

**FAQ Number** 17-0013 **FAQ Revision** 0 (Draft B)  
**FAQ Title** High Energy Arcing Fault (HEAF) Non-Suppression Probability (NSP)

Plant: Various Date: March 21, 2017  
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**Purpose of FAQ:**

This FAQ provides an update to the non-suppression probability (NSP) for high energy arcing fault (HEAF) fires based on a review of additional fire event data.

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**Relevant NRC document(s):**

NUREG/CR-6850  
NUREG/CR-6850 Supplement 1 (FAQ 08-0050)  
NUREG 2169

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**Details:**

**NRC document needing interpretation (include document number and title, section, paragraph, and line numbers as applicable):**

See list of relevant NRC documents

**Circumstances requiring interpretation or new guidance:**

The non-suppression probability for high energy arcing fault (HEAF) fires provided in NUREG/CR-6850 Supplement 1 (FAQ 08-0050) and NUREG 2169 are considered overly conservative based on durations that extended past the control point in the fire event. As a result, the risk associated with HEAFs in critical fire areas may be artificially high.

**Detail contentious points if licensee and NRC have not reached consensus on the facts and circumstances:**





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not the official documentation of the fire event, such as the LER, the additional information agrees with the LER (Ref. 6) which states:

*When the fire brigade entered the room, they quickly extinguished the fire with a CO2 extinguisher, before offsite assistance arrived. After clearing smoke from the room, the fire was declared out at 0143 PDT.*

This suggests that a significant time lag may have occurred between extinguishing what is referred to as the “small fire” and the official declaration. A 35 minute fire duration is considered reasonable based on the available data and is a refinement on the original, conservative duration provided in the FEDB and utilized in NUREG-2169.

2.4. **Fire Event #106 (SG 20010203):** This fire event was reported as having a 154 minute duration in NUREG-2169 and a 156 minute duration in the FEDB (Ref. 2 and 4). The event is also cited as 141 minutes in NUREG/CR-6850 Supplement 1, which is a revision from the NUREG/CR-6850 duration of 136 minutes (Ref. 3 and 5). There is no explanation provided in NUREG-2169 or NUREG/CR-6850 Supplement 1 for the discrepancy between the documents. The LER for this event details that the event began at 1514 and that fire responders reported the fire extinguished at 1544; it was later determined that the fire was not extinguished at that time, but flames were no longer visible (Ref. 8). The delay is attributed to extinguishing due to high energy and resistance to using water; however the fire was under control and limited to the cubicle at the time of the report (Ref. 8). Therefore, an event duration of 31 minutes is appropriate for use in the PNS curve, as this reflects the time required for the fire to be suppressed and controlled.

2.5. **Fire Event #127 (VY 20040618):** This fire event was reported as having a 71 minute duration in NUREG 2169 and the FEDB (Ref. 2 and 4). The event was not included in NUREG/CR-6850 or NUREG/CR-6850 Supplement 1 (Ref. 3 and 5). The LER for this event establishes that the event occurred at 0640 and that the fire brigade declared the fire under control at 0717, resulting in a 37 minute duration (Ref. 9). The FEDB also reports that the fire was under control by 0717 but that the fire was not extinguished until 0751; use of the time to extinguishment resulted in the 71 minute duration (Ref. 3).

### 3. Additional Fire Events

This review also identified two fire events that were originally binned as electrical fires for the calculations of non-suppression probability in NUREG-2169 but which are bin 16.1 and 16.2 HEAF fires (Ref. 2). The fire events in this category are #922 and #792 with a fire duration of 5 minutes and 3 minutes respectively. The LER for fire event #922 was reviewed and it was determined that several of the characteristic challenges that have been shown to inhibit fire suppression in HEAF events, specifically the need to de-energize the high energy equipment and suppress secondary fires, were present in this scenario (Ref. 12). The fire originated in a bus bar connecting the Main Auxiliary Transformers from 6160 volt busses due to a phase to ground (Ref. 12). In order to suppress the fire, the Main Auxiliary Transformer was de-energized and plant personnel manually suppressed a secondary fire caused by slag emitted

**Commented [MN1]:** •15:26: Fire fighters determine source of heat and smoke is 3A07 switchgear cabinet  
•15:23: SOFD Shift Captain requested Camp Pendleton assistance  
•15:28: Fire extinguishers applied to 3A07 vents but are ineffective  
•15:36: Camp Pendleton fire engine arrives on scene  
•15:36: FTA Reports 125VDC is on in all panels  
•15:44: Control Room receives report from FTA fire was out  
•16:01: Fire extinguishers applied again to 3A07 vents  
•17:20: Cabinet Door to A07 switchgear opened flames, visible inside, attempted , but failed to extinguish using portable extinguishers  
•17:40: Incident Commander receives permission to use water from Operations Shift Manager  
•17:41: Preplan tailboard with fire team and place equipment to use utilize water for cooling and extinguishing of A07 fire  
•17:56: Fire fighters apply water to bus 3A07  
•18:11: Fire is out

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from the bus (Ref. 12). Based on the characteristics of this fire, although it occurred outside of an electrical panel, the fire is considered to represent the same challenges as a typical HEAF scenario and inclusion in the non-suppression probability calculations is considered appropriate.

Fire event #792 occurred in the “A” isolated-phase bus duct due to damaged ground straps and a deteriorated gasket (Ref. 13). Although the fire does not represent similar combustibles to that of a typical electrical cabinet, the challenges related to the fire are similar to that of a typical HEAF; specifically that the bus ducts were required to be de-energized prior to suppression (Ref. 13). Therefore, inclusion of this fire event in the calculations for the non-suppression probability of a HEAF fire is considered more appropriate than inclusion in the electrical fire bin.

In addition, the most recent revision to the EPRI FEDB includes an additional published event that was not available for review at the time of NUREG-2169. Fire Event #162 occurred on August 5, 2009 and is reported to have a 46 minute fire duration (Ref. 4). The event was detected at 0751 hours when the conductor in one of the supply busses catastrophically failed, melting all three phases of the conductor (Ref. 14). The fire was declared out at 0811 hours (Ref. 14).

These three fire events, as well as the refined event durations above have been included in the updated calculations of non-suppression probability.

The re-binning of Fire Events #792 and #922 as HEAF fires versus electrical fires for the non-suppression probability necessarily results in a revision to the electrical fire non-suppression probability. The changes are reflected in the proposed revisions to NUREG-2169 included as part of this FAQ.

