SAND2016-0009PE

OVERVIEW OF CIRCUIT ANALYSIS PROCESS

FIT - 12

BROOKHAVEN NATIONAL LABORATORY
U.S.NRC UNITED STATES NUCLEAR REGULATORY COMMISSION Protecting People and the Environment
Sandia National Laboratories

Objectives

- To identify cables and/or circuits of concern to post-fire safe shutdown
- Determine the specific effect of fire damage to those cables and/or circuits on the plant's ability to achieve and maintain safe shutdown conditions.

Outline

- Overview of Safe Shutdown Analysis
- Circuit Analysis Process
  - Select SSD Success Path
  - Identify Electrically Operated or Controlled Components
  - Identify Cables That Could Adversely Affect the Desired Operation of Component if Damaged by Fire
  - Determine Cable Routing
  - Appendix R
    - Determine the Classification of Success Path Components
    - Identify Interactions for Important Components
    - Develop Appropriate Mitigating Strategies
  - NFPA 805
    - Identify variances from deterministic requirements (VFDR) and deposition them
  - Document Results

Regulations

- Current regulatory framework does not explicitly require the performance of a detailed circuit analysis.
- No analysis is necessary if it assumed that fire damage to cables related to a shutdown component will cause the component to fail in an undesired manner and appropriate fire protection features are provided to prevent such damage.
- The staff has determined that the deterministic methodology described in Chapter 3 of NEI 00-01, Rev. 2 provides an acceptable approach* for performing a Safe Shutdown Analysis (SSA), when used in conjunction with RG 1.189.

* There are several exceptions to the endorsement of Chapter 3

Safe Shutdown Analysis

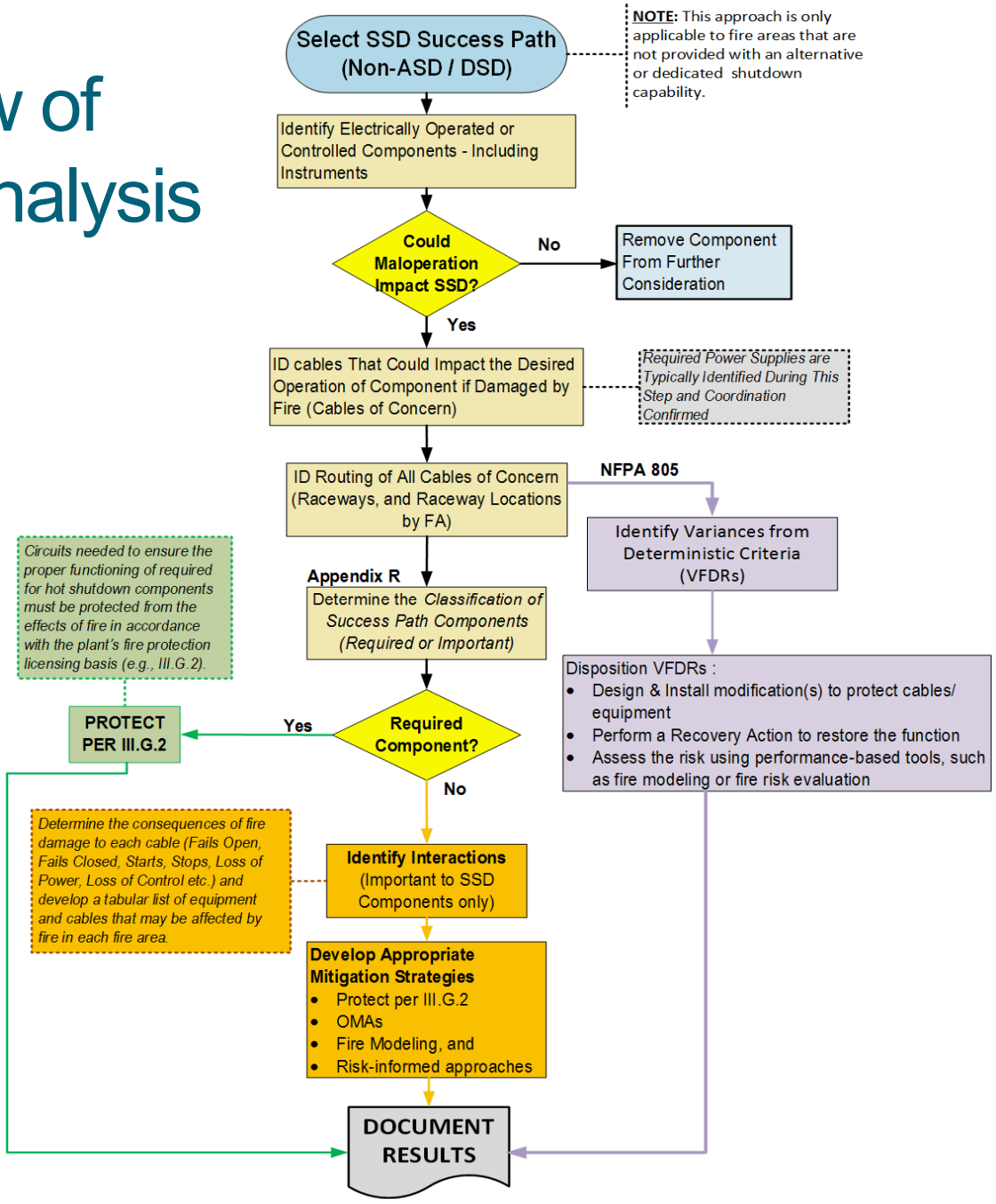
- SSAs typically consist of a number of plant-specific evaluations, including:
  1. Safe-Shutdown System Selection/Path Development
  2. Plant Configuration Review
  3. **Circuit Analysis**
  4. Operational Implementation Review
  5. Long-term Maintenance of PFSSD Capability

