CRITICAL REVIEW: HISTORICAL PERSEPECTIVE AND EVOLUTION OF COMMERCIAL NUCLEAR UTILITY CONTROL ROOM VENTILATION SYSTEMS

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Abstract

The Main Control Room (MCR) of any nuclear station is the epicenter for control over many systems and components critical for safe operation of the station both in normal and abnormal plant conditions. The MCR is contained within a larger habitable zone, the Control Room Envelope (CRE) or emergency zone. Typically, the design and licensing basis for the CRE is that it is accessible and habitable during all plant conditions. The CRE generally contains such areas as the MCR, kitchen, offices and sanitary facilities yet may include additional areas such as HVAC Equipment Rooms, Auxiliary Electric Equipment Rooms (AEER), Cable Spreading Rooms (CSR), Switchgear Rooms or a Main Security Control Center (MSCC). The physical layout of the CRE varies from station to station but the habitability requirements generally protect the MCR operators from radiation and toxic gas regardless of the origin (on-site or off-site). How this habitability is maintained has been an evolutionary process from the onset. The environment within the CRE must meet specific parameters such as temperature, relative humidity, noise level, airflow rate and lighting level based upon the specific licensing bases of the station. To accomplish this controlled environment for personnel as well as equipment, ventilation systems are designed, tested, maintained and operated to specific design criteria, regulations, regulatory guides, standard review plans, industry guidelines and standards and procedures. Understanding the nuclear power plant licensing bases and the design bases for the control room ventilation system and integrating these into current day regulatory interpretations is a dynamic process and remains a challenge for the industry. HVAC systems have normally been assumed to be self-sustaining and for the most part this has been true. In the last few years it has become apparent that these system warrant further attention and scrutiny especially with the advent of the ability to quantify the unfiltered inleakage into the CRE.

Introduction

In March of 1979 the nuclear stations were first informed of the Three-Mile Island (TMI) actions for the operating reactors. After numerous discussions, the USNRC approved the requirements of the TMI action plan for those stations near term operating licensing and five requirements for the operating reactors. Following the accident at Three Mile Island Unit 2, the NRC staff developed the Action Plan, NUREG-0660, 'NRC Action Plan Developed as a Result of the TMI-2 Accident' (May 1980, Rev 1 August 1980) to provide a comprehensive and integrated plan to improve safety at power reactors. Specific items were approved by the Commission for implementation at reactors. Specific items include information about schedules, applicability, method of implementation, review, submittal dates, and clarification of technical positions. The total set of TMI-related actions were collected in NUREG-0660, but those items that the Commission approved for implementation were included in NUREG-0737.

Task Action Plan NUREG 0660 implementation requirements and schedule, were distributed to all licensees to assure that control room operators would be adequately protected against the effects of accidental release of toxic and radioactive gases and that the nuclear power plant could be safely operated or shut down under design basis accident (DBA) conditions. All licensees were required to make a submittal to the NRC regardless of whether or not they met the criteria of the Standard Review Plans. This submittal was due by January 1, 1981. Implementation issues arose quickly and were clarified in September 1980 followed by several workshops for implementation assistance. Implementation of III.D.3.4 continued and NUREG 0737 was issued in October 1980 under 10 CFR 50.54 (f). NUREG 0737 requested confirmation of the degree of implementation and dates to be met by the licensee.

In May 1982, Generic Letter (GL) 82-10 was issued which addressed III.D.3.4 items that would be implemented after March 1982. It was later confirmed in March 1983 by order that Post-TMI requirements improve the level of safety at stations. It further required that commitments would be required in the interest of public health and safety.

Standards Review-Air Cleaning Systems

Regulatory guides, standard review plans, industry codes and standards provide specific guidance but carry less authority than does the General Design Criteria (GDC). Although the GDC verbiage is general in nature, it clearly requires the use of an MCR and that air cleaning systems should be provided in the design to protect the MCR operators.