#### 4. Comparison with International Events

The scope of the previous non-suppression probability analyses has been limited to events occurring in the United States. However, the Organisation for Economic Co-operation and Development (OECD) has recently released Fire Project Topical Report No. 1 “Analysis of High Energy Arching Fault (HEF) Fire Events” (Ref. 1). This report identified 48 HEAF events that had been reported to the OECD from Canada, Czech Republic, Finland, France, Germany, Japan, Korea, Spain, Sweden and the United States. The database includes 11 events in the United States, although this included non bin 16 HEAFs (e.g., cable HEAFs and HEAFs occurring in the Yard transformers). The OECD report included 18 bin 16 HEAF events occurring outside of the United States. The average duration for these fires was 31.3 minutes; while the average time for the US only events reviewed as part of this FAQ is 35 minutes. The average time for all events, both US and international, is 32.7 minutes. The use of an average time of 35 minutes for US HEAF events is therefore considered conservative and in agreement with the trend of HEAF fire event durations internationally.

**Commented [MN2]:** Bus duct fires should not be included with the HEAF electrical cabinet NSP probability. While the need for de-energization is similar the fire loading is completely different for bus duct scenarios. This FAQ could be expanded to separate out the two bins if necessary.

**Commented [MN3]:** Agree that the fire is not necessarily appropriate in the electrical bin but should not be included in HEAF electrical enclosure bins. The combustible loading largely drives the ensuing fire as well as the difficulty with firefighting. The difficulty in extinguishing HEAF events in enclosures with CO2 agents or dry chemical is largely related to configuration of the cabinet and deep seated fires in the damaged breakers which requires water.

**Commented [MN4]:** If we are adding a new event from the applicable timeframe do we need to alter the frequency as well? Currently the frequency and the NSP are linked in 2169 which was the reason they are revised together.

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## 5. Summary/Conclusion

Based on the documentation review and considering the expanded data set, the mean suppression rates proposed in NUREG/CR-6850 Supplement 1 and NUREG 2169 are overly conservative. It is proposed that the mean suppression rate should be increased by approximately a factor of two (from 0.011/0.013 to 0.029) to reflect the revised average fire duration for HEAFs originating in high energy equipment in the US.

A chi squared distribution was applied, consistent with NUREG-2169, to calculate the percentiles based on the number of events and total durations presented in table 5-1.

Attachment 1 and Attachment 2 to this FAQ are provided to summarize the fire event data review and the resulting average durations and non-suppression probability that would result from expanding the data set.

### **If appropriate, provide proposed rewording of guidance for inclusion in the next Revision:**

The following are proposed revisions to NUREG 2169:



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**Table 5-2**  
Updated numerical results for suppression curves (Originally, Table 14-1 from NUREG/CR-6850, Supplement 1)

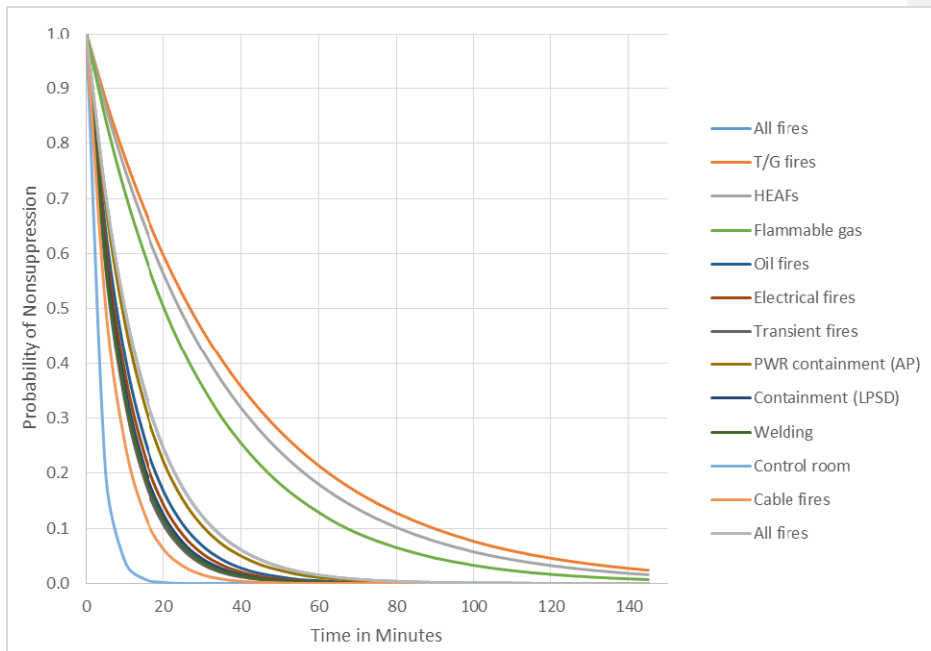
| Time (min) | T/G fires | HEAFs | Outdoor Transformers | Flammable Gas | Oil fires | Electrical fires | Transient fires | PWR containment (AP) | Containment (LPSD) | Welding | Control Room | Cable Fires | All Fires |
|------------|-----------|-------|----------------------|---------------|-----------|------------------|-----------------|----------------------|--------------------|---------|--------------|-------------|-----------|
| 0          | 1.0       | 1.0   | 1.0                  | 1.0           | 1.0       | 1.0              | 1.0             | 1.0                  | 1.0                | 1.0     | 1.0          | 1.0         | 1.0       |
| 5          | 0.879     | 0.867 | 0.879                | 0.843         | 0.641     | 0.616            | 0.572           | 0.687                | 0.595              | 0.584   | 0.198        | 0.502       | 0.705     |
| 10         | 0.773     | 0.751 | 0.772                | 0.710         | 0.411     | 0.380            | 0.328           | 0.472                | 0.355              | 0.341   | 0.039        | 0.252       | 0.497     |
| 15         | 0.680     | 0.651 | 0.678                | 0.599         | 0.263     | 0.234            | 0.188           | 0.325                | 0.211              | 0.200   | 0.008        | 0.126       | 0.350     |
| 20         | 0.598     | 0.565 | 0.596                | 0.505         | 0.169     | 0.144            | 0.108           | 0.223                | 0.126              | 0.117   | 0.002        | 0.063       | 0.247     |
| 25         | 0.526     | 0.490 | 0.524                | 0.425         | 0.108     | 0.089            | 0.062           | 0.153                | 0.075              | 0.068   | *            | 0.032       | 0.174     |
| 30         | 0.462     | 0.424 | 0.460                | 0.359         | 0.069     | 0.055            | 0.035           | 0.105                | 0.045              | 0.040   | *            | 0.016       | 0.123     |
| 35         | 0.407     | 0.368 | 0.404                | 0.302         | 0.044     | 0.034            | 0.020           | 0.072                | 0.027              | 0.023   | *            | 0.008       | 0.087     |
| 40         | 0.358     | 0.319 | 0.355                | 0.255         | 0.028     | 0.021            | 0.012           | 0.050                | 0.016              | 0.014   | *            | 0.004       | 0.061     |
| 45         | 0.314     | 0.276 | 0.312                | 0.215         | 0.018     | 0.013            | 0.007           | 0.034                | 0.009              | 0.008   | *            | 0.002       | 0.043     |
| 50         | 0.277     | 0.240 | 0.274                | 0.181         | 0.012     | 0.008            | 0.004           | 0.024                | 0.006              | 0.005   | *            | 0.001       | 0.030     |
| 55         | 0.243     | 0.208 | 0.241                | 0.153         | 0.007     | 0.005            | 0.003           | 0.016                | 0.003              | 0.003   | *            | *           | 0.021     |
| 60         | 0.214     | 0.180 | 0.212                | 0.129         | 0.005     | 0.003            | 0.002           | 0.011                | 0.002              | 0.002   | *            | *           | 0.015     |
| 65         | 0.188     | 0.156 | 0.186                | 0.108         | 0.003     | 0.002            | *               | 0.008                | 0.001              | 0.001   | *            | *           | 0.011     |
| 70         | 0.165     | 0.135 | 0.164                | 0.091         | 0.002     | 0.001            | *               | 0.005                | *                  | *       | *            | *           | 0.007     |
| 75         | 0.145     | 0.117 | 0.144                | 0.077         | 0.001     | 0.001            | *               | 0.004                | *                  | *       | *            | *           | 0.005     |
| 80         | 0.128     | 0.102 | 0.126                | 0.065         | *         | *                | *               | 0.002                | *                  | *       | *            | *           | 0.004     |
| 85         | 0.112     | 0.088 | 0.111                | 0.055         | *         | *                | *               | 0.002                | *                  | *       | *            | *           | 0.003     |
| 90         | 0.099     | 0.076 | 0.098                | 0.046         | *         | *                | *               | 0.001                | *                  | *       | *            | *           | 0.002     |
| 95         | 0.087     | 0.066 | 0.086                | 0.039         | *         | *                | *               | *                    | *                  | *       | *            | *           | 0.001     |
| 100        | 0.076     | 0.057 | 0.075                | 0.033         | *         | *                | *               | *                    | *                  | *       | *            | *           | 0.001     |



