Initiating Event SDP White Paper

Background

The Reactor Oversight Process (ROP) was initially developed in the late 1990s and is described in SECY-99-007 and SECY-99-007A. The ROP as envisioned consists of Performance Indicators (PI) for cornerstones that monitor the safety and security aspects of nuclear facilities. Additionally for areas that cannot be monitored through PIs, supplementary inspections were identified to provide a full picture of plant performance. One of the cornerstones monitored in the ROP is Initiating Events. The objective of the Initiating Events cornerstone was defined in SECY-99-007:

> *The objective of this cornerstone is to limit the frequency of those events that upset plant stability and challenge critical safety functions, during shutdown as well as power operations. If not properly mitigated and multiple barriers are breached, a reactor accident could result which would compromise the public health and safety. Licensees can reduce the likelihood of a reactor accident by maintaining a low frequency of these initiating events. Such events include reactor trips due to turbine trips, loss of feedwater, loss of off-site power, and other reactor transients.*

Thresholds were defined for licensee performance based on changes on core damage frequency (CDF) and large early release frequency (LERF). Licensee performance outside the normal performance range, but still within an acceptable level of performance was defined as a White indicator. Performance in this band was considered to be within the objectives of the cornerstone and within Technical Specification (TS) limits, but there is indication of declining performance and reduced safety limits. Degradation in performance in this band was defined as changes in risk of up to ΔCDF of 10^{-5}/year or ΔLERF of 10^{-6}/year associated with either PIs or inspection findings. The CDF and LERF threshold characteristics were selected to be consistent with Regulatory Guide (RG) 1.174 applications. Similarly Yellow indicators were defined as degradation in performance typified by changes in risk of up to ΔCDF of 10^{-4}/year or ΔLERF of 10^{-5}/year associated with either PIs or inspection findings. And finally Red indicators were defined as changes in risk greater than ΔCDF of 10^{-4}/year or ΔLERF of 10^{-5}/year associated with either PIs or inspection findings. Since both performance indictor and inspection program inputs to the ROP are based on changes in CDF or LERF, they are equivalent in terms of their significance.

Summary of Issue

The RASP Handbook, Revision 2 incorporated methodology for treatment of initiating events in significance determination process (SDP) evaluations. This methodology uses conditional core damage probability (CCDP) as the metric to determine event significance. CCDP for some transients modeled in plant probabilistic risk assessments (PRAs) are greater than 10^{-6} even for uncomplicated scrams. Using CCDP as the measure for significance for an event analysis would result in a White finding, effectively changing the threshold for uncomplicated scrams. The RASP Handbook methodology of converting CCDP to ΔCDF by dividing CCDP by one year is not technically justified. This is equivalent to assuming the event would happen once per year, year after year in the future.

To be considered in the SDP process, initiating events, unlike PIs, must be the result of a finding. Findings identified during an event analysis that are separable from the scram should not be included in significance determination of the initiating event, but may be evaluated separately.

For SDP initiating event risk assessments, the additional annualized CDF risk due to deficient licensee performance must be dependent only upon the performance issue itself and not the particular plant configurations during which the issue occurred. Therefore, the actual plant configuration at the time of the reactor trip due to maintenance or testing is not considered, and the average maintenance PRA baseline model is used. Also, the SDP evaluation only considers both the initiating event and any additional component failure unavailability in the same initiating event analysis if the same performance deficiency was involved. If the cause of some SSC failure that was also present at the time of the plant trip was associated with a different performance deficiency than that which caused the plant trip, it is also not used in the SDP risk assessment.

The NRC issued Interim Staff Guidance (ISG) to supplement the guidance in the RASP Handbook, Revision 2 Section 8. The ISG notes that its' use is appropriate only when the finding involves conditions that would always cause the initiator. Therefore findings on procedure or maintenance issues where the procedure or maintenance was performed previously without causing the initiator should not be subject to an SDP. For example if a procedure change was incorporated into a procedure and performance of that procedure did not cause an initiating event every time the procedure was executed, but then later causes a scram, the event would be captured as part of the plant scram performance indicators and the procedure change finding would not be subject to an SDP.

Analysis

The objective for the Initiating Events cornerstone is to limit the frequency of plant upsets that challenge safety functions. Initiating event frequency is an input to all current plant probabilistic risk assessments, and is based on generic data and plant-specific experience.

The change in CDF due to an experienced initiating event is dependent on the change in frequency of the initiating event. The change in initiating event frequency can be determined by a direct assessment of the impact of the finding on the initiating event frequency. The data used as the basis for the prior initiating event frequency modeled in PRAs includes initiating events due to all causes including prior findings.

Proposed Solution

Revised guidance should be provided for analysis for significance determination of events involving the Initiating Event cornerstone. For a finding associated with an initiating event, the effect on the frequency of the initiating event must be assessed to determine the potential change in CDF or LERF.

The proposed approach in analyzing an occurrence of an initiating event would be to first determine if the conditions leading to the occurrence would result in both a reactor trip and loss of mitigating equipment. If neither an initiating event nor a loss of mitigating equipment would be expected, the issue should screen to Green consistent with the Phase 1 SDP worksheet in IMC 609 Attachment 4. However the event should be evaluated against the plant Performance Indicators for initiating events. An SDP should only be performed if the finding is assessed to always result in an initiating event and contributes to the likelihood of the initiating event and the likelihood of mitigating equipment being unavailable.

