U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

6.4 CONTROL ROOM HABITABILITY SYSTEM

REVIEW RESPONSIBILITIES

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

Secondary - Organization responsible for the review of design basis accident radiological consequence analyses

- Organization responsible for the review of chemical engineering

I. AREAS OF REVIEW

The SRP section is applicable to construction permit (CP) and operating license (OL) applications submitted under 10 CFR Part 50 and design certification (DC) and combined license (COL) applications submitted under 10 CFR Part 52. The SRP was originally written for Part 50 license applications. For DC and COL applications submitted under 10 CFR Part 52, the level of information reviewed should be consistent with that of a final safety analysis report (FSAR) submitted in an OL application. However, verification that the as-built facility conforms with the approved design is performed through the inspections, tests, analyses, and acceptance criteria (ITAAC) process.

The control room ventilation system and control building layout and structures, as described in the applicant's safety analysis report (SAR) or design control document (DCD), are reviewed to ensure that plant operators are adequately protected against the effects of accidental releases of toxic and radioactive gases and to assure conformance with the requirements of General Design Criteria 4, 5, and 19, and of 10 CFR 50.34(f)(2)(xxviii), 10 CFR 52.47(b)(1), and 10 CFR 52.80(a). Additionally, review is performed to ensure that the control room can be

maintained as the backup center from which technical support center personnel can safely operate in the case of an accident. These objectives are accomplished by the following:

The specific areas of review are as follows:

1. The zone serviced by the control room emergency ventilation system is examined to confirm all critical areas needing access in the event of an accident are included within the zone (control room, kitchen, sanitary facilities, etc.) and to ensure that those areas not needing access are generally excluded from the zone.

2. The capacity of the control room in terms of the number of people it can accommodate for an extended period of time is reviewed to confirm the adequacy of self-contained breathing apparatus and to determine the length of time the control room can be isolated before CO2 levels become excessive.

3. The control room ventilation system layout and functional design is reviewed to determine flow rates and filter efficiencies for input into the analyses of the buildup of radioactive or toxic gases inside the control room, assuming a design basis release. Basic deficiencies that might impair the effectiveness of the system are examined. In addition, the system operation and procedures are reviewed.

4. The physical location of the control room with respect to potential release points of hazardous airborne materials is reviewed. The layout of the control building is reviewed to ensure that airborne materials will not enter the control room from corridors or ventilation ducts, etc.

5. Radiation shielding provided by structural concrete is analyzed to determine the effectiveness of shielding and structure surrounding the control room. The control building layouts are checked to see if radiation streaming through doors or other apertures or from equipment might be a problem.

6. Independent analyses are performed to determine the radiation doses and toxic gas concentrations.

7 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 structures, systems, and components (SSCs) related to this SRP 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 SRP 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.

8. 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 sections interface with this section as follows:

1. The review of potential sources of hazardous gas is performed under SRP Section 2.2.1-2.2.2. The review will also include the preparation of the sources, source locations, estimated hazardous gas concentrations near the control room building, and probability estimates for accidental releases related to transportation.

2. The review dispersion of airborne contamination is performed under SRP Sections 2.3.4 and 2.3.5.

3. The review of the emergency standby atmosphere filtration system and iodine removal efficiencies of the control room atmosphere filtration system is performed under SRP Section 6.5.1.

4. The review of the design of the control room ventilation system is performed under SRP Section 9.4.1.

5. The review of the storage and location of CO2 or other firefighting materials is performed under SRP Section 9.5.1.

6. The review of the radiation shielding and exposures is performed under SRP Sections 12.1 through 12.5.

7. The review of the radiation levels external to the control room from design basis accidents (DBAs) is performed under SRP Section 15.6.5, Appendix A, SRP 15.0.1, or SRP 15.0.3, as applicable.

8. The review of the Technical Specifications is performed under SRP Section 16.0.

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

II. ACCEPTANCE CRITERIA

Requirements

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

1. General Design Criterion 4 (GDC 4), "Environmental and Dynamic Effects Design Bases," as it relates to SSCs important to safety being designed to accommodate the effects of and to be compatible with the environmental conditions associated with postulated accidents.

2. General Design Criterion 5 (GDC 5), "Sharing of Structures, Systems and Components," as it relates to ensuring that sharing among nuclear power units of SSCs important to safety will not significantly impair the ability to perform safety functions, including, in the event of an accident in one unit, an orderly shutdown and cooldown of the remaining unit(s).

3. General Design Criterion 19 (GDC 19), "Control Room," as it relates to maintaining the nuclear power unit in a safe condition under accident conditions and providing adequate radiation protection.

4. 10 CFR 50.34(f)(2)(xxviii), as it relates to evaluations and design provisions to preclude certain control room habitability problems. For Part 50 applicants not listed in 10 CFR 57.34(f), the provisions of 50.34(f) will be made a requirement during the licensing review.

5. 10 CFR 52.47(b)(1), which requires that a DC application contain the proposed inspections, tests, analyses, and acceptance criteria (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 plant that incorporates the design certification is built and will operate in accordance with the design certification, the provisions of the Atomic Energy Act, and the NRC's regulations.