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**Figure 5-2**  
Non-suppression curve plots: probability vs. time to suppression

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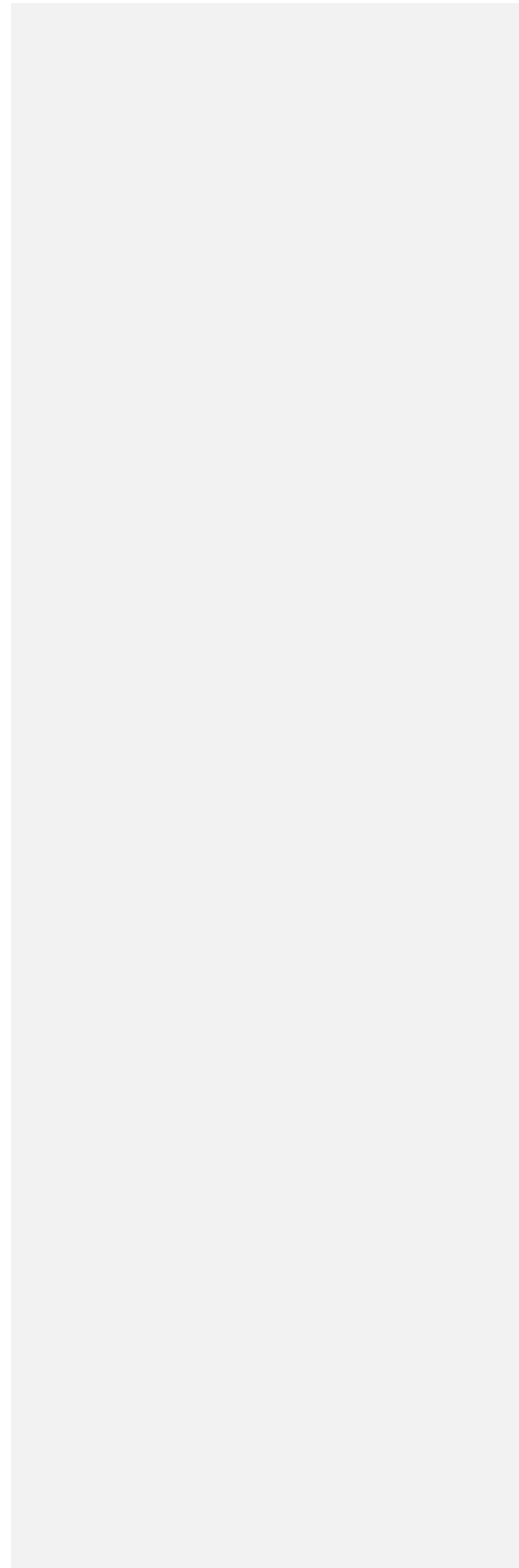
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## References

1. NEA/CSNI/R(2013)6, Nuclear Energy Agency OECD Fire Project – Topical Report No. 1, “Analysis of High Energy Arcing Fault (HEAF) Fire Events,” June 25, 2013
2. NUREG 2169, “Nuclear Power Plant Fire Ignition Frequency and Non-Suppression Probability Estimation Using the Updated Fire Events Database,” December 2014
3. NUREG/CR-6850 Supplement 1, “Fire Probabilistic Risk Assessment Methods Enhancements,” September 2010
4. EPRI 1025284, “The Updated Fire Events Database: Description of Content and Fire Event Classification Guidance,” July 2013
5. NUREG/CR-6850, “Fire PRA Methodology for Nuclear Power Facilities,” September 2005
6. PG&E Letter DCL-00-115, Licensee Event Report 1-2000-004-01, “Unit 1 Unusual Event Due to a 12kV Bus Fault,” August 30 2000
7. Preliminary Notification of Event or Unusual Occurrence, PNO-IV-00-011, “Unusual Event Because of a Fire Lasting Greater than 15 Minutes,” May 15, 2000
8. Southern California Edison Docket No. 50-362, Licensee Event Report 2001-001, “Fire and RPS/ESF Actuations Caused by the Failure of a Non-Safety Related 4.16kV Circuit Breaker” April 2, 2001
9. Entergy Licensee Event Report 2004-003-01, “Vermont Yankee Nuclear Power Station License No. DPR-28 (Docket No. 50-271) Reportable Occurrence No. LER 2004-003-01,” June 14, 2005
10. Waterford Licensee Event Report 95-002-01, Accession # 9801160136, “Reactor Trip and Non-Safety Related Switchgear Fire,” January 13, 1998
11. Oconee Nuclear Station Unit 1 Licensee Event Report, “Fire in ITA Switchgear Due to Unknown Cause,” February 2, 1989
12. Kewaunee Nuclear Power Plant Licensee Event Report 87-009-00, “Electrical Bus Bar Failure Causes Undervoltage on RXCP Buses and Reactor Trip,” August 10, 1987
13. EPRI 1003111, “Fire Events Database and Generic Ignition Frequency Model for U.S. Nuclear Power Plants,” November 2001
14. US Nuclear Regulatory Commission Region IV Report 05000397/2009010, “Columbia Generating Station – NRC Special Inspection Report,” November 23, 2009

