U.S. NUCLEAR REGULATORY COMMISSION

DESIGN-SPECIFIC REVIEW STANDARD FOR mPOWER^{TM} iPWR DESIGN

6.2.5 COMBUSTIBLE GAS CONTROL IN CONTAINMENT

REVIEW RESPONSIBILITIES

Primary - Organization responsible for review of containment integrity

Secondary – None

I. AREAS OF REVIEW

The Babcock & Wilcox (B&W) mPower^{TM} design is for a two reactor, two containment small, modular plant. It has an integral pressurized water reactor design with the reactor, steam generator, pressurizer and control rod drives all located in a single pressure vessel. The reactor design has no large cold or hot leg piping and employs conventional balance-of-plant systems. Each reactor has its own containment. The containment is intended to be at atmospheric pressure and entirely below grade.

This section covers the information presented in the applicant's Technical Submittal concerning the control of combustible gases in the containment following a beyond-design-basis accident involving 100 percent fuel clad-coolant reaction or postulated accident to ensure conformance with the requirements of General Design Criteria (GDC) 5, 41, 42, and 43, and 10 CFR 50.44.

Following an accident, hydrogen and oxygen may accumulate inside the containment. After an accident, combustible gas is predominantly generated within the containment as a result of:

(a) Fuel clad-coolant reaction between the fuel cladding and the reactor coolant.

(b) Molten core-concrete interaction in a severe core melt sequence with a failed reactor vessel.

If a sufficient amount of combustible gas is generated, it may react with the oxygen present in the containment at a rate rapid enough to breach the containment or cause a leakage rate in excess of Technical Specification limits. Additionally, the associated pressure and temperature increase could damage systems and components essential to continued control of the postaccident conditions. This review includes the following general areas:

1. The production and accumulation of combustible gases within the containment following a beyond-design-basis accident.

2. The capability to mix the combustible gases with the containment atmosphere and prevent high concentrations of combustible gases in local areas.

3. The capability to monitor combustible gas concentrations within containment.

ADAMS Accession No. ML12276A124

4. The capability to reduce combustible gas concentrations within containment by suitable means such as recombiners or igniters.

The specific areas of review are as follows:

1. Analysis of combustible gas (e.g., hydrogen, carbon monoxide, oxygen) production and accumulation within the containment following a beyond-design-basis accident.

2. Analysis of the functional capability of the systems or passive design features provided to mix the combustible gas within the containment.

3. Analysis of the functional capability of the systems provided to reduce combustible gas concentrations within the containment.

4. Analyses of the capability of systems or system components to withstand dynamic effects, such as transient differential pressures that would occur early in the blowdown phase of an accident.

5. Analyses of the consequences of single active component malfunctions, to meet GDC 41.

6. The quality classification of each system.

7. The seismic design classification of each system.

8. The results of qualification tests performed on system components to demonstrate functional capability.

9. The design provisions and proposed program (including Technical Specifications at the operating license (OL) or combined license (COL) stage of review) for periodic inservice inspection, operability testing, and leakage rate testing of each system or component.

10. The functional aspects of instrumentation provided to monitor system or system component performance.

    At the construction permit (CP) stage of review, the design of the systems provided for monitoring and controlling combustible gases within the containment may not be completely determined. In such cases, staff reviews the applicant's preliminary designs and statements of intent to comply with the acceptance criteria for such systems. At the OL stage, staff reviews the final designs of these systems to verify that they meet the acceptance criteria detailed in subsection II of this DSRS section.

11. Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC). For design certification (DC) and combined license (COL) reviews, the staff reviews the applicant's proposed ITAAC associated with the structures, systems, and components (SSCs) related to this DSRS section in accordance with Standard Review Plan (SRP) Section 14.3, "Inspections, Tests, Analyses, and Acceptance Criteria." The staff recognizes that the review of ITAAC cannot be completed until after the rest of this portion of the application has been reviewed against acceptance criteria contained in this DSRS section.

