# Proposed - For Interim Use and Comment

U.S. NUCLEAR REGULATORY COMMISSION

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

**3.5.1.3 TURBINE MISSILES**

**REVIEW RESPONSIBILITIES**

**Primary** - Organization responsible for the review of materials engineering issues related to flaw evaluation and welding

**Secondary** - Organization responsible for the structure analysis reviews

I. <u>AREAS OF REVIEW</u>

General Design Criterion 4 (GDC 4), "Environmental and Missile Dynamic Effects Design Bases," of Appendix A to 10 CFR Part 50 requires that structures, systems, and components (SSCs) important to safety shall be designed to accommodate the effects of and to be compatible with environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including loss-of-coolant accidents. These include safety-related or risk significant SSCs as listed in RG1.115, "Protection Against Low-Trajectory Turbine Missiles," Revision 2 and Design-Specific Review Standard (DSRS) Section 3.2.2. These SSCs shall be appropriately protected against dynamic effects including, among others, the effects of missiles. The mPower$^{TM}$ plant configuration may consist of multiple turbine units at one site and the effect of missiles from each turbine must be considered in the evaluation. Turbines significantly different from the current 1,800 revolutions per minute units used in nuclear plants will be reviewed on a case-by-case basis.

All safety-related and risk-significant systems, structures, and components (SSCs) are subject to missile protection. An SSC may be classified as:

Safety-related and risk-significant equipment
Safety-related and nonrisk-significant equipment
Nonsafety-related and risk-significant Regulatory Treatment of Nonsafety Systems (RTNSS) equipment
Nonsafety-related nonrisk-significant equipment.

The mPower$^{TM}$ application will include the classification of SSCs, a list of risk significant SSCs, and a list of RTNSS equipment. Based on this information, the staff will review the application according to NUREG-0800, Standard Review Plan (SRP), Sections 17.4 and 19.3, and DSRS Section 3.2, to confirm the determination of safety-related and risk-significant SSCs.

The specific areas of review are as follows:

1. The large steam turbines have rotors with large masses and rotate at relatively high speeds during normal reactor operation. The failure of a rotor may result in the generation of high energy missiles that could affect safety-related or risk-significant

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SSCs. Plant designs are reviewed to determine whether these SSCs have adequate protection against the effects of potential turbine missiles. The primary review area is the evaluation of the turbine missile generation probability.

2. 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 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.

3. 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. Review of the turbine missile impact effects on steel and concrete barriers (e.g., penetration depth, scabbing, and structural response) is performed under DSRS Section 3.5.3.

2. Review of the turbine rotor failure analysis, fracture toughness properties, turbine startup procedures, and inservice inspection is performed under DSRS Section 10.2.3.

3. Review of the turbine overspeed protection, including overspeed sensing and tripping, and turbine startup procedures, is performed under DSRS Section 10.2. Review of the SSCs to be protected from turbine missiles is performed under DSRS Section 3.5.2.

4. Review of the adequacy of the inservice testing program of pumps and valves is performed under DSRS Section 3.9.6.

5. Review of the Probabilistic Risk Assessment is performed under SRP Section 19 for potential risk significance of SSCs.

## II. ACCEPTANCE CRITERIA

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

1. The NRC acceptance criteria is based on meeting the relevant requirements of General Design Criteria (GDC) 4, “Environmental and dynamic effects design bases,” as it relates to SSCs important to safety being appropriately protected against environmental and

dynamic effects, including the effects of missiles, that may result from equipment failure. Failure of large steam turbines in the main turbine generator has the potential to eject high-energy missiles that can produce such damage. The staff's overall safety objective is to ensure that SSCs important to safety are adequately protected from the effects of turbine missiles. Accordingly, consideration should be given to safety-related or risk-significant systems as described in RG1.115, "Protection Against Low-Trajectory Turbine Missiles," Revision 2 and DSRS Section 3.2.2.

