U.S. NUCLEAR REGULATORY COMMISSION

# STANDARD REVIEW PLAN

## 6.2.4 CONTAINMENT ISOLATION SYSTEM

**REVIEW RESPONSIBILITIES**

**Primary -** Organization responsible for the review of containment integrity

**Secondary -** None

I. AREAS OF REVIEW

The containment isolation system allows the normal or emergency passage of fluids through the containment boundary while preserving the ability of the boundary to prevent or limit the escape of fission products from postulated accidents. This Standard Review Plan (SRP) section, therefore, addresses the isolation of fluid systems penetrating the containment boundary, including design and testing requirements for isolation barriers and actuators. Isolation barriers include valves, closed piping systems, and blind flanges. The specific areas of review are as follows:

1. The design of containment isolation provisions, including:

   A. The number and location of isolation valves (*i.e.*, the isolation valve arrangements and their physical locations as to the containment).

   B. The actuation and control features for isolation valves.

   C. The positions of isolation valves for normal plant operating conditions (including shutdown), post-accident conditions, and valve operator power failures.

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D. The valve actuation signals.

E. The basis for selection of closure times of isolation valves.

F. The mechanical redundancy of isolation devices.

G. The acceptability of closed piping systems inside containment as isolation barriers.

2. The protection of containment isolation provisions against loss of function from missiles, pipe whip, and earthquakes.

3. The environmental conditions inside and outside the containment considered in the design of isolation barriers.

4. The design criteria applied to isolation barriers and piping.

5. The provisions for detecting needs to isolate remote manual-controlled systems like engineered safety feature systems.

6. The design provisions and technical specifications for testing of isolation barrier operability and leakage rate.

7. The calculation of containment atmosphere released prior to isolation valve closure for lines that provide direct paths to the environs.

8. The containment purging/venting design features minimizing purging time consistent with as low as reasonably achievable principles for occupational exposure.

9. The reliability of the purge system in isolating under accident conditions.

10. The containment isolation and valve indication provisions for station blackout (SBO).

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. COL action items may be identified in the NRC staff's final safety evaluation report (FSER) for each certified design to identify information that COL applicants must address in the application. Additionally, DCs contain requirements and restrictions (e.g., interface requirements) that COL applicants must address in the application. For COL applications referencing a DC, the review performed under this SRP section includes information provided in response to COL action items and certification requirements and

restrictions pertaining to this SRP section, as identified in the FSER for the referenced certified design.

Review Interfaces

The listed SRP sections interface with this section as follows:

1. Sections 3.2.1 and 3.2.2: review of system seismic design and quality group classification, respectively.

2. Section 3.6.2: review of postulated pipe rupture locations, the containment penetration exclusion area, and related dynamic effects on containment isolation capability.

3. Section 3.8: review of the containment isolation system structural design for adequate protection against earthquakes.

4. Section 3.9: review of the containment isolation system mechanical design for adequate protection against breach of integrity, missiles, pipe whip, and jet impingement.

5. Section 3.10: evaluation of the qualification test program for electric valve operators and the operability assurance program for containment purge and vent valves.

6. Sections 3.10 and 3.11: review of sensing and actuation instrumentation of the plant protection system located both inside and outside of containment.

7. Section 7.5: evaluation of the actuation and control features for isolation valves.

8. Sections 8.3.1 and 8.3.2: review of the power sources for containment isolation valve operators in each line penetrating the containment for whether any single fault can prevent isolation of the line.

9. Section 8.4: review of capability to withstand or cope with and recover from SBO coordinated with review of containment isolation system for appropriate system functioning for SBO.

10. Section 15.6.5: review of the closure time for containment isolation valves in lines that provide a direct path to the environs for the prediction of onset of accident-induced fuel failure.

11. Section 15.6.5, Appendix A: review of the radiological dose consequence analysis for the release of containment atmosphere prior to closure of containment isolation valves in lines providing a direct path to the environs.

12. Section 16.0: review at the operating license stage of proposed technical specifications for operability and leakage-rate testing of isolation barriers and closure time for containment isolation valves.

13. Section 19.1 (proposed): for new plant applicants, review of containment integrity issues during shutdown and low-power operations under the systematic assessment of shutdown risk.

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. General Design Criterion (GDC) 1, as it relates to designing, fabricating, erecting, and testing safety-related SSCs to quality standards commensurate with the importance of the safety functions to be performed.

2. GDC 2, as it relates to designing safety-related SSCs to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform safety functions.

3. GDC 4, as it relates to designing safety-related SSCs to accommodate the effects of and to be compatible with environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, and as it relates to the requirement that these SSCs shall be appropriately protected against dynamic effects, including the effects of missiles, pipe whipping, and discharging fluids.

4. GDC 16, as it relates to reactor containment and associated systems, establishing an essentially leak-tight barrier against the uncontrolled release of radioactivity to the environment.

5. GDC 54, as it relates to the requirement that piping systems penetrating the containment be provided with leak detection, isolation, and containment capabilities having redundancy, reliability, and performance capabilities which reflect the importance to safety, and as it relates to designing such piping systems with a capability to periodically test the operability of the isolation valves and associated apparatus and to determine if valve leakage is within acceptable limits.

6. GDCs 55 and 56, as to isolation valves for lines penetrating (GDC 55) the primary containment boundary as parts of the reactor coolant pressure boundary or as direct connections to the containment atmosphere (GDC 56) as follows:

   A. One locked-closed isolation valve[1] inside and one outside containment; or

   B. One automatic isolation valve inside and one locked-closed isolation valve outside containment; or

   C. One locked-closed isolation valve inside and one automatic isolation valve[2] outside containment; or

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[1] Locked-closed isolation valves are defined as sealed closed barriers (see SRP Acceptance Criteria II.6).