Furthermore, the staff reviews the ITAAC to ensure that all SSCs in this area of review are identified and addressed as appropriate in accordance with SRP Section 14.3.

12. COL Action Items and Certification Requirements and Restrictions. For a DC application, the review will also address COL action items and requirements and restrictions (e.g., interface requirements and site parameters). For a COL application referencing a DC, a COL applicant must address COL action items (referred to as COL license information in certain DCs) included in the referenced DC. Additionally, a COL applicant must address requirements and restrictions (e.g., interface requirements and site parameters) included in the referenced DC.

Review Interfaces

Other SRP and DSRS sections interface with this section as follows:

1. The review of seismic design and quality group classifications is performed under DSRS Section 3.2.1 and DSRS Section 3.2.2, respectively.

2. The actuation and control features of active components, including the hydrogen and oxygen monitors are reviewed under SRP Section 7.5.

3. The qualification test program for electrical valve operators, fans, hydrogen/oxygen sampling or analyzing equipment, igniters, and sensing and actuation instrumentation of the plant protection system, located both inside and outside the reactor containment is reviewed by organization responsible for Instrumentation and Control (DSRS 3.11).

4. Proposed Technical Specifications pertaining to the operability and leakage rate testing of systems and components is reviewed under DSRS Section 16.0.

5. Accessibility of combustible gas control systems equipment under postulated accident conditions is reviewed under DSRS Section 12.3.

6. Probabilistic Risk Assessment and Severe Accident Evaluation for mPower™ design and LOCA analysis scenarios are discussed in SRP Section 19.

II. ACCEPTANCE CRITERIA

Requirements

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

1. 10 CFR 50.44 Combustible gas control for nuclear power reactors shall provide.

    (1) Containments which have a capability for ensuring a mixed atmosphere during design-basis and significant beyond design-basis accidents.

    (2) Containments which limit hydrogen concentrations in containment during and following an accident that releases an equivalent amount of hydrogen as would be generated from a 100 percent fuel clad-coolant reaction, uniformly distributed, to less than 10 percent (by volume).

(3) *Equipment Survivability.* Containments must be able to establish and maintain safe shutdown and containment structural integrity with systems and components capable of performing their functions during and after exposure to the environmental conditions created by the burning of hydrogen. Environmental conditions caused by local detonations of hydrogen must also be included, unless such detonations can be shown unlikely to occur. The amount of hydrogen to be considered must be equivalent to that generated from a fuel clad-coolant reaction involving 100 percent of the fuel cladding surrounding the active fuel region.

(4) *Monitoring.* Equipment provided for monitoring hydrogen in the containment must be functional, reliable, and capable of continuously measuring the concentration of hydrogen in the containment atmosphere following a significant beyond design-basis accident for accident management, including emergency planning.

(5) *Structural analysis.* An applicant must perform an analysis that demonstrates containment structural integrity. The analysis must address an accident that releases hydrogen generated from 100 percent fuel clad-coolant reaction accompanied by the hydrogen burning. Systems necessary to ensure containment integrity must also be demonstrated to perform their function under these conditions.

2. GDC 5 as it relates to providing assurance that sharing of structures, systems, and components important to safety among nuclear power units will not significantly impair their ability to perform their safety functions.

3. GDC 41 as it relates to systems being provided to control the concentration of hydrogen or oxygen that may be released into the reactor containment following postulated accidents to ensure that containment integrity is maintained; systems being designed to suitable requirements, i.e., that there be suitable redundancy in components and features, and suitable interconnections to ensure that for either a loss of onsite or a loss of offsite power the system safety function can be accomplished, assuming a single failure; and systems being provided with suitable leak detection, isolation, and containment capability to ensure that system safety function can be accomplished.

4. GDC 42 as it relates to the design of the systems to permit appropriate periodic inspection of components to ensure the integrity and capability of the systems.

