NUREG-0800

U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

11.3 GASEOUS WASTE MANAGEMENT SYSTEM

REVIEW RESPONSIBILITIES

Primary - Organization responsible for the review of radioactive gaseous effluent source terms, gaseous effluent releases, and associated doses to offsite receptors.

Secondary - Organization responsible for the review of the gaseous waste management system functional performance.

I. AREAS OF REVIEW

The gaseous waste management system (GWMS) involves the gaseous radwaste system (GRS), which deals with the management of radioactive gases collected in the offgas system (this system contains charcoal delay beds) or the waste gas storage and decay tanks. In addition, it involves the management of a condenser air removal system, steam generator blowdown flash tank (if applicable), and containment purge exhausts for PWRs; hydrogen and oxygen recombiners and instrumentation to control hydrogen and oxygen levels; gland seal exhaust and mechanical vacuum pump operation exhaust for BWRs; and building ventilation system exhausts for both PWRs and BWRs. The management for gaseous effluents to the environment from the above sources may, in turn, involve the use of mobile equipment connected to permanently installed systems to reduce releases of radioactive materials in effluents from the above sources. The review of the GWMS includes the design, design objectives, design criteria, methods of treatment, expected releases, and methods and principal parameters used in calculating effluent source terms and releases of radioactive materials (noble gases, radioiodines, tritium, carbon-14, and particulates). SRP Section 12.3-12.4 considers the presence of N-16, as a noble gas, in assessing doses from external radiation from the turbine buildings of BWR plants. The review will include system piping and instrumentation diagrams (P&IDs) and process flow diagrams showing methods of operation and factors that influence waste treatment (e.g., system interfaces and potential bypass routes

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to nonradioactive systems).

The specific areas of review are as follows:

1. Equipment and ventilation system design capacities, expected flows, source terms and radionuclide concentrations, expected decontamination factors or removal efficiencies for radionuclides, and holdup or decay time.

2. System design capacity relative to the design and expected input flows, the period of time the system is required to be in service to process normal waste flows, availability of standby equipment, alternate processing routes, and interconnections between subsystems. This information is used to evaluate the overall ability of the system to meet anticipated demands imposed by major processing equipment downtime and waste volume surges cause by anticipated operational occurrences.

3. Quality group classifications of piping and equipment, the bases governing the chosen design criteria, design and expected temperatures and pressures, and materials used to construct the system components.

4. Design provisions incorporated in the equipment and facility design to facilitate operation and maintenance in conformance with Regulatory Guide 1.143 for gaseous wastes produced during normal operation and anticipated operational occurrences.

5. Design features that would reduce the volumes of gaseous waste to the GWMS; reduce radioactivity levels and discharges of radioactive materials in gaseous effluents; minimize, to the extent practicable, contamination of the facility and environment; facilitate eventual decommissioning; and minimize, to the extent practicable, the generation of radioactive waste.

6. Design features to reduce leakage of gaseous waste or discharges of radioactive materials in gaseous effluents to avoid uncontrolled and unmonitored releases to the environment, special design features, topical reports incorporated by reference, and data obtained from previous experience with similar systems as described in the SAR.

7. Design features to preclude the possibility of an explosion if the potential for hydrogen and oxygen explosive mixtures exist in system components.

8. For multi-unit stations, descriptions and design features of equipment and components (either as permanently installed systems or in combination with mobile processing equipment) normally shared between interconnected processing and treatment subsystems.

9. Types and characteristics of filtration and adsorbent media to treat gaseous process and effluent streams, including expected removal efficiencies, decontamination factors, and holdup or decay times.

10. Definition of the boundary of the GWMS, beginning at the interface from plant systems provided for the collection of process streams and radioactive gaseous waste to the points of controlled discharges to the environment as defined in the Offsite Dose Calculation Manual (ODCM), or at the point of storage in holdup tanks or decay beds in accordance with Regulatory Guide 1.143 for gaseous wastes produced during normal operation and anticipated operational occurrences.

11. Inspection, Test, Analysis, and Acceptance Criteria (ITAAC). For design certification

(DC) and combined license (COL) reviews, the applicant's proposed information on the ITAAC associated with the systems, structures, and components (SSCs) related to this SRP section is reviewed in accordance with SRP Section 14.3, "Inspections, Tests, Analyses, and Acceptance Criteria - Design Certification." The staff recognizes that the review of ITAAC is performed after review of the rest of this portion of the application against acceptance criteria contained in this SRP section. Furthermore, the ITAAC are reviewed to assure that all SSCs in this area of review are identified and addressed as appropriate in accordance with SRP Section 14.3.

12. COL Action Items and Certification Requirements and Restrictions. For a DC application, the review will also address COL action items and requirements and restrictions (e.g., interface requirements and site parameters).

    For a COL application referencing a DC, a COL applicant must address COL action items (referred to as COL license information in certain DCs) included in the referenced DC. Additionally, a COL applicant must address requirements and restrictions (e.g., interface requirements and site parameters) included in the referenced DC.

Review Interfaces

The listed SRP sections interface with this section as follows:

1. Review of the independent source term and dose calculations for the purpose of assessing the performance of the GWMS against the NRC requirements of 10 CFR 20.1302; Table 2, Column 1, of Appendix B to 10 CFR Part 20; and the dose objectives of Appendix I to 10 CFR Part 50, is conducted under SRP Section 11.1 and SRP Section 11.5.

2. Review of design provisions incorporated into the GWMS to control, sample, and monitor radioactive materials in gaseous processes and effluent streams is performed under SRP Section 11.5.

3. Review of the the dose calculation methods and parameters of the Standard Radiological Effluent Controls (SREC), as they relate to the ODCM is performed under SRP Section 11.5.

4. Review of the acceptability of the design analyses, procedures, and criteria used to establish the ability of Seismic Category I structures housing the system and supporting systems to withstand the effects of natural phenomena, such as the safe-shutdown earthquake, the probable maximum flood, and tornadoes and tornado missiles, is performed under SRP Sections 3.3.1, 3.3.2, 3.4.2, 3.5.3, 3.7.1 through 3.7.4, 3.8.4, and 3.8.5.

5. Review of the GWMS fire protection and prevention program is performed under SRP Section 9.5.1.

6. Review of the acceptability of the seismic and quality group classifications for structures and system components is performed under SRP Sections 3.2.1 and 3.2.2.

7. Review of technical specifications (TS) for the GWMS is performed under SRP Section 16.0.

8. Review of quality assurance is performed under SRP Section 17.0.

9. Review of design features of the GWMS process and post-accident sampling subsystems is conducted under SRP Sections 9.3.2 and 11.5.

10. Review of design features of building exhaust and ventilation systems servicing areas where radioactive materials are present (e.g., use of HEPA and charcoal filters) is conducted under SRP Section 9.4 and under SRP Section 11.5 for instrumentation used to monitor and control radioactive effluent releases.

11. The review of design features for the protection of potable and sanitary water systems is conducted under SRP Section 9.2.4.

The specific acceptance criteria and review procedures are contained in the referenced SRP sections.

II. ACCEPTANCE CRITERIA

Requirements

Acceptance criteria are based on meeting the relevant requirements of the following Commission regulations:

1. 10 CFR 20.1302, as it relates to radioactivity in gaseous effluents released to unrestricted areas.

2. 10 CFR 20.1406, as it relates to the design and operational procedures (for applications other than renewals, after August 20, 1997) for minimizing contamination, facilitating eventual decommissioning, and minimizing the generation of radioactive waste.

3. 10 CFR 50.34a, as it relates to the provision of sufficient design information to demonstrate that design objectives for equipment necessary to control releases of radioactive effluents to the unrestricted areas are kept as low as reasonably achievable.

4. General Design Criterion 3 (GDC) 3, as it relates to the design of gaseous waste handling and treatment systems to minimize the effects of explosive mixtures of hydrogen and oxygen.

5. GDC 60, as it relates to the design of the GWMS to control releases of radioactive materials to the environment.

6. GDC 61, as it relates to radioactivity control in the GWMS associated with fuel storage and handling areas.

7. 10 CFR Part 50, Appendix I, Sections II.B, II.C, and II.D, as they relate to the numerical guides for design objectives and limiting conditions for operation to meet the “as low as is reasonably achievable” criterion.

8. 40 CFR Part 190 (EPA generally applicable environmental radiation standards), as implemented under 10 CFR 20.1301(e), as it relates to limits on total annual doses from all sources of radioactivity and external radiation from the site (with single or multiple units).