Circuit Analysis demonstrates that a fire in any single fire area cannot, through its effects on electrical circuits and cables, prevent safe-shutdown systems and equipment from accomplishing their intended functions or initiate an event, such as a loss of reactor coolant, that is beyond the capability of the safe-shutdown systems.

Overview of Safe Shutdown Analysis (SSA)

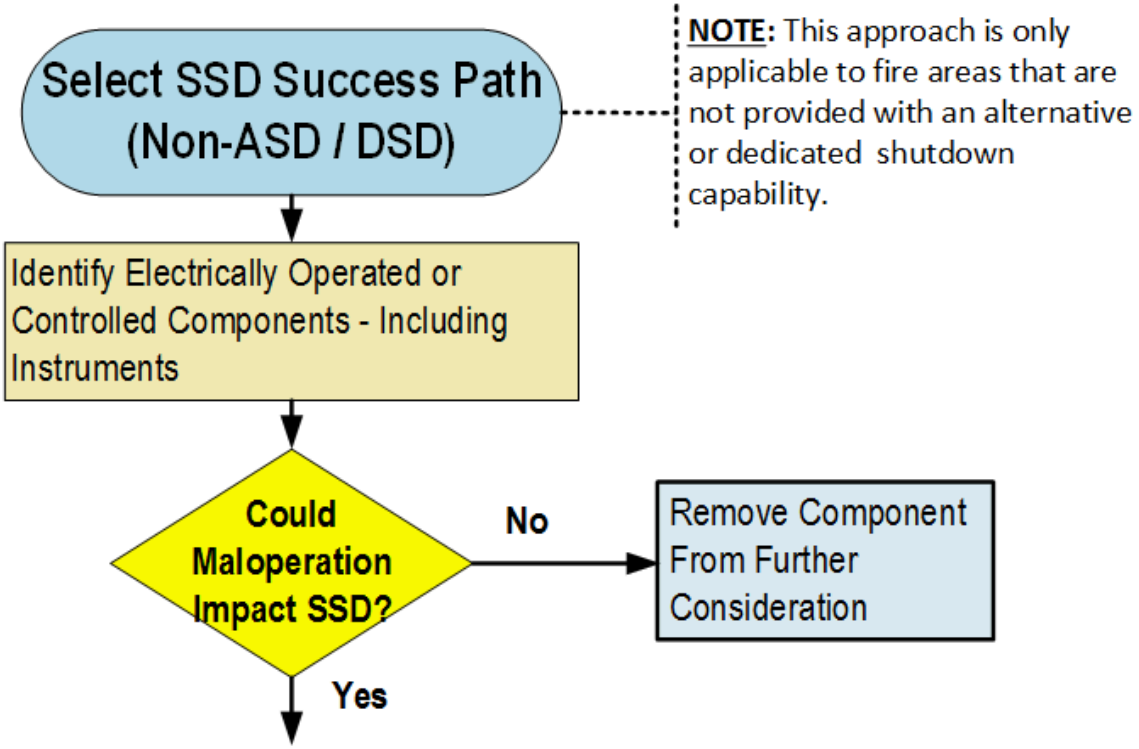
- At this point in the evaluation, the following SSA tasks are normally complete:
  1. Fire areas have been defined
  2. Safe shutdown success paths have been developed
  3. A safe shutdown equipment list (SSEL) has been completed
  4. SSEL components (Pumps, Switchgear, MCCs, MOVs, etc.) have been correlated to the fire area in which they are located.
