U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

15.8 ANTICIPATED TRANSIENTS WITHOUT SCRAM

REVIEW RESPONSIBILITIES

Primary - Organization responsible for review of transient and accident analyses for PWRs/BWRs

Secondary - Organization responsible for the review of instrumentation and control systems

I. AREAS OF REVIEW

An anticipated transient without scram (ATWS) is an anticipated operational occurrence (AOO) as defined in Appendix A to 10 CFR Part 50 followed by the failure of the reactor trip portion of the protection system specified in General Design Criterion (GDC) 20. Since protection systems (e.g., the reactor trip system) must satisfy the single-failure criterion, multiple failures or a common mode failure must cause the assumed failure of the reactor trip. The probability of an AOO, in coincidence with multiple failures or a common mode failure, is much lower than the probability of any of the other events that are evaluated under SRP Chapter 15. Therefore, an ATWS event cannot be classified as either an AOO or a design-basis accident.

The failure of the reactor to shut down during certain transients can lead to unacceptable reactor coolant system pressures, fuel conditions, and/or containment conditions. Typical AOOs that may result in unacceptable conditions following a pressurized-water reactor (PWR) scram failure are loss of feedwater, loss of load, turbine trip, inadvertent control rod withdrawal, loss of alternating current power, and/or loss of condenser vacuum. For a boiling-water reactor (BWR), AOOs with failure to scram that could lead to unacceptable conditions include closure of main steamline isolation valves, or turbine trip with bypass available if unmitigated unstable power oscillations are allowed to grow.

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Safety issues associated with an ATWS have been evaluated since the early 1970s. During NRC evaluations of vendor models and analyses addressing ATWS events, the agency formally identified the ATWS as Unresolved Safety Issue (USI) A-9, "Anticipated Transients Without Scram." The agency presents the NRC staff's studies and findings regarding USI A-9 in NUREG-0460. In 1986, the NRC resolved USI A-9 through publication of 10 CFR 50.62, the ATWS rule (the rule). Although the rule does not require ATWS analyses, SECY 83-293 and the Federal Register notice of the final rule in 49 FR 26036 present the bases for current regulatory requirements related to ATWS events, including the associated regulatory evaluation.

The rule requires that certain light-water-cooled plants have prescribed systems and equipment that have been determined to reduce the risks attributable to ATWS events, for each of the nuclear steam supply system (NSSS) vendor's designs, to an acceptably low level. The rule also requires applicants to demonstrate the adequacy of their plants' prescribed systems and equipment.

During design certification (DC) reviews of evolutionary plant designs, the NRC developed additional requirements criteria (i.e., to provide a diverse scram system or to demonstrate that the consequences of ATWS events are acceptable).

<u>COL Action Items and Certification Requirements and Restrictions</u>. 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.

<u>Review Interfaces</u>

Other SRP sections interface with this section as follows:

1. General information on transient and accident analyses is provided in SRP Section 15.0.

2. Design basis radiological consequence analyses associated with design basis accidents are reviewed under SRP Section 15.0.3.

3. Reactivity coefficients and control rod worths are reviewed under SRP Section 4.3

4. Confirmation of acceptable BWR standby liquid control system (SLCS) negative reactivity insertion capability for ATWS events, including automatic capability where required by 10 CFR 50.62, is performed under SRP Sections 4.3 and 9.3.5.

5. Determination that design and quality assurance criteria specified for instrumentation are consistent with criteria established in conjunction with 10 CFR 50.62 (the ATWS rule) is performed under SRP Sections 7.1 and 7.8.

6. Determination that the design and reliability of the reactor trip system are acceptable and that required ATWS-related features are independent and diverse from the reactor trip system where required by the rule is performed under SRP Section 7.2.

The specific acceptance criteria and review procedures are contained in the referenced SRP sections.

II. ACCEPTANCE CRITERIA

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

1. 10 CFR 50.62 (the ATWS rule), as it relates to the acceptable reduction of risk from ATWS events via (a) inclusion of prescribed design features and (b) demonstration of their adequacy

2. 10 CFR 50.46, as it relates to maximum allowable peak cladding temperatures, maximum cladding oxidation, and coolable geometry

3. GDC 12, found in Appendix A to 10 CFR Part 50, as it relates to ensuring that oscillations are either not possible or can be reliably and readily detected and suppressed

4. GDC 14, as it relates to ensuring an extremely low probability of failure of the coolant pressure boundary

5. GDC 16, as it relates to ensuring that containment design conditions important to safety are not exceeded as a result of postulated accidents

6. GDC 35, as it relates to ensuring that fuel and clad damage, should it occur, must not interfere with continued effective core cooling, and that clad metal-water reactor must be limited to negligible amounts

7. GDC 38, as it relates to ensuring that the containment pressure and temperature are maintained at acceptably low levels following any accident that deposits reactor coolant in the containment

8. GDC 50, as it relates to ensuring that the containment does not exceed the design leakage rate when subjected to the calculated pressure and temperature conditions resulting from any accident that deposits reactor coolant in the containment.

