NRC RAIs on LTR NEDO-33148

BWROG Option 3 Committee
Tony Browning (DAEC), Chairman

Topics

- Introduction
- Intent of NEDO-33148
- First session: PRA-related RAIs
- Second session: RAIs related to the MAAP code
- Third session: Preliminary responses to 2005 NRC Electrical Branch comments on the LTR

Introduction

- BWROG purposes for this meeting
  - Clarify BWROG intent for this LTR
  - Clarify NRC staff RAIs
- This information will drive the schedule for BWROG response to the RAIs

Introduction

- BWROG intends to work with the NRC staff to implement lessons learned from these and other risk-informed applications
  - Reformat LTR to RG 1.174 application
  - Expand Chapter 9 (plant-specific implementation guide) to address key
    - NRC staff concerns
    - PRA quality
    - Parametrics
  - Additional demonstrations/sensitivity studies could be accommodated in the Lead Plant submittal

Introduction

- Concerned that NRC staff direction is not compatible with original LTR intent
  – Extensive new bounding analyses, either PRA and T/H, appear to be required
  – Current NRC staff direction in the RAIs appears different from the original understanding of the LTRs purpose

NEDO-33148

- Intent of this LTR
  - Provide the technical and regulatory basis for an exemption request and licensee guidance for implementation
    - Uses of other published reports, both NRC and Industry, for its justification of several important assumptions made in this study, e.g., LBLOCA probability, consequential/delayed LOOP, and "double sequencing" of electrical loads.
  - Be referenced by any BWR licensee in a specific 10 CFR 50.12 exemption request without the need to perform extensive plant specific analyses
    - Should help streamline the Staff's review of the individual submittals and provide the supporting framework for the proposed rulemaking

NEDO-33148

- Summary of Approach
  - Basic assumptions
    - LBLOCA/LOOP combination is redefined from a design basis event to a severe accident, for which some mitigation capability must be assured
    - Continued compliance with 10 CFR 50.46 (and all other relevant regulations) must be demonstrated after any plant changes to the revised design basis

NEDO-33148

- Specific design changes facilitated by the LTR
  - Allow EDG warm up prior to loading
  - Optimize the loads sequenced on to the EDGs
  - Start EDGs only when needed
  - Simplified EDG testing
  - Increased MOV stroke times
  - Automatically start one RHR loop in suppression pool cooling mode
  - Eliminate LPCI loop select

NEDO-33148

- Supporting analysis provided
  - Risk impact of changes
  - Thermal-hydraulic assessment
  - Compliance with regulations
  - Defense-in-depth and safety margin assessments
- Implementing guidance provided

PRA RAIs

- Define NRC goals for PRA analysis to support the LTR
  - Address need for generic vs plant-specific PRA analyses
  - Clarify other PRA information needs for NRC
- Address BWROG level of effort and schedule to respond to RAIs
- Discuss additional PRA information that needs to be included with a utility exemption request
- Discussion of RAIs follows
  - Close with session summary

MAAP RAIs

- Define NRC goals for thermal-hydraulic analysis to support the LTR
  - Address usefulness of and industry reliance on MAAP code
  - Clarify other T/H information needs for NRC
- Address BWROG level of effort and schedule to respond to RAIs
- Discuss additional T/H information that needs to be included with a utility exemption request
- Discussion of RAIs follows
  - Close with session summary

Electrical Branch RAIs

- NRC Electrical Branch commented in 2005 on EPRI reports 1009110 and 1007966 supporting NEDO-33148
- Formal response in preparation
  – Summary of preliminary responses follows
- Determine the need and schedule for additional Electrical Branch RAIs on this LTR

Preliminary Comment Responses, EPRI-1009110

- Comment 1 (p. 7-2 Item 8):
  - *The transmission system operator cannot be relied upon to control a plant's post-trip switchyard voltage to the level that is necessary for the nuclear plant, unless the transmission operator has been made aware of the nuclear plant's requirements, and arrangements have been negotiated to control the switchyard voltage to that level, post-trip.*
  - Preliminary BWROG response: Agree, but no change needed. GL 79-36 and related BTP suffice. Users should consider all items in Section 7.

