INSPECTION MANUAL CHAPTER 0609 APPENDIX F ATTACHMENT 4

# GUIDANCE FOR DETERMINING FIRE IGNITION FREQUENCY

Fire Ignition Source Mapping Table:

See additional counting instructions at end of table.

| Table A4.1 - Mapping Fire Ignition Source Scenarios to Fire Frequency, the Fire Severity Characteristics, and the Applicable Manual Fire Suppression Curve | | | | |
|---|---|---|---|---|
| Ignition Source Bin | Counting Unit | Fire Frequency per Counting Unit (/ry) | Use These Fire Severity Characteristics | Use This Manual Fire Suppression Curve |
| Cables – Thermoplastic: | | | | |
| Low Loading | per fire area | 7.0E-06 | Cable Tray Fires | Cable Fires |
| Medium Loading | | 1.8E-04 | | |
| High Loading | | 5.2E-04 | | |
| Electrical Cabinets (non-HEAF): | | | | |
| General Electrical Cabinets | per distinct vertical section | 4.0E-05 | Electrical Cabinets | Electrical Fires |
| Main Control Board | per unit control room | 4.9E-03 | Main Control Board Fires | Control Room |
| Electric Motors: | | | | |
| Electric Motors | per motor | 1.4E-3 | Electric Motors | Electrical Fires |
| Generators – General: | | | | |
| Diesel Generators | per generator | 6.2E-04 | Electrical Cabinets | Electrical Fires |
| | | 3.3E-03 | Oil Spills | Oil Fires |
| | | 3.9E-03* | Oil Spills | Oil Fires |
| Gas Turbine Generators | per generator | 1.6E-02 | Oil Spills | Oil Fires |
| RPS MG Sets | per generator set | 7.7E-04 | Electric Motors | Electrical Fires |
| High Energy Arcing Faults: | | | | |
| Electrical Cabinets (≤1000 V) | per distinct vertical section | 3.0E-06 | HEAFs | HEAFs |
| Electrical Cabinets (>1000 V) | | 2.8E-05 | HEAFs | HEAFs |
| Segmented Bus Ducts | per fire area | 1.1E-03** | HEAFs | HEAFs |
| Iso-Phase Bus Ducts | per bus duct end | 3.0E-04 | HEAFs | HEAFs |
| Hot Work: | | | | |
| Hot Work – Low | per fire area | 3.5E-05 | Transients | Welding |
| Hot Work – Medium | | 1.1E-04 | | |
| Hot Work – High | | 1.1E-03 | | |
| Hydrogen Sources: | | | | |
| $H_2$ Recombiner (BWR) | per recombiner | 1.9E-03 | Hydrogen Fires | Flammable Gas |
| $H_2$ Storage Tanks | per $H_2$ tanks | 4.9E-03 | Hydrogen Fires | Flammable Gas |
| Miscellaneous $H_2$ Fires | per fire area | 1.6E-03 | Hydrogen Fires | Flammable Gas |
| Main Turbine-Generator Set: | | | | |
| TG Exciter Fire | per exciter | 4.2E-04 | Electrical | Turbine Generator |
| TG Oil Fires | per lube oil system | 1.1E-03 | Oil Spills | |
| TG Hydrogen Fires | per $H_2$ system | 1.4E-03 | Gas Fires | |

| Table A4.1 - Mapping Fire Ignition Source Scenarios to Fire Frequency, the Fire Severity Characteristics, and the Applicable Manual Fire Suppression Curve | | | | |
|---|---|---|---|---|
| Ignition Source Bin | Counting Unit | Fire Frequency per Counting Unit (/ry) | Use These Fire Severity Characteristics | Use This Manual Fire Suppression Curve |
| Miscellaneous Components: | | | | |
| Air Compressors | per compressor | 2.9E-04 | Electrical | Electrical Fires |
| | | 1.8E-04 | Oil Spills | Oil Fires |
| Battery Banks | per interconnected battery set | 9.8E-05 | Electric Motors | Electrical Fires |
| Boiler Heating Units | per boiler | 1.1E-03 | Oil Spills | Oil Fires |
| Electric Dryers | per dryer | 1.2E-03 | Transients | Transients |
| Ventilation Subsystems | per major ventilation system | 1.1E-04 | Electric Motors<br>Oil Spills | Electrical Fires, Oil Fires, Transients |
| Pumps: | | | | |
| Reactor Coolant Pump(PWR)<br>Reactor Feed Pump (BWR) | per pump | 1.9E-04 | Pumps (Electrical) | Electrical Fires |
| | | 1.2E-03 | Oil Spills | Oil Fires |
| Main Feedwater Pumps | per main feedwater pump | 4.8E-04 | Pumps (Electrical) | Electrical Fires |
| | | 3.9E-03 | Oil Spills | Oil Fires |
| Other Pumps | per pump | 1.6E-04 | Pumps (Electrical) | Electrical Fires |
| | | 1.4E-04 | Oil Spills | Oil Fires |
| Transformers: | | | | |
| Outdoor/Yard | per transformer | 2.8E-03 | | Outdoor Transformers |
| Indoor Dry | | 1.6E-04 | Electric Motors | Electrical Fires |
| Indoor Oil-Filled | | 1.6E-04 | Oil Spills | Oil Fires |
| Transient Fuels: | | | | |
| Transients – Low | per fire area | 4.6E-05 | Transients | Transients |
| Transients – Medium | | 1.4E-04 | | |
| Transients – High | | 1.4E-03 | | |
| Ignition Sources Requiring Total Plant Unit Count Estimates: | | | | |
| Battery Chargers | per charger | 1.12E-03** | Electrical Cabinets | Electrical Fires |
| Hot Work Cable Fires | per fire area | 1.40E-03** | Cable Tray Fires | Cable Fires |
| Junction Boxes | per junction box | 3.61E-03** | Electrical Cabinets | Electrical Fires |