9. 10 CFR 52.47(a)(1)(vi), as it relates to ITAAC (for design certification) sufficient to assure that the SSCs in this area of review will operate in accordance with the certification.

10. 10 CFR 52.97(b)(1), as it relates to ITAAC (for combined licenses) sufficient to assure that the SSCs in this area of review have been constructed and will be operated in conformity with the license and the Commission's regulations.

SRP Acceptance Criteria

Specific SRP acceptance criteria to meet the relevant requirements of the NRC's regulations identified above are as follows for review described in Subsection I of this SRP section. The SRP is not a substitute for the NRC's regulations, and compliance with it is not required. However, an applicant is required to identify differences between the design features, analytical techniques, and procedural measures proposed for its facility and the SRP acceptance criteria and evaluate how the proposed alternatives to the SRP acceptance criteria provide acceptable methods of compliance with the NRC regulations.

1. The GWMS should have the capability to meet the dose design objectives and should include provisions to treat gaseous radioactive wastes such that the following is true:

    A. The calculated annual total quantity of all radioactive materials released from each reactor to the atmosphere will not result in an estimated annual external dose from gaseous effluents to any individual in unrestricted areas in excess of 0.05 mSv (5 mrem) to the total body or 0.15 mSv (15 mrem) to the skin. Regulatory Guides 1.109, 1.111, and 1.112 provide acceptable methods for performing this analysis.

    B. The calculated annual total quantity of radioactive materials released from each reactor to the atmosphere will not result in an estimated annual air dose from gaseous effluents at any location near ground level which could be occupied by individuals in unrestricted areas in excess of 0.01 cGy (10 millirads) for gamma radiation or 0.02 cGy (20 millirads) for beta radiation. Regulatory Guides 1.109, 1.111, and 1.112 provide acceptable methods for performing this analysis.

    C. The calculated annual total quantity of radioiodines, carbon-14, tritium, and all radioactive materials in particulate form released from each reactor at the site in effluents to the atmosphere will not result in an estimated annual dose or dose commitment from such releases for any individual in an unrestricted area from all pathways of exposure in excess of 0.15 mSv (15 mrem) to any organ. Regulatory Guides 1.109, 1.111, and 1.112 provide acceptable methods for performing this analysis.

    D. In addition to 1.A, 1.B, and 1.C, above, the GWMS should include all items of reasonably demonstrated technology that, when added to the system sequentially and in order of diminishing cost-benefit return, for a favorable cost-benefit ratio, can effect reductions in dose to the population reasonably expected to be within 80 km (50 mi) of the reactor. Regulatory Guide 1.110 provides an acceptable method for performing this analysis.

    E. The concentrations of radioactive materials in gaseous effluents released to an unrestricted area should not exceed the limits specified in Table 2, Column 1, of Appendix B to 10 CFR Part 20.

F. The regulatory position contained in Regulatory Guide 1.140 is met, as it relates to the design testing and maintenance of normal ventilation exhaust system air filtration and adsorption units at nuclear power plants.

G. The regulatory position contained in Regulatory Guide 1.143 is met, as it relates to the seismic design and quality group classification of components used in the structures housing the GRS and the provisions used to control leakages of gaseous wastes produced during normal operation and anticipated operational occurrences.

H. The regulatory position contained in Regulatory Guide 1.143 is met, as it relates to the definition of the boundary of the GWMS, beginning at the interface from plant systems to the point of controlled discharges to the environment as defined in the ODCM, or at the point of storage in holdup tanks or decay beds for gaseous wastes produced during normal operation and anticipated operational occurrences.

2. The GWMS should be designed to meet the anticipated processing requirements of the plant. Adequate capacity should be provided to process gaseous wastes during periods when major processing equipment may be down for maintenance (single failures) and during periods of excessive waste generation. Systems that have adequate capacity to process the anticipated wastes and that are capable of operating within the design objectives during normal operation, including anticipated operational occurrences, are acceptable. To meet these processing demands, the reviewer will consider shared systems, redundant equipment, mobile equipment, and reserve storage capacity.

3. The seismic design and quality group classification of components used in the GWMS and structures housing the system should conform to Regulatory Guide 1.143. The design should include precautions to stop continuous leakage paths (i.e., to provide liquid seals downstream of rupture discs) and to prevent permanent loss of the liquid seals in the event of an explosion due to gaseous wastes produced during normal operation and anticipated operational occurrences.

4. System designs should describe features that will minimize, to the extent practicable, contamination of the facility and environment; facilitate eventual decommissioning; and minimize, to the extent practicable, the generation of radioactive waste in accordance with Regulatory Guide 1.143, for gaseous wastes produced during normal operation and anticipated operational occurrences, and the requirements of 10 CFR 20.1406 or the DC application, update in the SAR, or the COL application to the extent not addressed in a referenced certified design.

5. System designs should use the guidelines in Regulatory Guide 1.140 for the design testing and maintenance of HEPA filters and charcoal adsorbers installed in normal ventilation exhaust systems. If decontamination factors for radioiodines that differ from those specified in Regulatory Guide 1.140 are used for design purposes, they should be supported by test data under operating or simulated operating conditions (temperature, pressure, humidity, expected iodine concentrations, and flow rate). The test data should also support the effects of aging and poisoning by airborne contaminants.

6. If the potential for explosive mixtures of hydrogen and oxygen exists, the GRS portion of the GWMS should either be designed to withstand the effects of a hydrogen explosion or be provided with dual gas analyzers with automatic control functions to preclude the formation or buildup of explosive mixtures. The GRS is normally the only portion of the system that is vulnerable to potential hydrogen explosion.

   A. For a system designed to withstand the effects of a hydrogen explosion, the design pressure of the system should be approximately 20 times the operating absolute pressure (including the intermediate stage condenser for BWR offgas systems).

   B. Small allowances should be made to conform to standard design pressures for off-the-shelf components (e.g., if the system operating pressure is nominally 103 kPa (15 psia) but could approach 138 kPa (20 psia) by design, piping could be designed to 2413 kPa (350 psia), since the next higher standard pressure rating is 4137 kPa (600 psia)).

   C. The process gas stream should be analyzed for potentially explosive mixtures and annunciated both locally and in the control room.

   D. For systems not designed to withstand a hydrogen explosion, dual gas analyzers (with dual being defined as two independent gas analyzers continuously operating and providing two independent measurements verifying that hydrogen and/or oxygen are not present in potentially explosive concentrations) with automatic control functions are required to preclude the formation or buildup of explosive hydrogen/oxygen mixtures. Gas analyzers should annunciate alarms both locally and in the control room. Analyzer "high alarm" setpoints should be set at approximately 2 percent and "high-high alarm" setpoints should be set at a maximum of 4 percent hydrogen or oxygen.

   Control features to reduce the potential for explosion should be automatically initiated at the "high-high alarm" setting. The automatic control features should be as follows:

      i. For systems designed to preclude explosions by maintaining either hydrogen or oxygen below 4 percent, the source of hydrogen or oxygen (as appropriate) should be automatically isolated from the system (valves should fail in closed position).

      ii. For systems using recombiners, if the downstream hydrogen and/or oxygen concentration exceeds 4 percent (as appropriate), acceptable control features include automatic switching to an alternate recombiner train.

      iii. Injection of diluents to reduce concentrations below the limits specified herein.

   Systems designed to operate below 4 percent hydrogen and below 4 percent oxygen may be analyzed for either hydrogen or oxygen; systems designed to operate below 4 percent hydrogen only (no oxygen restrictions) should be analyzed for hydrogen; and systems designed to operate above 4 percent hydrogen should be analyzed for oxygen.

   For BWR systems with steam dilution upstream of the recombiners, analysis for hydrogen (oxygen is not an acceptable alternative) should be downstream of the recombiners and upstream of the delay portions of the system (analysis upstream of the recombiners is not required if the system is designed to assure the availability of dilution steam during operation). For PWR systems using recombiners, analysis for hydrogen and/or oxygen should be downstream of the recombiners. In addition, unless the system design features preclude explosive gas mixtures of hydrogen and oxygen upstream of the recombiners, analysis for hydrogen and/or oxygen (as appropriate) should be upstream of the recombiners as well.

The number of gas analyzers and control features at each location should be in accordance with this SRP section. One gas analyzer upstream and one gas analyzer downstream of the recombiners should not be construed as dual gas analyzers. For systems involving pressurized storage tanks (excluding surge tanks), at least one gas analyzer is required between the compressor and the storage tanks. Dual gas analyzers set to sequentially measure concentrations both upstream and downstream of a recombiner are acceptable for a PWR. When two or more potentially explosive process streams are combined before entering a component, each stream or the combination thereof, is required to have dual gas analyzers.