5. GDC 43 as it relates to the systems being designed to permit periodic testing to ensure system integrity, and the operability of the systems and active components.

6. 10 CFR 52.47(b)(1), which requires that a DC application contain the proposed ITAAC that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a facility that incorporates the design certification has been constructed and will be operated in conformity with the design certification, the provisions of the Atomic Energy Act (AEA), and the U.S. Nuclear Regulatory Commission’s (NRC's) regulations.

7. 10 CFR 52.80(a), which requires that a COL application contain the proposed inspections, tests, and analyses, including those applicable to emergency planning, that the licensee shall perform, and the acceptance criteria that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, the facility has been constructed and will operate in conformity with the combined license, the provisions of the AEA, and the NRC's regulations.

DSRS Acceptance Criteria

Specific DSRS acceptance criteria acceptable to meet the relevant requirements of the NRC's regulations identified above are set forth below. The DSRS is not a substitute for the NRC's regulations, and compliance with it is not required. Identifying the differences between this DSRS section and the design features, analytical techniques, and procedural measures proposed for the facility, and discussing how the proposed alternative provides an acceptable method of complying with the regulations that underlie the DSRS acceptance criteria, is sufficient to meet the intent of 10 CFR 52.47(a)(9), "Contents of applications; technical information." The same approach may be used to meet the requirements of 10 CFR 52.79(a)(41) for COL applications.

1. In meeting the requirements of 10 CFR 50.44, and GDC 41 to provide systems to control the concentration of hydrogen in the containment atmosphere, materials within the containment that would yield hydrogen gas due to corrosion from the emergency cooling or containment spray solutions should be identified, and their use should be limited as much as practicable.

2. In meeting the requirements of 10 CFR 50.44, and GDC 41 to provide systems to control the concentration of hydrogen or oxygen in the containment atmosphere, the applicant should demonstrate by analysis, that the design can safely accommodate hydrogen generated by an equivalent of a 100 percent fuel clad-coolant reaction, while limiting containment hydrogen concentration, with the hydrogen uniformly distributed, to less than 10 percent (by volume), and while maintaining containment structural integrity.

3. In meeting the requirements of 10 CFR 50.44(c)(3), regarding equipment survivability, equipment necessary for achieving and maintaining safe shutdown of the plant and maintaining containment structural integrity should perform its safety function during and after being exposed to the environmental conditions attendant with the release of hydrogen generated by the equivalent of a 100 percent fuel clad-coolant reaction including the environmental conditions created by activation of the combustible gas control system.

4. In meeting the requirements of 10 CFR 50.44, to provide the capability for ensuring a mixed atmosphere in the containment during design bases and significant beyond-design-bases accidents, and of GDC 41 to provide systems as necessary to ensure that containment integrity is maintained, this capability may be provided by an active, passive, or combination system. Active systems may consist of a fan, a fan cooler, or containment spray. For passive or combination systems that use convective mixing to mix the combustible gases, the containment internal structures should have design features which promote the free circulation of the atmosphere. For all containment types, an analysis of the effectiveness of the method used for providing a mixed atmosphere should be provided. This analysis is acceptable if it shows that combustible gases will

not accumulate within a compartment or cubicle to form a combustible or detonable mixture that could cause loss of containment integrity. Atmosphere mixing systems prevent local accumulation of combustible or detonable gases which could threaten containment integrity or equipment operating in a local compartment. Active systems installed to mitigate this threat should be reliable, redundant, single-failure proof, able to be tested and inspected, and remain operable with a loss of onsite or offsite power.

5. In meeting the requirements of 10 CFR 50.44, and GDC 41 regarding the functional capability of the combustible gas control systems to ensure that containment integrity is maintained, the design should meet the provisions of RG 1.7, Revision 3, Section C.1.