  5. The routing of cables associated with each piece of equipment included in the SSEL is known or an evaluation has been performed to demonstrate that fire damage to the cables of equipment on the SSEL will have no adverse impact on PFSSD capability.

Overview of Circuit Analysis Process



Select SSD Success Path

- SSD Success Paths have been developed as part of the SSA



Identify Electrically Operated or Controlled Components - Including Instruments

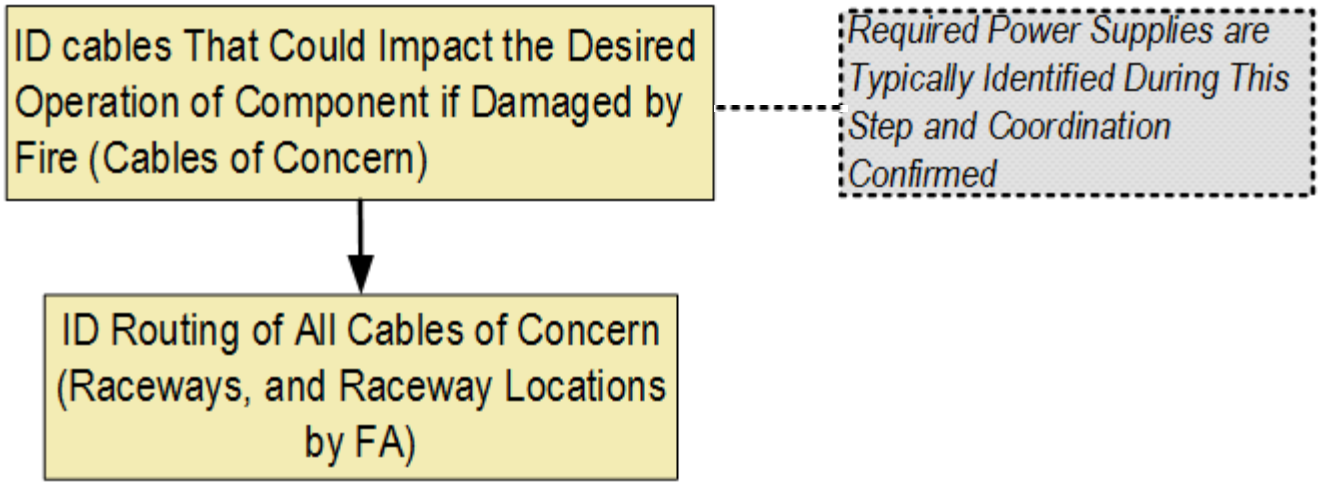
- Identify electrically operated or controlled equipment that must operate or be prevented from mal-operating in order to ensure the proper functioning of the SSD success paths credited in the SSA.
- Only components assigned to active status require electrical power supplies for proper operation.
  - Active component examples: motor operated valves, other components that respond to an outside signal.
  - Passive component examples: check valves, manually operated valves, components that have no external wiring.