If gas analyzers are to be used to sequentially measure several points in a system not designed to withstand a hydrogen explosion, at least one gas analyzer which is continuously on stream is required. The continuous gas analyzer should be located at a point common to streams and measured sequentially (i.e., the analyzer should be sampling the combined stream).

Gas analyzers should have daily sensor checks, monthly functional checks, and quarterly calibrations.

Gas analyzers installed in systems designed to withstand a hydrogen explosion should be capable of withstanding a hydrogen explosion; gas analyzers installed in the systems not designed to withstand a hydrogen explosion need not be capable of withstanding a hydrogen explosion (similar requirements apply to radiation monitors which are internal to lines containing potentially explosive mixtures).

All gas analyzer instrumentation systems shall be nonsparking.

7. Branch Technical Position (BTP 11-5), as it relates to potential releases of radioactive materials (noble gases) as a result of postulated leakage or failure of a waste gas storage tank or offgas charcoal delay bed.

Technical Rationale

The technical rationale for application of these requirements to reviewing this SRP section is discussed in the following paragraphs:

1. 10 CFR 20.1302 requires that surveys of radiation levels in unrestricted areas and radioactive materials in effluents released to unrestricted areas be performed to demonstrate system compliance with the dose limits to individual members of the public contained in 10 CFR 20.1301.

   10 CFR 20.1302 identifies two approaches, either of which can demonstrate compliance with the dose limits of 10 CFR 20.1301 and 10 CFR 20.1301(e). One of these

approaches requires a demonstration of the following:

A. That the annual average concentrations of radioactive materials released in gaseous and liquid effluents at the boundary of the unrestricted area do not exceed the values specified in Table 2 of Appendix B to 10 CFR Part 20.

B. That the annual and hourly doses from external sources to an individual continuously present in an unrestricted area will not exceed 0.5 mSv (0.05 rem) and 0.02 mSv (0.002 rem), respectively.

Meeting the above requirements provides assurance that the dose limits to individual members of the public specified in 10 CFR 20.1301 will not be exceeded. The review detailed in this SRP section will evaluate the ability of the system to meet the dose requirements identified above. SRP Section 11.2 identifies compliance with the limits on liquid effluent concentrations in unrestricted areas as an acceptance criterion; consequently, the ability of a facility to meet this criterion will be evaluated under Section 11.2.

2. Under the provisions of 10 CFR 20.1406, the NRC focuses on design features or operational procedures that would reduce the amount of gaseous wastes, reduce radioactivity levels and discharges of radioactive materials in effluents, minimize contamination of the facility and environment, and avoid or reduce the potential for uncontrolled and unmonitored releases to the environment. In the context of this SRP section, relevant and specific guidance to meet 10 CFR 20.1406 includes:

   A. Gaseous waste processing systems (either as permanently installed systems or in combination with mobile equipment) with a potential for leakage should include the means to control and contain this leakage to prevent contamination of building floors and interconnected systems (e.g., curbing, floor sloping to local drains, floor-to-floor seals over floor expansion joints, wall-to-floor joint seals, sheathed hoses, drip pans or containment boxes, backflow preventers, siphon breakers, self-sealing quick-disconnects, and operational interlocks). See guidance given in IE Bulletin No. 80-10 as an example.

   B. In minimizing the generation of waste, provisions should be made to clean contaminated equipment (e.g., system components) and to reuse charcoal adsorbent media via regeneration, when feasible.

   C. Mobile gaseous waste processing systems with interconnections to a permanently installed plant GWMS and condensate drains connected to LWMS subsystems should include provisions that (1) avoid the contamination of nonradioactive systems, (2) prevent uncontrolled and unmonitored releases of radioactive materials in the environment, and (3) avoid interconnections with nonradioactive systems.

3. Acceptance Criterion II.3 gives the technical rationale for 10 CFR 50.34a requirements.

   Meeting the requirements of 10 CFR 50.34a, as they relate to the GWMS, provides assurance that nuclear power reactors will meet the criterion that controlled releases of radioactive materials in effluents to unrestricted areas in the vicinity of a nuclear facility will be kept as low as is reasonably achievable and that the GWMS will have the necessary design features and equipment to control releases of gaseous effluent to the environment in accordance with the requirements of 10 CFR Part 20, 10 CFR 20.1302, and 10 CFR 20.1301(e); Appendix I to 10 CFR Part 50; and GDC 60 and 61.

4. GDC 3 provides that SSCs important to safety shall be designed and located, consistent with other safety requirements, to minimize the probability and effect of fires and explosions.

   With regard to the GRS portion of the GWMS, if a potential for explosive hydrogen and oxygen mixtures exists, then designing the GRS to withstand the effects of such an explosion or providing the GRS with dual instrumentation and design features to annunciate and prevent the buildup of potentially explosive mixtures, satisfies the requirements of GDC 3..

   Meeting the requirements of GDC 3 provides assurance that the GRS is protected from the effects of an explosive mixture of hydrogen and oxygen and that the safety functions of other SSCs will not be compromised.

5. Compliance with GDC 60 requires that design provisions be included in the nuclear power unit to control releases of radioactive materials in gaseous effluents to the environment during normal reactor operation, including anticipated operational occurrences.

   GDC 60 specifies that the radwaste processing systems provide for a holdup capacity sufficient to retain radioactive waste, particularly where unfavorable site environmental conditions may impose unusual operational limitations upon the release of effluents. The holdup capacity also provides time to allow shorter lived radionuclides to decay before they are further processed or released to the atmosphere. The holdup or decay times are used in source term calculations based on the methods described in NUREG-0016 or NUREG-0017 and Regulatory Guide 1.112.

   The review will evaluate the types and characteristics of filtration and adsorbent media proposed to treat gaseous process and effluent streams, including removal efficiencies and decontamination factors, taking into account the expected physical, chemical, and radiological properties of gaseous process and effluent streams. The review should determine whether performance meets or exceeds that noted in NRC guidance (Regulatory Guide 1.140 and NUREG-0016 or NUREG-0017), standard DCs, industry standards, or topical reports.

   Meeting the requirements of GDC 60 provides assurance that releases of radioactive materials in gaseous effluents to unrestricted areas during normal plant operation and anticipated operational occurrences will not result in offsite radiation doses exceeding the dose objectives specified in Appendix I to 10 CFR Part 50 and concentrations of radioactive materials in gaseous effluents in any unrestricted area exceeding the limits specified in Table 2, Column 1, of Appendix B to 10 CFR Part 20.

6. Compliance with GDC 61 requires that the GWMS and other systems (either as permanently installed systems or in combination with mobile equipment) that may contain radioactivity shall be designed to assure adequate safety under normal and postulated accident conditions. This criterion specifies that such facilities shall be designed with a capability to permit inspection and testing of components important to safety and with suitable shielding for radiation protection.

Regulatory Guide 1.140 provides design guidance acceptable to the NRC staff relating to design, testing, and maintenance criteria for air filtration and adsorption units, and Regulatory Guide 1.143 describes design guidance acceptable to the NRC staff relating to seismic and quality group classification and quality assurance provisions for the GRS portion of the GWMS structures and components, involving gaseous wastes produced during normal operation and anticipated operational occurrences.

Meeting the requirements of GDC 61 provides assurance that releases of radioactive materials during normal operation and during anticipated operational occurrences will not result in radiation doses that exceed the limits specified in 10 CFR 20.1302. In addition, meeting these requirements will help to assure that the GWMS will continue to perform its safety function(s) under postulated accident conditions, given the guidance of Regulatory Guide 1.52.

7. Appendix I to 10 CFR Part 50 provides numerical guidance for design objectives to meet the requirements that radiation doses from radioactive materials in effluents released to unrestricted areas be kept as low as is reasonably achievable. Section II of Appendix I relates to the numerical guides for dose design objectives, limiting conditions for operation, and controls to meet the as low as is reasonably achievable criterion.

   Regulatory Guides 1.109 and 1.111 provide acceptable methods in performing dose analyses to demonstrate that the GWMS design results in doses from releases of radioactive materials from each reactor that comply with the Appendix I dose objectives.

   Regulatory Guide 1.110 provides an acceptable method of performing cost-benefit analysis to demonstrate that the GWMS design includes all items of reasonably demonstrated technology capable of reducing cumulative population doses from releases of radioactive materials in effluents from each reactor to levels as low as is reasonably achievable.