6. To satisfy the design requirements of GDC 41:

   A. Performance tests should be performed on system components, such as hydrogen recombiners and combustible gas monitors. The tests should support the analyses of the functional capability of the equipment.

   B. Combustible gas control system designs should include instrumentation needed to monitor system or component performance under normal and accident conditions. The instrumentation should be capable of determining that a system is performing its intended function, or that a system train or component is malfunctioning and should be isolated. The instrumentation should have readout and alarm capability in the control room. (The containment hydrogen and oxygen monitors should meet the provisions of RG 1.7, Revision 3, Section C.2.)

7. To satisfy the inspection and test requirements of GDC 41, 42, and 43, combustible gas control systems should be designed with provisions for periodic inservice inspection, operability testing, and leak rate testing of the systems or components.

8. In meeting the requirements of 10 CFR 50.44(c)(5), regarding containment structural integrity, an analysis must demonstrate containment structural integrity, using an analytical technique that is accepted by the NRC staff and including sufficient supporting justification to show that the technique describes the containment response to the structural loads involved. The analysis must address an accident that releases hydrogen generated from 100 percent fuel clad-coolant reaction accompanied by combustible gas burning. Systems necessary to ensure containment integrity must also demonstrate the capability to perform their functions under these conditions. (One acceptable analytical technique is a demonstration that specific criteria of the ASME Boiler and Pressure Vessel Code, described in RG 1.7, Revision 3, Section C.5, are met.)

9. In meeting the requirements of 10 CFR 50.44(c), and GDC 41 for the design and functional capability of the combustible gas control systems, preliminary system designs and statements of intent in the SAR are acceptable at the CP stage of review if the (guidelines of RG 1.7, Revision 3, are endorsed.)

III. REVIEW PROCEDURES

The procedures described below provide guidance for the detailed review of the combustible gas control systems.

Upon request from the primary review organization, the review organizations with review interface responsibilities will provide input for the areas of review, as stated in Subsection I of this design-specific review standard (DSRS) section. The input obtained will ensure that the review is complete. The combustible gas control systems include systems for mixing combustible gases, monitoring combustible gas concentrations, and reducing the combustible gas concentrations. In general, all of the combustible gas control systems should meet the DSRS acceptance criteria outlined in subsection II. For deviations from these specific acceptance criteria, the staff should review the applicant's evaluation of how the proposed alternatives to the criteria provide an acceptable method of complying with the relevant NRC requirements identified in Subsection II. The system description and schematic drawings presented in the SAR should be sufficiently detailed to permit judgments to be made regarding system acceptability.

1. Programmatic Requirements - In accordance with the guidance in NUREG-0800 "Introduction," Part 2 as applied to this DSRS Section, the staff will review the programs proposed by the applicant to satisfy the following programmatic requirements. If any of the proposed programs satisfies the acceptance criteria described in Subsection II, it can be used to augment or replace some of the review procedures. It should be noted that the wording of "to augment or replace" applies to nonsafety-related risk-significant SSCs, but "to replace" applies to nonsafety-related nonrisk-significant SSCs according to the "graded approach" discussion in NUREG-0800 "Introduction," Part 2. Commission regulations and policy mandate programs applicable to SSCs that include:

   - Maintenance Rule SRP Section 17.6 (DSRS Section 13.4, Table 13.4, Item 17, RG 1.160, "Monitoring the Effectiveness of Maintenance at Nuclear Power Plants." and RG 1.182; "Assessing and Managing Risk Before Maintenance Activities at Nuclear Power Plants".

   - Quality Assurance Program SRP Sections 17.3 and 17.5 (DSRS Section 13.4, Table 13.4, Item 16).

   - Technical Specifications (DSRS Section 16.0 and SRP Section 16.1) – including brackets value for DC and COL. Brackets are used to identify information or characteristics that are plant specific or are based on preliminary design information.

   - Reliability Assurance Program (SRP Section 17.4).