[2] A simple check valve is not an acceptable automatic isolation valve for use outside containment.

D. One automatic isolation valve inside and one outside[2] containment.

7. GDC 57, as it relates to the requirement that lines penetrating the primary containment boundary and neither part of the reactor coolant pressure boundary nor connected directly to the containment atmosphere have at least one locked-closed, remote-manual, or automatic isolation valve[2] outside containment.

8. 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.

9. 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.

10. 10 CFR 52.47(a) and 52.79(a), as they relate to demonstrating compliance with any technically relevant portions of the Three Mile Island (TMI)-related requirements set forth in 10 CFR 50.34(f)(2)(xiv) and 10 CFR 50.34(f)(2)(xv), for DC and COL reviews, respectively.

11. 10 CFR 50.62(a)(2), as it relates to ensuring that appropriate containment integrity is maintained in the event of a station blackout for a specified duration.

These GDCs establish requirements for the design, testing, and functional performance of isolation barriers in lines penetrating the primary containment boundary and, in general, require two isolation valves in series to maintain the isolation function, assuming any single, active failure in the containment isolation provisions. However, containment isolation provisions different from the explicit requirements of GDCs 55 and 56 are acceptable if the differences are justified.

SRP Acceptance Criteria

Specific SRP acceptance criteria acceptable 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. Regulatory Guide (RG) 1.11 describes acceptable containment isolation provisions for instrument lines. In addition, instrument lines closed both inside and outside containment are designed to withstand pressure and temperature conditions following a loss-of-coolant accident (LOCA) and dynamic effects are acceptable without isolation valves.

2. Containment isolation provisions for lines in engineered safety feature or engineered safety feature-related systems may include remote-manual valves, but should detect possible leakage from these lines outside containment.

3. Containment isolation provisions for lines in systems needed for safe shutdown of the plant (e.g., liquid poison system, reactor core isolation cooling system, and isolation condenser system) may include remote-manual valves, but there should be provisions for detecting leakage from such lines outside containment.

4. Containment isolation provisions for lines in the systems of items 2 and 3 normally consist of one isolation valve inside and one outside containment. If it is not practical to locate a valve inside containment (for example, the valve may be under water as a result of an accident), both valves may be located outside containment. For this type of isolation valve arrangement, the valve nearer the containment and the piping between the containment and the valve should be enclosed in a leak-tight or controlled-leakage housing. If, in lieu of housing, the piping and valve are designed to preclude a breach of piping integrity, the design should comply with SRP Section 3.6.2 requirements. Design of the valve or the piping compartment should provide the capability to detect and terminate leakage from the valve shaft or bonnet seals.

5. Containment isolation provisions for lines in engineered safety feature or engineered safety feature-related systems normally consist of two isolation valves in series. A single isolation valve is acceptable if system reliability can be shown to be greater, the system is closed outside containment, and a single active failure can be accommodated with only one isolation valve in the line. The closed system outside containment should be protected from missiles, designed to seismic Category I and Group B quality standards (References 15 and 16), and have a design temperature and pressure rating at least equal to that for the containment. The closed system outside containment should be leak-tested unless system integrity can be shown to be maintained during normal plant operations. For this type of isolation valve arrangement the valve is located outside containment, and the piping between the containment and the valve should be enclosed in leak-tight or controlled-leakage housing. If, in lieu of housing, piping and valve are designed conservatively to preclude a breach of piping integrity, the design should comply with SRP Section 3.6.2 requirements. Design of the valve or the piping compartment should provide the capability to detect and terminate leakage from the valve shaft or bonnet seals.

6. Sealed-closed barriers may be used in place of automatic isolation valves. Sealed-closed barriers include blind flanges and sealed-closed isolation valves which may be closed manual valves, closed remote-manual valves, or closed automatic valves which remain closed after a LOCA. Sealed-closed isolation valves should be under administrative control so they cannot be opened inadvertently. Administrative control includes mechanical devices to seal or lock the valve closed or to prevent power supply to the valve operator.

7. Relief valves may be used as isolation valves provided the relief setpoint is greater than 1.5 times the containment design pressure.

8. 10 CFR 50.34(f)(2)(xiv) requires that systems penetrating the containment be classified as either essential or nonessential. Reference 26 presents guidance on the classification of systems as essential and nonessential. Essential systems, like those described in items 2 and 3, may include remote-manual containment isolation valves, but there should be provisions for detecting leakage from the lines outside containment. 10 CFR 50.34(f)(2)(xiv) also requires that nonessential systems be isolated automatically by the containment isolation signal.

9. Isolation valves outside containment should be located as close to it as practical, as required by GDCs 55, 56, and 57.

10. To meet the requirements of GDCs 55 and 56, upon loss of actuating power, automatic isolation valves should take the position of greatest safety. The position of an isolation valve for normal and shutdown plant operating and post-accident conditions depends on the fluid system function. If a fluid system has no post-accident function, the isolation valves in the lines should be closed automatically. For engineered safety feature or engineered safety feature-related systems, isolation valves in the lines may remain open or be opened. In a power failure to the valve operator isolation valves should be in the "safe" position, normally the post-accident valve position. For lines equipped with motor-operated valves, a loss of actuating power leaves the affected valve in the "as-is" position, which may be the open position; however, redundant isolation barriers ensure that the isolation function for the line is satisfied. All power-operated isolation valves should have position indications in the main control room.