   Regulatory Guide 1.140 presents methods acceptable to the NRC staff for implementing the regulations in Appendix I to 10 CFR Part 50 by providing guidance on the design, testing, and maintenance criteria for HEPA filters and charcoal adsorbers in filtration systems.

   The requirements of Sections II.B, II.C, and II.D of Appendix I to 10 CFR Part 50 provide assurance that the limits for external radiation doses to a maximally exposed offsite individual, maximum offsite air doses from noble gases (as gamma and beta radiation), and radiation doses from carbon-14, tritium, particulates, and radioiodines to a maximally exposed offsite individual from gaseous effluents, specified in Sections II.B and II.C, and the acceptance criterion for cost-benefit analysis specified in Section II.D for meeting the as low as reasonably achievable objective will be met.

8. BTP ~~ETSB~~ 11-5 describes acceptable methods to evaluate doses associated with the postulated releases of radioactive gases resulting from the failure of a gas decay tank or bed or a leak from a GWMS component.

   The BTP presents guidelines for selecting the type of failure and model assumptions that provide reasonable assurance that the radiological consequences of a single failure of an active component will not result in doses exceeding a small fraction (10 percent) of the 10 CFR Part 100 dose limits for the whole body to any offsite individuals for the postulated event of systems designed to withstand explosions and earthquakes, or 1 mSv (0.1 rem) for systems not designed to withstand explosions and earthquakes. The analysis assumes that the waste gas system fails to meet its design bases, as required by 10 CFR 50.34a and GDC 60 and 61. The analysis relies on methods described in BTP ~~ETSB~~ 11-5 and the use of the PWR-GALE or BWR GALE code (NUREG-0016 or NUREG-0017) and Regulatory Guide 1.112.

9. 10 CFR 20.1301(e) requires that NRC-licensed facilities comply with the EPA generally applicable environmental radiation standards of 40 CFR Part 190 for facilities that are part of the fuel cycle. The EPA annual dose limits are 0.25 mSv (25 mrem) to the whole body, 0.75 mSv (75 mrem) to the thyroid, and 0.25 mSv (25 mrem) to any other organ.

   10 CFR 20.1301(e) requires that all potential sources of external radiation and radioactivity be considered, including liquid and gaseous effluents and external radiation exposures from buildings, storage tanks, radioactive waste storage areas, and N-16 skyshine from BWR turbine buildings. The EPA standards apply to the entire site or facility, whether with single or multiple units. SRP Sections 11.2 and 11.4 address the sources of radioactivity and doses associated with liquid effluents and solid wastes, respectively. SRP Section 12.3-12.4 addresses the source of radiation and external radiation exposures from buildings, storage tanks, radioactive waste storage areas, and N-16 skyshine from BWR turbine buildings.

   Meeting the requirements of 10 CFR 20.1301(e) provides assurance that doses to an individual located in an unrestricted area will not exceed the EPA standards by taking into account all sources of radioactivity and radiation.

III. REVIEW PROCEDURES

The NRC will review the description of the design features of the GWMS provided in the SAR, the DC application, the update of the FSAR, or the COL application to the extent not addressed in a referenced certified design, including SRP Sections 11.1, 11.2, 11.4, 11.5, and 12.3-12.4, for completeness in accordance with Regulatory Guide 1.70 or 1.206.

The reviewer will select and emphasize material from the procedures described below, as may be appropriate for a particular case.

For each area of review specified in Subsection I of this SRP section, the review procedure is identified below. The review procedures are based on the identified SRP acceptance criteria. For deviations from these specific acceptance criteria, the staff should review the applicant’s evaluation of how the proposed alternatives to the SRP criteria provide an acceptable method of complying with the relevant NRC requirements identified in Subsection II.

1. The review of the GWMS will evaluate P&IDs and system process flow diagrams to identify all sources and amounts of gaseous waste; points of collection of gaseous wastes; flowpaths of gases through subsystems, including all potential bypasses to nonradioactive systems; treatment methods; expected decontamination factors or removal efficiencies and holdup or decay times; and points of release of gaseous effluents to the environment.

   This information is used to calculate the quantity of radioactive materials (noble gases, radioiodines, tritium, carbon-14, and particulates) released annually in gaseous effluents during normal operations, including anticipated operational occurrences, using the given parameters and calculational techniques of NUREG-0016 or NUREG-0017 and

Regulatory Guide 1.112. The results of this calculation will determine whether the proposed GWMS design meets the acceptance criterion of SRP Acceptance Criteria 1 of this SRP section and relevant sections of SRP Section 11.1.

Compliance with the acceptance criteria of SRP Acceptance Criteria 1.A, 1.B, and 1.C of this SRP section concerning exposures of the total body, skin, and thyroid will be determined based on dose and source term calculations performed by NRC staff using NUREG-0016 or NUREG-0017, Regulatory Guide 1.112, and NUREG/CR-4653 (GASPAR II code).

The NRC staff will determine conformance with the acceptance criterion given in SRP Acceptance Criteria 1.D of this SRP Section, concerning the cost-benefit analysis based on an analysis that includes population cumulative dose calculations (person-Sv (person-rem)) and cost-benefit studies. Regulatory Guide 1.110 describes methods for performing such cost-benefit analyses.

2. The review of the GWMS design capacity will encompass the following major areas:

   A. The capability of the GRS to process gaseous wastes in the event of a single major equipment item failure. For nonredundant equipment or components, a 3-week downtime every other year will be assumed (10 days per year average).

   B. The capability of the GRS to process gaseous wastes at design-basis fission product levels (i.e., from 1 percent of the fuel-producing power in a PWR or in a BWR, consistent with a noble gas release rate of 3.7 MBq/s per MWt (100 μCi/s per MWt) with a 30-minute delay.

   C. The operational flexibility designed into the GRS (e.g., cross-connections between subsystems, redundant or reserve processing equipment, and reserve storage capacity, including the use of mobile processing and treatment systems).

   D. In the evaluation of charcoal delay systems for radioactive gas decay, the bed dimensions, mass of charcoal, flow rate, temperatures, pressures, humidity, and dynamic adsorption coefficients are used to calculate the effective holdup times.

   E. Types and characteristics of filtration and adsorbent media to treat gaseous process and effluent streams, with removal efficiencies and decontamination factors meeting or exceeding the performance of NRC generic guidance (NUREG-0016 or NUREG-0017 and Regulatory Guide 1.140), standard design certifications, or topical reports, taking into account the expected physical, chemical, and radiological properties of gaseous process and effluent streams.

   F. Analysis and results demonstrating compliance with BTP ~~ETSB~~ 11-5 for doses to any offsite individuals associated with the postulated failure of a waste gas system component or leak.

3. The quality group classification of piping and equipment in the GRS portion of the GWMS is compared to the guidelines of Regulatory Guide 1.143 for gaseous wastes produced during normal operation and anticipated operational occurrences. The seismic design criteria of equipment and of structures housing the GRS is also compared to the design guidance identified in Regulatory Guide 1.143. When applicable, SRP Sections 3.2.1, 3.2.2, 3.3.1, 3.3.2, 3.5.3, 3.7.1 through 3.7.4, 3.8.4,

and 3.8.5 will be used to evaluate exceptions.

The applicant's design is reviewed to ensure that it includes adequate provisions to stop continuous leakage paths after an explosion. The areas of concern are (1) process streams where water decomposition gases (hydrogen and oxygen) exist in a BWR, (2) cover gas streams where air in-leakage can occur in a PWR, and (3) areas where there is a possibility of liquid hydrocarbons and ozone collecting in a cryogenic distillation system.

4. The GRS design, system layout, equipment design, method of operation, and provisions to reduce leakage and to facilitate operations and maintenance are compared to Regulatory Guide 1.143 for gaseous wastes produced during normal operation and anticipated operational occurrences. Special design features provided to control leakage from system components and topical reports on system designs will be evaluated on a case-by-case basis.

5. The review will compare the design, testing, and maintenance criteria for HEPA filters and charcoal adsorbers in filtration systems against the provisions of Regulatory Guide 1.140.

6. If a potential for explosive hydrogen and oxygen mixtures exist, it will be determined, using the system description and P&IDs, whether the applicant has designed the GRS to withstand the effects of such an explosion or has provided the required dual instrumentation and design features to annunciate and prevent the buildup of potentially explosive mixtures, respectively.

