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Control Room Habitability Guidance

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The Nuclear Energy Institute (NEI) Task Force on Control Room Habitability developed the *Control Room Habitability Guidance* document. We appreciate the task force members contributing to its development and the industry contributors who commented on it to improve the content and clarity.

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EXECUTIVE SUMMARY

This document addresses Control Room Habitability (CRH) issues identified by industry and the NRC based on experiences with operating plants. The goal of the document is to provide guidance to assist licensees in assuring that their control rooms satisfy the NRC regulations and licensee commitments associated with control room habitability. This document addresses:

- Licensing / design basis or operator dose analyses
- Design basis accident (DBA) analyses
- Toxic gas evaluation
- Control room unfiltered inleakage
- Impact of smoke events on shutting down the reactor
- Control Room Emergency Filtration System (CREFS) technical specifications

The document describes the general process for assuring and maintaining the control room habitability. The document is divided into three primary sections:

- Background
- Initial Actions
- CRH Program

The *Background* section discusses basic CRH licensing and design basis information and summarizes the CRH issues addressed in this document.

The *Initial Actions* section provides guidance, including recommended actions, on assembling the CRH licensing basis and assessing if a CRH issue is applicable to a specific plant. If deficiencies are identified, guidance for corrective actions consistent with the plant corrective action program is provided.

The *CRH Program* section discribes a licensee controlled program for managing CRH. The program recommends performance of periodic retesting of Control Room Envelope (CRE) inleakage and periodic reassessment of the toxic gas program.

In addition, the document recognizes that training is an important element of a licensee CRH program.

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1 INTRODUCTION

1.1 PURPOSE AND SCOPE

This document addresses Control Room Habitability (CRH) issues identified by the NRC and licensees based on experiences with operating plants. The goal of the document is to provide guidance to assist licensees in assuring that their control rooms satisfy the NRC regulations and licensee commitments associated with control room habitability. This document addresses:

- Licensing / design basis or operator dose analyses
- Design basis accident (DBA) analyses
- Toxic gas evaluation
- Control room unfiltered inleakage
- Impact of smoke events on shutting down the reactor
- Control Room Emergency Filtration System (CREFS) technical specifications

1.2 DOCUMENT ORGANIZATION

The main body of the document describes the general process for assuring and maintaining control room habitability. Appendices are cited to provide in-depth guidance and other useful information.

The main body of the document is divided into three parts:

- Background
- Initial Actions
- CRH Program

Section 2, *Background*, discusses basic CRH licensing and design basis information and summarizes the CRH issues addressed in this document.

Section 3, *Initial Actions*, provides guidance, including recommended actions, on assembling the CRH licensing basis and assessing if a CRH issue is applicable to a specific plant. If deficiencies are identified, guidance for corrective actions consistent with the plant corrective action program is provided.

Section 4, *CRH Program*, defines a licensee controlled program for managing CRH. The recommended program defines periodic retesting of Control Room Envelope (CRE) inleakage and periodic reassessment of the toxic gas program.

Section 5, *Training*, recognizes the importance of having appropriate training to manage control room habitability.

2 BACKGROUND

2.1 INTRODUCTION

This section identifies documents containing regulatory requirements and guidance related to CRH. It also discusses the CRH issues identified by industry and the NRC staff and addressed by this document.

In this document, the control room envelope (CRE) encompasses the control room and other rooms and areas within the confines of the control room boundary (CRB). The CRB consists of the physical barriers (e.g., ducts, dampers, floors, ceilings, walls, doors) that separate the CRE from other plant areas. Control Room Envelope Integrity is the condition whereby the control room habitability systems (CRHS) are functioning to provide a habitable environment for operators to perform under normal and accident conditions to ensure the public is protected. The CRHS are the plant systems that help ensure CRE integrity, including the control room emergency filtration system (CREFS) and the control room heating, ventilating and air-conditioning (CR HVAC) systems

2.2 CRH REGULATORY REQUIREMENTS

Appendix AA provides a brief history of the development of the NRC control room regulations and guidance. Appendix BB provides a listing of the NRC regulations and other NRC documents related to CRH.

Appendices AA and BB may provide useful information to licensees when assembling their CRH licensing and design bases, but are not considered part of this document's guidance.

2.3 CRH ISSUES

The following topics have been identified as areas of concerns for CRH:

- Licensing / design basis or operator dose analyses /
- Design basis accident (DBA) analyses
- Toxic gas evaluation
- Control room unfiltered inleakage
- Impact of smoke events on shutting down the reactor
- Control Room Emergency Filtration System (CREFS) technical specifications

The following subsections summarize CRH issues addressed in this document. Section 3.2 provides guidance on assessing applicability of each CRH issue for a particular plant and defines actions for applicable issues.

2.3.1 LICENSING / DESIGN BASIS OR OPERATOR DOSE ANALYSES

During review of license amendments, licensees and the NRC staff have observed that some licensees have introduced inconsistencies between the plant's licensing basis and the as-built plant. Differences between the description of the control room envelope, the HVAC systems controlling the airflow within the envelope, and the as-built condition of the plant have been identified and documented. Modifications to systems or the envelope boundary may have inadvertently changed the CR response. In addition, maintenance or operation activities may have resulted in repositioned dampers that could influence the system response or associated control room boundary integrity.

In addition, the design analyses used to determine the operator exposure to a radiological event include several input values that are based on system design parameters and assumed system operation. Licensees and the NRC have observed that some systems may have been operated differently from the assumptions or values used in the analyses. Power up-rates, steam generator replacement and alternate repair criteria for steam generator tubing are examples of modifications that could affect the results of a licensee's CRH analysis.

Section 3.2.1 provides specific guidance.

2.3.2 DESIGN BASIS ACCIDENT (DBA) ANALYSES

Each plant is required to analyze the limiting design basis accident relating to CRH within the scope of its licensing basis. Most licensees and the NRC assumed that the large break LOCA was the limiting DBA for CRH. Reanalysis at various plants has shown that other licensing basis accidents can result in a more limiting dose to the operator.

Section 3.2.2 provides specific guidance.

2.3.3 TOXIC GAS EVALUATION

Control rooms are typically evaluated to assure that they can manage a toxic gas event consistent with NRC guidance contained in Revisions 0 of Regulatory Guides 1.78 and 1.95. Regulatory Guide 1.78, Revision 1 combines Revisions 0 of Regulatory Guides 1.78 and 1.95 and provides additional guidance. Some licensees may not have reassessed the plant's toxic gas evaluation since the early 1980s when it was provided in response to Three Mile Island (TMI) NUREG-0737, item III.D.3.4. If the control room inleakage is greater than that assumed or toxic gas sources have changed over time.the existing toxic gas assessment could need reassessment to be consitent with the current situation.

Section 3.2.3 provides specific guidance.

2.3.4 CONTROL ROOM INLEAKAGE

Tracer gas tests have been conducted at numerous nuclear power plant control rooms to determine the total amount of air inleakage (filtered and unfiltered). Test results usually showed that the measured inleakage was greater than the amount assumed in CRH design basis analyses. In some cases, the difference was significant. This is a concern because control room inleakage values are used in the evaluation of both radiological and toxic gas events**.**

Section 3.2.4 provides specific guidance to address control room inleakage greater than assumed in operator dose analysis.

Greater than assumed inleakage affects two areas. These are as follow:

2.3.4.1 Radiological Considerations

The unfiltered inleakage rate is one of several input values used in the analyses used to determine operator doses. The term unfiltered refers to potentially contaminated air entering the control room envelope that does not pass through an appropriate filtration device. With greater unfiltered inleakage, the fission product removal credited in the accident analyses may be inaccurate and non-conservative. Therefore, increased control room unfiltered inleakage could result in the control room personnel being exposed to a larger dose than previously analyzed.

An increase in the rate of filtered inleakage may also increase the dose to the control room personnel, because of system lineup, location of inleakage, mode of operation, and timing of the event.

2.3.4.2 Toxic Gas Considerations

Inleakage is also a concern for toxic gas events. Increased inleakage may invalidate the conclusions of previous toxic gas analyses. The plant alignment used to determine the amount of inleakage for the toxic gas analysis might be different from that used for a radiological event. A typical control room response to a radiological event is to isolate and pressurize, whereas a typical response to a toxic gas event is to isolate only. This creates different system configurations and different surface areas subject to inleakage.

2.3.5 SMOKE EVALUATION

The original designs of many control rooms assumed that the primary source of inleakage was due to the ingress and egress from opening and closing of entrance doors. Recent CRH inleakage tests results indicate that the original assumptions may not be correct and inleakage is likely to be greater than initially assumed. Therefore, licensees need to assure that the reactor can be shut down from either the control room or an alternate shutdown panel in the event of an internal or

external smoke event. This may require special consideration when the alternate shutdown panel is located within the control room envelope.

Section 3.2.5 and Appendix A provides specific guidance.

2.3.6 EXISTING TECHNICAL SPECIFICATIONS

The Standardized Technical Specifications have a Control Room Emergency Filtration System (CREFS) surveillance requirement to verify that one train can maintain a positive pressure of greater than one-eighth inch water gage relative to adjacent areas. The basis for this surveillance states that it verifies the integrity of the control room enclosure and the assumed inleakage rates of the potentially contaminated air. This surveillance requirement would not apply to non-pressurized control rooms.

Integrated inleakage testing at a number of plants demonstrated that the measured inleakage rates were greater than the inleakage originally assumed rates in the safety analyses. These licensees, with positive pressure control rooms, had passed their positive pressure surveillance acceptance criteria. However, the positive pressure surveillance does not verify the assumed inleakage rate. The NRC staff has stated its belief that the existing deficiency should be corrected because 10 CFR 50.36 requires technical specifications to be derived from the safety analyses. In addition, the NRC staff has suggested that correction of the technical specifications would be consistent with the NRC Administrative Letter 98– 10, *Dispositioning Of Technical Specifications That Are Insufficient To Assure Plant Safety*, which describes the NRC staff's expectation that licensees correct technical specifications that are found to ''contain non-conservative values or specify incorrect actions.''

Section 3.2.6 provides specific guidance.

3 INITIAL ACTIONS

Licensees implementing the guidance of this document are to perform the one-time actions addressed in this section:

- Assemble the licensing and design bases and analyses
- Assess the applicability of the CRH issues identified in Section 2, and
- Recommend additional actions to address those CRH issues that are applicable to the plant.

3.1 CRH LICENSING AND DESIGN BASES AND ANALYSES

Prior to determining the applicability of the CRH issues discussed in Section 3.2, licensees are to assemble and document the CRH licensing and design bases and relevant analyses. The following subparagraphs provide some items that licensees may want to consider as they assemble and document this information.

If the licensee has previously assembled and documented its CRH licensing and design basis and analyses, the Section 3.1 actions may be omitted.

3.1.1 ASSEMBLE LICENSING AND DESIGN BASES

The NRC approved licensing bases of a plant are likely to have changed over time. Changes to the licensing basis contained in the operating license (OL) may have occurred because of plant modifications, response to NRC questions, or in response to TMI Action Item lII.D.3.4.

A group of plants received their construction permits or OLs before the General Design Criteria (GDC) were issued. Prior to the publication of the GDC's, *proposed GDCs* (sometimes called *Principal Design Criteria*), were published in the *Federal Register* for comment. These *proposed GDCs* addressed CRH. Although facilities may have been licensed before the promulgation of the GDCs, licensees may have committed to the form of the GDCs that existed at the time of licensing.

Appendices AA and BB provide a description of the licensing basis history and regulatory documents associated with CRH. Licensees may want to consider the content of these appendices when assembling the licensing and design bases.

NEI 97-04, Revision 1, *Design Basis Program Guidelines*, also provides guidelines for identifying design basis information. Even though design basis information is only a subset of the licensing basis, licensees may find the process identified in NEI 97-04 to be useful when assembling the plant's licensing basis.

3.1.2 ASSEMBLING THE CRH ANALYSES

An important part of a control room design basis is the CRH analysis. This analysis is typically performed during initial plant design to determine operator exposure to the hazards produced by DBAs. For most plants, a CRH analysis will not be available as a stand-alone document. Rather, the licensee will need to assemble it from its component parts. These parts should be found as written design basis documentation and licensing commitments. The following types of information should be reviewed to assemble the CRH analyses:

- Design basis accident analyses within the plant's licensing basis. Licensees should have a thorough understanding of the design basis accidents analyzed for CRH and should know the analysis results (such as radiological consequences) to ensure that the most limiting accident is identified.
- Specific performance requirements for components that provide a radiological, toxic gas or smoke mitigation function along with component performance data.
- Analysis input values, such as the amount of unfiltered inleakage or control room volume, their bases and source documents. For example, inputs such as occupancy factors may have been adopted from the Standard Review Plan.
- All modes of control room ventilation system operation and system alignments necessary to mitigate radiological, toxic gas, and smoke events.
- Component functions. The design basis documents for controlling the performance of components important to CRH should be identified and reviewed to ensure consistency. Such documents may include:
    - Design specifications
    - Piping and instrumentation diagrams (P&ID)
    - Logic diagrams
    - Wiring diagrams
    - Performance test acceptance criteria.
- Technical Specification performance limits and surveillance requirements for credited components.
- Commitments and other requirements regarding operation of the control room envelope may be identified in such documents as the licensee's Updated Final Safety Analysis Report (UFSAR), Design Basis Documents (DBD), Design Criteria Manuals or Memoranda, operating procedures, surveillance test procedures, etc.
- License submittals that may have an effect on CRH such as steam generator replacement, steam generator alternate repair criteria and power uprates.

3.1.3 DOCUMENTATION

If the licensee already has a plant process developed for documenting the CRH licensing basis, the licensee should ensure that all appropriate CRH related information has been recorded. Otherwise, a process should be developed. The CRH licensing basis identification program should include means to identify, retain and update these items.

The process should ensure that all source documentation is reviewed. When licensing basis information is identified, it should be captured and accurately referenced to allow subsequent retrieval in its original context to facilitate review and verification if necessary.

3.2 EVALUATING CRH ISSUES

This section provides guidance for evaluating the plant specific applicability of the areas of concern introduced in Section 2.

This section recommends actions to address the applicable areas of concern. Perform activities of Sections 3.2.1 though 3.2.3 in sequence; prior to performing activities of Sections 3.2.4 through 3.2.6.

3.2.1 LICENSING / DESIGN BASIS OR OPERATOR DOSE ANALYSES

3.2.1.1 Applicability

Compare the control room (CR) system configuration, operation and maintenance practices to assure that they agree with the licensing and design bases.

This comparison is needed because new procedures and methods of operation, maintenance and testing may have been developed and revised during the years of plant operation. Systems may be operated differently from the assumptions or values used in analyses that determined operator exposure from radiological or toxic gas events. Given these potential changes, it is prudent to confirm that current practices are consistent with the licensing basis.

The following subparagraphs provide guidance on performing this comparison.

3.2.1.1.1 As-Built Plant

Review the as-built configuration of the control room envelope and ventilation systems to ensure that the construction and configuration satisfy the design and licensing bases. As a minimum, include:

- Review plant drawings to ensure that the design provides the desired CR isolation function and supports the DBA analysis assumptions.
  - For example, confirm that assumed automatic response functions (isolation, pressurization, etc.) have been implemented.
- Review component specifications to ensure that the licensing and design bases are consistent with current design. For example:
  - Do fans provide the required flow rates?
  - Do dampers provide the design leak tightness?
  - Are duct design requirements consistent with leakage assumptions?

- Perform a system walkdown to ensure that the actual field configuration agrees with the plant drawings/design. For example:
  - Are the air sources from the assumed location(s)
- Compare the control room envelope assumed for inleakage evaluations to that identified in plant documents or surveillance procedures to ensure the identified boundaries are accurate.

3.2.1.1.2 Analyses

Review the CRH analyses to assure that they are consistent with the licensing basis, current control room envelope, and the HVAC procedures and configuration. Verify the following:

- System lineups assumed in the CRH analyses agree with the current procedures
- Assumptions in the CRH analyses are appropriate in light of current operations and configurations

3.2.1.1.3 Operating Procedures Different than Licensing Basis

A. Normal and Emergency Operating Procedures

Review the plant operating procedures to ensure that the licensing and design bases are maintained. This includes review of procedures for both normal and emergency (off-normal) conditions. This should include as a minimum that:

- Emergency operating procedures (EOPs) do not invalidate the licensing basis while attempting to restore area cooling in certain situations.
- Normal operating procedures align the system to establish the proper flow paths. Ensure that damper settings are correct to establish the necessary flow rates and isolation capability.
- Emergency Operating Procedures (EOP) place the control room ventilation system in the correct configuration for the existing plant condition. For example, the proper configuration may be recirculation for a toxic gas event, pressurization for a radiological release, or a combination of both.

B. Control Room Ventilation Systems and the Associated Envelope

Review testing procedures to assure the following:

- The procedures adequately demonstrate the operability of the intended components.
- The procedures ensure that the envelope is not inadvertently breached, or otherwise made inoperable during the test.
- The system is properly realigned after completion of the test.
- Post-maintenance testing is sufficient to ensure that the system is functional and properly configured before being returned to an operable state.

- Where components are being tested for inleakage, the test configuration and test conditions must appropriately reflect those expected under accident conditions.

C. Maintenance Practices and Procedures

Assess maintenance practices and procedures to assure that they do not adversely affect the control room envelope integrity or render a system inoperable. For example:

- Ensure maintenance planning considers the required operability of control room ventilation components for the expected plant-operating modes, as defined in Technical Specifications.
- Review maintenance practices affecting structures to ensure that the CR envelope could not be inadvertently breached.
- Ensure maintenance procedures for system components address CR integrity requirements. Procedures should note that removal of inspection plates or opening access doors might constitute a breach of the CR envelope.
- Ensure breach control programs and procedures designed to seal, maintain and inspect the integrity of the control room envelope are of sufficient detail to examine all likely sources of control room inleakage. Easily damaged components, such as door seals, should receive increased scrutiny.

D. Plant Modification Procedures

Evaluate the design control procedures to ensure that changes that may have a direct or indirect impact on CRH are properly evaluated. Design change procedures should include a check of the effect of the modification on the control room envelope integrity. Ensure these items are addressed:

- Direct modification of the ventilation system could change the system's performance characteristics.
- Modification of ventilation systems in areas adjacent to the control room could affect the inleakage values for the control room envelope.
- Electrical work such as installing new conduit or pulling cable could create new inleakage paths.
- Installing or modifying floor or equipment drains could result in new or altered inleakage paths.

3.2.1.2 Recommended Action

If discrepancies are identified, take corrective actions in accordance with the plant's corrective action program as described in Section 3.3.

3.2.2 DESIGN BASIS ACCIDENT (DBA) ANALYSES

3.2.2.1 Applicability

The large-break loss-of-coolant accident (LBLOCA) DBA was frequently assumed by licensees to be the bounding accident for control room habitability dose analyses and was used to assess the adequacy of the CRH design. However, recent assessments have identified instances where the LBLOCA was not the limiting DBA for the control room habitability assessment.

Assess if the limiting DBA has been used to determine the adequacy of the CRH design. This assessment is to consider as a minimum those DBAs in the plant's current licensing basis (CLB). If the licensee plans to implement DG-1113 (when issued) or RG 1.183 to perform the analyses, the guidance contained in these regulatory guides or in the associated regulations must be followed to determine the limiting DBA for CRH.

The limiting CRH assessment is to consider the impact of different plant configurations, responses or atmospheric dispersion from other accidents, including accidents at adjacent units within the licensing basis, on the radiological consequences to the reactor operators. Changes to plant design or operations must be evaluated or analyzed over the spectrum of the plant licensing basis events to determine the CRH response.

Factors that may influence the limiting CRH DBA include:

- For accidents where the CRH features are actuated by containment isolation or safety injection (SI) signals, there is little or no actuation delay. Typically, control room isolation is activated by engineered safety feature signals such as containment high pressure or safety injection, or radiation monitors, or both. Where the CRH features are actuated by radiation monitor alarm signals, there may be a time delay to achieve control room isolation. Manual actuation of equipment may impose additional delays. In such cases, contaminated air may enter the control room during these periods.

- Radiation monitor configuration may affect the ability to actuate the CRH features in a timely manner.

- Differences in source terms for the different postulated accidents can have a significant impact on monitor response.

- Radiological release locations can dictate which analyzed accident is limiting. Some considerations are:

- The distance between the control room intake and release points may be different for each postulated accident.
- Release points for some accidents may be in a direction frequently downwind of the control room intake, while those for other accidents may usually be upwind.
- A ground-level release associated with a non-LOCA event may be more limiting than the elevated release associated with a LOCA at units with a secondary containment or enclosure building.

