

Discussion of JACQUE-FIRE Volume 3 Papers and Revision to NEI 00-01

Nuclear Energy Institute (NEI)

Circuit Failures Issue Task Force (CF ITF)

March 17, 2016

Agenda

- JACQUE-FIRE Volume 3 – Papers
- Revision to NEI 00-01
- Additional Discussion Topics
- Plan for Endorsement

JACQUE-FIRE Volume 3 - Papers

- Proper Polarity
- MSO Rule of Four
 - MSO Development & Combinations
- Appendix I – Shorting Switches
 - Design Considerations
- Appendix J – Use of PIRT Data
 - Technical Basis for Appendix J
- Hot Short Duration

Revision to NEI 00-01

- Started with approved Revision 2
 - Included selected information from Revision 3
 - Criteria for classifying Required for Hot Shutdown and Important to Safe Shutdown Components with some adjustments
 - Revised List of MSOs from Appendix G
 - Removed licensing related statements
 - Attempted to make the document less legal and more technical

Revision to NEI 00-01

- Started with approved Revision 2 [continued]
 - Addressed JACQUE-FIRE Volume 3 Papers
 - Proper Polarity [Recommendations included]
 - MSO Rule of Four [Recommendations included]
 - MSO Development & Combinations
 - Appendix I – Shorting Switches [Entire Paper included]
 - Design Considerations
 - Design Implementation still required
 - Appendix J – Use of PIRT Data [Entire Paper included]
 - Technical Basis for Appendix J [some figures included]
 - Hot Short Duration [Recommendations included]

Revision to NEI 00-01

- Proper Polarity [Summary of Recommendations]
 - “By creating this circuit configuration, the actuating device is essentially isolated from the balance of the circuit. As an isolated component, the actuating device can be energized only by either closing the open contacts or providing a proper polarity potential path above and below the actuating device. For most actuating devices, a proper polarity potential path can involve the positive potential either above or below the actuating device with the negative potential return path on the opposite conductor. Additionally, as explained in NUREG/CR 7150 Volume 3, JACQUE-FIRE Volume 3, due to the broad range of possible actuating devices and due to the uncertain characteristics of cable fire interactions, it must be assumed that AC actuating devices can be energized and actuated by either another AC device, or even, another DC device. Similarly, it must be assumed that a DC actuating devices can be energized and actuated by another DC device, or even, another AC device. Although for specific actuating devices in specific circuit configurations, it is possible to demonstrate that AC devices cannot energize and actuate DC devices and vice-versa, in the absence of a specific engineering evaluation, supported, as necessary, by testing, demonstrating this conclusion, the assumptions outlined above must be used. The information discussed above is explained in more detail the Proper Polarity Paper (ML16047A370) transmitted by NRC Research in a letter dated March 9, 2016 (ML16047A367) and is depicted in the figure below.”

Revision to NEI 00-01

- MSO Rule of Four [Recommendations]
 - “Number of Hot shorts for Transient In-rush - Any MSO scenario involving the failure of a safe shutdown power supply as a result of a potential overload condition caused by more than a single load inrush current (i.e., overlapping inrush current from multiple separate loads) from control cable hot short spurious operation is not required to be considered provided the load power supply function or load sequencer, if applicable, is not degraded by the fire effects and the hot short target conductors for each of the potentially spuriously operated loads are in separate cables. In these cases, the power supply availability for the fire event can be assessed by the steady-state loading (i.e., anticipated load plus fire-induced spurious operation load) in combination with the worst case individual (or anticipated by design) inrush current transient load is considered in the power supply analysis. This criteria assumes:
 - The load spurious operation(s) is caused by fire damage to control cables for the load(s) from the power supply of concern. The load is otherwise operating correctly and has no potential for power cable fire damage. Thus, the load transient inrush current expected is normal and not impacted by the fire event.
 - The power supply is not degraded by the effects of the fire damage.
 - The load sequencer, if applicable, for the associated power supply is not degraded by effects of the fire damage such that the fire damage could cause multiple loads to start simultaneously.
 - Target conductors that could spuriously start/energize loads powered from the same power supply are in separate cables.