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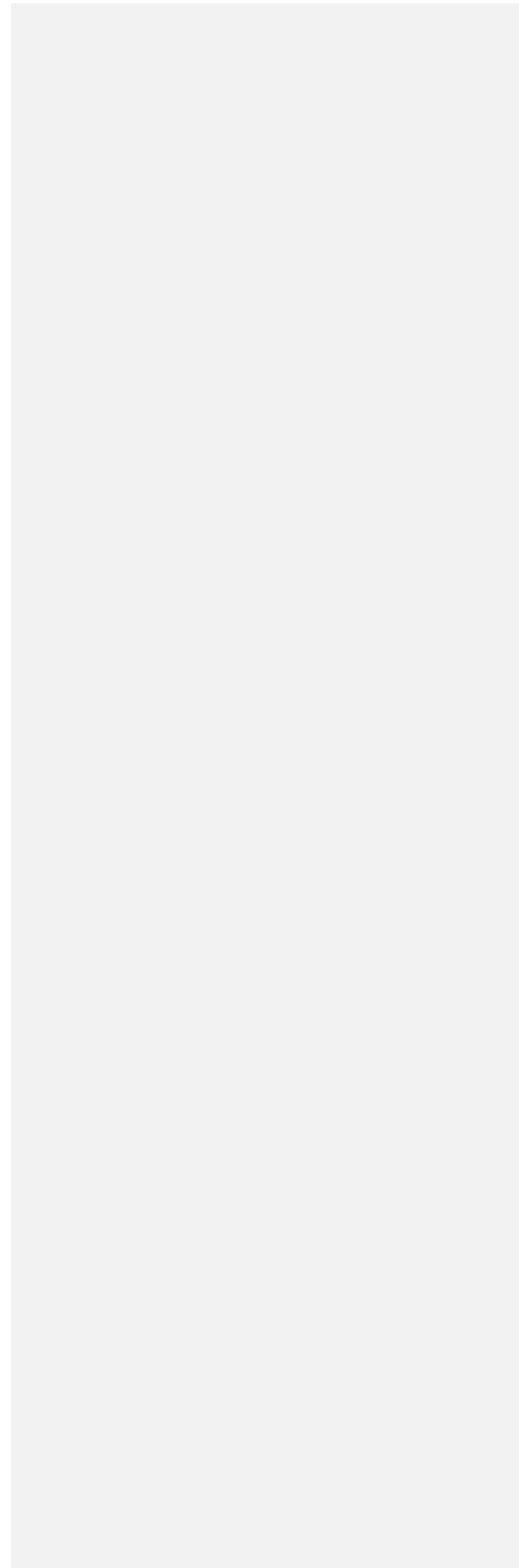
**Attachment 1: Data Summary Table**





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**Attachment 2: Fire Event Data Summary**



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| Unique Identifier | BIN  | *Reference | FEDB # | Include/Exclude  | Reason for Include/Exclude       | Outlier (Y/N)/ Basis                | Country | Plant    | Date     | Event Title  | Component  | Voltage Level | Location  | Fuel  | Damage Limited to Initial Component | Extinguished by (all means involved)  | Time Data | Duration [h:min] |
|-------------------|------|------------|--------|------------------|----------------------------------|-------------------------------------|---------|----------|----------|--|--|---------------|---|---|-------------------------------------|---|-----------|------------------|
| GER 20040823      | 12   | 1          | None   | Exclude - BIN 12 | Cable HEAF                       | Yes - No suppression time available | Germany | GER009   | 20040823 | Failure in the auxiliary power supply with consequential reactor scram                                 | high voltage cable   | 10 kV         | outside the plant, Not switchyard, other cable room | cable insulation materials                    | No                                  | self- extinguished  | Unknown   | 0:00             |
| USA 20100328      | 12   | 1          | None   | Exclude - BIN 12 | Cable HEAF                       | N/A                                 | USA     | USA027   | 20100328 | Plant trip due to electrical fault   | cable run (self-ignited): power cables                       | 4 kV          | turbine building                                    | cable insulation material                     | No                                  | on-site plant fire brigade; people available in the fire area                     | Unknown   | 0:15             |
| GER 19790811      | 16.b | 1          | None   | Exclude          | No suppression time is available | N/A                                 | Germany | GER027   | 19790811 | High energy electric arc at circuit breaker and isolator   | circuit breaker (sub-distribution board)                     | Unknown       | auxiliary building, room for ventilation            | cable insulation materials                    | Yes                                 | self- extinguished  | Unknown   | Unknown          |
| USA 19840802      | 16.a | 1, 2       | 434    | Exclude          | Event time undetermined          | N/A                                 | USA     | Unknown  | 19840802 | Electrical cabinets with HEAF  | Electrical cabinet   | Unknown       | Unknown   | Unknown                                       | Unknown                             | Unknown   | Unknown   | Unknown          |
| JPN 19850831      | 16.b | 1          | None   | Include          | Bin 16                           | N/A                                 | Japan   | JPN044   | 19850831 | Fire at the cabinet containing 6.9 kV bus for start-up   | high or medium voltage electrical cabinet                    | 6.9 kV        | turbine building, switchgear room                   | cable insulation materials                    | Yes                                 | fixed extinguishing system, manually actuated; external fire brigade participated | Unknown   | 2:14             |
| GER 19860530      | 16.a | 1          | None   | Include          | Bin 16                           | N/A                                 | Germany | GER011   | 19860530 | Damage of the 380 V busbar CR (auxiliary power supply of train 4) by a fire                            | bus bar  | 380 V         | electrical building, cable spreading room           | cable insulation materials; other insulations | No                                  | on-site plant fire brigade  | Unknown   | 0:25             |
| KW 19870710       | 16.1 | 2, 4       | 922    | Include          | Bin 16                           | N/A                                 | USA     | Kewaunee | 19870710 | Bus-duct   | Bus duct   | Unknown       | Unknown   | Unknown                                       | Unknown                             | Unknown   | Unknown   | 0:03             |
| GER 19870909      | 16.b | 1          | None   | Include          | Bin 16                           | N/A                                 | Germany | GER022   | 19870909 | Short circuit in the exciter system of an emergency diesel generator unit                              | high or medium voltage electrical cabinet (emergency diesel) | Unknown       | electrical building, switchgear room                | cable insulation materials                    | Yes                                 | on-site plant fire brigade  | Unknown   | 0:09             |
| GER 19880419      | 16.b | 1          | None   | Include          | Bin 16                           | N/A                                 | Germany | GER024   | 19880419 | Short circuit in the 220 kV/380 kV switchgear with consequential loss of offsite power                 | high voltage switchgear                                      | 220 kV        | switchyard  | hardly inflammable liquid                     | Yes                                 | on-site plant fire brigade  | Unknown   | 0:46             |
| USA 19880715      | 16.2 | 2, 4       | 792    | Include          | Bin 16                           | N/A                                 | USA     | Unknown  | 19880715 | Iso-phase bus ducts  | Iso-phase bus ducts  | Unknown       | Unknown   | Unknown                                       | Unknown                             | Unknown   | Unknown   | 0:05             |
| OC 19890103       | 16.b | 2, 4       | 947    | Include          | Bin 16                           | N/A                                 | USA     | Oconee   | 19890103 | During power escalation after startup following a trip a Fire occurred in the Unit 1 6900 V switchgear | 6.9 KV Switchgear  | 6.9kV         | Switchgear Room                                     | Unknown                                       | Unknown                             | fire brigade (water, CO2, dry chemical)   | 1916-2002 | 0:46             |
| GER 19890517      | 16.a | 1          | None   | Include          | Bin 16                           | N/A                                 | Germany | GER025   | 19890517 | Electric arc at a feeder control panel in the 380 V switchgear   | switchgear (380 V switchgear, injection area)                | 380 V         | electrical building, switchgear room                | cable insulation materials                    | Yes                                 | people available in the fire area   | Unknown   | 0:12             |