- For plants with approved alternate repair criteria (ARC) for steam generators, the main steam line break accident may be the limiting accident with regard to CRH especially if the licensee has maximized the postulated control room operator dose in order to maximize the number of tubes to which the ARC is applied.

- Adjacent Unit Accidents:

  - A special case of limiting DBA could result from an accident release from an adjacent unit that does not share a common control room. The release point, atmospheric dispersion and postulated source term for the adjacent unit should be reviewed to assess the impact on an operating unit. This potential limiting DBA must be considered if it is within the licensing basis of the plant evaluating its control room, or if the methodology in RG-1.183 or DG-1113 (when issued) is used.

  - If there are adjacent units with separate control rooms, then an accident in one unit should not prevent the safe shutdown of the adjacent unit. Atmospheric transport mechanisms between the accident unit and the HVAC intakes to the operating unit control room should be reviewed for impact on CRH.

3.2.2.2 Recommended Action

If a new CRH limiting DBA is identified, take corrective action in accordance with the plant's corrective action program as described in Section 3.3.

3.2.3 TOXIC GAS EVALUATION

3.2.3.1 Applicability

As discussed in Section 2.3.3, the sources of toxic gas may have changed over time and the existing evaluation may not account for the current toxic gas threats near the plant.

Assess if the sources of toxic gas have changed sufficiently to require revising the plant's toxic gas evaluation.

3.2.3.2 Recommended Action

Update the toxic gas evaluation in accordance with the plant licensing basis. Use Regulatory Guides 1.78 and 1.95 as appropriate for performing this update. The current revisions of these regulatory guides or the revisions cited in the CLB may be used to perform these assessments. Appendix DD provides information beyond that contained in Regulatory Guide 1.78 in the areas of specifying toxicity limits, identifying sources of on-site and off-site hazardous materials, determining hazardous chemical release characteristics and applying updated atmospheric dispersion modeling techniques.

3.2.4 CONTROL ROOM INLEAKAGE

3.2.4.1 Applicability

As discussed in Section 2.3.4, unfiltered and filtered air inleakage values are assumptions used in radiological and toxic gas evaluations. Inleakage tracer gas tests have been conducted at numerous nuclear plant control rooms to determine the total amount of air inleakage. Most tests indicated that the actual measured inleakage exceeded the value(s) originally assumed in the accident analyses. This issue is applicable to all plants.

3.2.4.2 Recommended Action

Some plants have already performed an integrated inleakage test. These plants have resolved or are in the process of resolving any discrepancies between measured inleakage and the inleakage value assumed in their accident analyses. For those plants that have not performed an integrated inleakage test, perform a baseline test per Section 4.2 to determine numerical values for control room inleakage that can be compared to the accident analyses assumptions and used to assess actual inleakage occurring with the control room emergency filtration in accident configurations.

3.2.5 IMPACT OF SMOKE EVENTS ON SHUTTING DOWN THE REACTOR

3.2.5.1 Applicability

As discussed in Section 2.3.5, the presence of smoke in the control room originating from internal or external events may challenge an operator's ability to shut down the reactor. This issue is applicable to all plants.

3.2.5.2 Recommended Action

Since no regulatory limit exists on the amount of smoke allowed in the control room, the plant's ability to manage smoke infiltration is assessed qualitatively. Perform a qualitative evaluation of smoke management capabilities per Appendix A. The assessment is to consider smoke events generated either internal or external to the control room. The assessment is to assure that the plant operators are able to shut down the reactor from either the control room or the alternate shut down panel.

Address any inconsistencies in accordance with the plant's corrective action program as described in Section 3.3.

3.2.6 ADEQUACY OF EXISTING CREFS TECHNICAL SPECIFICATIONS

3.2.6.1 Applicability

As discussed in Section 2.3.6, if a licensee has a surveillance requirement (SR) to verify operability of the pressurization system by demonstrating a differential pressure between the CRE and adjacent areas, determine if there is an inconsistency between the Technical Specification Surveillance Requirement, its TS Bases, and the safety analyses for the CREFS.

3.2.6.2 Recommended Action

Verify the design basis for pressurizing the control room envelope as described in the plant's safety analyses.

If an inconsistency exists, several options are available. One option is to adopt the new Standard Technical Specification for Control Room Emergency Filtration System (CREFS) being developed by the Technical Specification Task Force (TSTF), which includes a new SR and TS administrative program for control room integrity. The program being referenced in the new Standard TS will be based on the guidance in Section 4. Another option is to revise the technical specification bases using 10 CFR 50.59 to be consistent with the safety analyses design basis and adopt a control room integrity program in accordance with the program described in Section 4.

In either case, Section 4 discusses the need for licensees to perform a baseline test and to periodically assess and retest the control room envelope for inleakage.

3.3 DISPOSITIONING AND MANAGING DISCREPANCIES

3.3.1 PURPOSE AND SCOPE

Conditions adverse to quality must be promptly identified and corrected in accordance with 10 CFR Part 50, Appendix B, Criterion XVI. Each licensee's Corrective Action Program accomplishes this. The primary guidance for identifying and resolving degraded and nonconforming conditions is provided by Generic Letter (GL) 91-18, Revision 1, *Information to Licensees Regarding NRC Inspection Manual Section on Resolution of Nonconforming Conditions*. Reportability criteria are specified by 10 CFR 50.72, *Immediate notification requirements for operating nuclear power reactors* and 10 CFR 50.73, *Licensee event reporting system*.

In addition, if changes are required, the criteria of 10 CFR 50.59, *Changes, tests and experiments*, may apply.

3.3.2 GENERIC LETTER 91-18

Generic Letter 91-18 informed licensees of the issuance of a revised section to Part 9900, *Technical Guidance of the NRC Inspection Manual*. The revised section was entitled *Resolution of Degraded and Nonconforming Conditions* and provides guidance to NRC inspectors and provides explicit insights on appropriate actions to take when a degraded or nonconforming condition exists. The document directs assessment of the following:

- Operability determination
- Justification for continued operation
- Reasonable assurance of safety
- Compensatory measures (if used).

Generic Letter 91-18 describes three potential scenarios for addressing degraded and nonconforming conditions:

The licensee may restore the structure, system, or component (SSC) to the condition that is described in the licensing basis. For example, if the assumed control room inleakage is explicitly described in the UFSAR and an inleakage test reveals excessive inleakage, the licensee may take corrective action to repair various seals and openings to reduce the inleakage to within the UFSAR analyses input value(s). See Appendix CC for information on sealing.

- The licensee may accept a condition "as-is" which results in something different from that described in the UFSAR or may modify the plant to something different than that described in the UFSAR. These options would be considered a change and would be subject to 10 CFR 50.59 unless another regulation applies. An example of this is modifying the control room envelope to enhance the leakage prevention characteristics of the system. Another example would be revising the appropriate accident analyses to demonstrate the acceptability of increased inleakage.

- The licensee may take interim compensatory measures until the permanent corrective actions identified be implemented. These compensatory measures may be subject to 10 CFR 50.59. For example, potassium iodide (KI) tablets and/or self-contained breathing apparatus (SCBA) may be utilized to minimize operator dose until other actions are taken. See Appendix B for possible compensatory methods that may be used.

3.3.3 DETERMINING OPERABILITY AND REPORTABILITY

If a degraded or nonconforming condition is identified, appropriate action must be taken to maintain the plant in a safe condition. Generic Letter 91-18 provides guidance with respect to performing operability determinations. Appendix D states that it is advisable

to develop contingency plans and operability determination actions prior to performing inleakage tests. Such planning can provide insights about the baseline testing acceptance criteria. A licensee may want to determine the maximum inleakage that can be accommodated:

- Within the current licensing basis analysis and regulatory limits,
- Within the current licensing basis analysis, but with the analysis improvements of DG-1111 (when issued),
- Using the TID-14844 source term, but with the analysis improvements of DG-1111 (when issued) and DG-1113 (when issued), or
- Using the alternative source term (10 CFR 50.67 and Regulatory Guide 1.183), with or without the atmospheric dispersion improvements of DG-1111 (when issued).

Realistic assumptions may be used to calculate reactor core fission product inventory based upon actual reactor operating parameters for the fuel cycles. In addition, the compensatory measures of Appendix B (or other, plant-specific compensatory measures) should be considered for use in case the above levels cannot be met.

The reportability evaluation ensures timely NRC notification of significant conditions or events relative to regulatory compliance. The corrective action process should ensure that an identified discrepancy is evaluated for potential reportability to NRC under the requirements of 10 CFR 50.72 and 10 CFR 50.73.

The basis for operability and reportability, including evaluations and analyses, should be documented and retained for future use.

3.3.4 METHODS AVAILABLE TO ADDRESS DEGRADED OR NONCONFORMING CONDITIONS

3.3.4.1 Compensatory Measures

Compensatory measures may be implemented in the short term to mitigate an identified discrepancy that may result in the plant being in an unanalyzed condition or outside its design or licensing basis (i.e., degraded or nonconforming condition per Generic Letter 91-18). Compensatory measures must provide reasonable assurance of safety until final corrective actions are complete. Compensatory measures can consist of additional administrative or procedural controls, additional testing or inspection of system components, and additional protection provided to control room operators through the availability of self-contained breathing apparatus and/or potassium iodide tablets. Licensees must ensure that compensatory actions can be implemented under 10 CFR 50.59 or request prior NRC approval. Guidance regarding compensatory measures related to CRH is provided in Appendix B.

3.3.4.2 Dose Analysis Revision Option

A revised dose analysis may be part of the short-term justification for continued operation or part of the long-term resolution of the nonconforming condition.

Revision of the analysis of record for the dose consequences to the control room operator may be an acceptable method for addressing a condition different from that described in the UFSAR and for meeting the requirements of the current licensing basis (CLB). Revision of the dose analysis of record may be desirable in combination with plant modifications to improve the margin to regulatory limits.

An option for consideration in the development of the final resolution of the degraded condition is to revise the licensing basis. An example of a new licensing basis would be the implementation of the Alternative Source Term based on 10 CFR 50.67 and Regulatory Guide 1.183. A plant may also choose to use the guidance in DG-1111 (when issued) and DG-1113 (when issued) to revise their dose analysis.

An increase in previously calculated operator doses may require NRC review and approval. In addition, some changes to the licensing basis (e.g., AST, or use of DG-1113, when issued) or analysis methodology may also require prior NRC approval in accordance with 10 CFR 50.59. Regulatory Guide 1.187 and NEI 96-07, *Guidelines for 10 CFR 50.59 Implementation*, provide additional guidance to address criteria for making this determination.

3.3.4.3 Repairing or Modifying the Plant

The identified inleakage source may be corrected by a repair of the physical condition or by sealing the leak path.

In some instances, a plant modification may be desirable. Licensees may decide to modify their control room envelope boundary by:

- Moving HVAC equipment within the CRE
- Replacing ducts with seam-welded heavy construction material to eliminate ducting as a leakage source
- Modifying system controls to change actuation signal timing
- Securing non-emergency ventilation systems that contribute to inleakage during operation and pressurization
- Modifying the system modes of operation.

Repair or modification may require a retest to ensure that they were successful in elimination of the excessive inleakage and provide appropriate validation of the assumed new inleakage value.

3.3.4.4 Technical Specification Changes

Degraded or nonconforming conditions may be addressed by technical specification changes. The nonconforming degraded condition may be eliminated if one of the parameters associated with the limiting accident is in the technical specifications and can be changed. Examples might be reactor coolant activity levels, containment leak rate, or primary-to-secondary leak rates.

4 CRH PROGRAM

4.1 PURPOSE AND SCOPE

This section defines the Control Room Habitability (CRH) Program, which is comprised of a one-time baseline control room inleakage test and periodic inleakage test and assessment activities. This program assures that CRH is maintained in accordance with NRC regulations and licensee commitments.

4.2 BASELINE CR INLEAKAGE TEST

4.2.1 PREPARATION FOR BASELINE TEST

Prior to performing a baseline test, perform a system assessment per Appendix C.

The system assessment includes a walkdown to identify (1) discrepancies in the envelope, and (2) components vulnerable to inleakage. The system assessment should help to find potential inleakage paths that are candidates for pre-test maintenance or design modifications.

The licensee may choose to perform maintenance to eliminate any suspected inleakage paths before performing the baseline test for inleakage.

The control room envelope encompasses the control room and other rooms and areas within the confines of the control room boundary (CRB). The CRB is the physical barriers (e.g., ducts, dampeners, floors, ceilings, walls, doors) that separate the CRE from other areas.

4.2.2 BASELINE TEST PERFORMANCE

Perform a baseline test to determine the value of control room inleakage for use in control room habitability analyses. Appendix D defines acceptable test methods and the scope of their application.

4.2.3 USE OF BASELINE TEST RESULTS

Compare the nominal measured baseline inleakage value(s) to those used in the CRH radiological and toxic gas analyses. Acceptable results exist if the nominal measured inleakage value(s) is less than or equal to the analysis input. If the measured inleakage value is greater than the analysis input, the licensee must take corrective actions per its corrective action program as discussed in Section 3.4.

Corrective actions may include reanalysis, a design change, sealing and re-baseline testing to ensure the design and licensing basis are met. If the licensee uses reanalysis to resolve the discrepancy, it may be useful to revise the licensing bases and implement NRC DG-1113 (when issued), DG-1111 (when issued), or the alternative source term rule, 10 CFR 50.67 and Regulatory Guide 1.183.

Following completion of the baseline test and any resulting corrective actions, implement the Section 4.3.4, *Administrative Controls*. These controls will be used as part of the periodic assessment discussed in Section 4.3.1.

4.3 CRE INTEGRITY PROGRAM[1]

A CRE integrity program per the following subparagraphs is to be implemented following performance of a baseline test. Figure 1 illustrates the CRH Program.

Licensees that have already performed a baseline test will need to determine the point at which to enter the program illustrated in Figure 1. When initiating this program, ensure that the Section 4.3.4 administrative controls are in place.

- If the baseline test was performed, more than six years prior to implementation of NEI 99-03, then initiate this program with a retest per Section 4.3.2, or
- If the baseline test was performed 3 to 6 years prior to implementation of NEI 99-03, then initiate this program with an assessment per Section 4.3.1, or
- If the baseline test was performed within 3 years prior to implementation of NEI 99-03, then initiate the program with an assessment per Section 4.3.1 three years after the baseline test was performed.

4.3.1 ASSESSMENT

Three years following completion of the Section 4.2 baseline test and any corrective actions perform a CRE Assessment per Section 4.4.1.

- If no discrepancies are found, perform a retest per Appendix D in three years.
- If discrepancies are found, determine if the discrepancies are procedural, minor or major.
  - If necessary, notify the NRC in accordance with any applicable regulations or the plant technical specification.

1 The time periods listed in this CRE Integrity Program are considered nominal and a margin of +/- one (1) year is considered acceptable.

- If the discrepancy is procedural or minor correct the discrepancy per the plant's corrective action program (Section 3.3) and perform a periodic retest per Appendix D in three more years.

- If the discrepancy is major, fix the discrepancy per the plant corrective action program (Section 3.3), and retest the CRE inleakage per Appendix D. Perform a periodic retest in three years.

4.3.2 PERIODIC RETEST

Perform a periodic retest for CRE inleakage per Appendix D.

4.3.3 PERIODIC RETEST RESULT REVIEW

Review the periodic retest results. Acceptable results exist if the nominal measured inleakage value(s) is less than or equal to the analysis input.

- If the results pass, perform a reassessment in three years per Section 4.3.1

- If the results fail, implement either of the following in accordance with the plants corrective action program (Section 3.3):

  - Demonstrate conformance with the plant licensing basis using reanalysis and perform a periodic retest per Appendix D in three years, or

  - Fix the discrepancy and retest the CRE inleakage per Appendix D; then perform a periodic retest per Appendix D in three years.

4.3.4 ADMINISTRATIVE CONTROLS

Establish administrative controls for the CRE Integrity program using the guidance in this section.

4.3.4.1 CRE Boundary / Breach Control

Establish a control room envelope boundary control program. Appendix E contains the guidance for establishing these controls, if they do not already exist at the plant. The controls assure that boundary breaches are recognized, that uncontrolled breaches to the CRE do not occur and that known breaches do not result in an unanalyzed condition.

4.3.4.2 Procedure Control

Review the procedural control program to assure that potential CR integrity issues are recognized and appropriately considered when generating or revising procedures. If procedural controls are not in place to appropriately address CR integrity issues when procedures are issued, it is recommended that such guidance be added to the control program.

4.3.4.3 Toxic Chemical Control

Review the plant's existing chemical controls program and licensee commitments to ensure that the impact of potential release of on-site chemicals to the control room is assessed. See Appendix DD for addition inforamtion.

Guidance contained in RG 1.78 and/or RG 1.95 may be part of the licensee commitments. It is recommended the controls also provide guidance regarding acceptable quantities, locations or container sizes for chemicals approved for use on-site.

Offsite sources of toxic gas releases to the control room are addressed in Section 4.4, *Periodic CRE Assessments and Inleakage Retest*.

4.3.4.4 Design Change Control

Review the plant design change control process to ensure that the CRE integrity issues listed in Section 2.3 are addressed in the design change process. Both permanent and temporary modifications should be addressed. In addition, appropriate post-modification testing should ensure that safety analyses assumptions remain valid. It is recommended that the CR HVAC system engineer be familiar with habitability issues and review each related modification package for impact on CRH.

4.3.4.5 Safety Analyses Control

The design change process typically ensures that the associated safety analysis is reviewed and revised as part of a design change. However, safety analysis calculations may be revised for purposes other than a design change. Therefore, ensure that the calculation control procedure has a requirement to review safety analysis calculation revisions for impacts on control room integrity, particularly when calculations are not being revised as part of the design change process.

Examples of assumptions that can affect CRH are:

- Inleakage values
- Change in release location, quantity or type
- System isolation characteristics

- Assumed accident source term
- Operator action assumptions

4.3.4.6 Maintenance Control

Review the plant maintenance control process to ensure controls are in place addressing CR integrity issues during the performance of maintenance.

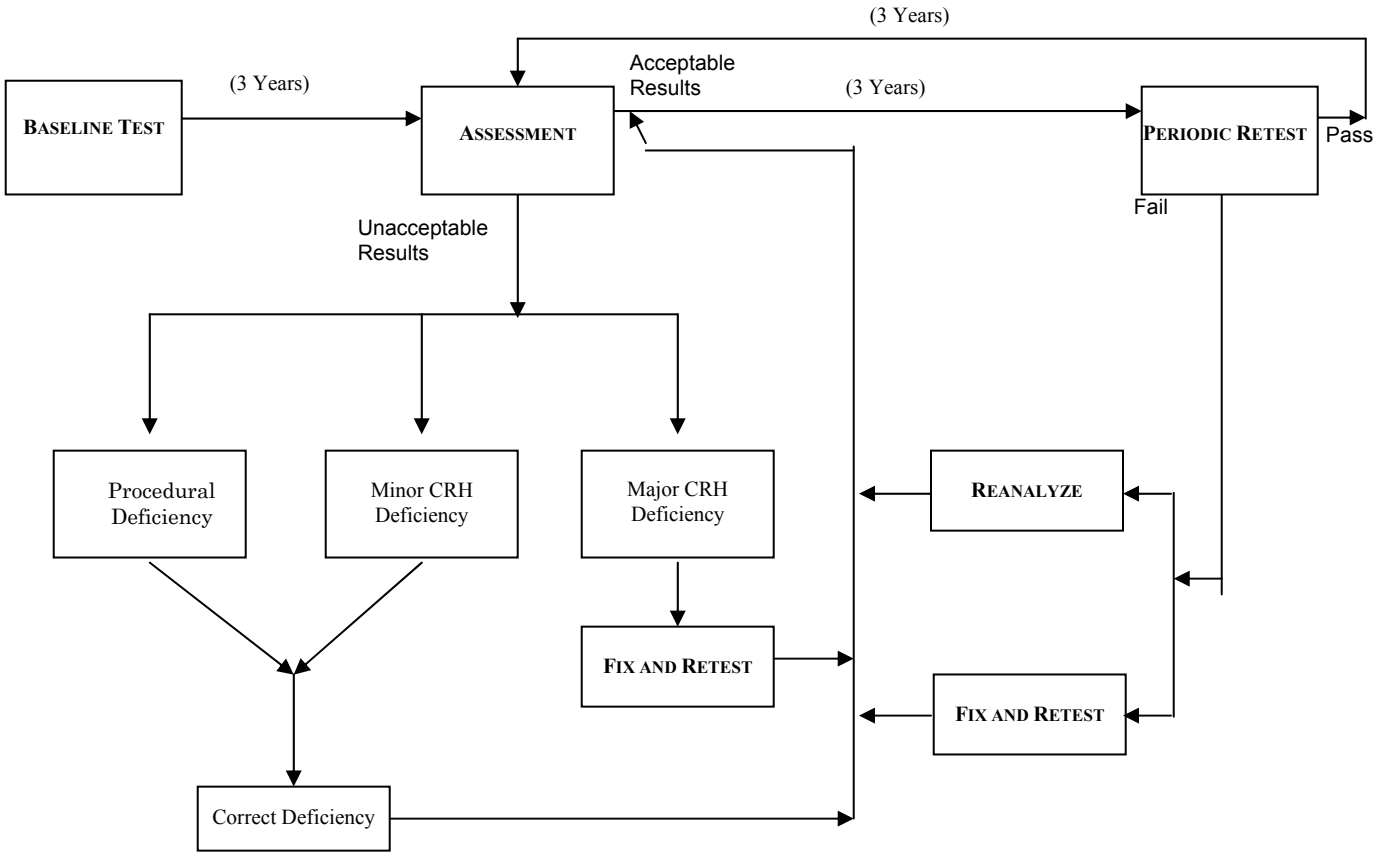
An example of this is periodic maintenance on degradable items (door seals, damper seals, etc.) to ensure that CRE integrity will be maintained. Appendix CC provides additional information in areas where periodic maintenance can be developed.