Preliminary Comment Responses, EPRI-1009110

- Comment 2 (P. 7-3, sentence immediately following item 10):
  - *"Best estimate LOOP [loss of offsite power] frequency" is not the important parameter for LOCAs [loss-of-coolant-accidents]. The important parameter for LOCAs is "conditional LOOP probability given a LOCA." This is the parameter that should be determined for LOCA initiators including degraded voltage situations.*
  - Preliminary BWROG Response: Intend to eliminate use of "best estimate." Affected sentence would read, "The above guidelines should assist the user in determining the probability of occurrence of a degraded voltage-induced LOOP."

Preliminary Comment Responses, EPRI-1009110

- Comment 3 (partial paragraph following that sentence in Comment 2):
  - *With regard to the statement, "While a LOOP is not likely to cause a LOCA," it is noted that a LOOP that results in a full-load rejection of a nuclear plant's turbine generator has some potential to cause a LOCA due to stuck-open safety or relief valves.*
  - Preliminary BWROG response: We do not believe that a stuck-open SRV should be classified as a LOCA
    - To be addressed further in the formal response

Preliminary Comment Responses, EPRI-1009110

- Comment 4 (P. 7-3, last bullet):
  - *With regard to the sentence that reads, "The delay in tripping the turbine is nominally about 30 seconds, however the reverse power relays usually operate considerably sooner and trip the generator." The beginning of that sentence should read, "The delay in tripping the generator is ..." Also, it is our understanding that Westinghouse plants and some other pressurized water reactors (PWRs) utilize 30 second time delays only and do not necessarily utilize reverse power relays to trip the generator and transfer loads (reactor coolant pump shaft seizure event credit).*
  - Preliminary BWROG response: Would change reference from "turbine" to "generator." Would likely revise sentence to read "The delay in tripping the turbine is nominally set at 30 seconds, however, in the case of some units, other protective devices may be set to cause a generator trip in advance of 30 seconds for reasons of preventing damage to the main generator windings."

Preliminary Comment Responses, EPRI-1009110

- Comment 5 (P. 7-4, 2nd bullet):
  - *With regard to the sentence that reads, "High-speed transfer schemes have historically functioned very reliably," NRC report AEOD/E-93-02 and EPRI Advanced Light Water Reactor [ALWR] Requirements Document for the ALWR Evolutionary Plant, Chapter 11, indicate that high speed transfer schemes have <u>not</u> functioned very reliably.*
  - Preliminary BWROG response: Would change the wording in the report from "High-speed transfer schemes have historically functioned very reliably." to "High-speed transfer schemes have not historically been a major contributor to loss of offsite power events nor have they been demonstrated to unduly stress transferred loads."

Preliminary Comment Responses, EPRI-1009110

- Comment 6 (Page 7-5 – First three bullets on page)
  - *The assumptions of these three bullets is that as long as the duration of safety system deenergization is small compared to the capabilities of the batteries (1-hour useful discharge life), double, triple, or even quadruple sequencing would not affect the batteries capability. The margin that is believed to exist on the batteries is not as large as assumed here. The first one-minute loading on batteries that is due to load sequencing is almost always limiting. The battery voltages during this period are pulled down very close to the minimum required voltages of the loads due to current inrushes of loads like circuit breaker charging motors. Although the battery may have one or more hours capacity at much lower current demands, a substantial amount of capacity does not have to be discharged before it cannot meet the limiting load sequencing requirement. The battery may not be capable of providing two, three, or four load sequencing repetitions if the charger is not available due to low input voltage or late sequencing on the emergency diesel generator (EDG).*
  - *Preliminary BWROG response: The document should not serve to relieve the users of the requirement to determine that the above is or is not the case for their unit(s). The words "triple, or even quadruple" will be removed . The revised discussion would also acknowledge that not all nuclear units have a 125 VDC system.*