Revision to NEI 00-01

- MSO Rule of Four [Recommendations] [Continued]
 - Number of Inter-cable Hot Shorts Regardless of Latching Characteristics or Coping Time – If the MSO requires four (4) or more independent, i.e., separate, cables with inter-cable hot shorts, excluding GFEHS, then the MSO is not required to be considered and the MSO is considered to be “Incredible”, regardless of whether the circuits are latching or non-latching. There is no sustained time duration consideration required for this case.
 - The ground fault equivalent hot short (GFEHS) is not included as an inter-cable failure mode for this recommendation. For ungrounded power supplies, credible GFEHS is significantly more likely than inter-cable hot shorts and as such, is not included in this recommendation. Spurious operation(s) for the MSO scenario that can be caused by GFEHS must be considered unless otherwise limited by the guidance. Inter-cable failures that can result in a GFEHS cannot be counted as part of this limit of four or more separate inter-cable hot shorts.

Revision to NEI 00-01

- MSO Rule of Four [Recommendations] [Continued]
 - Number of Non-Latching Hot Shorts with 10 minute Coping Time regardless of Circuit Failure Mode – If the MSO requires (a) three (3) or more concurrent fire-induced cable shorts on separate target cables in non-latching circuits and (b) the hot shorts must be sustained for more than 10 minutes to cause the MSO condition, then the MSO is not required to be considered regardless of conductor hot short failure mode (i.e., intra-cable, inter-cable, or GFEHS).
 - For MSO scenarios that result in conditions that cannot be tolerated for 10 minutes or less, any number of non-latching intra-cable circuit failures must be considered.
 - In addition, for latching fire induced hot shorts, any number of intra-cable circuit failures must be considered unless otherwise limited by the guidance.

Revision to NEI 00-01

- MSO Rule of Four [Recommendations] [Continued]
 - Sequentially Selected Fire-Induced Circuit Failures – If the MSO requires a selective sequence of more than four independent, i.e., separate, cables with specific fire induced cable failures (i.e., failure 1 must occur before failure 2, failure 2 before 3, failure 3 before 4 and failure 4 before 5), where the adverse condition will not occur if the specific sequence is not produced by the fire-induced circuit failures (e.g., hot short, short to ground, open circuit), then the MSO is considered “Incredible” and need not be considered for MSOs regardless of fire-induced failure durations, circuit configurations, or fire-induced failure types. [Note: At least two (2) of these failures must be hot short induced spurious operations.]
 - To be beyond what needs to be considered for MSOs, the total number of sequential failures must exceed the threshold established above without including the following as one of the sequential failures: (1) the more probable failures of conductor grounding of grounded AC circuits in armored cable or (2) for ungrounded DC circuits, the more probable failures of intra-cable short or ground fault equivalent hot short in armored cable.
 - Metal armor of armored cable is assumed to always be grounded in accordance with NFPA 70.”

Revision to NEI 00-01

- Hot Short Duration [Recommendation]
 - “Duration of hot short: The duration of a hot short in an AC circuit may be assumed to be limited to 20 minutes. The duration of a hot short in an DC circuit may be assumed to be limited to 40 minutes. ...”

Revision to NEI 00-01

- NEI 00-01 Draft Revision 4
 - Overview of high level changes as time permits
 - Not intended as a line-by-line review
 - Refer to Back-up Slides

Additional Discussion Topics

- Use of risk insights to address safe shutdown circuit failure combinations
 - Using Fire PRA
 - In conjunction with currently allowed fire modeling
- Any high level comments by NRR on current revisions of NEI 00-01
- Steps to NRC endorsement
 - Submittal of NEI 00-01 Revision 4
 - Review & Comment by NRC
 - Comment incorporation by NEI
 - Endorsement by NRR in revision to Regulatory Guide (RG) 1.189

Plan for Endorsement

- NRR Feedback on Additional Discussion Topics
 - Use of risk insights
 - Any NRR high level comments on the existing revisions of NEI 00-01
- NEI complete internal review of NEI 00-01 Rev 4
- NEI submit NEI 00-01 Rev 4 to NRR
- NRR review and comment on NEI 00-01 Rev 4
- NEI incorporate NRR comments and re-review NEI 00-01 Rev 4
- NEI re-submit NEI 00-01 Rev 4 to NRR
- NRR process a revision to RG 1.189
- NEI review and comment on revision to RG 1.189
- NRR issue revision to RG 1.189

Back-up Slides

[NEI 00-01 Draft Rev 4]

- Section 1.1 Purpose:
 - “Issuance of NEI 00-01 Revision 4 or endorsement of it in a revision to a Regulatory Guide does not re-define or alter what any plant’s licensing basis is or should be. A plant’s licensing basis is defined in its FSAR. A plant’s licensing basis could be modified if a plant chooses to adopt the NRC endorsed revision of NEI 00-01 and to include it in their FSAR. A plant’s licensing basis could also be modified if the NRC issues rulemaking that requires compliance with the criteria outlined in the endorsed revision of NEI 00-01.”