   - Initial Plant Test Program (RG 1.68, "Initial Test Programs for Water-Cooled Nuclear Power Plants, "DSRS Section 14.2, and DSRS Section 13.4, Table 13.4, Item 19).

   - ITAAC (DSRS Chapter 14).

2. In accordance with 10 CFR 52.47(a)(8),(21), and (22), for new reactor license applications submitted under Part 52, the applicant is required to (1) address the proposed technical resolution of unresolved safety issues (USIs) and medium- and high-priority generic safety issues (GSIs) that are identified in the version of NUREG-0933 current on the date 6 months before application and that are technically relevant to the design; (2) demonstrate how the operating experience insights have been incorporated into the plant design; and, (3) provide information necessary to demonstrate compliance

with any technically relevant portions of the Three Mile Island requirements set forth in 10 CFR 50.34(f), except paragraphs (f)(1)(xii), (f)(2)(ix), and (f)(3)(v). These cross-cutting review areas should be addressed by the reviewer for each technical subsection and relevant conclusions documented in the corresponding safety evaluation report (SER) section.

3. The reviewer determines that all potential, active mechanical failures and passive electrical failures have been identified and that no single failure would incapacitate an entire system.

4. The reviewer compares the quality standards applied to the systems to the provisions of RG 1.7, Revision 3.

5. The reviewer compares the seismic design classifications of the systems to the provisions of RG 1.7, Revision 3.

6. The reviewer reviews the qualification testing of systems and components to establish the functional capability of the equipment.

7. The reviewer reviews the provisions made in the design of the systems and the program for periodic inservice inspection and operability testing of the systems or components. The inspections are reviewed with regard to the purpose of each inspection. The operability tests that will be conducted are reviewed with regard to what each test is intended to accomplish. Judgment and experience from previous reviews are used to determine the acceptability of the inspection and test program.

8. For plants at the COL stage of review, the reviewer reviews the proposed technical specifications for the systems used to control and monitor combustible gas and oxygen concentrations in the containment to ensure that the requirements of 10 CFR 50.44 and GDC 5, 41, 42, and 43 are met.

9. The reviewer reviews the capability to monitor system performance and control active components to be sure that control can be exercised over a system and that a malfunctioning system train or component can be isolated. The instrumentation provided for this purpose should be redundant and should enable the operator to identify the malfunctioning system train or component.

10. The reviewer reviews analyses of the functional capability of the systems, or passive design features, provided to mix combustible gases within the containment. The reviewer reviews the supporting information in the safety analysis report which should include elevation drawings of the containment showing the routing of ductwork and the circulation patterns caused by fans, sprays, or thermal convection. Special attention is paid to interior compartments to ensure that combustible gases cannot collect in them without mixing with the bulk containment atmosphere. The reviewer ensures that interior compartments are identified in the SAR and the provisions made to ensure circulation within them are discussed.

    Systems provided to mix the combustible gases within the containment may also be used for containment heat removal, e.g., the fan cooler and spray systems. The acceptability of the design of these systems is considered in the review of the containment heat removal systems in DSRS Section 6.2.2.

11. The reviewer reviews the manner in which the systems provided to reduce combustible gas concentrations will be operated. The point at which the system is actuated (the control point) will be determined from the safety analysis report. For deliberate ignition systems, the control point is typically core exit temperature exceeding 1200 degrees Fahrenheit.

12. For review of a DC application, the reviewer should follow the above procedures to verify that the design, including requirements and restrictions (e.g., interface requirements and site parameters), set forth in the final safety analysis report (FSAR) meets the acceptance criteria. DCs have referred to the FSAR as the design control document (DCD). The reviewer should also consider the appropriateness of identified COL action items. The reviewer may identify additional COL action items; however, to ensure these COL action items are addressed during a COL application, they should be added to the DC FSAR.

    For review of a COL application, the scope of the review is dependent on whether the COL applicant references a DC, an early site permit (ESP) or other NRC approvals(e.g., manufacturing license, site suitability report or topical report).

