

MODELING OF NUREG/CR-7150 SPURIOUS DURATION PROBABILITIES

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Purpose

- The purpose of this paper **is** to present lessons learned and challenges that were encountered during the application of spurious duration probabilities in a recent fire PRA development.

Fire Induced Spurious Operations

- Fire PRA models include a host of complex assumptions and impacts as a result of fire induced failures.
- Namely fire induced spurious operations have been shown to have a significant impact to these models; probabilities can be very high $>.1$ (up to 1.0 for instrumentation circuits due to a lack of testing).
 - Result in isolation or diverting flow paths
 - Inducing RCS leakages; resulting in a loss of coolant accident (LOCA)

Spurious Duration Probability

- NUREG/CR-7150 provides a probabilistic approach to account for certain components returning to their original fail safe position once the induced spurious operation clears. Limited to components that have fail safe positions:
 - Air Operated valves
 - Solenoid Operated Valves
- MOVs are explicitly excluded due fail as is.
- The approach is based on empirical evidence that most fire induced (hot) shorts will clear on their own after some period of time.

Spurious Duration Probability Cont.

- Per NUREG/CR-7150, the component must be demonstrated that at the time the component(s) return to the original position, the accident sequence can return to transient event and no other plant response or impacts would occur.
- Evidence needs to be sufficiently documented; this can be very time consuming.
- Some unique cases were noted during the development of a fire PRA model that appear to be inline with this requirement. However these cases did not completely fit into the “no other plant impacts would occur” bucket.

Case Studies

- For the purpose of this paper two case studies were investigated for the application of the spurious duration probability.
 1. spurious operation would propagate through a single accident sequence independent of the spurious impact on the component during the mean duration floor
 2. a spurious operation terminating at a certain time would result in a return to the original accident sequence but would require an additional action.
- Case 2 above may not explicitly meet the criteria from NUREG/CR-7150, but as a result of the case studies it was judged to be applicable as long as the additional impact is accounted for in the logic model.

Case 1: 7150 Directly Applicable

- Air operated containment isolation valves, spuriously open as a result of a fire induced failure.
- These valves are only required in the PRA model to prevent releases; post core damage.
- For the operating four loop Westinghouse plant that was reviewed, it was found that the fastest time to core damage was
 - 1) greater than the spurious floor durations (AC = 9 minutes, DC = 7 minutes), and
 - 2) greater than the fire's burn time as postulated in the fire PRA.
- Therefore no release from containment can occur due to the CIVs spuriously operating if core damage has not occurred and the valves are able to reclose.

Case 2: Non-Directly Applicable Case Study

- Reactor Coolant System (RCS) Power Operated Relief Valves, spuriously opening resulting in a LOCA.
- Spurious operation of the valve will result in the LOCA, however if the hot short clears, the PORV can return to its original position and terminate the LOCA.
- To determine applicability of the spurious duration probability the plant specific thermal hydraulic analysis was consulted.
 - As expected within the mean floor durations no core damage could occur
 - However, as a result of the short term LOCA; it was noted that conditions would be present that require the actuation of a safety injection (SI) signal

Case 2: Non-Directly Applicable Case Study (Cont.)

- The SI signal actuation could be seen as a beneficial failure if secondary heat removal failed (precursor to feed and bleed) which would not be credited.
- From a mitigating standpoint once the SI signal occurred and the PORV re-closed; RCS inventory would continue increase until such time as it is either terminated or a relief valve opens (resulting in LOCA).
- As a result the operators would need to terminate SI to return the event to transient sequence.

Results of reclosure can get back to the pre-spurious conditions but may need additional consideration.

Justification for Spurious Duration Application to Case 2

- The scenario in which the PORV recloses differs from the guidance provided in NUREG/CR-7150 as the reclosure of the component does not put the plant back into the original transient condition on its own.
- Once the SI is present, action must be taken to prevent the overpressurization event; however, this event would no longer be due to the PORV moving to the incorrect position.
- However, the existing case study plant PRA model already incorporates a spurious SI signal generation as does the fire model due to other unrelated spurious operation issues.