4.3.5 PERFORMANCE BASED TEST AND ASSESSMENT FREQUENCY

The interval for the reassessment and retest process is specified as shown in Figure 1 as 3 years. After industry and licensees develop an experience base regarding testing and assessment, it may be appropriate for licensees to adjust the period between assessments and tests. After completing periodic testing, a licensee may elect to justify increasing the intervals between future assessments or tests based on satisfactory test performance. If testing or assessments experience is unsatisfactory, a licensee should consider decreasing the intervals between future assessments or tests based on test performance as part of the Corrective Action Program response.

Figure 1

CRH Program



4.4 PERIODIC CRH ASSESSMENTS AND INLEAKAGE RETEST

4.4.1 PERIODIC CRH ASSESSMENT

A periodic assessment is performed to assure that modifications to the plant maintain the CRH licensing and design bases. Performance of a CRH assessment involves assessing configuration controls, performing walkdowns, and reviewing operating and maintenance procedures. It is intended that this assessment will be performed by a team of individuals, with industry peer participation, as appropriate.

The assessment plan should include a review of the administrative controls addressed in Section 4.3.4. Use the following guidance when developing the assessment plan:

a) **CRE Boundary Control -** Review CRE boundary controls to ensure that CRE boundary breaches have been controlled since the previous assessment (see Appendix E for guidance).
b) **Procedure Control** - Review applicable procedure revisions to ensure that CRH issues were considered when revising procedures since the previous assessment.
c) **Toxic Chemical Control -** Review toxic chemical controls to ensure that new chemicals brought on-site were reviewed and were considered for impact of a potential release on CRH. Offsite sources of toxic chemicals should be reviewed in the periodic assessments.
d) **Design Change Control -** Review design change controls to ensure that CRH issues were considered when issuing design changes since the previous assessment.
e) **Safety Analysis Control** - Review safety analysis controls to ensure that CRH issues were considered when safety analyses were revised or issued as part of a design change (either temporary or permanent) since the previous assessment.
f) **Maintenance Control** - Review maintenance controls to ensure that CRH issues were considered during the performance of applicable maintenance since the previous assessment. Review maintenance controls to ensure that required periodic maintenance of the control room boundary was performed since the previous assessment.

Walkdown the control room boundary to assure that it is in accordance with plant drawings (see Appendix C for guidance). Review test performance results on the appropriate control room systems to ensure system performance has not degraded since the previous test/assessment. Additional areas that can be included in the assessment are:

- Confirmation of differential pressure margin for pressurized control rooms between the CRE and adjacent spaces. If the differential pressure margin has changed since the last test, further assessment is required. Corrective actions may be required.
- Examination of industry operating experience to confirm that industry problems have been addressed.

Ensure that findings and areas for improvement that result from the assessment are entered, as appropriate, into the plant corrective action program. Guidance is provided on the direction of required corrective actions in section 4.3.1.

4.4.2 PERIODIC CRE INLEAKAGE RETEST

A periodic retest is performed using methods per Appendix D.

5 TRAINING

Perform a training needs analysis to assess if operations, maintenance and engineering personnel understand the bases for the CRE integrity program as well as issues that influence control room habitability. If a training need is identified, perform the appropriate training. The information contained in this document along with plant specific information provides a good basis to develop any needed training modules.

6 REFERENCES

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3. USNRC, "A Prioritization of Generic Safety Issues," NUREG 0933, U.S. Nuclear Regulatory Commission, June 2000.

4. USNRC, "Assumptions for Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release," Regulatory Guide 1.78, U.S. Nuclear Regulatory Commission, June 1974.

5. USNRC, "Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release," Regulatory Guide 1.78, Revision 1, U.S. Nuclear Regulatory Commission, December 2001.

6. USNRC, "Protection of Nuclear Power Plant Control Room Operators Against an Accidental Chlorine Release," Regulatory Guide 1.95, U.S. Nuclear Regulatory Commission, January 1977.

7. 10 CFR 50, "Domestic Licensing of Production and Utilization Facilities," Part 50, Code of Federal Regulations, Office of the Federal Register, National Archives and Records Administration.

8. NEI, "Guidelines for Managing NRC Commitment Changes," NEI 99-04, Revision 0, Nuclear Energy Institute, 1999.

9. USNRC, "Information to Licensees Regarding NRC Inspection Manual Section on Resolution of Degraded and Nonconforming Conditions," Generic Letter 91-18, U.S. Nuclear Regulatory Commission, 1991.

10. USNRC, "Resolution of Degraded and Nonconforming Conditions," Inspection Manual, Part 9900, U.S. Nuclear Regulatory Commission.

11. J.J. DiNunno et al., "Calculation of Distance Factors for Power and Test Reactor Sites," USAEC TID-14844, U.S. Atomic Energy Commission (now USNRC), 1962.

12. USNRC, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Boiling Water Reactors," Regulatory Guide 1.3, Revision 2, U.S. Nuclear Regulatory Commission, June 1974.

13. USNRC, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Pressurized Water Reactors," Regulatory Guide 1.4, Revision 2, U.S. Nuclear Regulatory Commission, June 1974.

14. 10 CFR 100, "Reactor Site Criteria," Part 100, Code of Federal Regulations, Office of the Federal Register, National Archives and Records Administration.

15. USNRC, "Alternative Radiological Source Terms For Evaluating Design Basis Accidents at Nuclear Power Reactors," Regulatory Guide 1.183, Revision 0, U.S. Nuclear Regulatory Commission, July 2000.

16. NEI, "Guidelines for 10 CFR 50.59 Implementation," NEI 96-07, Nuclear Energy Institute, November 2000.

APPENDIX A

SMOKE EVALUATION

1. PURPOSE/SCOPE

This appendix provides a qualitative assessment tool for managing the issue of smoke present in the control room. The guidance ensures that the operator maintains an ability to safely shut down the plant during a smoke event originating inside or outside the control room.

2. ASSESSMENT

Perform an assessment to assure that the operator has the capability to safely shut down the plant from either the control room or the alternate shutdown locations during a single credible smoke event originating either inside or outside of the control room. A design basis event does not need to be assumed simultaneous with the smoke event. Consider the following items:

- Verify that the alternate shutdown panels or controls and the control room are adequately separated by distance or appropriate barriers, such that a single credible smoke event in one area could not adversely affect the habitability of the other.
- Verify that a credible smoke event does not exist that could affect control room habitability while simultaneously blocking the normal egress path to the alternate shutdown panels or controls. Otherwise, verify that an alternate egress path exists and that it is addressed in plant procedures. Although desirable, this guidance does not require that the alternate route be equipped with emergency lighting to specifically cover this scenario.
- Verify that sufficient procedural guidance exists to mitigate credible smoke events. Smoke response procedures should contain provisions to manually align ventilation systems to exhaust smoke away from the control room and alternate shutdown panel when practical.
- Verify that a sufficient number of control room operators per shift are qualified in the use of self-contained breathing apparatus (SCBA) to safely shut-down the plant if SCBAs are credited for success.
- Verify that the appropriate SCBA and smoke removal equipment are available and properly staged if credited for success.
- Verify that initial and continuing training is performed to ensure familiarity with the success paths credited in a licensee's response to smoke events.

3. SUCCESS PATH LOGIC

The steps below outline possible success paths to ensure safe shutdown capability is maintained during a smoke event. These paths should provide confidence that a smoke event can be mitigated.

- Should an excessive amount of smoke infiltrate the control room envelope, the operators may isolate the ventilation system if the outside air intake is the primary entry point of the smoke. Efforts should then be taken to clear the smoke using either an installed smoke removal system or portable blowers. A short-term limited use of SCBAs may be expected in this situation. The ability to clear the smoke in a reasonable period would be considered a success path.
- If smoke removal is not a success path in the short term, then assess if the smoke would have a detrimental effect on the operator's ability to control the plant. Consideration should be given to evacuate to the alternate shutdown panel(s) or controls. This decision would be based on the severity of the situation and the availability of a safe egress path to the alternate shutdown panel(s).
- If the alternate shutdown panel(s) or controls are also contaminated with smoke, it may be advantageous to remain in the control room using SCBAs until smoke can be cleared from one of the locations.
- If the decision is made to evacuate the control room, choose a primary or an alternate path to the alternate shutdown panels or controls that are least affected by the event. It may be necessary to use SCBA while transiting to the alternate shutdown panels or controls.
- If the assessment determines that a potential situation exists where a success path is not assured, the condition should be entered into the plant's corrective action process for appropriate resolution.

APPENDIX B

COMPENSATORY MEASURES ALLOWABLE ON AN INTERIM BASIS

1. PURPOSE/SCOPE

Licensees may need to implement compensatory measures as part of the plant's corrective action program. This appendix identifies two actions that may be considered for use as compensatory measures in the event of unacceptable radiological dose consequences. These actions are the use of self-contained breathing apparatus (SCBA) and the use of potassium iodide (KI) tablets. Other plant specific compensatory actions may be appropriate. The use of any compensatory measure will require a plant specific evaluation to justify its use.

The use of SCBA and KI has been determined to be acceptable for addressing unacceptable radiological release consequences in the interim situation until the licensee remediates the control room envelope integrity issue. However, use of SCBA or KI in the mitigation of situations where inleakage does not meet design basis limits is not acceptable as a permanent solution. 10 CFR 20.1701 states that engineering/process controls shall be used to the extent practical. If not practical, then 10 CFR 20.1702 methods should be used. Therefore, the use of SCBAs should be a last resort. The length of time for which credit is allowable should be determined on a case-by-case basis. If credit is currently part of the licensing basis, special considerations may be necessary.

The use of SCBA to mitigate adverse toxic gas release consequences is allowed by Regulatory Guide 1.78, Revisions 0 and 1 and Regulatory Guide 1.95. The approved use of SCBA under these circumstances is not considered a compensatory measure. In addition, plant modifications such as the installation of local toxic gas monitors should be considered in the event of unacceptable toxic gas release consequences. Additional guidance is provided in Regulatory Guide 1.78.

2. SELF CONTAINED BREATHING APPARATUS

Credit for the use of SCBAs as a compensatory measure is allowed provided an approved respiratory protection program is in effect. Per 10 CFR Part 20, Subpart H and Appendix A, an approved respiratory protection program utilizing SCBAs can allow for an inhalation dose protection factor values between 100 to 10,000. In addition to the requirements of 10 CFR 20 Subpart H, the following are key considerations for crediting SCBA use in support of control room habitability assessments.

2.1 Approved Respiratory Protection Program

2.1.1. An approved respiratory protection program in accordance with 10 CFR Part 20, Appendix C, Regulatory Guide 8.15, Rev. 1, *Acceptable Programs for Respiratory Protection* and NUREG-0041, Rev. 1, *Manual of Respiration, Protection Against Airborne Radioactive Materials* is established and in place.

- Maintaining an adequate respiratory protection program is vital to workers' safety and, thus, to their ability to respond in a timely fashion to emergencies.
- Plant operators and emergency response workers can face not only radiological airborne hazards, but, in many cases, are challenged by unknown and potentially immediately dangerous to life and health (IDLH) conditions. Therefore, non-radiological hazards should also be considered.

2.1.2. Plans for dealing with emergencies should include consideration of:

- Postulated duration of SCBA use
- Quantities and kinds of materials against which protection must be provided
- Physical characteristics of the hazardous area
- Access requirements
- Numbers of people and technical skills needed
- Amounts, types and locations of equipment necessary
- Need for and availability of backup/replacement supplies for use in emergencies
- Enhancement of communications
- Capability of control room facilities to accommodate operators working with SCBA
- Visual impairment

2.2 Training and Qualify Sufficient Operators for SCBA Use

The licensee should ensure there will always be sufficient numbers of control room operators on shift that are qualified for SCBA use.

Since SCBA use is expected to be infrequent, there should be adequate periodic, hands-on training and practice with donning and wearing SCBA including communication techniques and vision impairment during SCBA use.

If SCBA units will be used as an interim compensatory measure for greater than 180 days while the plant is in Operating Condition or Mode 1, then simulator crew training accident scenarios should be run in which operators don and wear SCBAs. These scenarios should represent design basis accident response actions, include a bottle changeout, and simulate a watch turnover.

Additionally, operators should be trained and practiced to change out air cylinders and know where spare charged air cylinders are stored for emergency use.

Effective program oversight and controls should be in place for tracking and maintaining operators' required periodic retraining and SCBA fit testing.

2.3 Adequate Supplies of Equipment

Sufficient dedicated, surveyed, and inventoried equipment with various size face pieces should be available for use by control room operators at all times.

A sufficient number of support personnel should be assigned to transport and replenish supplies for the duration of the need for SCBA.

2.4 Corrective Lenses for SCBA Users

In accordance with 10 CFR Part 20.1702(e), all those requiring vision correction should use contact lenses or approved spectacle adapters.

A lack of required vision correction could hamper the control room operator's performance of licensed duties, including timely and effective response to emergencies.

Corrective lenses with temple bars interfering with the sealing surface of any respirator facepiece shall not be worn while using such equipment.

Semi-permeable prescription contact lenses may be worn if their use has been satisfactorily demonstrated.

Hard contact lenses should not be worn with full-facepiece respirators. Hard contact lenses present a distinct hazard to the individual due to the possibility of the lenses slipping because of pressure on the outside corners of the eye from a full face mask or a speck of dirt getting under them while the respirator is being worn.

2.5 Respirator Fit

Persons using tight fitting (facepiece) respirators should not have any facial features that interfere with the sealing surfaces of the respirator. The required minimum staffing of Control Room Operators qualified in SCBA use should be clean-shaven.

2.6 Method(s) to Refill SCBA Air Cylinders

This includes proper location of air compressor intakes (e.g., not down-wind from release points).

When a compressor is used, it should be properly monitored and attended to ensure that the air intake remains in an uncontaminated atmosphere.

The impact of loss of offsite power should be factored into the refill methods available.

2.7 Relief From Respirator

Provisions should be considered for operators wearing SCBA to leave the area if necessary.

2.8 Monitoring Program

An appropriate air sampling program should be implemented to monitor control room airborne radioactivity levels to determine individual exposure levels based on stay times, protection factors and respirator usage.

Protection factors apply only in a respiratory protection program that meets the requirements of 10 CFR Part 20.

- These protection factors are applicable to radiological, oxygen deficiency, toxic gas and smoke hazards and may not be appropriate for hazards that involve skin adsorption.
- Prompt emergency response does not lend itself to pre-work assessment of airborne hazards. In emergency situations, for example, it is illogical to take a "no-protection" assumption for entry into Immediately Dangerous to Life and Health (IDLH) areas of unknown hazards.

3. POTASSIUM IODIDE

Certain forms of iodine help the thyroid gland work correctly. Most people consume the iodine their thyroid needs from foods such as iodized salt and fish. However, the thyroid can hold or store only a certain amount of iodine. In the event of a nuclear accident involving the release of large amounts of radioiodines, significant uptake of radioiodines by the thyroid could occur from inhalation and ingestion. The basis for using KI to limit thyroid dose is that administration of stable iodide as a prophylaxis can prevent thyroidal uptake of radioiodines, and thus reduce post-accident radiation dose to the thyroid.

KI is an effective thyroid blocking agent when administered immediately before or after an exposure to radioactive iodine (that is, within one to two hours). If KI is administered more than four hours after an acute inhalation or ingestion of radioiodine, then its effectiveness as thyroid blocking agent is substantially reduced. The prompt administration of KI in the event of a nuclear accident is critical to its effectiveness as a protective measure. Credit may be taken for a factor of 10 reduction in thyroid dose due to the administration of KI. Plant procedures should be in place to ensure KI can be administered to control room operators (and to oncoming shifts) soon after the start of an event where radioiodine has been released or could be released.

3.1 Considerations for Crediting KI

Although KI is a non-prescription medication, the licensee's internal policies on administering medications to employees should be reviewed and followed as required.

Personnel who are candidates for receiving KI must be screened for possible allergic reactions to iodine. Shift personnel who are allergic to KI may need to be temporarily reassigned, or provisions made for relieving them from duty in the event of a radioiodine release.

Personnel who are identified as candidates to receive KI after an accident must be on an approved list. The approved list should be readily accessible so that prompt administration can be performed.

It is not mandatory for control room operators to take KI as a protective measure. Those who choose not to take KI should evacuate the control room and be replaced by another qualified operator.

Adequate supplies of KI must be available in the control room for control room operators. Provisions must be made for storing KI tablets properly, and for periodic replacement prior to the shelf life being exceeded. Adequate supplies should also be available to administer KI to relief personnel.

Plant procedures should be in place to direct administration of KI to control room personnel within two hours of a radioiodine release. Procedures should also be in place to administer KI to on-coming shifts as necessary if radioiodine releases continue.

Controls should be in place to determine if follow-up administration of KI is required. The decision to have follow-up administration of KI should be done in consultation with the licensee's company medical representative and the plant's emergency response organization.

4. REFERENCES AND SUPPORTING INFORMATION

1. USNRC, "Task III.D.3: Worker Radiation Protection Improvement (Revision 3), TMI Action Item III.D.3.2 (4), Develop Air Purifying Respirator Radioiodine Cartridge Testing and Certification Criteria," *Clarification of TMI Action Item Requirements*, NUREG-0737, U.S. Nuclear Regulatory Commission, 1980.
2. 10 CFR 20, "Respiratory Protection and Controls to Restrict Internal Exposures," Part 20 (RIN 3150-AF81), Code of Federal Regulations, Office of the Federal Register, National Archives and Records Administration.
3. 10 CFR 20, Appendix A, "Assigned Protection Factors (APF) for Respirators," Part 20, Appendix A, Code of Federal Regulations, Office of the Federal Register, National Archives and Records Administration.

4. USNRC, "Problems With Emergency Preparedness Respiratory Protection Programs," NRC Information Notice 98-20, U.S. Nuclear Regulatory Commission, June 3, 1998.
5. USNRC, "Acceptable Programs For Respiratory Protection," Regulatory Guide 8.15, U.S. Nuclear Regulatory Commission, October 1976.
6. USNRC, "Manual of Respiratory Protection Against Airborne Radioactive Materials," NUREG-0041, U.S. Nuclear Regulatory Commission, October 1976.
7. USNRC, "Inadvertent Discharge Of Carbon Dioxide Fire Protection System And Gas Migration," NRC Information Notice 99-05, U.S. Nuclear Regulatory Commission, March 8, 1999.
8. USNRC, "Guidance Concerning 10 CFR 20.103 and Use of Pressure Demand SCBA's," HPPOS-094, U.S. Nuclear Regulatory Commission, 1991.
9. USNRC, "OSHA Interpretation: Beards and Tight-Fitting Respirators," HPPOS-116, U.S. Nuclear Regulatory Commission, 1991.
10. David C. Aldrich and Roger M. Blond, "Examination of the Use of Potassium Iodide (KI) as an Emergency Protective Measure for Nuclear Reactor Accidents," NUREG/CR-1433, U.S. Nuclear Regulatory Commission, 1980.
11. H. Behling, K. Behling and H. Amarasooriya, "An Analysis of Potassium Iodide (KI) Prophylaxis for the General Public in the Event of a Nuclear Accident," NUREG/CR-6310, U.S. Nuclear Regulatory Commission, 1995.
12. NCRP, "Protection of the Thyroid Gland in the Event of Releases of Radioiodine," NCRP Report No. 55, National Council on Radiation Protection and Measurements, August 1, 1977.