11. To improve the reliability of the isolation function, addressed in GDC 54, 10 CFR 50.34(f)(2)(xiv) requires reduction of the containment setpoint pressure that initiates containment isolation for nonessential penetrations to the minimum value compatible with normal operating conditions.

12. There should be diversity in the parameters sensed for the initiation of containment isolation to satisfy the GDC 54 requirement for reliable isolation capability.

13. To improve the reliability of the isolation function, addressed in GDC 56, system lines which provide open paths from the containment to the environs (*e.g.*, purge and vent lines addressed in 10 CFR 50.34(f)(2)(xiv)) should be equipped with radiation monitors capable of isolating these lines upon a high-radiation signal, which should not be considered a diverse containment isolation parameter.

14. In meeting GDC 54 requirements, the performance capability of the isolation function should reflect the safety importance of isolating system lines. Consequently, containment isolation valve closure times should be selected for rapid isolation of the containment following postulated accidents. Valve closure time for a power-operated valve to be in the fully-closed position after the actuator power has reached the operator assembly does not include the time to reach actuation signal setpoints or instrument delay times, which, with system design capabilities, should be considered for establishing valve closure times. For lines providing open paths from the containment to the environs (e.g., the containment purge and vent lines), isolation valve closure times of five seconds or less may be necessary. The closure times of these valves should be established to minimize the release of containment atmosphere to the environs, to mitigate the offsite radiological consequences, and to prevent degradation of emergency core cooling system effectiveness by reduced containment back-pressure. Analyses of the radiological consequences and the effect on the containment back-pressure of the release of containment atmosphere should justify the selected valve closure time. Branch Technical Position (BTP) CSB 6-4 presents additional guidance on the design and use of containment purge systems which may be used during the normal plant operating modes (*i.e.*, startup, power operation, hot standby, and hot shutdown).

    Containment purge valves that do not satisfy the operability criteria of Branch Technical Position CSB 6-4 must be sealed closed as defined in subsection II.6 of this

SRP section during operational conditions 1, 2, 3, and 4 (Reference 25). Furthermore, closure of these valves must be verified at least every 31 days. These requirements should be incorporated into the technical specifications for plant operation.

15. The use of a closed system inside containment as one of the isolation barriers is acceptable if the closed system design satisfies the following requirements:

    A. The system does not connect with either the reactor coolant system or the containment atmosphere.

    B. The system is protected against missiles and pipe whip.

    C. The system is designated seismic Category I.

    D. The system is classified Quality Group B (Reference 15).

    E. The system is designed to withstand temperatures equal to at least that of the containment design.

    F. The system is designed to withstand the external pressure from the containment structure acceptance test.

    G. The system is designed to withstand the LOCA transient and environment.

    As to the structural design of containment internal structures and piping systems, the protection against loss of function from missiles, pipe whip, and earthquakes is acceptable if 1) isolation barriers are located behind missile barriers; 2) pipe whip was considered in the design of pipe restraints and the location of piping penetrating the containment; and 3) the isolation barriers, including the piping between isolation valves, are designated seismic Category I, i.e., designed to withstand the effects of the safe-shutdown earthquake, as recommended by Regulatory Guide 1.29.

16. To meet the requirements of GDCs 1, 2, 4, and 54, appropriate reliability and performance considerations should be included in the design of isolation barriers to reflect the safety importance of their integrity *(i.e.*, containment capability) under accident conditions. The design criteria for components performing a containment isolation function, including the isolation barriers and the piping between them or the piping between the containment and the outermost isolation barrier, are acceptable if:

    A. Group B quality standards, as defined in RG 1.26, apply to the components, unless the service function dictates that Group A quality standards apply.

    B. The components are designated seismic Category I in accordance with RG 1.29.

17. GDC 54 requires reliable isolation capability; therefore, for remote-manual isolation valves, the design of the containment isolation system is acceptable if there are provisions to allow the operator in the main control room to know when to isolate fluid systems equipped with remote-manual isolation valves. Such provisions may include instruments to measure flow rate, sump water level, temperature, pressure, and radiation level.

18. GDC 54 specifies requirements for the containment isolation system; therefore, to satisfy GDC 54, the design of the containment isolation system should provide for operability testing of the containment isolation valves and leakage rate testing of the isolation barriers. The isolation valve testing program should be consistent with that proposed for other engineered safety features. SRP Section 6.2.6 presents acceptance criteria for the leakage rate testing program for containment isolation barriers.

19. GDC 54 requires reliable isolation capability. To satisfy this requirement, the design of the containment isolation system should reduce the possibility of unintended isolation valve reopening following isolation. 10 CFR 50.34(f)(2)(xiv) requires control systems for automatic containment isolation valves be designed for resetting the isolation signal without automatically reopening the valves. Reopening of containment isolation valves should require deliberate operator action and combined reopening of containment isolation valves is not acceptable. Reopening of isolation valves must be valve by valve or line by line, provided that electrical independence and other single-failure criteria remain satisfied.

    Administrative provisions to close all isolation valves manually before resetting the isolation signals is not an acceptable method for meeting this design requirement.

20. In meeting 10 CFR 50.34(f)(2)(xv) purging requirements, the regulatory guidance of BTP CSB 6-4, "Containment Purging During Normal Plant Operations," should be used to establish compliance with this regulation.