* Use when the nature of the fire (electrical vs. oil) cannot be determined.

** Plant-wide FIF. To determine the per unit fire frequency the analyst should make an estimate of the affected fraction plant-wide and use this to apportion.

Additional Counting Instructions:

Electrical Cabinets (including Main Control Board):

- Count distinct vertical sections
- Do not count individual cubicles for devices such as breakers and MCCs - count vertical sections.
- Do not count fully enclosed wall-mounted electrical panels and junction boxes.

- General electrical cabinets include MCCs, switchgear, load centers, breakers, electrical distribution cabinets, battery chargers, inverters, and all other similar cabinets generally associated with power distribution and/or power switching.
- General electrical cabinets also includes control cabinets such as relay cabinets, signal conditioning cabinets, signal multiplexing cabinets, cabinets provided for local control of systems and components such as the diesel generator, remote shutdown panels, and all other similar cabinets generally associated with plant instrumentation and control functions.

Electric Motors:

- Do not count motors that are 5 HP or less.
- Do not count any motor already included as a part of another fire ignition source:
    - Pump motors are counted as part of the pump.
    - Ventilation fan/blower motors are counted as a part of a ventilation subsystem.

High Energy Arcing Faults - Segmented Bus Ducts (see FAQ 07-0035 for additional details)

- If the transition points along the length of the segmented bus duct can be identified based on external visual inspection or by plant electrical construction drawings, count the total number of transition points, excluding the bus end termination points.
- If the transition points cannot be identified, partitioning of fire frequency to a specific fire scenario is based on apportioning of the fire frequency equally along the length of the bus duct. This requires the following:
    - Estimate the total length of segmented bus duct present in the plant under analysis.
    - Measuring the length of duct for which identified targets fall within the bus duct arc fault zone of influence (see Attachment 3 for a discussion of the zone of influence of segmented bus duct HEAFs). If this length is less than 12 ft., a minimum length of 12 ft. should be assumed.

Miscellaneous Components - Air Compressors:

- Do not count air compressors if the drive motor is 5 HP or less.

Miscellaneous Components - Batteries:

- Count interconnected banks of batteries.
- Do not count small batteries (e.g., individual battery cells) associated with back-up power to a small component
- Do not count emergency lighting batteries.

Miscellaneous Components - Ventilation Subsystems:

- Do not count wall mounted ventilation fans if the drive motor is 5 HP or less.

Pumps - Other Pumps:

- Do not count small sampling pumps.
- Do not count pumps if the drive motor is 5HP or less.

Transformers - Indoor Dry Transformers:

- Count only transformers that are at least 1 cubic foot in size.
- Count wall-mounted transformers if they do satisfy other counting criteria.
- Do not count lighting transformers.
- Do not count control power transformers.
- Do not count small transformers integrated as an individual component within a larger electrical panel - these are included as a part of the panel.
- Battery chargers and inverters are counted as general electrical cabinets.

Likelihood Ratings for Thermoplastic Cables:

- Low - used for areas that have a few cable trays that are generally less than half full. For example, this level may be used for a fire area where there are four vertical cables attached to one wall and each cable tray carries no more than 10 cables. Areas that will typically be assigned a low cable loading include pump rooms.
- Medium - used for areas that have several cable trays that are generally more than half full. For example, this level may be used for a fire area where there are four vertical cable trays attached to one wall and all four trays carry large number of cables. Typical rooms that will likely be assigned a medium cable load are areas such as a switchgear room.
- High - used for areas that have a large concentration of cable trays (e.g., the cable spreading room, cable vaults, cable tunnels, other areas used for general routing of cables).