APPENDIX C

SYSTEM ASSESSMENT

1. PURPOSE

This appendix provides guidance on performing walkdowns and inspections of the control room envelope and associated ventilation systems to identify potential vulnerabilities to inleakage.

2. SCOPE

This system assessment should not be confused with the CRE integrity assessment discussed in Section 4.4. This system assessment is a prerequisite for baseline testing.

This appendix provides the direction for:

- Identifying potential vulnerabilities to inleakage into the control room envelope,
- Determining whether the system is configured and will align in a manner consistent with its licensing basis,
- Identifying areas where maintenance activities should be directed,
- Determining whether the control room envelope (CRE) and adjacent area ventilation systems are performing in a manner consistent with their licensing and design bases.

This appendix does not provide guidance for minimizing inleakage vulnerabilities. Informational Appendix CC provides additional supporting information for minimizing vulnerabilities and sealing once the inleakage source is identified.

3. ASSESSMENT METHODOLOGY

3.1 Boundary

This section ensures the user has a good understanding of the boundaries for the control room envelope (CRE) and the ventilation system(s) by performing the following process:

3.1.1 Obtain copies of the drawings (e.g., flow, physical, general arrangement, etc.) that show the CRE and surrounding areas, the CR HVAC system(s), and ventilation systems that traverse the control room envelope boundary.

3.1.2 Highlight the following on the drawings. This may require more than one set of drawings if the system response is different for different types of events:

- Boundaries of the CRE,
- Boundaries of the ventilation system(s) that serve the CRE,
- Portions of the ventilation system(s) that are physically located outside the boundary or perform a boundary isolation function (e.g., dampers). This should include system alignments for response to both radiological and toxic gas events, and
- Non-ventilation system(s) that traverse the CRE boundary. Highlight and label on the drawings the routing of other ventilation systems that traverse the envelope.

3.2 Operating Configurations

Control room inleakage must be measured under conditions that support the licensee's accident analysis. If identical alignments cannot be met, justification must be given which ensures the results are conservative. The information identified in this section will be used in section 5.2 of Appendix D to establish test alignments.

3.2.1 Operating Parameters

Establish the design performance parameters for the ventilation systems for the different challenges (radiological, toxic gas). These parameters include but are not limited to differential pressures, makeup and recirculation flow rates, duct static pressures and filter differential pressures.

The purpose of this activity is to identify portions of the CRE that are at lower pressure than the surrounding areas. Identify ductwork of non-CR HVAC systems that traverse the envelope and are at a higher pressure than the envelope. If this was done earlier as part of the design bases review for other sections of this document, simply refer to that work.

3.2.2 Consider the Challenges

Consider all accident configurations of the CR HVAC and of the ventilation systems in adjacent areas during review of the pressures in the envelope and adjacent areas. Particular attention should be paid to the automatic and/or manual responses of the systems to different challenges (examples: LOCA, FHA, MSLB, SGTR, and Toxic Gas). For example:

- A control room envelope could be pressurized during a radiological event and not pressurized during a toxic gas event.
- Operator actions taken per operating procedures during post-accident mitigation to realign ventilation systems can result in system alignments different than configurations due to automatic starting signals.

- The response of ventilation systems in adjacent areas can be different for a safety injection (SI) event versus a control room high radiation event (non-SI event).

3.2.3 LOOP versus a Non-LOOP Event

Evaluate operating alignments in a manner that maximizes the dose to CR operator.

For example:

Ventilation system alignments serving the CRE and serving adjacent areas should consider the most limiting configurations. Consistent with the licensing basis for the facility, the user may consider a loss of off-site power (LOOP) coincident with the event. A LOOP is typically assumed to occur concurrent with an accident, but not with a toxic gas release.

It is recognized that assuming a LOOP coincident with the event may not provide the limiting condition for control room inleakage. For example, ventilation systems in adjacent spaces may continue to operate during a non-LOOP situation and result in a less favorable differential pressure condition across the control room boundary. If the assumption of a LOOP results in the envelope being positive to all adjacent spaces, it may be more conservative to assume a non-LOOP event. This would need to be examined within the overall accident response.

3.2.4 Single Active Failure

Consider single active failures consistent with the licensing basis for the facility.

Note: Cases may exist where assuming all trains function as designed (i.e., no single failure occurs) could be more limiting from an inleakage perspective. For example:

- For a neutral pressure control room, running both trains can result in an increased number of rooms within the control room envelope that have negative pressure relative to the adjacent areas.

- For a positive pressure control room, running both pressurization systems can result in increased unfiltered inleakage if the fans are located outside the envelope.

3.2.5 Seasonal or Daily Changes

Consider alignments that may vary due to seasonal variation. The alignment of ventilation systems and the corresponding pressures in the adjacent compartments (from those alignments) can be affected by the time of year or the time of day. During different seasons or different times of the day, the ventilation systems serving these areas may be operated in different configurations depending on such things as outside air temperature. For example a PWR turbine building ventilation system adjacent to

the CRE may be at a negative pressure with respect to the CRE for summer; but positive for winter operation.

3.3 Walkdown Performance

Perform a walkdown to determine potential leak locations. There are several methods available and some of these are described below. These methods do not provide quantitative methods for determining inleakage; but only aid the user in determining potential inleakage locations.

The walkdown should:

- Confirm that all components are constructed in accordance with the design
- Confirm that all components can be configured in their accident modes
- Verify that the normally indicated system parameters in the various operating configurations are consistent with the design and licensing parameters
- Verify the proper operation of ventilation systems adjacent to the control room boundary for the various challenges.

Section 3.4, provides detailed discussion of the types of items to consider during these inspection activities.

3.3.1 Visual Examination

Perform a visual examination that consists of a thorough walkdown of both the inside and the outside of the envelope boundary, where accessible, to determine the physical condition and identify any unwanted openings. This is important because numerous small openings can yield relatively high leakage rates. Specific areas to be visually inspected are identified in Section 3.4.

Tools such as smoke pencils can be helpful to determine if leakage exists. Smoke pencils should be used deliberately to distinguish between a leak and random air currents. ASTM E-1186 provides additional information on how to use smoke pencils.

Out-leakage may affect the ability of a positive pressure system to sufficiently pressurize the envelope. Out-leakage requires additional makeup air to maintain the positive pressure; even though this air is usually filtered, it still affects radiological and toxic gas assessments. Outleakage is also important for a neutral pressure control room since the outleakaget must be compensated by inleakage.

Easily accessible and large inleakage sources are most likely to be identified via walkdown.

3.4. Specific Inspection Areas

Determine specific inspection areas for identification of vulnerabilities. Table C-1 provides a list of items to consider when evaluating potential vulnerabilities to control room inleakage. Consider both unfiltered and filtered inleakage vulnerabilities. The items in the table are applicable to several different potential system and envelope configurations, but not all of these may be applicable to any given plant. Table C-1 is not to be considered an all-inclusive list but only as guidance for the types of potential vulnerabilities. It may be helpful to list the vulnerabilities by type (e.g., doors, dampers, structural joints, etc.) and rank them in order of importance or suspected leakage.

The following subparagraphs provide additional insight of the actions that plant personnel should consider when performing the Section 3 walkdowns and assessments described in Table C-1.

3.4.1 CR HVAC

For portions of ventilation systems located outside the control room envelope:

- CR ventilation systems that are located outside the control room envelope can experience inleakage if portions of these systems (e.g., return ducting) are at a negative pressure relative to the area(s) they pass through.
- Some ventilation ducting (commercial, pocket lock, non-seal welded, non-bolted connections, etc.) can be a source of potential leakage locations. Insulated ductwork can be difficult to inspect but can be a leakage source. If the ducting is a potential leakage source, the insulation may need to be removed to facilitate inspection.
- Air Handling Unit (AHU) housings can be a source of inleakage if they are not welded or their integrity is compromised. For example, the underside of the housing can be a location of corrosion due to moisture accumulation.
- AHU electrical and instrumentation penetrations can be a source of unfiltered inleakage.
- AHU and ventilation system doors, hatches, etc., can be a source of unfiltered inleakage. Inspect such items as latches, sealing surfaces, seal compression, etc.
- Fan shafts can be a source of inleakage if not sealed. This is due to the negative pressure at the fan shaft location.
- Loop seals and drains can be a source of inleakage.

For portions of ventilation systems located inside the control room envelope:

- Portions of pressurization ductwork upstream of the filter and within the control room envelope can be a potential source of inleakage. This portion of the system may operate at a higher pressure than the pressure in the envelope.
- Ducting that is isolated can be a source of unfiltered inleakage if the isolation dampers are not leak tight. Typically this is a concern if the ductwork interfaces with the suction side of a fan (recirculation, AHU, etc.).

3.4.2 Other Ventilation System Ducting within the CRE

Ducting associated with other ventilation systems may be routed through the control room envelope. These can be a source of inleakage if the system(s) operate at a higher pressure than the pressure within the envelope. Control room pressure (or in some cases no pressure – example: isolation only for a toxic gas event) can influence the leakage from this ducting such that the lower the control room pressure, the more the duct leaks. As an alternative to duct sealing or replacement, it is acceptable to change the operating mode of the subject ventilation system or secure it to ensure that it operates with a lower pressure than the envelope pressure. Isolating the ducting during post-accident mitigation does not exclude it from being a source of inleakage because damper leakage in isolated ductwork may provide a potential source of inleakage.

Ventilation ducting (commercial, pocket lock, non-seal welded, non-bolted connections, etc.) can be a potential leakage location. Seal welded ductwork should be visually inspected to ensure the integrity of the welds. Insulation may need to be removed from the ductwork to facilitate inspection to locate leaks.

3.4.3 CRE Boundary Penetrations

- Penetrations such as cables and conduits, small pipes, etc., can be a potential source of inleakage. To the extent practical, both the inside of the conduit and the conduit/wall penetration should be inspected to determine that seals are present and functional.
- Other items such as concrete anchors through block walls, if not sealed, can be a leakage source at the interface.
- Ventilation equipment drains, system drains, floor drains, etc., commonly penetrate the envelope boundary. To prevent leakage through these lines, check valves or loop seals should be installed. If used, verify that the check valve design is appropriate for this application and the loop seals are maintained to keep them filled.

3.4.4 Doors in Control Room Envelope Boundary

Door seals can be a potential significant source of inleakage. Experience has indicated that the door-to-door frame (sides and top of door) and the floor (bottom of door) can

be significant leak locations. The inspection should ensure not only the integrity of the seals but verify that the door is properly compressing the seals.

3.4.5 Ventilation System Isolation Dampers

CR HVAC isolation dampers that close to ensure the integrity of the system and the envelope during an event can be potential sources of inleakage if they do not seal properly or have degraded seals.

Leakage can also occur through damper shafts or other associated sub-components that penetrate the ducting pressure boundary.

3.4.6 Other Non-HVAC Systems in the Envelope

Instrument air and/or service air systems can enter the envelope to provide air for damper controls, breathing air, etc. The compressors for these systems may be located outside the envelope and provide a means of unfiltered inleakage if the components inside the envelope leak, or venting of air is part of the component operation.

Radiation monitors outside the envelope that draw samples from inside the control room envelope can be a source of inleakage if the sample lines leak.

3.4.7 General Boundary Construction

Certain construction configurations or deficiencies are more susceptible to inleakage. For example, porous (non-filled) block walls can leak, where poured intact concrete walls should not leak significantly. Deficiencies such as cracks or inadequate sealing materials can be locations for inleakage. Deficient expansion joints can be a source of leakage.

Areas that have been overlooked are those that are not readily visible; e.g., above dropped ceilings, below raised floors, against walls behind panels, etc. These should be inspected to the extent practical. In some cases, it may be possible to verify the boundary by looking at the other side.

3.4.8 System Flow Measurements

Airflow rates should be measured to ensure that the system flow rates are as expected for the various configurations. This document does not provide guidance on determining system flow rates. These measurements must be obtained from test results and compared with applicable limits to ensure that control room HVAC and interfacing systems are operating as designed. Ensure the tests were performed within an appropriate time frame and represent current system parameters.

A determination should be made to ensure that the filter flow requirements in the emergency mode are not invalidated by inleakage. An example of this is a condition where a flow instrument is located upstream of the filter housing and recirculation fan and shaft inleakage exists.

Significant discrepancies in air flow rates (i.e., the sum of the individual flow rates do not equal the whole) need to be evaluated. These types of conditions indicate the possibility for leakage and unwanted airflow. Differences may also be due to the uncertainty of the measurements.

4. Documentation

Document the control room boundary, the modes of operation, and the walkdown results including any inleakage vulnerabilities (list vulnerabilities identified).

Document areas lacking seals and/or requiring refurbishment of seals.

This information is to be used in performing testing per Appendix D.

Document any deficiencies identified during the assessment in the licensee's corrective action program.

Table C-1 DETERMINATION OF VULNERABILITY SUSCEPTIBILITY	
System / Component[2]	**Determining Inleakage Vulnerability**
CRHVAC Operation (Section 3.2)	Determine the operating parameters and alignments of the systems
CRHVAC Integrity (Section 3.4.1)	Determine if control room ducting and/or HVAC equipment located outside the envelope is at a negative pressure with respect to adjacent areas. This is applicable to both operating and non-operating equipment. If this condition exists then inleakage is possible. The following vulnerabilities may then exist: Ductwork including previous repairs with RTV sealant Bellows, flanged and flexible joints Equipment housings System penetrations such as chiller lines, electrical and instrumentation Accesses such as doors or hatches Fan shaft (AHU, Recirculation fan, etc). Determine if portions of the pressurization ducting inside the envelope between the envelope boundary and the filter are operated at a higher pressure than the envelope pressure (for portions of the ductwork located inside the envelope). Determine if AHU fans have the potential to draw air from isolated ducting lines (i.e., damper leakage) that penetrate the envelope boundary.

2 The Section references shown in this column refer to paragraphs in this appendix.

Table C-1 DETERMINATION OF VULNERABILITY SUSCEPTIBILITY

System / Component[2]	Determining Inleakage Vulnerability
Other Ventilation Systems (Section 3.4.2)	Determine if other system ducting is routed through the envelope when the control room is isolated. If so: • Determine the post-accident pressure in the ducting relative to the pressure in the envelope (consider the effects of this ducting both as a means of in-leakage and out-leakage). • If the ducting is isolated, consider the potential for damper leakage. • Determine the integrity of this ducting. Consider the items identified above under CR HVAC integrity.

Table C-1 DETERMINATION OF VULNERABILITY SUSCEPTIBILITY

System / Component[2]	Determining Inleakage Vulnerability
Penetrations in the Envelope Boundary (Section 3.4.3)	Determine that wall, floor and ceiling penetrations (i.e., conduits, electrical cable trays, etc.) are sealed. Check for voids inside cable bundles that may be covered with cable coating or voids under the cable in the tray. Check for non-leak-tight flexible conduit or armored cables passing through penetration seals. Check seals inside the conduit and between the conduit and the wall. Check conduit connectors, couplings and terminations. Check caps on spare embedded sleeves. Determine that ventilation ducting penetrations and dampers are properly sealed. Check for space around fire damper sleeves. Note that space around fire dampers is necessary to allow damper expansion during a fire for proper damper functioning. Assure that the space is within requirements for expansion such that the fire damper retains if capability to function for a fire. Should the spaces need to be sealed consult fire damper standards (i.e., contact the manufacturer of the damper) to assure damper integrity is retained. Check for concrete anchors or other bolts through block walls that are not sealed. Determine that drains (floor or equipment) have loop seals or check that valves and abandoned drains are sealed. If used, verify that the check valve design is appropriate for this application. Determine if there are other types of penetrations that can provide potential leakage pathways.

Table C-1 DETERMINATION OF VULNERABILITY SUSCEPTIBILITY

System / Component[2]	Determining Inleakage Vulnerability
Envelope Doors (Section 3.4.4)	Determine that there are no defects in the doors. Determine that door seals (including sweeps) are not cracked, are not missing and have proper fit. Determine that doors are properly compressed or fitting against the door seals. Determine that door latches are functioning properly to maintain the door securely closed. Determine that doorframes are properly sealed.
Isolation Dampers (Section 3.4.5)	Determine that control room isolation damper seals are not cracked, are not missing seals and have proper fitting seals. Determine that control room isolation damper linkages are functioning properly to assure compression of the seals against the damper blade(s). Determine that damper shaft penetrations are properly sealed.
Other Non-HVAC Systems in the Envelope (Section 3.4.6)	Determine if there are instruments or service air lines that enter the envelope boundary and could provide potential unfiltered air sources due to leakage or operational venting of air operated components. Consider other equipment operations providing a mechanism for air in-leakage such as radiation monitors that are located outside the envelope and draw a sample from within the envelope.

Table C-1 DETERMINATION OF VULNERABILITY SUSCEPTIBILITY

System / Component[2]	Determining Inleakage Vulnerability
General Boundary Construction (Section 3.4.7)	Determine that the general envelope boundary is in good condition, including: • Block walls – unsealed or unpainted, cracked or missing mortar • Metal deck – joints and ceiling interfaces with walls • Plaster or drywall – unsealed over armor plate • Steel/concrete interfaces – structural steel, doorframes • Concrete – cold joints, expansion joints, seismic gaps • Hidden or abandoned chases or spaces or joints hidden under carpet • Fireproofing - penetrating envelope or covering joints or penetrations

APPENDIX D

TESTING PROGRAM

1. PURPOSE

This appendix provides guidance on preparing for and performing control room envelope (CRE) inleakage tests to demonstrate conformance to the plant licensing and design bases.
The CRE encompasses the control room and other rooms and areas within the confines of the control room boundary. The control room boundary consists of the physical barriers (e.g., ducts, dampers, floors, ceilings, walls, doors) that separate the CRE from other plant areas.

2. SCOPE

This appendix focuses on conducting a test that will quantify inleakage into the control room envelope. The guidance includes the attributes of an acceptable test program, acceptable testing options, preparation for testing, performance of testing, and disposition of test results. This appendix is intended to aid plant personnel in the development of a plant specific procedure for testing.

3. TEST ATTRIBUTES

The attributes of an acceptable test program are:

- The test must be comprehensive.
- Integrated system testing must be conducted with systems and components under conditions that bound their accident configuration lineups.
- Testing must be performed using an industry standard.

The following subparagraphs provide additional guidance on the definition of a acceptable test program.

3.1. COMPREHENSIVE

A test is considered comprehensive if it quantifies all of the inleakage associated with a control room envelope. A comprehensive test program determines the total control room envelope inleakage for each challenge (e.g., toxic gas, radiological) that may be encountered. Some plant designs may be such that the CR HVAC system(s) and associated components function in the same manner regardless of the challenges. In those cases, the results of one test will identify the leakage associated with both challenges.

3.2. CONFIGURED AND OPERATING

Test conditions are to bound the limiting conditions in the design basis.

When possible, perform tests with the envelope, its associated ventilation systems, and adjacent ventilation systems all aligned and functioning the way they would if a radiological or toxic gas event were to occur. Alternatively, individual leakage sites may be tested with the ventilation systems in a non-accident alignment providing the test conditions for the components are representative of the accident condition. For example, damper leakage may be tested in a static condition as long as the ambient temperature and pressure differential test condition bound the accident condition.

3.3. INDUSTRY STANDARD

Perform tests that demonstrate control room envelope integrity using a recognized industry standard. The industry standard must be relevant to the determination of inleakage for the specific application. See Table D-1 for examples.

4. TESTING

This section provides guidance on test prerequisites, choosing the system mode of operation, choosing an appropriate test method, performing the test, and dispositioning the test results.