7. Part of the review identified in SRP Sections 11.5 and 16.0 will evaluate the SREC, ODCM, and Administrative Controls section of the TS proposed by the applicant for process and effluent controls. The reviewer will determine that the content of the SREC and ODCM, calculation methods, and scope of the programs identified in the Administrative Controls section of the TS are in agreement with the requirements identified as a result of the staff's review. The review will include the evaluation or development of appropriate controls and the limiting conditions for operation and their bases, consistent with the plant design. The ODCM, SREC, and TS are reviewed with respect to the requirements of 10 CFR 50.36a using Generic Letter 89-01 and guidance contained in NUREG-1301 (PWR) or NUREG-1302 (BWR) or NUREG-0133 for either type of plant. (Note: Generic Letter 89-01 is included in NUREG-1301 and NUREG-1302.)

8. The review considers information describing design features that will minimize, to the extent practicable, contamination of the facility and environment; facilitate eventual decommissioning; and minimize, to the extent practicable, the generation of radioactive waste in accordance with the requirements of 10 CFR 20.1406 and Regulatory Guide 1.143 for gaseous wastes produced during normal operation and anticipated operational occurrences. The review may also consider the information contained in the DC application, the update in the SAR, or the COL application, to the extent not addressed in a referenced certified design. NRC guidance includes the following:

   A. IE Bulletin No. 80-10

   B. Memorandum from Larry W. Camper to David B. Matthews and Elmo E. Collins, dated October 10, 2006 (ADAMS Accession No. ML0619201830), and NUREG/CR-3587, as they relate to the design issues that need to be addressed to meet the requirements of 10 CFR 20.1406

C. "Liquid Radioactive Release Lessons Learned Task Force, Final Report," Sections 2.0 and 3.2.2, September 1, 2006 (ADAMS Accession No. ML062650312)

D. Regulatory Guides 1.143 and 1.11

E. Industry standards, e.g., ANSI/ANS-55.4-1993 (1999), ANSI/ANS-40.37-1993 (200x updated draft)

9. In determining compliance with 40 CFR Part 190, as implemented under 10 CFR 20.1301(e), the review considers all sources of radiation and radioactivity as a potential contributor to doses to members of the public from the site (which may have either single or multiple units). The review focuses on sources of radioactivity, as gaseous and liquid effluents, and external radiation exposures from buildings, storage tanks, radioactive waste storage buildings, and N-16 skyshine from BWR turbine buildings. The source terms and associated doses from gaseous effluents are evaluated in this section of the SRP, while SRP Sections 11.2 and 11.4 evaluate source terms and doses from liquid effluents and solid wastes. In turn, SRP Section 11.5 addresses compliance with all sources of effluents. SRP Section 12.3-12.4 evaluates doses associated with external radiation from buildings and contained sources of radioactivity.

10. For reviews of DC and COL applications under 10 CFR Part 52, the reviewer should follow the above procedures to verify that the design set forth in the safety analysis report, and if applicable, site interface requirements meet the acceptance criteria. For DC applications, the reviewer should identify necessary COL action items. With respect to COL applications, the scope of the review is dependent on whether the COL applicant references a DC, an ESP or other NRC-approved material, applications, and/or reports.

    After this review, SRP Section 14.3 should be followed for the review of Tier I information for the design, including the postulated site parameters, interface criteria, and ITAAC.

IV. EVALUATION FINDINGS

The reviewer verifies that the applicant has provided sufficient information and that the review and calculations (if applicable) support the following conclusions to be included in the staff's safety evaluation report. The reviewer also states the bases for those conclusions.

The staff concludes that the design of the GWMS (either as a permanently installed system or in combination with a mobile system) includes the necessary equipment to process and control releases of radioactive materials in gaseous effluents in accordance with GDC 3, 60, and 61 of Appendix A to 10 CFR Part 50 and 10 CFR 50.34a. The staff concludes that the design of the GWMS is acceptable and meets the requirements of 10 CFR Part 20, 10 CFR 20.1301 and 20.1302, 10 CFR 20.1301(e), and 10 CFR 20.1406; 10 CFR Part 50 and 10 CFR 50.34a; GDC 3, 60, and 61; and Appendix I to 10 CFR Part 50.

This conclusion is based on the following:

1. The applicant has met the requirements of GDC 60 and 61 with respect to controlling

releases of radioactive materials to the environment by assuring that the design of the GWMS includes the equipment and instruments necessary to detect and control the release of radioactive materials in gaseous effluents.

2. The applicant has met the requirements of Appendix I to 10 CFR Part 50 by meeting the as low as is reasonably achievable criterion as follows:

   A. Regarding Sections II.B and II.C of Appendix I, the staff has considered releases of radioactive material (noble gases, radioiodine, tritium, carbon-14, and particulates) in gaseous effluents for normal operation, including anticipated operational occurrences, based on expected amounts and concentrations of gaseous wastes over the life of the plant for each reactor on the site. The staff has determined that the proposed GWMS is capable of maintaining releases of radioactive materials in gaseous effluents such that the calculated individual doses in an unrestricted area from all pathways of exposure are less than 0.05 mSv (5 mrem) to the total body or 0.15 mSv (15 mrem) to the skin and less than 0.15 mSv (15 mrem) to any organ from releases of radioiodines, tritium, carbon-14, and radioactive materials in particulate form.

   B. The staff has determined that the calculated air doses from gaseous effluents at any location near ground level that could be occupied by individuals in unrestricted areas will be less than 0.01 cGy (10 millirads) for gamma radiation and 0.02 cGy (20 millirads) for beta radiation.

   C. Regarding Section II.D of Appendix I, the staff has considered the potential effectiveness of augmenting the proposed GWMS using reasonably demonstrated technology and determined that further gaseous effluent treatment will not effect reductions in cumulative population doses within an 80-km (50-mi) radius of the reactor at a cost of less than $1000 per man-rem or $1000 per man-thyroid-rem.

3. The applicant has met the requirements of 10 CFR 20.1302 since the staff has considered the potential consequences resulting from reactor operation with “1% of the operating fission product inventory in the core being released to the primary coolant” for a PWR, or “a fission product release rate consistent with a noble gas release rate to the reactor coolant of 3.7 MBq/sec per MWt (100 μCi/ sec per MWt) after 30 minute decay” for a BWR. The staff has further determined that, under these conditions, the concentrations of radioactive materials in gaseous effluents in unrestricted areas will be a small fraction of the limits specified in Table 2, Column 1, of Appendix B to 10 CFR Part 20.

4. The staff has reviewed the sources of radiation and radioactivity and associated doses to members of the public and concludes that annual doses from all sources of radioactivity and radiation from the site (which may have either single or multiple units), including liquid and gaseous effluents and external radiation exposures from buildings and storage tanks and N-16 skyshine from a BWR turbine building as a source of external radiation, will not exceed the EPA generally applicable environmental radiation standards of 40 CFR Part 190 as implemented under 10 CFR Part 20.1301(e).

5. The staff has considered the ability of the proposed GWMS to meet the anticipated demands of the plant resulting from anticipated operational occurrences and has concluded that the system capacity and design flexibility are adequate to meet the

anticipated needs of the plant.

6. The staff has reviewed the design features and operational programs and procedures to minimize, to the extent practicable, contamination of the facility and the environment; facilitate decommissioning; and minimize, to the extent practicable, the generation of radioactive waste. The staff concludes that the proposed design features and operational programs and procedures are consistent with NRC guidance and the requirements of 10 CFR 20.1406.

7. The staff has reviewed the applicant's quality assurance provisions for the GRS portion of the GWMS, the quality group classifications used for the GRS components, the seismic design applied to the design of the GRS, and the structures housing the GRS. The design of the GRS and the structures housing it meet the criteria set forth in Regulatory Guide 1.143 for gaseous wastes produced during normal operation and anticipated operational occurrences.

8. The staff has reviewed the provisions incorporated in the applicant's design to control the release of radioactive materials in gaseous wastes from inadvertent releases, avoid the contamination of nonradioactive systems, prevent uncontrolled and unmonitored releases of radioactive materials in the environment, and avoid interconnections with nonradioactive systems, and concludes that the measures proposed by the applicant are consistent with the requirements of GDC 60 and 64, and guidance of Regulatory Guide 1.143 for gaseous wastes produced during normal operation and anticipated operational occurrences.

9. The staff has reviewed the provisions incorporated in the applicant's design to control releases from hydrogen explosions in the GRS and concludes that the measures proposed by the applicant are adequate to prevent the occurrence of an explosion or to withstand the effects of an explosion, in accordance with GDC 3.

For DC and COL reviews, the findings will also summarize (to the extent that the review is not discussed in other SER sections) the staff's evaluation of the ITAAC, including design acceptance criteria, as applicable, and interface requirements and combined license action items relevant to this SRP section.