21. RG 1.155, "Station Blackout," Regulatory Position C.3.2.7, provides guidance for meeting the requirements of the SBO rule, 10 CFR 50.63(a)(2), for containment isolation valves and valve position indication.

22. 10 CFR Part 50, Appendix K, provides guidance for the determination of the extent of fuel failure (source term) in the radiological calculations.

<u>Technical Rationale</u>

The technical rationale for application of these requirements and/or SRP acceptance criteria to the areas of review addressed by this SRP section is discussed in the following paragraphs:

1. GDC 1, "Quality Standards and Records," requires that safety-related SSCs be designed, fabricated, erected, and tested to quality standards commensurate with the safety functions performed.

    This SRP section defines appropriate reliability and performance standards for the design of the containment isolation system. These standards reflect the importance of forming an essentially leak-tight barrier to prevent the release of fission products in an accident. RG 1.26 specifies quality standards applicable to containment isolation system components. This SRP section also contains TMI-related requirements for containment isolation dependability, containment purging/venting during plant operation, and purge/vent valves.

    Compliance with GDC 1 requirements provides reasonable assurance that the containment isolation system will perform its safety function and prevent the release of radioactive materials to the environment.

2. GDC 2, "Design Bases for Protection Against Natural Phenomena," requires that safety-related SSCs be designed to withstand the effects of natural phenomena like earthquake, tornado, hurricane, flooding, tsunami, and seiche without loss of capability to perform safety functions.

   GDC 2 applies to this SRP section because the reviewer evaluates the containment isolation system for its capability to isolate the containment under accident conditions (e.g., LOCA) combined with severe natural phenomena. RG 1.29 provides guidance acceptable to the staff for developing designs with the capability to withstand earthquakes.

   Compliance with GDC 2 requirements provides reasonable assurance that the containment will act as an essentially leak-tight barrier and prevent the release of radioactive materials to the environment under all plausible conditions.

3. GDC 4, "Environmental and Dynamic Effects Design Bases," requires that safety-related SSCs (A) be designed to accommodate the effects of, and be compatible with, environmental conditions of normal operation, maintenance, testing, and postulated accidents (including LOCAs) and (B) be protected appropriately against dynamic effects (including those of missiles, pipe whipping, and discharging fluids) of equipment failures and events and conditions outside the nuclear power unit.

   GDC 4 applies to this SRP section because the reviewer evaluates the containment isolation system for its capability to perform its isolation function at all times in any environmental condition to which the system's components may be exposed, including dynamic effects. BTP CSB 6-4 provides guidance as to dynamic effects that should be considered in the design of containment purge and vent valves.

   Compliance with GDC 4 requirements provide reasonable assurance that the containment isolation system has the capability to perform its safety function of containment isolation and to prevent the release of radioactive materials to the environment. These requirements also ensure that containment purge and vent valves are designed for reliable isolation under accident conditions.

4. GDC 16, "Containment Design," requires that the reactor containment and its systems establish an essentially leak-tight barrier against the uncontrolled release of radioactive materials to the environment.

   GDC 16 applies to this SRP section because the reviewer evaluates the containment isolation system for whether it allows the normal or emergency passage of fluids through the containment boundary while preserving the capability of the boundary to prevent or limit the escape of fission products from postulated accidents. This SRP section provides guidance as to design requirements for containment isolation provisions, including the number and location of isolation valves, their actuation and control features, redundancy, valve actuation signals, and closure times.

   Compliance with GDC 16 requirements provides reasonable assurance that the containment and its systems will act as an essentially leak-tight barrier to prevent the uncontrolled release of radioactive materials to the environment in an accident.

5. GDC 54, "Piping Systems Penetrating Containment," requires that piping systems that penetrate the primary reactor containment have leak-detection, isolation, containment, redundancy, reliability, and performance capabilities that reflect the safety importance of isolating these piping systems.

   GDC 54 applies to this SRP section because the reviewer evaluates the containment isolation system for whether valves in piping systems that penetrate the containment are designed to close reliably under accident conditions and prevent the uncontrolled release of radioactive materials. To ensure reliability of these valves, this SRP section provides guidance as to leak detection, redundancy, leakage testing, and functional testing. RGs 1.11 and 1.141 provide guidance acceptable to the staff for isolating instrument lines that penetrate the containment and for fluid systems, respectively. Nonessential lines are isolated automatically by the containment isolation signal.

   Compliance with GDC 54 requirements provides reasonable assurance that the containment isolation system will isolate piping systems penetrating containment reliably as required.

6. GDC 55, "Reactor Coolant Pressure Boundary Penetrating Containment," requires that each line of the reactor coolant pressure boundary penetrating the primary reactor containment meet specified criteria for the use and positioning of isolation valves.

   GDC 55 applies to this SRP section because the reviewer evaluates the containment isolation system to ensure that there is no direct connection between the primary coolant and the plant environs. This assurance is provided by specific requirements for isolation valves (i.e., locked-closed, automatic, or a combination of locked-closed and automatic) on both sides of the containment barrier. Isolation valves outside the containment should be located as close to the containment as is practical. Upon loss of actuating power, automatic valves must take the position of greatest safety. Other requirements (e.g., those for higher quality in design, additional inservice inspection, and protection against severe natural phenomena) may be imposed based on use and physical characteristics of the plant-site environs.

   Compliance with GDC 55 requirements provides reasonable assurance that lines penetrating the containment and connected to the reactor coolant system will not be sources of excessive offsite radiation doses due to either line rupture or failure of a valve to close.