6. 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.

SRP Acceptance Criteria

Specific SRP acceptance criteria acceptable to meet the relevant requirements of the NRC's regulations identified above are as follows for the review described in 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. Control Room Emergency Zone

   The control room emergency zone should include the following:

   A. Instrumentation and controls necessary for a safe shutdown of the plant, i.e., the control room, including the critical document reference file;

   B. Computer room, if it is used as an integral part of the emergency response plan;

   C. Shift supervisor's office; and

   D. Operator washroom and the kitchen.

   E. The control room emergency zone should conform to the guidelines of Regulatory Guide 1.196, May 2003, "Control Room Habitability at Light Water Nuclear Power Reactors," and Regulatory Guide (RG) 1.197, May 2003, "Demonstrating Control Room Envelope Integrity at Nuclear Power Reactors."

2. Ventilation System Criteria. The ventilation system should include the following design features:

   A. Isolation dampers used to isolate the control zone from adjacent zones or the outside should be low leakage dampers or valves. The degree of leaktightness should be documented in the SAR.

   B. Single failure of an active component should not result in loss of the system's functional performance. All the components of the control room emergency filter train should be considered active components. See Appendix A to this SRP for criteria regarding valve or damper repair.

3. Pressurization Systems. Ventilation systems that will pressurize the control room during a radiation emergency should meet the following criteria:

   A. Systems having pressurization rates of greater than or equal to 0.5 volume changes per hour should be subject to periodic verification (every 18 months) that the makeup is ± 10% of design value. During plant construction or after any modification to the control room that might significantly affect its capability to maintain a positive pressure, measurements should be taken to verify that the control room emergency zone is pressurized to at least to the value used in the accident analysis relative to all surrounding air spaces while applying makeup air at the design rate.

   B. Systems having pressurization rates of less than 0.5 and equal to or greater than 0.25 volume changes per hour should have identical testing requirements as indicated in acceptance criteria 1 above. In addition, at the construction permit (CP), combined license, or standard design certification stage, an analysis should be provided (based on the planned leaktight design features) that ensures the feasibility of maintaining the tested differential pressure with the design makeup airflow rate.

   C. Systems having pressurization rates of less than 0.25 volume changes per hour should meet all the criteria for acceptance criteria 2 above, except that periodic verification of control room pressurization (every 18 months) should be specified.

4. Emergency Standby Atmosphere Filtration System. Iodine removal for this system should be in accordance with the guidelines of Regulatory Guide 1.52. For new applications, the system should also conform with ASME Code AG-1, "Code on Nuclear Air and Gas Treatment" including the AG-1a-92 Addenda (Reference 14). Protection of control room personnel from releases of chlorine or other toxic gases is addressed in Regulatory Guide 1.78 as discussed in the criteria below.

5. Relative Location of Source and Control Room. The control room inlets should be located with consideration of the potential release points of radioactive material and toxic gases. Specific criteria as to radiation and toxic gas sources are as follows:

   A. Radiation sources. As a general rule the control room ventilation inlets should be separated from the major potential release points by at least 31 meters (100 feet) laterally and by 16 meters (50 feet) vertically. However, the actual minimum distances should be based on the dose analyses (Ref. 9).

B. Toxic gases. The minimum distance between the toxic gas source and the control room is dependent upon the amount and type of the gas in question, the container size, and the available control room protection provisions. The acceptance criteria for the control room habitability system are provided in the regulatory positions of Regulatory Guide 1.78 with respect to postulated hazardous chemical releases in general.

6. Radiation Hazards

A. For current operating reactors that do not implement an alternative source term under 10 CFR 50.67, 10 CFR Part 50, Appendix A, General Design Criterion 19 (GDC 19) "Control room," requires that "Adequate radiation protection shall be provided to permit access and occupancy of the control room under accident conditions without personnel receiving radiation exposures in excess of 5 rem whole body, or its equivalent to any part of the body, for the duration of the accident."

In accordance with GDC 19, these doses to an individual in the control room should not be exceeded for any postulated design basis accident. The whole body gamma dose consists of contributions from airborne radioactivity inside and outside the control room, as well as direct shine from all radiation sources.

i. For current operating reactors the dose guidelines for evaluating the emergency zone radiation protection provisions are as follows:

whole body gamma:	50 mSv (5 rem)
thyroid:	300 mSv (30 rem)
beta skin dose:	300 mSv (30 rem)[1]

(1) The whole-body gamma, thyroid, and beta skin doses are consistent with the recommendations of International Committee on Radiation Protection (ICRP) 26, which were used in the May 21, 1991, revision of 10 CFR Part 20. 10 CFR 20.1201 limits organ dose to 50 rem annually.

ii. For current operating reactors conforming to and implementing the guidance of RG 1.195 in conjunction with RG 1.196, the dose guidelines for evaluating the emergency zone radiation protection provisions are relaxed as follows:

whole body gamma:	50 mSv (5 rem)
thyroid:	500 mSv (50 rem)[2]
beta skin dose:	500 mSv (50 rem)[1, 2]

B. Applicants for and holders of construction permits and operating licenses under 10 CFR Part 50 who apply on or after January 10, 1997, applicants for design certifications under 10 CFR Part 52 who apply on or after January 10, 1997, applicants for and holders of combined licenses under 10 CFR Part 52 who do not reference a standard design certification, or holders of operating licenses using an alternative source term under 10 CFR 50.67, shall meet the requirements of GDC 19, except that with regard to control room access and occupancy, adequate radiation protection shall be provided to ensure that radiation exposures shall not exceed 0.05 Sv (5 rem) total effective dose equivalent (TEDE) as defined in 10 CFR 50.2 for the duration of the accident.