Regulatory Guides

Two regulatory guides were written for commercial nuclear power stations and can be applied to control room air cleaning systems to ensure the control room operators would be protected. Regulatory Guide 1.52 (March 1978), "Design, Testing, and Maintenance Criteria for Post Accident Engineered Safety Feature Atmosphere Cleanup System Air filtration and Adsorption Units of Light Water Cooled Nuclear Power Plants," contains criteria for control room air cleaning systems to operate in a post accident environment.[1] Regulatory Guide 1.52 'applies only to post-accident engineered-safety-feature atmosphere cleanup systems designed to mitigate the consequences of postulated accidents' therefore it 'does not apply to atmosphere cleanup systems designed to collect airborne radioactive materials during normal plant operation, including anticipated operational occurrences.' Environmental and system design criteria, component design criteria, qualification testing, maintenance, and in-place testing are discussed in detail in each section.

Regulatory Guide 1.140 (March 1978), "Design, Testing, and Maintenance Criteria for Normal Ventilation Exhaust System Air filtration and Adsorption Units of Light-Water-Cooled Nuclear Power Plants," contains similar information pertaining to normal ventilation systems that are continuously in operation at nuclear power plants. [2] Regulatory Guide 1.140 'applies only to atmosphere cleanup systems to collect airborne radioactive materials during normal plant operations, including anticipated operational occurrences and addresses the atmosphere cleanup systems including the various components and ductwork in the normal operating environment.'

Air cleaning systems per Regulatory Guide 1.52 or 1.140 both provide the ability to deliver air in sufficient quantities that is clean and free of toxic chemicals to afford the control room operators a suitable atmosphere in which to perform their duties. Non-Safety Related (NSR), non technical specification, normal ventilation system air handling units without the benefit of carbon or HEPA filtration are often used to supply outside air that is isolated in the event of a toxic chemical or radiation release. Air filtration systems meeting the requirements of Regulatory Guide 1.140 criteria is imposed for normal operation. Although designed to seismic Category 1, it often times is not redundant and credit is not normally taken for this filtration during an accident analysis. The air filtration units designed to Regulatory Guide 1.52 are also designed to seismic Category 1 and are redundant and Safety Related. These units contain demisters to remove entrained moisture, pre-filters to remove the majority of upstream particulate matter, upstream HEPA filters, a carbon adsorption bed, and downstream HEPA filters. Also included in the filtration unit are ducting, fans, necessary instrumentation and heaters. The efficiency of these units is often misrepresented in an accident analysis.

ANSI/ASME Standards

More specifically, ANSI/ASME N509-1976, "Nuclear Power Plant Air Cleaning Units and Components", covers the design, construction, and testing of units and components which make up high efficiency air and gas cleaning systems used in nuclear power stations to bring in filtered clean air from the outside atmosphere.[3] ANSI N510-1975, "Testing of Nuclear Air-Cleaning Systems", provides the methodology for field testing of nuclear air cleaning systems. [4] Additionally, the standard provides the basis for establishing that air flow and air flow characteristics of the system are adequate to achieve the desired air cleaning function, that there are no bypasses or leaks and that components are installed properly and are in good working order. These standards have been updated commensurate with the updated industry methodologies.

Each of the atmosphere cleanup systems commonly referred to as charcoal filtration units are periodically tested to verify that the charcoal maintains the ability to remove radioactive material from the atmosphere that may be released in an accident. Concern for standardization of charcoal laboratory testing was issued as NRC Information Notice 87-32 (July 10, 1987) where deficiencies were noted in the testing of nuclear-grade activated charcoal used for accident mitigation in nuclear facilities. This resulted in only testing laboratories capable of controlling critical test parameters and achieving acceptable test results, being allowed to perform the laboratory testing for the nuclear industry.

Control Room Ventilation System Critical Parameters

The ventilation system requirements for the control room assumes that hazardous chemicals are not stored within the control room envelope but are kept outside. Generally keeping the control room at a slightly positive pressure during normal operation, and at +1/8 iwg during accident conditions, to all adjacent areas mitigates the intrusion of such chemicals. Fumes generated within the CRE proper are assumed to be alleviated by the air turnover rate. The MCR pressure requirement both during normal and accident conditions to all adjacent areas is achieved and maintained by periodic surveillance testing.

