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Subject: Identification of Issues of Importance for MSPI

Below is an expanded version of the issue identification list with an introduction that contains some thoughts on specific things we might want to look at in our look at the ASME Standard. I've modified the issue list in response to our discussions last week, and I've tried to focus only on those issues that appear in the same cutsets as the systems of importance. I haven't tried to rank the issues by importance, though there is some implication in the way I've ordered them. We need to find out which of these issues could indeed lead to the sort of big changes we talked about.

Introduction

In RG 1.174 and in RG 1.200, the PRA quality required for an application is defined in terms of the scope of the PRA, its level of detail, and its technical adequacy. Consistent with the scope of the MSPI, the scope of PRA required for the MSPI application is a level 1 PRA at full power. Since a Standard to support the scope of PRA required has been endorsed in RG 1.200, the MSPI application can be classified as a Phase 2 type application in the Commission's Phased Approach to PRA quality.

Since an importance measure of a single item is affected to some extent by everything else in the PRA model, it is necessary, when making an assessment of what capability category is appropriate for the specific MSPI application, to take this into account. Essentially it will be necessary to have confidence that the structure of the PRA model is such that it is reasonably complete in addressing significant contributors, and correctly captures the various functional and inter-system dependencies.

The contributions to the MSPI derive from the accident sequence cutsets that include failures of the components of the system as defined in the MSPI guidance. Therefore, an additional concern is that such cutsets are not truncated or otherwise screened out of the model. The relative importance of systems is affected by the failures that prevent the system from being called on, e.g., a conservative treatment of depressurization in a BWR will lessen the significance of the low pressure systems. While this does not affect the MSPI directly, it does raise a concern about the approach to truncation. Screening of contributors could happen for example if, assuming that a human error probability is the dominant contributor to the system unavailability, leads to omitting the system hardware failure contributions. Another concern is whether support system initiators have been included correctly. For example, a support system initiator that makes a train of an MSPI system unavailable would result in the redundant train(s) becoming relatively more important.

Even if a PRA meets the requirements of the Standard at the specified capability categories, there will still be variability in the methods used by different licensees for dealing with certain issues, e.g., the assessment of human error probabilities. Some of this will not have a significant impact on the MSPI values. However, there is a subset of issues that can have a direct and potentially significant impact on the importance of specific MSPI systems. Of particular concern are those PRA features whose treatment may vary significantly from licensee to licensee. From the NRC's perspective, the greatest concern is those issues that have the potential for inappropriate modeling that drives down the significance of an MSPI system, i.e., artificially lowers its FV or Birnbaum importance. The requirements of the ASME Standard that deal with features should be looked at carefully. Since the Standard is not prescriptive in many of these areas, the aim should be to determine whether there is sufficient confidence that inappropriate modeling practices would either have been identified during the peer review process, or, since the peer reviews have already been performed, by the self assessment process (NEI-00-02).

In terms of the overall capability of the PRAs, since, as discussed above, the importance of any SSC is affected by the whole model, it is probably reasonable to start from the premise that a capability category II PRA would be a good place to start, but to see if there's anything we can relax (i.e., capability category I) and not have a significant effect on MSPI.

In the following, those features of the PRA model are identified that have an influence on the importance of the system to CDF. Some commentary is added to illustrate how the MSPI might be affected by adopting a particular approach or implementing certain assumptions in the PRA. We need to be able to identify the most significant.

The approach taken is the following. Those CDF sequences are identified in which failures of the MSPI systems appear. For the purpose of this analysis the sequences are discussed at a relatively high level, corresponding to functional or systemic description. It is these sequences that directly impact the Birnbaum importance of the system/components. It is the absolute value of the change in CDF resulting from failures of those system components that is important.

BWR MSPI Systems

Emergency ac power
HPCI/HPCS/FWCI
RCIC/isolation condenser
RHR
cooling water (SW/ESW)

<u>Emergency ac power</u>

The system is modeled in the loss of offsite power (LOOP) event tree. Sequences initiated by LOOP, and involving failure of the ac power system, including the station blackout (SBO) sequences, are usually significant contributors to core damage. The sequences typically involve the assessment of the convolution of the progression to core damage as a result of inventory boil off and the recovery of an ac power source. The frequencies of these accident sequences are a function of the frequency of the loss of offsite power initiating event, the derivation of the various time windows for recovery of offsite power, the probability of recovery of ac power as a function of time, including credit taken for cross-tie between units and use of alternate on- or off-site sources (e.g., combustion gas turbines), and the failure probabilities and the common cause failure (CCF) probability(ies) of the diesels themselves. The CCF of the station batteries may be a significant factor in SBO frequency, but since the batteries are not included in the system boundary, they will not impact the MSPI. Partial station blackout sequences (i.e., those with one or more diesel generators operating) will involve the usual complement of makeup and heat removal sequences. The most significant issues affecting the evaluation of the MSPI for the emergency ac power system are:

- assessment of the frequency of offsite power as a function of duration
- credit taken for recovery of ac power, including:
    - recovery of offsite power
    - cross-tie with sister unit
        - typically dominated by human error
    - availability of alternate sources, e.g., combustion gas turbine, including consideration of operator action
- time windows for recovery based on factors such as;
    - battery depletion (including credit for load shedding)
    - room heat up
- CCF probabilities of diesel generators
- For the special case of BWRs with isolation condenser, the likelihood of a stuck open SRV

<u>HPCI/HPCS/FWCI</u>

HPCI: In core damage sequences of transient event trees failure of HPCI is either coupled with failure of other high pressure injection systems (RCIC, recovery of feedwater, CRD) and failure of depressurization, or failure of other high pressure injection systems and failure of low pressure injection. The importance of HPCI is affected by the credit taken for additional injection systems (over and above RCIC). For example, taking credit for firewater (as an additional low pressure system) or CRD or recovery of feedwater (as a high pressure system) can lessen the importance of HPCI.

In the LOOP/SBO tree a significant function of HPCI is to provide a delay to give time to recover the offsite power. Therefore, the modeling of recovery of offsite power in the short term (given that HPCI has failed), the frequency of LOOP, and the CCF probability of the diesels and the station batteries all have an impact on the importance of HPCI.

HPCI importance is therefore affected by:

- HEP for depressurization
- credit for alternate injection systems (e.g., fire water, SW cross-tie, CRD, recovery of feedwater)
- LOOP frequency, CCF of diesels and batteries, and the factors associated with the short time recovery of ac power given a LOOP

HPCS: This closely follows HPCI.

FWCI: For BWRs with an isolation condenser, the FWCI is the high pressure injection system used in case of failure of the isolation condenser. Credit for the IC will impact the MSPI.

<u>RCIC/IC</u>

RCIC: The importance of RCIC should fairly closely parallel that of HPCI. For plants with a HPCS, the credit taken for cross-tie of the Div III diesel to other buses may reduce its significance on SBO sequences.

IC: The IC will appear in sequences combined with failure of FWCI (or PCS) and failure to depressurize or failure of LPI.

<u>RHR</u>

The RHR pumps are also the LPCI pumps. Therefore, the importance of this system is affected by system failures and human failure events that appear with failure of LPCI in TQUV type sequences (failure of all injection), and with failure of RHR in the TW (loss of containment heat removal) sequences.

TQUV sequences: The importance of LPCI is affected by consideration of additional systems (e.g., firewater, CRD). Also, on a relative basis, these sequences may be of less significance if a conservative assessment is made of the probability of failure to depressurize the reactor following a loss of high pressure injection. However, this should not impact the MSPI, since it is only those cutsets that involve failures of the LPCI system that are relevant.

TW sequences: The importance of RHR is affected by the HEP for failure to initiate suppression pool cooling, and the credit taken for venting and continued injection, post-venting.

The issues affecting the importance of RHR are:

- credit taken for alternate injection systems (e.g., firewater, SW cross-tie, CRD)
- treatment of venting (HEP, recognizing that for MSPI, this occurs in the same cutset as equipment failure of RHR, not the failure to depressurize)
- Injection post-venting (NPSH issues, environmental survivability of systems in the reactor building (Mk II containments), sources injecting from outside the containment/RX building, e.g., SW, firewater)

QUESTION: Will a too conservative treatment of the failure to initiate RHR lead to a truncation of the cutsets for the equipment failures? Do we have to worry about this?

Cooling water systems (SW/ESW/RHRSW)

The cooling water systems are required for cooling diesel generators and for the secondary side of the RHR heat exchangers. While room cooling may be required for some pumps, e.g., HPCI, RCIC, CS, that function is not included in the system function for MSPI. Therefore, the sequences of interest are:

LOOP sequences: while the importance of cooling water systems will be affected by the same things as the emergency ac power system, the effect will be smaller because the failure of SW to the diesels is typically a small contribution to CDF cutsets.

TW sequences: again the importance will be impacted by those things that affect the suppression pool cooling function of RHR, i.e., credit for venting and post-venting injection, and initiation of suppression pool cooling. If significant credit is taken for success of venting then this will decrease tie significance of the cooling water system in the same way as it does for RHR.

In some cases, failures of cooling water systems may be candidates for consideration as support system initiators. Inappropriately excluding their contribution will result in an underestimate of the importance of the system.