Preliminary Comment Responses, EPRI-1009110

- Comment 7a (*Page 7-6 – Table 7-1, Item 1 and its associated Note 1)*
  - *This item evaluates 4kv motor and control switchgear buses and breakers from a loading duty cycle perspective, but that is not the limiting case for double sequencing. An evaluation should be performed of the circuit breaker (CB) anti-pump logic and load sequencing logic for the double sequencing scenario. Actuation of CB anti-pump logic due to double sequencing can result in a trip and lockout of CBs feeding safety equipment. CB anti-pump logic designs that re-charge CB closing springs following a trip of the CB are especially vulnerable, but all CB anti-pump designs are vulnerable to some degree. Such vulnerability was identified at Indian Point 3 in April 5, 1994, letter to the NRC. NUREG/CR-6538 provides additional background on CB anti-pump logic vulnerabilities during double sequencing.*
  - Preliminary BWROG response: We concur with the breaker anti-pumping comment and would revise the document to ensure that the user is aware of the need to complete a unit-specific review of that circuit's design and ability to function properly during a double sequencing evolution.

Preliminary Comment Responses, EPRI-1009110

- Comment 7a *(Page 7-6 – Table 7-1, Item 1 and its associated Note 1)*
  - *Load sequencing logic that is not specifically designed for double sequencing can result in overloading emergency diesel generators (EDGs) due to failure to load shed previously sequenced loads during double sequencing, paralleling the EDG out-of-phase with motor residual voltages, and/or it can simply result in lockup of the sequencer. Additional information on these load sequencing vulnerabilities can be found in NRC Information Notice 92-53, "Potential Failure of Emergency Diesel Generators Due to Excessive Rate of Loading," and NUREG/CR-6538.*
  - *Preliminary BWROG response: A design that allows an emergency diesel generator (EDG) to become overloaded and/or damage itself and/or its loads due to an out-of-synchronization breaker closure is inappropriate and requires correction. A sequencer design that works properly in the long-term post-LOCA should work equally properly in the near-term post-LOCA. None-the-less, our revisions will include references to NUREG-6538 and the related NRC Issue 171 since these can be helpful to users of the double sequencing documents.*

Preliminary Comment Responses, EPRI-1009110

- Comment 8 (*Page 7-6 – Table 7-1, Item 2 and its associated Note 2)*
  - *This item evaluates 4kV protective relaying. It only evaluates electro-mechanical induction disk time-overcurrent relaying. IEEE Standard 741-1997 identifies solid state overload (SSO) relays with thermal memory capability that have been used on the motors of motor-operated valves (MOVs). If these relays are also used on 4 kV motors, it provides a greater potential that the relay will trip during double sequencing because the relay is not completely reset back to zero following the first start of the motor. This is the case for any motor-current overload protective device that utilizes a thermal memory capability, e.g., thermal overload (TOL) protective devices in motor starters.*

  - Preliminary BWROG response: We concur that our Note 2 explanation using induction disk type time-overcurrent relays as the example too narrowly focuses on one relay type and does so without consideration for load inertia. The document will be revised accordingly, likely recommending that licensees review limiting cases.

Preliminary Comment Responses, EPRI-1009110

- Comment 9 (*Page 7-6 – Table 7-1, Item 3 and its associated Note 3)*
  - *This item evaluates 4kV 125Vdc control power. Note 3 concludes that control power for the metal-clad 4kV switchgear at most, if not all units, is supplied by a 125Vdc battery system and is therefore not subject to the effects of double sequencing. Comments 6 and 7 above apply.*
  - Preliminary BWROG response: Our responses to Comments 6 and 7 above relative to the 125 VDC systems also apply to this comment.

