) applications and 10 CFR 52.79(a)(1)(iii) for combined license (COL) applications; and Regulatory Guide (RG) 1.113, “Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I.” The acceptance criteria addressing site geology and hydrology are being clarified in ISG-014.

The review addresses on-site features that must be considered in analyzing the consequences of a release of radioactive materials into groundwater and surface water resources, with an emphasis on site information derived from onsite measurements. Compliance with 10 CFR 100.20(c) requires that the site’s physical characteristics (including seismology, meteorology, geology, and hydrology) be taken into account when determining its acceptability for a nuclear power reactor.

To satisfy the hydrological requirements of 10 CFR Part 100, the applicant’s Safety Analysis Report (SAR) needs to consider local geological and hydrological characteristics when determining the acceptability of the site. The geological and hydrological characteristics of the site have a bearing on the transport and potential consequences of radioactive effluents accidentally released from the facility. Applicants should consider the use of mitigating design features (such as steel liners installed in tank rooms, and dikes or retention basins installed around outdoor tanks) if a reactor is to be located at a site where radioactive liquid process streams and wastes could readily flow into nearby streams or rivers or find ready access to aquifers, and, thereby, impact members of the public.

2. SRP Section 11.2

The focus of SRP Section 11.2 is on the Liquid Waste Management System (LWMS). The LWMS ensures that liquids and liquid wastes produced during normal operation and anticipated operational occurrences are handled, processed, recycled as coolant, or released in accordance with relevant NRC regulations and guidance. Typically, the LWMS includes tanks, pumps, filters, demineralizers, and additional equipment that are necessary to process, treat, and store liquid wastes. Besides the LWMS, other plant systems have tanks that contain large amounts of radioactive liquids; such systems include condensate storage tanks and refueling water storage tanks, located outside of containment or outdoors.

The requirements and acceptance criteria that are particularly relevant to this ISG include GDC 2 and 61 of 10 CFR Part 50, Appendix A, and effluent concentration limits and unity rule of Table 2, Column 2 of Appendix B to 10 CFR Part 20. Compliance with GDC 60 and 64 requires, as addressed in SRP Section 11.5 in demonstrating compliance with liquid effluent releases, that the nuclear power plant design shall include means to control and monitor releases of radioactive materials in gaseous and liquid effluents and provide adequate safety during normal reactor operation, including anticipated operational occurrences.

GDC 2 and 61 are applicable because these SRP sections are concerned with tanks and associated components outside of containment or outdoors that could contain radioactive liquids. A single failure of one of these tanks could release radioactive liquids to surface water or groundwater and potentially impact the public and result in unnecessary radiation exposures.

Meeting these criteria provides assurance that releases of radioactive materials due to a single failure of liquid-containing tanks outside of containment or outdoors during normal operations or anticipated operational occurrences will not result in useable water concentrations exceeding the limits and unity rule specified in Appendix B to 10 CFR Part 20. Under the existing guidance, the effluent concentration limits and unity rule of Appendix B to Part 20 are applied as acceptance criteria only for the purpose of assessing the acceptability of the results of the consequence analysis.

Compliance with the requirements of 10 CFR 20.1406 addressing the minimization of contamination of plant facilities and avoidance of unmonitored and uncontrolled releases of radioactive materials are addressed separately. Besides the requirements of 10 CFR 20.1406, NRC guidance is presented in RG 1.143 (Design Guidance for Radioactive Waste Management Systems, Structures and Components Installed in Light-Water-Cooled Nuclear Reactor Power Plants), RG 4.21 (Minimization of Contamination and Radioactive Waste Generation: Life Cycle Planning), and ISG-06 (Evaluation and Acceptance Criteria for 10 CFR 20.1406 to Support Design Certification and Combined License Applications) (Ref. 19, 21, and 27). Industry guidance is contained in American National Standards Institute (ANSI)/American Nuclear Society (ANS) (ANSI/ANS 2007), and Nuclear Energy Institute (NEI) 08-08A in considering the incorporation of specific design features (Ref. 23, 24, and 28).

3. BTP 11-6

BTP 11-6 of SRP Section 11.2 complements both SRP Sections 2.4.13 and 11.2 by providing specific guidance on how to evaluate the consequences of a radioactive release due to a failure of a tank containing radioactive liquid. In BTP 11-6, the NRC staff considers a gross failure of a tank and components to be unlikely, such as a failure involving the near total loss of the system's inventory of radioactive materials. However, the malfunction of a tank and its components, a valve misalignment, tank overflow, or an operator error appear more likely and are assumed to be the types of failures warranting an evaluation of their consequences. Although BTP 11-6 designates no specific types of system failures as being representative, the guidance considers that for the evaluation of such systems, the type of malfunctions analyzed should be limited to the postulated failure or rupture of a tank located outside of containment or outdoors. The evaluation considers the impact of the failure on the nearest potable water supply in the unrestricted area, and the long-term use of water for direct human consumption or indirectly through animals (livestock watering), crops (agricultural irrigation), and food processing (with water being an ingredient).

BTP 11-6 provides guidelines for defining the mechanism of the failure, assumptions used for the analysis, and approach applied in assessing the radiological impact. The objective is to develop an estimate of the amounts of radioactive materials released in an unrestricted area, and to assure that the radiological consequences will not exceed SRP acceptance criteria. Licensees use the results of this analysis to develop technical specification limits for liquid holding tanks to comply with 10 CFR 50.36a and design objectives for liquid effluents under 10 CFR 50.34a.

Issue

The issue being addressed in this ISG is the inconsistent guidance presented in SRP Sections 2.4.13 and 11.2 and BTP 11-6. The major differences between the two SRP sections are:

1. The requirements and acceptance criteria of SRP Section 2.4.13 include 10 CFR Part 100, GDC 2, and RG 1.113. The focus of 10 CFR 100.10(c) and 10 CFR 100.20(c) is on-site features that have a bearing on the analysis of the consequences of a release of radioactive materials into groundwater and surface water resources, with an emphasis on site information derived from onsite measurements. However, SRP Section 2.4.13 does not address whether the applicant has included design features that would mitigate the impact from the release of radioactivity in the nearest groundwater or surface water body. Moreover, the SRP guidance places an emphasis on applying very conservative assumptions, such as "most adverse contamination," "extreme events," or "the most severe of natural phenomena," while SRP Section 11.2 and BTP 11-6 do not apply conservative assumptions to the same extent. Finally, BTP 11-6 sets forth specific

requirements, based on RG 1.143, but does not prohibit the implementation of more rigorous design codes, standards, or quality assurance measures. Also, it does not require a re-evaluation of LWMS with limiting conditions or controls for operation based on more conservative analysis and assumptions used in demonstrating compliance with its acceptance criteria.