4.1. PREREQUISITES TO TESTING

a) **Baseline Test only** - Perform an assessment[3] of the control room boundary in accordance with Appendix C of this document.
b) **Baseline Test only** - Determine the areas that need sealing, refurbishment, or repairs, using the information from Appendix C, and perform the necessary work prior to performing the baseline test.
c) Determine acceptance criteria for inleakage. The acceptance criterion is that inleakage which corresponds to the configuration that results in the maximum consequences to the operator. This inleakage value may or may not be the maximum possible inleakage into the CRE (see also Section 4.2 of this appendix).
d) Develop contingency plans to address results that may challenge the operability of the control room ventilation system. Development of contingency plans should include calculations on maximum allowable radiological inleakage, maximum allowable radiological inleakage for operability determinations, and maximum allowable toxic gas inleakage. For operability determinations, it is permissible to use analyses features approved in NRC regulatory guides that are not part of the current licensing basis. The features need to be applicable to the plant. If permanent credit is taken for these features, they will need to become part of the facility's licensing basis using applicable regulatory change processes. Contingency plans may include compensatory measures. (See Appendix B)

[3] An assessment of the control room boundary is essential if inleakage is going to be determined using the Integrated Component Test Method.

e) Align HVAC systems (including adjacent spaces HVAC systems) consistent with the design basis. For individual component leak tests, the conditions across the test boundary must bound the design basis.
f) Consider the impact of other plant activities on the test, and of the test on other plant activities. An example of this is that control room boundary ingress and egress may need to be limited during the test.

Note: Plants that use outside air for pressurizing their control rooms, and have Technical Specifications addressing pressurizing air, will still need to continue to verify that the amount of pressurizing air is within acceptable limits.

4.2. DETERMINE SYSTEM MODE OF OPERATION FOR TESTING

a) Establish the mode of operation (i.e., CRHS alignment) for testing. This must match, to the extent practical, with the aliengment evaluated in the design basis analysis. If it is not possible to establish this alignment, an alternative line up may be used provided that it is conservative and documented.
b) Perform testing, with a sufficient number of different system modes of operation, to verify the adequacy of the system for all design basis events[4]. If the plant can show that one test configuration encompasses all operational configurations (i.e., the mode being tested will yield the highest inleakage value and this value can support all applicable analysis) then multiple tests are not required[5].
c) Document the system modes for testing along with the basis for the system mode tested.

Additional Information: Since some plants have different alignments for radiological and toxic gas challenges, licensees multiple inleakage tests may be required (i.e., one for a toxic gas event and one for a radiological event). The acceptance criteria for each test should correspond to the inleakage that results in the maximum consequence to the Operator for the particular event being tested. Two common modes of operation are pressurization (isolation with pressurization) and isolation (isolation without pressurization). The pressurization mode is generally for protection from radiological events and the isolation mode is generally for protection from toxic gas events. However, this varies among plants and the possible system alignments that need to be tested should be carefully determined by each licensee. For example, if the plant has a toxic gas event that results in a required isolation of the control room, the system should be tested in the isolated mode. Depending on sytem

[4] The conditions that exist in the areas adjacent to the CRE influence the performance of the CRHS. Although systems in adjacent areas might not be expected to operate during an emergency, during a loss of offsite power, or with a single failure, inleakage may be increased if they do operate. Potential interactions between the CRHS and adjacent areas that may increase the transfer of contaminants into the control room should be identified. These interactions may be caused by ventilation systems that supply or exhaust air from areas adjacent to the control room, are located in areas adjacent to the control room, or have ductwork that traverses the control room or areas adjacent to the control room.

[5] For the case of a plant designed for positive pressure to radiation but neutral for toxic gas, leakage through the envelope boundaries in the neutral configuration can be either in or out, depending on the direction of the differential pressure. Therefore, performing two separate tests should be considered for the toxic gas and the radiological control room response.

alignment and function, theinleakage determination could include both the HVAC serving the control room and the HVAC serving adjacent spaces.

4.3. DETERMINE METHOD OF TESTING

Document the type of testing that is to be performed along with the basis for the test chosen. Sections 4.3.1, 4.3.2 and 4.3.3 provide additional information on two acceptable methods of testing plus guidance criteria if the licensee decides to develop an alternative test method. The method of testing selected depends primarily on the best method for accurately measuring inleakage based on the plant's design. The plant may perform an economic evaluation of the different appropriate test methods to determine the optimum choice. The method that provides inleakage results with the least uncertainty is another consideration.

Acceptable standards are listed in Table D-1.

4.3.1. INTEGRATED TRACER GAS TEST METHOD BACKGROUND INFORMATION

This test method is applicable to all control room designs, uses standard ASTM E741[6] as a guide, and will provide the total inleakage value. This test method will not distinguish whether the inleakage is filtered or unfiltered, the inleakage contribution of individual components, or the specific location of the leakage. For pressurized, low-leakage control rooms, the uncertainty in the test can be a significant percentage of the allowable inleakage, due to typical uncertainty in the pressurizing flow measurement. This test method is described in ASTM E741, "Standard Test Method for Determining Air Change in a Single Zone by Means of a Tracer Gas Dilution" determines total inleakage by one of three techniques. They are (1) concentration decay, (2) constant injection and (3) constant concentration. Depending upon the technique, this involves the measurement of makeup flow to the control room envelope, the concentration of the tracer gas in the control room envelope, and the injection rate of the tracer gas.

The concentration decay method has generally proven the most effective method for the system mode that relies on isolation without pressurized makeup air. The constant injection technique has generally proven the most effective method for the system mode that relies on pressurized makeup air. This test method uses the measurement of tracer gas dilution to determine the air change within the CRE. The measurement of the concentration, and sometimes the volume rate of the tracer gas that is injected into the CRE, allows calculation of the volume rate of outgoing air from the CRE. The inleakage can be inferred from these measurements. A combination of these test methods may be applied to test a given control room configuration.

ASTM E741 provides a description of the limitations associated with the tracer gas test and identifies the knowledge and expertise requirements of individuals using the test method. Consider also when performing a tracer gas test that:

[6] Vendors have traditionally taken exceptions to the standard. Section 5.3.1.1 provides exceptions to ASTM E741 that may be used when using the Integrated Tracer Gas test methodology.

- This test is dependent upon ensuring uniform tracer gas concentration throughout entire control room volume and upon appropriate sampling techniques.
- Multizone buildings are difficult to treat as single zones and meet the uniformity of tracer gas concentration required for this test method. A zone is defined by the air handling system serving it. Redundant air handlers serving the same area can still be treated as one zone.
- Opening normally closed doors, removing ceiling tiles, and using portable fans to assist mixing can affect operating ventilation systems and CRE leakage characteristics. Accurately quantifying these effects is difficult.
- Proper selection of the best measuring points for tracer gas test and injection points for tracer gas prior to test initiation is important to the success of this test method.
- Determination of the net volume of the control room envelope may also be important. This volume enters into the calculations of inleakage for the concentration decay test method. The more accurate the value, the more accurate the results of the tracer gas test.
- Effects of the environment on the test results should be considered. Performing the test to minimize environmental influence is recommended. The test instruction should contain guidance on environmental effects. For example, the test should not be performed if there is a strong consistent wind (>15 mph) and the control room envelope is significantly exposed to the outside environment. The lower the wind speed, the more accurate the test results. Because of test complexity, plants typically require outside expertise to perform this test.

4.3.1.1. TYPICAL EXCEPTIONS TO IMPLEMENTATION OF ASTM E-741

Vendors performing Integrated Control Room tracer gas testing using procedures based on ASTM E741 have traditionally taken exceptions to ASTM E741, and therefore based on existing practices exceptions to the 2000 edition may be taken .

These paragraphs of ASTM E741-2000 may be totally excluded from implementation: 6.6.1, 6.6.2, 6.7, 6.7.1, 6.7.2, 8.5.4, 9.5.3, 9.5.4, 11.1.1, 12.3.2, 12.3.2.2, 13.2.1.2, 13.2.2, 13.4.2. Other editions are acceptable and may require similar exceptions.

The following exceptions may also be taken:

- Use the Sections 1 through 5 only to define the test method and the equipment to be used.
- Section 8.5.3.1: A decay test using the regression method may be used to obtain confidence intervals as a part of the regression calculation,
- Section 9.2.1: The standard is not typically used when there is a non-steady flow since such a test would only permit establishing bounds on the inleakage.
- Sections 9.2.3.1, 9.2.3.2, 9.2.3.3, 9.2.3.4 are not typically used, since makeup flow rate is typically used to estimate the anticipated concentration for an assumed tracer gas injection flow rate.

- Section 9.4.2 is not followed since a statistically significant number of samples are usually taken over one or two hours following the establishment of equilibrium.
- Sections 9.5.3.1, 9.5.3.2 calculations are not used since the vendor demonstrates that concentration in CRE is not changing before making measurements designed to calculate total inleakage.
- Section 10 is not used in total.
- Section 11.1 is not used to measure indoor and outdoor temperatures or wind speed and direction, unless there is a direct need for the information.
- Section 15 is not used in total.
- Section 16 is not used in total. The vendor's report is to present the theory, data analysis, sampling locations, operating conditions, procedures, quality assurance records for the particular plant work order, data, calculations and references.
- Section 17 is not used in total. The information is useful, but most vendors performing the test have been doing this type of testing for years in many industrial settings and already know these cautions and conditions. Uncertainty analysis or precision analysis may use ANSI PT 19.1 Standard to calculate the 95% confidence intervals.

4.3.2. INTEGRATED COMPONENT TEST METHOD BACKGROUND INFORMATION

This test method will provide the total inleakage value by summing the results from the individual leakage location tests. This test method will distinguish whether the inleakage is filtered or unfiltered. The inleakage contribution of individual components will be identified. A limited number of inleakage tests using this method have been performed at facilities in the industry. In these cases, the uncertainty in the Integrated Component Test results has been smaller than the uncertainty in the Integrated Tracer Gas Test results at these facilities.

For licensees to use the test, the initial inleakage test results must be correlated with the test results from the performance of an integrated test using the Integrated Tracer Gas Test Method. The Integrated Component Test Method is considered correlated as long as the nominal inleakage value accounts for no less than 95 percent of the nominal inleakage test result from performance of the Integrated Tracer Gas Test Method.

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If licensees can benchmark their assessment method and design to a facility that has correlated the Integrated Component Test Method with the Integrated Tracer Gas Test Method, then the licensee can use the Integrated Component Test Method for baseline testing and any subsequent tests. Benchmarking a design, as used in this context, means that the facility design can be compared to a similar plant design that has already correlated the two test methods. Similar design implies that the design, construction and operation are sufficiently alike so as to assure comparable results between the two plants. Benchmarking the assessment method means that it was conducted in a systematic manner as provided in Step 2 of this section. Although not required, a peer reviewer from the benchmarked plant is recommended to strengthen the assessment team and provide assurance of the implementation of a similar assessment method

Other aspects that should be understood prior to the performance of this test are:

- This test is dependent on the correct selection of components vulnerable to inleakage based on a systematic assessment performed in accordance with Appendix C.
- The identification and establishment of test pressures and airflow conditions to bound the limiting condition for an individual component may be difficult.
- This test is expected to be within the capability of the plant staff.

The control room design limits the selection of this test method. This test method is applicable only to positive pressure CRE designs. The following control room design features support the selection of this method of testing:

- CREs are maintained at positive pressure with respect to all adjacent spaces.
- Majority of control room HVAC equipment and ducting is located within the control room envelope.
- Minimal non-control room ventilation ducting or air system piping penetrate the control room envelope.
- Ventilation ducting located outside the CRE should be of a tight design (e.g., seam welded) and is in good material condition.
- Small number of vulnerable locations to inleakage exists.

This method requires three steps.

Step 1 - Performance of a comprehensive differential pressure test on the entire control room boundary. This verifies that the pressure inside the CRE is greater than the pressure in the outside adjacent areas. This test is dependent upon the premise that the CRE is at a positive pressure to all adjacent areas; however, testing must validate this premise. In this respect, the differential pressure measurements are critical. These differential pressure measurements are used to demonstrate that there is only out leakage across *the boundary walls, floors and roofs/ceilings. This includes the doors and all penetrations in the boundary*. Any component of the boundary that cannot be verified to have a positive differential pressure across the boundary must be tested for inleakage.

The comprehensive test of the control room boundary must include a sufficient number of test points on each side of the boundary so that the test points in aggregate represent the entire boundary that is credited in the test. If a test point represents an entire room, then the remote locations in the room should be checked to ensure that the test pressure represents the condition throughout the entire room. If not, additional test points will be required. For example, complicated room configurations with restrictions to air flow (panels, half walls, etc.) can result in pressure variations within the room. Each test result should be corrected, as necessary, to a standard set of environmental conditions.

The control room ventilation system should be in the limiting train pressurization mode of operation as discussed in Section 5.2 of this appendix. Elevation and temperature differences can also affect pressure differential and should be addressed. All areas adjacent to the boundary must be represented by a pressure measurement. Note, that out-

leakage at least equal to the pressurization makeup flow is expected to exist across the entire boundary.

Step 2 - Identification of vulnerable components to be tested. The Appendix C assessment identified any areas vulnerable to inleakage. Then using Appendix C and the differential pressure test, components are identified where the pressure inside the control room boundary is less than the pressure outside the boundary. Any components thus identified are determined to be vulnerable to inleakage and will require an individual leakage test.

Step 3 - Performance of leak tests on components vulnerable to leakage. Where the pressure inside the CRE cannot be verified to be greater than the pressure in the outside adjacent areas, these locations in the boundary must be individually leak tested. The final set of tests are the leakage tests for the individual components determined to be vulnerable to inleakage. These integrated component test methods should be performed using industry standards. Any exceptions to the consensus standards should be noted. Although the control room ventilation system does not necessarily have to be in the limiting accident condition, the test pressure and flow conditions across the tested component should bound the accident condition. The effect of HVAC systems in adjacent areas under accident conditions must be addressed when establishing integrated component test method conditions. The sum of the inleakage test results will represent the integrated control room inleakage value.

4.3.3. ALTERNATE TEST METHODS BACKGROUND INFORMATION

Licensees may propose alternate test methods. Alternate test methods must meet the following criteria:

- Test all potential leak paths and produce an overall inleakage value in CFM for the entire CRE.
- Performed in accordance with industry test standards such as those listed in Table D-1. Any exceptions to the consensus standards shall be noted.
- Conducted in a manner that reflects or bounds accident configuration leakage.
- Will require correlation and/or benchmarking. See discussion of these items in section 5.3.2

Licensees that propose to measure inleakage using an alternate test method will require a detailed description and justification of the proposed method to allow a knowledgeable reviewer to ascertain the acceptability of the test.

The documented information should include:

- Summary of the test method
- Description of the test apparatus and tolerances
- Parameter specifications
- Material requirements
- Safety implications of the test (e.g., personnel safety, impact on plant operations, plant equipment)

- Preparations before initiation of the test
- Calibration of test equipment
- Test procedure
- Manner of calculating inleakage and associated error from the test results
- Uncertainty (e.g., precision, accuracy) of results obtained with the test method
- Correlation and/or benchmarking results and evaluations

See the attached Table D-1 for methods that may be considered for development as an alternative test method. Note that a combination of methods may be necessary to produce an overall inleakage value in CFM for the entire envelope.

4.4. INLEAKAGE TESTING

Based on the determination made in Section 4.3, either Section 4.4.1 (Integrated Tracer Gas Test Method) or 4.4.2 (Integrated Component Test Method) may be used. If an alternate test method is chosen, then the utility should establish the guidance related to the alternate test.

4.4.1. THE INTEGRATED TRACER GAS TEST METHOD

The industry standard currently being used for a tracer gas test to determine inleakage is ASTM E741, Standard Test Method for Determining Air Change in a Single Zone by Means of a Tracer Gas Dilution. It is beyond the scope of NEI 99-03 to provide a detailed procedure applying ASTM E741; however, general guidance is presented in preparing and conducting the test.

4.4.1.1. PRELIMINARY ACTIONS

Perform the following steps prior to performing a tracer gas test.

- Determine if the test is to be performed in house or by a contractor.
- Select the method of measurement[7] that is appropriate for the CRE to be tested (examples: concentration decay, constant injection and constant concentration).
- Walkdown the CRE to select best measuring points and injection points for tracer gas prior to test initiation. This should be conducted with a set of as-built drawings.
- Obtain Material Safety Data Sheets for the tracer gas for incorporation/approval by the site's material control program.
- Determine the net volume of the CRE, if needed. This volume enters into the calculations of inleakage for the concentration decay test method. The more accurate the value, the more accurate the results of the tracer gas test.
- If a contractor is to perform the test then:
    - Ensure the contractor is familiar with this type of testing.

[7] Key factors affecting accurate testing are:

- Uniform mixing within a zone,
- Representative sampling (multiple samplers),
- Determination of CRE net volume and
- Measurement of pressurizing flow rate, if applicable.

- Determine if the contractor has a 10 CFR 50 Appendix B QA program. This will play a major role in deciding whose QA program will apply and whether the vendor can provide calibrated measuring and test equipment.
- Familiarize contractor personnel with the plant configuration, the purpose of test and the control room HVAC mode to be tested prior to arrival on-site.
- Review the CRE Boundary and CREFS configuration and operation (on-site) in detail with the tracer gas testing contractor identifying:
    a) test configuration(s)
    b) measured data required for habitability analysis
    c) CRE boundary and boundary condition walk-down
    d) CREFS configuration walkdown
- Verify that contractor test procedures are compatible with plant procedures (includes but not limited to):
    a) Test equipment calibrations
    b) Test personnel qualifications
    c) Tracer gas test compatibility with plant chemical tracking program.

- Determine the minimum time needed to perform the test as provided in ASTM E741. This is a function of the method of measurement.
- Prepare plant specific test procedure (s) in accordance with plant requirements. The test procedure should allow for using the contractor's actual tracer gas test methodology (if a contractor was selected). Consider the effects of the environment on the test results consistent with the plant design basis assumptions. The test instruction should contain this guidance on environmental effects. For an example: the test should not be performed if there is a strong consistent wind (>15 mph) and the CRE is exposed significantly to the outside environment. The lower the wind speed, the more accurate the test results. Consider including a requirement to limit door openings/closings during the test.
- Perform testing in accordance with plant procedures.
- Retest, if necessary.

4.4.2. THE INTEGRATED COMPONENT TEST METHOD

4.4.2.1. COMPREHENSIVE DIFFERENTIAL PRESSURE MEASUREMENTS TEST

- Identify acceptance criteria for an acceptable positive pressure. For adjacent spaces that are essentially outside atmosphere, a positive 1/8 (0.125) inch water gage pressure differential is recommended to allow for atmospheric variation. For adjacent areas inside a building where conditions are more stable, a positive pressure of 0.05 inches water gage[8] is sufficiently high enough to allow accurate measurements. The

[8] Use 0.125" WG or 0.05" WG if no other pressure differential is specified by design. The 0.125" WG is referenced from the Standard Review Plan NUREG 0800 Section 6.4. The 0.05" WG is based on current engineering practice in the cleanroom and healthcare industry. In the April 2001 revision of Guidelines for Construction of Hospital and Health-Care Facilities, the American Institute of Architects recommends a minimum of 0.01" WG ΔP (negative) for airborne infection isolation rooms, and a minimum of 0.01" WG ΔP (positive) for critical care areas such as intensive care and surgical rooms. In Chapter 15 of the ASHRAE HVAC 2001 Applications Handbook, 0.05" WG

use of two precision instruments is recommended[9]. The adjacent measurements should be timed and corrections made for elevation differences and other environmental influences between different spaces.

- Perform a control room positive pressure test to determine if there are any adjacent areas that are at a higher pressure than the rooms within the CRE. The system mode of operation when the pressure measurements are taken must be consistent with the modes of operation defined in Section 4.2 of this appendix.

When measuring the differential pressure:

- Use a drawing to identify all the control room areas and adjacent spaces to be measured.
- Measure the pressures in all adjacent areas to the envelope.
- Ensure hard to get areas such as above dropped ceilings or below raised floors are measured.
- Record and compare the pressures of the adjacent spaces to the areas inside the control room boundary to show the control room is at a positive pressure to all adjacent spaces. Document the portion of the boundary represented by each test point inside and outside the boundary.
- Monitor atmospheric pressure conditions while taking differential readings across the CRE boundary. Many instruments are very sensitive and changes such as the passing of a weather front can inject significant changes in data readings.
- If it is discovered that adjacent area(s) are at a higher pressure than the pressure inside the CRE, actions may be taken to reduce the pressure in the adjacent area. Ventilation system operating configurations should be considered as well as securing fans (if feasible) and providing pressure relief paths. If the system is rebalanced or in any way changed such that the differential pressure measurements are affected, then sufficient additional measurements must be taken to assure that the CRE walls, floors, ceiling/roofs are still positive to all adjacent spaces.