Standard Review Plan

Standard Review Plan (SRP) 6.4 was issued (Rev 2, July 1981), and stated that 'all critical areas requiring access in the event of the accident be included within the zone which refers to the MCR, kitchen, sanitary facilities etc.' [5] Plants that did not meet SRP 6.4 were to perform the necessary evaluations and identify any modifications. A radiological analysis was to be performed to consider the LOCA as the DBA with pathways as described in SRP 15.6.5 and its appendices. Other DBA were to be considered if they were shown to be more limiting. The staff recognized that technical specification changes would be required to implement this process. SRP 6.4 provided guidelines to assure that all plant operators were adequately protected against the effects of accidental releases of toxic and radioactive gases. Further, per SRP 6.4, the control room envelope is to be 'maintained as the backup center from which technical support center personnel can safely operate in the case of an accident' [5], therefore it was required to be accessible during an accident.

Toxic Gas

For guidance in meeting the SRP 6.4 guidelines on toxic gas and chlorine release, several references have been provided. Regulatory Guide 1.78, "Assumptions for Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release", lists the most common chemicals that in sufficient quantities could result in the control room being uninhabitable.[6] The levels of toxicity are listed and the design recommendations to assess the capability of the control room to withstand the release of hazardous chemicals. These chemicals can occur either on-site or in the local area. Regulatory Guide 1.78 stipulates 2-minutes to be the maximum exposure without physical incapacitation by the average human. This provides time for any operator to obtain and don any respirator equipment. Limits are placed on the storage of toxic gases adjacent to the nuclear facility to preclude their release should adverse weather conditions be present.

Additionally, chlorine storage on site is fully addressed in Regulatory Guide 1.95, "Protection of Nuclear Power Plant Control Room Operators Against An Accidental Chlorine Release". Note that 'control room' is defined to include all zones serviced by the emergency ventilation system. Design considerations assume automatic isolation of the control room, the control room being leak tight and that respirator equipment is available. Only two minutes is allowed at 15 ppm chlorine before the average human becomes incapacitated. Some nuclear stations have deactivated the chlorine sensing systems at the outside air intake because of the diminished chlorine danger due to allowable storage limitations and excessive maintenance requirements based on unreliable instrumentation for chlorine detection. Special care must be exercised by all nuclear stations to ensure toxic gas intrusion from storage meets the guidelines set forth in the Regulatory Guide. A concern not addressed by this regulatory guide is the temporary storage of various chemicals that are not necessarily missile protected per GDC Criterion 4. The concentration of one chemical alone does not constitute a toxic concern. However, the combination with other chemicals stored adjacent to each other that could combine in the event of adverse weather conditions could affect the atmosphere in the control room.

Key Parameters

Temperature and relative humidity control are also a requirements for the MCR. This is not only to address the comfort of the operators but also that of the equipment and the control of static electricity. Depending on the licensing basis for the individual nuclear power plant one should reference the ASHRAE 55 guidelines for comfort zones. Temperatures of 85°F may be acceptable even at elevated relative humidity however a lower humidity is recommended. Sustained air temperatures in excess of 104°F detract from operator response and the ability to function.

Noise level control is a distinctive requirement for the smooth and efficient operation of the control room. Per NUREG 0700, "Guidelines for Control Room Design Review" (Sept 1981), 65 dba is the limit for noise levels in the control room. When ventilation systems are balanced or modified that could affect the flow rate, the change in noise level should be taken into consideration and carefully monitored. Noise levels should be verified under normal as well as accident ventilation lineups to ensure compliance.

Main Control Room Habitability-GDC 19

The basic regulatory requirement for the MCR in a nuclear station is General Design Criteria 19 of Appendix A to Part 50 of Title 10 of the U.S. Code of Federal Regulations-10CFR50, Appendix A). Other regulations are affixed to the control room but apply to fire protection such as the technical specifications, 10 CFR 50.36, 10 CFR 50.48 and 10 CFR Part 50, Appendix R. The fire protection issues will not be discussed in this paper.

