August 4, 2009

MEMORANDUM TO: AFPB File

FROM: Alexander R. Klein, Chief ***/RA/***
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Division of Risk Assessment
Office of Nuclear Reactor Regulation

SUBJECT: CLOSURE OF NATIONAL FIRE PROTECTION ASSOCIATION 805 FREQUENTLY ASKED QUESTION 08-0044 MAIN FEEDWATER PUMP OIL SPILL FIRES

The purpose of this memorandum is to close National Fire Protection Association (NFPA) Standard 805 Frequently Asked Question (FAQ) 08-0044. The enclosed position was previously sent for comment under the joint U. S. Nuclear Regulatory Commission's (NRC) Office of Nuclear Regulatory Research (RES) / Electric Power Research Institute (EPRI) Memorandum of Understanding (MOU) process. RES and the NRC's Office of Nuclear Reactor Regulation (NRR) collaborated on resolving the comments that were received from the MOU. It was later sent to the Nuclear Energy Institute's (NEI) NFPA 805 Task Force for industry and other stakeholder comment. No comments were received from the NEI Task Force. The enclosed position represents a joint resolution of this FAQ between RES and NRR.

Enclosure:
As Stated

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FAQ 08-0044: Main Feedwater Pump Oil Spill Fires

Guidance for Frequency and Severity of Main Feedwater Pump Oil Spill Fires in NUREG/CR-6850

Background:

Frequently Asked Question (FAQ) 08-0044 was proposed by the Nuclear Energy Institute (NEI), through its National Fire Protection Association (NFPA) 805 Task Force, to clarify the guidance from NEI 04-02, "Guidance for Implementing a Risk-Informed, Performance-Based Fire Protection Program under Title 10 of the *Code of Federal Regulations* Part 50 (10 CFR 50).48(c)," which in turn cited guidance on modeling oil spill fires as provided in NUREG/CR-6850 (EPRI 1011989), "EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities," as appropriate for use in developing Fire Probabilistic Risk Assessments (PRAs). The authors believed that the guidance on oil spill fires cited in NUREG/CR-6850 did not specifically address such fires specifically from main feedwater (MFW) pumps and that, when applied to MFW pump oil spill fires, could lead to misrepresentative estimates for both the ignition frequency and severity factor (in terms of size of oil spill) that could subsequently yield overly conservative estimates of risk when used generically in fire PRAs. Initial analyses were performed under the Memorandum of Understanding (MOU) between the Electric Power Research Institute (EPRI) and Office of Nuclear Regulatory Research (NRC-RES), but were not concluded prior to EPRI publication of EPRI 1016735, "Fire PRA Methods Enhancements: Additions, Clarifications, and Refinements to EPRI 1011989," in December 2008.

The U. S. Nuclear Regulatory Commission (NRC) developed the interim position discussed below in order to achieve closure of this FAQ in a timely manner. This interim position was developed using currently existing information, databases, and experimental results, and should not be seen as prejudicing the NRC's view of future developments in this area. Final endorsement of this position will be addressed through the next revision of either Regulatory Guide 1.205 or NUREG/CR-6850.

Discussion:

Early applications of this guidance to the specific case of main feedwater (MFW) pumps have led to anomalous results. Given the large quantity (several hundred gallons) of oil found in a typical MFW pump, even assignment of the "small fire" severity level (i.e., 10% of the oil) in NUREG/CR-6850 leads the analyst to postulate a fire that is actually very severe, with a frequency higher than indicated by industry experience. Depending on the Fire PRA components and cables near a MFW pump, the postulated fire scenarios can be risk significant. The guidance mentioned above was not developed with high-volume oil systems in mind, but rather, was aimed primarily at smaller-volume pump lubrication systems. Revised guidance has been developed specifically for MFW pump oil fires to more accurately represent industry experience regarding such fires.

<u>Introduction and Problem Statement</u>

Appendix E, Section E.3, of NUREG/CR-6850 provides guidance for the treatment of oil spill fires as follows:

The following steps are recommended for assigning the severity factor to scenarios involving oil spill fires.