4.4.2.2. IDENTIFICATION OF VULNERABILITIES

- Identify all components vulnerable to inleakage from the assessment performed in Section 4.1. This list will be used for all subsequent Integrated Component Tests unless a new assessment is performed that identifies new vulnerabilities or deletes existing vulnerabilities or design changes are made to change/reduce the vulnerabilities.
- Verify that each vulnerable component can be tested using a consensus standard.
- Any component that cannot be verified to have a positive differential pressure across the boundary must be tested for inleakage. Use the differential pressure measurements from Section 5.4.2.1 and the guidance in Table D-2 to make this

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is noted as a widely used standard for semiconductor cleanrooms, and pharmaceutical and biomanufacturing clean spaces. This supports the selection of 0.05" WG as a pressure measurement.

[9] The preferable method is to measure with a differential pressure (d/p) gage for accuracy considerations. If a d/p gage is not available, measuring the pressures with a pressure gage, barometer, or precision manometer is acceptable.

determination. Each vulnerability (i.e., component) that was identified in Appendix C must be addressed. Record the components that are to be tested. Examples of components that could be tested individually are air handling units, ductwork and isolation dampers.

4.4.2.3. INDIVIDUAL COMPONENT LEAK TESTS

A. SELECT TEST METHOD FOR THE COMPONENT

Available methods for testing the leak tightness of components[10] are provided in Table D-2. Perform the following steps prior to performing each test.

- Determine that the test configuration will bound the limiting condition.
- Develop plant procedures for the individual components that will be tested.
- Determine if each test can be performed by the site testing organization or if contractor expertise will be required.
- Calibrate test equipment to the expected leakage rates.

B. PERFORM THE APPLICABLE TEST

- Perform each test as prescribed in 4.4.2.3.A.
- Record the leakage measurements made[11].
- Determine if the inleakage is filtered or unfiltered by a review of the leak path. Sum all the filtered and unfiltered leakage measurements. Include the pressurized makeup flow as filtered inleakage.

4.4.2.4. TEST RESULTS

- Document all test results including leakage measurements.
- Determine one value[12] for total filtered and one value for the total unfiltered inleakage for each lineup tested.
- Determine if the test results meet the acceptance criteria derived from the regulatory limits. Document how uncertainty addressed in this determination. Current practice is to use the nominal value of the testing results in the radiological and hazardous chemical analyses when these nominal values are in a reasonable range and the variability in results, as represented by the uncertainty, is understood. This is an

[10] Dampers that close when ventilation systems realign to the emergency mode such that the pressure inside the damper is negative with respect to the outside air may become a potential source of additional inleakage into the control room envelope that can be filtered or unfiltered depending upon the damper location in the system. ANSI N510-1989 provides methods to test this leakage using a totalizing gas flow meter or possibly a calibrated rotating vane anemometer. Industry standard ASTM E 2029-99, "Standard Test Method for Volumetric and Mass Flow Rate Measurement in a Duct Using Tracer Gas Dilution," discusses the use of tracer gas on a component level by a constant injection at the damper air intake with measurements downstream of the closed damper. The constant injection method is considered advantageous in that control test volumes are not required that may require fabrication within the installed ductwork. Measurement uncertainties can be determined using ANSI Standard PTC 19.1, "Measurement Uncertainty."

[11] For control room envelopes that can tolerate large amounts of unfiltered inleakage, flow measurements are acceptable provided the measurements consider instrument error.

[12] Inleakage during ingress and egress should be included when evaluating the test results against acceptance criteria. An accepted assumption for this inleakage contribution is 10 CFM. If a licensee uses less than 10 CFM, the basis for the exception should be justified and documented.

acceptable approach since conservative margins are routinely applied to other input parameters in these analyses, for example in the determination of χ/Q for radiological and toxic gas control room habitability analyses.

- If measured values are higher than acceptance criteria, compensatory measures may need to be taken to maintain the control room ventilation system operable until permanent resolution is achieved (See Appendix B for guidance). Inleakage values that result in doses greater than that currently reported in the UFSAR will require evaluation per the plant's corrective action program.
- If the Integrated Component Test Method is performed, document each differential pressure test point and portion of boundary represented by the differential pressure measurements.
- If the Integrated Component Test Method is performed, document the individual components tested.

TABLE D-1
TESTING OPTIONS

PURPOSE OF TEST	Standard Used to Develop Site Specific Procedure (Note 1)	DISCUSSION	Performed with systems in their accident configuration	Optimum Accuracy	Quantitative
Measurement of Inleakage Using a Tracer Gas	ASTM E741	This test method has been accepted by NRC and has been used for the majority tests performed to date (Note 2, 3)	Yes	± 10%	Yes
Measurement of Inleakage Using A Component Test	ASTM E779 ASTM E741 ASTM E1827 ASTM E2029 ASME N510 ASME AG-1 10CFR50, App J, Type C LLRT method (Note 4)	These test methods are used to measure individual component leakages. The are used, as discussed in the text of this appendix, in conjunction with identification of vulnerabilities and pressure measurements to establish control room envelope inleakage. The text of this appendix discusses the integrated component test method which uses individual component tests for measuring component leakage. Note that in order to use an integrated component test method it must be correlated and benchmarked to an integrated tracer gas test (see section 3.3.2 of this appendix). Dampers may be tested by 1. Direct Measurement Method of ANSI N510 Standard; 2. Tracer Gas Technique using ASTM E 2029 Standard; 3. ANSI /ANS-56.8, "Containment System Leakage Testing Requirements"(Note 5) Ducting and housings may be tested by 1. Direct Measurement Method of ANSI N510 or 2. ASME AG-1. (Note 5)	Section by section	Test dependent	Yes
Detection of Leaks	ASTM E779 ASTM E1554 ASTM E1186	These test methods, though not discussed in the text of the appendix, are listed here for information. They are listed as they may prove useful in determining location of leaks. These procedures can be used in addition to walkdowns, audible detection, and use of smoke pencils.	Not applicable	Not applicable	Not applicable

Notes:

1. Each standard listed provides the information necessary to develop a site specific test to measure inleakage. Other methods may be acceptable if they are associated with a standard.
2. Tracer gas testing is comprehensive for neutral pressure control rooms but requires flow measurements for positive pressure control rooms, which increases the overall uncertainty of the test result. If the actual unfiltered in-leakage is small (< 100 CFM) and the pressurizing air flow is relatively large (>1000 CFM), the uncertainty in the air flow measurement causes the accuracy of the tracer gas test to become very poor (30% - 60%). Using the parenthetical numbers as an example, an uncertainty of 10 percent in the airflow measurement yields an error band of at least +/- 100 CFM. When this error is compared to the measured in-leakage, the overall test uncertainty may approach (or exceed) 100 percent measured.
3. Testing developed by Brookhaven National Laboratory using multiple tracer gases has the potential for conforming to an acceptable test. This method has the ability to discriminate and quantify leakage through different barriers.
4. The volume between closed isolation dampers installed in tandem can be pressurized and the volumetric flow required to maintain the test pressure measured as the leakage. One of the two dampers will be tested in the direction opposite the normal differential pressure condition. The results should be conservative since damper leakage in this direction should be greater than if it is tested in the normal differential pressure direction
5. Other methods may be acceptable if they are associated with a standard. The methods presented above are already accepted by the industry and NRC for measuring leakage in ducts, housings and dampers.

TABLE D-2
SELECTION OF COMPONENTS FOR TEST

Vulnerability Area	Discussion	Test Required/Not Required	Acceptable Test
CRE ceiling/roof	The positive pressure measurements of the CRE would show that this vulnerability would not exhibit in-leakage as the leakage would be out of the CRE.	Required	Section 4.4.2.1 of this appendix
CRE walls	The positive pressure measurements of the CRE would show that this vulnerability would not exhibit in-leakage as the leakage would be out of the CRE.	Required	Section 4.4.2.1 of this appendix
CRE floor	The positive pressure measurements of the CRE would show that this vulnerability would not exhibit in-leakage as the leakage would be out of the CRE.	Required	Section 4.4.2.1 of this appendix
CRE penetration in roof/ceilings; walls; floor	This examines the external portions of the penetrations. The positive pressure measurements of the CRE would show that the perimeter of these penetrations would not exhibit in-leakage as the leakage would be out of the CRE. This also includes other types of penetrations that can provide potential leakage pathways; for example, concrete anchors through block walls, which are not sealed.	Required	Section 4.4.2.1 of this appendix
CRE doors	The positive pressure measurements of the CRE would show that this vulnerability would not exhibit in-leakage as the leakage would be out of the CRE.	Required	Section 4.4.2.1 of this appendix
Electrical conduits	Determine that wall, floor and ceiling penetrations (i.e., conduits, electrical cable trays, etc.) are sealed. If the internals are not sealed then smoke pencils may be used to verify no leakage through the open conduit, etc. However, if there is flow indicated passing through the open conduits into the CRE then an integrated tracer gas test may be required.	Not required provided that the conduits, etc. are properly sealed internally and/or exhibit outleakage	NA, otherwise use smoke pencils. See discussion.
Ducting, housings located outside the CRE	Determine if control room ducting and/or HVAC equipment located outside the CRE is at a negative pressure with respect to adjacent areas. This is applicable to both operating and non-operating equipment, and to both HVAC ducting and filter system ducting. Any ducting and/or housings under a negative pressure are a potential source for in-leakage. Access doors, hatches, instrument lines, drain lines (should have loop seals to prevent leakage), damper and fan shafts,	Required	See Table D-1 for guidance on type of test.
Isolation dampers located outside the CRE and the ducting between the CRE wall/floor/ceiling and the damper	Determine if AHU fans have the potential to draw air from isolated ducting lines (i.e., damper leakage) that penetrate the envelope boundary. Dampers may leak at the damper seals and/or the ducting may leak.	Required	See Table D-1 for guidance on type of test.
Ducting, housings located within the CRE	Determine if AHU fans have the potential to draw air from isolated ducting lines that penetrate the envelope boundary.	Required for ducting that is susceptible to in-leakage	See Table D-1 for guidance on type of test.

Vulnerability Area	Discussion	Test Required/Not Required	Acceptable Test
Isolation dampers within the CRE and the ducting between the CRE wall/floor/ceiling and the damper	Determine if AHU fans have the potential to draw air from isolated ducting lines (i.e., damper leakage) that penetrate the envelope boundary. Dampers may leak at the damper seals and/or the ducting may leak.	Required	See Table D-1 for guidance on type of test.
Ducting passing through the CRE that is not isolated and is not part of the CR HVAC.	Determine if internal pressure of ducting is greater than the CRE. Ducting may leak into the boundary and be a source of in-leakage.	Required	See Table D-1 for guidance on type of test.
Other systems	Radiation monitors and pneumatic air airlines may be a source of in-leakage. These systems should be reviewed for leakage. Constant bleed air regulators can be a source of unfiltered in-leakage along with operational venting of air operated components.	Not required if it can be shown that the lines do not leak. Alternatively, when the pneumatic air bleed is set at the maximum amount of design bleed for a component (continuous or as cycled), no test will be required for this item.	NA

APPENDIX E

CONTROL ROOM ENVELOPE BOUNDARY CONTROL PROGRAM

1. PURPOSE/SCOPE

This appendix provides guidance for controlling breaches of the Control Room Envelope (CRE) and is to be used to develop plant specific procedures.

2. SCOPE

A boundary control program manages activities that breach the CRE such as:

- The creation of a new penetration in the CRE
- Opening of an existing penetration in the CRE
- Any activity that restricts the normal closure of a CRE door
- The removal of a CRE door/hatch from its design location
- The blockage or breach of a CRE ventilation duct
- Removal of or changes to structural components such that CRE boundary leak tightness may be affected
- Removal of fire, steam, high energy line break or flood barriers that also serve as the CRE boundary
- Any piping system breach (e.g., valves, pumps or pipes) that creates a flow path through the CRE boundary.
- The removal or alteration of equipment and/or floor drain plugs from the CRE boundary, or dryput of loop seals in the CRE boundary.
- Normal use of doors, access panels, or inspections plugs, for example, does not constitute a breach.

3. DISCUSSION

The physical CRE boundary is a fundamental element of CRE integrity. It is important to control the CRE boundary to ensure that the design is maintained such that the accident analyses remain valid. In the event that planned maintenance, testing or plant conditions have potential to affect the CRE boundary, administrative control of the boundary should be procedurally maintained. This includes controlling openings in the boundary required for maintenance and modifications as well as preventing inadvertent openings. Assure that a program exists to:

- Evaluate the impact on the accident analyses when breaching the boundary
- Monitor active breaches

- Ensure pre-planned responses to close the breach in the event of a toxic gas or radiological challenge are in place
- Ensure that the boundary is restored.

Baseline testing measured the actual CRE inleakage. This measured value is typically less than the maximum inleakage that can be calculated to satisfy regulatory limits. For a positive pressurize CRE the difference between these two values may represent margin that can be used to determine the maximum allowable size of a CRE breach to ensure that system operability is maintained. For a neutral pressure CRE, this cannot be done; however, the inleakage margin may be used to control breaches as described in Section 4.2.2 below.

For pressurized CRE the breach size can affect the ability to maintain the minimum required differential pressure across the CRE boundary. If positive pressure cannot be maintained, this may result in greater inleakage. Additionally, the maximum pressurization airflow rate allowed by the accident analyses may be adversely affected.

4. PROCESS

4.1 Impact Evaluation

Evaluate the activity to be performed for the affect on control room habitability prior to breaching the CRE boundary. This evaluation should consider, as a minimum, the breach size and the ability to maintain the CRE integrity or rapidly restore the boundary. The impact on fire boundaries, tornado protection boundaries, security boundaries, etc., should also be considered when opening up a boundary.

4.2 Breach Size

4.2.1 Pressurized CRE

For pressurized CRE, evaluate the effect the breach has on inleakage margin, pressurization flow rate and required differential pressure across the boundary. Implement the following two steps:

- Determine the impact on the differential pressure across the boundary that will be breached under accident conditions.
- Calculate the maximum breach size using the allowable inleakage and differential pressure as inputs to the orifice equation. If the anticipated breach size is less than the maximum breach size, the planned activity is allowed.

If the breach size adversely affects the accident analyses or system performance requirements, compensatory measures may be necessary. These compensatory measures may need a 10 CFR 50.59 evaluation.

4.2.2 Neutral CRE

For neutral pressure CRE, if possible evaluate the effect the breach has on inleakage margin considering any localized differential pressure across the boundary. Implement the following three steps:

- Determine the maximum breach size to identify the allowable inleakage based on the margin of the accident analyses.
- Determine the impact from the differential pressure across the boundary that will be breached under accident conditions.
- Calculate the maximum breach size using the allowable inleakage and differential pressure as input values in the orifice equation. If the anticipated breach size is less than the maximum breach size, the activity is allowed.

If the breach size adversely affects the accident analyses or system performance requirements, compensatory measures may be necessary. These compensatory measures may need a 10 CFR 50.59 evaluation.

If a breach is in an area known to have non-detrimental inleakage characteristics (i.e., the χ/Q for this location provides a large margin), a smaller degree of rigor may be used in the breach assessment/evaluation.

4.3 Ability to Rapidly Restore the Boundary

Breaches such as blocking doors open do not require evaluation if the breach can be quickly restored. To make use of this exception, a worker must be assigned whose primary responsibility is to shut the door at the onset of abnormal conditions. The assigned worker must be in communication with the control room.

4.4 Breach Monitoring

Establish programmatic controls to monitor the number of breaches and ensure that the sum effect of all the active breaches does not result in exceeding regulatory limits. This may be accomplished via a breach permit tracking system, differential pressure monitoring or controlling the number of work orders that affect control room habitability.

4.5 Boundary Restoration

The breach shall be verified closed when the barrier has been restored (e.g., qualified penetration seal installed) and work-related compensatory measures removed. All restoration activities should be documented.

Informational Appendices

The following Appendices contain information that may be useful to licensees implementing the NEI 99-03 guidance. They are not a formal part of the NEI 99-03 guidance

APPENDIX AA

LICENSING BASIS HISTORY

This appendix provides an overview of the control room habitability regulatory and licensing history.

1. CR GENERAL DESIGN CRITERIA AND EARLY REGULATORY GUIDANCE

In February 1971, the Atomic Energy Commission published Appendix A, *General Design Criteria (GDC) for Nuclear Power Plants* to 10 CFR 50. 10 CFR 50.34(a)(3)(i) requires an applicant for a construction permit to describe the preliminary design of the facility including the principal design criteria in a preliminary Safety Analysis Report (PSAR). This paragraph includes a reference to Appendix A as establishing the minimum requirements. Criterion 19 (GDC 19), *Control Room*, provides for a control room, alternative shutdown station(s) and habitability requirements. GDC 19, in part, requires:

> *"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*."

Between 1965 and 1971, the NRC staff worked on issuing the final version of the GDCs. The control room criterion was variously numbered as GDC 11, 13, 17 and finally, 19. There were several draft versions and much coordination between the Commission, the staff, and the Advisory Committee on Reactor Safeguards (ACRS). In June 1967, the Commission published a draft of the GDCs in the *Federal Register* for public comment and interim guidance. Applicants for construction permits and operating licenses during this period may have referenced it in their PSARs and FSARs. Many licensees were required to meet the draft GDC on control room habitability as a condition for receiving their construction permit and/or their operating license.

While the GDCs were under development, applicants proposed, and the staff approved, various criteria for the control room. As an example, at one plant the NRC approved the criterion of l0 percent of the 10 CFR Part 100, §100.11 dose guidelines.

In the early 1970's, K. Murphy and K. Campe presented a method for evaluating radiological events in the control room. Additional information can be found in a 1974 paper by Murphy and Campe[13]. In 1974 and 1975, NRC Regulatory Guides 1.78 and 1.95 were issued to provide direction on the protection of the control room operator from accidental releases of hazardous chemicals or chlorine gas respectively.

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13 K.G. Murphy and K.M. Campe, *Nuclear Power Plant Control Room Ventilation System Design for Meeting General Criterion 19, In Proceeding of 13th AEC Air Cleaning Conference, San Francisco, CA, CONF-740807,* U.S. Atomic Energy Commission, 1974.

2. TMI EFFECT ON CRH CRITERIA

Because of the accident at Three Mile Island, the NRC staff developed a number of proposed actions to be implemented on operating reactors and on plants under construction. These actions were presented in NUREG-0660, TMI-2 Action Plan. In October 1980, NUREG-0737, *Clarification of TMI Action Plan Requirements*, was published. NUREG-0737 contained all TMI-related items approved for implementation by the Commission as of October 31, 1980. The actions in NUREG-0737 were applicable to operating reactors and applicants for operating licenses. The letter that transmitted NUREG-0737 was addressed to all licensees of operating plants, and applicants for operating licenses and holders of construction permits. The letter in NUREG-0737 stated that the staff "…expected the requirements contained herein will be met." Pursuant to 10 CFR 50.54(f), operating reactor licensees were to confirm that the implementation dates in Enclosure 1 of NUREG-0737 would be met. If they could not, a revised date was to be provided along with a justification for the delay, a proposed revised date for completion and any planned safety actions during the interim.

The Standard Review Plan (NUREG-0800), Revision 1 was issued by the NRC in July 1981. The Standard Review Plan (SRP) provides standard regulatory acceptance guidance to the NRC staff for review and approval of Licensee Safety Analysis Reports. The SRP identified that the limiting design basis accident (DBA) for CRH is the loss of coolant accident. However, other DBAs were to be reviewed to determine whether they could be more limiting. Licensees were to provide assurance that the habitability systems will operate under all postulated conditions (DBA) to permit the control room operators to remain in the control room to take appropriate actions required by GDC 19. Where modifications were needed for compliance with CRH requirements, a schedule for completion of these modifications was required. Some modifications and other CRH actions were deferred pending future resolution of certain regulatory issues such as the alternative source term (10 CFR 50.67).

In May 1982, Generic Letter 82-10 was issued, that requested licensees to implement on a timely basis those TMI Action Items from NUREG-0737, which had not been addressed by Generic Letter 82-05. The Enclosure to Generic Letter 82-10 identified those items for which a schedule needed to be established or, if a schedule had been previously submitted, a reconfirmation of those schedule dates. TMI Action Item III.D.3.4, Control Room Habitability Requirements was in that Enclosure. In March 1983, the NRC issued an order to each reactor facility confirming licensee's commitment to post-TMI related issues. The order required each licensee to implement and maintain the specific items described in the Attachments to the Order in the manner described in the licensee's submittal noted in the Order.

Two classes of licensees were identified in item III.D.3.4.

