NEI 99-03: Control Room Habitability Assessment Guidance[1]

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Background

Control Room Habitability (CRH) is the term used to describe the systems, structures, and components used to protect commercial nuclear power plant operators and control room equipment during normal and accident plant operating conditions. Criterion 19, *Control Room*, to 10 CFR Part 50, *Domestic Licensing of Production and Utilization Facilities*, requires that a control room be provided from which actions can be taken to operate the nuclear power plant safety under normal conditions and to maintain it in a safe condition under accident conditions. In addition, Criterion 4, *Environmental and Missile Design Basis*, of 10 CFR Part 50 requires, in part, that structures, systems, and components important to safety (e.g., control room habitability) be designed to accommodate the effects of and to be compatible with environmental conditions associated with normal operation, maintenance, testing and postulated accidents.

Concerns regarding the adequacy and maintenance of control room designs began to emerge during the mid-1980s when numerous NRC reviews revealed deficiencies in the areas of control room boundary maintenance, knowledge of station personnel concerning control room habitability, treatment of control room habitability as a low priority item, and testing of the control room boundary. These concerns were heightened during the last several years when a number of utilities testing for control room unfiltered in-leakage all obtained results that exceeded the in-leakage assumptions used to license their plants (Figure 1). The conclusion from these testing efforts is that even the best-analyzed plant may not perform well due to unforeseen problems in the design and operation of control room ventilation systems. This could lead to unanalyzed plant accident doses or toxic gas exposures.

In response to these concerns, the Nuclear Energy Institute (NEI) formed the Control Room Habitability Task Force in 1998. For the last year or so, the Task Force has conducted a series of meeting with the NRC to resolve CRH technical and regulatory issues. The ultimate goal of the Task Force is to develop a voluntary guidance document (NEI 99-03) that will provide acceptable methods for establishing and maintaining control room habitability. The Task Force hopes to obtain both industry and NRC endorsement of the guideline. The current schedule is to have a draft of NEI 99-03 distributed for industry comments by December 2000, re-released as a draft for formal NRC comments by March 2001, and released as a final document by July 2001.

Industry-Wide Issues

The NRC conducted a Control Room Habitability (CRH) Workshop in July 1998 to discuss CRH issues of concern. The major issues of concern included the following:

[1] Much of the material presented in this paper was adopted from NEI correspondences on this issue.

- Licensing Basis Different from As-Built Plant

  Differences between the FSAR description of the control room envelope, the HVAC systems controlling the airflow within this envelope, and the as-built condition of the plant have been observed. For example, modifications to HVAC systems and maintenance and operations activities can influence CRH system response and its associated boundary integrity.

- Analyses Different From As-Built or As-Operated

  The design analyses used to determine the exposure to the operator from a radiological event or a toxic gas event have several inputs that are based on CRH system design parameters and assumed system operation. It has been observed that some systems may be operated differently from the assumptions or values used in these analytical calculations. Power up-rates, steam generator replacements, and alternative repair criteria for steam generator tubing are examples of plant modifications whose impact on control room habitability might not have been analyzed.

- DBA Analyzed not Most Limiting

  Plants are required to have analyzed the limiting Design Basis Accident (DBA) within the scope of their licensing basis for CRH considerations. Traditionally most licensees and the NRC have assumed that the large break Loss of Coolant Accident (LOCA) was the limiting DBA for CRH. However, some plants have discovered that, upon reanalysis, another accident described in their licensing basis may be limiting for control room dose consequences.

- Smoke

  Smoke may be a habitability concern if a large amount is introduced in the control room that challenges the ability of operators to remain in the control room to shut down the reactor or inhibits operator access to the Auxiliary Shut Down Panel. The NRC does not consider the effects and responses to smoke (whether generated internally or externally) to be bounded by Appendix R evaluations.

- Toxic Gas Evaluations Questioned

  Most licensees have evaluated their susceptibility to toxic gas events, typically in accordance with Regulatory Guide 1.78 and 1.95. However, there is concern that the amount of in-leakage that the control room would experience during an event may be greater than assumed in the evaluation. There is also a concern that the sources of toxic gas release may have changed over time and their effect may not have been appropriately considered.

