U.S. NUCLEAR REGULATORY COMMISSION

# DESIGN-SPECIFIC REVIEW STANDARD FOR mPOWER$^{TM}$ iPWR DESIGN

## 9.4.1 CONTROL ROOM AREA VENTILATION SYSTEM

**REVIEW RESPONSIBILITIES**

**Primary -** Organization responsible for review of ventilation and air filtration

**Secondary -** None

I. AREAS OF REVIEW

The mPower$^{TM}$ reactor utilizes one shared control room for each two-unit module. The control room area ventilation system (CRAVS) is a subsystem of the Reactor Service Building (RSB) heating, ventilation, and air conditioning (HVAC) system. The nonsafety-related portion of the CRAVS provides a controlled environment for the comfort and safety of control room personnel and assures the operability of control room components during all normal operating conditions when AC power is available. The safety-related risk-significant CRAVS consists of two independent fan/filter trains each powered by an independent channel of dedicated Class 1E 72-hour batteries and inverters (with nonsafety-related, risk-significant standby diesel generator powered battery chargers). The CRAVS maintains acceptable habitability and equipment operability conditions in the main control room envelope (MCRE) and provides emergency pressurization and make-up air supply of the MCRE to maintain sufficient oxygen levels and protection from the effects of smoke, airborne radionuclides, and toxic gasses during anticipated operational transients, and design-basis accident conditions, including coping with and recovering from a prolonged station blackout (SBO) event affecting the whole site

The organization responsible for the review of ventilation and air filtration reviews the CRAVS from the air intake to the point of discharge where the system connects to the gaseous cleanup and treatment system or station vents to ensure compliance with General Design Criteria (GDCs) 2, 4, 5, 19, and 60 and with Title 10 of the *Code of Federal Regulations* (10 CFR) Part 20.1406 and 10 CFR 50.63. The review includes such components as air intakes, ducts, air conditioning units, filters, blowers, isolation dampers, exhaust fans and associated instrumentation and control systems used to govern operation of the system under normal and operating conditions. CRAVS review covers the control room, switchgear and battery room, access control area, control building heating, ventilating, and air conditioning equipment room, and computer room.

The mPower$^{TM}$ CRAVS may include the following classifications of equipment:

1. Safety-related and risk-significant equipment

2. Safety-related and nonrisk-significant equipment

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3. Nonsafety-related and risk-significant Regulatory Treatment of Nonsafety Systems (RTNSS) equipment

4. Nonsafety-related nonrisk-significant equipment.

The mPower™ application will include the classification of systems, structures, and components (SSCs), a list of risk significant SSCs, and a list of RTNSS equipment. Based on this information, the staff will review according to Design Specific Review Standard (DSRS) Section 3.2, SRP Sections 17.4 and 19.3 to confirm the determination of safety-related and risk-significant SSCs.

The specific areas of review are as follows:

1. The organization responsible for the review of ventilation and air filtration reviews the CRAVS to determine the safety significance of the system. Based on this determination, the safety-related portions of the system are reviewed with respect to the functional performance requirements to maintain the habitability of the control room area and other safety-related areas served by the CRAVS during adverse environmental occurrences, normal operation, anticipated operational occurrences, and subsequent to postulated accidents. The review includes the effects of radiation, combustion, other toxic products, and the coincidental loss of offsite power. The review of this DSRS section interfaces with the review for DSRS Section 6.4,"Control Room Habitability." The organization responsible for the review of ventilation and air filtration reviews safety-related portions of the system to assure that:

   A. A single active failure cannot result in loss of system functional performance capability.

   B. Failures of nonseismic Category I equipment or components will not affect the CRAVS.

2. The ability of the active control room heating and cooling subsystems to maintain a suitable ambient temperature, humidity, and breathing air for control room personnel and equipment under normal operating and accident conditions with alternating current (AC) power available and the ability of passive features such as large structural thermal mass to maintain suitable conditions with an extended loss of AC power.

3. The ability to detect, filter, or expedite safe discharge of airborne contaminants inside the control room.

4. The capability to detect the need for isolation and to isolate portions of the system in the event of fires, failures, or malfunctions, and the capability of the system to function under such conditions.

5. The ability of essential equipment serviced by the ventilation system to function under the worst anticipated degraded CRAVS performance.

6. The capability to actuate components not normally operating that are required to operate during accident conditions and to provide necessary isolation.

7. The expected environmental conditions in areas served by the CRAVS and the extent, if any, to which the CRAVS is relied upon to function for a prolonged SBO event.

8. Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC). For design certification (DC) and combined license (COL) reviews, the staff reviews the applicant's proposed ITAAC associated with the SSCs related to this DSRS section in accordance with SRP Section 14.3, "Inspections, Tests, Analyses, and Acceptance Criteria." The staff recognizes that the review of ITAAC cannot be completed until after the rest of this portion of the application has been reviewed against acceptance criteria contained in this DSRS section. Furthermore, the staff reviews the ITAAC to ensure that all SSCs in this area of review are identified and addressed as appropriate in accordance with SRP Section 14.3.

9. 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

Other SRP and DSRS sections interface with this section as follows:

1. Section 2.2.1-2.2.2: review to evaluate potential plant site external hazards or hazardous materials.

2. Section 2.2.3: review to consider an applicant's probability analysis of potential accidents involving hazardous materials or activities at the plant site.