Preliminary Comment Responses, EPRI-1009110

- *<u>Comment 10a (Page 7-6 – Table 7-1, Item 4 and associated Note 4)</u>*
  - (excerpt) *Neither Tables 7-3 nor 7-4 under Note 4 provide any data on fan motors. This information should be provided as well as an evaluation of the effects of double sequencing on the fan motors. Fans and their motors should be specifically evaluated in this EPRI report, rather than leaving it to the individual plants, since they may be the most limiting electrical motors under double sequencing conditions.*
  - Preliminary BWROG response: We concur that our document needs to evaluate a few fan-loaded motors at a minimum. Our recommendation that users evaluate bounding fan load cases would likely remain, however, as it may not be possible to identify a bounding typical case. It is appropriate to provide a sampling of results and we would strive to obtain the necessary detailed information from the owners of the pilot units studied.

Preliminary Comment Responses, EPRI-1009110

- <u>*Comment 10b (Page 7-6 – Table 7-1, Item 4 and associated Note 4)*</u>
  - *(excerpt) Under the degraded voltage condition discussed, the applied voltage will not meet the minimum specified voltage in MG1-20.45; and as a result will not meet the requirements in MG1-20.43 for two starts in succession. This should be discussed in Note 4. It is noted that in Section 2.3, page 2-3 of the report, there appears to be no acknowledgement that switchyard voltage could drop immediately following the trip of the plant's generator due to the loss of the generator's MVAR support to the grid. This should be addressed in Section 2.3.*
  - *Preliminary BWROG response:*
    - *We will advise users to evaluate a bounding case using the minimum voltage which could persist for the duration of their second level undervoltage relay time delay.*
    - *Our revisions will seek to provide guidance as to a means for calculating a degree of voltage degradation that is both conservative and reasonable.*
    - *We will continue to consider the second start of equipment to be under normal power supply conditions. . Experience shows EDGs to be excellent suppliers of stand-alone power for the starting of motors*
    - *We will include some discussion of switchyard voltage drop in both Section 2.3 and when specifically addressing motor starts.*

Preliminary Comment Responses, EPRI-1009110

- Comment 10c (Page 7-6 – Table 7-1, Item 4 and associated Note 4)
  - *On page 7-9 of the report, Note 4 states that motors are nominally designed for a life of from 20 to 40 years and, in many applications have, with reasonable preventive maintenance, lasted significantly longer than the design life. Note 4 should acknowledge that the majority of plants will be operating for 60 years under license renewal and address the consequences of this on motor design life.*
  - Preliminary BWROG response: We would revise the report to acknowledge the likelihood of most plants operating for 60 years and provide some of the generic reasons why motors may be acceptable for life extension given their relatively mild service environment, low number of starts, routine preventive maintenance etc.

Preliminary Comment Responses, EPRI-1009110

- Comment 10d (Page 7-6 – Table 7-1, Item 4 and associated Note 4)
  - *Note 4 references Table 7-3 data from Millstone and states that sizeable safety margins are evident between the inertia the motors could accelerate to rated speed and the inertia of the actual plant loads. Are the actual plant load inertias provided in Table 7-3, the inertia with the pump discharge valves initially in the closed or open position? During double sequencing, the first pump start will typically be with the pump discharge valves in the closed position resulting in low load inertia; but during the second pump start the valves will likely be in the fully open opposition resulting in high load inertia. This issue was identified during an Advisory Committee on Reactor Safeguards (ACRS) hearing on delayed LOOP, and the ACRS indicated that the design of the pumps generally only provide for starting of the pump against a closed discharge valve.*

  - Preliminary BWROG response: A properly designed pump motor start control circuit includes interlocks to preclude starts under incorrect discharge valve lineups when valve position is important. A Service Water Pump (SWP) at one of the pilot units is a good example for discussion and will be considered for inclusion in the report.