2. SRP Section 11.2 and BTP 11-6 considers site features that are important in assessing the consequences of a release of radioactive materials in the nearest groundwater or surface water body. These documents also provide guidance on how to develop the radioactive source term, consider whether design features are included that might mitigate the impact of a release, and provide acceptance criteria based on annual average effluent concentration limits and the unity rule of Table 2, Column 2, in Appendix B to 10 CFR Part 20. In the context of BTP 11-6, the acceptance criteria apply at the nearest source of potable water, i.e., point of use in unrestricted areas.

Rationale for Revision

The staff finds, based on experience with reviews of COL applications, that the current guidance is inconsistent between SRP Sections 2.4.13 and 11.2, and BTP 11-6 of SRP Section 11.2, and is difficult to implement. To address these inconsistencies and implementation issues, the staff will:

1. define a consistent set of acceptance criteria in both SRP sections with which to assess the results of a consequence analysis;

2. incorporate into SRP Section 2.4.13 provisions in considering plant design features that would mitigate the impact of a release;

3. re-assess whether the approach applied in SRP Section 2.4.13 provides the means to define conditions that envelope the characteristics of the site in attenuating the transport of radioactivity. Specifically, RG 1.113 addresses accident conditions and routine releases, while SRP Section 2.4.13 relies on most severe conditions;

4. provide guidance on identifying current and likely future water users who may become dose receptors;

5. provide specific guidance on meeting the requirement of measuring onsite hydrogeologic characteristics as specified in 10 CFR 100.20(c);

6. expand the discussion and guidance, via SRP Section 2.4.13 and ISG-014, on modeling surface water or groundwater flow and transport processes from the point of release to the nearest receptor, including dispersion and dilution mechanisms; and

7. provide further guidance on justifying and describing the assumed type of failure event and radioactive source term, including radionuclide distributions and concentrations, total inventory of radioactivity, processes by which the radioactivity is assumed to be released to the environment, whether the release is to surface water or groundwater or

both, and justifications for the use of plant design features and mitigating measures that would reduce the radiological impact on groundwater or surface water users.

Accordingly, the purpose of this ISG is (a) to reconcile differences between SRP sections in assessing potential impacts on members of the public, (b) incorporate current lessons-learned from COL application reviews, and (c) update the guidance in the corresponding sections of the SRP.

Overview of Interim Staff Guidance

In the near-term, the staff will apply the following interim guidance in conducting the review of COLs, certified design applications, and early site permit applications. The interim guidance contains eight major steps, including:

1. Failure Mechanism and Radioactivity Releases,
2. Mitigating Design Features,
3. Radioactive Source Term,
4. Calculations of Transport Capabilities in Groundwater and Surface Water,
5. Exposure Scenarios and Acceptance Criteria,
6. SRP Dose Acceptance Criteria,
7. Specifications on Tank Waste Radioactivity Concentration Levels, and
8. Evaluation Findings for Reviews of Part 52 COL and Other Applications.

The regulatory guidance presented here provides acceptable methods in demonstrating compliance with NRC regulations. If, however, an applicant were to make use of assumptions and calculation methods that differ from this NRC guidance, the applicant must describe in details the bases for the alternative methods and parameters applied in the analysis. In such instances, the applicant must provide sufficient information to enable the staff to conduct an independent evaluation of the results and conclusions presented in the application.

Two different technical disciplines, Health Physics and Hydrologic Engineering, take part in the review process. The revised guidance presented in the following sections identifies the responsible technical discipline for each step of the process. The Health Physics staff is responsible in leading the evaluation of all steps except the fourth step. The fourth step, addressing the transport of radioactivity in surface water and groundwater and deriving radionuclide concentrations in unrestricted areas, is the responsibility of the Hydrologic Engineering staff. The corresponding guidance for the Health Physics staff is described in this ISG and the guidance for the Hydrologic Engineering staff is provided in ISG-014.

Conceptually, the review process is shared as follows:

a. Health Physics staff will confirm the applicant's approach used in developing the postulated tank failure scenario, confirm the radiological source term for the assumed failed tank and components, confirm the assumptions applied in modeling exposures and doses to members of the public, conduct an independent assessment of dose results, confirm compliance with the SRP acceptance criteria, and determine whether the results of the analysis warrant, as specifications, the imposition of maximum radioactivity limits in the tank(s) identified by the applicant. The Heath Physics staff will coordinate its review with other technical disciplines, including civil engineering in evaluating building plant structures and foundations and mechanical engineering for the review of plant systems and components and design of mitigating features. The corresponding guidance for the Health Physics staff is described in this ISG and, later, in SRP Section 11.2 and BTP 11-6, once updated.

b. In a parallel effort, the Hydrologic Engineering staff will review and evaluate the applicant's approach in modeling the transport of radioactivity in surface water and groundwater, confirm the validity of the defined point of entry in unrestricted areas in light of available site-specific information and stated assumptions, and verify the resulting radionuclide concentrations at the point of entry in unrestricted areas. The Hydrologic Engineering staff will confirm whether the information and results comply with the acceptance criteria of SRP Section 2.4.13 and requirements of 10 CFR 100.20(c). The Health Physics staff will use the resulting radionuclide concentrations in its evaluation once the approach used in modeling the transport of radioactivity in surface water or groundwater and resulting radionuclide concentrations in unrestricted areas are deemed acceptable by the Hydrologic Engineering staff. The corresponding guidance for the Hydrologic Engineering staff is described in ISG-014 and, later, in SRP Section 2.4.13, once updated.

As part of the review process, the staff will evaluate whether the applicant has applied a screening approach to the consequence analysis, starting with a simple worst-case scenario and then progressing to more realistic site-specific analyses. If the results of the worst-case analysis do not demonstrate compliance with the SRP acceptance criteria, the applicant would need to conduct a more refined analysis using a site-specific conceptual model and parameters until compliance with SRP acceptance criteria is demonstrated. If the results of site-specific analyses still do not demonstrate compliance with the SRP acceptance criteria, the applicant is expected to propose technical specifications limiting the total amount of radioactivity in such tanks and components. In all instances, the applicant is requested to provide sufficient information for the staff to conduct independent analyses to confirm compliance with the regulations and SRP acceptance criteria.