Identify Cables That Could Impact the Desired Operation of Component if Damaged by Fire

- Find all cables associated with SSD success path components identified in previous slide.
- Each cable should be related back to the same shutdown path as the equipment it supports.
- In cases where the failure of a single cable could impact more than one piece of equipment, the cable should be associated with each piece of equipment.
- Cables such as those associated with interposing relay interlock contacts that are external to the primary circuit scheme should also be included in the analysis.

Identify Cables That Could Adversely Affect the Desired Operation of Component if Damaged by Fire (Cont.)

- Required power supplies are typically identified during this step and coordination confirmed
  - For each SSD Success path component, determine if electrical power is required for proper operation.
  - If power is required, identify the closest upstream power supply and verify that it is on the safe shutdown equipment list.

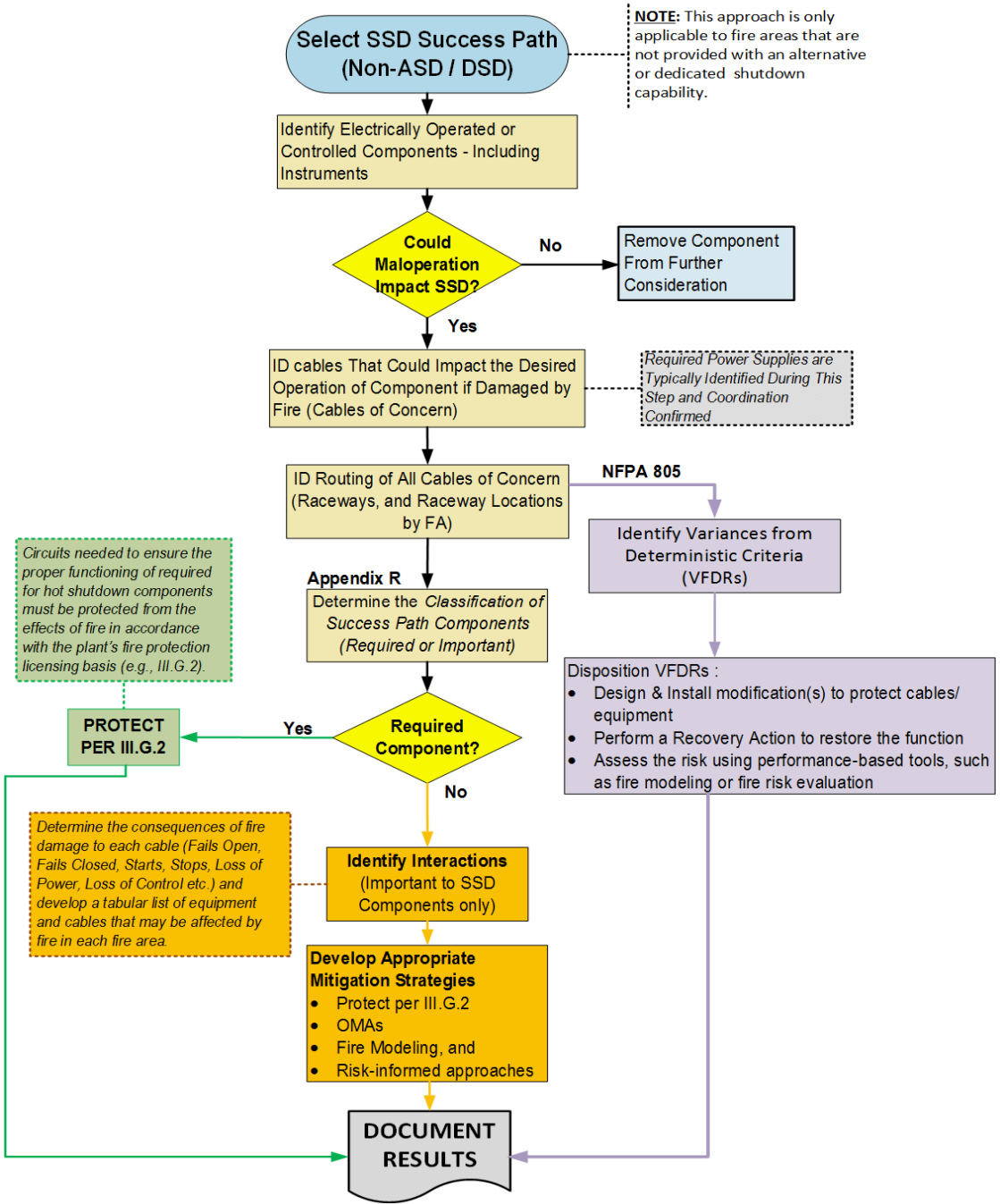


ID Routing All Cables of Concern

- Determine the routing of cables identified in previous step and identify their location by fire area.
- If the routing of a cable is unknown, the licensee could:
  - Make conservative assumptions about its location (e.g., assuming the cable is damaged as a result of fire in any fire area).
  - Assume the cable is damaged and protect the cable in accordance with the plant's licensing basis.

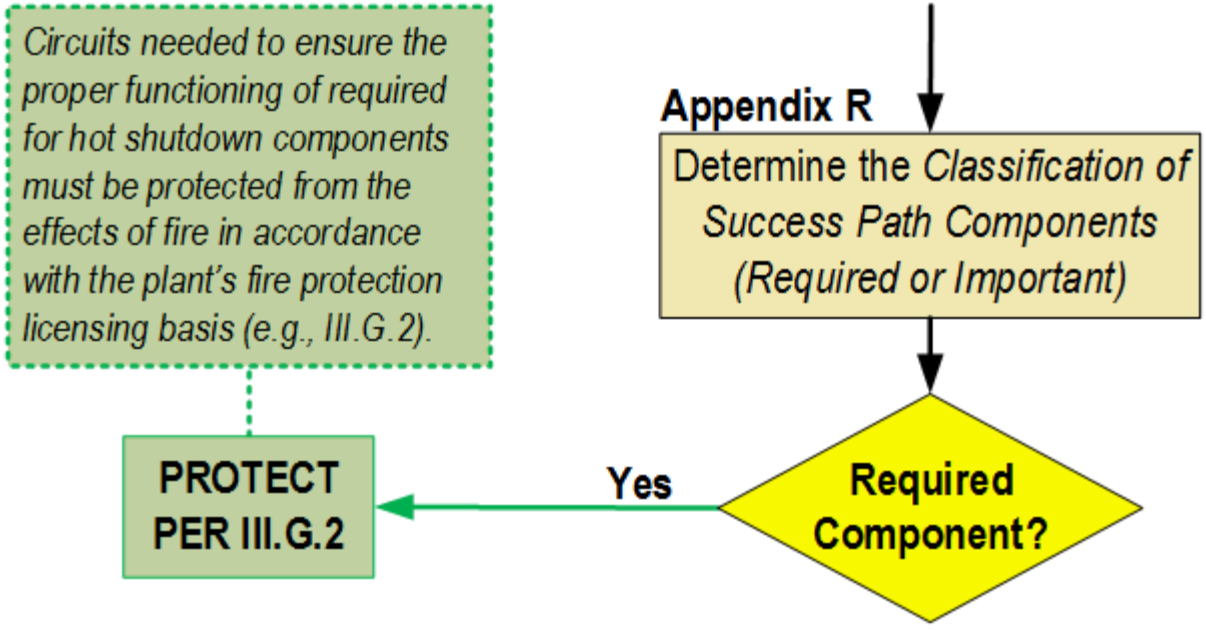
NFPA 805 and Appendix R Split

- Once cables have been identified, two paths to compliance
- Both paths will be discussed in this presentation



