

NRC INSPECTION MANUAL

APOB

INSPECTION MANUAL CHAPTER 0609 APPENDIX F ATTACHMENT 6

GUIDANCE FOR THE IDENTIFICATION OF TARGETS AND
THEIR IGNITION AND DAMAGE CRITERIA

Effective Date: January 1, 2025

0609F.6-01 PURPOSE

This attachment provides guidance for identifying various types of targets and for establishing damage and ignition thresholds for each of these target types. The damage and ignition criteria are used in the ignition source screening process (Step 2.3 of the Fire Protection Significance Determination Process (SDP), IMC 0609 Appendix F), determination of severity factors (SFs) (Step 2.6 of the Fire Protection SDP), and calculation of damage and ignition times (Step 2.7 of the Fire Protection SDP).

0609F.6-02 IGNITION AND DAMAGE CRITERIA FOR ELECTRICAL CABLES

The identification of nearest ignition and damage targets will most often involve the identification of cables as both ignition and damage targets. Often the same cable will represent both targets. For thermoplastic (TP) and thermoset (TS) cables, the ignition and damage criteria will be assumed to be the same. The heat flux and temperature criteria for damage and/or ignition of electrical cables are identified below:

| Table A6.1 – Screening Criteria for the Assessment of the Ignition and Damage Potential of Electrical Cables | | |
|--|--|----------------------|
| Cable Type | Radiant Heating Criteria | Temperature Criteria |
| Thermoplastic | 6 kW/m ² (0.5 BTU/ft ² s) | 205°C (400°F) |
| Thermoset | 11 kW/m ² (1.0 BTU/ft ² s) | 330°C (625°F) |

TP damage thresholds are assumed for Kerite FR cable. Kerite FR-II, FR-III, and HT cable are assigned TS damage thresholds. In addition, since all Kerite cable varieties are qualified, TS ignition thresholds are assigned to these types of cables.

The previous version of the Fire Protection SDP assumed that an electrical cable will be damaged (or will ignite) instantaneously when the plume temperature at a vertical cable target reaches the applicable temperature threshold from Table A6.1, or when the incident radiant heat flux to a radial target reaches the applicable heat flux threshold. In the present version of the Fire Protection SDP, damage (or ignition) is assumed to be delayed because of the time that is needed to heat a cable target to failure or ignition. The approach to calculate this delay time for a specified time-varying plume temperature or incident radiant heat flux is referred to as the heat soak method. The heat soak method is described in Appendix A of NUREG-2178 Vol. 2 and in Section 06.03.01 of the basis document (IMC 0308 Attachment 3 Appendix F). The heat soak method was used for the zone of influence (ZOI), SF, and damage/ignition time calculations in the development of table and plot sets A, D, and E in Attachment 8.

02.01 Rules for application in the target identification task

- Cables in conduit will be considered potential damage targets, but not ignition targets. Cables in conduit will not contribute to fire growth and spread. The conduit will be given no credit for delaying the onset of thermal damage. Consequently, the time to damage of a cable in conduit is calculated using the heat soak method in the same way as for a cable target that is directly exposed and not in conduit.