3. Sections 3.2.1 and 3.2.2: review to determine the acceptability of the seismic and quality group classifications for system components.

4. Sections 3.3.1, 3.3.2, 3.5.3, 3.7.1 through 3.7.4, 3.8.4, and 3.8.5: review of the acceptability of the design analyses, procedures, and criteria establishing the capability of seismic Category I structures housing the system and supporting systems to withstand the effects of natural phenomena like the safe shutdown earthquake, the probable maximum flood, and tornado missiles.

5. Section 3.4.1: review of flood protection.

6. Section 3.5.1.1: review of the protection against internally-generated missiles.

7. Section 3.5.1.4: review of the protection against missiles generated by tornadoes and extreme winds.

8. Section 3.5.2: review of SSCs to be protected against externally-generated missiles.

9. Section 3.6.1: review of high- and moderate-energy pipe breaks.

10. Sections 3.9.1 through 3.9.3: review to determine that components, piping, and structures are designed in accordance with applicable codes and standards.

11. Section 3.9.6: review of the adequacy of the inservice testing program of pumps and valves.

12 Section 3.10: review of the seismic qualification of Category I instrumentation and electrical equipment as part of their primary and secondary review responsibilities, respectively.

13. Section 3.11: review of the environmental qualification of mechanical and electrical components.

14. Section 6.4: review of the concentrations of airborne contaminants in the vicinity of the intake and exhaust vents resulting from accidental release on the plant site and system capability to maintain control room habitability.

15. Section 6.5.1: review of the effectiveness of CRAVS filters to remove airborne contaminants prior to discharge to the environment.

16. Section 6.6: review to verify that inservice inspection requirements are met for system components.

17. Sections 7.3 and 8.3.1: review to determine the adequacy of the design, environmental ratings, installation, inspection, and testing of all essential instrumentation and electrical components (sensing, control, and power) required for proper operation and review for overall compliance with the SBO requirements.

18. Section 9.5.1: review of fire protection.

19. Section 11.5: review of the capability of the CRAVS to detect and control leakage of radioactive contamination from the system.

20. Section 12.3-12.4: review of radiation protection criteria.

21. Section 16.0: review of technical specifications.

22. Chapter 17: review of quality assurance programs.

23. Chapter 19: review of SSCs for risk significance.

## II. ACCEPTANCE CRITERIA

Acceptability of the CRAVS design, as described in the applicant's safety analysis report (SAR) is based on relevant regulations, specific general design criteria, and regulatory guides.

The design of safety-related portions of the CRAVS is acceptable if the integrated design of the system is in accordance with the requirements and DSRS acceptance criteria presented in this section.

Requirements

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

1. GDC 2, “Design Bases for Protection Against Natural Phenomena,” as it relates to system capability to withstand the effects of earthquakes.

2. GDC 4, ”Environmental and Dynamic Effects Design Bases,” as it relates to the CRAVS being appropriately protected against dynamic effects and being designed to accommodate the effects of, and to be compatible with, the environmental conditions of normal operation, maintenance, testing, and postulated accidents, including hazards from collocated site facilities. The GDC 4 evaluation includes the adequacy of environmental support for safety-related SSCs within areas served by the CRAVS.

3. GDC 5, ”Sharing of Structures, Systems, and Components,” as it relates to shared SSCs among nuclear power units.

4. GDC 19, ”Control Room,” as it relates to providing adequate protection to permit access to and occupancy of the control room under accident conditions.

5. GDC 60, “Control of Release of Radioactive Materials to the Environment,” as it relates to system capability to suitably control release of gaseous radioactive effluents to the environment.

6. 10 CFR 20.1406, as related to the design and operational procedures to minimize contamination, minimize the generation of radioactive waste, and facilitate eventual decommissioning.

7. 10 CFR 50.63, as it relates to necessary support systems providing sufficient capacity and capability to ensure the capability for cope with an SBO event, including a prolonged SBO affecting multiple units. An analysis to determine capability for withstanding (if an acceptable alternate ac source is provided) or coping with an SBO event is required. The analysis should address, as appropriate, the potential failures of equipment/systems during the event (e.g., loss or degraded operability of heating, ventilating, and air conditioning systems, including the CRAVS, as appropriate), the expected environmental conditions associated with the event, the operability and reliability of equipment necessary to cope with the event under the expected environmental conditions, and the habitability of plant areas requiring operator access during the event and associated recovery period.

8. 10 CFR 52.47(b)(1), which requires that a DC application contain the proposed ITAAC that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a facility that incorporates the design certification has been constructed and will be operated in conformity with the design certification, the provisions of the Atomic Energy Act (AEA), and the U.S. Nuclear Regulatory Commission’s (NRC's) regulations.

9. 10 CFR 52.80(a), which requires that a COL application contain the proposed inspections, tests, and analyses, including those applicable to emergency planning, that the licensee shall perform, and the acceptance criteria that are necessary and sufficient

to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, the facility has been constructed and will operate in conformity with the combined license, the provisions of the Atomic Energy Act, and the NRC's regulations.

DSRS Acceptance Criteria

Specific DSRS acceptance criteria acceptable to meet the relevant requirements of the NRC's regulations identified above are as follows for review described in this DSRS section. The DSRS is not a substitute for the NRC's regulations, and compliance with it is not required. Identifying the differences between this DSRS section and the design features, analytical techniques, and procedural measures proposed for the facility, and discussing how the proposed alternative provides an acceptable method of complying with the regulations that underlie the DSRS acceptance criteria, is sufficient to meet the intent of 10 CFR 52.47(a)(9), "Contents of applications; technical information."