1. *Determine the amount of oil that can be spilled in the room.*
2. *Assign a severity factor of 0.02 to a scenario consisting of 98% or more of the amount of oil spilled and ignited.*
3. *Assign a severity factor of 0.98 to a scenario consisting of 10% of the amount of oil spilled and ignited.*

Figure 1 below provides a qualitative depiction of this guidance assuming that the amount of oil represents fire severity. The severity curve is divided into two parts: "small," represented by 10% of the oil, and "large," represented by 98% of the oil.

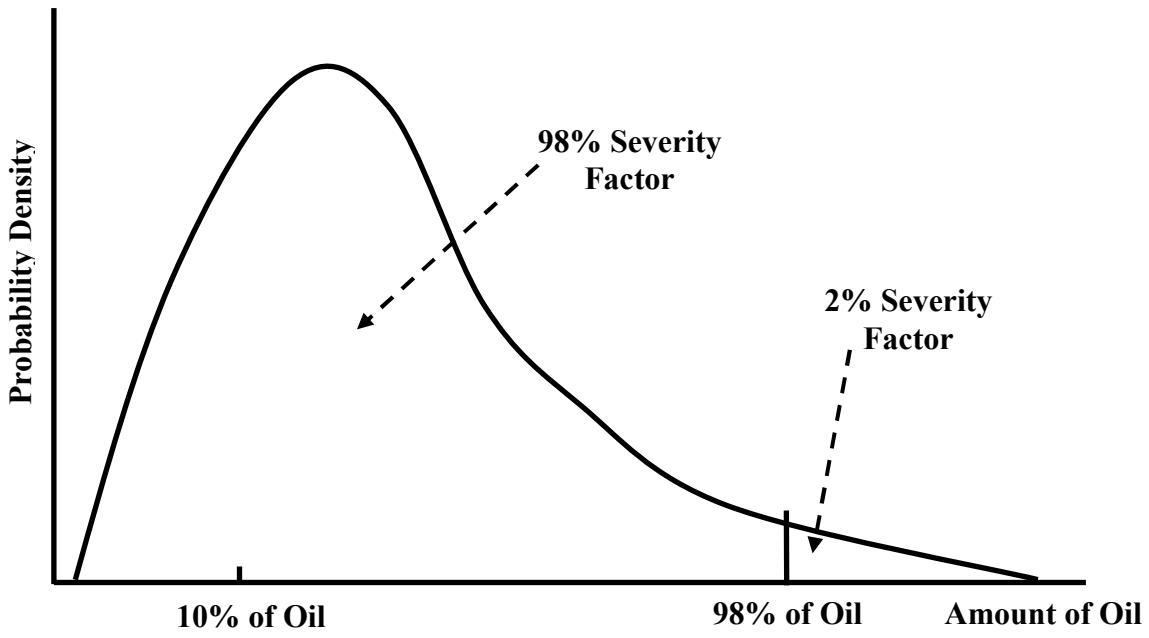

Figure 1. Oil Fire Severity Factor Guidance

Basis for the MFW Pump Oil Fire Revised Guidance

A similar partitioning approach toward fire severity is followed as documented in the original guidance, except that three severity levels are now defined instead of just two to reflect that (1) most MFW pump fire events had limited effect on the surrounding items and (2) none of them involved a large quantity of the pump lubricating oil. The three levels attempt to capture this experience and the potential for severe impact that can be experienced from an uncontrolled MFW pump oil spill. This is shown qualitatively in Figure 2 below.