For those plant areas where the only cables that are not enclosed are small sections of cables (i.e., a few feet long) that provide the power to the electrical equipment in the plant area, it may be assumed that cables have no contribution to the fire frequency of the area. For example, the room where a residual heat removal pump is located may contain no cables except for a 3-foot length of a power cable between the pump motor and the floor.

Most cable trays have ladder-type construction and are therefore open on both sides. Some trays may have a solid bottom or a sheet metal cover on top or both (i.e., solid bottom and sheet metal cover). In the latter case, the trays are not hermetically sealed. Therefore, a fire inside the cable tray may impact other adjacent cables. The analyst may elect to include such fully enclosed cable trays in the fire frequency calculation. However, some cable trays may be fully wrapped or boxed in a fire retardant material and construction. For such cases, the analyst may ignore the influence of those cable trays on the fire frequency.

Likelihood Ratings for Transients (see FAQ 12-0064 for additional details):

Criteria for assigning a relative transient fire likelihood rating focus on the following factors:

- Extent of general plant personnel traffic passing through an area - higher traffic tends to be indicative of a higher likelihood rating.
    - Exception: a roving fire watch or routine security patrols passing through an area will not be taken as indicative of a higher transient fire likelihood.
- Normal occupancy during at-power operations - higher occupancy levels and rates are taken as indicative of a higher likelihood rating.
    - Exception: continuous occupancy of the main control room will not be taken as indicative of a higher transient fire likelihood because extraordinary vigilance is expected for this fire area.
    - Exception: a continuous fire watch in a fire area will not be taken as indicative of a higher transient fire likelihood.
- The frequency of maintenance activities undertaken in the area - maintenance activities may introduce transient fuels and/or ignition sources and increases the likelihood rating.
- Storage practices for transient materials - areas will be assigned a higher likelihood rating if, by plant practice, they are used to store transient materials such as trash, maintenance materials, flammable liquids, packing materials, etc., or to stage materials in anticipation of an outage or other maintenance activity. Storage may be occasional and temporary (generally indicative of a medium rating) or continuous (generally indicative of a high rating).
- Restrictions imposed by administrative controls - less restrictive combustible materials and/or activity-related administrative controls are taken as indicative of a higher transient fire likelihood.

Given these factors, the relative transient fire likelihood rating is assigned as follows:

- Low - applies to fire areas that are normally closed for any type of traffic, are not visited often (no more than once per week), are not occupied during normal plant operations, and where maintenance activities would generally be disallowed during normal at-power plant operations. Furthermore, the fire area is subject to administrative controls that disallow leaving transient fuel sources unattended in the area (e.g.: no storage of transient materials is allowed; maintenance materials may not be left unattended). Examples:
    - Pipe tunnels that contain nothing but pipes, that are accessible but are not generally visited by plant personnel can be regarded as "low" transient combustible level areas.
    - Low can also be assigned to a cable spreading room with cables only assuming that access to the room is strictly controlled and administrative controls are in place as described above. Low may also apply to other similar areas such as cable vault and tunnel areas.
    - Low will generally apply to main control rooms.
    - Low will generally apply to the containment structure.
- Medium - used for areas that either have occasional to frequent foot traffic (no more than once per shift and the area is not a regular access/transit pathway) or are occasionally, but not continuously, occupied during normal plant operations. Modest storage of transients may be allowed. Medium would also apply to a fire area where maintenance activities are allowed during at-power plant operation, but these activities are subject to strict administrative controls such as activity-specific permit and/or combustible controls

program, and are a relatively rare occurrence (e.g., not more than once per operating year). Examples:

- A fire area that is not normally locked but is not used as a passage to other parts of the plant may be regarded as "medium" transient combustible level area. A DC Power distribution panel room at the end of a corridor can be regarded as such a room.
- The room is not locked, but only a few plant personnel may enter the room once or twice per shift.
- Normal plant operations may, infrequently, involve plant personnel occupying the area for up to several hours.
- Medium can also be assigned to a cable spreading room that contains components other than cables.
- Items may be stored in the room on a temporary basis, for example, to conduct repair work on equipment nearby. Such storage should be infrequent rather than routine.
- Repair/maintenance work that may result in introduction of transient fuels or ignition sources (e.g., pump oil change-out activities or routine maintenance on motor bearings) is relatively common (e.g., two or more times per year) while the plant is at power.
- Most pump rooms and areas within the Reactor Building or Auxiliary Building would likely fall into this category (case specific exceptions are possible).
- Most switchgear rooms would typically be ranked medium.
- Batteries rooms would generally be ranked medium depending on the frequency of battery maintenance activities.