The design of safety-related portions of the CRAVS is acceptable if its integrated design is in accordance with the following criteria:

1. Protection Against Natural Phenomena. Information that addresses the requirements of GDC 2 regarding the capability of structures housing the CRAVS and the CRAVS itself to withstand the effects of natural phenomena will be considered acceptable if the guidance of Regulatory Guide (RG) 1.29, Position C.1 for safety-related portions of the CRAVS and Position C.2 for nonsafety-related portions of the CRAVS are appropriately addressed.

2. Environmental and Dynamic Effects. Information that addresses the requirements of GDC 4 regarding consideration of environmental and dynamic effects will be considered acceptable if the acceptance criteria in the following DSRS sections, as they apply to the CRAVS, are met: SRP and DSRS Sections 3.5.1.1, 3.5.1.4, 3.5.2, and 3.6.1.

3. Sharing of Structures, Systems, and Components. Information that addresses the requirements of GDC 5 regarding the capability of shared systems and components important to safety to perform required safety functions will be considered acceptable if the use of the CRAVS in multiple-unit plants during an accident in one unit does not significantly affect the capability to conduct a safe and orderly shutdown and cool-down in the remaining unit(s).

4. Control Room. Information that addresses the requirements of GDC 19 regarding the capability of the control room to remain functional to the degree that actions can be taken to operate the nuclear power unit safely under normal conditions and to maintain the plant in a safe condition under all accident conditions will be considered acceptable if adequate protection against radiation and hazardous chemical releases are provided to permit access to and occupancy of the control room under accident conditions. RG 1.78 provide guidance acceptable to the staff for meeting these control room occupancy protection requirements. RG 1.194 provides guidance on determining atmospheric relative concentration values in support of design basis control room radiological habitability assessments. RG1.195 provides guidance on acceptable methods and assumptions for performing evaluations of fission product releases and radiological consequences of postulated light water reactor design basis accidents. RG 1.196 provides guidance on adequate radiation protection to be provided to control room

occupants under accident conditions. RG 1.197 provides guidance to demonstrate control room envelope integrity.

5. Control of Releases of Radioactive Material to the Environment. Information that addresses the requirements of GDC 60 regarding the suitable control of the release of gaseous radioactive effluents to the environment will be considered acceptable if the guidance of RGs 1.52 and 1.140 as related to design, inspection, testing, and maintenance criteria for post-accident and normal atmosphere cleanup systems, ventilation exhaust systems, air filtration, and adsorption units of light-water-cooled nuclear power plants are appropriately addressed. For RG 1.52 rev 2, the applicable regulatory position is C.2. For RG 1.52 rev 3, the applicable regulatory position is C.3. For RG 1.140 rev 1, the applicable regulatory positions are C.1 and C.2. For RG 1.140 Revision 2, the applicable regulatory positions are C.2 and C.3.

6. 10 CFR 20.1406. Minimization of contamination to the facility and the environment, and designs to facilitate eventual decommissioning, will be considered acceptable if the design identifies provisions to detect contamination that may enter as inleakage from other systems, identifies potential collection points such as water treatment systems or system low points, and addresses the long term control of radioactive material in the system. DC/COL-ISG-06 and RG 4.21 relate to acceptable levels of detail and content required to demonstrate compliance with 10 CFR 20.1406. NEI 08-08A, Revision 0, "Generic FSAR Template Guidance for Life Cycle Minimization of Contamination," also provides NRC-endorsed industry guidance on life-cycle minimization of contamination.

7. Loss of All Alternating Current Power. Information that addresses the requirements of 10 CFR 50.63 regarding the necessary support systems providing sufficient capacity and capability for coping with an SBO event, including a prolonged SBO affecting multiple units, will be considered acceptable if the guidance of RG 1.155, including position C.3.2.4 is applied appropriately.

8. 10 CFR 52.47(b)(1) specifies that the application of a design certification should contain proposed ITAAC for SSCs necessary and sufficient to provide reasonable assurance that the facility has been constructed and will be operated in conformity with the design certification. 10 CFR 52.97(b) specifies that the COL identifies the ITAAC for SSCs necessary and sufficient to provide reasonable assurance that the facility has been constructed and will be operated in conformity with the license. SRP Section 14.3 provides guidance for reviewing the ITAAC. The requirements of 10 CFR 52.47(b)(1) and 10 CFR 52.97(b) will be met, in part, by identifying inspections, tests, analyses, and acceptance criteria of the top-level design features of the CRAVS in the design certification application and the combined license, respectively.

Technical Rationale

The technical rationale for application of these acceptance criteria to the areas of review addressed by this DSRS section is discussed in the following paragraphs:

1. GDC 2, as to system capability to withstand the effects of earthquakes, requires that SSCs important to safety be designed to withstand the effects of a design-basis earthquake without loss of capability to perform safety functions.

The function of the CRAVS is to provide a controlled environment for the comfort and safety of control room personnel during normal operation, anticipated operational occurrences, and during and after postulated accidents, including the coincidental loss of offsite power. This requirement ensures that the control room will remain functional in the event of a design basis earthquake. RG 1.29 provides guidance acceptable to the staff for meeting these control room occupancy protection requirements.