- Control Room In-leakage Greater than Assumed

  Tracer gas tests conducted at over 15 control rooms to determine the amount of filtered and unfiltered in-leakage have shown that actual in-leakage was greater (and in some cases, significantly greater) than the amount assumed in control room habitability safety analyses. Since most licensees have never measured their control room unfiltered in-leakage, there is concern that other plants are likely to have an in-leakage value that is larger than analysis assumptions. This introduces a concern that the licensee's control room operator radiological dose evaluation and the toxic gas event evaluation may be non-conservative.

NEI 99-03 Guidance

In response to the industry-wide concerns identified above, the NEI formed the Control Room Habitability Task Force in 1998. The Task Force is developing a voluntary guidance document, NEI 99-03, which provides guidance on the establishment and maintenance of control room habitability. NEI 99-03 will be suggesting a multi-faceted assessment effort be used to address CRH concerns as follows:

- Review of control room licensing and design bases
- Comparison of these bases to plant design, configuration, and operation
- Evaluation of plant vulnerabilities to specific industry issues (as discussed above)
- Baseline testing of the envelope in-leakage
- Handling of findings and vulnerabilities under the Corrective Action Program
- Periodic re-assessment of habitability
- Establishment of programs to maintain and assure habitability.

NEI 99-03 is being structured with a main section which will provide background information, describe the CRH assessment process, and present guidance on establishing and maintaining control room integrity. There will also be several appendixes intended to provide detailed guidance.

Of most interest to the nuclear power meteorological community are two proposed appendixes dealing with atmospheric dispersion modeling for radiological dose assessments and toxic gas assessments. Synopses of these proposed appendixes follow.

- Atmospheric Dispersion Modeling for Radiological Assessments

  This appendix will provide guidance for performing atmospheric dispersion calculations in support of control room habitability analyses for design basis radiological accidents. The appendix will discuss the general difficulty in determining atmospheric dispersion factors when both the release point and receptor are located within or near atmospheric turbulence created by a complex of buildings and will provide an overview of NRC modeling efforts in this area.

  A description of the traditional Murphy-Campe methodology (Reference 1) as well as the more recent ARCON96 computer code methodology (Reference 2) will be provided. Detailed recommendations concerning the implementation of ARCON96 will also be provided. As part of the cooperation between the NEI CRH Task Force and the NRC in developing NEI 99-03, the NRC has hired the author of ARCON96, Dr. Van Ramsdell, to revise the model to calculate the effective stack height from high temperature, high velocity safety relief valve and atmospheric steam dump valve releases as well as to upgrade ARCON96's modeling of elevated stack releases.

  The appendix will probably state that appropriately structured site-specific atmospheric diffusion tests can be considered as an alternative to analytical methods. The appendix will probably also state that although the Task Force believes that wind tunnel tests can be a valuable tool for developing atmospheric factors, the NRC remains unconvinced that wind tunnel tests are a viable alternative. In addition, the appendix will clarify that licensees have the option to re-use the methodology in their current licensing basis in lieu of the analytical methodologies presented in this appendix.

- Atmospheric Dispersion Modeling for Toxic Gas Assessments

  This appendix will provide guidance in assessing the habitability of the control room during and after a postulated external release of hazardous chemicals. A revised toxic gas assessment would be

necessary if an in-leakage value used in an existing toxic gas evaluation is found to be non-conservative; a new toxic gas assessment is required if a new significant source of hazardous chemicals is found in the vicinity of the plant.

Much of the guidance presented in this appendix will be adopted from Regulatory Guide 1.78 (Reference 3) as updated by NUREG/CR-6624 (Reference 4). This appendix will also provide additional guidance beyond that contained in Regulatory Guide 1.78 in the areas of specifying toxicity limits, identifying release characteristics, and applying updated atmospheric dispersion modeling techniques (i.e., the computer code EXTRAN, Reference 5), including dense gas atmospheric dispersion models. Licensees will also have the option of using the methodology that currently serves as their licensing basis.

Remaining Unresolved Issues

Completion of NEI 99-03 is on hold pending resolution of several technical issues with the NRC staff. A summary of the remaining issues and the Task Force and NRC position on each are presented in Figure 2.