For multi-unit sites some plants have the capability to cross-tie systems between units. Depending on the credit given this can have a significant impact on the significance of a support system.

For the fault tree linking approach to PRA, the method used to cut logic loops (dependence of support systems on support systems) if done incorrectly can result in under or overestimation of the significance of the system.

Inappropriate screening of the need for room cooling will lead to underestimating the significance of the cooling systems.

The issues affecting the importance of the cooling water systems are:
- significance of the LOOP scenarios
- treatment of support system initiators
- credit for venting and post-venting injection (TW sequences)
- credit for cross-tie with a sister unit
- approach to cutting logic loops
- screening of the need for room cooling

PWR MSPI Systems

emergency ac power
high pressure safety injection
auxiliary feedwater system
residual heat removal system
cooling water support (SW/CCW)

Emergency ac power system

As for BWRs, the frequency of the loss of offsite power, the derivation of the various time windows for recovery of offsite power, the probability of recovery, and the failure probabilities and CCF probabilities of the diesels will affect the significance of the emergency ac power system. However, in addition, the treatment of RCP seal LOCAs can have a significant effect on the importance of the diesel generators. The issues affecting the importance of the emergency ac power system are:

- frequency of offsite power as a function of duration
- RCP seal cooling model
- credit taken for recovery of ac power, including:
  - recovery of offsite power
  - cross-tie with sister unit
  - alternate sources, e.g., combustion gas turbine
- time windows for recovery based on factors such as;
  - battery depletion (including credit for load shedding)
  - room heat up
  - credit taken for providing alternate seal cooling
- CCF probabilities of diesel generators

High pressure safety injection

For injection, HPSI is primarily required for small and medium LOCAs, and SGTR. Its importance will be affected by LOCA frequencies, and the modeling of SGTR, in particular the HEP for failure to isolate the faulted generator. If credit is taken for depressurization to allow low head pumps to inject (core cooling recovery), the significance of the HPSI will decrease.

For those plants for which feed and bleed is an option, the importance of HPSI will be affected by the unavailability of the AFW system, and any credit taken for recovery of main feedwater. The issues affecting the importance of the HPSI are:

- small and medium LOCA frequencies (including stuck open PORVs)
- credit for core cooling recovery (rapid depressurization)
- SGTR frequency and HEP for failure to isolate the faulted generator

Auxiliary feedwater system

AFW importance can be affected by the credit taken for recovery of main feedwater, and, for those plants for which it is an option, probably more so by the credit taken for feed and bleed, which is a function of the HEP and the assumptions on the success criteria (1 PORV vs 2). In all cases, sequences involving loss of the AFW will need to address containment heat removal. This is typically achieved by establishing RHR following cooldown and depressurization, or by sump recirculation. The issues affecting the importance of the AFW system are:

- Credit taken for Feed and Bleed (if applicable)
  - the HEP for failure to initiate feed and bleed
  - the assumed success criterion, (1 vs. 2 PORVs)
- Credit for recovery of main feedwater

- probabilities of failure to establish containment heat removal, particularly the HEPs for either establishing RHR (including cooldown and depressurization), or establishing sump recirculation

Residual heat removal system

All sequences that include failure of AFW and PCS will contribute to the importance of the RHR system. For those plants that require the low pressure pumps for high head recirculation (piggy-back mode), the sequences that end in sump recirculation will contribute to the importance of the RHR system. For plants where the RHR pumps are also the low pressure injection pumps, the importance of the system is affected by the assumptions made for the large and medium LOCAs. For some plants (Beaver Valley, Surry and North Anna) the RHR function is performed by the inside and outside containment spray recirculation system. While, in a relative sense, the importance of the RHR system will be less than that for the other plants, the same issues will affect its significance on an absolute basis. The issues that can affect the significance of the RHR system are:

- LOCA frequencies (all categories) (for all plants there are LOCA sequences that include failure of residual heat removal, either from failure of RHR or failure of sump recirculation)
- Credit for recovery of main feedwater

Cooling water systems

These are typically required for diesel generator cooling, for RCP seal cooling (CCW and SW), for pump cooling and RHR in the recirculation mode, and other decay heat removal functions. They may or may not be needed for pump cooling for injection from the RWST following a LOCA, but since ultimately all F&B and LOCA sequences transfer to the requirement for decay heat removal they all require cooling water. Failures of cooling systems may be identified as support system initiators. The issues that can influence the importance of the cooling water systems are:

- treatment of support system initiators
- the assessment of LOOP and recovery of ac power
- LOCA treatment
- credit for inter-unit cross-ties