7. GDC 56, "Primary Containment Isolation," requires that each line that connects directly to the containment atmosphere and penetrates the primary reactor containment must meet specified criteria for the use and positioning of isolation valves.

   GDC 56 applies to this SRP section because the reviewer evaluates the containment isolation system to ensure that (A) there is no direct connection between the containment atmosphere and the plant environs or (B) if there is direct communication (as that during containment purging or venting) that the lines can be reliably isolated. This assurance is provided by specific requirements for isolation valves (*i.e.*, locked-closed, automatic, or a combination of locked-closed and automatic) on both sides of the containment barrier. Isolation valves outside the containment should be located as close to the containment as is practical. Upon loss of actuating power, automatic valves must take the position of greatest safety. BTP CSB 6-4 contains specific requirements for containment purge and vent valves, providing a high degree of assurance that these valves will isolate reliably under accident conditions.

Compliance with GDC 56 requirements provides reasonable assurance that lines penetrating the containment and connected to the containment atmosphere will not be sources of excessive offsite radiation doses due to either line rupture or failure of a valve to close.

8. GDC 57, "Closed System Isolation Valves," requires, for each line penetrating the primary reactor containment which is neither part of the reactor coolant pressure boundary nor connected directly to the containment atmosphere, at least one containment isolation valve that is automatic, locked-closed, or capable of remote-manual operation. Isolation valves must be located on the outside of the containment barrier as close to the containment as is practical.

   GDC 57 applies to this SRP section because the reviewer evaluates the containment isolation system for whether there is no direct connection between the fluids in the closed system and the plant environment. Assurance is by specific requirements for a closed system and for an isolation valve that is locked-closed, automatic, or capable of remote-manual operation. A single valve is specified because the system is closed; hence, failure of the valve to close would not, by itself, allow contact between fluids in the closed system and the plant environment.

   Compliance with GDC 57 requirements provides reasonable assurance that lines penetrating the containment and connected to closed systems will not be sources of excessive offsite radiation doses due to line rupture or failure of a valve to close.

9. 10 CFR 50.63 requires that all light-water-cooled nuclear power plants be able to withstand and recover from an SBO, that necessary systems be capable of cooling the core, and that appropriate containment integrity be maintained in SBO. Guidance for compliance with 10 CFR 50.63 is provided in RG 1.155. As many safety systems necessary to support safe operation and shutdown of the reactor depend on alternating current (AC) power, the consequences of an SBO could be severe, particularly if the integrity of barriers to prevent the release of fission products (e.g., fuel cladding, reactor coolant pressure boundary, containment) are not maintained throughout the event and its recovery period. The containment isolation system, including its provisions for control, indication, and performance under loss/restoration of power conditions, is instrumental in maintaining integrity of the containment barrier without undue interference with flow paths essential for cooling the reactor core. Compliance with 10 CFR 50.63 and the positions of RG 1.155 in the performance of the containment isolation system for an SBO, therefore adds defense in depth against unacceptable offsite radiological consequences if both offsite and onsite emergency AC power systems fail by maintaining containment integrity for such an event.

## III. REVIEW PROCEDURES

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. These 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.

The procedures provide guidance on review of the containment isolation system. Portions of the review may be done generically for aspects of containment isolation common to a class of containments or by adoption of the results of previous reviews of plants with essentially the same containment isolation provisions.

Upon request from the primary reviewer, other reviewers provide input for the areas of review stated in subsection I of this SRP section. The primary reviewer uses such input as required to complete this review.

1. The reviewer determines acceptability of the containment isolation system by comparison of the system design criteria to the design requirements for an engineered safety feature. The quality standards and the seismic design classification of the containment isolation provisions, including the piping penetrating the containment, are compared to RGs 1.26 and 1.29, respectively.

   The reviewer also ascertains whether any single fault can prevent isolation of the containment by reviewing the containment isolation provisions for each line penetrating the containment for two isolation barriers in series and by reviewing the power sources to the valve operators.

   The SAR information justifying containment isolation provisions which differ from the explicit requirements of GDCs 55, 56, and 57 is reviewed. The acceptability of these containment isolation provisions is based on a comparison to the acceptance criteria of subsection II of this SRP section.

   The isolation valve positions are reviewed for normal and shutdown plant operating conditions, post-accident conditions, and valve operator power failure conditions as listed in the SAR. The position of an isolation valve for each condition depends on the system function. Power-operated valves in fluid systems having no post-accident safety function (nonessential systems) should close automatically.

   In the event of a power failure to a valve operator, the valve position should be that of greater safety, normally the post-accident position; however, special cases are considered individually for the acceptability of the prescribed valve positions. The reviewer also ascertains from the SAR whether all power-operated isolation valves have position indicators in the main control room.

2. Reviewers responsible for the structural design of the containment internal structures and piping systems, including restraints, ensure that the containment isolation provisions are protected adequately against missiles, pipe whip, and earthquakes. The review determines whether for all containment isolation provisions, missile protection and protection against loss of function from pipe whip and earthquakes were design considerations. The system drawings (which should show the locations of missile barriers as to the containment isolation provisions) are reviewed for whether isolation provisions are protected from missiles. The design criteria for the containment isolation

provisions are reviewed for whether protection against dynamic effects like pipe whip and earthquakes was considered in the design. The reviewer requests review of the design adequacy of piping and valves for which conservative design in lieu of leak-tight housing is assumed to preclude possible breach of system integrity.

