U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

6.4 CONTROL ROOM HABITABILITY SYSTEM

REVIEW RESPONSIBILITIES

Primary - Accident Evaluation Branch (AEB)

Secondary - Effluent Treatment Systems Branch (ETSB)
Siting Analysis Branch (SAB)

I. AREAS OF REVIEW

The control room ventilation system and control building layout and structures, as described in the applicant's safety analysis report (SAR), are reviewed with the objective of assuring that plant operators are adequately protected against the effects of accidental releases of toxic and radioactive gases. A further objective is to assure 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. To assure that these objectives are accomplished the following items are reviewed:

1. The zone serviced by the control room emergency ventilation system is examined to ascertain that all critical areas requiring access in the event of an accident are included within the zone (control room, kitchen, sanitary facilities, etc.) and to assure that those areas not requiring 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 CO_2 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 assure 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. Estimates of dispersion of airborne contamination are made in conjunction with the assigned meteorologist.

A secondary review is performed by the Effluent Treatment Systems Branch (ETSB) and the Siting Analysis Branch (SAB) and the results are used by AEB in its overall evaluation of the control room habitability. ETSB reviews the iodine removal efficiencies of the control room atmosphere filtration system. The efficiencies are transmitted to AEB for use in the analysis and are referenced in the SER. The evaluation of the potential hazardous gas sources is performed by the SAB under SRP Section 2.2. The SAB will provide AEB with a description of the sources. In those cases where the identified sources are found to have the potential for incapacitating people in the vicinity of the control room building, the SAB will provide AEB with source location, estimated hazardous gas concentrations near the control room building, and probability for the releases with respect to transportation accidents.

In addition, AEB will coordinate the evaluation with other branches that interface with the review of the control room habibility system as follows: the Auxiliary System Branch (ASB) reviews the design of the control room ventilation system as part of its primary review responsibility for SRP Section 9.4.1. The Radiological Assessment Branch (RAB) reviews radiation shielding and exposures as part of the primary review responsibility for SRP Sections 12.1 through 12.5. The review for technical specifications are coordinated and performed by the Licensing Guidance Branch (LGB) as part of the primary review responsibility for SRP Section 16.0. The acceptance criteria necessary for the review and their application are contained in the above referenced SRP section of the corresponding primary branch.

II. ACCEPTANCE CRITERIA

The control room habitability system design is acceptable if the requirements of the following regulations are met:

a. General Design Criterion 4, "Environmental and Missile Design Bases" (Ref. 1), as it relates to accomodating the effects of and being compatible with postulated accidents, including the effects of the release of toxic gases.

b. General Design Criterion 5, "Sharing of Structures, Systems and Components" (Ref. 2), as it relates to facilities which have a single control room for more than one nuclear power unit and with

respect to ensuring that such sharing 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).

c. General Design Criterion 19, "Control Room" (Ref. 3), as it relates to maintaining the control room in a safe, habitable condition under accident conditions by providing adequate protection against radiation and toxic gases.

The specific criteria necessary to meet the relevant requirements of General Design Criteria 4, 5 and 19 and to assure that the control room habitability positions of item III.D.3.4 of NUREG-0737 (Ref. 4) are met are as follows:

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 wash room and the kitchen.

2. Ventilation System Criteria

The ventilation system is reviewed by ASB under SRP Section 9.4.1, "Control Room Area Ventilation System." The AEB reviewer ascertains from the ASB if the following system performance and availability criteria are met:

a. Isolation dampers - dampers used to isolate the control zone from adjacent zones or the outside should be leaktight. This may be accomplished by using low leakage dampers or valves. The degree of leaktightness should be documented in the SAR.

b. Single failure - a 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 requirements:

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 $\pm$ 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 is pressurized to at least 1/8-inch water gauge 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 (1), above. In addition, at the CP stage an analysis should be provided (based on the planned leaktight design features) that ensures the feasibility of maintaining 1/8-inch water gauge differential with the design makeup air flow rate.