Conclusion

NEI 99-03 will offer insights and guidance provided by industry experts concerning acceptable methods for establishing and maintaining control room habitability. The intent of the document is to provide a consistent methodology that has been endorsed by both industry and the NRC. The advantages NEI 99-03 provides industry includes offering approaches that reduce analytical conservatism found in existing analyses. Not adopting NEI 99-03 would potentially result in losing improvements in analysis tools that reduce unneeded conservatism as well as result in NRC refusal to review licensee actions that impact control room dose without test results quantifying actual control room in-leakage rate.

References

1. KG Murphy and KM 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. JV Ramsdell and CA Simonen, *Atmospheric Relative Concentrations in Building Wakes*, NUREG/CR-6331, Revision 1, Pacific Northwest National Laboratory, May 1997.

3. Regulatory Guide 1.78, *Assumptions for Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release*, U.S. Atomic Energy Commission, June 1974.

4. LB Sasser et al, *Recommendations for Revision of Regulatory Guide 1.78*, NUREG/CR-6624, Pacific Northwest National Laboratory, November 1999.

5. JV Ramsdell and SA Stage, *Computer Codes for Evaluation of Control Room Habitability (HABIT)*, NUREG/CR-6210 Supplement 1, Pacific Northwest National Laboratory, September 1998.

FIGURE 1

Control Room Unfiltered In-Leakage Tracer Gas Test Results
(Values in cfm)

Plant	Assumed Unfiltered In-Leakage	Measured Unfiltered In-Leakage	Re-Measured Unfiltered In-Leakage[1]
A	10	144	-
B	10	49	-
C	10	71	-
D	120	442	-
E	262	4,056	162
F	35	1,086	700
G	50	2,902	855
H	100	133	91
I	10	379	80
J	10	260	73
K	165	349	166
L	260	273	88
M	10	339	181
N	910	4,300	3,000

[1] Many plants performed a retest after conducting a sealing program and other plant modifications.

FIGURE 2

Remaining Issues Requiring Resolution

Task Force Position	NRC Position
Baseline In-leakage Measurements and Periodic Evaluation	
▪ A baseline test should be performed to measure unfiltered in-leakage. ▪ Baseline tests may be made using either a tracer gas test or a component test (component testing requires a positive pressure control room and tests only those components vulnerable to in-leakage). ▪ A periodic reassessment of the control room envelope integrity should be performed.	▪ The use of component testing to determine in-leakage is not acceptable; there is concern that missed in-leakage pathways will result in indeterminate test accuracy. ▪ A basis for periodic reassessment methodology needs to be developed.
Limiting Accident Analysis	
▪ The limiting accident should be evaluated from the perspective of the control room; only DBA defined in the UFSAR need to be considered.	▪ Additional accident scenarios, including accidents at adjacent sites, should be considered even if they are not in the plant's UFSAR.
Smoke Management Methods	
▪ Smoke management methods include the ability to isolate the control room, maintain access to remote and auxiliary shutdown panels, purge smoke, and use self-contained breathing apparatus.	▪ More quantitative acceptance criteria for smoke management should be developed.[1]
Radiological and Toxic Gas Analysis Methods	
▪ New methods for evaluating radiological accidents and toxic gas events can be used (e.g., ARCON96, alternative source term, refined assumptions for use with the traditional TID-14884 source term) ▪ Vulnerability to toxic gas events should be reassessed periodically.	▪ Use of these new methods requires adoption of other recommendations that may be more restrictive than current practice (e.g., evaluating the possibility of additional accidents that are not in the plant's UFSAR).
Control Room Habitability Program	
▪ A CRH program that will facilitate long term maintenance of the control room envelope integrity should be adopted.	▪ Implementation of the entire CRH program outlined in NEI 99-03 is required to obtained NRC acceptance of many of the enhancements included in the document.
Technical Specifications	
▪ A commitment should be made to develop a CRH Program that ensures the maintenance of CRH over the life of the plant. Options under consideration include committing to a CRH program without tech spec changes, developing an administrative tech spec to require a CRH program, or moving existing CRH requirements currently contained in the tech specs to a licensee controlled document.	▪ A control room in-leakage surveillance requirement should be adopted within tech specs.

[1] In order to perform a quantitative evaluation, several elements for such an evaluation, such as the definition of design basis fire, need to be developed.