Preliminary Comment Responses, EPRI-1009110

- Comment 11 (Page 7-6 – Table 1, Item 5 and its associated Note 4)
  - *This item evaluates 4kV fan motors. Comment 10a above applies.*
  - Preliminary BWROG response: Our response to Comment 10a applies to this comment as well.

- Comment 12 (*Page 7-6 – Table 7-1, Item 8 and its associated Note 7)*
  - *This item evaluates 480V load center switchgear and breakers. Comment 7 above applies to 480V breakers that are load sequenced.*
  - Preliminary BWROG response: Our response to Comment 7 applies to the comment as well.

Preliminary Comment Responses, EPRI-1009110

- Comment 13 (Page 7-6 –Table 7-2, Item 10 and its associated Note 9)
  - *This item evaluates 480V load control center switchgear and breakers. Comment 7 above applies to 480V breakers that are load sequenced.*
  - Preliminary BWROG response: Our response to Comment 7 applies to this comment as well.
- Comment 14 (Page 7-6 – Table 7-2, Item 10 and its associated Note 9)
  - *This item evaluates 125Vdc control power for 480V load control centers. Comment 6 above applies.*
  - Preliminary BWROG response: Our response to Comment 6 applies to this comment as well.

Preliminary Comment Responses, EPRI-1009110

- Comment 15 (Page 7-6 – Table 7-1, Item 11 and its associated Note)
  - *This item evaluates 480V load center powered pump motors. The number of the note associated with it appears to be in error. The staff believes Note 4 was intended. Comments 10a, b, c, and d above apply.*
  - Preliminary BWROG response: The equipment numbers in the Table are not appropriately indexed to the notes. In addition to correcting this overall condition, we would also correct the note numbering error that you have identified when we revise the document. Our responses to Comments 10a, b and c apply to this comment as well.

Preliminary Comment Responses, EPRI-1009110

- Comment 16 (Page 7-7 – Table 7-1, Item 12 and its associated Note 4)
  - *This item evaluates 480V load center powered fan motors. Comment 10a above applies.*
  - Preliminary BWROG response: Our response to Comment 10a applies to this comment.

- Comment 17 (Page 7-7 – Table 7-1, Item 13)
  - *This item evaluates 480V motor control centers molded case circuit breakers. No note is associated with this item, but it appears Note 10 was intended to apply.*
  - Preliminary BWROG response: We will correct this omission.

Preliminary Comment Responses, EPRI-1009110

- Comment 18 (Page 7-7 – Table 7-1, Item 14 and its associated Notes 10 & 11)
  - *This item evaluates 480V motor control center protective relaying. It appears that only Note 11 applies to this item and Note 10 was intended to apply to Item 13. Note 11 states that double sequencing will not cause improper operation of thermal overload protectors if these relays are set in accordance with standard industry practice. The staff does not believe this is necessarily true, particularly if the double sequencing is due to degraded voltage. Comment 10b above discusses the degraded voltage scenario. The double sequencing, in combination with the prolonged inrush current during the first degraded voltage start, could cause actuation of thermal overload protectors due to the excessive pre-heating of the thermal element during the first start. Comment 8 above also applies.*
  - Preliminary BWROG response: We will correct the notation error. The document will be expanded to cover this issue and the potential need for unit-specific sensitivity checks of bounding motor/load thermal overload combinations. Our response to Comment 8 is closely related to this comment.

Preliminary Comment Responses, EPRI-1009110

- **Comment 19 (Page 7-7 – Table 7-1, Item 17 and its associated Note 13)**
  - *This item evaluates 480V MOV reversing and non-reversing contactors. The associated Note 13 addresses the high continuous inrush current that can flow to the coils of motor starters during a sustained degraded voltage condition. It describes fuse blowing experiment results at Millstone that found properly sized fuses remained intact with inrush current flowing from 40 to 60 seconds. Degraded voltage relay time delays have typically been chosen to be short enough to preclude the fuses from blowing, but did not consider the second additional short reenergization and inrush that would occur during double sequencing initiated by a degraded voltage condition. Degraded voltage relays, particularly those with longer time delays, should be evaluated to ensure the second reenergization will not blow the fuse.*
  - Preliminary BWROG response:
    - We will add a reminder that fuse sizing criteria and second level undervoltage time delay need to be evaluated on a unit-specific bounding case basis.
    - We do not, in general, agree that the second contactor pickup demand has the potential to blow the fuse even if only minor fuse opening margin remains after the first attempt. We will discuss the need to consider this potential in our revisions to the document.