Specific Acceptance Criteria

Specific SRP acceptance criteria acceptable to meet the relevant requirements of the NRC's regulations identified above are as follows for the review described in this SRP section. The SRP is not a substitute for the NRC's regulations, and compliance with it is not required. However, an applicant is required to identify differences between the design features, analytical techniques, and procedural measures proposed for its facility and the SRP acceptance criteria and evaluate how the proposed alternatives to the SRP acceptance criteria provide acceptable methods of compliance with the NRC regulations.

The rule specifies that light water reactors must have a number of prescribed systems, and equipment that are design-dependent, and have been proven to reduce the risk attributable to the ATWS events, to an acceptable level. In addition, the applicants must submit information sufficient to demonstrate the adequacy of the implemented ATWS features. Design and quality assurance criteria for the required systems and equipment should meet or exceed the criteria established in conjunction with ATWS rulemaking, as described in SRP Section 7.1, Appendix A, to ensure adequate independence, diversity, and reliability where required by the ATWS rule.

1. Acceptance criteria for Boiling Water Reactors (BWRs):

   A. Equipment shall be provided to initiate an automatic reactor coolant re-circulation pumps trip under conditions indicative of an ATWS.

   B. An alternate rod injection system (ARI) is provided independent and diverse from the reactor trip system sensor output to the final actuation device. The system shall have independent scram air header exhaust valve.

   C. A standby by liquid control system (SLCS) shall be provided that is capable of initiating reactivity control equivalent to injection of 326 liters per minute (or 86 gallons per minute) of 13 weight percent sodium pentaborate decahydrate solution of Boron-10 into a 638 centimeters (251 inches) inside diameter reactor pressure vessel operating at a power density consistent with the original licensed thermal power (OLTP).

   D. The SLCS initiation is automatic for the plants specified in 10 CFR 50.62(c)(4).

   E. For BWRs, reactor coolant system pressures should not exceed ASME Service Level C limits (approximately 10.3 MPa (1500 psi).

   F. Each plant Emergency Operating Procedures (EOPs) or Instructions (EOIs) must implement the ATWS/Stability Mitigation Actions as described in References 8 and 10. The two main mitigation actions are:

      i. Following a failure to scram, the reactor vessel water level must be lowered to a level below the feedwater spargers that will allow vessel steam to preheat the cold feedwater.

      ii. if unstable power oscillations are detected following a failure to scram, boron injection through the SLCS must be initiated manually.

2. For Pressurized Water Reactors (PWRs):

   A. Provide measures to automatically initiate the auxiliary (or emergency) feedwater system and a turbine trip under conditions indicative of an ATWS. This equipment shall be independent and diverse from the reactor trip system from sensor output to the final actuation device.

B. Combustion Engineering or Babcock and Wilcox reactors applicants shall have provision for a scram system that is independent and diverse from the reactor trip system, from sensor output to the points of interruption of power to the control rods.

C. These system and equipment shall be demonstrated to provide reasonable assurance that unacceptable plant conditions do not occur in the event of an anticipated transients

D. The reactor coolant system (RCS) pressure shall not exceed ASME Service Level C limits (approximately 22 MPa or 3200 psig) containment safety parameters (e.g., temperature or pressure) should not exceed design limits

3. For Evolutionary Plants

A. For evolutionary plants where the ATWS rule does not explicitly require a diverse scram system, the applicant may provide either of the following:

i. A diverse scram system satisfying the design and quality assurance criteria specified in SRP Section 7.2

ii. Demonstrate that the consequences of an ATWS event are within acceptable values.

B. For evolutionary plants, some of the equipment required to satisfy the rule may not be apply. For example, passive BWRs do not have recirculation pumps; therefore, these designs cannot provide equipment to trip them as required by the rule. For these designs provision of an equivalent action such as reducing the vessel water level may be acceptable.