Meeting the requirement of GDC 2 provides assurance that the habitability of the control room area will be maintained and that equipment in the control room will operate as designed, thereby minimizing the potential for loss of function.

2. GDC 4 requires that SSCs important to safety be designed to accommodate the effects of, and to be compatible with, environmental conditions of normal operation, maintenance, testing, and postulated accidents, including loss-of-coolant accidents. GDC 4 also requires that SSCs important to safety be appropriately protected against dynamic effects (including those of missiles, pipe whipping, and discharging fluids) that could result from equipment failures or from events and conditions outside the nuclear power unit.

   The function of the CRAVS is to provide a suitable and controlled environment for the control room during normal operation, anticipated operational occurrences, and during and after postulated accidents, including loss of offsite power. To ensure performance of these functions under accident conditions, portions of the CRAVS must be designed to accommodate accident environmental effects and be appropriately protected from dynamic effects associated with postulated accidents. The requirements of GDC 4 ensure that control room area systems and components important to safety (with environmental support from the CRAVS) and safety-related portions of the CRAVS are designed to address the expected environmental conditions and dynamic effects associated with the specified events and conditions for which they are required to function, including hazards associated with collocated site facilities.

   GDC 4 requirements provide assurance that the CRAVS will support the functioning of systems and components important to safety by maintaining suitable environmental conditions for performance of safety functions.

3. GDC 5 requires that SSCs important to safety not be shared among nuclear power units unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions, including, in the event of an accident in one unit, an orderly shutdown and cooldown of the remaining units.

   With regard to the CRAVS, GDC 5 requires the component parts of the CRAVS be essentially independent in order to ensure that an accident in one unit of a multiple-unit facility will not propagate to other units. The CRAVS should be designed to accommodate the load resulting from accident conditions. At the same time, the operating environment of equipment in the shared control room must be maintained within specified limits.

   GDC 5 requirements provide assurance that a failure or accident in one unit will not affect additional units onsite.

4. Compliance with GDC 19 requires that the control room remain functional to the degree that actions can be taken to operate the nuclear power unit safely under normal conditions and to maintain the plant in a safe condition under accident conditions, including loss-of-coolant accidents.

   With regard to the CRAVS, GDC 19 requires that adequate protection against radiation and hazardous chemical releases be provided to permit access to and occupancy of the control room under accident conditions. RG 1.78 provides guidance acceptable to the staff for meeting these control room occupancy protection requirements. RG 1.194 provides guidance on determining atmospheric relative concentration values in support of design basis control room radiological habitability assessments. RG 1.195 provides guidance on acceptable methods and assumptions for performing evaluations of fission product releases and radiological consequences of postulated light water reactor design basis accidents. RG 1.196 provides guidance on adequate radiation protection to be provided to control room occupants under accident conditions. RG 1.197 provides guidance to demonstrate control room envelope integrity.

   GDC 19 requirements provide assurance that access to and occupancy of the control room will be protected under accident conditions.

5. GDC 60 requires nuclear power unit designs to include provisions to control the release of radioactive materials entrained in gaseous effluents during normal reactor operation, including anticipated operational occurrences.

   RGs 1.140 and 1.52 offer design, testing, and inspection criteria acceptable to the staff for air filtration and adsorption units of normal ventilation systems and for post-accident engineered-safety-feature atmosphere cleanup systems in light-water-cooled nuclear power plants. Atmosphere cleanup systems are included in the design to reduce the quantities of radioactive materials entrained in gaseous effluents released to the environment.

   GDC 60 requirements provide assurance that release of radioactive materials entrained in gaseous effluents will not exceed specified 10 CFR Part 20 limits for normal operation and anticipated operational occurrences. 10 CFR 20.1406 requires the design of a nuclear power unit to address minimization of contamination of the facility and the environment, and to facilitate eventual decommissioning. 10 CFR 20.1406 applies to this DSRS section because the CRAVS could interface with contaminated structures or systems. DC/COL-ISG-06 and RG 4.21 provide guidance to meet 10 CFR 20.1406. Specific guidance to meet 10 CFR 20.1406 is identified in RG 4.21 Positions C.1 through C.4. NEI 08-08A also provides NRC-endorsed industry guidance on life-cycle minimization of contamination.

6. 10 CFR 50.63 requires a demonstration of the capability of a nuclear power plant to withstand and recover from an SBO (i.e., loss of offsite electric power system concurrent with reactor trip and unavailability of the onsite emergency AC electric power system), including a prolonged SBO affecting multiple reactor modules. An SBO analysis covering a minimum acceptable duration (either to withstand the event until an alternate AC source and shutdown systems are lined up for operation or to cope with it for its duration, including the recovery period) is required. RG 1.155 provides guidance for compliance with SBO requirements.

Regardless of the extent, if any, to which the CRAVS is expected to function to maintain suitable environmental conditions during an SBO event, control room-area equipment necessary for core cooling, maintenance of appropriate containment integrity, and other functions for withstanding or coping with the event, should be able to function under the expected environmental conditions of the event. The reviewer therefore verifies that the SBO analysis appropriately addresses the potential failures of equipment/systems during the event (e.g., loss or degraded operability of the CRAVS, as appropriate), the expected environmental conditions of the event, the operability and reliability of equipment necessary to cope with the event under the expected environmental conditions, and the habitability of plant areas requiring operator access during the event and recovery period.