- Cables coated by a fire-retardant coating will be considered as both thermal damage and fire spread targets. For the purposes of the Phase 2 analysis, no credit will be given to the coating for delaying or preventing the onset of damage and/or ignition. Consequently, the time to damage of a cable coated with a fire-retardant coating is calculated using the heat soak method in the same way as for a cable target that is directly exposed and not coated by a fire-retardant coating.
- In identifying damage targets, do not include components directly within or associated with the fire ignition source itself. The fire ignition source will inherently be assumed to be damaged given any fire involving itself as the source so further evaluation of the components as damage targets is unnecessary.
 - Example 1: For an electrical panel fire, all equipment and components within the panel will be assumed to fail. Per the counting guidance for non-high energy arching fault (HEAF) fires, a panel will be defined as a distinct vertical section in this context.
 - Example 2: Given a self-ignited cable fire, all cables in the initiating raceway will be assumed to fail immediately on fire ignition (time zero).
- Cables in stacks of cable trays will be considered as both thermal damage and fire spread targets. Flame spread and fire propagation characteristics for fires involving ignition sources and stacks of cable trays are discussed in the section for FDS 2 scenarios in Attachment 3 and in Section 06.03.03 of the basis document (IMC 0308 Attachment 3 Appendix F).
- Cables in Trays with Solid Bottoms: Bottom tray covers do not affect the ignition and damage thresholds of cables in the tray but can be assumed to delay ignition and damage to TS and TP cables by 20 min and 4 min, respectively. A longer delay can be assumed if the heat soak method predicts a damage or ignition time that exceeds 20 min or 4 min for TS and TP cables, respectively. For example, consider an FDS1 scenario involving a TP cable tray with a solid bottom for which the pertinent table in set D of Attachment 8 indicates that the damage time exceeds 4 min. In this case the analyst may use the tabulated damage time instead of assuming a 4 min delay.
- Mixed Cable Insulation/Jacket Type Configurations: There are cables that are formulated with a TS insulation and a TP jacket, and potentially, *vice-versa*. The parts of a cable are shown in Figure A6.1 below. Armored cables may have a bare metal armor exposed or may have either a TS or TP covering over the metallic armor. For such cases, some special consideration is needed. In the SDP process, the analysis does not distinguish between ignition and damage behaviors, except for Kerite cable as explained above. Ignition of a TS or TP cable is taken as an indication of imminent failure. In the assessment of whether to treat a cable as TS or TP, the weakest link will dominate. Therefore, if any part of the cable is TP, the entire cable is treated as TP. For example, a cable with a TS insulation and a TP jacket will be treated using the failure criteria of a TP cable to reflect the reduced resistance to ignition of the jacket material. A cable with a TP insulation and a TS jacket will also be treated as a TP due to the likelihood of melting of the insulation material. The following table provides a decision matrix for the selection of which failure/ignition property set to apply to a given cable.

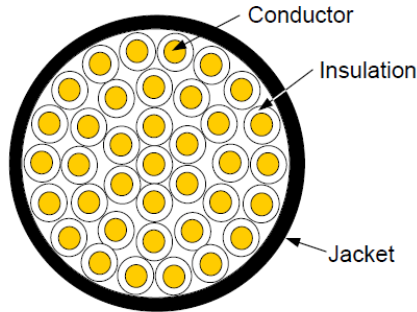


Figure A6.1: Illustration of Parts of a Cable

| Table A6.2 – Cable Properties Selection Decision Matrix | | |
|---|----------------------|--|
| Cable Construction / Configuration | | Ignition/Damage Parameter Set to be Used |
| Insulation Type | Jacket/Covering Type | |
| TS | TS | TS |
| TS | TP | TP |
| TP | TS | TP |
| TP | TP | TP |
| Armored – TS | TS, or No Cover | TS |
| Armored – TS | TP Cover | TP |
| Armored – TP | TS, TP, or No Cover | TP |

0609F.6-03 IGNITION AND DAMAGE CRITERIA FOR OTHER TYPES OF TARGETS

Targets other than electrical cables may also be vulnerable to fire damage. Large, strictly mechanical components (e.g., pipes, check valves, structural supports, tanks, etc.) are not considered vulnerable to fire damage for the purposes of SDP Phase 2 analyses. Should an issue related to potential fire-induced failures of such elements (e.g., fire-induced collapse of a structure or structural supports) be deemed relevant, the analyst should consult NRC HQ staff for guidance.

For the majority of plant components, electrical cables servicing the equipment (power, control, and/or instrument cables) will be the most vulnerable aspect of the component. Hence, failure of the cables will represent the predominant failure mode for the component. In these cases, the failure criteria for the component will be based on failure of the cables servicing the component as already described. This approach applies to any electrical or electro-mechanical component with a thermal mass that exceeds that of a short segment of cable. Such components would include motors, pumps, fans, most valves, transformers, electro-mechanical relays, switchgear, breakers, mechanical switches, hand switches on a control board, etc.