7. Toxic Gas Hazards. Three exposure categories are defined: protective action exposure (2 minutes or less), short-term exposure (between 2 minutes and 1 hour), and long-term exposure (1 hour or greater). Because the physiological effects can vary widely from one toxic gas to another, the following general restrictions should be used as guidance: there should be no chronic effects from exposure; acute effects, if any, should be reversible within a short period of time (several minutes) without benefit of any measures other than the use of self-contained breathing apparatus.

The allowable limits should be established on the basis that the operators should be capable of carrying out their duties with a minimum of interference caused by the gas and subsequent protective measures. The limits for the three categories normally are set as follows:

A. Protective action limit (2 minutes or less): Use a limit that will ensure that the operators will quickly recover after breathing apparatus is in place. In determining this limit, it should be assumed that the concentration increases linearly with time from zero to two minutes and that the limit is attained at two minutes.

---

(2) Credit for the beta radiation shielding afforded by special protective clothing and eye protection is acceptable if the applicant commits to its use during severe radiation releases. However, even though protective clothing is used, the calculated unprotected skin dose should not exceed 750 mSv (75 rem). The skin and thyroid dose levels are to be used only for judging the acceptability of the design provisions for protecting control room operators under postulated design basis accident conditions. They are not to be interpreted as acceptable emergency doses. The dose levels quoted here are derived for use in the controlled plant environment and should not be confused with the conservative dose computation assumptions used in evaluating exposures to the general public for the purposes of comparison with the values of 10 CFR Part 100.

B. Short-term limit (2 minutes to 1 hour): Use a limit that will ensure that the operators will not suffer incapacitating effects after a 1-hour exposure.

C. Long-term limit (1 hour or greater): Use a limit assigned for occupational exposure (40-hour week).

The protective action limit is used to determine the acceptability of emergency zone protection provisions during the time personnel are in the process of fitting themselves with self-contained breathing apparatus. The other limits are used to determine whether the concentrations with breathing apparatus in place are applicable. They are also used in those cases where the toxic levels are such that emergency zone isolation without use of protective gear is sufficient. Self-contained breathing apparatus for the control room personnel (at least 5 individuals) should be on hand. A 6-hour onsite bottled air supply should be available with unlimited offsite replenishment capability from nearby location(s). As an example of appropriate limits, the following are the three levels for chlorine gas:

protective action:	15 ppm by volume
short-term:	4 ppm by volume
long-term:	1 ppm by volume

Regulatory Guide 1.78 provides a partial list of protective action levels for other toxic gases.

Technical Rationale

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

1. Compliance with GDC 4 requires that structures, systems, and components important to safety be designed to accommodate the effects of, and be compatible with, environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including loss-of-coolant accidents (LOCAs). These structures, systems, and components shall be appropriately protected against dynamic effects (e.g., the effects of missiles, pipe whipping, and discharging fluids) that may result from equipment failures and from events and conditions outside the nuclear power unit.

   The function of the control room habitability system is to provide a suitable and controlled environment for the control room and equipment located therein during normal operation, anticipated operational occurrences, and during and after postulated accidents, including LOCAs. GDC 4 applies to this SRP section because the reviewer verifies that the control room will remain functional throughout the course of operating and accident events and that operators will be able to carry out their responsibilities without being subject to undue stress.

   Meeting the requirements of GDC 4 provides assurance that the control room habitability system will function as designed, thereby providing protection to plant operators against the effects of accidental releases of toxic and radiological gases.

2. Compliance with GDC 5 requires that structures, systems, and components 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 in the remaining units.

   For a multiple-unit facility in which there is a common control room, components of the control room habitability system will necessarily be shared; whereas, for a multiple-unit facility in which there are separate control rooms, components of the control room habitability system need not be shared. For either design, it should be demonstrated that the operating environment of control areas for each unit remains within specified limits in the event of an accident or toxic gas release, thereby ensuring that control room operators and essential equipment in the control room will be able to continue functioning effectively throughout the course of the event. In this manner, an event at one unit will be prevented from propagating to another unit.

   Meeting the requirements of GDC 5 provides assurance that a failure in one unit of a multiple-unit site will not affect an orderly shutdown and cooldown in remaining units.

3. Compliance with GDC 19 requires provision of a control room from which actions can be taken (a) to operate the nuclear power unit safely under normal conditions and (b) to maintain the plant in a safe state under accident conditions, including LOCAs.