- High - used for areas that have heavy foot traffic, are frequently or continuously occupied, where transient items are typically stored, where plant refuse is routinely gathered in substantive quantities for eventual collection, where ignition sources are often brought into the area, and/or where maintenance activities during normal operation are relatively common. Examples:
  - Those parts of a power plant with characteristics similar to an office can be regarded as "high". In such an area, personnel are present for a large fraction of the time. Paper based items (i.e., letters, reports, computer printouts, etc.) are brought in and maintained in the area. Small electrical tools or appliances (e.g., hot plates, portable heaters, microwave ovens, and coffee pots) may be used in the area once every few weeks or more frequently. Health physics access control areas, break room areas, any area used for food preparation, and security stations are examples. Note that this category is not intended to apply to the main control room itself, but may apply to kitchen or security areas associated with or adjacent to the main control room.
  - Any area where smoking is not prohibited or where there is evidence of smoking.
  - An area with an open trash can that routinely contains substantive quantities of general trash.
  - An area where rad protection gear (e.g., jump suits, gloves, boots, etc.) are stored or collected including turn-out/change-out areas.
  - Any area used for the storage (permanent or temporary) of flammable or combustible fluids.
  - A staging area where items are repaired or constructed before they are taken to other parts of the plant for installation.
  - An area where materials are pre-staged in anticipation of a planned outage.
  - A truck loading and unloading bay.

- An area where hot work is relatively common during at-power plant operations, but is not subject to a continuous fire watch.
- For most plants, areas within the turbine building, service building, diesel generator rooms, intake structure, and rad waste areas would typically be categorized as high for transient combustible fire potential.

Likelihood Ratings for Hot Work (see FAQ 12-0064 for additional details):

As a starting point, the same likelihood rating assigned to the fire area for transient fires is also used as the hot work fire likelihood rating. However, plant specific conditions may be considered if such information is readily available, and an alternate hot work likelihood rating may be assigned as appropriate.

The hot work fire likelihood ratings are representative of the following conditions:

- Low - fire areas where hot work is precluded during at-power plant operations.
- Medium - fire areas where hot work activities might be undertaken during at-power operation, but would only be expected to occur only rarely (e.g., on the order of once per operating year).
- High - fire areas where hot work activities are allowed and likely to occur during at-power operation (e.g., on the order of two or more times per operating year).

Note that the above rating categories presume that all hot work activities within the plant would be subject to administrative controls (e.g., hot work permit programs and fire watches) regardless of their location.

Ignition Sources that Require Total Plant-Wide Unit Count Estimates:

The following ignition sources require a total plant-wide unit count to determine the per unit fire frequency:

- Segmented bus duct HEAFs – requires an estimate of the total plant-wide number of segmented bus duct transition points, or the total length of segmented bus ducts in the plant.
- Battery chargers – requires an estimate of the total number of battery chargers in the plant.
- Junction boxes – requires an estimate of the total number of junction boxes in the plant.

The apportioning of the fire frequency for cable fires caused by hot work is more complicated. Guidance from either Regional or Headquarters staff should be sought for the treatment of these fires.

ATTACHMENT 1
Revision History for IMC 0609, Appendix F Attachment 4

| 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) |
|---|---|---|---|---|
| | 05/28/2004<br>CN 14-016 | IMC 0609, App F, Att 4 "Fire Ignition Source Mapping Information: Fire Frequency, Counting Instructions, Applicable Fire Severity Characteristics, and Applicable Manual Fire Suppression Curves," is added to provide the tools to estimate the fire frequency for ignition sources. | None | N/A |
| | 02/28/2005<br>CN 05-007 | IMC 0609, App F, Att 4 "Fire Ignition Source Mapping Information: Fire Frequency, Counting Instructions, Applicable Fire Severity Characteristics, and Applicable Manual Fire Suppression Curves" is revised to correct title for the cables ignition source bin on page F4-1 to properly indicate it only applies to non-qualified cables. | | |
| | ML17089A421<br>DRAFT<br>CN 17-XXX | Revised to reflect changes to the Phase 2 process and for consistency with the guidance in NUREG/CR-6850 and superseding guidance in NFPA 805 FAQs and NUREG-2169. Renamed "Guidance for Determining Fire Ignition Source Frequency."<br>CA Note sent 7/18/17 for information only, ML17191A681. Issued 10-11-17 as a draft publically available document to allow for public comments. | November 2017 | ML17093A183 |
| | ML18087A406<br>05/02/18<br>CN 18-010 | 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 | ML17093A183 |