2. 10 CFR 52.47(b)(1), which requires that a DC application contain the proposed inspections, tests, analyses, and acceptance criteria (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, and the NRC's regulations.

3. 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 Atomic Energy Act, 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 as follows for review described in this DSRS section. 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."

1. The probability of unacceptable damage resulting from turbine missiles, $P_4$, is expressed as the product of (a) the probability of turbine failure resulting in the ejection of turbine rotor (or internal structure) fragments through the turbine casing, $P_1$; (b) the probability of ejected missiles perforating intervening barriers and striking safety-related or risk significant structures, systems, or components, $P_2$; and (c) the probability of struck structures, systems, or components failing to perform their safety function, $P_3$. Stated in mathematical terms, $P_4 = P_1 \times P_2 \times P_3$.

   In accordance with the guidance provided in SRP Section 2.2.3 and RG 1.115, the probability of unacceptable damage from turbine missiles should be less than or equal to 1 in 10 million per year for an individual plant (i.e., $P_4$ should be $\leq 10^{-7}$ per year per plant).

   Although the calculation of strike probability, $P_2$, is not difficult in principle (i.e., a straightforward ballistics analysis), in practice it requires numerous modeling approximations and simplifying assumptions to define the properties of missiles, interactions of missiles with barriers and obstacles, trajectories of missiles as they interact with and perforate (or are deflected by) barriers, and identification and location

of safety-related or risk significant targets. Specific approximations and assumptions tend to have a significant effect on the resulting value of $P_2$. Similarly, a reasonably accurate specification of the damage probability, $P_3$, is complicated by difficulties associated with defining the missile impact energy required to render safety-related or risk significant systems unavailable to perform their safety functions and with postulating sequences of events that would follow a missile-producing turbine failure.

Because of the uncertainties associated with calculating $P_2$ and $P_3$, the staff concludes that such analyses are "order of magnitude" calculations only. On the basis of simple estimates for a variety of plant layouts, the strike and damage probability product can be reasonably assumed to fall in a range that depends on the gross features of turbine generator orientation.

A. For favorably oriented turbine generators, the product of $P_2$ and $P_3$ tends to be in the range of $10^{-4}$ to $10^{-3}$ per year per plant.

B. For unfavorably oriented turbine generators, the product of $P_2$ and $P_3$ tends to be in the range of $10^{-3}$ to $10^{-2}$ per year per plant.

Favorably oriented turbine generators are located such that the containment and all, or almost all, safety-related or risk significant SSCs outside containment are excluded from the low-trajectory hazard zone described in RG 1.115.

Because of assumptions and modeling difficulties in the probabilistic calculations as described above, the staff does not encourage applicants to calculate $P_2$, $P_3$, or their product. Instead, the staff accepts a product of strike and damage probabilities of $10^{-3}$ per year per plant for a favorably oriented turbine and $10^{-2}$ per year per plant for an unfavorably oriented turbine. The suggested values represent the staff's best estimate of the product of $P_2$ and $P_3$, based on the results of calculations performed at the NRC (NUREG-1048, Supplement No. 6, and NUREG-0887, Supplement No. 3) and elsewhere.

2. Operating experience indicates that turbine rotor crack (NUREG/CR-1884; PNO-111-81-104, "Circle in the Hub of the Eleventh Stage Wheel in the Main Turbine"; and NRC Memorandum from E. Jordan to W. Russell), turbine stop and control valve failures (J.J. Burns, Jr.; License Event Report No. 82-132, Docket No. 50-361; and NRC Memorandum from E. Jordan to W. Russell), blade failures, and rotor ruptures can result in the generation of high-energy missiles (D. Kalderon and NRC Memorandum from E. Jordan to W Russell). Analyses indicate that missile generation can be modeled and the probability of missile generation can be strongly influenced by a suitable program of periodic inservice testing and inspection.