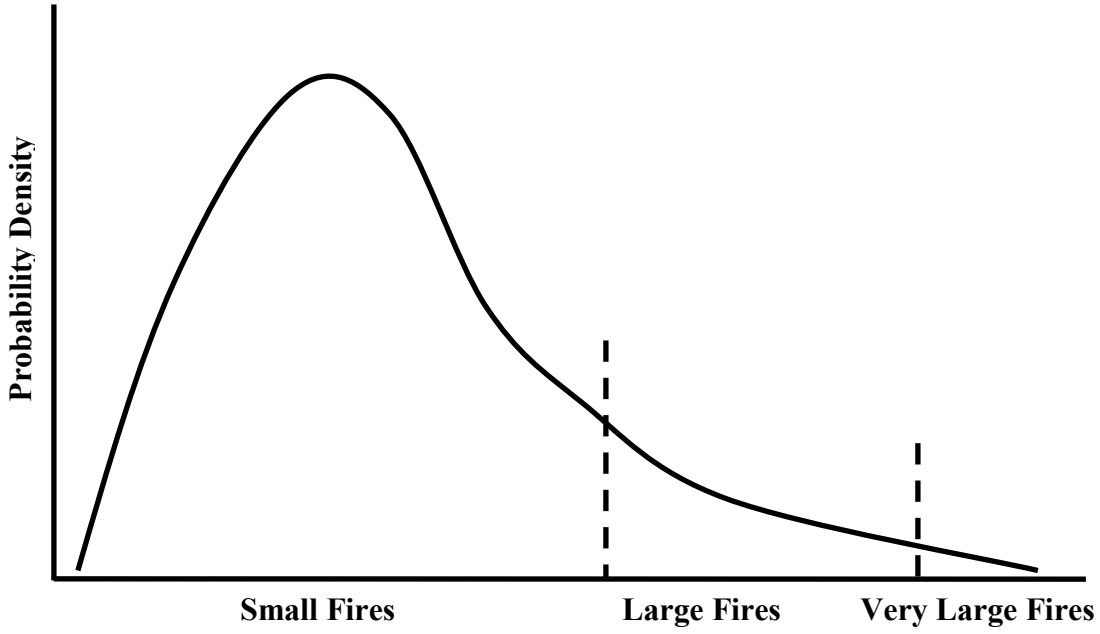

Figure 2. Main Feedwater Pump Oil Fire Severity Factors

The three severity levels are defined as follows:

- *Small fires* are defined as fires involving small oil leaks leading to the ignition of oil-soaked insulation on piping and equipment. These fires will involve a fraction of the oil inventory smaller than assumed in the following fire sizes. Fire damage is expected to be limited to the MFW pump.

- *Large fires* are defined as fire events involving a spill of 10% of the oil content (consistent with the small fire category in the original oil spill severity factor guidance as cited above).

- V*ery large fires* are fire events that involve a spill of up to 100% of the oil inventory (again consistent with the large fire category in the original guidance as cited above).

Available fire modeling tools should be used to establish cable damage for Large and Very Large fire sizes.

As described further below, all of the MFW pump fire events from the fire events database (FEDB), as referenced in NUREG/CR-6850, fell into the category of small fires. None of these events included reports of damage to anything other than the burning insulation itself. However, some of the event reports state that open flaming was observed in the area of the burning insulation. These observations clearly indicate that some potential existed for fire spread to combustible materials or failure of fire PRA targets susceptible to fire damage had these been near the burning insulation.

The intent of the recommended approach is to ensure that the potential for fire spread or fire PRA target damage is considered based on scenario specific conditions.

The next question that must be answered is the relative likelihood that, given a MFW pump oil leak/spill, the quantity of oil released would be equivalent to each of the three severity levels defined above (i.e., the severity factor or split fractions for *small*, *large* and *very large* fires). This assessment is based on a review of the MFW pump oil fires identified in the FEDB. Table 1 provides the Main Feedwater Pump related fire events in the FEDB that involved oil. Fifteen fire events are presented in this table. Of these 15 events, 12 events were labeled as "challenging" and three as "undetermined" in the original fire frequency analysis.

Very large oil spills and fires have occurred, but only involving main turbine oil systems and not MFW pump oil systems. Given that larger oil spills have occurred in other plant lubrication systems, the possibility of such a spill from the MFW pump lubrication system cannot be entirely dismissed.