C. Applicants must demonstrate that the failure probability of failing the ATWS success criteria is sufficiently small because either: (1) the criteria are met, or (2) a diverse scram system is installed that reduces significantly the probability of a failure to scram. The analysis leading to the ATWS rule in NUREG-0460 used the following ATWS success criteria, which have their bases in the Commission regulations and GDC listed above. Applicant's design shall maintain :

i. <u>Coolable geometry for the reactor core.</u> If fuel and clad damage were to occur following a failure to scram, GDC 35 requires that this condition should not interfere with continued effective core cooling. 10 CFR 50.46 defines three specific core-coolability criteria: (1) Peak clad temperature shall not to exceed 1221°C (2200°F), (2) Maximum cladding oxidation shall not to exceed 17% the total cladding thickness before oxidation, and (3) Maximum hydrogen generation shall not to exceed 1% of the maximum hypothetical amount if all the fuel clad had reacted to produce hydrogen.

ii. Maintain reactor coolant pressure boundary integrity. Appendix A to WASH-1270 states that in evaluating the reactor coolant system boundary for ATWS events, "the calculated reactor coolant system transient pressure should be limited such that the maximum primary stress anywhere in the system boundary is less than that of the 'emergency conditions' as defined in the ASME Nuclear Power Plant Components Code, Section III." The acceptance criteria for reactor coolant pressure, based upon the ASME Service Level C limits, are approximately 10.3 MPa (1500 psig) for BWRs and approximately 22MPa (3200 psig) for PWRs.

iii. Maintain containment Integrity. Following a failure to scram, the containment pressure and temperature must be maintained at acceptably low levels based on GDC 16 and 38. The containment pressure and temperature limits are design dependent; but to satisfy GDC 50, those limits must ensure that containment design leakage rates are not exceeded when subjected to the calculated pressure and temperature conditions resulting from any ATWS event.

Technical Rationale

The technical rationale for application of these acceptance criteria to the areas of review addressed by this SRP section is discussed in the following paragraphs:

1. 10 CFR 50.62 (the ATWS rule), as it relates to the acceptable reduction of risk from ATWS events via (a) inclusion of prescribed design features and (b) demonstration of their adequacy

   Meeting the ATWS rule (10 CFR 50.62) requires that light-water-cooled plants be equipped with systems and equipment that are designed to reduce risks attributable to ATWS events to an acceptable level. The rule also requires a demonstration of the adequacy of the features as specified in the staff requirements and the discussion contained in the statement of considerations of the final rule.

2. 10 CFR 50.46, as it relates to maximum allowable peak cladding temperatures, maximum cladding oxidation, and coolable geometry.

   The applicant's design must satisfy limits derived from regulations at 10 CFR 50.46, which define specific core-coolability criteria, such as peak clad temperature, Maximum cladding oxidation and hydrogen generation, such as not to exceed certain limits as specified in specific acceptance criteria (Section II).

3. GDC 12 as it relates to ensuring that oscillations are either not possible or can be reliably and readily detected and suppressed.

4. GDC 13, as it relates to instrumentation used for ATWS mitigation systems.

5. GDC 14, as it relates to ensuring an extremely low probability of failure of the coolant pressure boundary;

6. GDC 16, as it relates to ensuring that containment design conditions important to safety are not exceeded as a result of postulated accidents;

7. GDC 35, as it relates to ensuring that fuel and clad damage, should it occur, must not interfere with continued effective core cooling, and that clad metal-water reactor must be limited to negligible amounts;

8. GDC 38, as it relates to ensuring that the containment pressure and temperature are maintained at acceptably low levels following any accident that deposits reactor coolant in the containment; and

9. GDC 50, as it relates to ensuring that the containment does not exceed the design leakage rate when subjected to the calculated pressure and temperature conditions resulting from any accident that deposits reactor coolant in the containment.

III. <u>REVIEW PROCEDURES</u>

The reviewer will select and emphasize material from the procedures described below, as may be appropriate for a particular case. The reviewer may perform portions of the evaluation on a generic basis for aspects common to a class of plant designs, or by adopting the results of previous reviews of plants with similar design. The areas to be given attention and emphasis are determined based on whether the information provided in the applicant's safety analysis report is similar to that reviewed for other similar plant designs, previously accepted ATWS evaluations and/or NSSS vendor topical reports are referenced, new or unique features affecting ATWS risk are proposed, and items of special safety significance are involved.