   GDC 19 applies to this SRP section because the reviewer verifies that adequate radiation protection and protection from hazardous chemical releases will be provided to permit access to and occupancy of the control room under accident conditions. Regulatory Guides 1.52 and 1.78 present methods acceptable to the staff for meeting control room occupancy protection requirements.

   Regulatory Guides 1.195, 1.196 and 1.197 provide acceptable guidance for meeting control room habitability requirements. For future reactors or for plants implementing an alternate source term (AST) pursuant to 10 CFR 50.67, the guidance on dose analysis of Regulatory Guide 1.183 is applicable in place of Regulatory Guide 1.195.

   Meeting the requirements of GDC 19 provides assurance that adequate protection will be maintained to permit access to and occupancy of the control room under accident conditions.

4. Compliance with 10 CFR 50.34(f)(2)(xxviii) requires the evaluation of potential pathways for radioactive materials that may lead to problems related to control room habitability under certain accident conditions; it also requires making necessary design provisions to preclude such problems.

   The requirements of 10 CFR 50.34(f)(2)(xxviii) apply to this SRP section because the review evaluates issues involving isolation of the control room, pressurization to assist in preventing inleakage, filtration of the control room air, and location of ventilation intakes. Collectively, these criteria are designed to mitigate the radiological consequences of accidents in the control room.

   Meeting the requirements of 10 CFR 50.34(f)(2)(xxviii) provides assurance that, in the event of an accident, radiation doses to operators will not exceed acceptable limits and, consequently, will not prevent operators from performing required functions.

III. REVIEW PROCEDURES

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

These review procedures are based on the identified SRP 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.

For reviews under 10 CFR Part 50, the procedures below are used during the construction permit (CP) or reviewed to determine that the design criteria and bases and the preliminary design as set forth in the preliminary safety analysis report meet the acceptance criteria given in subsection II of this SRP section. For the review of operating license (OL) applications, the procedures are used to verify that the initial design criteria and bases have been appropriately implemented in the final design as set forth in the final safety analysis report. The review procedures for OL applications include a determination that the content and intent of the technical specifications prepared by the applicant are in agreement with the criteria for system testing, and minimum performance developed as a result of the staff review as indicated in subsection I of this SRP section.

1. Control Room Emergency Zone. The reviewer verifies that the control room emergency zone includes the areas identified in the acceptance criteria of subsection II.1 of this SRP section. The emergency zone should be limited to those spaces needing operator occupancy. Spaces such as battery rooms, cable spreading rooms, or other spaces not needing continuous or frequent occupancy after a design basis accident (DBA) generally should be excluded from the emergency zone. Inclusion of these spaces may increase the probability of smoke or hazardous gases entering the emergency zone. They may also increase the possibility of infiltration into the emergency zone, thus decreasing the effectiveness of the ventilation system in excluding contamination. It is advantageous to have the emergency zone located on one floor, with the areas included in the zone being contiguous.

2. Control Room Personnel Capacity. A control room designed with complete isolation capability from the outside air to provide radiation and toxic gas protection is reviewed to determine if the buildup of carbon dioxide could present a problem. The air inside a 2830 m^3 (100,000 cubic foot) control room would support five persons for at least six days. Thus, CO_2 buildup in an isolated emergency zone is not normally considered a limiting problem.

3. Ventilation System Layout and Functional Design. The reviewer evaluates the control room ventilation system in order to establish appropriate parameters to be used in the control room dose calculations. The control room ventilation system design and performance is evaluated in accordance with SRP Section 9.4.1. The reviewer should use Regulatory Guide 1.52 and, for new applications, ASME Code AG-1 including the AG-1a-92 Addenda to evaluate the system. The procedures are as follows:

   A. The type of system proposed is determined. The following types of protection provisions are currently being employed for boiling water reactor (BWR) or pressurized water reactor (PWR) plants:

i. Zone isolation, with the incoming air filtered and a positive pressure maintained by the ventilation system fans. This arrangement is often provided for BWRs having high stacks. Airflow rates are between 190 and 1900 L/s (400 and 4000 cfm).

ii. Zone isolation, with filtered recirculated air. This arrangement is often provided for BWRs and PWRs with roof vents. Recirculation rates range from 950 to 14,200 L/s (2000 to 30,000 cfm).

iii. Zone isolation, with filtered recirculated air, and with a positive pressure maintained in the zone. This arrangement is essentially the same as that in (2), with the addition of the positive pressure provision.

iv. Dual air inlets for the emergency zone. In this arrangement, two widely spaced inlets are located outboard, on opposite sides of potential toxic and radioactive gas sources. The arrangement ensures at least one inlet being free of contamination, except under extreme no-wind conditions. It can be used in all types of plants. Makeup air supplied from the contamination-free inlet provides a positive pressure in the emergency zone and thus minimizes infiltration.

v. Bottled air supply for a limited time. In this arrangement, a flow rate of 190 to 290 L/s (400 to 600 cfm) is provided from compressed air containers for about 1 hour to assist in preventing inleakage. It is used in systems having containments whose internal atmospheric pressure becomes negative within an hour after a DBA (subatmospheric containments).