V. IMPLEMENTATION

The staff will use this SRP section in performing safety evaluations of DC applications and license applications submitted by applicants pursuant to 10 CFR Part 50 or 10 CFR Part 52. Except when the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the staff will use the method described herein to evaluate conformance with Commission regulations.

The provisions of this SRP section apply to reviews of applications docketed six months or more after the date of issuance of this SRP section, unless superceded by a later revision.

VI. REFERENCES

1. 10 CFR 20.1301, "Dose Limits for Individual Members of the Public."

2. 10 CFR 20.1302, "Compliance with Dose Limits for Individual Members of the Public."

3. 10 CFR 20.1406, “Minimization of Contamination.”

4. 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.”

5. 10 CFR 50.34a, “Design Objective for Equipment to Control Releases of Radioactive Materials in Effluents—Nuclear Power Reactors.”

6. 10 CFR 50.36a, “Technical Specifications on Effluents from Nuclear Power Reactors.”

7. 10 CFR Part 50, Appendix A, General Design Criterion 3, “Fire Protection.”

8. 10 CFR Part 50, Appendix A, General Design Criterion 60, “Control of Releases of Radioactive Materials to the Environment.”

9. 10 CFR Part 50, Appendix A, General Design Criterion 61, “Fuel Storage and Handling and Radioactivity Control.”

10. 10 CFR Part 50, Appendix I, “Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion ‘As Low As Is Reasonably Achievable’ for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents.”

11. Regulatory Guide 1.11, “Instrument Lines Penetrating Primary Reactor Containment.”

12. Regulatory Guide 1.33, “Quality Assurance Program Requirements (Operation).”

13. Regulatory Guide 1.52, “Design, Inspection, and Testing Criteria for Air Filtration and Adsorption Units of Post-Accident Engineered-Safety-Feature Atmosphere Cleanup Systems in Light-Water-Cooled Nuclear Power Plants.”

14. Regulatory Guide 1.70, “Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants.”

15. 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.”

16. Regulatory Guide 1.110, “Cost Benefit Analysis for Radwaste Systems for Light-Water-Cooled Nuclear Power Reactors.”

17. Regulatory Guide 1.111, “Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors.”

18. Regulatory Guide 1.112, “Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluent from Light-Water-Cooled Power Reactors.”

19. Regulatory Guide 1.140, “Design, Testing, and Maintenance Criteria for Normal Ventilation Exhaust System Air Filtration and Adsorption Units of Light-Water-Cooled Nuclear Power Plants.”

20. Regulatory Guide 1.143, “Design Guidance for Radioactive Waste Management

Systems, Structures and Components Installed in Light-Water-Cooled Nuclear Reactor Power Plants."

21. Regulatory Guide 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition)."

22. NUREG-0016, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Boiling Water Reactors (BWRs) (BWR GALE-Code)."

23. NUREG-0017, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors (PWRs) (PWR GALE Code)."

24. NUREG-0133, "Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants."

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

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

27. NUREG/CR-4653, "GASPAR II—Technical Reference and User Guide."

28. IE Bulletin No. 80-10, "Contamination of Nonradioactive System and Resulting Potential for Unmonitored, Uncontrolled Release of Radioactivity to Environment," May 6, 1980.

29. Memorandum from Larry W. Camper to David B. Matthews and Elmo E. Collins, dated October 10, 2006, "List of Decommissioning Lessons Learned in Support of the Development of a Standard Review Plan for New Reactor Licensing" (ADAMS Accession No. ML0619201830) and NUREG/CR-3587, "Identification and Evaluation of Facility Techniques for Decommissioning of Light Water Reactors."

30. Office of Nuclear Reactor Regulation, "Liquid Radioactive Release Lessons Learned Task Force, Final Report," Sections 2.0 and 3.2.2, September 1, 2006 (ADAMS Accession No. ML062650312)

31. ANSI/ANS-55.4-1993 (1999), "Gaseous Radioactive Waste Processing Systems for Light Water Reactor Plants." Reaffirmed in 1999.

32. ANSI/ANS-40.37-1993 (200x updated draft), "American National Standard For Mobile Low-Level Radioactive Waste Processing Systems." Proposed 2007 draft for public comments.

PAPERWORK REDUCTION ACT STATEMENT

The information collections contained in the draft Standard Review Plan are covered by the requirements of 10 CFR Part 50 and 10 CFR Part 52, and were approved by the Office of Management and Budget, approval number 3150-0011 and 3150-0151.

PUBLIC PROTECTION NOTIFICATION

The NRC may not conduct or sponsor, and a person is not required to respond to, a request for information or an information collection requirement unless the requesting document displays a currently valid OMB control number.

BRANCH TECHNICAL POSITION 11-5

Postulated Radioactive Releases Due to a Waste Gas System Leak or Failure

I. BACKGROUND

During normal operation of a nuclear power plant, the reactor generates radioactive fission and activation gases and gases resulting from the radiolytic decomposition of water. These gases are continuously removed from the reactor coolant. After separation, the gases may be treated for volume reduction of the non-radioactive species before they are stored for radioactive decay and ultimately released to the environment. The waste gas system accomplishes this separation, reduction, and decay process.

The waste gas system at BWRs may include steam air ejectors, vacuum pumps, decay pipes, moisture separators, condensers, cryogenic distillation, tanks, ambient or chilled charcoal adsorber beds, filters, process sampling, instrumentation and radiation monitoring, and associated control features. The waste gas system at PWRs may include volume control tanks, letdown or shim bleed gas separation, gas stripping, cover gas collection, compressors, recombiners, surge and storage tanks, ambient or chilled charcoal adsorbers, moisture separators, condensers, filters, process sampling, instrumentation and radiation monitoring, and control features. In all cases, the waste gas system is part of the radioactive GWMS and information on the system is considered as part of the design information required by 10 CFR 50.34a. System operation is required to be in accordance with 10 CFR 50.36a. SRP Section 11.3 describes the design acceptance criteria for waste gas systems (as part of the GWMS).

The basic criterion for reactor accidents, including waste gas system failures, is that offsite doses shall not exceed 25 rem to the whole body (10 CFR Part 100). However, that criterion assumes that the probability of occurrence is very small. It is recognized that the probability of an accidental release from the waste gas system is relatively high and that lower dose criteria are appropriate.

Generally, the following two kinds of waste gas system failures have been designated as warranting evaluation:

(1) gross system failures, such as rupture of a decay tank (Regulatory Guide 1.24) or rupture of a line (Regulatory Guide 1.98)

(2) malfunctions, such as operator errors, valve misalignments, malfunction of attendant equipment, and active component failures

Both the probabilities and the consequences of a waste gas system leak or failure depend on the kind of accident considered and the characteristics of the system (as defined in Tables 15-1 and 15-4 in Section 15.7.1 of Regulatory Guide 1.70).

Waste gas system design characteristics differ between plants, particularly between BWRs and PWRs, but the most important common characteristic among plants is that designs incorporate the guidance of Regulatory Guide 1.143 to withstand the effects of a hydrogen explosion and earthquakes for gaseous wastes produced during normal operation and anticipated operational occurrences. As a result, a gross failure of the waste gas system is considered highly unlikely, e.g., such as a failure involving the near total loss of the system's inventory of radioactive materials. However, for present purposes, the most important aspect ~~difference between systems~~ is that they have been designed in accordance with Regulatory Guide 1.143, and ~~Gross failure of the system is considered much less likely if the system is designed to withstand explosions and earthquakes.~~ therefore, the NRC ~~initially~~ considered a higher dose criterion for evaluating gross failures of such fortified systems. The goal of this position paper is to minimize potential radiation exposures to the public and to provide reasonable assurance that the radiological consequences of a single failure of an active component in the waste gas system will not result in a dose in excess of a small fraction (i.e., 10 percent) of the 10 CFR Part 100 limit for whole body dose to any offsite individual for a postulated event.

The dichotomy in having dose criteria for systems designed to withstand explosions and earthquakes that differ from those systems that are not designed to withstand such events has led to a problem. System malfunctions appear to be the controlling failure mode and resistance to explosions and earthquakes provides no protection against operator error and system malfunction. No specific types of system malfunction failures have been designated as being representative. However, it appears that an event, such as valve misalignment or over-pressure, could result in a release approximating that from the rupture of a tank or pipe. Therefore, it was considered that, for future safety evaluations of waste gas systems, the failures analyzed could be limited to tank or pipe ruptures, but the dose criterion in every case should not exceed 25 mSv (2.5 rem) at the exclusion area boundary, given that such systems are fortified to withstand the effects of a hydrogen explosion and earthquakes. However, for systems not designed to withstand explosions and earthquakes, the criterion is 1 mSv (0.1 rem) at the exclusion area boundary.