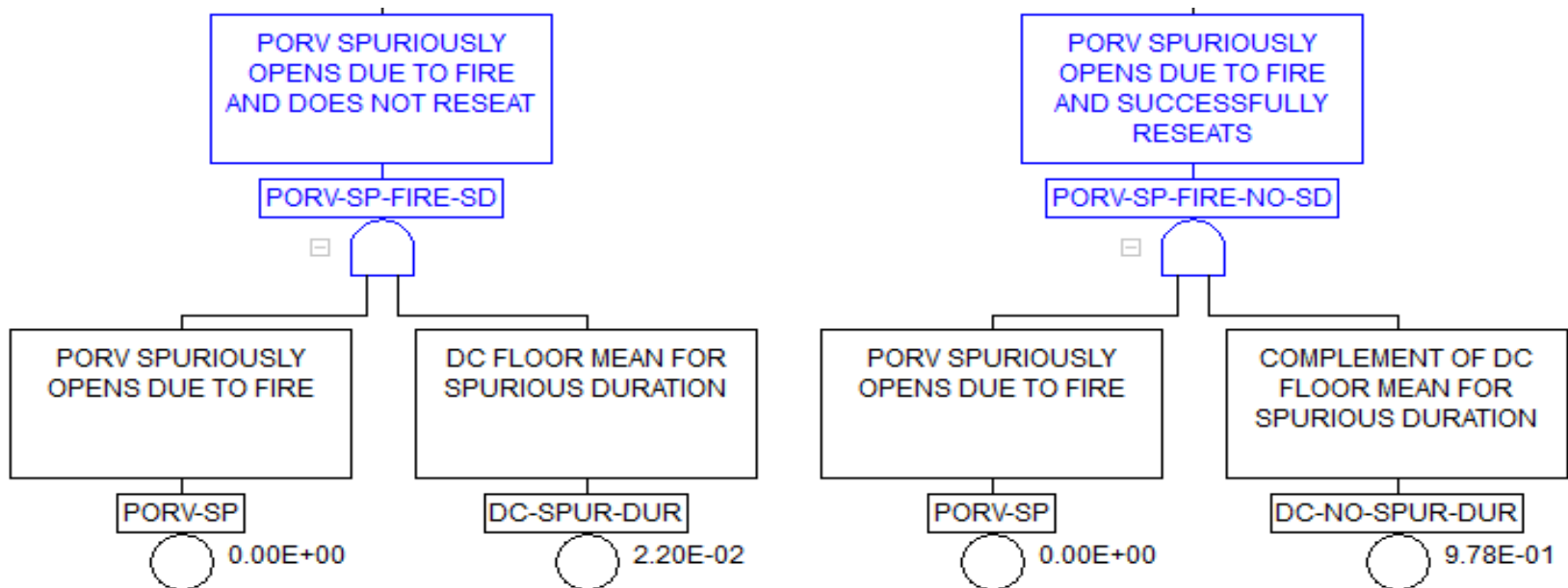
Justification for Spurious Duration Application to Case 2 Cont.

- Therefore while this case does not match exactly to the guidance, it would not be unreasonable to take credit for the hot short induced spurious operation clearing at the floor duration value as long as the additional consideration for the spurious SI are met.
- Additional analysis was also performed to confirm that the fire impacts (beyond the spurious operation) would not prevent the operator's ability to terminate the SI.