Reviewing the event descriptions of all 15 MFW pump fire events, it was concluded that 10 events have sufficient information available to conclude that they were small fires that remained confined to the pump or nearby piping (e.g., oil-soaked insulation). In these 10 fire events, there was no reported damage to items above or adjacent to the location of the fire. Insufficient information is available to establish the severity of five of the events. However, it can be argued that if any of these five events were of the type classified here as either *large* or *very large fires,* then additional attention would have been expended in documenting the event (e.g., a more complete description would have been provided). Therefore, it can be inferred that these five events were also small fires.

Since NUREG/CR-6850 – EPRI 1011989 uses only at-power operation fire events for estimating the frequency of MFW pump fires, one may conclude that no *large* or *very large* MFW oil fires have taken place during power operation. Using the counting approach of NUREG/CR-6850 - EPRI 1011989, there were 12 challenging and three undetermined events (counted as 0.5 each) for a total of 13.5 fire events with no *large* or *very large* fires. From these statistics we can conclude that the conditional probability of a *large* or *very large* fire given a MFW pump oil fire is 0.5/14.5 = 0.034, or 3.4% (using Jeffreys' approach).

Thus, one can conclude that 0.034 (3.4%) represents the fraction of MFW pump oil spills/fires that would be considered *large* or *very large* per the definitions given above. As noted above, none of the MFW pump fire events could be labeled as a *very large* spill/fire. The recommended estimate recognizes that very large spills would occur, but with a lower probability than large spills, and assumes 10% of the *large* or *very large* spills/fires would actually be *very large* spills/fires. This yields a net severity factor of 0.0034 (0.34%) for the very large fire case.

<u>Summary of Recommended MFW Pump Oil Fire Revised Guidance</u>

The following steps are recommended for assigning the severity factor to scenarios involving MFW pump oil fires:

1. Determine the amount of oil available in the system for the large and very large oil spill fires.

2. The MFW pump oil fire plant-wide fire frequency remains unchanged.

3. Assign a severity factor of 0.0034 (0.34%) to *very large fires:* scenarios involving 100% of the total oil inventory spilled and ignited.

4. Assign a severity factor of 0.0306 (3.06%) to *large fires:* scenarios involving 10% of the total oil inventory spilled and ignited.

5. Assign a severity factor of 0.966 (96.6%) for *small fires:* scenarios involving a leak that leads to a fire that only impacts the MFW pump.

If either the very large or large fire scenario is found to be risk significant, the analyst may conduct a plant-specific analysis of the oil-containing devices/systems to identify various spill scenarios with the corresponding quantity of oil spilled and size of burning oil pool.

References:

1. Revision 0 to FAQ 08-0044, March 31, 2008, Accession No. ML081200099

2. EPRI 1016735, December 2008, Accession No. ML090290195

3. NUREG/CR-6850 (EPRI 1011989), Accession Nos. ML050940183 (Vol. 1) and ML050940189 (Vol. 2)

4. NEI 04-02, Guidance for Implementing a Risk-Informed, Performance-Based Fire Protection Program Under 10 CFR 50.48(c), Revision 1, Accession No. ML052590476

5. NFPA 805, Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants, 2001 Edition (available through the Public Document Room or NFPA)

6. Regulatory Guide 1.205, Risk-Informed, Performance-Based Fire Protection for Existing Light-Water Nuclear Power Plants, Accession No. ML061100174

7. NRC Regulatory Information Summary 2007-19, Process for Communicating Clarifications of Staff Positions Provided in Regulatory Guide 1.205 Concerning Issues Identified During The Pilot Application of National Fire Protection Association Standard 805, Accession No. ML071590227