B. The input parameters to the radiological dose model are determined. The parameters are emergency zone volume, filter efficiency, filtered makeup airflow rate, unfiltered inleakage (infiltration), and filtered recirculated airflow rate.

C. The ventilation system components and the system layout diagrams are examined. As noted earlier the reviewer will determine if the system meets the single failure criterion as well as other safety requirements under SRP Section 9.4.1. Damper failure and fan failure are especially important. The review should confirm that the failure of isolation dampers on the upstream side of fans will not result in too much unfiltered air entering the control room. The radiation dose and toxic gas analysis results are used to determine how much unfiltered air can be tolerated.

D. The iodine protection factor (IPF) methodology of Reference 9 may not be adequately conservative for all DBAs and control room arrangements because it models a steady-state control room condition. Since many analysis parameters change over the duration of the event, the IPF methodology should only be used with caution.

E. The following information may be used in evaluating the specific system types (see Ref. 9 for further discussion):

i. Zone isolation with filtered incoming air and positive pressure. These systems may not be sufficiently effective in protecting against iodine. The staff allows an iodine protection factor (IPF), which is defined as the

time-integrated concentration of iodine outside over the time-integrated concentration within the emergency zone, of 20 to 100 for filters built, maintained, and operated according to Regulatory Guide 1.52. An IPF of 100 needs deep bed filters. Such systems are likely to provide a sufficient reduction in iodine concentration only if the source is at some distance from the inlets. Thus, the staff consider that in most cases, only plants with high stacks (about 100 meters) would meet GDC 19 with this system.

ii. Zone isolation with filtered recirculated air. These systems have a greater potential for controlling iodine than those having once-through filters. IPFs ranging from 20 to over 150 can be achieved. These are the usual designs for plants having vents located at containment roof level. A system having a recirculation rate of 2400 L/s (5000 cfm) and a filter efficiency of 95% would be rated as follows:

Infiltration L/s (cfm)	IPF[3]
100 (200)	25
50 (100)	49
24 (50)	96
12 (25)	191

Infiltration should be determined conservatively. Measured gross leakage is used to determine the infiltration rate that will be applied in the evaluation of the radiological consequences of postulated accidents. This rate is determined in accordance with the guidance of Regulatory Guide 1.197. "Demonstrating Control Room Envelope Integrity at Nuclear Power Reactors," May 2003.

The base infiltration rate is augmented by adding to it the estimated contribution from opening and closing of doors associated with such activities in accordance with by the plant emergency plans and procedures. Normally, 5 L/s (10 cfm) is used for this additional contribution.

iii. Zone isolation with filtered recirculated air and a positive pressure. This system is essentially the same as the preceding one. However, an additional operational mode is possible. Makeup air for pressurization is admitted. It is filtered before entering the emergency zone. Pressurization reduces the unfiltered inleakage that is assumed to occur when the emergency zone is not pressurized. Assuming a filter fan capacity of 2400 L/s (5000 cfm) and a filter efficiency of 95%, the following protection factors result (flows in L/s (cfm)):

[3] Within the range of interest, the iodine protection factor is directly proportional to recirculation flow rate multiplied by efficiency.

Makeup Air	Recirculated Air	IPF (Assuming No Infiltration)	IPF (Assuming Infiltration[4])
190 (400)	2200 (4600)	238	159
350 (750)	2000 (4250)	128	101
470 (1000)	1900 (4000)	96	80

For method of operation, the following methods have been considered:

(1) automatic isolation with subsequent manual control of pressurization.

(2) automatic isolation with immediate automatic pressurization.

The first is advantageous in the case of external puff releases. Simple isolation would maintain the buildup of the unfilterable noble gases. It would also protect the filters from excessive concentrations in the case of a chlorine release. However, the second method does ensure that infiltration (unfiltered) is reduced to near zero immediately upon accident detection. This would be beneficial in the case where the contamination transport path to the emergency zone is mainly inside the building. Method (i) should be used in the case of a toxic gas release and either method (i) or (ii) should be used in the case of a radiological release, provided GDC 19 can be satisfied.

A substantial time delay should be assumed where manual isolation is assumed, e.g., 20 minutes for the purposes of dose calculations.

iv. Dual air inlets for the emergency zone. Several plants have utilized this concept. The viability of the dual inlet concept depends upon whether or not the placement of the inlets ensures that one inlet will always be free from contamination. The assurance of a contamination free inlet depends in part upon building wake effects, terrain, and the possibility of wind stagnation or reversal. For example, in a situation where the inlets are located at the extreme edges of the plant structures (e.g., one on the north side and one on the south side), it is possible under certain low probability conditions for both inlets to be contaminated from the same point source. SRP Section 2.3.4 presents the position for dealing with the evaluation of the atmospheric dispersion (X/Q values) for dual inlet systems.