- Licensees with control rooms that meet the guidance of the SRP needed only to describe their basis for determining that the guidelines were met.
- Licensees with control rooms that did not meet the guidelines of the SRP were required to analyze the control room exposures and submit the results.

3. CRH IN THE 1980'S

Two issues related to CRH were identified by the ACRS in the early 1980s. These issues, which are discussed in NUREG-0933, are:

- GSI B-66, *Control Room Infiltration Measurements*, which identified that a key parameter affecting control room habitability is the magnitude of control room air infiltration rates.
- GSI 83, *Control Room Habitability*, which identified that loss of control room habitability following an accidental release of external airborne toxic or radioactive material or smoke can impair or cause loss of the control room operators' capability to safely control the reactor.

The ACRS issued a letter to the Commission, on August 18, 1982, which identified a wide range of deficiencies in the maintenance and testing of engineered safety features designed to maintain control room habitability. These ACRS concerns encompassed both plant licensing review and operations and inspection activities.

In January 1983, the NRC staff responded to the ACRS concerns and recommended increased training of NRC and licensee personnel in inspection and testing of control room habitability systems. The staff also provided a profile of control room HVAC system component failures based on an analysis of Licensee Event Reports from 1977 through mid-1982. On April 28, 1983, Nuclear Reactor Regulation (NRR) and Office of Inspection & Enforcement (OIE) representatives met with the ACRS Subcommittee on Reactor Radiological Effects to discuss the staff response. Based on the accomplishments above, GSI B-66 was considered resolved.

In May 1983, the ACRS issued a letter to the Executive Director of Operations (EDO) that expressed continuing concerns about control room habitability and provided both general and specific comments and recommendations for further staff evaluation. This basically defined GSI 83. In July 1983, NRR transmitted to the EDO a joint NRR/OIE proposal for evaluating the ACRS comments and recommendations and the adequacy of the control room habitability licensing review process and criteria. In August 1983, the EDO indicated agreement with the proposal and directed NRR to coordinate with OIE and the NRC Regional Offices to complete the program and submit a report to the EDO by June 1, 1984. In September 1983, NRR established a Control Room Habitability Working Group and a Steering Group for conducting and guiding the proposed review. The Control Room Habitability Working Group was expected to identify any recommended actions that would correct significant deficiencies in control room habitability design, installation, test or maintenance.

Following issuance of NUREG/CR-4960, it was recognized that the methodology used to evaluate control room habitability system design needed improvement. Accordingly, the NRC staff initiated activities to develop:

- improved methods for calculating control room dose and exposure levels,
- improved meteorological models for use in control room habitability calculations and
- revised exposure limits to toxic gases for control room operators.

The results of the improved methods were documented in NUREG/CR-5669 and NUREG/CR-6210. The HABIT Code was developed to provide an integrated code package for evaluating control room habitability. In the year 2000, the NRC issued a new regulation (10 CFR 50.67) allowing licensees to voluntarily request license amendments to revise their design basis to use alternate source term information in radiological consequence assessments, including those for control room habitability.

As recommended by the ACRS, the staff was expected to consider National Institution for Occupational Safety and Health recommendations for toxic chemicals in its revision of Regulatory Guide 1.78.

4. EVOLUTION OF AN INDUSTRY ACTIVITIES

Numerous control rooms have used the tracer gas test to determine the amount of inleakage entering into the control room envelope. The NRC reported early testing results at a July 16, 1998, public meeting on control room habitability. The testing data indicated that actual inleakage was much greater than the amount assumed in control room habitability analyses. Licensees embarked on sealing programs, design improvements and/or revision to dose consequence analyses to ensure regulatory requirements were met.

NUREG/CP-0167, *Proceedings of the 25th DOE/NRC Nuclear Air Cleaning and Treatment Conference,* reported on control room envelope reconstitution efforts at one nuclear power plant and control room air inleakage testing results at two nuclear power plants. Some of the conclusions from these reports were:

- Tracer gas testing was instrumental in definition and quantification of unfiltered leakage paths and represented documented measured inleakage rates. The constant injection tracer technique was considered the most useful method.
- Well-managed sealing efforts are instrumental for assuring control room integrity.
- Proper airflow balancing is essential to obtaining control room envelope and adjacent area HVAC system design basis.

Following the July 1998 public meeting with NEI, utility representatives and representatives from the Nuclear HVAC Users Group, the NRC staff agreed to work with the industry to resolve issues regarding control room habitability.

NEI agreed to take the lead. This document, NEI 99-03, presents the results of a joint industry and NRC effort to develop guidance to address CRH.

5. GDC 19 REVISION

In conjunction with the January 2000 issuance of the *Alternative Source Term* regulation, 10 CFR 50.67, GDC-19 was revised to allow licensees to use a dose criterion of 0.05 Sv (5 rem) total effective dose equivalent (TEDE) when implementing an alternative source term. Regulatory Guide 1.183, *Alternative Radiological Source Terms For Evaluating Design Basis Accidents At Nuclear Power Reactors*, was issued in July 2000 to provide guidance on implementing an alternative source term.

APPENDIX BB

REGULATORY DOCUMENTS ASSOCIATED WITH CRH

1. SCOPE

This appendix lists the regulatory documents associated with designing, constructing, operating and managing control room habitability.

2. REGULATORY REQUIREMENTS

General Design Criterion (GDC) 19 of Appendix A to 10 CFR Part 50 is the controlling requirement for control room habitability (CRH). Plants licensed or issued construction permits before 1971 may not be committed to GDC 19. The text of this criterion, as amended in December 1999 with the issuance of 10 CFR 50.67, is provided below:

Criterion 19-Control room. *A control room shall be provided from which actions can be taken to operate the nuclear power unit safely under normal conditions and to maintain it in a safe condition under accident conditions, including loss-of-coolant accidents. 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.*

Equipment at appropriate locations outside the control room shall be provided (1) with a design capability for prompt hot shutdown of the reactor, including necessary instrumentation and controls to maintain the unit in a safe condition during hot shutdown, and (2) with a potential capability for subsequent cold shutdown of the reactor through the use of suitable procedures.

Applicants for and holders of construction permits and operating licenses under this part who apply on or after January 10, 1997, applicants for design certifications under part 52 of this chapter who apply on or after January 10, 1997, applicants for and holders of combined licenses under part 52 of this chapter who do not reference a standard design certification, or holders of operating licenses using an alternative source term under § 50.67, shall meet the requirements of this criterion, 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 § 50.2 for the duration of the accident.

It is important to note that although GDC-19 provides a specific numeric criterion for only radiation doses, the scope of the GDC applies to other conditions that would prevent the requisite actions from being performed.

3. REGULATORY GUIDES

The control room is expected to be habitable following design basis events. The design basis events that establish the parameters for the design of control room features may vary from plant to plant. The Regulatory Guides listed below address various events and define some of the assumptions to be considered in the analysis and evaluation of each event.

- Regulatory Guide 1.3 - *Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Boiling Water Reactors*
- Regulatory Guide 1.4 - *Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Pressurized Water Reactors*
- Regulatory Guide 1.5 - *Assumptions Used for Evaluating the Potential Radiological Consequences of a Steam Line Break Accident for Boiling Water Reactors*
- Regulatory Guide 1.24 - *Assumptions Used for Evaluating the Potential Radiological Consequences of a Pressurized Water Reactor Radioactive Gas Storage Tank Failure*
- Regulatory Guide 1.25 - *Assumptions Used for Evaluating the Potential Radiological Consequences of a Fuel Handling Accident in the Fuel Handling and Storage Facility for Boiling and Pressurized Water Reactors*
- Regulatory Guide 1.52 - *Design, Testing, and Maintenance Criteria for Postaccident Engineered-Safety-Feature Atmosphere Cleanup System Air Filtration and Adsorption Units of Light-Water-Cooled Nuclear Power Plants*
- Regulatory Guide 1.77 - *Assumptions Used for Evaluating a Control Rod Ejection Accident for Pressurized Water Reactors*
- Regulatory Guide 1.78 - *Assumptions for Evaluating the Habitability of a Nuclear Power Plant Control Room during a Postulated Hazardous Chemical Release*
- Regulatory Guide 1.95 - *Protection of Nuclear Power Plant Control Room Operators Against an Accidental Chlorine Release*
- Regulatory Guide 1.98 - *Assumptions Used for Evaluating the Potential Radiological Consequences of a Radioactive Offgas System Failure in a Boiling Water Reactor*
- Regulatory Guide 1.145 - *Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants*
- Regulatory Guide 1.183 - *Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors*

4. NUREGS

The technical reports listed below provide general information and results of research related to CRH.

- NUREG-0737 - *Clarification of TMI Action Plan Requirements*

  As noted in Appendix A, Generic Letter 82-10 required licensees to submit a report describing their efforts to address the TMI Action Plan Requirements and provide

schedule commitments. The NRC issued orders confirming these commitments. The applicability of any NUREG-0737 item to a particular facility is dependent on the specific commitments made by the licensee.

NUREG-0737, Action Item III.D.3.4, *Control Room Habitability Requirements,* is one of the activities identified by the NRC after the Three Mile Island (TMI) accident. Each licensee and applicant was required to make a submittal addressing several questions regarding the design of their control room and habitability systems. Based on a review of these responses, the NRC typically documented the closeout of this TMI issue in a safety evaluation report (SER).

As a part of the CRH assessment effort, each utility should consider the response it provided to this issue, determine whether it still reflects the current design of the CRH features and confirms that there is a SER closing out the issue for its plant.

For a few plants, the NRC issued SERs that allowed some control room habitability issues to remain open due to pending anticipated NRC actions. The NRC has permitted some plants to use temporary compensatory measures, such as the use of self-contained breathing apparatus or potassium iodide pills to mitigate radiological dose after an accident.

With the issuance of the accident source term rule, 10 CFR 50.67, the NRC encouraged licensees to comply with TMI Action Item III.D.3.4 without compensatory measures.

- NUREG-0800 - *Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants*

  The Standard Review Plan (SRP) was developed to provide guidance primarily for the NRC staff performing reviews of license applications. It was intended to better assure the quality and consistency of the review effort. It also offered a means of communication for information about regulatory matters and the license process.

  The SRP was originally issued in 1975 as NUREG-75/087. The SRP was revised in its entirety in 1981 and republished as NUREG-0800. The new revision outlined the requirements and acceptance criteria for each topic and incorporated new regulatory positions, including several derived since the Three Mile Island accident (see NUREG-0737, discussed above).

  The SRP follows much the same outline as that for the Final Safety Analysis Report (at least for those plants that followed the standard format of Regulatory Guide 1.70). The key sections that relate to control room habitability include:

  - Section 6.4 – *Control Room Habitability Systems*
  - Section 9.4.1 – *Control Room Ventilation Systems*
  - Section 11.3 – *Waste Gas System Failure and Liquid Tank Rupture Events*
  - Chapter 15 sections – *Accident Analysis*

The SRP typically identified the applicable regulatory requirements, outlined the regulatory considerations and often provided acceptable values for analysis assumptions. The following excerpt from NUREG-0800, Section 6.4 is provided as an example:

> *The LOCA source terms determined from the EAB review in accordance with Appendix A to SRP Section 15.6.5 are routinely used to evaluate radiation levels external to the control room. .... Other DBAs [Design Basis Accidents] 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.*

- NUREG-0933 - *A Prioritization of Generic Safety Issues*

  NUREG-0933 presents the priority rankings for generic safety issues related to nuclear power plants. The purpose of these rankings is to assist in the timely and efficient allocation of NRC resources for the resolution of those safety issues that have a significant potential for reducing risk. Two issues related to CRH are Items GSI-B66 and GSI-83. These issues are considered to be resolved with no new requirements for licensees to implement.

- NUREG-1465 - *Accident Source Terms for Light Water Nuclear Power Plants*

  In 1962, the U. S. Atomic Energy Commission published TID-14844 to specify the release of fission products from a postulated accident involving a substantial meltdown of the core. This source term was used by nearly all licensees to demonstrate compliance with the reactor siting criteria of 10 CFR 100 and has subsequently been used to estimate control room doses.

  In 1995, the NRC published NUREG-1465 and provided more realistic estimates of the source term released from the core. This updated source term guidance was specifically applicable to future reactors. The Alternative Source Term Rule (10 CFR 50.67) was issued in December 1999 and provided for the implementation of the new source term insights of NUREG-1465 by currently licensed facilities. Regulatory Guide 1.183 provides a PWR and BWR alternative source term acceptable to the NRC staff and provides guidance regarding the attributes of an acceptable source term.

  The NRC staff has also rebaselined a PWR and BWR using the NUREG-1465 source terms (SECY-98-154) and concluded the alternative source term need not be imposed on licensees because use of TID-14844 provides adequate protection of the public. The NRC concluded that voluntary application of the alternative source term by licensees of currently operating plants would be acceptable as an opportunity for burden reduction. Implementation must be approved by the NRC in an amendment to

the plant operating license.

While not directly associated with the CRH issue, the alternative source term does offer an improved basis for a larger control room inleakage value than initially assumed. The new source term, in conjunction with the regulation change to use a total effective dose equivalent acceptance criteria, may yield acceptable calculated dose consequences for the postulated accidents in a plants' licensing basis.

- NUREG/CP-0167 - *25th DOE/NRC Nuclear Air Cleaning and Treatment Conference*

NUREG/CP-0167 contains papers presented at the conference without associated comments. Major topics included control room safeguards. For example, one session was "HVAC Systems for Control Rooms and Other Nuclear Facilities."

- NUREG/CR-4960 - *Control Room Habitability Survey of Licensed Commercial Nuclear Power Generating Station*

NUREG/CR-4960 presents the results of a survey of 12 plants regarding the design of their systems used for control room habitability. The survey was conducted from 1986 to 1988 and was published in September 1988. The observations may offer insights to licensees preparing to assess the integrity and effectiveness of their own control room envelope.

- NUREG/CR-6210 - *Computer Codes for Evaluation of Control Room Habitability (HABIT)*

NUREG/CR-6210 describes the HABIT package of computer codes designed to be used for the evaluation of control room habitability in the event of an accidental release of toxic chemicals or radioactive materials.

HABIT is an integrated package of several programs that previously needed to be run separately and required considerable use intervention. Two of these modules, EXTRAN and CHEM, are used for estimating chemical exposures. EXTRAN determines the release rate of a chemical in the event of leaks or ruptures of liquid or gas tanks. It also uses a model that computes atmospheric dilution, including the effects of building wakes, to determine the chemical concentration arriving at the intake to the control room. CHEM models the dilution of the chemical by flows in the control room and determines the chemical exposure to control room personnel.

Regulatory Guide 1.78, Revision 1, *Evaluating the Habitability of a Nuclear Power Plant Control Room during a Postulated Hazardous Chemical Release*, endorses the use of EXTRAN to model the atmospheric transport of a released hazardous chemical as part of a licensee's toxic gas assessment. The use of EXTRAN as part of a toxic gas assessment is also discussed in Appendix DD.

- NUREG/CR-6331, Rev. 1 - *Atmospheric Relative Concentrations in Building Wakes (ARCON96)*

  NUREG/CR-6331 describes the Atmospheric Relative Concentration in Building Wakes (ARCON96) computer code. ARCON96 is an atmospheric dispersion code intended for use in control room habitability assessments. The code uses hourly meteorological data and refined methods for estimating dispersion near buildings to calculate relative concentrations at control room air intakes that would be exceeded no more than 5 percent of the time. These concentrations are calculated for averaging periods ranging from one hour to 30 days in duration.

- NUREG/CR-6604 - *RADTRAD: A Simplified Model for Radionuclide Transport and Removal and Dose Estimation*

  NUREG/CR-6604, documents the RADTRAD computer code developed for the NRC to estimate transport and removal of radionuclides and dose at selected receptors. The code can be used to estimate releases using various source terms. Additionally, the code can account for a reduction in the quantity of radioactive material due to containment sprays, natural deposition, filters and other natural and engineered safety features.

5. INSPECTION AND ENFORCEMENT NOTICES (IEN) AND INFORMATION NOTICES (IN)

The following notices provide information regarding designs or events that had an identified impact on control room habitability.

- IEN 83-41 – *Actuation of Fire Suppression System Causing Inoperability of Safety-Related Equipment*
- IEN 83-62 – *Failure of Redundant Toxic Gas Detectors Positioned at Control Room Ventilation Air Intakes*
- IEN 83-69 – *Improperly Installed Fire Dampers at Nuclear Power Plants*
- IEN 86-76 – *Problems Noted in Control Room Emergency Ventilation Systems*
- IN 88-61 – *Control Room Habitability - Recent Reviews of Operating Experience*
- IN 89-44 – *Hydrogen Storage on the Roof of the Control Room*
- IN 91-56 – *Potential Radioactive Leakage to Tank Vented to Atmosphere*
- IN 92-18 – *Potential for Loss of Remote Shutdown Capability during a Control Room Fire*
- IN 92-32 – *Problems Identified with Emergency Ventilation Systems for Near-Site (within 10 Miles) Emergency Operations Facilities & Technical Support Centers*
- IN 93-06 – *Potential Bypass Leakage Paths Around Filters Installed in Ventilation Systems*

- IN 97-01 – *Improper Electrical Grounding Results in Simultaneous Fires in the Control Room and the Safe Shutdown Equipment Room*
- IN 97-79 – *Potential Inconsistency in the Assessment of the Radiological Consequences of a Main Steam Line Break Associated With the Implementation of Steam Generator Tube Alternate Repair Criteria*
- IN 97-82 – *Inadvertent Control Room Halon Actuation Due to a Camera Flash*
- IN 99-05 – *Inadvertent Discharge of Carbon Dioxide Fire Protection System and Gas Migration*

6. REGULATORY ISSUE SUMMARIES

- RIS 2001-09 – *Control of Hazard Barriers*
- RIS 2001-19 - *Deficiencies in the Documentation of Design Basis Radiological Analyses Submitted in Conjunction with License Amendment Requests*

7. GENERIC LETTERS

- GL 82-05 – *Post TMI Requirements*
- GL 82-10 – *Post-TMI Lessons Learned*
- GL 99-02 – *Laboratory Testing of Nuclear-Grade Activated Charcoal*

8. GENERIC ISSUES

Two issues related to CRH were identified by the ACRS in the early 1980s. These two generic safety issues (GSIs), which are discussed in NUREG-0933, are:

- GSI B-66, *Control Room Infiltration Measurements*, which identified that a key parameter affecting control room habitability is the magnitude of control room air infiltration rates. GSI B-66 was closed in 1983.
- GSI 83, *Control Room Habitability*, which identified that loss of control room habitability following an accidental release of external airborne toxic or radioactive material or smoke can impair or cause loss of the control room operators' capability to safely control the reactor. GSI 83 is still open.

APPENDIX CC

CRE MAINTENANCE AND SEALING

1. PURPOSE/SCOPE

The purpose of a control room envelope (CRE) sealing program is to monitor and maintain the pressure boundary penetrations such that the CRE habitability design and licensing bases are met and maintained.

2. CRE BARRIER CONTROL

Control of the CRE pressure boundary should be maintained at all times, Appendix E provides guidance on a breach program applicable to maintaining the CRE. In the event that planned maintenance work, testing or plant conditions will affect the CRE boundary, administrative control of the boundary should be procedurally maintained.

3. SEALING PROGRAM

A CRE assessment, as outlined in Appendix C, should consider the vulnerability of the envelope to leakage. The assessment should include a review of applicable building and system drawings and walkdowns. This information can then be used to identify all penetrations, prioritize them according to safety significance and develop a cost-effective sealing program. Such a program should include required inspection frequency, type of acceptable materials, and repair and test procedures. The method and frequency of inspection/repair/modification will depend on the type and safety significance of the seal.

The following is a list of typical penetrations and/or items that may have seals that would allow inleakage.

Abandoned pipe chases
AHU drains
AHU housing
Cable trays
Card readers
Conduits
Conduit penetrations
Control Room pressure boundary ducting outside CRE
CRE walls/ceilings/floors
Doors
Duct access panels
Duct expansion joints

Duct penetrations
Ducting traversing CRE and at higher pressure
Expansion joints or seismic gaps
Fan housing/shaft
Fire dampers
Filter housing/drains
Flanged joints
Gaps at building wall/floor/ceiling intersections
Gaps (required for fire damper thermal expansion) around fire dampers
Instrument air lines supplying CRE pneumatic components
Isolation dampers / shafts and gaps
Other instrument lines
Previous repairs with RTV sealant
Through bolts for hangers or equipment

Basic guidelines for inspection are as follows, however, specific requirements will vary with application, equipment vendor, type of sealant, etc. The term "approved," as used below, means that the material, component or technique has been approved by the plant engineering staff for the particular application.