Per SRP 6.4, the control room habitability design was to be considered acceptable if GDC 4, "Environment and Missile Design Bases", GDC 5, "Sharing of Structure, Systems and Components" and General Design Criteria 19, "Control Room", were met. The control room emergency zone 'should be limited to those spaces requiring frequent operator occupancy. Spaces such as battery rooms, cable spreading rooms, or other spaces not requiring continuous or frequent occupancy after a design basis accident generally should be excluded from the emergency zone' i. e. CRE. Some stations have included such rooms in the CRE yet during CRE reconstitution efforts, some rooms have been removed from the CRE. Be advised that the supply and return ducting runs are an essential part of the CRE as well. It was further advised that the emergency zone 'should be included on one floor, with the areas included in the zone being contiguous.' It is quite obvious that this design was not accomplished in many nuclear plant designs. Some CRE areas with attached ducting extend hundreds of feet from the MCR. This design becomes very challenging from an inleakage maintenance standpoint.

Some stations were built and licensed prior to General Design Criteria (GDC) 19 being issued and refer to GDC 11 or drafts of GDC 19. GDC 11 states that 'The facility shall be provided with a control room from which actions to maintain safe operational status of the plant can be controlled. Adequate radiation protection shall be provided to permit access, even under accident conditions, to equipment in the control room or other areas as necessary to shut down and maintain safe control of the facility without radiation exposures of personnel in excess of 10 CFR 20 limits. It shall be possible to shut the reactor down and maintain it in a safe condition if access to the control room is lost due to fire or other cause.'

GDC 19 requires that '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 and 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.'

The applicability of General Design Criteria 19 appears to differ between the staff and the industry. A USNRC memo indicates that the staff will not apply GDC 19 to nuclear power plants with construction permits issued prior to May 21, 1971 and would not require exemptions to GDC 19. [7] According to the staff, GDC 19 and III.D.3.4 apply to all stations and each should consider their individual licensing bases and commitment to the NRC. According to NUREG 0737, TMI Action Item III.D.3.4 provides the control room habitability evaluation for plants with control rooms that do not meet GDC-19 and SRP 6.4. Per III.D.3.4 the DBA radiation source term should be for the LOCA containment leakage and ESF leakage contribution outside containment. Additionally, BWR's should include any leakage from main steam isolation valves (MSIV) and add this to the containment leakage and ESF leakage following a LOCA. These commitments were confirmed by an order in 1981. SRP 6.4 is applicable to plants with operating license and construction permits docketed after May 17, 1982. SRP 6.4 is a general guideline that establishes the review criteria by the staff, however compliance is not mandatory. The existing plant licensing basis varies with each station depending on the vintage of the plant and the extent of the commitments to GDC-19 and the SRP. Each station should consider the accident sequences, dose limits and the methodology for estimating dose and inleakage rates to further ensure GDC 19 dose limits are being met. Special care should be exercised to ensure an Ureviewed Safety Question (USQ) does not exist. Recent discussions in a workshop environment on USQ criteria have indicated that the staff would consider it an USQ if one part of the entire entity moves in the non-conservative direction even though the limit is not exceeded. [8]

Current MCR Habitability Issues

Control room habitability and integrity is a dynamic process that is often challenged and reconstituted on a continuing basis. Control room habitability requires the maintenance of the CRE integrity to control the unfiltered inleakage to the licensing analysis value contained in the current dose calculation for the most limiting accident. Charcoal filtration units with adequate adsorption material filter the non-noble gas isotopes in the outside air introduced into the CRE by ventilation systems or inleakage. Toxic gas intrusion assumes a properly maintained envelope both in accident and normal ventilation lineups to allow operators sufficient time to take the necessary action to withstand the consequences of such a challenge.

Unfiltered Inleakage

The licensing bases and design bases for each station has identified the allowable unfiltered inleakage under the most limiting accident scenarios. Although the tracer gas technique has been used for over 20 years in other industries it has not been extensively applied to the nuclear industry until the last few years. The tracer technique has been used to determine damper leakage, system flow rate where pitot tube traverse is not possible, and of course the CRE inleakage. Tracer gas technique is currently being used to quantify the amount of unfiltered inleakage that enters the CRE from ducting or other means. There is evidence to show that GDC 19 limits can not be met with just a positive pressurized control room because it does not account for unfiltered inleakage. Several nuclear power stations have performed initial tracer gas CRE inleakage tests in an effort to quantify unfiltered inleakage. Of the approximately 8-10 stations to test for CRE inleakage, none have met the inleakage assumed in the respective stations' dose calculations. These tests were done on BWR as well as PWR with the ducting inside and outside the CRE. In fact the inleakage prior to any sealing action has been far in excess (2-50 times) of the inleakage assumed in the accident analysis. As you can see from the papers to be given during this air cleaning conference, this is a major concern for the industry as well as the staff.