**Commented [MN5]:** What does "include" mean? Above it says the new values are based on only US events.

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| Unique Identifier | BIN  | *Reference | FEDB # | Include/Exclude | Reason for Include/Exclude | Outlier (Y/N)/ Basis | Country | Plant         | Date     | Event Title   | Component   | Voltage Level                     | Location   | Fuel  | Damage Limited to Initial Component | Extinguished by (all means involved)                                     | Time Data | Duration [h:min] |
|-------------------|------|------------|--------|-----------------|----------------------------|----------------------|---------|---------------|----------|---|---|-----------------------------------|--|---|-------------------------------------|--|-----------|------------------|
| GER 19890908      | 16.b | 1          | None   | Include         | Bin 16                     | N/A                  | Germany | GER001        | 19890908 | Short circuit in the auxiliary electrical system  | high voltage switchgear (10 kV injection cell); circuit breaker                 | 10 kV                             | electrical building, switchgear room                 | cable insulation materials; plastics / polymeric materials                    | No (multiple components)            | on-site plant fire brigade   | Unknown   | 0:26             |
| USA 19900713      | 16.b | 2, 4       | 18     | Include         | Bin 16                     | N/A                  | USA     | Unknown       | 19900713 | HEAF for medium voltage electrical cabinet (>1000V)   | Electrical cabinet  | >1kV                              | Unknown  | Unknown   | Unknown                             | Unknown  | Unknown   | 0:10             |
| FRA 19901030      | 16.b | 1          | None   | Include         | Bin 16                     | N/A                  | France  | FRA042        | 19901030 | Loss of a 6.6 kV emergency switchboard.   | high or medium voltage electrical cabinet                                       | 6.6 kV                            | electrical building, switchgear room                 | cable insulation materials  | Yes                                 | shift personnel  | Unknown   | 0:07             |
| FIN 19910412      | 16.b | 1          | None   | Include         | Bin 16                     | N/A                  | Finland | FIN001        | 19910412 | Fire at 6.6 kV switchgear   | electrical cabinet, high or medium voltage (current transformer inside cabinet) | 6.6 kV                            | electrical building, switchgear room                 | cable insulation materials, other insulations                                 | No (multiple components)            | on-site plant fire brigade   | Unknown   | 0:37             |
| USA 19911014      | 16.b | 2, 4       | 20284  | Include         | Bin 16                     | N/A                  | USA     | Unknown       | 19911014 | HEAF - other electrical or electronic equip   | Unknown   | Unknown                           | Unknown  | in-situ   | Yes                                 | Unknown  | Unknown   | 0:02             |
| WF 19950610       | 16.b | 2, 3, 4    | 74     | Include         | Bin 16                     | N/A                  | USA     | Waterford     | 19950610 | Fault on lightning arrester in the switchyard, reactor trip, and then fire in a 4.16kV Non-safety related bus. Damage limited "mainly" to breaker and adjoining cabinet | fault in 230kV/34.5kV transformer, fire in 4.16kV Switchgear                    | 230kV/34.5kV transformer (4.16kV) | TG Building  | Unknown   | No                                  | brigade (halon, CO2 and dry chem extinguishers), fire department (water) | 0858-1018 | 1:20             |
| GER 19960208      | 16.b | 1          | None   | Include         | Bin 16                     | N/A                  | Germany | GER017        | 19960208 | Disconnection of a main bus due to a short circuit in a switching module  | electrical cabinet (busbar, breaker subassembly)                                | 500 V                             | auxiliary building, switchgear room                  | cable insulation materials  | Yes                                 | on-site plant fire brigade   | Unknown   | 0:17             |
| JPN 19960907      | 16.1 | 1          | None   | Include         | Bin 16                     | N/A                  | Japan   | JPN029        | 19960907 | Fire of the bus-duct in the power supply room for the emergency diesel generator  | bus duct  | 460 V                             | reactor building, EDG switchgear room                | cable insulation materials  | No                                  | shift personnel; external fire brigade participated                      | Unknown   | 0:42             |
| DC 20000515       | 16.1 | 1, 2, 4    | 100    | Include         | Bin 16                     | N/A                  | USA     | Diablo Canyon | 20000515 | Unit 1 unusual event due to a 12 kV bus fault and fire  | 12kV bus, busbar/ bus duct  | 12kV                              | 12kV Switchgear room, auxiliary building             | other solid material; plastics, solid material; plastics/ polymeric materials | No                                  | fire brigade extinguished the small fire with CO2                        | 0025-0100 | 0:35             |
| FRA 20010119      | 16.b | 1          | None   | Include         | Bin 16                     | N/A                  | France  | FRA008        | 20010119 | Incipient fire on ultimate emergency diesel generator   | high or medium voltage electrical cabinet                                       | 6.6 kV                            | diesel generator building, electrical / process room | other insulations, plastics / polymeric materials                             | No (multiple components)            | self- extinguished   | Unknown   | 0:05             |