Those portions of the CRAVS, if any, that are identified in a coping analysis as necessary to support the functioning of equipment required to cope with the event or recovery therefrom are verified to be of sufficient capacity and capability for such support.

10 CFR 50.63 requirements provide assurance that necessary operator actions can be performed and that necessary control room-area equipment will be functional under the expected environmental conditions during and following an SBO, thereby ensuring that the core will be cooled and appropriate containment integrity will be maintained.

## III. REVIEW PROCEDURES

These review procedures are based on the identified DSRS acceptance criteria. For deviations from these acceptance criteria, the staff should review the applicant's evaluation of how the proposed alternatives provide an acceptable method of complying with the relevant NRC requirements identified in Subsection II.

These procedures should be followed for the review of a DC and a COL application.

The procedures for standard DC reviews of designs for which new standard technical specifications are required and for combined licenses include a determination that the proposed technical specifications agree with the requirements for system testing, minimum performance, and surveillance developed in the staff's review.

The primary reviewer coordinates this review with the other areas of review as stated in subsection I of this DSRS section. The primary reviewer uses such input as required to complete this review procedure.

1. Programmatic Requirements and Guidance - In accordance with the guidance in NUREG-0800 "Introduction," Part 2 as applied to this DSRS Section, the staff will review the programs proposed by the applicant to satisfy the following programmatic requirements . If any of the proposed programs satisfies the acceptance criteria described in Subsection II, it can be used to augment or replace some of the review procedures. It should be noted that the wording of "to augment or replace" applies to nonsafety-related risk-significant SSCs, but "to replace" applies to nonsafety-related nonrisk-significant SSCs according to the "graded approach" discussion in NUREG-0800

"Introduction," Part 2. Commission regulations and policy mandate programs applicable to SSCs. Examples of those programs and associated guidance follows:

- Maintenance Rule SRP Section 17.6 (DSRS Section 13.4, Table 13.4, Item 17, RG 1.160, "Monitoring the Effectiveness of Maintenance at Nuclear Power Plants." and RG 1.182; "Assessing and Managing Risk Before Maintenance Activities at Nuclear Power Plants".

- Quality Assurance Program SRP Sections 17.3 and 17.5 (DSRS Section 13.4, Table 13.4, Item 16).

- Technical Specifications (DSRS Section 16.0 and SRP Section 16.1) – including brackets value for DC and COL. Brackets are used to identify information or characteristics that are plant specific or are based on preliminary design information.

- Reliability Assurance Program (SRP Section 17.4).

- Initial Plant Test Program (RG 1.68, "Initial Test Programs for Water-Cooled Nuclear Power Plants, "DSRS Section 14.2, and DSRS Section 13.4, Table 13.4, Item 19).

- ITAAC ( DSRS Chapter 14).

2. In accordance with 10 CFR 52.47(a)(8),(21), and (22), and 10 CFR 52.79(a)(17) and (20), for new reactor license applications submitted under Part 52, the applicant is required to (1) address the proposed technical resolution of unresolved safety issues and medium- and high-priority generic safety issues which are identified in the version of NUREG-0933 current on the date up to 6 months before the docket date of the application and which are technically relevant to the design; (2) demonstrate how the operating experience insights have been incorporated into the plant design; and, (3) provide information necessary to demonstrate compliance with any technically relevant portions of the Three Mile Island requirements set forth in 10 CFR 50.34(f), except paragraphs (f)(1)(xii), (f)(2)(ix), and (f)(3)(v). These cross-cutting review areas should be addressed by the reviewer for each technical subsection and relevant conclusions documented in the corresponding safety evaluation report (SER) section.

3. The SAR is reviewed to verify that the system description and schematics or piping and instrumentation diagram (P&IDs), if applicable, show the CRAVS equipment used for normal and emergency operations, and the ambient temperature limits for the areas serviced. The system performance requirements section is reviewed to determine that it describes allowable component operational degradation (e.g., loss of cooling function, damper leakage) and describes the procedures that will be followed to detect and correct these conditions. The reviewer, using results from failure modes and effects analyses as appropriate, determines that the safety-related portion of the system is capable of functioning in spite of the loss of any active component. Typically, required redundancy is provided by separate, independent subsystems or trains for safety-related functions.

   The essential portions of the CRAVS regarding their quality standards are met by acceptable application of quality group classifications and application of quality

standards, codes, and industry practice. The system review should verify conformance with ASME Code AG-1, "Code on Nuclear Air and Gas Treatment," ASHRAE 62.1-2010, "Ventilation for Acceptable Indoor Air Quality," ASME N509-2002, "Nuclear Power Plant Air-Cleaning Units and Components," and ASME N510-2007, "Testing of Nuclear Air Treatment Systems."

4. The system description and schematics or P&IDs, if applicable, layout drawings, and component descriptions and characteristics are then reviewed to determine that:

   A. Essential portions of the CRAVS are correctly identified and are isolable from nonessential portions of the system. The system description and schematics or P&IDs, if applicable, are reviewed to verify that they clearly indicate the physical divisions between such portions and indicate design classification changes. System drawings are also reviewed to verify that they show the means for accomplishing automatic or manual isolation for all operational modes in response to radiation or other actuation signals. The system description is reviewed to identify minimum performance requirements for the isolation dampers.