    For review of both DC and COL applications, SRP Section 14.3 should be followed for the review of ITAAC. The review of ITAAC cannot be completed until after the completion of this section.

13. The reviewer evaluates the methods use by the applicant for (1) predicting the internal pressure capacity for containment structures above the design-basis accident pressure, and, (2) demonstrating containment structural integrity related to combustible gas control. The guidance approved by the NRC is found in RG 1.216, Containment Structural Integrity Evaluation for Internal Pressure Loadings above Design Basis Pressure

IV. EVALUATION FINDINGS

The reviewer verifies that the applicant has provided sufficient information and that the staff's technical review and analysis, as augmented by the application of programmatic requirements in accordance with the staff's technical review approach in the DSRS Introduction, support conclusions of the following type to be included in the staff's safety evaluation report. The reviewer also states the bases for those conclusions.

The staff concludes that the design and expected performance of the combustible gas control systems are acceptable and meet the requirements of 10 CFR 50.44, and GDC 5, 41, 42, and 43. This conclusion is based on the following:

1. The applicant has met the requirements of (cite regulation) with respect to (state limits of review in relation to regulation) by (for each item that is applicable to the review, state how it was met and why acceptable with respect to the regulation being discussed)

    A. meeting the regulatory positions in Regulatory Guide(s) ________;

B. providing and meeting an alternative method to regulatory positions in Regulatory Guide _____, that the staff has reviewed and found to be acceptable because ________;

C. meeting the regulatory position in Branch Technical Position (BTP) ___;

D. using calculational methods for (state what was evaluated) that have been previously reviewed by the staff and found acceptable; the staff has reviewed the impact parameters in this case and found them to be suitably conservative or performed independent calculations to verify acceptability of their analysis; and/or

E. meeting the provisions of (industry standard number and title) that have been reviewed by the staff and determined to be appropriate for this application.

2. Repeat discussion for each regulation cited above.

For DC and COL reviews, the findings will also summarize the staff's evaluation of requirements and restrictions (e.g., interface requirements and site parameters) and COL action items relevant to this DSRS section.

In addition, to the extent that the review is not discussed in other SER sections, the findings will summarize the staff's evaluation of the ITAAC, including design acceptance criteria, as applicable.

V. IMPLEMENTATION

The staff will use this DSRS section in performing safety evaluations of mPower^{TM}-specific DC, or COL, applications submitted by applicants pursuant to 10 CFR Part 52. The staff will use the method described herein to evaluate conformance with Commission regulations.

Because of the numerous design differences between the mPower^{TM} and large light-water nuclear reactor power plants, and in accordance with the direction given by the Commission in SRM- COMGBJ-10-0004/COMGEA-10-0001, "Use of Risk Insights to Enhance the Safety Focus of Small Modular Reactor Reviews," dated August 31, 2010 (ML102510405), to develop risk-informed licensing review plans for each of the small modular reactor reviews including the associated pre-application activities, the staff has developed the content of this DSRS section as an alternative method for mPower^{TM} -specific DC, or COL submitted pursuant to 10 CFR Part 52 to comply with 10 CFR 52.47(a)(9), "Contents of applications; technical information."

This regulation states, in part, that the application must contain "an evaluation of the standard plant design against the SRP revision in effect 6 months before the docket date of the application." The content of this DSRS section has been accepted as an alternative method for complying with 10 CFR 52.47(a)(9) as long as the mPower^{TM} DCD FSAR does not deviate significantly from the design assumptions made by the NRC staff while preparing this DSRS section. The application must identify and describe all differences between the standard plant design and this DSRS section, and discuss how the proposed alternative provides an acceptable method of complying with the regulations that underlie the DSRS acceptance criteria. If the design assumptions in the DC application deviate significantly from the DSRS, the staff will use the SRP as specified in 10 CFR 52.47(a)(9). Alternatively, the staff may supplement the DSRS section by adding appropriate criteria in order to address new design assumptions. The same approach may be used to meet the requirements of 10 CFR 52.79(a)(41) for COL applications.