FAQ Number 17-0002

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FAQ Title High Energy Arcing Fault (HEAF) Non-Suppression Probability (NSP)

| Unique Identifier | BIN  | *Reference | FEDB # | Include/Exclude | Reason for Include/Exclude | Outlier (Y/N)/ Basis   | Country | Plant          | Date     | Event Title  | Component                                     | Voltage Level | Location   | Fuel  | Damage Limited to Initial Component                       | Extinguished by (all means involved)   | Time Data | Duration [h:min] |
|-------------------|------|------------|--------|-----------------|----------------------------|--|---------|----------------|----------|--|---|---------------|--|---|---|--|-----------|------------------|
| SG 20010203       | 16.b | 1, 4       | 437    | Exclude         | Duplicate                  | This event occurs on the same day and at the same time as FEDB event 106. FEDB event 437 was not included in NUREG 2169. | USA     | SONGS          | 20010203 | Fire and RPS/ESF actuations caused by the failure of a Non-safety related 4.16 kV circuit breaker  | 4.16kV bus 3A07                               | 4.16kV        | turbine switchgear room                                    | cable insulation, solid materials                         | No second breaker in same bus failed & arced due to smoke | fire brigade   | 1514-1544 | 0:31             |
| SG 20010203       | 16.b | 2, 3, 4    | 106    | Include         | Bin 16                     | There are two entries in the FEDB for the same day and time (106 and 437). NUREG 2169 cites only event 106               | SG      | SONGS          | 20010203 | The event was caused when breaker x faulted which caused arcing, localized overheating and started a fire within the breaker cubicle.  | HEAF medium voltage electrical cabinet (>1kV) | 4kV           | Auxiliary building   | circuit breaker   | No  | on-site plant fire brigade, external fire brigade participated                   | 1514-1544 | 0:31             |
| Pr Isl 20010803   | 16.b | 2, 4       | 112    | Include         | Bin 16                     | N/A  | USA     | Prairie Island | 20010803 | During startup, operators transferring power, closed breaker and breaker failed initiating a fire in bus cubicle. It was a "c-phase to ground arcing event, which quickly involved all phases. The arcing led to actuation of the protective relaying, which resulted in a turbine/reactor trip" | 4 kV Bus                                      | 4 kV          | Bus 12   |   |   | fire brigade   | Unknown   | 1:30             |
| FRA 20010918      | 16.b | 1          | None   | Include         | Bin 16                     | N/A  | France  | FRA022         | 20010918 | Loss of 400 kV power supply following a fire in the 6.6 kV AC Normal distribution system cubicle   | high or medium voltage electrical cabinet     | 6.6 kV        | electrical building, switchgear room                       | hardly inflammable liquid, plastics / polymeric materials | No (multiple components)                                  | shift personnel; external fire brigade participated                              | Unknown   | 1:11             |
| GER 20020811      | 16.b | 1          | None   | Include         | Bin 16                     | N/A  | Germany | GER017         | 20020811 | Fire in the 500 V switchgear of one train of the independent emergency system  | switchgear                                    | 500 V         | independent emergency building, switchgear room            | cable insulation materials                                | No  | on-site plant fire brigade   | Unknown   | 1:25             |
| GER 20021030      | 16.b | 1          | None   | Include         | Bin 16                     | N/A  | Germany | GER009         | 20021030 | HEAF with consequential fire occurred by exchange of a 0.4 kV switchgear subassembly   | switchgear                                    | 400 V         | electrical building, room for electrical control equipment | cable insulation materials                                | No  | self- extinguished   | Unknown   | < 00:03          |
| VY 20040618       | 16.2 | 1, 2, 4    | 127    | Include         | Bin 16                     | N/A  | USA     | Vermont Yankee | 20040618 | Iso-phase bus duct two- phase electrical fault and fire with secondary fires   | 22kV iso-phase bus                            | 22kV          | turbine building and yard (main xfmr)                      | flammable liquid, hydrogen; other solid material          | No  | auto suppression, fire brigade extinguished using hose stream and nearby hydrant | 0640-0717 | 0:37             |



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|-------------------|------|------------|--------|--------------------|---|--|----------------|----------|----------|---|--|---------------|--------------------------------------|--------------------------------|-------------------------------------|--|-----------|------------------|
| CAN 20051015      | 16.a | 1          | None   | Include            | Bin 16  | N/A  | Canada         | CAN004   | 20051015 | Electrical arc resulting in injury  | low voltage electrical cabinet                 | 600 V         | electrical building, switchgear room | cable insulation materials     | Yes                                 | on-site plant fire brigade                                     | Unknown   | < 00:05          |
| GER 20080314      | 16.b | 1          | None   | Include            | Bin 16  | N/A  | Germany        | GER003   | 20080314 | Fire in a circuit breaker and switch-off of the emergency busbar FB   | high voltage circuit breaker                   | 660 V         | electrical building, switchgear room | plastics / polymeric materials | Yes                                 | on-site plant fire brigade                                     | Unknown   | 0:34             |
| USA 20080727      | 16.1 | 2, 4       | 10584  | Exclude            | No suppression time is available  | Indeterminate Supp Time  | USA            | Unknown  | 20080727 | HEAF for segmented bus duct   | HEAF for segmented bus duct                    | Unknown       | Unknown                              | Unknown                        | Unknown                             | Unknown  | Unknown   | Unknown          |
| CO 20090805       | 16.b | 2, 4       | 162    | Include            | Bin 16  | event duration Not well established                                    | USA            | Columbia | 20090805 | Cable tray HEAF?  | Non-safety related 6.9kV feed bus              | 7KV           | Turbine Building                     | Insulation                     | confined to floor of origin         | self-extinguished  | 0750-0811 | 0:46             |
| CZE 20100217      | 16.a | 1          | None   | Include            | Bin 16  | N/A  | Czech Republic | CZE003   | 20100217 | Fire at 0.4 kV switchgear   | switchgear                                     | 0.4 kV        | electrical building, switchgear room | cable insulation materials     | Yes                                 | on-site plant fire brigade                                     | Unknown   | 0:05             |
| JPN 20110311      | 16.b | 1          | None   | Consider Excluding | Seismic event initiates the HEAF and may explain the significant duration time compared to other events | Yes - duration is significantly greater than all other reported events | Japan          | JPN022   | 20110311 | Seismic induced arcing fault in Non-emergency metal clad (M/C) switchgear cabinet   | high or medium voltage electrical cabinet      | 6.9 kV        | turbine building, switchgear room    | cable insulation materials     | No                                  | on-site fire brigade   | Unknown   | 7:58             |
| USA 20050825      | 21   | 2, 4       | 135    | Exclude            | A condensate pump is the initiating component   | N/A  | USA            | Unknown  | 20050825 | Electrical Failure (overheating, spark, HEAF) Contained to the object of origin   | electric motor driven pumps                    | 7KV           | Turbine Building                     | in-situ                        | Yes                                 | fire brigade   | 1125-1317 |                  |
| SWD 20060915      | 21   | 1          | None   | Exclude            | Pump  | N/A  | Sweden         | SWD007   | 20060915 | Fire in a 6 kV electrical cabinet in room D2.21, cabinet feed power to the pump 725 P1. A breaker in the cabinet is burning | electrically driven pump                       | 6 kV          | turbine building, process room       | other solid material           | No                                  | on-site plant fire brigade                                     | Unknown   | 1:05             |
| USA 20061212      | 21   | 1, 4       | 1      | Exclude            | The circ water pump is the initiating component,  | N/A  | USA            | USA066   | 20061212 | Automatic reactor trip due to circulating water pump surge capacitor failure  | electrically driven pump                       | 12 kV         | intake building, process room        | capacitor, insulation material | Yes                                 | on-site plant fire brigade                                     | 0025-0100 | 0:34             |
| USA 20070925      | 21   | 4          | 10472  | Exclude            | The fault originated in a circ water pump   | N/A  | USA            | Unknown  | 20070925 | HEAF - other electrical or electronic equip   | Unknown  | Unknown       | Unknown                              | in-situ                        | Yes                                 | Unknown  | Unknown   | Unknown          |
| SWD 20061114      | 23   | 1          | None   | Exclude            | A transformer is the originating component  | N/A  | Sweden         | SWD010   | 20061114 | Fire in transformer supplying the 6 kV on-site electrical systems train A and C from the generator 20 kV busbar c           | medium or low voltage transformer - oil filled | 6 kV / 20 kV  | outside plant buildings              | hardly inflammable liquid      | No                                  | on-site plant fire brigade; external fire brigade participated | Unknown   | 2:40:00          |