      For the typical system, the drawings and description are reviewed to verify that two automatically operated isolation dampers in series separate nonessential portions and components from the essential portions

   B. Essential portions of the CRAVS, including the isolation dampers separating essential from nonessential portions, are classified seismic Category I. Safety analysis report (SAR) component and system descriptions of mechanical and performance characteristics are reviewed to verify that the classifications are included and that the system description and schematics or P&IDs, if applicable, indicate any points of change in design classification.

   C. Design provisions have been made that permit appropriate inservice inspection and functional testing of system components important to safety. It is acceptable if the SAR information delineates a testing and inspection program and if the system drawings show the necessary test recirculation loops around pumps or isolation valves that would be required by this program.

5. The CRAVS is reviewed to ensure that it meets the requirements of 10 CFR 20.1406 for which guidance is provided in DC/COL-ISG-06, RG 4.21, and NEI 08-08A. The review includes provisions made to monitor, collect, and control contaminated liquids (e.g., condensate from coolers or in ductwork) that may form or be carried through the system.

6. The reviewer verifies that the system has been designed so that system function will be maintained as required in the event of adverse environmental phenomena, hazardous chemical release in the plant vicinity, or loss of offsite power. The reviewer evaluates the system, using engineering judgment, results of failure modes and effects analyses, and guidance from RGs 1.194, 1.195, 1.196, and 1.197 to determine that:

   A. The failure of nonessential portions of the systems or of other systems not designed to seismic Category I standards and located close to essential portions of the system, or of nonseismic Category I structures that house, support, or are close to essential portions of the CRAVS, will not preclude operation of the

essential portions of the CRAVS. Reference to SAR sections describing site features and the general arrangement and layout drawings will be necessary, as well as the SAR tabulation of seismic design classifications for structures and systems. Statements in the SAR that verify that the above conditions will be met are acceptable.

B. The essential portions of the CRAVS are protected from the effects of floods, hurricanes, tornadoes, and internally and externally generated missiles. Flood protection and missile protection criteria are discussed and evaluated in detail under the Section 3 series of the DSRS. The location and the design of the system, structures, and fan rooms (cubicles) are reviewed to determine that the degree of protection is adequate. A statement to the effect that the system is located in a seismic Category I structure that is tornado missile and flood protected, or that components of the system will be located in individual cubicles or rooms that will withstand the effects of both flooding and missiles is acceptable.

C. The CRAVS will maintain control room habitability in the event of release of airborne contamination that may enter the control room via the intake vents. Final determination of the identification and the concentration of the contaminants will be completed at the COL stage of review.

D. The total system has the capability to detect and control leakage of airborne contamination into the system. It is acceptable if the following conditions are met:

i. The system description and schematics or P&IDs, if applicable, show monitors located in the system intakes that are capable of detecting radiation, smoke, and toxic chemicals in accordance with RG 1.78. The monitors should actuate alarms in the control room.

ii. The capability for isolation of nonessential portions of the CRAVS by two automatically actuated dampers in series is described in the system description and schematics or P&IDs, if applicable.

iii. The CRAVS has provisions for an internal recirculation filtering mode of operation or can discharge airborne contaminants from the control room area using a once-through ventilation mode, as applicable.

iv. Provisions for isolation of the control room upon smoke detection at the air intakes are shown on the description and schematics or P&IDs, if applicable. The isolation may be actuated manually for most cases. Automatic isolation may be required in special cases such as for fires resulting from aircraft crashes.

E. Essential components and subsystems can function as required in the event of loss of offsite power to maintain control room habitability, including a prolonged SBO and multiple-unit events. The system design will be acceptable if the CRAVS meets minimum system requirements as stated in the SAR assuming a failure of a single active component within the system itself or in the auxiliary electric power source which supplies the system. The SAR is reviewed to see

that for each CRAVS component or subsystem affected by the loss of offsite power, the resulting system operation will not affect safety of control room personnel or the performance of any essential equipment. Statements in the SAR and the results of failure modes and effects analyses are considered in verifying that the system meets these requirements. This will be an acceptable verification of system functional reliability.

7. The descriptive information, description and schematics or P&IDs, if applicable, CRAVS drawings, and failure modes and effects analyses in the SAR are reviewed to ensure that essential portions of the system can function following design basis accidents assuming a concurrent single active failure. The reviewer evaluates the analyses presented in the SAR to ensure function of required components, traces the availability of these components on system drawings, and checks that the SAR contains verification that minimum system isolation or filtration requirements are met for each accident situation for the required time spans. For each case the design will be acceptable if minimum system requirements are met.

8. The reviewer verifies that a suitable environment is demonstrated to be maintained in areas served by the CRAVS for the duration of an SBO event and the associated recovery period, including a prolonged SBO affecting multiple reactor modules, with or without credit for CRAVS operation, as applicable. Where applicable, the functionality of equipment necessary to cope with the event under the expected environmental conditions and the habitability of areas where operator actions are performed should be appropriately addressed during the review as described in RG 1.155, position C.3.2.4. Where the CRAVS (or portions thereof) is credited to function for coping with an SBO, the reviewer verifies that the CRAVS has been designed so that system functions will be performed as required in the event of an SBO, that the CRAVS has sufficient capacity and capability to maintain a suitable environment for the duration of an SBO event and the associated recovery period, and that failure of non-required portions of the CRAVS will not adversely affect the functioning of required equipment. As necessary, the reviewer interfaces with other reviewers responsible for DSRS Chapter 7 and Section 8.3.1 as described in subsection I to evaluate the instrumentation and electrical provisions for CRAVS functionality in the event of an SBO and also to ensure that appropriate control room-area instrumentation and electrical equipment environmental limits have been considered.