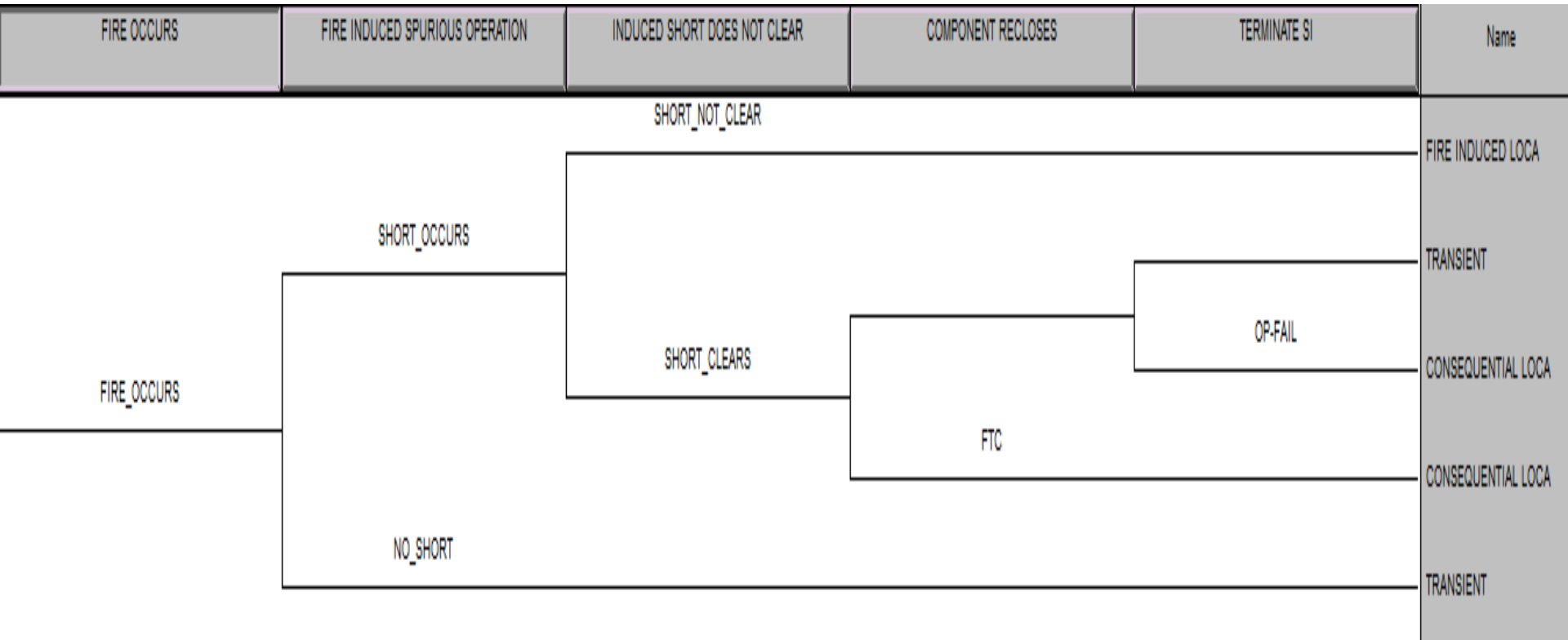
Similar impacts are already within the scope of the model and its capabilities.

Case 2 Modeling Considerations

- To account for the modeling two subtrees were developed:
 - Spurious operation occurs and the valve does not reclose
 - Spurious operation occurs and the valve recloses



Case 2 Modeling Considerations Cont.



Overestimation and Other Issues

- Component failure to reseal does not necessarily need to be modeled; consistent with the treatment in NUREG/CR-7150.
 - Reasonable based on the exact spurious operation position not being known (full open, partially open, etc.)
 - Component is returning to its fail safe position.
- Return to the transient portion of the tree after successful reclosure and SI termination, can be non-minimal to the no spurious operation case (if the assumed probability of 1).
 - Conservation of probability ($2.8E-1$ and $7.2E-1$) for small number approximations will have minor impact compared to other fire related issues
 - ~28% over estimation of a small number is still a small number
 - May need further investigation as models become more refined

Conclusion

- NUREG/CR-7150 provides appropriate high level guidance on how to apply spurious duration probabilities.
- Guidance does not discuss how to model components that successfully reposition but may slightly alter the model response within its current capabilities.
- To model these failures analysts must account for:
 1. the potential impacts while the component is spuriously operating within the spurious floor duration and
 2. the impact of the spurious signal clearing.
- TH analysis and/or engineering analysis may be required.
- Creating a spurious operation event tree with spurious operation was found to be helpful in developing the final fault tree logic.

Questions?