Because damage to the ducting might seriously affect the system capability to protect the operators, the ducting should be seismic Category I and should be protected against tornado missiles. In addition,

[4] Normally 5 L/s (10 cfm) infiltration is assumed for conservatism. This flow could be reduced or eliminated if the applicant provides assurance that backflow (primarily as a result of ingress and egress) will not occur. This may mean installing two-door vestibules or equivalent.

the number and placement of dampers should be such as to ensure both flow and isolation in each inlet assuming one single active component-failure (see Appendix A for information on the damper repair alternative). The location of the intakes with respect to the plant security fence should also be reviewed. Evaluation of the design options described above depends on the physical characteristics of the site as well as the plant design and, thus, can be finalized only at the COL stage of review.

v. Bottled air supply for a limited time. In some plant designs, the containment pressure is reduced below atmospheric within 1 hour after a DBA. This generally ensures that, after 1 hour, significant radioactive material will not be released from the containment. Such a design makes it feasible to maintain the control room above atmospheric pressure by use of bottled air. Periodic pressurization tests are necessary to determine that the rated flow, normally about 150 to 300 L/s (300 to 600 cfm), is sufficient to pressurize the control room emergency zone. The system should also be composed of several separate circuits, one of which is assumed to be inoperative to account for a possible single failure. At least one nonredundant, once through filter system for pressurization as a standby for accidents of long duration should be provided.

Compressed air bottles should be protected from tornado missiles or internally generated missiles and should be placed so as not to cause damage to vital equipment or interference with operation if they fail.

4. Atmosphere Filtration Systems. The primary organization responsible for ventilation and air filtration evaluates the iodine removal efficiency of the atmosphere filtration systems under SRP Section 6.5.1, determines the appropriate credit to be given, and advises the organization responsible for emergency preparedness and radiation protection. The review by the primary organization responsible for ventilation and air filtration should include evaluation of the testing proposed for the filtration system and should use applicable positions of Regulatory Guide 1.52 for guidance.

5. Relative Location of Source and Control Room. SRP Sections 2.2.1 and 2.2.2 provide guidance on identifying potential sources of toxic or otherwise potentially hazardous gases. The organization responsible for the review of SRP Sections 2.2.1 and 2.2.2 will provide its findings to the organization responsible for ventilation and air filtration for its toxic gas estimates for use in the control room habitability analysis. There are three basic categories: Radioactive sources, toxic gases such as chlorine, and gases with the potential for being released inside confined areas adjacent to the control room. Evaluation of the relative locations of sources and airborne transport of toxic or otherwise potentially hazardous gases depends on the physical and meteorological characteristics of the site, and plant design and, thus, can be finalized only at the COL stage of review.

A. Radiation Sources. The organization responsible for the review of design basis accident radiological consequence analyses will review SRP Section 15.6.5, Appendix A or SRP section 15.0.1 (for AST plants that implement 10 CFR 50.67) or SRP Section 15.0.3 (for future reactors) to determine the LOCA source terms that are routinely used to evaluate the radiation levels external to the control room envelope. Contamination pathways internal to the plant are examined to

determine their impact on control room habitability. Other DBAs are reviewed to determine whether they might constitute a more severe hazard than the LOCA. If appropriate, an additional analysis is performed for the suspect DBAs. See SRP Section 2.3.4.

B. Toxic Gases. The organization responsible for the review of materials and chemical engineering will review and identify those toxic substances stored or transported in the vicinity of the site which may pose a threat to the plant operators upon a postulated accidental release. The method used to determine whether the quantity or location of the toxic material is such as to need closer study is described in Regulatory Guide 1.78. This guide also discusses the methods for analyzing the degree of risk and states, in general terms, the various protective measures that could be instituted if the hazard is found to be too great. In the case of chlorine, specific acceptable protective provisions are provided in Regulatory Guide 1.78.

In summary, the facility should include the following provisions or their equivalent for the emergency zone ventilation system:

i. quick-acting toxic gas detectors,

ii. automatic emergency zone isolation,

iii. emergency zone leaktightness,

iv. limited fresh air makeup rates, and

v. breathing apparatus and associated bottled air supply.

The best solution for a particular case will depend on the toxic gas in question and on the specific ventilation system design.

C. Confined Area Releases. The reviewer in the organization responsible for the review of ventilation and air filtration studies the control building layout in relation to potential sources of radiation and toxic gases inside the control building or adjacent connected buildings. The following is considered:

i. Storage location of CO_2 or other firefighting materials should be such as to eliminate the possibility of significant quantities of the gases entering the emergency zone. The review will be coordinated with the organization responsible for the review of materials and chemical engineering.

ii. The ventilation zones adjacent to the emergency zone should be configured and balanced to preclude airflow toward the emergency zone.

iii. All pressurized equipment and piping (e.g., main steam lines and turbines) that could cause significant pressure gradients when failed inside buildings should be isolated from the emergency zone by multiple barriers such as multiple door vestibules or their equivalent.

6. Radiation Shielding. Control room operators as well as other plant personnel are protected from radiation sources associated with normal plant operation by a

combination of shielding and distance. The review of the adequacy of this type of protection for normal operating conditions is coordinated with the organization responsible for the review of design bases accident radiological consequence analysis. To a large extent, the same radiation shielding (and missile barriers) also provides protection from DBA radiation sources. This is especially true with respect to the control room walls, which usually consist of at least 46 cm (18 in) of concrete. In most cases, the radiation from external DBA radiation sources is attenuated to negligible levels. The following items should be considered qualitatively in assessing the adequacy of control room radiation shielding and should be coordinated with the organization responsible for the review of design basis accident radiological consequence analyses, who will be requested to provide assistance as necessary.