    In general, two modes of turbine rotor failure can result in turbine missile generation: (a) rotor material failure at approximately the rated operating speed and (b) failure of the overspeed protection system. Failure of turbine rotors at or below the design speed (nominally, 120% of normal operating speed) can be caused by small flaws or cracks that grow to critical size during operation. Failure of the turbine rotors at destructive overspeed (about 180% to 190% of normal operating speed) can result from failure of the overspeed protection system. The material properties of the turbine casing are of interest because secondary missiles could be generated if the casing fails or, alternatively, the casing could serve to arrest and contain missiles.

The missile generation probability at the design speed should be related to rotor design parameters, material properties, and the intervals of inservice examinations of disks. The missile generation probability at the destructive overspeed should be related to the speed sensing and tripping characteristics of the turbine governor and overspeed protection system, the design and arrangement of main steam control and stop valves, the reheat steam intercept, reheat stop valves, and the inservice testing and inspection intervals for system components and valves. In addition, the turbine casing material in its operational environment should be evaluated for fracture toughness properties. DSRS Section 10.2 provides additional guidance regarding inspection and testing of turbine generator components. Further information regarding turbine missile generation mechanisms and probabilities can be found in NUREG-1048, NRC Memorandum from E. Jordan to W. Russell, and Letter from C. Rossi (NRC) to J. Martin (Westinghouse Electric Corporation).

3. The staff believes that maintaining an acceptably low missile generation probability, $P_1$, by means of a suitable program of periodic testing and inspection is a reliable method for ensuring that the objective of precluding generation of turbine missiles (and hence the possibility of damage to safety-related or risk significant structures, systems, and components by those missiles) can be met. The NRC safety objective for turbine missiles (i.e., $P_4$ should be $\leq 10^{-7}$ per year per plant) is best expressed in terms of either of two sets of criteria applied to missile generation probability, $P_1$. All applicants are expected to commit to operating criteria (see Table 3.5.1.3-1) appropriate to the applicable turbine orientation. One set of criteria should be applied to favorably oriented turbines; the other should be applied to unfavorably oriented turbines.

   This approach places responsibility on the applicant for initially demonstrating, and thereafter maintaining, an NRC-specified turbine reliability. Accordingly, the applicant should commit to conduct appropriate inservice inspection and testing throughout the life of the plant. Accordingly, the applicant should demonstrate the capability to perform visual, surface, and volumetric (ultrasonic) examinations suitable for inservice inspection of turbine rotors and shafts and provide reports, as required, describing the applicant's methods for determining turbine missile generation probabilities (*See* NUREG-1048 Supplement No 6; Letter from C. Rossi (NRC) to J. Martin (Westinghouse Electric Corporation); and NUREG-0887) for NRC review and approval.

4. Applicants obtaining turbines from manufacturers that have prepared NRC-approved reports to describe their methods and procedures for calculating turbine missile generation probabilities are expected to meet criteria appropriate to the orientation of the turbine (see Table 3.5.1.3-1). Turbine manufacturers should provide applicants with tables of missile generation probabilities versus time (inservice visual, surface, and volumetric rotor inspection interval for design speed failure and inservice valve testing interval for destructive overspeed failure) for each turbine. These probabilities should be used to establish inspection and test schedules that meet NRC safety objectives.

**TABLE 3.5.1.3-1**
PROBABILITY OF TURBINE FAILURE RESULTING IN THE EJECTION OF TURBINE ROTOR (OR INTERNAL STRUCTURE) FRAGMENTS THROUGH THE TURBINE CASING ($P_1$) AND RECOMMENDED LICENSEE ACTIONS