Preliminary Comment Responses, EPRI-1009110

- Comment 20 (Page 7-7 – Table 7-1, Item 18 and its associated Note 14)
  - *This item evaluates short duty cycle (15 minute) motors. The associated Note 14 states that even in the most severe applications, several strokes from one position to the other can be completed without violating the 15-minute criteria. The Note does not address double sequencing that is initiated by a degraded voltage. In this scenario, the MOV motor inrush and operating cycle during the first degraded voltage start can be excessively long since the motor torque is a direct function of the applied V^2. During the second sequence, if the MOV has not fully cycled, there will be a second motor inrush. This could potentially trip the motor overload protection and should be evaluated. Comment 18 above also applies.*
  - Preliminary BWROG response: Our report would be modified to note that for nuclear units wherein the thermal overloads are not bypassed either full time or upon occurrence of an accident event per NRC guidance, a review of a bounding case will be necessary to determine if the thermal overload is appropriately sized.

Preliminary Comment Responses, EPRI-1009110

- Comment 21 (Page 9-2 – Recommendation 5)
  - *This recommendation indicates that increasing the failure probability of the diesel generators and the grid-related LOOP initiating frequency are two approaches to modeling the risk impact of double sequencing in plant-specific probabilistic risk assessment (PRA) models, and those can easily be implemented in the nuclear plant equipment out-of-service computer program. The staff does not agree with this view and would reject an analysis that used only these approaches. Increasingly the failure probability of the diesel generators, which is the second proposed approach, is only a portion of the vulnerability of double sequencing scenarios. A PRA should consider the other equipment vulnerabilities addressed in the EPRI report as amended by the totality of these NRC comments. If the vulnerabilities do not make the particular safety equipment unavailable altogether, the analysis should consider how the equipment failure rates would increase under the double sequencing scenario conditions and stresses.*
  - Preliminary BWROG response: This requires further discussion. Regarding the issue of "conditional probability" and as noted earlier in our responses, we will refrain from using that terminology since a double sequencing event can only occur if there is a safeguards actuation and otherwise has no meaning.

Preliminary Comment Responses, EPRI-1007966

- Comment 1 (General):
  - *The comments provided for EPRI Report 1009110, Revision 1, "The Probability and Consequences of Double Sequencing Nuclear Power Plant Safety Loads," apply equally to this report and boiling water reactors (BWRs) in general, since the electrical equipment in BWRs is not substantially different from pressurized water reactor designs.*

  - Preliminary BWROG response: We agree that, with minor exception, the comments on the major report are equally applicable to BWRs. An example of one exception is the discussion of the 30-second time delayed trip of the main generator in PWR plants included in your Comment 4.

Preliminary Comment Responses, EPRI-1007966

- Comment 2 (Page 7-3 – Discussion in Section 7.4)
  - *In this discussion it is indicated that BWR/6 designs have additional margin and are less affected by double sequencing because they have a dedicated diesel generator for the HPCS system. It is not clear if these conclusions recognize that the HPCS is normally powered from offsite power and is powered from its diesel only when offsite power is lost. It is therefore subject to energization and reenergization similar to double sequencing. There is also at least one BWR/6 plant that has a short sequence of an HPCS pump and a cooling water pump on the HPCS diesel generator, which would make it even a bit more like the double sequencing designs.*
  - Preliminary BWROG response: We would research this comment and revise the document as appropriate.