3. The signals from the plant protection system to initiate containment isolation are reviewed. In general, there should be a diversity of parameters sensed (e.g., abnormal conditions in the reactor coolant system, the secondary coolant system, and the containment) generating containment isolation signals. As plant designs differ and many different signal combinations from the plant protection system initiate containment isolation, the reviewer considers proposed arrangements individually for overall acceptability of the containment isolation signals. The containment setpoint pressure that initiates containment isolation for nonessential penetrations is reviewed. This pressure setpoint should be the minimum value compatible with normal operation, as required by 10 CFR 50.34(f)(2)(xiv)(D). Additional guidance for review of this setpoint is presented in Item II.E.4.2 of NUREG-0737.

4. The reviewer verifies that the control system for automatic containment isolation valves is designed for resetting of the isolation signal without automatic reopening of containment isolation valves and that combined reopening of isolation valves is not possible.

5. Systems having post-accident safety functions (essential systems) may have remote-manual isolation valves in the lines penetrating the containment. Provisions for detecting leakage from these lines outside containment and for allowing the operator in the main control room to isolate the system train if leakage occurs are reviewed. Leakage detection provisions may include instrumentation for measuring system flow rates or the pressure, temperature, radiation, or water level in areas outside the containment like valve rooms or engineered safeguards areas. Acceptance of the leakage detection provisions described in the SAR is based on capability to detect leakage and identify lines that should be isolated.

   The reviewer determines whether the containment isolation provisions are designed for individual leak-testing of isolation barriers. This information should be tabulated in the SAR to facilitate review.

6. The reviewer determines from the SAR descriptive information whether provisions in the design of the containment isolation system allow periodic operability testing of the power-operated isolation valves and the containment isolation system. At the operating license stage of review, the reviewer determines whether the content and intent of proposed technical specifications for operability and leak-testing of containment isolation equipment agree with requirements developed by the staff. In particular, there should be the following technical specifications: containment purge or vent valves that do not satisfy BTP CSB 6-4 operability criteria must be sealed closed as defined in subsection II.6 (Acceptance Criteria) of this SRP section and verified sealed closed at least every 31 days during all operational conditions except cold shutdown and refueling; purging or venting time should be minimized consistently with as low as reasonably achieved principles for occupational exposure; and containment purge or vent valves with resilient seals must be subjected to leakage-testing and periodic resilient seal replacement.

7. The reviewer determines the acceptability of the use of closed systems inside containment as isolation barriers by comparing the system designs to the Acceptance Criteria of subsection II of this SRP section.

8. Isolation valve closure times are reviewed. In general, valve closure times should be less than one minute regardless of valve size. (See the Acceptance Criteria for valve closure times in subsection II of this SRP section). Valves in lines that provide direct paths to the environs *(e.g.*, the containment purge and ventilation system lines and main steam lines for direct cycle plants) may have to close in times much shorter than one minute. Closure times for these valves may be dictated by radiological dose analyses or emergency core cooling system performance considerations. The reviewer requests reviews of analyses justifying closure times for these valves as necessary.

9. The reviewer evaluates the design features of the purging/venting system for minimizing purging time and verifies whether there is a high degree of assurance that the purge system will isolate reliably under accident conditions.

10. The reviewer verifies whether appropriate containment integrity is maintained in SBO by the capability, independent of the preferred and blacked-out unit's onsite emergency AC power supplies, for valve position indication and closure for containment isolation valves that may be in open positions at the onset of SBO. Certain containment isolation valves are excluded from consideration as addressed in RG 1.155.

    For pressurized water reactors the reviewer verifies whether sufficient procedures and controls reasonably assure that containment closure (as defined in Reference 25) is possible during reduced inventory conditions. Containment closure must be achieved prior to the time at which loss of decay heat removal coupled with inability to initiate alternate cooling or addition of water to the reactor coolant system inventory could cause an uncovered core. These controls should be in use:

    A. Prior to a reduced RCS inventory condition for Combustion Engineering or Westinghouse nuclear steam supply systems and

    B. Prior to an RCS condition in which the water level is lower than four inches below the top of the flow area of the hot legs at the junction of the hot legs to the reactor vessel for Babcock and Wilcock nuclear steam supply systems.

11. 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 early site permit, 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 conclusions of the following type to be included in the staff's safety evaluation report (SER). The reviewer also states the bases for those conclusions.

The staff concludes that the containment isolation system functional design is acceptable and meets the requirements of GDCs 1, 2, 4, 16, 54, 55, 56, and 57, 10 CFR Part 50, Appendix K, the additional TMI-related requirements 10 CFR 50.34(f)(2)(xiv) and 10 CFR 50.34(f)(2)(xv), and the SBO requirements of 10 CFR 50.63(a)(2). The conclusion is based on the following findings:

1. The applicant has met the requirements of [regulation] for [limits of review under regulation] by (for each item applicable to the review how it was met and why acceptable for the regulation):

   A. Meeting the regulatory positions in NUREG __________ or RGs _____;

   B. Meeting an alternative method to regulatory positions in RG _____ reviewed by the staff and found acceptable;

   C. Meeting the regulatory position in BTP ________;

   D. Using calculation methods (for what was evaluated) previously reviewed by the staff and found acceptable; the staff has reviewed the impact parameters in this case and found them suitably conservative or has performed independent calculations to verify acceptability of their analysis; or

   E. Meeting the provisions (industry standard number and title) reviewed by the staff and determined to be appropriate for this application.

2. Repeat discussion for each regulation cited.

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 superseded by a later revision.

## VI. REFERENCES


1. 10 CFR 50.34(f), "Additional TMI-Related Requirements," subparagraph (2)(xiv), regarding TMI Action Plan Item II.E.4.2, "Containment Isolation Dependability."