| Case | PROBABILITY | PROBABILITY | RECOMMENDED LICENSEE ACTION |
|---|---|---|---|

| | PER YEAR FOR A FAVORABLY ORIENTED TURBINE | PER YEAR FOR AN UNFAVORABLY ORIENTED TURBINE | |
|---|---|---|---|
| A | $P_1 < 10^{-4}$ | $P_1 < 10^{-5}$ | This condition represents the general, minimum reliability requirement for loading the turbine and bringing the system on line. |
| B | $10^{-4} < P_1 < 10^{-3}$ | $10^{-5} < P_1 < 10^{-4}$ | If this condition is reached during operation, the turbine may be kept in service until the next scheduled outage, at which time the licensee must take action to reduce $P_1$ to meet the appropriate Case A criterion before returning the turbine to service. |
| C | $10^{-3} < P_1 < 10^{-2}$ | $10^{-4} < P_1 < 10^{-3}$ | If this condition is reached during operation, the turbine must be isolated from the steam supply within 60 days, at which time the licensee must take action to reduce $P_1$ to meet the appropriate Case A criterion before returning the turbine to service. |
| D | $10^{-2} < P_1$ | $10^{-3} < P_1$ | If this condition is reached during operation, the turbine must be isolated from the steam supply within 6 days, at which time the licensee must take action to reduce $P_1$ to meet the appropriate Case A criterion before returning the turbine to service. |

5. Applicants are expected to commit to the following program if turbines are obtained from manufacturers that have not submitted, or received NRC approval for, reports describing their methods and procedures for calculating turbine missile generation probabilities:

   A. An inservice inspection program should be used to detect rotor or disk flaws that could lead to brittle failure at or below design speed in the steam turbine rotor assembly. The turbine rotor design should facilitate inservice inspection of all high-stress regions, including disk bores and keyways, without removal of the disks from the shaft. The volumetric inservice inspection interval for the steam turbine rotor assembly should be established according to the following guidelines:

      i. The initial inspection of a new rotor or disk should be performed before any postulated crack is calculated to grow to more than one-half the critical crack depth. If the calculated inspection interval is less than the scheduled first fuel cycle, the licensee should seek the manufacturer's guidance on delaying the inspection until the first refueling outage. If the

calculated inspection interval is longer than the first fuel cycle, the licensee should seek the manufacturer's guidance for scheduling the first inspection during a later refueling outage.

ii. Disks that have been inspected and found free of cracks or that have been repaired to eliminate all indications of cracks should be reinspected using the criterion described in (1) above. Crack growth should be calculated from the time of the last inspection.

iii. Disks operating with known and measured cracks should be reinspected before the elapse of one-half the time calculated for any crack to grow to one-half the critical depth. The guidance described in (1) above should be used to set the inspection date on the basis of the calculated inspection interval.

iv. Under no circumstances should the volumetric inservice inspection interval for low-pressure (LP) disks exceed 3 years or two fuel cycles, whichever is longer.

B. In accordance with the manufacturer's procedures, the turbine inservice inspection program should use visual, surface, and volumetric examinations to inspect turbine components such as couplings, coupling bolts, LP turbine shafts, blades and disks, and high-pressure (HP) rotors. Shafts and disks with crack(s) having depths at or near one-half the critical crack depth should be repaired or replaced. All cracked couplings and coupling bolts should be replaced.

C. The inservice inspection and test program should be used for the governor and overspeed protection system to provide further assurance that flaws or component failures will be detected in the overspeed sensing and tripping subsystems, main steam control and stop valves, reheat steam intercept and stop valves, or extraction steam non-return valves — any of which could lead to an overspeed condition above that specified by the design overspeed. The inservice inspection program for operability of the governor and overspeed protection system should include, at a minimum, the following provisions:

i. For typical turbine governor and overspeed protection systems, at intervals of approximately 3 years during refueling or maintenance shutdowns, at least one main steam control valve, one main steam stop valve, one reheat intercept valve, one reheat stop valve, and one of each type of steam extraction valve should be dismantled for examination. Visual and surface examinations of valve seats, disks, and stems should be conducted. Valve bushings should be inspected and cleaned and bore diameters should be checked for proper clearance. If any valve is shown to have flaws or excessive corrosion or improper clearances, the valve should be repaired or replaced. All other valves of that type should also be dismantled and inspected.

ii. At least once a week during normal operation, main steam control and stop valves, reheat intercept and stop valves, and steam extraction non-return valves should be exercised by closing each valve and observing directly the valve motion as it moves smoothly to a fully closed position.

iii. At least once a month during normal operation, each component of the electro-hydraulic governor system (which modulates control and intercept valves), as well as the primary and backup overspeed trip devices (both of which trip the main steam control and stop valves and the reheat intercept and stop valves), should be tested.