Back-up Slides

[NEI 00-01 Draft Rev 4]

- Section 1.3.2.1: [safe shutdown function identification]
 - “The acceptance criteria and the set of acceptable initial conditions for the thermal hydraulic/transient analysis used in support of post-fire safe shutdown are contained in Appendix H. Best estimate/nominal values for the parameters used in the thermal hydraulic/transient analysis may be used as outlined in Appendix H. The use of these criteria allow the thermal hydraulic/transient analysis performed for the plant internal events PRA to be usable in assessing impacts and timelines for post-fire safe shutdown events when the postulated failure conditions are the same. Note that RG 1.189, Branch Technical Position 9.5.1 and Appendix R do not require postulation of a fire concurrent with any other Accident, Transient, or Severe Natural Phenomenon. For the Control Room fire, i.e. Appendix R Section III.G.3/III.L, a loss of offsite power must be postulated. The loss of offsite power, when postulated, however, is assumed to occur as an initial condition. There is no need to assume a delayed, i.e. post-postulated fire damage, loss of offsite power.”

Back-up Slides

[NEI 00-01 Draft Rev 4]

- Section 1.3.2.3: [safe shutdown equipment identification]
 - “Classifying components as required for hot shutdown is done by reviewing the P&IDs and determining which components on the flow path are required to perform the required safe shutdown functions, e.g. suction valve , pump, injection valve. The review for determining the set of components and systems required for hot shutdown does not consider fire damage to components whose failure or spurious operation could potentially impact the ability of the required for hot shutdown components (and systems) to perform their post-fire safe shutdown function. The components with the potential to fail or spuriously operate and impact the required for hot shutdown components are addressed separately as important to safe shutdown components.”

Back-up Slides

[NEI 00-01 Draft Rev 4]

- Section 3.4.2.4: [mitigating strategies]
 - Cold Shutdown Only Components:
 - Any of the options provided for important to safe shutdown components.
 - Perform a repair in accordance with Appendix E.

Back-up Slides

[NEI 00-01 Draft Rev 4]

- Section 3.5.1 [criteria/assumptions]
 - Appendix J also classifies circuit failure types as either “implausible” or “incredible”. These terms are defined in Appendix J and re-stated below.
 - Implausible – “The term “implausible” when used in conjunction with a fire-induced circuit failure phenomenon, supports the PIRT Panel’s conclusion that the happening, while theoretically possible, would require the convergence of a combination of factors that are so unlikely to occur that the likelihood of the phenomenon can be considered statistically insignificant. In these cases, the PIRT Panel could find no evidence of the phenomenon ever occurring neither in operating experience nor during a fire test. Any likelihood value assigned to these types of phenomena would have little meaning.”
 - Incredible – “The term “incredible” used in conjunction with the phenomenon of a fire-induced circuit failure, signifies the PIRT panel’s conclusion that the event will not occur. In these cases, the PIRT panel could find no evidence of the phenomenon ever occurring, and there were no credible engineering principles or technical arguments to support its happening during a fire. Any likelihood value assigned to these types of phenomena would have little meaning.”

Back-up Slides

[NEI 00-01 Draft Rev 4]

- Section 3.5.1: [criteria/assumptions]
 - Circuit failure types classified as “implausible” need to be considered in a deterministic or risk-informed (e.g., Fire PRA, NFPA 805) post-fire safe shutdown analysis for any components classified as “high impact components”. “High impact components” are defined in Appendix J as follows:
 - For BWRs:
 - Spurious opening of both shutdown cooling suction valves (classified as “high/low pressure interfaces”)
 - Spurious opening of multiple Safety Relief Valves (SRVs) and failure (due to fire damage” effects) of a sufficient number of low pressure make-up systems such that the inventory loss is not bounded by design basis accident analysis.
 - For PWRs:
 - Spurious opening of the shutdown cooling suction valves (to SDC/LPSI/RHR – the “high/low pressure interfaces”)
 - Spurious opening of one or more Pressurizer Power Operated Relief Valves (PORV) and failure (due to “fire damage” effects) of its associated block valve to close or remain closed.