This BTP provides guidelines on postulated radioactive releases from a radioactive waste gas system leak or failure associated with normal operation and anticipated operational occurrences. The criteria in Section II, below, provide adequate and acceptable design solutions for the concerns outlined above. This position paper sets forth minimum requirements and does not prohibit the implementation of more rigorous design codes, standards, or quality assurance measures than those indicated. It also does not require a reevaluation of waste gas systems with limiting conditions for operation based on more conservative analysis and calculational assumptions.

II. BRANCH TECHNICAL POSITION

1. Waste Gas System Leak or Failure Analysis

A. Criteria

The SAR (Section 11.3) should provide an analysis of the radiological consequences of a single failure of an active component in the waste gas system. The analysis should provide reasonable assurance that, in the event of a postulated failure or leak of the waste gas system, the resulting total body exposure to an individual at the nearest exclusion area boundary will not exceed 25 mSv (2.5 rem) for systems designed to withstand explosions and earthquakes, or 1 mSv (0.1 rem) for systems not designed to withstand explosions and earthquakes. ~~This is consistent with the dose criterion for the event and is a small fraction of the 10 CFR Part 100 limit.~~ The bases for the analysis should include the assumption that the waste gas system fails to meet its design intent as required by 10 CFR 50.34a(c) and GDC 60 of Appendix A to 10 CFR Part 50.

B. Source Term

The safety analysis on the radiological consequences of a single failure of an active component in the waste gas system should use a system design-basis source term for light-water-cooled nuclear power plants. The NRC staff method of calculation for this analysis is based on conservative assumptions to maximize the design capacity source term (sustained power operation). These assumptions are given below:

i. For a PWR: 1 percent of the operating fission product inventory in the core being released to the primary coolant

ii. For a BWR: A fission product release rate consistent with the noble gas release to the reactor coolant of 100 μCi/s per MWt (after 30-minute decay)

The analysis should assume principal parameters and conditions typical of the equipment designed to remove radioactive gases from the coolant and to process and treat these gases during normal operation, including anticipated operational occurrences, by the waste gas system. The NRC staff believes that no major alteration would occur in the use or performance of gas separation, reduction, and decay equipment before and immediately following this unique unplanned release affected by the waste gas system maximum design capacity source term. The source terms and releases may be developed using the BWR-GALE Code (NUREG-0016) or PWR-GALE Code (NUREG-0017) with appropriately justified adjustments made in modeling a specific type of event.

C. Release

The NRC staff considers that the release to the environment resulting from the postulated event will occur via a pathway not normally used for planned releases, and the release will require a reasonable time to detect and take remedial action to terminate the release. The NRC staff considers that the release of a compressed gas storage tank of a batch-type waste gas system or the inadvertent bypass of the main decay portion of a continuous-type waste gas system (such as charcoal delay beds in a BWR-augmented offgas system) will provide a conservative assumption for the release, while the input to the waste gas system is at the system design-basis source term. Only the radioactive noble gases (xenon and krypton) are to be considered since the assumed transit time is long enough to permit major radioactive decay of oxygen and nitrogen isotopes. Particulates and radioiodines are assumed to be removed by pretreatment, gas separation, and intermediate radwaste treatment equipment. The release should be assumed to occur within the building structure housing the waste gas system storage tank or the main decay position of the system. It should further be assumed that the effluent resulting from the postulated event will be released to the environs without continuous effluent radiation monitoring to automatically isolate and/or terminate the effluent release. In addition, ground-level release without credit for a building wake factor should be assumed, and a conservative (5 percent) short-term diffusion estimate (X/Q), as determined by a method outlined in the acceptance criteria in SRP Section 2.3.4, should be assumed. No deposition is assumed to occur during downwind transport.

2. Staff Method for Analysis

A. Pressurized Storage Tanks: The safety analysis for the radiological consequences of a single failure of an active component in a waste gas system with compressed gas storage (holdup or decay) tanks or cover gas tanks assumes that the tank being filled has a major leak to the environs. The following general procedural steps should be used for this analysis:

(1) The radioactive noble gas inventory in the tank, at 100-percent capacity, should be determined based on the maximum expected radioactive source term and the system design capacity using the parameters and principal components considered for pretreatment and collection of waste gas to the waste gas system tanks during normal operation, including anticipated operational occurrences. The assumptions and parameters used in the analysis should be described and justified to include among others: a description of the event leading to the release, release path from the affected system and building to the environment, type of release, duration of the release, basis for the noble gas source term, assumed receptor location, atmospheric dispersion parameters, and any modifying factor specific to the event.

(2) The radiological impact should be determined using the noble gas radionuclide inventory determined step 1 above, total-body dose factor listed as DFB_i in Table B-1 of Regulatory Guide 1.109, in mrem-m^3/pCi-yr, any modifying factor specific to the event, and the relative concentration (X/Q, in s/m^3) at the nearest exclusion area boundary given in Figure 1 of Regulatory Guide 1.24 for ground-level releases.

~~To determine the pressurized storage tank noble gas inventory, the staff method alters the PWR-GALE Code (NUREG-0017) calculations and requires manual calculations to determine the radiological impact. Changes to the code's input parameters employ the following eight steps:~~

~~(1) Enter a value of zero for the "Holdup Time, in days, for Xe."~~

~~(2) Enter a value of zero for the "Holdup Time, in days, for Kr."~~

~~(3) Check the value entered for "Fill Time, in days." This should be the average volume for all storage or cover gas tanks. If this is a cover gas system, calculate the effective fill time based on 20 percent of the liquid tank volumes. (Charcoal delay systems are not applicable.) The PWR-GALE Code limits the minimum fill time to 0.01 days.~~

~~(4) Rerun the computer program for this analysis only.~~

(5) Multiply each noble gas given in the printout under "Gas Stripping—Continuous" by the ratio of the noble gas concentration in the reactor coolant corresponding to 1 percent failed fuel to that noble gas concentration in the coolant given by the GALE printout. This adjustment accounts for the design capacity source term correction.

(6) Divide the values in step (5) above by the number of tanks filled per year (equal to 365/value in step (3) above). This gives the tank inventory A_i for each nuclide.

(7) Calculate the radiological impact by the following equation:

$$\text{Dose} = \Sigma\ K_i\ A_i\ (X/Q)\ (10^{12}\ \text{pCi/Ci}) \div 3.15\times10^{7}\ \text{s/yr, in mrem}$$

where:

A_i = The noble gas nuclide activity determined in step 6 above, in curies/event.

K_i = The total-body dose factor listed as DFB_i in Table B-1 of Regulatory Guide 1.109, in mrem-m^3/pCi-yr.

(X/Q) = The relative concentration at the nearest exclusion area boundary given in Figure 1 of Regulatory Guide 1.24 for ground-level releases, in s/m^3.

(3 8) The dose, summed over all radionuclides, shall not exceed 25 mSv (2.5 rem) for systems designed to withstand explosions and earthquakes, or 1 mSv (0.1 rem) for systems not designed to withstand explosions and earthquakes. Using the same parameters, a corresponding TS can be defined to set a curie limit on a tank, based on the maximum of 25 mSv (2.5 rem) or 1 mSv (0.1 rem) at the nearest exclusion area boundary and same noble gas mixture to assure that the BTP criteria are met at the exclusion area boundary.

B. Charcoal Delay Units: The safety analysis for the radiological consequences of a single failure of an active component in a waste gas system with charcoal delay or decay beds units assumes that the charcoal unit is bypassed with a 1-hour release to the environs. The staff considers that either a line bypass valve malfunction, control error, or a charcoal bed bypass will require a remedial action by isolation and that starting an alternate charcoal unit, if available, or reducing reactor power could take up to 2 hours. The following general procedural steps should be used for this analysis:

(1) The radioactive noble gas inventory should be determined based on the maximum expected radioactive source term and the system design capacity using the parameters and principal components considered for pretreatment and collection of waste gas to the waste gas charcoal delay or decay beds during normal operation, including anticipated operational occurrences. The assumptions and parameters used in the analysis should be described and justified to include among others: a description of the event leading to the release, release pathway from the affected

system and building to the environment, type of release, duration of the release, basis for the noble gas source term after 30-minute decay, assumed receptor location, atmospheric dispersion parameters, and any modifying factor specific to the event.