2. 10 CFR 50.34(f), "Additional TMI-Related Requirements," subparagraph (2)(xv), regarding TMI Action Plan Item II.E.4.4, "Purging."

3. 10 CFR 50.63, "Loss of All Alternating Current Power," subparagraph (a)(2), regarding containment integrity in the event of a station blackout.

4. 10 CFR Part 50, Appendix A, GDC 1, "Quality Standards and Records."

5. 10 CFR Part 50, Appendix A, GDC 2, "Design Bases for Protection Against Natural Phenomena."

6. 10 CFR Part 50, Appendix A, GDC 4, "Environmental and Missile Design Basis."

7. 10 CFR Part 50, Appendix A, GDC 16, "Containment Design."

8. 10 CFR Part 50, Appendix A, GDC 54, "Piping Systems Penetrating Containment."

9. 10 CFR Part 50, Appendix A, GDC 55, "Reactor Coolant Pressure Boundary Penetrating Containment."

10. 10 CFR Part 50, Appendix A, GDC 56, "Primary Containment Isolation."

11. 10 CFR Part 50, Appendix A, GDC 57, "Closed System Isolation Valves."

12. 10 CFR Part 50, Appendix K, "ECCS Evaluation Models."

13. 10 CFR Part 100, "Reactor Site Criteria."

14. RG 1.11, "Instrument Lines Penetrating Primary Reactor Containment."

15. RG 1.26, "Quality Group Classifications and Standards for Water-, Steam-, and Radioactive-Waste-Containing Components of Nuclear Power Plants."

16. RG 1.29, "Seismic Design Classification."

17. RG 1.141, "Containment Isolation Provisions for Fluid Systems."

18. RG 1.155, "Station Blackout."

19. BTP CSB 6-4, "Containment Purging During Normal Plant Operations," attached to this SRP section.

20. NUREG-0737, "Clarification of TMI Action Plan Requirements."

21. NUREG-0718, "Licensing Requirements for Pending Application for Construction Permits and Manufacturing License."

22. NUREG-1449, "Shutdown and Low-Power Operation at Commercial Nuclear Power Plants in the United States," Final Report, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, September 1993.

23. NRC Generic Letter 83-02, "NUREG-0737 Technical Specifications," January 10, 1983.

24. NRC Inspection Manual Chapter IMC-2504, "Construction Inspection Program - Non-ITAAC Inspections," issued April 25, 2006.

25. NRC Letter to all Holders of Operating Licenses and Construction Permits for Pressurized Water Reactors (PWRs), "Loss of Decay Heat Removal (Generic Letter 88-17)," October 17, 1988.

26. Item II.E.4.2, "Containment Isolation Dependability," in NUREG-0737 and NUREG-0718.

**SRP Section 6.2.4**

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 section. See ADAMS accession number ML052070461.

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 3, dated [Month] 2007:

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

I. AREAS OF REVIEW

Reformatted the section with new numbering system. Incorporated reference to 10 CFR Part 52 from draft revision 3 - June 1996. Incorporated generic paragraphs relating to certified designs, ESPs, and COLs.

II. ACCEPTANCE CRITERIA

Reformatted the section with new numbering system. Incorporated reference to 10 CFR Part 52 from draft revision 3 - June 1996. Incorporated generic paragraphs relating to certified designs, ESPs, and COLs.

III. REVIEW PROCEDURES

Reformatted the section with new numbering system. Incorporated reference to 10 CFR 52 from draft revision 3 - June 1996. Incorporated generic paragraphs relating to certified designs, ESPs, and COLs.

IV. EVALUATION FINDINGS

None.

V. IMPLEMENTATION

None.

VI. REFERENCES

None.

## BRANCH TECHNICAL POSITION CSB 6-4

## CONTAINMENT PURGING DURING NORMAL PLANT OPERATIONS

### I. BACKGROUND

This branch technical position pertains to system lines which can provide open paths from the containment to the environs during normal plant operation (e.g., lines of the containment purge and vent systems). It supplements the position taken in Standard Review Plan (SRP) Section 6.2.4.

While the containment purge and vent systems provide plant operational flexibility, their designs must consider the importance of minimizing the release of containment atmosphere to the environs following a postulated loss-of-coolant accident (LOCA). Therefore, plant designs must not rely on their routine use.

The need for purging during reactor operation is not always anticipated in the design of plants, and therefore design criteria for the containment purge system are not fully developed. The purging experience varies considerably from plant to plant. Some plants do not purge during reactor operation, some purge intermittently for short periods, and some purge continuously. There is similar disparity in the need for, and use of, containment vent systems at operating plants.

Containment purge systems have been used in a variety of ways (e.g., to alleviate certain operational problems like excess air leakage into the containment from pneumatic controllers, to reduce airborne activity within the containment to facilitate personnel access during reactor power operation, and to control the containment pressure, temperature, and relative humidity). Containment vent systems typically relieve the initial containment pressure buildup caused by the heat load imposed on the containment atmosphere during reactor power ascension or periodically relieve the pressure buildup due to the operation of pneumatic controllers. However, the purge and vent lines provide open paths from the containment to the environs. If a LOCA occurs during containment purging when the reactor is at power, the calculated accident doses should be within 10 CFR Part 100 guideline values.