A. Control Room Structure Boundary. Wall, ceiling, and floor materials and thickness should be reviewed. Forty-six to 61 centimeters (Eighteen inches to 2 feet) of concrete or its equivalent will be adequate in most cases.

B. Radiation Streaming. The control room structure boundary should be reviewed with respect to penetrations (e.g., doors, ducts, stairways). The potential for radiation streaming from accident sources should be identified, and if deemed necessary, quantitatively evaluated.

C. Radiation Shielding from Internal Sources. If sources internal to the control room complex are identified, protective measures against them should be reviewed. Typical sources in this category include contaminated filter trains, or airborne radioactivity in enclosures adjacent to the control room. Evaluations of radiation shielding effectiveness with respect to the above items should be performed using simplified analytical models for point, line, or volume sources such as those presented in References 12 and 13. If more extended analysis is necessary, analytical support from the organization responsible for the review of design basis accident radiological consequence analyses should be requested. The applicant's coverage of the above items should also be reviewed in terms of completeness, method of analysis, and assumptions.

7. Independent Analyses. Pursuant to GDC 19, the applicant is required to calculate doses to the control room operators. Independent analyses are made by the organization responsible for the review of design basis accident radiological consequence analyses because of the diversity of control room habitability system designs and the engineering judgment involved in their evaluation. Since this analysis involves site-related characteristics, it can be finalized only at the COL stage of review. Using the approach indicated in RG 1.195 or RG 1.183, the source terms and doses due to each DBA are calculated. The source terim is determined by an independent analysis of low population zone (LPZ) doses for each DBA, by the organization responsible for the review of design basis accident radiological consequence analysis. The dose is then compared with the requirements of GDC 19. If the guideline values are exceeded, the applicant will be requested to improve the system. In the event that other DBAs are expected to result in doses comparable to or higher than the LOCA, additional analyses are performed. The limiting consequences of the accidents are compared with GDC 19.

8. Design Certification and COL Applications Review. 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 parameters), set forth in the final safety analysis report (FSAR) meets the acceptance criteria. DCs have

referred to the FSAR as 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 DC FSAR.

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).

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 review and calculations (if applicable) 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 control room area ventilation system is acceptable and meets the applicable requirements of GDC 4, 5, 19, and of 10 CFR 50.34(f)(2)(xxviii).

1. These conclusions are based on the staff's review and evaluation that the control room habitability systems meet the regulatory positions of Regulatory Guide 1.52, Revision 3, June 2001, "Design, Inspection, and Testing Criteria for Air Filtration and Adsorption Units of Post-Accident Engineered-Safety-Feature Atmosphere Cleanup Systems in Light-Water-Cooled Nuclear Power Plants," Regulatory Guide 1.78, Revision1, December 2001, "Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release," Regulatory Guide 1.195, May 2003, "Methods and Assumptions for Evaluating Radiological Consequences of Design Basis Accidents at Light-Water Nuclear Power Reactors" or Regulatory Guide 1.183, July 2000, "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors," Regulatory Guide 1.196, January 2007, "Control Room Habitability at Light-Water Nuclear Power Reactors," and Regulatory Guide 1.197, May 2003, "Demonstrating Control Room Envelope Integrity at Nuclear Power Reactors."

   If special protection provisions for toxic gases are not necessary, the following statement or its equivalent is made:

   The habitability of the control room was evaluated using the procedures described in Regulatory Guide 1.78. As indicated in Sections 2.2.1 and 2.2.2, no offsite storage or transport of chemicals is close enough to the plant to be considered a hazard. There are no onsite chemicals that can be considered hazardous under Regulatory Guide 1.78. A sodium hypochlorite biocide system will be used, thus eliminating an onsite chlorine hazard. Therefore, special provisions for protection against toxic gases will not be necessary. In accordance with plant emergency plans and procedures, self-contained breathing apparatus is provided for assurance of control room habitability in the event of occurrences such as smoke hazards.

   If special protection provisions are necessary for toxic gases, compliance or noncompliance with the guidelines of Regulatory Guide 1.78 should be stated. Since

toxic gas risk is related to site characteristics, this part of the evaluation will be completed at the COL stage of review.

In meeting the positions of these regulatory guides, the applicant has demonstrated that the control room will adequately protect the control room operators and will remain habitable in accordance with 10 CFR 50.34(f)(2)(xxviii).

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 SRP 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 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 submitted six months or more after the date of issuance of this SRP section, unless superseded by a later revision.

VI. REFERENCES

1. 10 CFR Part 50 Appendix A, General Design Criterion 4, "Environmental Dynamic Effects Design Bases."

2. 10 CFR Part 50, Appendix A, General Design Criterion 5, "Sharing of Structures, Systems and Components."