9. For review of a DC application, the reviewer should follow the above procedures to verify that the design, including requirements and restrictions (e.g., interface requirements and site-specific conditions and parameters), set forth in the design control document (DCD). The reviewer should also consider the appropriateness of identified COL action items. The reviewer may identify additional COL action items; however, to ensure these COL action items are addressed during a COL application, they should be added to the DCD.

   For review of a COL application, the scope of the review is dependent on whether the COL applicant references a DC, an early site permit (ESP) or other NRC approvals (e.g., manufacturing license, site suitability report or topical report).

10. For review of both DC and COL applications, SRP Section 14.3 should be followed for the review of ITAAC. The review of ITAAC cannot be completed until after the completion of this section.

## IV. EVALUATION FINDINGS

The reviewer verifies that the applicant has provided sufficient information and that the staff's technical review and analysis, as augmented by the application of programmatic requirements in accordance with the staff's technical review approach in the DSRS Introduction, support conclusions of the following type 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 and expected performance of the CRAVS is acceptable and meet the requirements of GDCs 2, 4, 5, 19, and 60 and 10 CFR 50.63. These conclusions are based on the following findings:

1. The applicant meets the requirements of [regulation] for [limits of review for regulation] by [for each item applicable to the review, how met and why acceptable under the regulation]:

   A. Meeting the regulatory positions in RG(s).

   B. Providing and meeting an alternative method to regulatory positions in RG _____, reviewed by the staff and found acceptable.

   C. Using calculational methods for [what was evaluated] that have been 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.

   D. Meeting the provisions of [industry standard number and title] reviewed by the staff and determined to be appropriate for this application.

2. Repeat the discussion for each regulation cited based on the following:

   A. The CRAVS includes all components and ducting from the intake vents to the exhaust structure. All portions of the system whose failure may result in release of radioactivity which causes an offsite dose of more than 5 mSv (0.5 rem) to the whole body or its equivalent to any part of the body are classified seismic Category I and safety related.

   B. The applicant meets the requirements of GDC 2, "Design Bases for Protection Against Natural Phenomena," with respect to system capability to withstand the effects of earthquakes by meeting the guidelines of RG 1.29, "Seismic Design Classification," Position C.1 for safety-related portions of the system and Position C.2 for nonsafety-related portions of the system.

   C. The applicant meets the requirements of GDC 4, "Environmental and Dynamic Effects Design Basis," by appropriately addressing adverse environmental conditions and dynamic effects in the design of the system to ensure its capability for maintaining environmental conditions in the control room within the design limits of equipment important to safety located therein for normal, transient, or accident conditions.

D. The applicant meets the requirements of GDC 5, ”Sharing of Structures, Systems, and Components,” with respect to capability of shared systems and components important to safety to perform required safety functions.

E. The applicant meets the requirements of GDC 19, ”Control Room,” with respect to the capability of the system to maintain a suitable environment in the control room for occupancy during normal and accident conditions by meeting the guidelines of RG 1.78, ”Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release” RG 1.194, “Atmospheric relative Concentrations for Control Room Radiological Habitability Assessments and Nuclear Power Plants,” RG 1.195, “Methods and Assumptions for Evaluating Radiological Consequences of Design Basis Accidents and Light-Water Nuclear Power Plants,” RG 1.196, “Control Room Habitability at Light-Water Nuclear Power Plants,” and RG 1.197, “Demonstrating Control Room Envelope Integrity at Nuclear Power Plants.”

F. The applicant has met the requirements of GDC 60, ”Control of Releases of Radioactive Materials to the Environment,” and 10 CFR 20.1406 with respect to the capability of the system to suitably control release of gaseous radioactive effluents to the environment by meeting the guidelines of RG 1.52, ”Design, Testing, and Inspection Criteria for Air Filtration and Adsorption Units of Post-Accident Engineered-Safety-Feature Atmosphere Cleanup Systems in Light-Water-Cooled Nuclear Power Plants,” and RG 1.140, ”Design, Testing, and Inspection Criteria for Air Filtration and Adsorption Units of Normal Atmosphere Cleanup Systems of Light-Water-Cooled Nuclear Power Plants,” as related to design, inspection, testing, and maintenance criteria for post-accident and normal atmosphere cleanup systems, ventilation exhaust systems, air filtration, and adsorption units of light-water-cooled nuclear power plants. For RG 1.52 Revision 2, the applicable regulatory position is C.2. For RG 1.52 rev 3, the applicable regulatory position is C.3. For RG 1.140 rev 1, the applicable regulatory positions are C.1 and C.2. For RG 1.140 rev 2, the applicable regulatory positions are C.2 and C.3.

G. The applicant has met the requirements of 10 CFR 50.63 by demonstrating that suitable environmental conditions to support operator access/egress and equipment functionality will be maintained during an SBO event, including a prolonged SBO affecting multiple reactor units or modules, and its associated recovery period in those areas of the control room which contain equipment whose function is required for the safe shutdown of the plant in the event of an SBO and by meeting the applicable guidance of RG 1.155, “Station Blackout.”

