

Lessons Learned In HRA Dependency Analysis

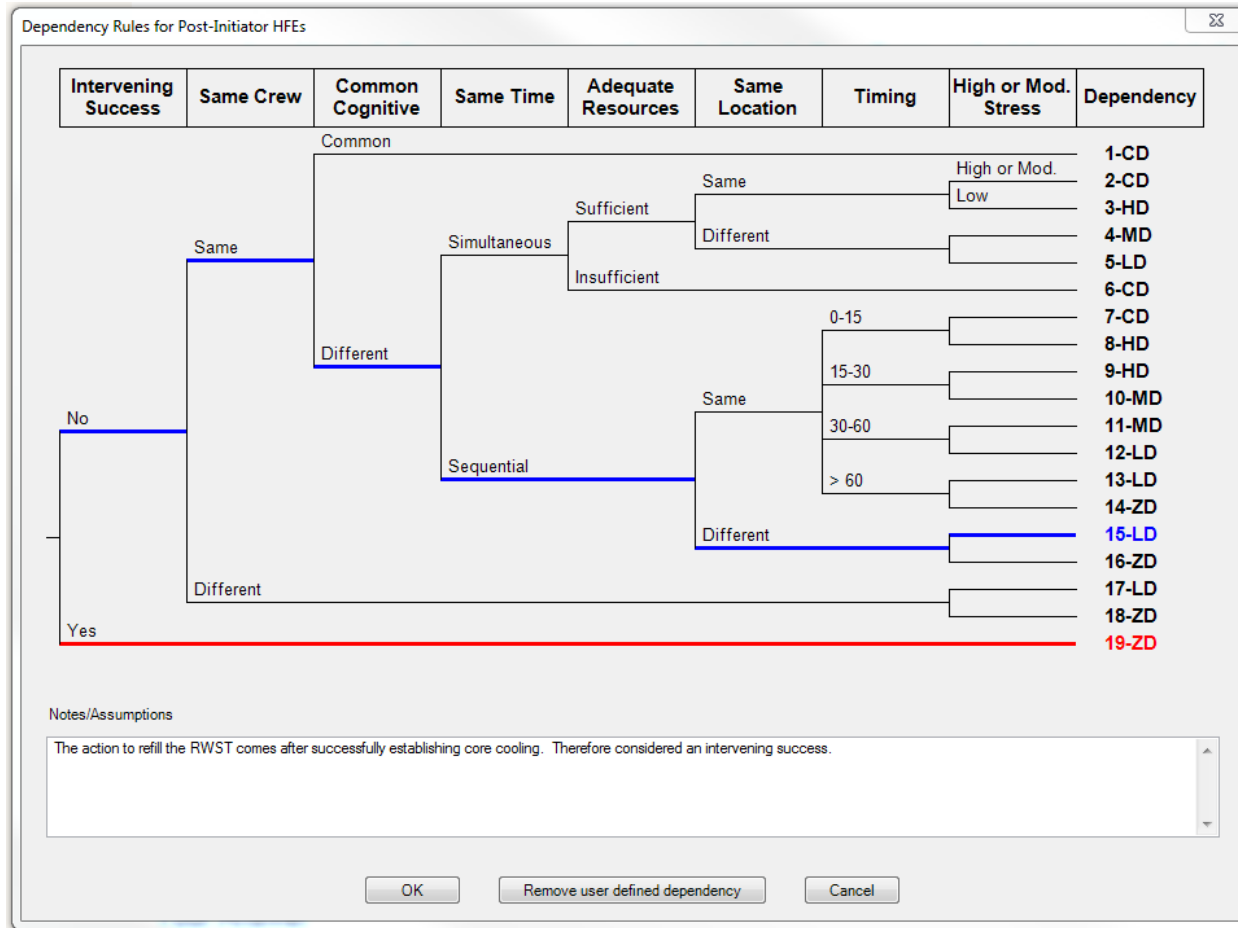
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Importance of HRA DA

- Dependencies between different operator actions are important to consider where such actions occur in the same cutsets
 - The associated human error probabilities (HEPs) are generally developed based on the timeline and complexity of the individual actions alone (independently).
 - This calculation occurs without consideration of previous, subsequent or concurrent actions which in many cases increase the complexity of the series of events the operators are responding to.
 - Cutset probabilities can be significantly underestimated if HEPs are not appropriately characterized to address dependencies.

What is Considered?



*Figure adopted from EPRI HRA Calculator



Methodology

Previous Analysis

- Performed in 2004-2005 and referenced no industry guidance for the methodology used
- The methodology was outlined but contained little to no basis for the dependency characterizations

Updated Analysis

- The methodology used for the update was based on the latest EPRI guidance
 - Includes some EPRI Knowledge Based Articles

Seeding and Quantification

- There was a significant difference in the number of cutsets/combinations identified which may be at least partially the result of increases in computing power

| | Previous | Updated | Delta Factor |
|-------------------------|----------|-----------|--------------|
| Seeding Cutsets | 33,000 | 1,500,000 | ~45 |
| Unique HRA Combinations | 1,600 | 4,000 | ~2.5 |

Use of Alarm Response Procedures

Previous Analysis

- Based on alarm response rather than Emergency Response Guidelines (ERGs) to keep generic and applicable to all initiators
- Difficult to develop timeline and assess dependency

Updated Analysis

- Based on ERGs and sister HEPs developed that vary by initiator as appropriate
- Much easier to put into a timeline for dependency consideration

Screening of Independent Events

Previous Analysis

- Actions more than 4 hours apart
- Actions in different locations
- Actions that were “very obvious”
- Actions using different procedures

Updated Analysis

- Actions at least 8 hours apart representing a different crew
- Location was one factor but resource levels and stress were also considered
- May improve HEP but this does not provide a basis for complete independence
- May improve DA but this is not a basis for complete independence

Identification of Complete Dependence

Previous Analysis

- Only assigned to actions using a common cognitive and in some cases this was missed
 - Manual start of safety and non-safety service water

Updated Analysis

- Common cognitive is just one example of complete dependence
 - Actions occurring within 15m that have either high or moderate stress

Identification of Intervening Success

Previous Analysis

- Very few dependencies identified so this was not used

Updated Analysis

- Difficult to identify because by definition successes are not shown in the cutsets
- Closely examined important combinations to determine if there was a successful operator action
 - having HEPs in the Event Trees can be helpful
- Also considered reactor trip to be an intervening success because it “resets” the operators as they enter the ERGs

Areas of Consideration/Debate

- Should simple actions such as tripping pumps be considered as intervening success or only more complex actions such as establishing Feed and Bleed?
- Stress levels are subjective but can have a significant impact on dependency
- First HEP in combination
 - Cause-Based Decision Tree selections
- Timeline for actions not supported by Thermal-Hydraulic analyses
- Excluding credit for actions could be non-conservative in some cases

Overall Takeaways

- Analysts really need to understand how the EPRI HRA Calculator is making the calculations in order to interpret and refine the results
- The HRA DA has a very large impact, especially on PRAs that rely on operator actions rather than automation
- HRA is a subjective process and the HRA DA propagates this subjectivity
- The industry needs to continue to develop and refine HRA methodologies to remove subjectivity as much as possible
 - Integrated Human Event Analysis System (IDHEAS)?

Questions?