The online test failure of any one of these subsystems mandates repair or replacement of failed components within 72 hours. Otherwise, the turbine should be isolated from the steam supply until repairs are completed. Refer to DSRS Section 10.2 for additional information regarding inspection and testing of turbine generator components.

D. The design, inspection, and operating conditions should provide assurance that the probability of turbine missile generation will not exceed those described in Table 3.5.1.3-1.

6. An applicant may propose to install barriers or to take credit for existing structures or features as barriers. Such a decision could be based on the applicant's deterministic judgment that a SSC is particularly vulnerable to destruction or unacceptable damage in the event of a turbine failure. The applicant should include specific details in the safety analysis report (SAR) supporting the need for such protection. If an applicant proposes to design or evaluate barriers to reduce or eliminate turbine missile hazards to equipment, the barriers should meet the acceptance criteria described in DSRS Section 3.5.3. Additional design guidance is provided in "Fundamentals of Protective Design," TM-5-885-1, Department of the Army, July 1965.

Technical Rationale

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

1. Compliance with GDC 4 requires that components important to safety be designed to accommodate the effects of, and be compatible with, environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including loss-of-coolant accidents. Components are to be appropriately protected against dynamic effects, including the effects of missiles, pipe whipping, and discharging fluids, that may result from equipment failure and from events and conditions outside the nuclear power unit.

2. The protection of safety-related or risk significant SSCs from the effects of turbine missiles is discussed in this DSRS section. The staff recommends that the calculated probability of damage to such equipment be less than 1 in 10 million per plant per year. Specific guidance regarding the arrangement, design, and inspection of turbine generators is provided to ensure that the probability of turbine missile damage will not exceed the limit value during the life of the plant.

3. Meeting the requirements of GDC 4 provides assurance that SSCs important to safety will be protected from the effects of turbine missiles and will be capable of performing their intended safety or risk significant function.

## III. REVIEW PROCEDURES

These review procedures are based on the identified DSRS acceptance criteria. For deviations from these acceptance criteria, the staff should review the applicant's evaluation of how the proposed alternatives provide an acceptable method of complying with the relevant NRC requirements identified in Subsection II.

The organizations responsible for various sections of the review interface will provide input for the areas of review stated in subsection I of this DSRS section. The primary reviewer organization obtains and uses such input as required to ensure that this review procedure is complete.

1. In accordance with 10 CFR 52.47(a)(8),(21), and (22), and 10 CFR 52.79(a)(17) and (20), for new reactor license applications submitted under Part 52, the applicant is required to (1) address the proposed technical resolution of unresolved safety issues and medium- and high-priority generic safety issues which are identified in the version of NUREG-0933 current on the date up to 6 months before the docket date of the application and which 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.

2. Review the plant layout to determine the relative placement of the containment and other safety-related or risk significant SSCs with respect to the turbine-generator unit(s). Determine whether the orientation of the turbine is favorable or unfavorable according to the acceptance criteria in subsection II. Compare the strike and damage probability with the acceptance criteria as described in subsection II.

3. Compare the applicant's turbine missile generation probability based on the applicant's input with the acceptance criteria described in subsection II. Review the applicant's methods and analyses to determine that the probability of turbine missile generation is acceptable. Compare the staff's acceptance criteria of inspection programs for defining turbine missile generation probability with the applicant's program. Review the applicant's inspection program to determine whether the applicant's level of commitment is acceptable.

4. Review the reasons for providing barriers and their placement against turbine missiles, if the applicant proposes to install barriers or use existing structures or features as barriers. The organization responsible for civil engineering and structures reviews the structural capability of these barriers to withstand turbine missiles in accordance with the procedures specified in DSRS Section 3.5.3.