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

4. Emergency Standby Atmosphere Filtration System

The atmosphere filtration system is reviewed by ETSB under SRP Section 6.5.1. The ETSB will determine the credit for iodine removal for this system in accordance with the guidelines of Regulatory Guide 1.52 (Ref. 5) and will advise the AEB accordingly. Efficiencies for systems not covered by Regulatory Guide 1.52 will be determined on a case-by-case basis by ETSB.

5. Relative Location of Source and Control Room

The control room inlets should be located considering 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 100 feet laterally and by 50 feet vertically. However, the actual minimum distances must be based on the dose analyses (Ref. 6).

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 (Ref. 7) with respect to postulated hazardous chemical releases in general and in Regulatory Guide 1.95 (Ref. 8) with respect to accidental chlorine releases in particular.

6. Radiation Hazards

The dose guidelines for evaluating the emergency zone radiation protection provisions are as follows:

whole body gamma: 5 rem

thyroid: 30 rem

beta skin dose: 30 rem*

In accordance with GDC 19 (Ref. 3), 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.

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 assure 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.

b. Short-term limit (2 minutes to 1 hour): use a limit that will assure 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).

*Credit for the beta radiation shielding afforded by special protective clothing and eye protection is allowed if the applicant commits to their use during severe radiation releases. However, even though protective clothing is used, the calculated unprotected skin dose is not to exceed 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 guideline values of 10 CFR Part 100.

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 six-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 (Ref. 7) provides a partial list for protective action levels for other toxic gases.

III. REVIEW PROCEDURES

The reviewer selects and emphasizes aspects of the areas covered by this review plan as appropriate for a particular case. The judgment on areas to be given attention and emphasis in the review is based on an inspection of the material presented to see whether it is similar to that recently reviewed for other plants and whether items of special safety significance are involved.

1. Control Room Emergency Zone

The reviewer verifies that the control room emergency zone includes the areas identified in Subsection II.1 of this SRP section. The emergency zone should be limited to those spaces requiring operator occupancy. Spaces such as battery rooms, cable spreading rooms, or other spaces not requiring 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 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 review is coordinated with the ASB which evaluates the control room ventilation system design and performance in accordance with SRP Section 9.4.1. 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:

(1) 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. Air flow rates are between 400 and 4000 cfm.

(2) Zone isolation, with filtered recirculated air. This arrangement is often provided for BWRs and PWRs with roof vents. Recirculation rates range from 2,000 to 30,000 cfm.

(3) 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.

(4) 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 guarantees 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.

(5) Bottled air supply for a limited time. In this arrangement a flow rate of 400 to 600 cfm is provided from compressed air containers for about one hour to prevent 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 (see Item 5 below). The parameters are emergency zone volume, filter efficiency, filtered makeup air flow rate, unfiltered inleakage (infiltration), and filtered recirculated air flow rate.

c. The ventilation system components and the system layout diagrams are examined. The review will be coordinated with the ASB in particular if there are questions pertaining to the system design. ASB 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 following information may be used in evaluating the specific system types (see Reference 6 for further discussion):

(1) 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 (Ref. 5). An IPF of 100 requires 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, in most cases only plants with high stacks (about 100 meters) would meet GDC 19 (Ref. 3) with this system.

(2) 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 5000 cfm and a filter efficiency of 95% would be rated as follows:

Infiltration (cfm)	IPF*
200	25
100	49
50	96
25	191

*Within the range of interest, the iodine protection factor is directly proportional to recirculation flow rate times efficiency.

Infiltration should be determined conservatively. The calculated or 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 as follows:

(i) The leakage from the control room when pressurized to 1/8-inch water gauge is calculated on the basis of the gross leakage data. One-half of this value is used to represent the base infiltration rate. Component leak rates may be used to calculate gross leakage (see, for example, References 9 and 10).

(ii) The base infiltration rate is augmented by adding to it the estimated contribution from opening and closing of doors associated with such activities as required by the plant emergency plans and procedures. Normally 10 cfm is used for this additional contribution.