VI. REFERENCES

1. RG 1.7, Revision 3, "Control of Combustible Gas Concentrations in Containment."

2. SECY-03-0127, "Final Rulemaking—Risk-Informed 10 CFR 50.44, "Combustible Gas Control in Containment," dated July 24, 2003.

3. SECY-00-0198, "Status Report on Study of Risk-informed Changes to The Technical Requirements of 10 CFR Part 50 (Option 3) And Recommendations on Risk-informed Changes to 10 CFR 50.44 (Combustible Gas Control)," dated September 14, 2000.

4. SECY-93-087, "Policy, Technical, And Licensing Issues Pertaining to Evolutionary and Advanced Light-water Reactor (ALWR) Designs," dated April 2, 1993.

5. RG 1.155, Revision 0, "Station Blackout," August 1988.

6. NUREG-1503, "Final Safety Evaluation Report Related to the Certification of the System 80+ Design, Docket No. 52-002," July 1994.

7. NUREG-1462, "Final Safety Evaluation Report Related to the Certification of the Advance Boiling Reactor Design," August 1994.

8. NUREG-1512, "Final Safety Evaluation Report Related to the Certification of the AP600 Standard Design, Docket No. 52-003," September 1998.

9. NUREG-1793, "Final Safety Evaluation Report Related to Certification of the AP1000 Standard Design, Docket No. 52-006," September 2004.

10. RG 1.97, "Instrumentation for Light-Water-Cooled Nuclear Power Plants to Assess Plant and Environs Conditions During and Following an Accident."

11. RG 1.68, Initial Test Programs for Water-Cooled Nuclear Power Plants.

12. RG 1.160, Monitoring the Effectiveness of Maintenance at Nuclear Power Plants.

13. RG 1.182, Assessing and Managing Risk Before Maintenance Activities at Nuclear Power Plants.

14. RG 1,206, Combined License Applications for Nuclear Power Plants (LWR Edition).

15. RG 1.215, Guidance for ITAAC Closure under 10 CFR Part 52.

16. 10 CFR Part 50, § 50.44, "Combustible Gas Control for Nuclear Power Reactors."

17. 10 CFR Part 50, § 50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light-Water Cooled Reactors."

18. 10 CFR Part 50, § 50.46a, “Acceptance Criteria for Reactor Coolant System Venting Systems.”

19. 10 CFR Part 50, Appendix A, General Design Criterion 5, “Sharing of Structures, Systems and Components.”

20 10 CFR Part 50, Appendix A, General Design Criterion 41, “Containment Atmosphere Cleanup.”

21. 10 CFR Part 50, Appendix A, General Design Criterion 42, “Inspection of Containment Atmosphere Cleanup System.”

22 10 CFR Part 50, Appendix A, General Design Criterion 43, “Testing of Containment Atmosphere Cleanup System.”

23. NUREG/CR-4905, “Detonability of H-Air-Diluent Mixtures,” Sandia National Laboratory, June 1987.

24. NUREG/CR-4961, “A Summary of Hydrogen-Air Detonation Experiments,” Sandia National Laboratory, June 1987.

25. NUREG/CR-5275, “Flame Facility” (The Effect of Obstacles and Transverse Venting on Flame Acceleration and Transition to Detonation of Hydrogen-Air Mixtures at Large Scale), Sandia National Laboratory, April 1989.

26. NUREG/CR-5525, “Hydrogen-Air-Diluent Detonation Study of Nuclear Reactor Safety Analyses,” Sandia National Laboratory, December 1990.

27. RG 1.216, Containment Structural Integrity Evaluation for Internal Pressure Loadings above Design Basis Pressure, August 2010