Interim Staff Guidance on Accidental Releases

1. Failure Mechanism and Radioactivity Releases

The Health Physics staff will verify the identification of the liquid waste tank and components outside of containment or outdoors that could release the most radioactivity to the environment in the event of a failure. The components selected for the analysis should reflect the specific design features of the plant, as described in COL applications (e.g., Final Safety Analysis Report (FSAR) Sections 5, 9, 10, 11, and 12). The Health Physics staff will evaluate the assumed failure and release mechanisms in ensuring that the proposed failure scenario is consistent with plant design features and that the applicant has applied reasonably conservative assumptions. For example, the staff will assess whether the applicant has considered the following:

- technical justification for defining the limiting event for the consequence analysis, given known plant process systems expected to contain radioactive materials

- all systems with potential sources of radioactivity contained in tanks and components located outside of containment and outdoors where there is a potential for radioactive materials to reach the environment. Such systems include permanently installed processing equipment and skid-mounted processing systems connected to the permanently installed LWMS or SWMS, with and without due consideration for durable and passive mitigation features

- types of failure mechanisms and descriptions of the types of durable and passive design features applied in mitigating the impacts of such releases

- whether the event results in a prompt release to surface water or a delayed release to groundwater

- conditions where surface water and groundwater could be impacted by a single event

- radiological impacts on members of the public for a given point of entry located in unrestricted areas in surface water and groundwater resources

The Health Physics staff will assess whether the applicant has:

1) evaluated and ranked tanks and components in terms of radioactivity levels and radionuclide concentrations,

2) considered whether the use of mobile skid-mounted processing systems located in readily accessible truck loading bays present a greater likelihood of failure and spills/leaks beyond the physical boundary of the building housing such equipment, and

3) applied a graded approach to considering all types of events, radioactive source terms, design features (durable and passive) assumed in mitigating releases, and potential offsite impacts.

For example, the volumes of liquid radioactive waste in tanks and components vary among plant systems. LWMS tanks usually contain less liquid than condensate storage tanks and refueling water storage tanks. For LWMS, the amounts are typically on the order of a few to several thousand gallons, while the volumes of condensate storage tanks and refueling water storage tanks are typically on the order of several hundred thousand gallons. The volumes of tanks used in other plant systems are typically on the order of a few thousand gallons or less. Similarly, the inventories of radioactivity vary, with higher radionuclide concentrations found in LWMS tanks and components, and lower concentrations observed in condensate storage tanks and refueling water storage tanks. Finally, the use of skid-mounted processing equipment connected to permanently installed LWMS and possible failures associated with system interfaces should be evaluated in confirming that the system tank and/or components selected for the analysis are conservatively bounding in terms of the total inventory of radioactive materials assumed in the failure scenario.

The Health Physics staff should account for these aspects and their inter-relationships when confirming that the applicant has selected (a) a case that assumes the highest release of radioactivity to the environment, or (b) an event involving plant systems and inventories of radioactive materials associated with system designs that exclude the use of mitigating features.

2. Mitigating Design Features

The Health Physics staff will consider the use of design features, e.g., steel liners or walls in areas housing components, dikes for outdoor tanks, and overflow and sump/drain provisions incorporated to mitigate the effects of a postulated tank and components failure. The types of failed system components typically are waste collection tanks or sample tanks, among others. However, the components selected for the analysis should reflect the specific design features of the plant, as described in COL applications (e.g., FSAR Sections 5, 9, 10, 11, and 12). The purpose of this review is to ensure that the analysis considers the proper selection of assumed failed equipment, appropriate release mechanisms from the selected equipment and buildings and structures housing such systems, and whether the proposed design is capable of retaining the liquid inventory of the failed tank and components and includes provisions to pump the spilled inventory back to proper processing systems with sufficient holding capacity. If an analysis takes credit for liquid retention design features, the applicant must provide information that demonstrates that such features are durable and passive and that the receiving system has the storage capacity to hold the expected volume of liquid wastes. Mitigating design features that rely primarily on operator actions for their effectiveness are not acceptable. Similarly, credit may not be taken for nuclear grade coatings and joint sealants applied to concrete floor and wall surfaces in rooms where tanks and components are located, or as leakage barriers outside of building foundations since such materials are not durable as they require repeated applications.

Applicants may use empirical evidence, operating experience, and modeling results to assess and confirm the efficacy of specific design features in retaining releases or retarding the movement of radioactivity once in the environment. In addition, applicants can review and apply the guidance of RG 1.143 (Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Reactor Power Plants) and RG 4.21 (Minimization of Contamination and Radioactive Waste Generation: Life Cycle Planning) and industry standards (ANSI/ANS 2007), and NEI 08-08A (Ref. 19, 21, 23, 24, and 28) in considering the incorporation of specific design features. Based on this information, the staff will determine if the analysis can take credit for the proposed design features. In cases where mitigating design features of tanks meet the conditions of the guidance, the staff may waive the need for a consequence analysis in the context of SRP Section 11.2 and BTP 11-6 since the use of durable and passive design features would provide reasonable assurance that the SRP acceptance criteria would be met.

The presence of mitigating design features does not change the requirements of SRP Section 2.4.13 that relate to demonstrating the adequacy of the site's hydrogeologic properties, via a consequence analysis that uses combined literature data and site-specific parameters characterizing transport mechanisms, such as aquifer materials, hydraulic conductivity, porosity, etc. See ISG-014 and SRP Section 2.4.13 for details on the type of information and site data that would be acceptable for characterizing the hydrogeologic properties of a site and staff's approach in evaluating the information provided by the applicant.

3. Radioactive Source Term

The Health Physics staff will review the proposed radionuclide distributions and concentrations assumed for the postulated failure of a tank and components using the information presented by the applicant. Conceptually, the analysis assumes that a system or component fails to meet the design bases as required by 10 CFR 50.34a or 10 CFR 52.79, and GDC 60, 61 and 64. The staff will evaluate the basis and assumptions used in developing the source term, radionuclide distributions and concentrations to ensure that the highest potential radioactive material inventory is selected among the expected types of liquid and wet waste streams processed by plant systems. Conceptually, the Health Physics staff will confirm that the applicant's approach in developing the radioactive source term has considered the following:

1. reactor system and thermal power consistent with the design certification,

2. description of system and components assumed to fail as permanently installed process equipment, including the interface of skid-mounted mobile processing systems, as justified,

3. process or waste streams selected,

4. location of failed tank and components in plant buildings and at outdoor locations, if applicable,

5. nominal volume of failed tank and components,

6. failed fuel fraction applied in deriving radioactivity inventory, if different than default value of SRP guidance,

7. radionuclide re-concentration factors applied in deriving radioactivity inventory, as mandated by the selected process or specific waste streams,

8. assumed radionuclide distributions and concentrations and total radioactivity inventory in tanks and components of systems located indoors and outdoors,

9. for systems located indoors, description of the release mechanism starting from the room or cubicle housing such systems to the underlying ground immediately below the building's foundation boundary,