(iii) An additional factor that is used to modify the base infiltration rate is the enhancement of the infiltration

occurring at the dampers or valves upstream of recirculation fans. When closed, these dampers typically are exposed to a pressure differential of several-inches water gauge. This is accounted for by an additional infiltration contribution over the base infiltration of 1/8-inch water gauge.

The use of an infiltration rate that is based on calculation is acceptable except in the case where the applicant has assumed exceptionally low rates of infiltration. In these cases, more substantial verification or proof may be required. For instance, if an applicant submits an analysis that shows a gross leakage rate of less than 0.06 volume changes per hour, the reviewer would require that the gross leakage be verified by periodic tests as described in Regulatory Position C.5 of Regulatory Guide 1.95 (Ref. 8).

(3) 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 5000 cfm and a filter efficiency of 95%, the following protection factors result (flows in cfm):

Makeup Air	Recirculated Air	IPF (Assuming No Infiltration)	IPF (Assuming Infiltration*)
400	4600	238	159
750	4250	128	101
1000	4000	96	80

The makeup flow rate should have adequate margin to assure that the control room will be maintained at a pressure of at least 1/8-inch water gauge. The applicant should indicate that an acceptance test will be performed to verify adequate pressurization. If the makeup rate is less than 0.5 volume changes per hour, supporting calculations are required to verify adequate air flow. If the makeup rate is less than 0.25 volume changes per hour, periodic verification testing is required in addition to the calculations and the acceptance test.

A question that often arises is whether "pressurization" or "isolation and recirculation" of the control room is to be preferred. Which design gives the lowest doses depends upon the assumptions as to unfiltered inleakage. Isolation limits the entrance of noble gases (not filterable) and, in addition, it

*Normally 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.

is a better approach when the accident involves a short-term "puff release." If infiltration is 25 cfm or less, "isolation" would be best in any event.

A second question related to the first involves the method of operation. The following possibilities have been considered:

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

(ii) automatic isolation with immediate automatic pressurization.

The first is advantageous in the case of external puff releases. Simple isolation would minimize 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 guarantee 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 (Ref. 3) 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.

(4) 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 assures 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. Reference 6 presents the position for dealing with the evaluation of the atmospheric dispersion (X/Q values) for dual inlet systems.

With dual inlets placed on plant structures on opposite sides of potential radiation release points (e.g, containment building) and capable of functioning with an assumed single active failure in the inlet isolation system, the following considerations may be applied to the evaluation of the control room X/Q's:

(i) Dual inlet designs without manual or automatic selection control - equation (6) of Reference 6 may be used with respect to the least favorable inlet location to estimate X/Q's. The estimated values can be reduced by a factor of 2 to account for dilution effects associated with a dual inlet configuration. This is based upon the dilution derived from drawing in equal amounts of clean and contaminated air through two open inlets.

(ii) Dual inlet designs limited to manual selection control - equation (6) of Reference 5 may be used with respect to the more favorable inlet location to estimate the X/Q's. The estimated values can be reduced by a factor of 4 to account for dilution effects associated with a dual inlet configuration and the relative probability that the operator will make the proper inlet selection. The reduction factor is contingent upon having redundant radiation detectors within each air inlet. The reduction factor is based on the judgment that trained control room operators, in conjunction with radiation alarm indication, will select and close the contaminated air inlet.

(iii) Dual inlet designs with automatic selection control features - equation (6) of Reference 6 may be used with respect to the more favorable inlet location to estimate the X/Q's. The estimated values can be reduced by about a factor of 10 to account for the ability to select a "clean" air inlet. The actual factor may be somewhat higher if the inlet configuration begins to approach the remote air inlet concept such that the probability of having one clean air inlet is relatively high. Plant configuration and meteorological conditions should be used as the principal basis for reduction factors greater than 10. The reduction factor of 10 or more is contingent upon having redundant detectors in each inlet and the provisions of acceptable control logic which would be used in the automatic selection of a clean air inlet.

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, the number and placement of dampers must be such as to assure 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.