3. 10 CFR Part 50, Appendix A, General Design Criterion 19, "Control Room."

4. 10 CFR 50.34(f), "Additional TMI-Related Requirements."

5. NUREG-0737, "Clarification of TMI Action Plan Requirements," Item III.D.3.4, "Control Room Habitability," November 1980.

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

7. Regulatory Guide 1.78, Revision1, December 2001, "Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release."

8. Regulatory Guide 1.195, May 2003, "Methods and Assumptions for Evaluating Radiological Consequences of Design Basis Accidents at Light-Water Nuclear Power Reactors."

9. K. G. Murphy and K. M. Campe, "Nuclear Power Plant Control Room Ventilation System Design for Meeting General Design Criterion 19," 13th AEC Air Cleaning Conference, August 1974.

10. "Leakage Characteristics of Openings for Reactor Housing Components," NM-SR-MEMO-5137, Atomics International, Div. of North American Aviation, Inc., June 20, 1960.

11. R. L. Koontz, et al., "Leakage Characteristics of Conventional Building Components for Reactor Housing Construction," Trans. Am. Nucl. Soc., November 1961.

12. R. G. Jaeger, et al., eds., "Engineering Compendium on Radiation Shielding," Vol. 1, "Shielding Fundamentals and Methods," Springer Verlag (1968).

13. N. M. Schaeffer, "Reactor Shielding for Nuclear Engineers," TID-75951, U.S. Atomic Energy Commission.

14. ASME Code AG-1, "Code for Nuclear Air and Gas Treatment," 1991 (including the AG-1a-92 Addenda thereto).

15. Regulatory Guide 1.196, May 2003, “Control Room Habitability at Light-Water Nuclear Power Reactors.”

16. Regulatory Guide 1.197, May 2003, “Demonstrating Control Room Envelope Integrity at Nuclear Power Reactors.”

17. Regulatory Guide 1.183, July 2000, "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors."

18. NRC Inspection Manual Chapter IMC-2504, “Construction Inspection Program - Non-ITAAC Inspections,” issued April 25, 2006.

PAPERWORK REDUCTION ACT STATEMENT

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

PUBLIC PROTECTION NOTIFICATION

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

APPENDIX A

SECTION 6.4

ACCEPTANCE CRITERIA FOR VALVE OR DAMPER REPAIR ALTERNATIVE

Pursuant to GDC____, the control room ventilation system should to function properly, even with a single failure of an active component. In certain cases, complex valve or damper configurations should meet the single failure criterion. For example, assurance of the isolation and operability of each leg of a dual inlet system at various times after a postulated accident could necessitate a four-valve arrangement in which two pairs of series valves are connected in parallel. The mechanical, power, and control components of such arrangements combine to form a rather complex system. Credit will be allowed for an alternative system that allows the failed valve to be manually repositioned so that it will not interfere with the operation of the system. For example, in the case of a dual inlet system, if credit for repair is given, then two valves in series in each leg of the dual inlet would be acceptable. Where a valve fails closed but meets the criteria given below, credit would be allowed for the valve to be repositioned and locked in an open position.

The approval of the repair option is contingent upon the intrinsic reliability of the internal components of the valve or damper and also upon the ease and ability to overcome the failure of the external actuating components (electrical relays, motors, hydraulic pistons, etc.). The facility should meet the following criteria or their equivalent.

1. The valve or damper components should be listed as to which are considered internal (nonrepairable) and which external (repairable). These should be designed to meet the following criteria.

   A. Internal valve components (i.e., components that are difficult to repair manually without opening the ductwork) should be judged to have a very low probability of failure. The component design details will be reviewed and characteristics such as simplicity, ruggedness, and susceptibility to postulated failure mechanisms will be considered in arriving at an engineered judgment of the acceptability of the internal component design with respect to reliability. For example, a butterfly valve welded or keyed onto a pivot shaft would be considered a high reliability internal component. Conversely, multiple blade dampers, actuated by multi-element linkages or pneumatically operated components internal to the ducts, would be viewed as being subject to failure.

   B. External valve components (i.e., components including motors and power supplies that are to be assumed repairable or removable) should be designed to ensure that the failed valve component can be bypassed easily and safely and that the valve can be manipulated into an acceptable position. The electronic components should be isolated from other equipment to ensure that the repair operations do not result in further equipment failure.

2. The location and positioning of the valve or damper should permit easy access from the control room for convenient repair, especially under applicable DBA conditions.

3. Appropriate control room instrumentation should be provided for a clear indication and annunciation of valve or damper malfunction.

4. Periodic manipulation of the valve or damper by control room operators should be required for training purposes and also to verify proper manual operability of the valve or damper.

5. The need for manual manipulations of the failed valve or damper should not be recurrent during the course of the accident. Manipulation should not occur more than once during the accident. Adjustment or realignment of other parts of the system should be possible from the control room with the failed valve in a fixed position.

6. The time for repair used in the computation of control room exposures should be taken as the time necessary to repair the valve plus a one-half hour margin. No manual correction will be credited during the first two hours of the accident.

7. Compliance with the above criteria should be documented in the SAR whenever the repair option is used.