5. 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 DSRS Section 3.5.1.3.

## 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.

1. This applicant having sufficiently demonstrated to the staff that the probability of turbine missile damage to safety-related or risk significant SSCs is acceptably low, the staff concludes that the turbine missile risk for the proposed plant design is acceptable and meets the requirements of GDC 4.

2. For design certification reviews, the findings will summarize, to the extent that the review is not discussed in other safety evaluation report sections, the staff's ITAAC evaluation, including site interface requirements, and COL action items that are relevant to this DSRS section.

3. 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™-specific design certification (DC), or combined license (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™ 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 (SMR) reviews including the associated pre-application activities, the staff has developed the content of this DSRS section as an alternative method for mPower™ -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 Standard Review Plan (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™ 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. 10 CFR Part 50, Appendix A, General Design Criterion 4, "Environmental and Dynamic Effects Design Bases."

2. 10 CFR Part 100, "Reactor Site Criteria."

3. Regulatory Guide 1.115, "Protection Against Low-Trajectory Turbine Missiles," Revision 2.

4. "Fundamentals of Protective Design," TM-5-855-1, Department of the Army, July 1965.

5. NUREG-1048, Supplement No. 6, "Safety Evaluation Report Related to the Operation of Hope Creek Generating Station," July 1986 (includes Appendix U, "Probability of Missile Generation in General Electric Nuclear Turbines") (ML13106A020).

6. NUREG/CR-1884, "Observations and Comments on the Turbine Failure at Yankee Atomic Electric Company, Rowe, Massachusetts," March 1981 (ML13106A021).

7. J. J. Burns, Jr., "Reliability of Nuclear Power Plant Steam Turbine Overspeed Control Systems," Chicago, IL; ASME 1977 Failure Prevention and Reliability Conference; page 27. September 1977.

8. W. G. Clark, Jr., B. B. Seth, and D. H. Shaffer, "Procedures for Estimating the Probability of Steam Turbine Disc Rupture From Stress Corrosion Cracking," St. Louis, MO; ASME/IEEE Power Generation Conference, October 4-8, 1981.

9. D. Kalderon, "Steam Turbine Failure at Hinkley Point A," Proceedings of the Institute of Mechanical Engineers, 186, 31/72, page 341. 1972.

10. License Event Report No. 82-132, Docket No. 50-361, "Failure of Turbine Stop Valve 2UV-2200E to Close Fully," San Onofre Nuclear Generating Station, Unit 2, November 19, 1982.

11. Preliminary Notification of Event or Unusual Occurrence, PNO-111-81-104, "Circle in the Hub of the Eleventh Stage Wheel in the Main Turbine," Monticello Nuclear Power Station, November 24, 1981.

12. NRC Memorandum from E. Jordan to W. Russell (with enclosed report, AEOD/S94-02 by H. Ornstein), "AEOD Special Study -- Turbine-Generator Overspeed Protection Systems at U.S. Light-Water Reactors," September 30, 1994 (ML13100A061).

13. Letter from C. Rossi (NRC) to J. Martin (Westinghouse Electric Corporation), "Approval for Referencing of Licensing Topical Reports WSTG-1-P, May 1981, 'Procedures for Estimating the Probability of Steam Turbine Disc Rupture From Stress Corrosion Cracking,' March 1974, 'Analysis of the Probability of the Generation and Strike of Missiles from a Nuclear Turbine,' WSTG-2-P, May 1981, 'Missile Energy Analysis Methods for Nuclear Steam Turbines,' and WSTG-3-P, July 1984, 'Analysis of the Probability of a Nuclear Turbine Reaching Destructive Overspeed,'" February 2, 1987 (ML13100A011).

14. NUREG-0887, Supplement No. 3, "Safety Evaluation Report Related to the Operation of Perry Nuclear Power Plant, Units 1 and 2," April 1983 (ML091310474.