The evaluation may be based upon referenced approved designs, analyses, and/or assessments as applied to the licensee's plant. The categories of referenced approved materials include topical reports, standard design approvals, regulatory analyses associated with the ATWS rulemaking, and designs of systems that the staff has previously reviewed and approved. If any aspect of a design is not identical to that referenced, an evaluation must address the differences, and the safety evaluation report (FSER) should include the conclusions regarding such differences.

1. The reviewer will verify that the applicable required equipment and systems detailed in Subsection II are provided, as follows:

    A. The reviewer will verify, using the methods described in SRP Sections 4.3 and 9.3.5, that the specified SLCS reactivity control capability is provided for BWRs, this control capability is adequate for limiting ATWS events, and the proposed injection location is designed for the reliable performance of system functions.

        i. The reviewer will verify that the capacity of the SLCS has been sized according to the equivalency criterion specified in Section II.1.C above. If the review involves a power-density increase, the applicant has two options:

(1) The applicant can size the SLCS so that the integrated heat to containment remains constant. For example, if the power density is increased by 10 percent, the boron injection time must be reduced by 10 percent so the integrated heat load remains constant.

(2) Alternatively, the applicant can demonstrate by analysis that the ATWS success criteria are satisfied under the new power density.

ii. The reviewer will verify that the SLCS is capable of injecting at the elevated reactor pressure during ATWS events without lifting the SLCS relief valve. The licensee must demonstrate a sufficient margin in the SLCS relief valve setpoint.

B. The reviewer will verify that the applicable required instrumentation-related equipment and systems are provided, including ARI, automatic recirculation pump trips, and automatic SLCS initiation for BWRs, automatic auxiliary feedwater and turbine trip initiation for PWRs and diverse scram systems for specified PWR designs.

C. The reviewer will confirm that required equipment and systems are designed for independence and diversity from the reactor trip system where specified in Subsection II. Appendix A to SRP Section 7.1 and SRP Section 7.2 describe the criteria and methods for these reviews.

2. The reviewer will verify that sufficient information is provided or referenced to conclude that the required features will satisfy the criteria for acceptable plant conditions specified in Subsection II. The reviewer will place particular emphasis on the identification of plant-design differences with respect to referenced previously accepted materials. The reviewer will also perform the following in connection with this review:

A. Evaluate the manner in which the applicant credits operator actions, including actions specified in applicable EPGs for the design or in EOPs or EOIs for the specific plant under review, as applicable.

B. Verify that the applicant demonstrates assured capability for long-term shutdown and cooling following an ATWS event using systems identified in EPGs, EOPs, or EOIs for ATWS events.

C. For PWRs, if applicable, evaluate the applicant’s assumptions regarding the moderator temperature coefficient (MTC) and determine them to be either consistent with MTC modeling assumptions serving as bases for the Rule or adequately justified. Appendix C to NUREG-0460 discusses the MTC values used by PWR vendors for ATWS analyses before promulgation of the Rule. Enclosure D, Section 5.5, of 49 FR 29036 discusses the probabilities assumed during the Rulemaking of “unfavorable” MTC values resulting in unacceptable plant conditions.

D. Coordinate with the reviewer responsible for instrumentation and controls and verify, to the extent necessary to support the overall review, that instrumentation parameters such as setpoints, tolerances, time delays, ranges, and channel response times specified in the design are acceptable with respect to any critical values assumed in the applicant's demonstration of the adequacy of required features.

E. For events in which the analysis results predict fuel damage and offsite releases, the reviewer will evaluate the predicted extent of fuel damage and resulting offsite consequences with respect to those predicted in the relevant topical reports that the staff has previously accepted, and with acceptance criteria for postulated accidents.

3. For evolutionary plants where 10 CFR 50.62 does not explicitly require a diverse scram system, the applicant may provide a diverse scram system satisfying the design and quality assurance criteria stated in Subsection II or alternatively demonstrate that the consequences of an ATWS event are acceptable.

A. Where a diverse scram system is proposed for such plants, the reviewer will verify its adequacy using procedures similar to those described in Section III.1.

B. Where the applicant alternatively chooses to demonstrate that the consequences of an ATWS event are acceptable, the reviewer will use procedures similar to those described in Section III.2 above to confirm acceptable consequences without credit for a diverse scram system.