10. for systems located outdoors, description of the release mechanism starting from the retention basin or diked area to the nearest point of entry into the site's

surface water runoff discharge system and location of its outfall in unrestricted areas, and groundwater if a pathway exists,

11. assumed dilution, retardation factors, and travel times in instances where groundwater or surface water models were not used to describe the transport of radioactivity from the site to the point of entry in unrestricted areas, and

12. assumed dilution factors applied beyond the point of entry in unrestricted areas in instances where groundwater or surface water models were not used to describe the movement of radioactivity between the point of entry into unrestricted areas and location of dose receptors

In assigning radionuclide distributions and concentrations for the relevant exposure scenario, the staff should consider whether the site conceptual model defines the release as through a surface water or groundwater pathway, and also consider conditions where surface water and groundwater resources could be impacted by a single event. For scenarios that include surface water pathways, the source term should consider both short and long-lived radionuclides. The rationale for including both types of radionuclides in surface water release scenarios is that releases to useable surface water resources and impacts would occur promptly with minimal time for retardation after a release. In assessing the movement of radioactivity in surface water bodies and streams, the dispersion of radioactivity is expected to be affected by various mechanisms, including near- and far-field mixing patterns, recirculation driven by current directions and flow rates, differences in temperatures in relation to the receiving water body, and impacts of tidal action, among others.

For groundwater pathways, the source term should consider radionuclides that are expected to persist in groundwater, taking into account radioactive half-lives, distribution coefficients, retardation factors, and environmental mobility in groundwater. For scenarios involving groundwater, the rationale is that releases to useable water resources and impacts to users are assumed to occur over protracted time periods, years to decades, which afford time for the radioactive decay of short-lived radionuclides with half-lives expressed in months or less than a few years. As a result, this consideration would include long-lived and mobile radionuclides, such as tritium, C-14, Ni-63, Sr-90, Tc-99, I-129, Cs-137, among others, and both parent and progeny radionuclides for radionuclides with decay chains.

The radionuclide inventory for the tank and its components that are assumed to fail should be based on a conservative estimate of 80 percent capacity of that tank and its components. The selection of 80 percent assumes that some of the content of the failed tank would remain in the tank and room or cubicle where the tank is located, with the associated amounts of radioactive materials being retained in the building itself and, therefore, not available for environmental transport. Attachment A presents a list of radionuclides which should be considered when defining source terms for surface water and groundwater release pathways. Depending on the type of scenario being considered in the radiological assessment, an applicant may exclude specific radionuclides, but must provide adequate justification to the staff for specific omissions. In those instances, the staff will review the basis of the justification for omitting specific radionuclides and evaluate the associated impacts on the results of the radiological assessment and confirm compliance with the SRP acceptance criteria.

The Health Physics staff will confirm that the selection of the type of radioactive materials and radionuclide distributions correspond to the highest expected concentrations and inventory of radioactivity in selected systems and components, and that the listed radionuclides are consistent with the plant design (see Attachment A), proposed release mechanism and exposure pathways at the point of entry into the nearest source of usable surface water or groundwater located in an unrestricted area.

The Health Physics staff will use the resulting radionuclide concentrations in its analysis once the approach used in modeling the transport of radioactivity in surface water or groundwater and resulting radionuclide concentrations in unrestricted areas are deemed acceptable by the Hydrologic Engineering staff.

The above described process in developing the assumed radioactive source term updates the methods and use of the computer code described in Chapter 4.4 and Appendices A and B of NUREG-0133, "Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants." Applicants may propose and use alternate methods in developing radioactive source terms. In such instances, applicants are responsible for providing sufficient information and justification to enable the staff to perform an independent evaluation of any proposed alternative methods. With respect to the guidance of NUREG-0133, this ISG updates that guidance for applications submitted six months after the issuance of the final version of this ISG. However, the guidance of NUREG-0133 remains in effect for holders of nuclear power reactor operating licenses under 10 CFR Part 50 or combined licenses under 10 CFR Part 52 prior to the effective date of this ISG, and for applicants for nuclear power reactor operating licenses under 10 CFR Part 50 or combined licenses under 10 CFR Part 52 that have committed, in applications docketed with the NRC as of the effective date of this ISG, to specific guidance in assessing the radiological consequences of a postulated failure of a tank containing radioactive materials.

4. Calculations of Transport Capabilities in Groundwater or Surface Water

The Hydrologic Engineering staff will make independent calculations of transport mechanisms and potential contamination pathways to surface water and groundwater environments that may, under accident conditions, transport radioactive contaminants to existing and future water users located in unrestricted areas.

See ISG-014 and SRP Sections 2.4.12 and 2.4.13 for details on the type of information and site data that would be considered in the development of a site conceptual model and staff's approach in evaluating the information provided by the applicant.

5. Exposure Scenarios and Acceptance Criteria

The Health Physics staff will review exposure scenarios and assumptions describing exposure pathways associated with the release of radioactivity from a postulated failed tank and components. The scenarios include:

a. Direct water use – This scenario assumes that members of the public would consume drinking water withdrawn near or at the point of entry in an unrestricted area. The sources of water include a groundwater well, or from a surface water body or river.

b. Indirect water use – This scenario assumes the use of water in indirect human consumption. Such scenarios may include livestock watering or irrigation of grazing pastures, consumption of animal products (meat and milk products), fish and invertebrate consumption, crop irrigation and consumption of such crops, or water used as an ingredient in food products or in food processing.

c. Combined use of water - This scenario assumes that there is dual use of water, direct and indirect usage. In such an instance, the scenarios would be modeled separately and the resulting doses would be summed up and compared to the SRP acceptance criteria.

For the purpose of the consequence analysis, the point of entry in unrestricted areas is defined as a location beyond the site boundary where the applicant has no administrative controls that could be used to restrict the use of surface water or groundwater resources, or require the treatment of surface water or groundwater for use as finished drinking water. When considering surface water resources, the selected point of entry in unrestricted areas should be identified as that location in a surface water body or stream affected only by near-field dilution near the point of entry. Modeling approaches that assume the effects of far-field dilution or turbulent mixing will not be acceptable to the staff as such assumptions are expected to result in excessively high and non-conservative dilution factors. In instances where far-field dilution and turbulent mixing are the only processes by which accidental releases are dispersed in the environment, the applicant should provide a justification for this approach and sufficient information to enable the staff to conduct an independent evaluation of the proposed dispersion processes. For groundwater resources, the applicant should assume the presence of a hypothetical well located at a nearby distance from the site boundary and depth within an aquifer, where the effects of groundwater hydraulic gradient, recharge properties, and velocity are suitable for groundwater contamination, would be acceptable in characterizing radionuclide concentrations in groundwater. As before, groundwater modeling approaches that result in excessively high and non-conservative dilution factors will not be acceptable to the staff. Finally, the consequence analysis may not take credit for the use of typical water supply system treatment methods as a mean of removing the presence of radioactivity or reducing radionuclide concentrations in finished drinking water or water used in food processing and as an ingredient.