Table 1. FEDB Events Involving Main Feedwater Pump Oil

Incident #	DATE	DESCRIPTION	Challenging / Power	Leak / Spill
8	19-Aug-70	Fire resulted when oil leaking from a pump-motor reservoir, through a temporary insulation crack, contacted hot pipe (520 F) and vaporized. This caused flashing when contacting ventilation air.	Challenging / At Power	Leak
24	13-Sep-72	A leak in the oil supply line to the feedwater pump soaked insulation on the feedwater supply line and ignition occurred when oil came in contact with a hot pipe. Fire quickly extinguished with dry chemical. As piping insulation was removed after fire (30 min), several flair-ups occurred which again were quickly extinguished. Fire brigade response was prompt (< 5 min).	Challenging / At Power	Leak
201	22-Apr-80	A smoldering fire resulted from lube oil that leaked from a main turbine shaft-driven feed water pump onto piping insulation.	Challenging / At Power	Leak
476	26-Jun-85	At 2126 hours on June 26, 1985, Waterford 3 Steam Electric Station was 91 percent reactor power when operations personnel received information of a fire in feedwater pump A. At 2131 hours the control room was informed by personnel on the scene that the B feedwater pump, rather than the A pump, was on fire. Since the A pump was already secured, and since the steam generator water levels were decreasing, operation personnel tripped the main turbine and reactor. The fire was extinguished by plant personnel at 2136 hours. The fire was started by a small oil leak, and it was limited to a small portion of the outer wrapping of insulation on the feedwater piping.	Challenging / At Power	Unknown
477	29-Jun-85	On June 29, 19845 at 0957 the reactor was manually scrammed and the main turbine manually tripped due to a fire in the reactor feedwater pump 1B, while the remaining reactor feedwater pump was secured for maintenance. The fire was extinguished and the plant shutdown in an orderly fashion.	Challenging / At Power	unknown

Table 1. FEDB Events Involving Main Feedwater Pump Oil

Incident #	DATE	DESCRIPTION	Challenging / Power	Leak / Spill
662	08-Jan-88	While performing routine rounds, an equipment operator observed smoke emitting from the 2C Reactor Feed Pump (RFP) discharge piping. As it was initially suspected an oil leak was causing the smoke. The fire was extinguished using fire extinguishers and fire water.	Challenging / At Power	Leak
737	29-Jul-88	As a result of maintenance activities, oil-soaked lagging and paper was ignited by the hot surface of Feed Water Pump "A" Suction pipe.	Challenging / At Power	Leak
739	30-Jul-88	Walking by Steam Generator Feedwater Pump A, plant personnel noticed smoke rising from the outboard pump bearing area, and he immediately contacted the control room. The fire brigade commenced attack from the feedpump platform, but were unable to determine the effectiveness of the attack due to the steam rising from the pump casing. They redirected their attack from the bottom of the feed pump, putting the fire out in its incipient stage.	Challenging / At Power	Leak
824	13-Jul-92	A fire was reported at the "B" reactor feed pump; the cause may have been due to oil-soaked insulation; the fire was extinguished in about 15 minutes.	Challenging / At Power	Leak
961	11-Aug-91	Event occurred on August 11, 1991. At approximately 08:55 a fire was reported in the Turbine building. The plant was at power operation. The fire was reported to be approximately 18 minutes in duration. The fire was detected and extinguished by the fire brigade. This fire was extinguished by using water and carbon dioxide. The fire apparently originated from oil-soaked insulation resulting from a lubrication oil leak. The root cause of this event was turbine bearing lube oil leaking from the flange gasket of the ground brush assembly. This saturated the surrounding insulation with oil which fueled the fire once ignited. A ground wire was pinched between the gasket and the flange creating a leak path.	Challenging / At Power	Leak
1110	02-Feb-90	--	Undetermined / At Power	unknown

Table 1. FEDB Events Involving Main Feedwater Pump Oil

Incident #	DATE	DESCRIPTION	Challenging / Power	Leak / Spill
1240	11-Sep-76	Oil-soaked insulation was smoldering. An air hose was being used to remove smoke from room to find its source. The air caused the insulation to flame.	Undetermined / At Power	Leak
2183	13-Sep-96	--	Undetermined / At Power	unknown
2388	16-Dec-93	Ref. SOS 93-2116	Challenging / At Power	unknown
2422	24-Aug-00	Residual lubrication oil caught fire on the B reactor feed pump. The fire was in the area of the outboard pump bearing. The fire was controlled with portable extinguishers and completely extinguished using less than 200 gallons of water from a hose line.	Challenging / At Power	Leak