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|-------------------|-----|------------|--------|-----------------|--|----------------------|----------------|---------|----------|---|---|----------------|--|-------------------------------|-------------------------------------|--|-----------|------------------|
| GER 20070628      | 23  | 1          | None   | Exclude         | The main transformer is the initiating component | N/A                  | Germany        | GER014  | 20070628 | Reactor trip caused by a temporary loss of station service supply due to a short circuit with a subsequent fire in a generator transformer              | high voltage transformer (main transformer)     | 400 kV         | other building / area, other type of room  | flammable liquid, paper, wood | Yes                                 | fixed extinguishing system, automatically actuated; on-site plant fire brigade; external fire brigade participated | Unknown   | 6:58             |
| SPN 19880622      | 27  | 1          | None   | Exclude         | The main transformer is the initiating component | N/A                  | Spain          | SPN001  | 19880622 | Trip of main transformer, followed by fire in phase "S" due to manufacturing defect. Subsequently, turbine trip and, with permissive P- 7, reactor trip | high voltage transformer (main transformer)     | 20 kV /400 kV  | outside plant buildings (Not switchyard)   | hardly inflammable liquid     | Yes                                 | fixed extinguishing system, actuated; on- site plant fire brigade; shift personnel                                 | Unknown   | 0:58             |
| SPN 19880820      | 27  | 1          | None   | Exclude         | The main transformer is the initiating component | N/A                  | Spain          | SPN001  | 19880820 | Trip of main transformer, followed by fire in phase "S" due to manufacturing defect. Subsequently, turbine trip and, with permissive P- 7, reactor trip | high voltage transformer (main transformer)     | 20 kV / 400kV  | outside plant buildings (Not switchyard)   | hardly inflammable liquid     | Yes                                 | fixed extinguishing system, actuated; on- site plant fire brigade; shift personnel                                 | Unknown   | 0:15             |
| SPN 19881202      | 27  | 1          | None   | Exclude         | The main transformer is the initiating component | N/A                  | Spain          | SPN001  | 19881202 | Main transformer tripped, followed by fire in phase "R"   | high voltage transformer (main transformer)     | 20 kV /400 kV  | outside plant buildings (Not switchyard)   | hardly inflammable liquid     | Yes                                 | fixed extinguishing system, actuated; on- site plant fire brigade; shift personnel                                 | Unknown   | Unknown          |
| CZE 19940203      | 27  | 1          | None   | exclude         | A transformer is the originating component       | N/A                  | Czech Republic | CZE003  | 19940203 | Fire of the station service load transformer 3BT02 caused by a defect on the power part of the branch lines switch followed by an explosion             | medium and low voltage transformer - oil filled | 15.75 kV/ 6 kV | outside the plant, Not switchyard, voltage transformers near to main transformer | flammable liquid              | No                                  | on-site plant fire brigade   | Unknown   | 0:16             |
| USA 20000524      | 27  | 2, 4       | 50701  | Exclude         | Binned as "Transformer Yard" in NUREG 2169       | N/A                  | USA            | Unknown | 20000524 | HEAF - other electrical or electronic equipment   | XFMR  | Unknown        | Yard   | in-situ                       | Yes                                 | automatic suppression  | Unknown   | Unknown          |
| KOR 20010130      | 27  | 1          | None   | Exclude         | The main transformer is the initiating component | N/A                  | Korea          | KOR010  | 20010130 | High energy arcing fault on phase 'B' of the main transformer which led to the reactor trip   | high voltage transformer (main transformer)     | 22/345kV       | outside plant buildings  | insulation material           | Yes                                 | self- extinguished   | Unknown   | 0:00             |
| KOR 20020422      | 27  | 1          | None   | Exclude         | The main transformer is the initiating component | N/A                  | Korea          | KOR001  | 20020422 | Fire on the main transformer leading to a generator trip  | high voltage transformer (main transformer)     | > 50 kV        | outside  | flammable liquid              | Yes                                 | fixed extinguishing system, automatically actuated,  | Unknown   | 0:13             |