3.1 Doors and Door Seals

The door should fit properly in the frame, with hinges securely attached. Door sweep should be in continuous contact with the floor or threshold for the entire width of the door. The gasket or seal should be an approved type, be free of cracks and should form a contact seal around the entire perimeter of the door. The door and frame should be free of breaks or open holes. With the door closed, the seal should be compressed against the door at all points.

3.2 Dampers

Dampers, associated linkages and actuators should be inspected for proper movement throughout the entire range of travel. If applicable, response to actuation signals and required cycle time should be verified. Commensurate with the design and safety analysis requirements, seal tightness should be verified. Frames should be checked for dimensional stability and be structurally sound. Frame-to-wall gaps should be minimized and consistent with vendor and Underwriters Laboratory (UL) requirements. Damper gaskets or seals, if required, should be an approved type, be free of cracks and should form a contact seal around the entire perimeter of the damper or where installed. The damper and frame should be free of breaks or open holes. With the damper closed, the seal should be evenly compressed against the damper at all points.

3.3 Gaps

All walls and intersections of the CRE should be visually inspected for integrity. Deficiencies in original construction, building differential settlement and deterioration of sealing materials can result in significant but unnoticed openings in the CRE. Due to equipment, cabling and other interferences, these areas are difficult to inspect. Repairs should be made using approved sealants or grouts, in accordance with vendor instructions.

3.4 Ducting, Duct Penetrations, Expansion Joints

Welded ducting is preferable for CR HVAC ducting outside the CRE and for other ductwork running through the CRE. For other types, all seams and connections should be sealed with an approved sealant, such as room temperature vulcanization or hardcast, and tested for leak tightness (Snoop or pressure decay methods). Duct penetrations should also be sealed with an approved sealant or grout.

Expansion joints should be sealed and firmly clamped at each end, and should be free of cracks, holes and or tears. If replacement of the joint is necessary, old adhesive should be removed from the mating surfaces should be inspected for defects. The length and width of the joint should allow for at least a one-inch overlap at each end. If the duct is located outside, additional width should be included for slack, and the material should be rated for sun and weather exposure, or be covered with an approved coating.

3.5 Electrical Cables, Conduits, Cable Trays

All electrical conduits and cable trays penetrating the CRE should be sealed with an approved sealant. Sealing of the inside of the conduits is especially important due to the large potential flow areas that may not be readily apparent during a normal visual walkdown or inspection.

Close attention should be paid to the condition of penetrations. Typically, many wall and floor penetrations are sealed with silicone foam. Although the penetration may appear to be sealed, inleakage may still be occurring due to shrinkage of the foam, voids in the seal due to cable relaxation, voids between the cables in cable bundles and improper cure of the foam. Delamination of material in wall seals is also possible.

Electrical conduits and cable trays provide a significant potential source of inleakage due to the large number of these components. Normal problem areas include unsealed conduits that terminate inside the CRE, intermediate connectors, junction boxes and panels, and non-leak-tight flexible conduit. Cable trays that are not filled completely by cable may leave voids that may have been overlooked during initial construction and sealing efforts.

3.6 Instrumentation Or Air Tubing

All instrumentation or air tubing penetrating the CRE should be inspected for potential leak paths such as open valves in abandoned lines or insufficient seal around the tubing.

3.7 Air Handling Unit (AHU) / Fan Housings and Shafts

Inlet and outlet flanges should be sealed with approved sealants, or preferably continuously welded on both sides. Any fan housing drains should have plugs installed. AHU drain loop seals should be verified periodically. Separate sections of AHU housings should have individual drains. High quality or double gaskets (not sealants) should be used on cover plates and access doors. Bolts on cover plates and access doors should be spaced on 3" to 4" centers. Recommended shaft seals are stuffing box seals, lip seals or mechanical type seals. An arrangement using a neutral purge gas is also effective.

3.8 Plumbing Equipment

All plumbing-related equipment in the CRE should be checked for potential leak paths. Floors, restrooms, kitchens, showers and water fountains have drains. These drains must have traps and should be inspected regularly to verify they are filled. Abandoned traps and piping should be permanently closed or sealed.

4. Alternatives to Sealing

As indicated above, there are various opportunities for degradation of the CRE to occur, such as normal equipment wear and changing operational practices. It may be advantageous, therefore, to consider alternatives to supplement the sealing program.

- **Problem:** Major equipment (AHUs, filters, dampers, etc.) and long duct runs located outside the envelope significantly increase the potential for unfiltered inleakage, and the effort required to detect and measure the inleakage.
    - **Solution:** Permanently moving this equipment or ducting inside the envelope by expanding the boundary walls, floors, etc, may be a cost-effective means of reducing this problem.
- **Problem:** Airflow balance inside the CRE may produce unfavorable pressure differentials within separate spaces in the CRE, leading to potential positive pressure differentials relative to the outside or adjacent spaces.
    - **Solution:** Careful flow balance testing may be required to resolve this problem. Maintaining CRE internal doors open, adding door louvers to internal doors or installing additional supply/return registers can improve pressure communication within the CRE and prevent this problem.

The design and operation of ventilation systems serving adjacent spaces, safety-related as well as non safety-related, should be reviewed to prevent unfavorable CRE-adjacent space pressure differentials post accident.

- This evaluation should consider scenarios both with and without off-site power.
- From a CRE perspective, an accident without a loss of off-site power (LOOP) may actually be worse due to continued operation of non-safety ventilation systems in adjacent spaces. In some cases, modifications should be considered to shut off non-safety exhaust or supply fans in the event that a LOOP does not occur.

5. POST-MAINTENANCE ACTIVITIES

During the time interval between periodic assessments and/or testing, various maintenance activities will occur that affects either the control room envelope or the performance of the control room HVAC system. This may result from preventive maintenance, corrective maintenance or implementation of modifications. It is important to perform a proper post-maintenance test (PMT) following these activities to ensure that the integrity of the CRE is maintained. The actual PMT may be a simple inspection to ensure that a gasketed surface has been sufficiently tightened to eliminate air gaps or it may be a full inleakage test if a major modification has significantly changed the boundary of the CRE.

The following examples are provided to illustrate possible PMTs that may be used to ensure that CRE integrity is maintained:

- A PMT that is performed under guidance of other documents, such as ANSI-N510 for filter change out, would not require additional testing in accordance with this document.
- A pipe that penetrates the CRE has a flange mounted pressure transmitter that requires replacing. The flange has a bolted gasket connection that is fully accessible for inspection. An adequate PMT could be a visual inspection to ensure that proper gasket crush is achieved after the new transmitter is installed.
- A door seal requires replacing. The geometry of the gap between the door and the frame is such that a visual inspection is difficult to perform. An adequate PMT could be the use of a “smoke pencil” to verify that the door gasket has been properly installed to minimize leakage.
- A major modification has been performed to incorporate the CR HVAC equipment room into the CRE. A full inleakage test may be required to ensure that the new configuration still meets the inleakage assumptions used in the accident analyses.

A modification has been performed on systems, structures and components outside the CRE that may affect CRE integrity. The complexity of the PMT would depend upon the effect of the modification on CRE integrity.

APPENDIX DD

TOXIC GAS ASSESSMENTS

This appendix provides information on performing an assessment of a hazardous chemical challenge to control room habitability.

1. SCOPE

This appendix applies to the release of hazardous chemicals from mobile or stationary sources, located off-site or on-site.

2. TOXIC GAS ASSESSMENT

The control room of a nuclear power plant should be appropriately protected from hazardous chemicals that may be discharged as a result of equipment failures, operator errors or events and conditions outside the control of the nuclear power plant. Potential sources of hazardous chemicals may be mobile or stationary and include storage tanks, pipelines, fire-fighting equipment, tank trucks, railroad cars and barges.

Guidance on hazard screening, risk evaluation, control room habitability evaluation, protection measures, and emergency planning is provided in Revision 1 to Regulatory Guide 1.78, *Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release* (Reference 1). This appendix provides information helpful in the areas of specifying toxicity limits, identifying sources of on-site and off-site hazardous materials, determining hazardous chemical release characteristics and applying updated atmospheric dispersion modeling techniques.

2.1. IDENTIFYING HAZARDOUS MATERIALS

2.1.1. OFF-SITE

Two federal laws were developed to provide information regarding hazardous chemicals at industrial facilities. The EPA and state and local governments maintain these data. Much of the information is easily available on the Internet or from state and local governments who receive reports from facilities.

The U.S. Department of Transportation Research and Special Program Administration maintain a HAZMAT database. The Emergency Planning and Community Right-to-Know Act (EPCRA) and the Clean Air Act Risk Management Program (RMP) require facilities to report on hazardous chemicals they store or handle. Both provide for public access to the information on these chemicals. The two regional government agencies that

receive the information are the Local Emergency Planning Committee (LEPC) and the State Emergency Response Commission (SERC). The information available from reporting facilities includes annual chemical inventories or lists of chemicals stored or handled, and accident data like worst-case release scenarios.

It is important to remember that only certain toxic chemical releases need to be considered. The number of facilities covered, for example, may be limited because only certain chemicals and threshold settings are required for reporting. In addition, the quantities for chemicals, if reported, are in broad ranges; it may not be possible to tell actual quantity. Therefore, a local resource (such as the fire department) is sometimes the best resource. Fire departments receive the same information as the LEPC but possess a broader knowledge of the community and smaller facilities.

Information on hazardous materials transported throughout the state via the highways can be obtained from the SERC or the state transportation department. The same agencies may have information on the transport of hazardous materials via railways. The railways should also be contacted directly. Information on the transportation of chemicals via rivers, the Great Lakes and coastal marine traffic can be obtained from the U.S. Coast Guard.

Internet sources of data on hazardous materials available at the time this appendix was written include the following:

LEPC/SERC contacts:
www.rtk.net/lepc

Toxic release information:
www.epa.gov/tri

Material Safety Data Sheets:
www.hazard.com

RMP data:
www.epa.gov/enviro

Right-to-Know data:
www.rtk.net or www.scorecard.org

2.1.2. ON-SITE

A facility's EPCRA and RMP reporting information is useful to determine the types and quantities of hazardous materials on-site. This information should be compiled with a site-wide "walk through" using as a checklist the list of EPCRA and RMP hazardous chemicals. The checklist should be compared against a recent chemical inventory, which can usually be supplied by a facility department like purchasing, chemistry or stores. The walk through should also emphasize identifying permanent or temporary use of bulk storage containers or tanks such as propane as well as storage of asphyxiates like nitrogen and carbon dioxide.

2.1.3. TOXIC LIMITS

The hazardous chemical toxicity limits presented in Regulatory Guide 1.78 are based on the IDLH exposure levels published by the National Institute for Occupational Safety and Health. Asphyxiating chemicals should also be considered, if they are stored on-site in significant quantities such that an accidental release could result in the displacement of a significant fraction of the control room air. According to OSHA Regulations, an oxygen deficient atmosphere (for permit-required confined spaces) is one containing less than 19.5 percent oxygen by volume (29 CFR 1910.146).

2.2. EVALUATING POTENTIAL ACCIDENTS

An existing toxic gas evaluation should be revised if: (1) the assumed inleakage value is found to be non-conservative; (2) a new significant source of hazardous chemical is identified in the vicinity of the plant; or (3) the quantity of chemicals is greater than previously assumed.

For each chemical considered, the value of importance is the maximum concentration that can be tolerated for two minutes without inducing physical incapacitation (i.e., severe coughing, eye burn or severe skin irritation) of an average human. NRC expects that two minutes is sufficient time for a control room operator to don a respirator and protective clothing.

If detailed calculations show that the two-minute toxicity limits will be exceeded in the control room for any time period for any given release scenario, compensating measures should be implemented.[14] As a minimum, a detection mechanism for each hazardous chemical release should be available. Such a system could include the installation of detectors or, if the buildup of the hazardous chemical in the control room is at a slow rate, human (i.e., smell) detection may be appropriate.[15] The detailed evaluation should demonstrate that if detection results in placing the control room in accident mode (i.e., automatic or manual closure of isolation dampers), the two-minute toxicity limits will not be exceeded. Otherwise, it would be expected that the control room operators will take protective measures (i.e., don protective equipment) within two minutes after the detection to avoid prolonged exposure at the two-minute toxicity limit levels.

There are additional aspects beyond those discussed in Regulatory Guide 1.78 that should be considered when performing detailed evaluations of control room habitability as described below.

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14 Compensating measures are not required for transportation-related accidents if it can be shown that the probability of occurrence of the initiating events leading to control room concentrations exceeding toxicity limits are less than 10^{-6} per year as discussed in Section 3.2 of Regulatory Guide 1.78.

15 The American Industrial Hygiene Association has established odor thresholds for a number of toxic chemicals (Reference 2). Some of these data are presented in NUREG/CR-6624 (Reference 3).

- **Release Characterization.** The release characterization defines the physical state of the chemical as it leaves its containment and the manner in which it enters the atmosphere to form a vapor cloud. Since hazardous chemicals may be stored under pressure or under refrigeration, they can be emitted from a container as a liquid, a vapor or both, depending on the chemical's physical properties. For example, released liquids may form a vapor cloud through volatilization. A liquid can be volatized either completely or partially as it is released, forming a vapor cloud or a vapor and droplet mixture. Conversely, chemicals stored as a gas may partially or completely condense to form liquid droplets when released. Condensed vapor may fall to the ground to form a pool that, in turn, volatizes to the atmosphere.

- **Atmospheric Dispersion:** The NRC sponsored the development of a computer code system for evaluating control room habitability called HABIT (References 4 and 5). Two of the HABIT program modules, EXTRAN and CHEM, can be run in sequence to predict chemical concentration and exposures in the control room. The EXTRAN program computes atmospheric chemical concentrations associated with a release of a toxic chemical and the CHEM program use the results of EXTRAN to determine the associated chemical exposures in the control room.

  In executing EXTRAN, the user should be aware of the following:

  - EXTRAN does not calculate release rates and, as such, the user must calculate the release rate outside the model for the *maximum concentration-duration accident*.
  - Regulatory Guide 1.78 suggests the atmospheric dilution factors to be used in the analysis should be that value which is exceeded only 5 percent of the time. Although EXTRAN uses a simple Gaussian dispersion model, the concentrations predicted by the model do not vary inversely with the wind speed because building wake correction is not a linear function of wind speed. In the case of evaporation, the highest emission rates are also related to high wind speeds. In addition, the building wake corrections are not particularly sensitive to atmospheric stability. Consequently, a range of meteorological conditions should be executed for determining the 5 percent atmospheric dilution factors.

Several references describing methodologies for calculating release characterizations (including release rates) include EPA's "Workbook of Screening Techniques for Assessing Impacts of Toxic Air Pollutants" (Reference 6), "Risk Management Program Guidance for Offsite Consequence Analyses" (Reference 7) and "Guidance on the Application of Refined Dispersion Models to Hazardous/Toxic Air Pollutant Releases" (Reference 8). The latter reference also provides guidance on how to execute several generally available dense gas atmospheric dispersion models.

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2. AIHA, "Odor Thresholds for Chemicals with Established Occupational Health Standards," American Industrial Hygiene Association (AIHA), 1989.

3. L. B. Sasser, et al., "Recommendations for Revision of Regulatory Guide 1.78," NUREG/CR-6624, Pacific Northwest National Laboratory, U.S. Nuclear Regulatory Commission, November 1999.

4. S.A. Stage, "Computer Codes for Evaluation of Control Room Habitability (HABIT)," NUREG/CR-6210, Pacific Northwest National Laboratory, Richland, Washington, U.S. Nuclear Regulatory Commission, June 1996.

5. J.V. Ramsdell and S. A. Stage, "Computer Codes for Evaluation of Control Room Habitability (HABIT V1.1)," NUREG/CR-6210, Supp. I, PNNL-10496, Pacific Northwest National Laboratory, Richland, Washington, U.S. Nuclear Regulatory Commission, November 1998.

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7. USEPA, "Risk Management Program Guidance for Offsite Consequence Analysis," EPA-550-B-99-009, U.S. Environmental Protection Agency, December 1992.

8. USEPA, "Guidance on the Application of Refined Dispersion Models to Hazardous/Toxic Air Pollutant Releases," EPA-454/R-93-002, U.S. Environmental Protection Agency, April 1993

APPENDIX EE

GLOSSARY OF TERMS

1. PURPOSE

This appendix contains definitions applicable to control room habitability issues.

2. DEFINITIONS

AIR CHANGE FLOW (from ASTM E741): The total volume of air passing through the zone to and from the outdoors per unit of time.

AIR CHANGE RATE (from ASTM E741): The ratio of the total volume of air passing through the zone to and from the outdoors per unit of time to the volume of the zone.

BOUNDARY: A combination of walls, floor, roof, ducting, doors, penetrations and equipment that physically form the CRE.

BREACH: Any work activity or testing that creates or enlarges an opening through a barrier, which would allow the propagation of a hazard through the barrier.

- Modification (addition, removal or degradation) of a penetration seal or structural component
- Core boring
- Blocking open a door/hatch or damper
- Modification (addition, removal, or degradation) of a door/hatch or damper

CONTROL ROOM ENVELOPE (CRE) - The area within the confines of the control room boundary that contains the spaces Operators inhabit and control the plant for normal and accident conditions. This space is protected for normal operation, natural events, and accident conditions.

CONTROL ROOM ENVELOPE (CRE) INTEGRITY - The condition whereby the control room habitability system (CRHS) are functioning to ensure the protection of the Operators in the CRE during normal and accident conditions.

CONTROL ROOM HABITABILITY SYSTEMS (CRHS) - The plant systems that help ensure CRE integrity. This includes the control room emergency ventilation system (CREFS) and the control room heating, ventilating and air-conditioning (CR HVAC) systems. The CREFS could be a subset of the CR HVAC and is used in that context in this document. This also assumes the control room (CRB) is intact. The CRB is the physical barrier that defines the CRE.

FILTERED INLEAKAGE: This is leakage that occurs at a location that allows contamination to be filtered prior to the air entering the habitability zone. An example is duct leakage on the suction side of a pressurization filter system where the duct is outside the control room envelope. Radionuclides are removed from this air prior to it entering the habitability zone. There is no filtering assumed for toxic gas events.

INOPERABLE BARRIER: A barrier that is inoperable such that it cannot fully perform its intended function.

INTEGRATED COMPNENT GAS TEST: A test method that provides the total in-leakage value by summing the results from individual leakage location tests. The test method distinguishes between filtered and unfiltered in-leakage, and identifies the in-leakage contribution of individual components

INTEGRATED TRACER GAS TEST: A tracer gas test to determine total leakage of the CRE. The tracer gas test is actually measuring the amount of air changing in the space (i.e., the air going out is being replaced by the air going in). This particular test does not locate leaks; it only provides a value for total inleakage.

LICENSING BASIS INLEAKAGE: This is the inleakage that is used in the plant design basis radiological analysis with design basis values of other plant parameters to calculate control room operator dose during a licensing basis accident.

MAXIMUM ALLOWABLE RADIATION INLEAKAGE: This is the value assumed in the current licensing basis analysis. Calculated inleakage value in cfm that will result in the control room operators receiving the maximum allowable dose with design basis inputs of all other parameters to the plant radiological analysis. This value must be calculated for each plant.

MAXIMUM ALLOWABLE RADIATION INLEAKAGE FOR OPERABILITY DETERMINATION: This is the calculated inleakage value in cfm that will result in the control room operators receiving the maximum allowable dose with realistic but verifiable inputs of all other parameters to the plant radiological analysis. This value may take credit for compensatory measures allowed by GL 91-18.

MAXIMUM ALLOWABLE TOXIC GAS INLEAKAGE: This is the maximum calculated inleakage of toxic gas that will result in the control room remaining habitable for the bounding toxic gas hazard evaluation.

PENETRATION: An opening in a CRE boundary wall or floor/ceiling, other than a door/hatch, which contains materials or mechanical devices that prevent the propagation of a hazard through the barrier. Some examples are:

- Penetration seals
- Structural material
- Dampers for example, fire, tornado, etc.

TRACER GAS (from ASTM E741): A gas that can be mixed with air in very small concentrations in order to study air movement.

UNFILTERED INLEAKAGE: This is leakage that occurs at a location in the habitability system that allows air to enter the control room envelope without any contaminants being removed at the point of entry. Examples would be penetrations and dampers that are at a negative pressure with respect to potentially contaminated surroundings and located such that radionuclides are not removed prior to the inleakage entering the control room.