The ICCDP and ICLERP associated with the finding should be calculated over the fault exposure time (FET) since the conditions resulting in the finding were introduced. Similar to the guidance in other sections of the RASP Handbook, the FET should be limited to one year.

In calculating the ΔCDF and ΔLERF:

1. The appropriate initiating event frequency should be set to an appropriate value to calculate a conditional core damage frequency (CCDF) or conditional large early release frequency (CLERF).
    a. In determining the initiating event frequency value consider the yearly frequency of opportunities that would lead to the initiating event if the finding was not corrected.
    b. Initiating events not affected by the finding should not be considered and their frequency should be set to 0.0 or FALSE.

2. The appropriate events in the model for the impacted mitigation equipment (if not accounted for in the initiating event) should be set to appropriate values such as 1.0 or TRUE for failed equipment. If events, including human failure events, are affected but not failed, their values should be adjusted to appropriate values other than 1.0 or TRUE.
    a. If applicable to the event and finding, the ability to restore operation of the affected mitigating systems after the initiating event should also be considered.
3. The new CDF or LERF should be calculated using the conditions imposed by 1 and 2 above.
4. The baseline CDF or LERF associated with the same initiating event should be subtracted from the new CDF or LERF calculated in 3 above to calculate the ΔCDF or ΔLERF.
5. The appropriate FET should then be applied to determine the final SDP results associated with the finding. The FET should be limited to a maximum of one year.

Example 1

A quarterly test is revised such that performance of the test will always result in a scram. The test also disables one train of Auxiliary Feedwater. The procedure change finding would result in an SDP since it directly resulted in an initiating event and affected mitigating equipment. Since the test is performed quarterly, the CCDF is calculated by setting the scram frequency to 4.0 per year in the PRA model. The ΔCDF is then the calculated CCDF with the applicable initiating event frequency and the probability of the AFW train failure set to 1.0 minus the baseline CDF contribution for the applicable initiating event at its normal initiating event frequency with nominal AFW failure rates. Consistent with the SDP process for mitigating systems, the ΔCDF must be adjusted by the FET for comparison to the SDP metrics. For a procedure change resulting in conditions leading to a scram, the FET would be the time from the effective date of the procedure revision to the performance of the procedure resulting in the scram.

In this example, assume the effective date of the procedure revision resulting in the conditions causing the scram was 3 months prior to the event (i.e., immediately following the last successful test). Calculate the conditional core damage frequency (CCDF) for the initiating event by setting the initiating event frequency to 4.0 for this specific initiating event and 0.0 for all other initiating events. For this example assume the CCDF for a reactor trip with failure of one train of AFW is 1.20E-5 per year. Assume the CDF contribution for reactor trip is normally 2.00E-07 per year. The ΔCDF would then be 1.18E-5 per year. Then adjusting for the FET of 0.25 years results in a ΔCDF of 2.95E-6 which would represent a White finding.

Example 2

For this case assume that equipment maintenance during an outage introduced a latent failure that did not become evident until the plant tripped six months after startup. The

trip caused a loss of offsite power (LOOP) with failure of one startup transformer to transfer to emergency supplies by fast bus transfer. The nature of the equipment degradation was such that the trip would only be generated after the equipment had been in service for some period with additional in-service degradation of the introduced fault.

For this case the switchyard centered LOOP initiating event frequency is 2.0 per year since the equipment degradation required six months of operation before a plant trip is initiated. The CCDF for the initiating event is calculated by setting the switchyard centered LOOP initiating event frequency to 2.0 and 0.0 for all other initiating events with the failure probability of the startup transformer also set to 1.0. For this example assume the CCDF for a switchyard centered LOOP with failure of one startup transformer is 2.20E-5 per year. Assume the baseline CDF contribution for switchyard centered LOOP is normally 1.70E-08 per year. The ΔCDF would then be 2.20E-05 per year. Then adjusting for the FET of 0.5 years results in a ΔCDF of 1.10E-05 which would represent a Yellow finding. If additional recovery credit is applied for manual alignment of the transformer following offsite power recovery, the significance could be further reduced.

Example 3

A revision to a 24-month preventative maintenance procedure is issued 3 months prior to its performance and contains an error that introduces a failure mechanism that results in failure (inadvertent closure) of Train A Main Feedwater Regulating Valve and failure (inadvertent opening) of Train A AFW Recirculation Valve after six months of operation. The issue results in a partial loss of main feedwater (PLMFW) with one train of AFW unavailable six months after the PM is performed.

The nominal baseline PLMFW frequency is 6.99E-1 per year and the finding would result in an additional 0.5 events per year for a total initiating event frequency of 1.199 per year. The CCDF for a PLMFW with the PLMFW frequency set to 1.199 and all other initiating event frequencies set to 0.0, and one train of AFW unavailable, is calculated as 6.23E-7 per year. The baseline CDF contribution of PLMFW is normally 2.73E-7 per year. The ΔCDF would then be 3.50E-7 per year. The FET exists from the issuance of the revised PM until the occurrence of the initiating event, or nine months. Adjusting for the FET of 0.75 results in a final ΔCDF of 2.63E-7 per year which would represent a Green finding.

Conclusion

The RASP Handbook approach for calculating ΔCDF caused by an initiating event finding (i.e., simply dividing the CCDP by one year) is not technically justifiable. The proposed approach will correctly calculate a ΔCDF or ΔLERF for a finding due to an initiating event and is consistent with the methodology for evaluating other SDP findings.

References

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