(5) Bottled air supply for a limited time. In some plant designs the containment pressure is reduced below atmospheric within one hour after a DBA. This generally assures that after one 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 required to determine that the rated flow (normally about 300 to 600 cfm) is sufficient to pressurize the control room to at least 1/8-inch water gauge. The system is also required to be composed of several separate circuits, one of which is assumed to be inoperative to account for a possible single failure. At least one non-redundant, 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

ETSB 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 AEB reviewer.

5. Relative Location of Source and Control Room

The SAB will identify all potential sources of toxic or otherwise potentially hazardous gases as described in SRP Section 2.2. The SAB will provide to the AEB the findings of 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.

a. Radiation Sources

The LOCA source terms determined from the AEB review in accordance with Appendix A to SRP Section 15.6.5 are routinely used to evaluate radiation levels external to the control room. The dispersal from the containment or the standby gas treatment vent is determined with a building wake diffusion model. This model is discussed in Reference 6. 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.

b. Toxic Gases

The SAB 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 require closer study is described in Regulatory Guide 1.78 (Ref. 7). 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 have been determined (Ref 8).

In summary, the following provisions or their equivalent are required for the emergency zone ventilation system:

(1) quick-acting toxic gas detectors,

(2) automatic emergency zone isolation,

(3) emergency zone leaktightness,

(4) limited fresh air makeup rates, and

(5) 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 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:

(1) 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 Chemical Engineering Branch (CMEB).

(2) The ventilation zones adjacent to the emergency zone should be configured and balanced to preclude air flow toward the emergency zone.

(3) 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 adequacy of this type of protection for normal operating conditions is coordinated with the RAB. 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 18 inches of concrete. In most cases, the radiation from external DBA radiation sources is attenuated to negligible levels. However, the following items should be considered qualitatively in assessing the adequacy of control room radiation shielding and should be coordinated with the RAB who will be requested to provide assistance as necessary.

a. Control room structure boundary. Wall, ceiling, and floor materials and thickness should be reviewed. Eighteen inches to two 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 11 and 12. If more extended analysis is required, analytical support from the RAB 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

The applicant is required to calculate doses to the control room operators. Independent analyses are made by the AEB because of the diversity of control room habitability system designs and the engineering judgment involved in their evaluation. Using the approach indicated in Reference 6, the source terms and doses due to a DBA are calculated. The source terms determined by the AEB's independent analysis of low population zone (LPZ) doses for a LOCA are used. The methods and assumptions for this calculation are presented in Appendix A to SRP Section 15.6.5. The control room doses are determined by estimating the X/Q from the source points to the emergency zone using meteorological input supplied by the assigned meteorologist, by determining the credit for the emergency zone's protection features, and by calculating the dose. The attached Table 6.4-1 is a form which may be used to summarize the information that is needed for the control room dose calculation. The effective X/Q's are used for calculating the doses. The dose is then compared with the guidelines 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 Criterion 19.

IV. EVALUATION FINDINGS

The reviewer verifies that sufficient information has been provided and that the review and calculations support conclusions of the following type, to be included in the staff's safety evaluation report (note: items 2 and 3 should be included only if appropiate):

> We conclude that the control room habitability system of the (insert PLANT NAME) facility is acceptable and meets the requirements of the following General Design Criteria:
>
> 1. GDC 19, "Control Room," with respect to maintaining the control room in a safe and habitable condition under accident conditions by providing adequate protection against radiation and toxic gases such that the radiological exposures are within the limits of this criterion, and
>
> 2. GDC 4, "Environmental and Missile Design Bases," with respect to the environmental effects of the release of toxic gases and
>
> 3. GDC 5, "Sharing of Structures, Systems and Components," with respect to ensuring that the control room, shared by Units __ and __ of the (insert PLANT NAME) facility will not significantly impair the ability of the control room personnel to perform safety functions, including, in the event of an accident in one unit, an orderly shutdown and cooldown of the other unit(s)."

These conclusions are based on the staff review and evaluation that the control room habitability systems meet the regulatory positions of Regulatory Guide 1.52, "Design Testing and Maintenance Critria for Engineered-Safety-Feature Atmospheric Cleanup System Air Filtration and Adsorption Units of Light-Water-Cooled Nuclear Power Plants," Regulatory Guide 1.78, "Assumptions for Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release," and Regulatory Guide 1.95, "Protection of Nuclear Power Plant Control Room Operators Against an Accidental Release."