4. When introducing new fuel designs or power-density changes in BWRs, the reviewer will evaluate whether the core moderator void reactivity coefficient is consistent with the analyzed ranges in the generic BWR ATWS analyses (NEDE-24222). If the void reactivity coefficient is outside those ranges, then the limiting events must be evaluated as follows:

A. Generically for every new fuel design. The fuel vendor must document the applicability of the new fuel to BWR ATWS events (e.g., Amendment 22 to GESTAR-II for GE fuels).

B. On a plant-specific basis, when the new fuel design or power-density change is introduced. The licensee must confirm that the BWR ATWS acceptance criteria listed in Section II are satisfied for the limiting events.

C. On a cycle-specific basis, the licensee must confirm that the ATWS analysis of record, based on the new fuel design or power-density change, bounds the plant-specific core configuration. The reviewer must pay special attention to transition cores involving mixed fuels.

5. For BWRs that implement both extended power uprate (EPU) and expanded power-flow domains (e.g., MELLLA+/Methods), the licensee must demonstrate the following:

A. The licensing ATWS code used to perform the analysis can model all the actions specified in the plant-specific EOPs or EOIs, including emergency depressurization if required. If the licensing ATWS code cannot model the plant-specific EOP actions, including depressurization if the suppression pool heat capacity temperature limit is reached, then the NRC cannot approve operation under the EPU and expanded operating domain.

B. In special cases, the staff may accept the use of the ATWS licensing code, even though it cannot model all the required actions specified in EOPs. In these cases, supplemental sensitivity analysis can be used to demonstrate that: (1) the licensing code results are conservative; and (2) the plant's ATWS response following the EOP actions comply with the NRC-approved BWR ATWS acceptance criteria. As an interim, the use of sensitivity analysis based on a non-licensing code or a code under staff review is acceptable, provided the code is capable of modeling, with reasonable degree of accuracy, the operator actions and the systems response as delineated by the EOPs. The licensee must demonstrate to the staff that the non-licensing code contains all features necessary for modeling the ATWS EOP actions and system actuations so that there is reasonable assurance that the ATWS acceptance criteria response results are adequate. The staff acceptance of the use of a non-licensing code is an interim measure. The licensees and the fuel vendors must commit to and submit the non-licensing code for staff review and approval.

C. If the ATWS acceptance criteria cannot be met based on plant-specific EOP actions under the EPU and expanded operating domain, the licensee must modify the ATWS protection features to ensure that the criteria are satisfied. For example, the licensee may reduce the hot shutdown boron weight injection time or modify the EOP mitigation actions (e.g., water-level strategies).

6. For BWRs, the ATWS/Stability evaluation was generically dispositioned based on the Mitigation Actions for plants operating up to OLTP.

A. For all applications, the reviewer will evaluate the implementation of the ATWS/Stability Mitigation Actions in design-specific EPGs, or plant-specific EOPs or EOIs. The reviewer will ensure that sufficient information has been provided to justify that the mitigation actions are effective in maintaining core coolability criteria for the limiting ATWS/Stability event.

B. For BWRs that implement both extended power uprate (EPU) and expanded power-flow domains (e.g., MELLA+), the licensee will demonstrate that the ATWS/Stability Mitigation Actions are effective in maintaining core coolability criteria for the limiting ATWS/Stability event.

C. For evolutionary BWRs, the licensee will provide EOPs or EOIs that implement ATWS/Stability Mitigation Actions equivalent to those approved in Reference 8, including manual boron injection if oscillations are detected. The licensee will demonstrate the EOPs or EOIs are effective in maintaining core coolability criteria for the limiting ATWS/Stability event.

7. Where new methods for the evaluation of ATWS events, risk reduction features, and/or consequences are proposed, based upon the unique features or ATWS sequences of a specific design, the reviewer will initiate a generic evaluation of affected portions of the applicant's assumptions, plant behavior criteria and models, data, and/or methods for the determination of offsite consequences. The staff may accept such new evaluations, consistent with the principles inherent in acceptable evaluation techniques and the basic approach to determining acceptable ATWS risks and consequences outlined in this SRP section.

8. The reviewer will ensure that the staff has reviewed and approved all analysis methodologies, including the treatment of uncertainties, used in the submittal.

9. The reviewer will ensure that all restrictions and limitations specified in safety evaluations approving a licensing topical report are met, especially when operating under expanded operating domains.

10. The reviewer will ensure that the actual component and actuation setpoint testing supports the technical specification values used in the analyses. The reviewer will evaluate plant testing data to ensure that component performance supports the plant-specific technical specification values used in the analyses. For example, the safety/relief valve (SRV) upper lift setpoint tolerance may drift, which might affect the ATWS peak pressure.