For DC and COL reviews, the findings will also summarize the staff’s evaluation of requirements and restrictions (e.g., interface requirements and site parameters) and COL action items relevant to this DSRS section.

In addition, to the extent that the review is not discussed in other SER sections, the findings will summarize the staff’s evaluation of the ITAAC, including design acceptance criteria, as applicable.

## V. IMPLEMENTATION

The staff will use this DSRS section in performing safety evaluations of mPower™-specific DC, or COL, applications submitted by applicants pursuant to 10 CFR Part 52. The staff will use the method described herein to evaluate conformance with Commission regulations.

Because of the numerous design differences between the mPower™ and large light-water nuclear reactor power plants, and in accordance with the direction given by the Commission in SRM- COMGBJ-10-0004/COMGEA-10-0001, "Use of Risk Insights to Enhance the Safety Focus of Small Modular Reactor Reviews," dated August 31, 2010 (ML102510405), to develop risk-informed licensing review plans for each of the small modular reactor reviews including the associated pre-application activities, the staff has developed the content of this DSRS section as an alternative method for mPower™ -specific DC, or COL submitted pursuant to 10 CFR Part 52 to comply with 10 CFR 52.47(a)(9), "Contents of applications; technical information."

This regulation states, in part, that the application must contain "an evaluation of the standard plant design against the Standard Review Plan (SRP) revision in effect 6 months before the docket date of the application." The content of this DSRS section has been accepted as an alternative method for complying with 10 CFR 52.47(a)(9) as long as the mPower™ DCD final safety analysis report does not deviate significantly from the design assumptions made by the NRC staff while preparing this DSRS section. The application must identify and describe all differences between the standard plant design and this DSRS section, and discuss how the proposed alternative provides an acceptable method of complying with the regulations that underlie the DSRS acceptance criteria. If the design assumptions in the DC application deviate significantly from the DSRS, the staff will use the SRP as specified in 10 CFR 52.47(a)(9). Alternatively, the staff may supplement the DSRS section by adding appropriate criteria in order to address new design assumptions. The same approach may be used to meet the requirements of 10 CFR 52.79(a)(41) for COL applications.

## VI. REFERENCES


1. 10 CFR 20.1406, "Minimization of Contamination."

2. 10 CFR 50.63, "Loss of All Alternating Current Power."

3. 10 CFR Part 50, Appendix A, GDC 2, "Design Bases for Protection Against Natural Phenomena."

4. 10 CFR Part 50, Appendix A, GDC 4, "Environmental and Dynamic Effects Design Bases."

5. 10 CFR Part 50, Appendix A, GDC 5, "Sharing of Structures, Systems, and Components."

6. 10 CFR Part 50, Appendix A, GDC 19, "Control Room."

7. 10 CFR Part 50, Appendix A, GDC 60, "Control of Releases of Radioactive Materials to the Environment."

8. DC/COL-ISG-06, "Final Interim Staff Guidance Evaluation and Acceptance Criteria for 10 CFR 20.1406 to Support Design Certification and Combined License Applications".

9. RG 1.29, “Seismic Design Classification.”

10. RG 1.52, ”Design, Testing, and Inspection Criteria for Air Filtration and Adsorption Units of Post-Accident Engineered-Safety-Feature Atmosphere Cleanup Systems in Light-Water-Cooled Nuclear Power Plants,” Revision 3, June 2001.

11. RG 1.68, “Initial Test Programs for Water-Cooled Nuclear Power Plants.”

12. RG 1.160, “Monitoring the Effectiveness of Maintenance at Nuclear Power Plants.”

13. RG 1.182, “Assessing and Managing Risk Before Maintenance Activities at Nuclear Power Plants.”

14. RG 1.194, “Atmospheric relative Concentrations for Control Room Radiological Habitability Assessments and Nuclear Power Plants.”

15. RG 1.195, “Methods and Assumptions for Evaluating Radiological Consequences of Design Basis Accidents and Light-Water Nuclear Power Plants.”

16. RG 1.196, “Control Room Habitability at Light-Water Nuclear Power Plants.”

17. RG 1.197, “Demonstrating Control Room Envelope Integrity at Nuclear Power Plants.”

18. RG 1.206, Combined License Applications for Nuclear Power Plants (LWR Edition).

19. RG 1.215, Guidance for ITAAC Closure Under 10 CFR Part 52.

20. RG 1.78, ”Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release,” Revision 1, December 2001.

21. RG 1.140, ”Design, Inspection, and Testing Criteria for Air Filtration and Adsorption Units of Normal Atmosphere Cleanup Systems in Light-Water-Cooled Nuclear Power Plants,” Revision 2, June 2001.

22. RG 1.155, ”Station Blackout,” August 1988.

23. RG 4.21, “Minimization of Contamination and Radioactive Waste Generation: Life-Cycle Planning.”

24. ASME Code AG-1, ”Code for Nuclear Air and Gas Treatment,” 2009.

25. ASHRAE Standard 62.1-2010, “Ventilation for Acceptable Air Quality.”

26. ASME N509-2002, “Nuclear Power Plant Air-Cleaning Units and Components.”

27. ASME N510-2007, “Testing of Nuclear Air Treatment Systems.”

28. NEI 08-8A, Revision 0, “ Generic FSAR Template Guidance for Life Cycle Minimization of Contamination.