03.01 Sensitive Electronics

The only case where damage criteria other than those applied to cables should be considered is solid state devices and printed circuit-based components (e.g., circuit cards, electronic relays, computers, electronic signal conditioning equipment, digital instrumentation and control circuits, electronic displays, etc.), collectively referred to as sensitive electronics. Electronic devices are generally vulnerable to failure at temperatures much lower than those that may cause cable failures. If a scenario should arise involving exposed solid state control components as a potentially risk-important thermal damage target, the failure criteria to be applied in screening are 3 kW/m² (0.25 BTU/ft²s) and 65°C (150°F), unless information is available to indicate the components are qualified for continuous operation at a higher temperature. However, as with cable targets, damage to sensitive electronics in FDS1 scenarios is not instantaneous and the heat soak method is used to calculate the time to damage of a sensitive electronic device that is exposed to an incident radiant heat flux. Consequently, the heat soak method was used to calculate the radial ZOIs for sensitive electronics in table and plot set A in Attachment 8, and the SFs and damage/ignition times in table and plot set E of Attachment 8.

Sensitive electronic components that are mounted inside a control panel (electrical enclosure) such that the enclosure walls, top, front, and back doors shield the component from the radiant energy of an exposure fire may be considered qualified up to the heat flux damage threshold for TS cables, provided that:

- The component is not mounted on the surface of the electrical enclosure (front or back wall/door) where it would be directly exposed to the convective and/or radiant energy of an exposure fire.
- The presence of louvers or other typical ventilation means does not invalidate the guidance provided for here.

03.02 Cable and Bus Duct Material Fragilities

As discussed in IMC 0609 Appendix F Attachment 3, the ZOI for a HEAF in a switchgear or load center depends on the fragility of the cable target. The ZOI for a HEAF in a non-segregated bus duct also depends on the fragility of the bus duct material. The fragilities of TP and TS cable targets and of steel and aluminum bus duct material are given in Table 6-1 of RIL 2022-01, which is duplicated as Table A6.3 below.

| Table A6.3 – Target Fragility Thresholds | |
|---|--------------------------------|
| Target Type | Threshold (MJ/m ²) |
| TP jacketed cables (including cables in conduit and cable trays) | 15 |
| TS jacketed cables (including cables in conduit and cable trays) | 30 |
| Aluminum enclosed bus ducts | 15 |
| Steel enclosed bus ducts | 30 |

END

Attachment 1: Revision History for IMC 0609, Appendix F Attachment 6

| Commitment Tracking Number | Accession Number Issue Date Change Notice | Description of Change | Description of Training Required and Completion Date | Comment Resolution and Closed Feedback Form Accession Number (Pre-Decisional, Non-Public) |
|----------------------------|---|---|--|---|
| | ML041700310 05/28/2004 CN 04-016 | IMC 0609, App F, Att 6 "Guidance for the Identification of Targets and Their Ignition and Damage Criteria," is added to provide for the development of specific fire growth and damage scenarios for fire ignition sources that were not screened out to this point by the process. This helps to evaluate the independence of the designated safe shutdown path. | None | N/A |
| | ML050700212 02/28/2005 CN 05-007 | IMC 0609, App F, Att 6 "Guidance for the Identification of Targets and Their Ignition and Damage Criteria," is revised to provide additional guidance for solid state components. | | |
| | ML17089A423 DRAFT CN 17-XXX | Revised to reflect changes to the Phase 2 process. CA Note sent 7/18/17 for information only, ML17191A681. Issued 10/11/17 as a draft publicly available document to allow for public comments. | November 2017 | ML17093A185 |
| | ML18087A410 05/02/18 CN 18-010 | Draft document revised to incorporate minor public comments and re-issued with new accession number in order to issue as an official revision after receipt of public comments. | Gap training covering changes to the procedure completed November 2017 | ML17093A185 |

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|----------------------------|---|--|--|---|
| | ML24145A033 09/05/24 CN 24-024 | This revision includes updating IMC 0609 Appendix F, its associated attachments, and the basis document to incorporate updated guidance for modeling transient fires per NUREG-2233, high energy arching faults per NUREG-2262, and electrical enclosure, electric motor, dry transformer and main control room fires per NUREG-2178 Volume 2. This revision also implements the heat soak method in the HRR and ZOI calculations. | | ML24155A261 |