The Health Physics staff will review the supporting basis for the selected scenario, the reasonableness of assumptions, and the degree of conservatism applied in modeling the scenario and selection of model parameters. With respect to consumption rates of water and food products impacted by indirect uses of water, the analysis should initially apply the recommended values for the maximum exposed individual in Table E-5 of RG 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I." The values of Table E-5 provide initially a reasonable level of conservatism in defining consumption rates and in estimating associated doses. For scenarios that consider the consumption of fish and invertebrates, the analysis should apply appropriate bio-accumulation factors for the assumed aquatic environment. The staff will confirm the appropriateness of the selected scenario and acceptability of underlying assumptions using the information provided by the applicant and information obtained from the results of a land-use census, if available, or information gleaned from Federal, State, and local or regional sources.

In its review, the Health Physics staff will use the radionuclide concentrations in water at the point of entry located in unrestricted areas that were calculated and determined to be acceptable by the Hydrologic Engineering staff, as described in item 4, above.

6. SRP Dose Acceptance Criteria

The Health Physics staff will compare the results of the analyses of radiological impacts with the appropriate acceptance criteria when assessing the acceptability of these results. The acceptance criteria presented here are based on doses to members of the public, rather than on effluent concentration limits, as was the case in previous guidance. The reason for this change is the need to better account for the effects of multiple exposure pathways. Releases may affect surface water and groundwater differently, consequently, the impact in some instances may be by way of direct consumption of water, while in others the impact may be only by indirect use of water, for example for livestock watering or crop irrigation. These different exposure scenarios and pathways can be quantified, because the applicant is expected to describe uses of water resources, based on local or regional land-use census information.

As currently described in SRP Section 11.2 and BTP 11-6, the acceptance criteria state that the postulated release should not result in radionuclide concentrations in useable surface water or groundwater exceeding the effluent concentration limits (ECLs) and unity rule of 10 CFR Part 20, Appendix B, Table 2, Column 2. While the ECLs are a reasonable standard for direct consumption of water, their use is not as obvious or practical for indirect uses of water and for the consumption of impacted food products. As a result, a dose-based limit is applied instead, because it provides the most flexibility in assessing compliance, regardless of the postulated exposure scenarios.

The dose acceptance criteria are defined as:

a. Radioactive releases associated with the postulated failure of a tank and components should not:

   i. result in radioactive material concentrations leading to a dose in excess of 100 mrem (1 mSv) at the point of entry into the nearest existing or a known future water supply when (1) used as a source of water for direct human consumption; or (2) used indirectly through livestock watering or irrigation of grazing pastures, consumption of animal products (meat and milk products), fish and invertebrate consumption, crop irrigation and consumption of such crops, or used as an ingredient in food products or food processing, and

   ii. result in a total dose in excess of 100 mrem (1 mSv) in instances where a scenario assumes the dual use of water, direct and indirect usage. In such an instance, the dose from each scenario must be derived separately and the resulting doses must be added, with the summation of doses compared to the SRP dose acceptance criteria.

b. If the results of site-specific analyses do not demonstrate compliance with the SRP dose acceptance criteria, the applicant is expected to propose technical specifications limiting the total amount of radioactivity in such tanks and components such that the total inventory of radioactivity will not result in doses in excess of 100 mrem (1 mSv) at the point of entry into the nearest existing or a known future water supply located in unrestricted areas when used as a source of water for direct and indirect human consumption.

c. In complying with the above SRP dose acceptance criteria, this guidance does not relieve any applicant or license holder from complying with the dose limits of 10 CFR 20.1301, 20.1301(e), and 20.1302, effluent concentration limits and the unity rule of Appendix B to 10 CFR Part 20, and design objectives and ALARA provisions of Appendix I to 10 CFR Part 50.

For the purpose of this ISG and ISG-014, a receptor is defined as a member of the public assumed to consume and use water at a point of entry located in an unrestricted area. Member of the public means any individual that is not receiving an occupational dose. Unrestricted area means an area, access to which is neither limited nor controlled by the licensee (10 CFR 20.1003). The point of entry in an unrestricted area is assumed be a domestic well, or part or all of a fresh surface water body (e.g., stream, river, lake). In the context of ISG-013, the point of entry is not the same as the point of discharge in light of the definition given in Regulatory Guide 1.21, Revision 2. Under ISG-013 (and ISG-014), radiological impacts associated with postulated accidental releases of radioactive materials are not used in demonstrating literal compliance with the requirements of 10 CFR 20.1301, 20.1302, and 20.1301(e) and design objectives and ALARA provisions of Appendix I to 10 CFR Part 50. Rather, the SRP dose acceptance criteria are defined as a measure of acceptability in assessing the radiological impacts of a postulated tank failure on usable sources of surface water or groundwater. Compliance with the above noted regulatory requirements is addressed in SRP Sections 11.2 to 11.5 using the guidance of Regulatory Guides 1.21 and 4.15 implemented under a plant and site-specific offsite dose calculation manual (ODCM).

The Health Physics staff will independently confirm that the dose results presented by the applicant comply with the acceptance criteria using the information provided in the supporting documentation and results of the parallel evaluation of surface water and groundwater transport models conducted by the Hydrologic Engineering staff.

7. Specifications on Tank Waste Radioactivity Concentration Levels

If the results of site-specific analyses do not demonstrate compliance with the SRP acceptance criteria, as described here and in Attachment B to this ISG, the applicant is expected to propose technical specifications limiting the total amount of radioactivity in such tanks and components. The Health Physics staff will evaluate the proposed technical specification limiting the radioactivity content of liquid-containing tanks and components to ensure that the technical specifications are consistent with the safety evaluation. The maximum inventory of radioactive materials, in the event of an uncontrolled release of radioactivity, is based on that quantity of radioactivity that will not exceed the SRP dose acceptance criteria of 100 mrem (1 mSv) from all relevant pathways at the defined point of entry in unrestricted areas. Chapter 16, Section 5.5, “Programs and Manuals,” of the FSAR addresses this commitment in COL applications. The milestones for the development and implementation of such plant and site-specific requirements are addressed in FSAR Sections 11.5 and 13.4 of COL applications. In addressing the requirements of Chapter 16, Section 5.5, this ISG does not relieve any applicant or license holder from complying with the dose limits 10 CFR 20.1301 and 20.1302, effluent concentration limits and unity rule of Appendix B to 10 CFR Part 20, and design objectives and ALARA provisions of Appendix I to 10 CFR Part 50.