11. The reviewer will ensure that if the technical specifications allow for equipment out of service, the ATWS analysis assumes the most conservative configuration. For example, if the technical specifications allow SRVs out of service, then the ATWS analysis should include this configuration irrespective of the basis for the technical specification section.

12. The reviewer will evaluate the need for staff confirmatory calculations if the design changes deviate significantly from established practice.

13. 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).

IV. EVALUATION FINDINGS

The reviewer verifies that the applicant has provided sufficient information and that the review and calculations (if applicable) 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 plant design adequately addresses ATWS events and meets the requirements of 10 CFR 50.62. This conclusion is based on the following:
>
> 1. The applicant's plant design includes the ATWS risk reduction features prescribed by the Rule.
>
> 2. These features are independent and diverse from the reactor trip system and are designed to be reliable, as required under the Rule.
>
> 3. The applicant has also provided or referenced information, analyses, and/or evaluations that demonstrate that limiting ATWS and event sequences have been considered and that features included in the design pursuant to the Rule result in reasonable assurance, that unacceptable plant conditions, as defined during the Rulemaking, will not occur because of ATWS events.

For evolutionary designs/plants that are not explicitly required to provide a diverse scram system under the Rule, the reviewer should state the finding from the two below that applies:

> 1. The applicant has also provided an acceptable diverse scram system.
>
> 2. The applicant has demonstrated acceptable consequences for ATWS events without credit for a diverse scram system.

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 SRP section.

V. IMPLEMENTATION

The staff will use this SRP section in performing safety evaluations of DC applications and license applications submitted by applicants pursuant to 10 CFR Part 50 or 10 CFR Part 52. Except when the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the staff will use the method described herein to evaluate conformance with Commission regulations.

The provisions of this SRP section apply to reviews of applications submitted six months or more after the date of issuance of this SRP section, unless superseded by a later revision.

VI. REFERENCES

1. 10 CFR 50.62, “Requirements for Reduction of Risk from Anticipated Transients Without Scram (ATWS) Events for Light-Water-Cooled Nuclear Power Plants.”

2. 10 CFR 50.46, “Acceptance Criteria for Emergency Core Cooling Systems for Light-Water Nuclear Power Reactors.”

3. 10 CFR 50.55a, “Codes and Standards.”

4. 10 CFR Part 50, Appendix A, “General Design Criteria for Nuclear Power Plants.”

5. NUREG-0460, “Anticipated Transients Without Scram for Light Water Reactors,” (Vol. 1) April 1978, (Vol. 2) April 1978, (Vol. 3) December 1978, (Vol. 4) March 1980.

6. SECY 83-293, “Amendments to 10 CFR 50 Related to Anticipated Transients Without Scram (ATWS) Events,” July 19, 1983.

7. U.S. Nuclear Regulatory Commission, “10 CFR Part 50.62, Reduction of Risk from Anticipated Transients Without Scram (ATWS) Events for Light-Water-Cooled Nuclear Power Plants,” Federal Register: Vol. 49, p. 26036, June 26, 1984.

8. A.C. Thadani, “Acceptance for Referencing of Topical Reports NEDO-32047 and NEDO-32164, Revision 0, BWR Owners’ Group Evaluation of ATWS Rule Issues and Mitigative Actions,” U.S. Nuclear Regulatory Commission, February 5, 1994.

9. NEDO-32047, “ATWS Rule Issues Relative to BWR Core Thermal-Hydraulic Stability,” General Electric Company, February 1992.

10. NEDO-32164, Revision 0, “Mitigation of BWR Core Thermal-Hydraulic Instabilities in ATWS,” General Electric Company, December 1992.

11. “BWR Owners’ Group Emergency Procedure and Severe Accident Guidelines,” Revision 2, March 2001.

12. WASH-1270, “Technical Report on Anticipated Transients Without Scram for Water-Cooled Power Reactors”, U.S. Atomic Energy Commission, September 1973.

13. NEDE-24011-P-A-14, “General Electric Standard Application for Reactor Fuel,” Global Nuclear Fuels, June 2000.

14. NEDE-24222, “Assessment of BWR Mitigation of ATWS, Volumes I and II (NUREG-0460 Alternate No. 3),” General Electric Company, December 1979.

15. NEDE-24223, “Assessment of BWR/3 Mitigation of ATWS (Alternate 3),” General Electric Company, December 1979.