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 Task Action Plan Item III.D.3.4 of NUREG-0737.

If the design is not adequate, the fact is stated. Alternatives such as an increase in the charcoal filter flow rate may be indicated as is given in the example below:

The staff has calculated the potential radiation doses to control room personnel following a LOCA. The resultant whole body doses are within the guidelines of General Design Criterion 19. The thyroid dose resulting from exposure to radioactive iodine exceeds the dose guidelines. A method of meeting GDC 19 would be to increase the filtration system size from 2000 cfm to 4000 cfm. This increased filtration will be sufficient to keep the estimated thyroid doses within the guidelines.

If special protection provisions for toxic gases are not required, 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 Section 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 required. 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 required for toxic gases, compliance or noncompliance with the guidelines of Regulatory Guides 1.78 and 1.95 should be stated.

V. IMPLEMENTATION

The following provides guidance to applicants and licensees regarding the staff's plans for using this SRP section.

Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides.

VI. REFERENCES

1. 10 CFR Part 50, Appendix A, General Design Criterion 4, "Environmental and Missles 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."

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5. Regulatory Guide 1.52, "Design, Testing, and Maintenance Criteria for Engineered-Safety-Feature Atmosphere Cleanup System Air Filtration and Adsorption Units of Light-Water-Cooled Nuclear Power Plants."

6. 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.

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

8. Regulatory Guide 1.95, "Protection of Nuclear Power Plant Control Room Operators Against an Accidental Chlorine Release."

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

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

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

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SECTION 6.4 APPENDIX A

ACCEPTANCE CRITERIA FOR VALVE OR DAMPER REPAIR ALTERNATIVE

The control room ventilation system must meet the criterion to function properly, even with a single failure of an active component. In certain cases, complex valve or damper configurations are required to 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 require a four-valve arrangement in which two pairs of series valves are connected in parallel. The mechnical, power, and control components of such arrangements combine to form a rather complex system. Credit will be allowed for an alternative system that allowed 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 following criteria or their equivalent will be required.

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

    a. Internal valve components (i.e., components that are difficult to repair manually without opening the ductwork) must be judged to have a very low probability of failure. The component design details will be reviewed and characteristics such as simplicity, ruggedness, and suspectibility 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) must 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 must be isolated from other equipment to assure that the repair operations do not result in further equipment failure.

2. The location and positioning of the valve or damper must 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 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.

TABLE 6.4-1 Summary Sheet for Control Room Dose Analysis

MEMORANDUM TO: _____, AEB Lead Reviewer
_____, Meteorologist

cc: Meteorology Section, AEB
AEB Habitability Files

CONCERNING CONTROL ROOM DOSE ANALYSIS FOR (Insert Plant Name)

The following summarizes the X/Q's used in determining the control room operator dose for the subject plant:

A. VENTILATION SYSTEM DESCRIPTION

B. SKETCH OF SYSTEM (and inlets/sources if applicable)

C. SUMMATION OF X/Q ANALYSIS

Source/Receptor Type and Distance

S/D Ratio K Factor

Number of 22-1/2° Wind Direction Sectors that Result in Exposure

Central Wind Sector (sector wind is blowing from)

5% Wind Speed (m/sec) 40% Wind Speed (m/sec)

Projected Area of Wake (m^2) 5% X/Q (sec/m^3)

Time	Wind Speed Factor	Wind Direction Factor	Occupancy Factor	Effective X/Q's
0-8 hr	1	1	1	
8-24 hr			1	
1-4 day			0.6	
4-30 day			0.4	

D. ACTION REQUESTED

Assigned Reviewer

- For your information only
- Please use the effective X/Q's in TACT run and provide control room doses. In addition, please summarize safety system assumptions and indicate their status (interim or final).

Meteorologist

- These are interim X/Q's. Please review to determine their reasonableness.
- These are final X/Q's. Please determine if they are accurate based on your analysis of site data.

Please Contact _____