As part of the ODCM, the applicant is required to confirm, via the conduct of yearly land-use census, whether the identified uses of water resources are still valid and limiting in establishing the maximum total inventory of radioactivity in tank(s) and components assumed to have failed in the consequence analysis. If not, the applicant is required to revise the consequence analysis using updated land-use information and define a new maximum total inventory of radioactivity for such tank(s) and components.

Attachment B to this ISG supersedes the corresponding guidance described in Section 4.4 of NUREG-0133 as indicated in the statement of applicability. The guidance of Section 4.4 of NUREG-0133 remains in effect for 10 CFR Part 50 licensees and 10 CFR Part 52 applicants and license holders that have incorporated the guidance of Section 4.4 of NUREG-0133 in their current licensing basis prior to the conditions noted in the statement of applicability.

8. Evaluation Findings for Reviews of Part 52 COL and Other Applications

The Health Physics and Hydrologic Engineering staff will document the results of the evaluation of site characteristics and compliance with the SRP radiological acceptance criteria. In its evaluation and conclusions, the Health Physics staff will refer to the evaluation performed by the Hydrologic Engineering staff and not reiterate in its analysis and conclusions the results presented by the Hydrologic Engineering staff in response to SRP Section 2.4.13, as described in ISG-014. Together, the evaluations of the Hydrologic Engineering and Health Physics staff support the staff’s conclusions as to whether the SRP acceptance criteria have been met and whether the applicant has appropriately applied applicable NRC guidance.

The reviewers will describe what was done to evaluate the applicant’s SAR. The staff’s evaluation will verify the applicant’s results, determine whether the applicant followed applicable regulatory guidance or used an alternative approach, perform independent calculations, and confirm the adequacy of all stated assumptions and model parameters used in the consequence analysis, as well as conclusions presented in the analysis.

The reviewers will summarize the information used in assessing the consequence of tank and component failures, including the assumed failure scenarios, the basis of the radioactive source term, site characteristics and parameters used in modeling the transport of radioactivity to the point of entry in unrestricted areas, and exposure scenarios and resulting doses to members of the public who use impacted surface water or groundwater.

The reviewers will then articulate the bases for the staff's conclusions and for acceptance of the results and supporting information. The reviewers will verify that the applicant has provided sufficient information and that the review and calculations (if applicable) support the conclusions of the reviewers.

The reviewers may state that certain information provided by the applicant was not considered to be essential to the staff's review and was not reviewed by the staff, or that the staff used alternative information or parameters in performing its independent evaluation.

The following are examples of conclusions that will be included in the staff's Safety Evaluation Report (SER), based on the approach and methods used by the applicant in demonstrating compliance with NRC guidance and acceptance criteria of SRP Section 11.2 and BTP 11-6.

a. The review confirmed the postulated radionuclide concentrations in the applicable failed components based upon the default pressurized-water reactor fuel failure rate or boiling-water reactor fuel release rate, and the effect of site hydrologic characteristics for those systems that have not been equipped with design features to mitigate the effect of tank and component failures. The selection of the failed tank and tank volume, radionuclide distributions and concentrations, total radioactive inventory, and assumed failure scenarios were found to be acceptable. The acceptance is based on the staff's review and independent evaluations confirming that the applicant has considered the appropriate plant systems, tanks and components assumed to fail, locations of tanks and components in the plant, appropriate credit for design features applied in mitigating the consequences of a tank and component failures, and the assumed mechanism for the radioactivity to enter a surface water body or groundwater beyond the physical boundary of the building housing such systems.

b. For cases where design features were incorporated in mitigating the consequences of a failure of a tank and components, the staff found such features acceptable. The design features that were evaluated include steel liners or walls or dikes surrounding the failed tanks and their components and tank overflow and sump/drain provisions. The basis for the staff's acceptance is the capability of design features (*Note: staff to list specific features in SER*) to prevent the release of radioactivity from entering a surface water body or groundwater in unrestricted areas using durable and passive features requiring no operator interventions. Therefore, the staff concludes that the design provisions incorporated by the applicant are acceptable and provide reasonable assurance in mitigating the effects of the failure of a tank and components, as described in the application.

c. The review confirmed the applicant's approach in modeling the transport of radioactivity in surface water or groundwater starting from the building housing the assumed failed tank and components to the nearest point of entry in unrestricted areas. For the reasons presented in Section 2.4.13 of this SER, the review concludes that the identification and consideration of the potential effects of postulated releases of radioactive liquid effluents in groundwater and surface water in the vicinity of the site are acceptable and meet the requirements of Part 50, Appendix A, GDC 2 and 61 and 10 CFR 100.10(c) or 10 CFR Part 52 and 10 CFR 100.20(c) and are consistent with the guidance of SRP Section 2.4.13.

d. The staff concludes that (1) the postulated failure of a tank and components has been evaluated, (2) the design features are acceptable and meet the requirements of Part 50, Appendix A, GDC 60 and 64 in controlling and limiting releases of radioactive materials to the environment, and (3) the design features provide an adequate level of safety during normal reactor operation, including anticipated operational occurrences. Plant facility structures and system design features described in the application provide reasonable assurance that the assumed release will not result in radionuclide concentrations in surface water or groundwater exceeding the SRP acceptance criterion of a total dose of 100 mrem (1 mSv) when used in unrestricted areas.

e. The staff concludes that the applicant's proposed technical specifications limiting the total amounts of radioactivity in tanks and components, as described in the application, are adequate based on the results of the staff's review and evaluation. The basis of the staff's acceptance of the technical specifications is based on the evaluation of the selected system and failed tank and components, assumed inventory of radioactive materials in the failed tank and components, assumed failure scenario, methods and assumptions used in modeling the transport of radioactivity into unrestricted areas, and definition of limiting exposure scenarios for direct and indirect uses of surface water or groundwater in unrestricted areas. The evaluation demonstrates compliance with the SRP acceptance criterion of a total dose of 100 mrem (1 mSv) for surface water or groundwater used in unrestricted areas. The Health Physics staff confirmed that the proposed technical specifications limiting the radioactivity content for the stated liquid-containing tank and components have been incorporated into Chapter 16, Section 5.5, "Programs and Manuals," of the FSAR, and identified as a program element, as addressed in FSAR Sections 11.5 and 13.4 of COL applications.

Final Resolution

In the long-term, the revised approach and information presented in ISG-013 will be formally incorporated in future updates of RG 1.206 and of SRP Section 11.2 and BTP 11-6 (NUREG-0800). The SRP updates will include revisions of the areas of review, review interface, acceptance criteria, technical rationale, review procedures, and evaluation findings in SRP Section 11.2 and BTP 11-6. Similarly, SRP Section 2.4.13 and RG 1.206 will be revised to address the updated guidance of ISG-014.