(2) The radiological impact should be determined using the noble gas radionuclide inventory determined step 1 above, total-body dose factor listed as DFB_i in Table B-1 of Regulatory Guide 1.109, in mrem-m^3/pCi-yr, any modifying factor specific to the event, and the relative concentration (X/Q, in s/m^3) at the nearest exclusion area boundary given in Figure 1 of Regulatory Guide 1.24 for ground-level releases.

~~The radioactive noble gas concentration should be determined based on the system design capacity source term using the parameters and principal components considered for pretreatment and collection of waste gas to the waste gas system charcoal delay units during normal operation, including anticipated operational occurrences. To determine the releases without the charcoal delay unit, the staff method uses the BWR-GALE Code (NUREG-0016) and requires manual calculations to determine the radiological impact. Alterations to the PWR-GALE Code (NUREG-0017) are also included. Changes to the code's input parameters employ the following seven steps:~~

~~(1) Enter a value of 0.02 for the "Holdup Time, in days, for Xe." (BWR or PWR GALE Code)~~

~~(2) Enter a value of 0.02 for the "Holdup time, in days, for Kr." (BWR or PWR GALE Code)~~

~~(This time, about 30 minutes, is considered sufficient for gases to travel through the components in the waste gas system via the release point to the nearest exclusion boundary.)~~

~~(3) Rerun the computer program for this analysis only.~~

~~(4) Multiply each noble gas printout given under "Air Ejector" by 0.002 MWe, where MWe represents the rated reactor power level, to account for the design capacity source term correction.~~

~~(5) Add to each noble gas value determined in step (4, above, the applicable value for the nuclide given in the source term for normal operation. This step accounts for noble gases that have been delayed in the charcoal unit being released during the event.~~

~~(6) Calculate the radiological impact by the following equation:~~

~~Dose = Σ K_i Q_i (X/Q) (10^{12} pCi/Ci) (7.25×10^{-12} yr^2/event-s), in mrem~~

~~where:~~

~~Q_i = The noble gas nuclide release rate determined in steps 4 and 5, above, in curies/yr rate for 2 hours.~~

~~K_i = The total-body dose factor given as DFB_i in Table B-1 of Regulatory Guide 1.109, in mrem-m^3/pCi-yr.~~

~~(X/Q) = The relative concentration at the nearest exclusion area boundary given in Figure 1 of Regulatory Guide 1.24 for ground-level releases, in s/m^3~~

(3 ~~7~~) The dose, summed over all radionuclides, shall not exceed 1 mSv (0.1 rem). Using the same parameters, a corresponding TS can be defined to set a maximum release rate to the waste gas system of 100 μCi/s per MWt (after 30-minute decay) or use the value of Q_i (in μCi/s) as determined above. Using the lowest of these two values will assure that the BTP criteria are met for an exposure duration of 2 hours at the exclusion area boundary.

III. <u>REFERENCES</u>

1. 10 CFR Part 50.34a, "Design Objective for Equipment to Control Releases of Radioactive Materials in Effluents—Nuclear Power Reactors."

2. 10 CFR 50.36a, "Technical Specifications on Effluents from Nuclear Power Reactors."

3. 10 CFR Part 50, Appendix A, General Design Criterion 60, "Control of Releases of Radioactive Materials to the Environment."

4. 10 CFR Part 100, "Reactor Site Criteria."

5. Regulatory Guide 1.24 (Safety Guide 24), "Assumptions Used for Evaluating the Potential Radiological Consequences of a Pressurized Water Reactor Radioactive Gas Storage Tank Failure."

6. Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants, LWR Edition."

7. Regulatory Guide 1.98, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Radioactive Offgas System Failure in a Boiling Water Reactor."

8. 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."

9. Regulatory Guide 1.143, "Design Guidance for Radioactive Waste Management Systems, Structures and Components Installed in Light-Water-Cooled Nuclear Reactor Power Plants."

10. NUREG-0016, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Boiling Water Reactors (BWRs) (BWR GALE-Code)."

11. NUREG-0017, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors (PWRs) (PWR GALE Code)."

12. NUREG-0800, Standard Review Plan, Section 15.7.1, "Waste Gas System Failure."

13. NUREG-0800, Standard Review Plan, Section 2.3.4, “Short-term Dispersion Estimates for Accidental Atmospheric Releases.”

SRP Section 11.3
Description of Changes

This SRP section affirms the technical accuracy and adequacy of the guidance previously provided in (Draft) Revision 3, dated June 1996 of this SRP. See ADAMS accession number ML032070610.

In addition this SRP section was administratively updated in accordance with NRR Office Instruction, LIC-200, Revision 1, "Standard Review Plan (SRP) Process." The revision also adds standard paragraphs to extend application of the updated SRP section to prospective submittals by applicants pursuant to 10 CFR Part 52.

The technical changes are incorporated in Revision 2, dated [Month] 2007:

1. Editorial changes were made to correct typographical and grammatical errors and provide further clarifications.

2. References were updated to reflect current versions of cited documents; additional references were added to reflect updated guidance to the staff, new requirements of 10 CFR 20.1406 and 10 CFR Part 52, and for consistency in cross-referencing supporting SRP sections.

3. Other than the provisions of 10 CFR 20.1406 and 10 CFR Part 52, the revision of this SRP section neither introduces new criteria nor changes those presented in its prior version.

4. The provisions of 10 CFR 20.1406, NRC criteria promulgated after the 1996 version of this SRP, were added to the acceptance criteria section, along with supporting information and guidance in sections addressing technical rationale, review procedures, and evaluation findings. This revision includes specific references to relevant regulatory guides, bulletins and circulars, and to an NRC staff memorandum (October 10, 2006) on decommissioning lessons learned (ADAMS Accession No. ML0619201830) and "Liquid Radioactive Release Lessons Learned Task Force, Final Report," Sections 2.0 and 3.2.2, September 1, 2006 (ADAMS Accession No. ML062650312) and "Liquid Radioactive Release Lessons Learned Task Force, Final Report," Sections 2.0 and 3.2.2, dated September 1, 2006 (ADAMS Accession No. ML062650312). The provisions of 10 CFR 20.1406 focus on design features that would reduce the amount of gaseous wastes, reduce radioactivity levels and discharges of radioactive materials in effluents, minimize contamination of the facility and environment, facilitate eventual decommissioning, and avoid or reduce the potential for uncontrolled and unmonitored releases to the environment.

5. The acceptance criteria section was revised to include the provisions of 10 CFR 52.47(a)(1)(vi) and 10 CFR 52.97(b)(1), as they relate to ITAACs for COLs in assuring that SSCs associated with a GWMS (either as a permanently installed system or in combination with mobile processing equipment) have been constructed and will be operated in accordance with NRC requirements and regulations.

6. The application of mobile gaseous waste processing and treatment equipment used in combination with a permanently installed GWMS was added in the sections addressing areas of review, technical rationale, review procedures, and evaluation findings. This update reflects a trend in the nuclear power industry to use mobile waste processing

equipment that incorporates improvements in waste treatment technology, as exemplified in recent 10 CFR Part 52 DC applications.

7. The guidance on meeting the requirements of 10 CFR 20.1301(e), as they relate to compliance with the EPA standards of 40 CFR Part 190, was elaborated upon for the purpose of identifying information about all potential sources of radioactivity and external radiation for sites with one or more nuclear power plants. The revision focuses on integrating dose results associated with all sources of external radiation and radioactivity released in gaseous and liquid effluents as is addressed in the review of other sections of the SRP, including SRP Sections 11.2, 11.4, 11.5, and 12.3-12.4.

8. The calculational procedure, described in Section II of BTP 11-5, was simplified for the purpose of assessing the radiological impacts associated with the postulated failure and release of radioactivity from the waste gas system. The revised BTP approach is no longer prescriptive as to the recommended calculational methods. For example, the procedure no longer requires one to follow specific steps in using NUREG-0016 (BWR GALE code) or NUREG-0017 (PWR GALE code). Rather, the revised approach allows one to propose a specific method in defining the mechanism of the component failure, assumptions applied in the analysis, and models used in assessing the radiological impact on members of the public. However, the revised BTP approach requires that all assumptions and parameters used in the analysis be described and justified. Other minor revisions were included in Section I of the BTP for technical clarifications. These changes do not introduce any substantive changes to the scope and objectives of the BTP.

Review Responsibilities - Reflects changes in review branches resulting from reorganization and branch consolidation. Change is reflected throughout the SRP.

I. AREAS OF REVIEW

II. ACCEPTANCE CRITERIA

III. REVIEW PROCEDURES

IV. EVALUATION FINDINGS

V. IMPLEMENTATION

VI. REFERENCES