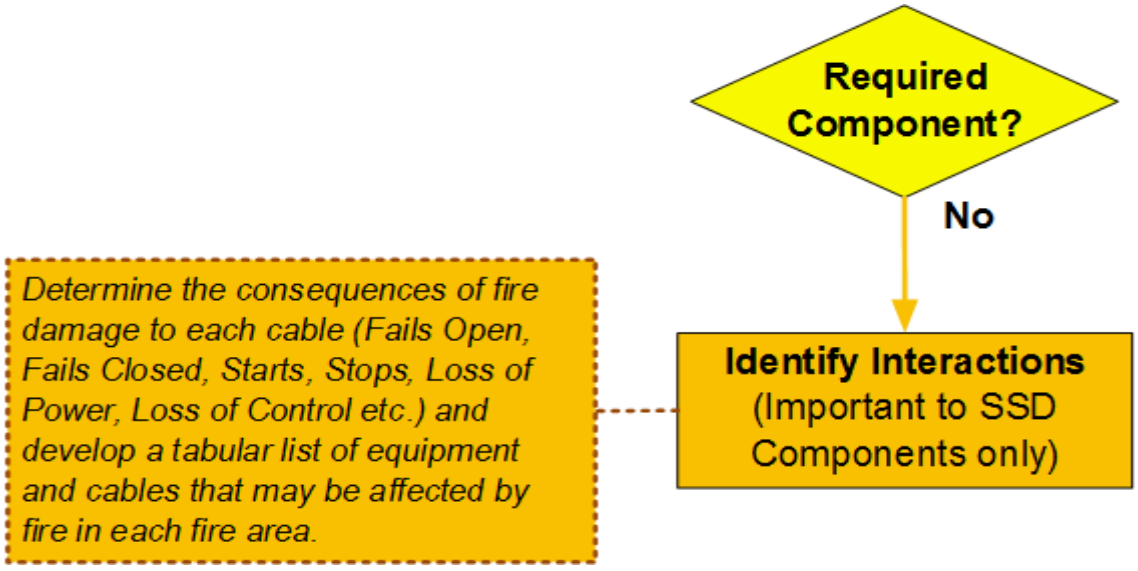
Appendix R: Determine the Classification of Success Path Components

- Determine if the SSD success path components should be classified as “required for SSD” or “important to SSD.”
- Classifications are not applicable to alternative or dedicated shutdown systems credited for post-fire SSD as defined in Appendix R, Section III.G.3.



Identify Interactions for **Important** Components

- Determine the failure mode (consequences) that may result from fire damage to each cable on a cable worksheet.



Identify Interactions for **Important** Components (Cont.)

- The following circuit failures should be considered for **important** components (from NEI 00-01 3.5.1.1):
  - Multiple spurious operations resulting from a fire-induced circuit failure affecting a single conductor.
  - Multiple fire-induced circuit failures affecting multiple conductors within the same multi-conductor cable with the potential to cause a spurious operation of an “important to safe shutdown” component should be assumed to exist concurrently.
  - Multiple fire-induced circuit failures affecting separate conductors in separate cables with the potential to cause a spurious operation of an “important to safe shutdown” component must be assumed to exist concurrently when the effect of the fire-induced circuit failure is sealed-in or latched.

Identify Interactions for **Important** Components (Cont.)