As part of these updates, the staff will confirm that the revisions of SRP Sections 2.4.13 and 11.2 and BTP 11-6 apply to ESP applications submitted under 10 CFR 52.17.

Also as part of these updates, for standard design certification applications submitted under 10 CFR 52.47, the staff will confirm that requirements of 10 CFR 100.20(c) and guidance of SRP 2.4.13 and 11.2 and BTP 11-6 do not apply directly. Instead, applicable requirements should be identified as COL information items in design certification applications. Later COLA applicants who rely on these design certifications will be responsible for addressing these requirements and guidance when applying for COL and ESP applications under 10 CFR 52.79 and 52.17.

Applicability

Under SPR Section 11.2 and BTP 11-6, this ISG is applicable to all license applications submitted under the requirements of 10 CFR Part 50 or 10 CFR Part 52 six months after the issuance of the final ISG.

With respect to the guidance of Section 4.4 of NUREG-0133 describing specifications for the content of radioactivity in liquid-containing tanks, Attachment B of ISG-013 updates that guidance for applications submitted six months after the issuance of the final version of ISG-013. However, the guidance of Section 4.4 of NUREG-0133 remains in effect for holders of nuclear power reactor operating licenses under 10 CFR Part 50 or combined licenses under 10 CFR Part 52 as of the effective date of this ISG, and for applicants for nuclear power reactor operating licenses under 10 CFR Part 50 or combined licenses under 10 CFR Part 52 that have committed, in applications docketed with the NRC as of the effective date of this ISG and revision of SRP Section 2.4.13, to specific guidance in assessing the radiological consequences of a postulated failure of a tank containing radioactive materials.

Similarly, this ISG updates the guidance of Section 4.4 and Appendices A and B of NUREG-0133 addressing the development of assumed radioactive source terms in failed tank and components. The reasons for updating the guidance of NUREG-0133 is that the computer code is no longer supported by the NRC, the computer code considers a very limited suite of radionuclides in the consequence analysis, and the acceptance criteria built into the code are not consistent with the current effluent concentration limits of Appendix B (Table 2, Column 2) to 10 CFR Part 20. While this ISG provides equivalent guidance, applicants may propose and use alternative methods in developing radioactive source terms. In such instances, applicants are responsible for providing sufficient information and justification to enable the staff to perform an independent evaluation of any proposed alternative method. The guidance of Appendices A and B of NUREG-0133 remains in effect for holders of nuclear power reactor operating licenses under 10 CFR Part 50 or combined licenses under 10 CFR Part 52 as of the effective date of this ISG, and for applicants for nuclear power reactor operating licenses under 10 CFR Part 50 or combined licenses under 10 CFR Part 52 that have committed, in applications docketed with the NRC as of the effective date of this ISG, to specific guidance in assessing the radiological consequences of a postulated failure of a tank containing radioactive materials.

References:

1. 10 CFR Part 100.10, under Subpart A, “Evaluation factors for stationary power reactor site applications before January 10, 1977 and for testing reactors.”

2. 10 CFR Part 100.20, under Subpart B, “Evaluation factors for stationary power reactor site applications on or after January 10, 1977.”

3. NUREG-0800, SRP Section 11.2, “Liquid Waste Management System,” March 2007 (ML063600412).

4. NUREG-0800, SRP Section 2.4.1, “Hydrologic Description,” March 2007 (ML070100646).

5. NUREG-0800, SRP Section 2.4.12, “Groundwater,” March 2007 (ML070730443).

6. NUREG-0800, SRP Section 2.4.13, “Accidental Releases of Radioactive Liquid Effluents in Ground and Surface Waters,” March 2007 (ML070730449).

7. NUREG-0800, SRP Section 11.2, “Liquid Waste Management System,” BTP 11-6 “Postulated Radioactive Releases Due to Liquid-Containing Tank Failures,” March 2007 (ML070720635).

8. 10 CFR Part 20, Appendix B, "Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage."

9. 10 CFR 50.34a, “Design objectives for Equipment to Control Releases of Radioactive Material in Effluents Nuclear Power Reactors.”

10. 10 CFR 50.36a, “Technical Specifications on Effluents from Nuclear Power Reactors.”

11. 10 CFR Part 50, Appendix A, GDC 2, “Design Bases for Protection Against Natural Phenomena.”

12. 10 CFR Part 50, Appendix A, GDC 60, “Control of Releases of Radioactive Materials to the Environment.”

13. 10 CFR Part 50, Appendix A, GDC 61, “Fuel Storage and Handling and Radioactivity Control.”

14. 10 CFR Part 50, Appendix A, GDC 64, “Monitoring Radioactivity Releases.”

15. Regulatory Guide 1.21, “Measuring, Evaluating, and Reporting Radioactive Material in Liquid and Gaseous Effluents and Solid Waste,” Rev. 2, June 2009 (ML091170109).

16. Regulatory Guide 1.109, “Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I,” October 1977 (ML003740384).

17. Regulatory Guide 1.113, "Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I," April 1977 (ML003740390).

18. Regulatory Guide 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition)," June 2007 (ML070720184).

19. Regulatory Guide 1.143, "Design Guidance for Radioactive Waste Management Systems, Structures and Components Installed in Light-Water-Cooled Nuclear Reactor Power Plants," Rev. 2, November 2001 (ML013100305).

20. Regulatory Guide 4.15, "Quality Assurance for Radiological Monitoring Programs (Inception Through Operations to License Termination) – Effluent Streams and the Environment," Rev. 2, July 2007 (ML071790506).

21. Regulatory Guide 4.21, "Minimization of Contamination and Radioactive Waste Generation: Life Cycle Planning," June 2008 (ML080500187).

22. NUREG-0133, "Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants," October 1978 (ML091050057).

23. American National Standards Institute (ANSI)/American Nuclear Society (ANS), ANSI/ANS 55.6-1993 (Reaffirmed May 14, 2007), "Liquid Radioactive Waste Processing System for Light Water Reactor Plants." Available from: www.ansi.org.

24. American National Standards Institute (ANSI)/American Nuclear Society (ANS), ANSI/ANS 40.37-1993 (Reaffirmed May 14, 2007), "Mobile Low-Level Radioactive waste Processing Systems." Available from: www.ansi.org.

25. NUREG-1301, "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors," April 1991 (ML091050061).

26. NUREG-1302, "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Boiling Water Reactors," April 1991 (ML091050059).

27. NRC, DC/COL-ISG-06, "Final Interim Staff Guidance - Evaluation and Acceptance Criteria for 10 CFR 20.1406 to Support Design Certification and Combined License Applications," as incorporated in SRP Section 12.3 -12.4 (ML092470100).