Alternative Testing Methodology

One may ask, is tracer gas testing the only methodology for determining unfiltered inleakage into the CRE? Should stations commit to periodic tracer inleakage tests? How will variations in allowable inleakage be affected by the new source terms? Is there a test method available that can serve as an indicator for the condition of the CRE boundary without a full tracer gas inleakage test? To address these issues, consider the following discussion.

The new source terms are not available as yet and are part of an on-going pilot program involving five nuclear stations by the USNRC. Although the new source terms may provide some relief, there will still be unfiltered inleakage concerns and issues. Tracer gas has proven to be an effective tool in quantifying unfiltered inleakage with the CRE. Some utilities have expended exorbitant amounts of time and resources in ensuring the CRE meets the licensing bases for unfiltered inleakage. Comparatively, the sealing effort can be 10 times the cost of the tracer gas test based upon needed resources to locate and repair the leaks as the sealing effort progresses.

One alternative to consider is to press-up the CRE to maintain a positive pressure with substantial pressure margin. Ensure the ducting system has properly sealed seams and joints or the system has welded seam ducting in the most sensitive areas (ducting under negative pressure outside the CRE). Additionally, isolation dampers shown to be bubble tight could substantiate an argument not to perform the tracer inleakage test. However, the question to be answered is, how do you know that you are currently meeting your unfiltered inleakage limit?

A more appropriate method may be to methodically seal the CRE using proven techniques and guidance, perform an initial tracer gas inleakage test and then maintain the CRE integrity through administrative means. Selective data recording after the sealing process to establish a baseline, could provide a litmus for identifying degradation of the CRE boundary. Periodic verification of the CRE boundary could be performed at extended intervals such as every 10 years. Careful examination of key data points may allow the station to quantify what the boundary status is to qualify for acceptable inleakage.

CRE Pressure Boundary Performance

Some of the poorer performing designs appear to be those systems with low recirculation rates, recirculation only, low make-up airflow rates, positively pressurized ducting passing through the CRE originating outside the CRE, and those which assume a very low unfiltered inleakage (10 cfm) value in the dose calculations. Both inleakage (GDC 19) and out-leakage (pressure) are concerns because if the GDC 19 limits are met for inleakage, the pressure boundary out-leakage may be a problem or vice versa.

Sources of out-leakage from the CRE detract from the ability to pressurize the CRE. These range from door seals, cracks, ducting leaks and poor penetration seals. Door seals tend to be a large source of out-leakage from the CRE diminishing the ability to maintain an acceptable positive pressure. Door seal replacement can be both, time consuming and risky. One methodology that has been utilized at one station to track door seal deterioration has been the use of thermography.[9] Thermography is a good predictive maintenance tool when a sufficient differential temperature exists. The leaking air coming from inside the CRE is easily detected using thermography. Baseline thermograms can be taken and monitored for deterioration over time. Cable leaks have also been detected using this method.

Sources for inleakage vary depending on the configuration of the system. Ducting under a negative pressure that re-enters the CRE can contribute to unfiltered inleakage. Pittsburgh lock seam ducting is more susceptible to inleakage than welded longitudinal seam ducting due to potential joint leakage. Welded seam ducting is not completely immune to inleakage because of tears or splits after years of operation. Supply ducting on the suction to supply fans will add to the inleakage factor as well. It is important to ensure all the supply air needed for CRE pressurization gets to the CRE. Supply fan exhaust ducting leaks however small, can add up and detract from the pressurization effort of the CRE. Ducting with traverse hole plugs of neoprene material are susceptible to degradation in the event of a fire or they may crack and leak over time. The use of vent locks is a recommended alternative to neoprene plugs.