- The following circuit failures should be considered for **important** components (from RG 1.189, exemptions to NEI 00-01):
  - For circuits not sealed-in or latched, licensees should consider multiple fire-induced circuit failures in ***at least two separate cables***. For circuits not sealed-in or latched that involves high-low pressure interfaces, licensees should consider circuit failures in ***at least three cables***. This applies where defense-in-depth features, such as automatic suppression and limits on ignition sources and combustibles, are present.
  - Where defense-in-depth features are not present, the number of cables to consider ***should not be limited*** to two or three. For multiconductor cables, all circuit faults that could occur within the cable should be assumed to occur.
  - The duration of a hot short may be limited to 20 minutes except for dc circuits. For dc circuits, the duration of a hot short is not limited.

Develop Appropriate Mitigating Strategies for Appendix R

Required for SSD (Green Path Components)

- Must be protected in accordance with:
  - Appendix R Section III.G.2
  - Section 5.3.1.1 of RG 1.189
  - Plant specific licensing action if located within the same fire area where they are credited for achieving hot shutdown

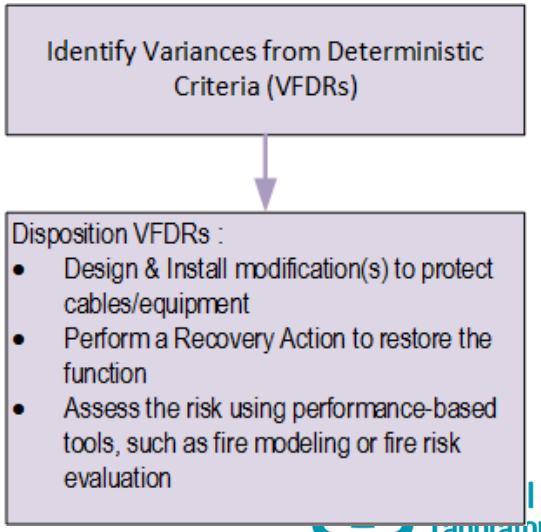
Important for SSD (Orange Path Components)

- Optional protection options (not required):
  - Appendix R Section III.G.2
  - Section 5.3.1.1 of RG 1.189
  - Operator Manual Actions* (Regulatory Position 5.3.1)
  - Fire Modeling* (Regulatory Position 5.3.1.1)

*Exemption requested for Appendix R plants

NFPA 805 Methodology

- Certain items that do not meet the separation requirements are identified as “Variances from the Deterministic Requirements” (VFDRs)
  - VFDRs are the items that undergo further analysis using performance-based tools as described in NFPA 805 Chapter 4
- VFDRs can be dispositioned in different ways
  - Design & install modification(s) to protect cables/equipment
  - Perform a Recovery Action to restore the function
  - Assess the risk using performance-based tools
    - Fire Modeling
    - Fire Risk Evaluation



Documentation

More information on the worksheet and examples will be discussed in a later presentation.

Safe Shutdown Cable Worksheet

Component Number_____ Component Type_____

Component Name_____ Component Power Supply_____

Position Information:

Normal:	
Desired:	
Failed:	

Cable Fault Analysis:

Cable Information		Cable Fault Consequences	Cable Required for SSD?		Notes
Cable Number	Cable Type **A**nnunciator, **P**ower, **C**ontrol, **I**ndication	**LOP** - Loss of Motive Power **LOC** - Loss of Control Capability **SPUR** - Component Spuriously operates to an undesired position **LOI** - Loss of Safe Shutdown Indication **None** - Loss of cable is acceptable	Y	N	

by: _____ date: _____ check:_____ date: _____ sht.____ - of -___

Circuit Analysis Process Summary

- Select SSD Success Path
- Identify Electrically Operated or Controlled Components
- Identify Cables That Could Adversely Affect the Desired Operation of Component if Damaged by Fire
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- Appendix R
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QUESTIONS?

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