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|-------------------|-----|------------|--------|-----------------|--|----------------------|---------|---------|----------|--|--|-----------------|---|---|-------------------------------------|--|-----------|------------------|
| FRA 20040929      | 27  | 1          | None   | Exclude         | The main transformer is the initiating component | N/A                  | France  | FRA035  | 20040929 | Electric fault on the main transformer leading to a reactor trip   | high voltage transformer (main transformer)    | > 50 kV         | other building  | cable insulation materials                    | Yes                                 | shift personnel  | Unknown   | 0:20             |
| USA 20080816      | 27  | 4          | 127    | Exclude         | The main transformer is the initiating component | N/A                  | USA     | Unknown | 20080816 | Transformer oil - HEAF confined to object of origin  | Main bank transformer                          | 13kV or greater | Main Transformer or Switch Yard                               | XFMR oil                                      | Yes                                 | Unknown  | 2357-0202 | 2:05             |
| USA 20090201      | 27  | 4          | 157    | Exclude         | The main transformer is the initiating component | N/A                  | USA     | Unknown | 20090201 | Transformer oil - HEAF confined to object of origin  | Main transformer                               | 13kV or greater | Main Transformer or Switch Yard                               | XFMR oil                                      | Yes                                 | Unknown  | 2156-2227 | 0:31             |
| FRA 20100725      | 27  | 1          | N/A    | Exclude         | The main transformer is the initiating component | N/A                  | France  | FRA012  | 20100725 | Automatic shutdown of the reactor following an explosion and a consequential fire on the main power transformer                  | high voltage transformer (main transformer)    | 225 kV          | switchyard (transformer room / bunker)                        | hardly inflammable liquid, cable              | No                                  | fixed extinguishing system, automatically actuated; on-site plant fire brigade; external fire brigade participated | Unknown   | 2:45             |
| USA 20021003      | 28  | 1, 2, 4    | 116    | Exclude         | A transformer is the originating component       | N/A                  | USA     | USA095  | 20021003 | Failure of start-up transformer ST 20  | high voltage transformer                       | > 50 kV         | transformer yard  | hardly inflammable liquid                     | Yes                                 | fixed extinguishing system   | 1513-1738 | < 00:10          |
| USA 20051029      | 28  | 1, 2, 4    | 137    | Exclude         | A yard transformer is the originating component  | N/A                  | USA     | USA064  | 20051029 | Reactor trip due to main transformer fault and fire  | high voltage transformer                       | > 50 kV         | outside the plant building (Not switchyard), main transformer | hardly inflammable liquid                     | Yes                                 | fixed extinguishing system; on-site plant fire brigade   | Unknown   | 0:28             |
| USA 20070406      | 28  | 1, 2, 4    | 148    | Exclude         | A yard transformer is the originating component  | N/A                  | USA     | USA043  | 20070406 | Automatic reactor trip due to a turbine generator trip caused by a fault on the 31 main transformer phase B high voltage bushing | high voltage transformer                       | 34.5 kV         | transformer yard  | hardly inflammable liquid                     | Yes                                 | on-site plant fire brigade   | Unknown   | 0:12             |
| USA 19991009      | 29  | 1, 2, 4    | 7      | Exclude         | A yard transformer is the originating component  | N/A                  | USA     | USA039  | 19991009 | Under voltage actuation due to a loss of reserve station service transformer   | busbar   | 4.16 kV         | outside turbine building                                      | cable connector / insulation materials        | Yes                                 | on-site plant fire brigade   | Unknown   | 0:09             |
| FRA 20030830      | 29  | 1          | None   | Exclude         | A transformer is the originating component       | N/A                  | France  | FRA024  | 20030830 | Explosion of an oil-filled current transformer leading to a fire in the 400 kV platform  | high voltage transformer (current transformer) | 6.6 kV / 400 kV | switchyard  | hardly inflammable liquid                     | No                                  | fixed extinguishing system, manually actuated; shift personnel; external fire brigade participated                 | Unknown   | 0:48             |
| CAN 20050415      | 29  | 1          | None   | Exclude         | A transformer is the originating component       | N/A                  | Canada  | CAN002  | 20050415 | Unit 6 forced outage due to M.O.T. failure   | high voltage transformer                       | 500 kV          | switchyard, switchgear room                                   | flammable liquid (transformer insulating oil) | Yes                                 | fixed extinguishing system, automatically actuated   | Unknown   | < 00:08          |

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|-------------------|------|------------|--------|-----------------|---|----------------------|---------|---------|----------|--|--|-----------------|--|--|-------------------------------------|---|--------------|------------------|
| FIN 20060927      | 29   | 1          | None   | Exclude         | A transformer is the originating component  | N/A                  | Finland | FIN002  | 20060927 | Voltage transformer fire due to human error during maintenance outage                      | medium or low voltage transformer - oil filled | 15.1 kV         | outside the plant (Not switch yard), voltage transformers near to main transformer | hardly inflammable liquid;; other insulations        | No (multiple components)            | on-site plant fire brigade (one fire); self-extinguished (another fire)           | Unknown      | 0:05             |
| JPN 20070716      | 29   | 1          | None   | Exclude         | A transformer is the originating component  | N/A                  | Japan   | JPN047  | 20070716 | House transformer fire induced by the Niigata- Chuetsu-Oki earthquake                      | medium or low voltage transformer - oil filled | 19 kV /6.9 kV   | outside  | flammable liquid                                     | Yes                                 | fixed extinguishing system, manually actuated; external fire brigade participated | Unknown      | 1:55             |
| SWD 20021030      | 33   | 1          | None   | Exclude         | The rectifier is part of the exciter for the turbine.                                   | N/A                  | Sweden  | SWD007  | 20021030 | Auto fire alarm about an arc event in a rectifier. The failure led to stop of one turbine. | rectifier                                      | 600 V           | turbine building, process room   | other solid material; plastics / polymeric materials | No (multiple components)            | on-site plant fire brigade; external fire brigade participated                    | Unknown      | 2:31             |
| USA 20011026      | 9999 | 4          | 10624  | Exclude         | Fire originated in the primary power distribution pole that feeds the HEEC transformer. | N/A                  | USA     | Unknown | 20011026 | HEAF - other electrical or electronic equip  | Unknown  | Unknown         | Unknown  | in-situ  | No                                  | Unknown   | Unknown      | Unknown          |
| USA 20080917      | 9999 | 4          | 50566  | Exclude         | basket contacts power line causing explosion  | N/A                  | USA     | Unknown | 20080917 | HEAF - other electrical or electronic equip  | Unknown  | 13kV or greater | Unknown  | in-situ  | Yes                                 | self-extinguished   | 0930-unknown | <0:05            |
| SWD 20110510      | 9999 | 1          | None   | Exclude         | Vacuum Cleaner  | N/A                  | Sweden  | SWD008  | 20110510 | Fire in the reactor containment: Arc in an electrical part in the portable vacuum cleaner  | vacuum cleaner                                 | Unknown         | containment  | plastics / polymeric materials                       | No                                  | self - extinguished   | Unknown      | Unknown          |
| USA 20020612      | SB4  | 1, 2, 4    | 113    | Exclude         | "Special bin, Not FPRA applicable" per NUREG 2169                                       | Yes, special Bin     | USA     | USA059  | 20020612 | Switchyard fire in 34.5 kV circuit breaker   | high voltage breaker                           | 34.5 kV         | switchyard   | flammable liquid                                     | Yes                                 | on-site plant fire brigade  | Unknown      | Unknown          |

\*Reference 1: NEA/CSNI/R(2013)6, Nuclear Energy Agency OECD Fire Project – Topical Report No. 1, “Analysis of High Energy Arcing Fault (HEAF) Fire Events,” June 25, 2013

\*Reference 2: NUREG 2169, “Nuclear Power Plant Fire Ignition Frequency and Non-Suppression Probability Estimation Using the Updated Fire Events Database,” December 2014

\*Reference 3: NUREG/CR-6850 Supplement 1, “Fire Probabilistic Risk Assessment Methods Enhancements,” September 2010

\*Reference 4: EPRI 1025284, The Updated Fire Events Database: Description of Content and Fire Event Classification Guidance,” July 2013