28. NEI 08-08A, "Generic FSAR Template Guidance for Life Cycle Minimization of Contamination," October 2009 (ML093220530).

29. NRC, DC/COL-ISG-014, "Interim Staff Guidance - Assessing the Radiological Consequences of Accidental Releases of Radioactive Materials from Liquid Waste Tanks in Ground and Surface Waters for Combined License Applications." (ML12191A330).

30. NRC, “Liquid Radioactive Release Lessons Learned Task Force,” Final Report, September 2006 (ML062650312).

Attachment A

Source Term Radionuclides

Table 1, below, contains a list of radionuclides that should be included, at a minimum, in any assessment of an accidental release of radioactive material from liquid waste tanks. The list includes all those non-gaseous radionuclides listed in ANSI/ANS 18.1-1999, "Radioactive Source Term for Normal Operation of Light Water Reactors." This standard is the basis in developing predicted reactor coolant and steam concentrations and annual effluent releases presented in FSAR Chapter 11 and contained radioactive sources in plant systems presented in FSAR Chapter 12. In addition to those radionuclides, the table also includes I-129 and Tc-99 because they are fission products that can escape into the reactor coolant and, when released into the environment, move readily with groundwater, with little retardation and radiological decay.

Table 1. Source Term Radionuclides

H-3	Tc-99
C-14	Ru-103
P-32 BWR only	Ru-106
Cr-51	Rh-103m BWR only
Mn-54	Rh-106 BWR only
Mn-56	Ag-110m
Fe-55	Te-129m
Fe-59	Te-129 PWR only
Co-58	Te-131 PWR only
Co-60	Te-131m
Ni-63 BWR only	Te-132
Cu-64 BWR only	I-129
Zn-65	I-131
Br-84 PWR only	I-132
Rb-88 PWR only	I-133
Rb-89 BWR only	I-134
Sr-89	I-135
Sr-90	Cs-134
Sr-91	Cs-136
Sr-92 BWR only	Cs-137
Y-90 BWR only	Cs-138 BWR only
Y-91	Ba-140
Y-92	La -140
Y-93	Ce-141
Y-91m PWR only	Ce-143 PWR only
Zr-95	Ce-144
Nb-95	Pr-144 BWR only
Mo-99	W-187
Tc-99m	Np-239

Attachment B

Specifications on the Contents of Radioactivity in Liquid-Containing Tanks

Under NUREG-1301 and -1302 (Ref. 25 and 26), Standard Technical Specification 3.11.1.4 and Tables 3.3-11 and 4.3-11 list liquid-containing tanks outside containment that are to be analyzed periodically to verify that the radioactivity content (curie/becquerel, excluding dissolved or entrained noble gases) is below specified values. Tanks included in this specification are those that are not surrounded by liners, dikes, or walls capable of holding the tank contents and do not have tank overflow provisions and sumps/drains connected to the LWMS. Indoor tanks are not included unless an analysis based on design basis fission product leakage from fuel assemblies results in doses to members of the public in excess of the SRP acceptance criteria of a total dose of 100 mrem (1 mSv) in the event that leaked or spilled fluids would impact the nearest existing or known future water supply in an unrestricted area. Water "supply" means a well or surface water intake that is used as a source of water for direct human consumption, or is used indirectly through livestock watering or irrigation of grazing pastures, consumption of animal products (meat and milk products), fish and invertebrate consumption, crop irrigation and consumption of such crops, or else is used as an ingredient in food products or food processing. Similarly, "known future" water supply means potential wells or surface water intakes whose current use or future construction may be identified, or may be reasonably deduced from available land-use census information.

For tanks included in Specification 3.11.1.4 and Tables 3.3-11 and 4.3-11, an activity limit (curie/becquerel) should be determined based on the methodology presented in SRP Section 11.2 and BTP 11-6. The methodology is based on the calculated radionuclide inventory in the selected tank and components filled at 80 percent capacity using a design basis fission product source term of:

(a) 0.12% of the operating fission product core inventory being released to the primary coolant for a pressurized water reactor (PWR), or

(b) consistent with a noble gas release rate of 15 uCi/MWt per second (0.56 MBq/MWt per second) with 30-minute decay for a boiling water reactor (BWR).

The selection of 80 percent assumes that some of the content of the failed tank would remain in the tank and room or cubicle where the tank is located, with the associated amounts of radioactive materials being retained in the building itself and, therefore, not available for environmental transport. The method cited above is used to derive the inventory of radioactivity that if contained in the tank and components would result in radioactivity concentrations equal to the SRP acceptance criteria of a total dose of 100 mrem (1 mSv) at the point of entry into the nearest existing or predicted future water supply that is used as a source of water for direct human consumption, or is used indirectly through livestock watering or irrigation of grazing pastures, consumption of animal products (meat and milk products), fish and invertebrate consumption, crop irrigation and consumption of such crops, or else is used as an ingredient in food products or food processing.

By excluding dissolved and entrained noble gases from surveillance requirements, Specification 3.11.1.4 should apply to the lowest radioactive inventory of activation and mixed fission products determined for any tank and component listed in Specification 3.11.1.4 as the radioactivity inventory limit for all tanks and components identified in that specification. Dissolved and entrained noble gases are not included since they do not remain in solution and are rapidly aerated out of the liquid phase during processing and spillage, should it occur. Since all process and storage tanks are vented, dissolved and entrained noble gases emanating from process fluids, and rooms where this equipment is located, are collected, monitored, and exhausted via the gaseous waste management system. Tritium is included because it is an environmentally mobile radionuclide and recent operating experience has shown that it is present in most incidents involving spills and leaks, as noted in the NRC's lessons learned task force report on liquid radioactive release.

Operational experience has shown that some operating reactors have required the use of temporary process and storage tanks during maintenance and service periods, or when temporary solidification equipment is used at the plant, and, consequently, Specification 3.11.1.4 should indicate such tanks as being temporary. The limit for the total inventory of radioactive materials in temporary tanks should be limited to ≤ 10 curies (0.37 TBq), excluding dissolved and entrained noble gases. If the temporary tank is mobile and not used (i.e., empty of liquid) for more than a calendar quarter, the tank need not be included in Tables 3.3-11 and 4.3-11 of the Specifications.

Regardless of the defined maximum inventory of radioactive materials for such tanks or components, these specifications do not relieve the licensee from regulatory requirements and practical considerations associated with radiation protection for plant personnel, such as conducting periodic surveys in monitoring external radiation levels in nearby and surrounding areas, and posting and restricting access to areas and/or rooms where such tanks are located.