Sealant

Regulatory Guide 1.52 Section 5.c, states 'the use of silicone sealant or any other temporary patching material on filters, housing, mounting frames, or ducts should not be allowed.' Section 3.n of Regulatory Guide 1.52 states, 'ductwork should be designed, constructed, and tested in accordance with the provisions of Section 5.10 of ANSI N509-1976.' ANSI N509-1976 Section 5.10.4 (Duct Construction) states that ducting may be constructed 'in accordance with SMACNA-High Velocity Duct Construction Standards (Pittsburgh Lock or Acme Lock Seam) as required to meet structural or leaktightness requirements'. Standard practices for the manufacture of a Pittsburgh Lock seam duct is to apply a bead of silicone sealant in the seam area. Additionally, Regulatory Guide 1.52 references ERDA 76-21, "Nuclear Air Cleaning Handbook, shows in Table 5.5, 'Guide for Selecting Recommended Duct Construction Levels for Various Applications in Nuclear Facilities', that Level 3 ducting is allowed. Level 3 ducting that meets the SMACNA- High Velocity Duct Construction Standards, requirements uses silicone sealant or the equivalent, on non-welded longitudinal seams, transverse joints. The SMACNA Standard also states that the entire exterior of the ducting may have hard-cast treatment. Hard Cast as well as silicone sealant appear to be allowed by the standards however appear to be in conflict with Regulatory Guide 1.52. Verbatim compliance issues are at the forefront of this concern. The staff is concerned with relying on visual inspection because how is one to know when the sealant has degraded over time with temperature transients and vibration experienced by the ductwork.

Concerns with the use of silicone sealant or hard cast tape type material to seal ducting is that the material would become brittle or crack over time when exposed to vibration, radiation and/or temperature ranges experienced in a nuclear plant environment. The concern that the material may deform and lose its ability to remain attached to the ducting is another concern. Data sheets for both materials indicate both will be acceptable for the function they perform. Additionally, radiation and temperature testing has been performed on both materials at Wylie Labs for Pittsburgh Lock seam application with acceptable results. [10]

Tracer Gas Testing-General

Some utilities have committed to periodic tracer gas testing of the control room envelope to quantify unfiltered inleakage. Periodic inleakage testing is not well supported in the industry. The normal cost of an initial tracer test is minimal compared to the total scope of CRE reconstitution and tracer gas retest are even less. Other stations have committed to a periodic visual inspection/walkdown by surveillance of the system to determine any degradation. The concern for walkdowns is how does one quantify the degradation? How will you know when to tracer test again? The staff is currently suggesting that tracer testing is a valid test method to accurately quantify the amount of unfiltered inleakage. The tracer test appears to be cost effective however, as previously stated, the sealing effort can expand the scope of the expenditures. What is the feasibility of a reconnaisance test? This test could be the litmus for determining when to retest. The 'reconnaissance test' would involve area dispersal of the tracer gas outside the CRE and testing for the presence of tracer gas within the envelope. NHUG in the interest of CRE habitability has consulted an experienced tracer gas vendor to consider the feasibility of such a test. [11] How to perform the test and how to quantify such a test will be the challenge?

Producing an inleakage number during a tracer gas inleakage test, accurate or not, can be achieved by anyone who performs this test and uses ASTM E741 as a guideline. [12] ASTM E741 provides guidance on tracer gas testing. The challenge is how to apply station system idiosyncrasies to the inleakage process. The tester must apply experience and knowledge of the respective station's system to properly apply the guidance of the ASTM standard. A number that is too high or too conservative can be misleading and result in severe and unnecessary expenditures by the utility. According to experienced testing facilities, a deficient test model will most likely fail high and conservative. NHUG, the Nuclear HVAC Utility Group, is supporting an effort to ensure accurate test results for the industry. As always, the licensing basis for each station should be considered when considering the tracer gas inleakage test.