The sizing of the purge lines in most plants is based on the need to control the containment atmosphere during refueling operations. This need has resulted in very large lines (about 42 inches in diameter) to penetrate the containment. As normally these are the only lines permitting some degree of control over the containment atmosphere to facilitate personnel access, some plants have used them for containment purging during normal plant operation. Under such conditions, calculated accident doses could be significant; therefore, the use of these large containment purge and vent lines should be restricted to cold shutdown conditions and refueling operations and they must be sealed closed in all other operational modes.

The design and use of the purge and vent lines should achieve acceptable calculated offsite radiological consequences and ensure that emergency core cooling system (ECCS) effectiveness is not degraded by a reduction in the containment back pressure.

Purge system designs acceptable for nonroutine use during normal plant operation can be achieved with additional purge lines.

The size of these lines should be limited so that in a LOCA, assuming the purge valves are open and subsequently close, the radiological consequences calculated in accordance with Regulatory Guides 1.3 and 1.4 would not exceed 10 CFR Part 100 guideline values. Also, the maximum time for valve closure should not exceed five seconds so that the purge valves would be closed before the onset of fuel failures following a LOCA. Similar concerns apply to vent system designs.

The size of the purge lines should be about eight inches in diameter for pressurized-water reactor (PWR) plants. This line size may be overly conservative from a radiological viewpoint for the Mark III boiling-water reactor (BWR) plants and the high-temperature gas reactor (HTGR) plants because of containment or core design features; therefore, larger line sizes may be justified. For any proposed line size, however, the applicant must demonstrate that the radiological consequences of a LOCA would be within 10 CFR Part 100 guideline values. In summary, the acceptability of a specific line size is a function of the site meteorology, containment design, and radiological source term for the reactor type (*e.g.*, BWR, PWR, or HTGR).

## II. <u>BRANCH TECHNICAL POSITION</u>

The systems that purge the containment for the reactor operational modes of power operation, startup, hot standby and hot shutdown (*i.e.*, the on-line purge system) should be independent of the purge system used for the reactor operational modes of cold shutdown and refueling.

1. The on-line purge system should be designed in accordance with the following criteria:

    A. GDC 54 requires that the reliability and performance capabilities of containment isolation valves reflect the safety importance of isolating the systems penetrating the containment boundary; therefore, the performance and reliability of the purge system isolation valves should be consistent with the operability assurance program of SRP Section 3.10. The design basis for the valves and actuators should include the buildup of containment pressure for the LOCA break spectrum and the supply line and exhaust line flows as a function of time up to and during valve closure.

    B. The number of supply and exhaust lines should be limited to one supply line and one exhaust line to improve the reliability of the isolation function as required by GDC 54 and to facilitate compliance with the requirements of 10 CFR Part 50, Appendix K, for the containment pressure used in the evaluation of ECCS effectiveness and 10 CFR Part 100 for offsite radiological consequences.

    C. The size of the lines should not exceed about eight inches in diameter without detailed justification for larger line sizes to improve the reliability and performance capability of the isolation and containment functions as required by GDC 54 and to facilitate compliance with the requirements of 10 CFR Part 50, Appendix K, for the containment pressure used in evaluating ECCS effectiveness and 10 CFR Part 100 for the offsite radiological consequences.

    D. As required by GDC 54, the containment isolation provisions for the purge system lines should meet the standards appropriate to engineered safety features (*i.e.*, quality, redundancy, testability and other appropriate criteria) to reflect the importance to safety of isolating these lines. GDC 56 establishes explicit requirements for isolation barriers in purge system lines.

E. To improve the reliability of the isolation function addressed in GDC 54, instrumentation and control systems isolating the purge system lines should be independent and actuated by diverse parameters (*e.g.*, containment pressure, safety injection actuation, and containment radiation level). Furthermore, if energy is required to close the valves, at least two sources of energy must be provided, either of which can effect the isolation function.

F. Purge system isolation valve closure times, including instrumentation delays, should not exceed five seconds to facilitate compliance with 10 CFR Part 100 for offsite radiological consequences.

G. Isolation valve closure must not be prevented by debris which could become entrained in the escaping air and steam.

2. The purge system should not be relied on for temperature and humidity control within the containment.

3. The need for purging of the containment should be minimized by containment atmosphere cleanup systems within the containment.

4. The availability of the isolation function and the leakage rate of the isolation valves during reactor operation should be tested.

5. The following analyses should justify the containment purge system design:

A. An analysis of the radiological consequences of a LOCA should be done for a spectrum of break sizes, and the instrumentation and setpoints that will actuate the purge valve closures should be identified. The source term in the radiological calculations should be based on a calculation under the terms of 10 CFR Part 50, Appendix K, to the extent of fuel failure and the concomitant release of fission products and the fission product activity in the primary coolant. A pre-existing iodine spike should be considered in determining primary coolant activity. The volume of containment in which fission products are mixed should be justified, and the fission products from the above sources should be assumed to be released through the open purge valves during the maximum interval required for valve closure. The radiological consequences should be within 10 CFR Part 100 guideline values.

B. An analysis which demonstrates the acceptability of the provisions made to protect structures and safety-related equipment (*e.g.*, fans, filters, and ductwork) located beyond the purge system isolation valves against loss of function in the environment created by the escaping air and steam.

C. An analysis of the reduction in the containment pressure caused by the partial loss of containment atmosphere during the accident for ECCS back pressure determination.

D. The maximum allowable leak rate of the purge isolation valves should be specified case by case with appropriate consideration for valve size, maximum allowable leakage rate for the containment (as defined in 10 CFR Part 50, Appendix J), and, where appropriate, the maximum allowable bypass leakage fraction for dual containments.