General Licensee Weaknesses

System Operations

Based upon several past NHUG Conferences, several weakness that could affect CR Habitability have been identified and are listed as follows:

1. Licensees should exam the station FSAR to ensure implications of positive, negative or differential pressure are met and the instrumentation that ensures such compliance is calibrated and checked by a PM or surveillance action. Reconciliation may be in order to determine the use of non-safety related equipment to perform a safety related function.
2. Licensees should ensure that the airflow rate numbers listed on the P&ID coincide with supporting calculations and FSAR/Technical Specification numbers.
3. Licensees should ensure the operability numbers for HVAC contained in the FSAR and Technical Specifications allow for instrument error or inaccuracies.

4. Licensees should ensure aggressive effort is made to comply with standards such as ANSI N509/510 and the words therein or take exception to specific sections.
5. Licensees should not wait an extended period of time (a week or more) prior to removing a carbon sample for laboratory testing following fire, painting or chemical release.
6. Licensees should know if the design documents P&ID, Calculation, FSAR and Technical specifications refer to ACFM or SCFM especially when the measurement is taken in the field.
7. What action is taken when the outside atmosphere is beyond the design bases for high and low temperatures?
8. Changes or challenges to the licensing bases should be realized by all individuals involved. As a minimum the design engineers and system managers should be fully aware of the design and licensing bases for the CRVS.
9. Ensure differential pressure of the CRE is measured to all adjacent and surrounding areas.
10. Ensure the CRE is clearly defined and understood.

Design/Licensing Bases Analysis Recommendations

Recently during a CR Habitability Workshop, some general guidance was provided on CR Habilitability and summarized as follows: [8]

1. Several stations have yet to incorporate the TMI III.D.3.4 action items and rely on compensatory measures such as iodine tablets or SCBA's, to mitigate the consequences of an accident.
2. Differences may exist between the licensing basis for the nuclear station and the design and operation or integrity of the CRE. Licensee's assessments may contain weaknesses in the licensing amendments.
3. ESF ventilation systems and the control room envelope should be operated consistent with the licensing basis.
4. Do not assume that a LOCA is the limiting accident. The most limiting accident for the GDC 19 limits and the sequence of accidents should be validated to be consistent with the licensing bases.
5. Analyses should be performed at tech spec or design values rather than existing plant conditions.
6. Assumptions made for charcoal adsorber efficiency should be verified to be accurate.
7. Radiation Monitors should be verified to isolate normal ventilation and initiate ESF ventilation
8. Accidents from adjacent units or nearby stations should be adequately considered in the accident analysis
9. Recognize that the isolation of the CRE and the actuation of the ESF ventilation system may vary with the accident.
10. Each accident could have a different release pathway for one χ/Q.
11. The impact of temporary modification or in-progress work should be an on-going assessment by the system owner. Modifications to the system may impact the licensing basis for the nuclear station.
12. Nuclear station personnel should not relinquish final ownership or responsibility of configuration changes of any structure, system or component to 'others'. This will ensure ownership for the modification and a historical perspective when things go wrong.
13. Accident analyses that are performed by others should be closely reviewed for compliance to the licensing basis. Although the analyses can be performed by 'others' adequately, the full responsibility for the final design rests with the owner, the station personnel.
15. Not all normal ventilation system supplies are isolated immediately on a DBA hence, the normal ventilation activity should be adequately considered in the dose analyses.
16. Understand current staff interpretations of an USQ.

Conclusions

1. The licensing and design basis for the Control Room Ventilation System should be fully understood by the applicable stations' system managers and regulatory assurance personnel.
2. Some stations still need to comply with NUREG 0737 III.D.3.4 commitments.
3. The CRE boundary or emergency zone and adjacent areas should be clearly defined.

4. The availability of the new source terms to the stations should be expedited.
5. Accident analyses should include accurate and verified assumptions.
6. The most costly item to CRE reconstitution is the sealing effort.
7. There may be alternatives to tracer gas testing, but these efforts need to be carefully considered by each station and compared to the licensing bases.
8. The unfiltered inleakage should refer to the licensing analysis value contained in the current dose calculation for the most limiting accident.
9. Licensee weaknesses need to be thoroughly reviewed by each station to determine the applicability.
10. An Unreviewed Safety Question could exist if one factor of the total limit moves in the non-conservative direction even though the total meets the limit.

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