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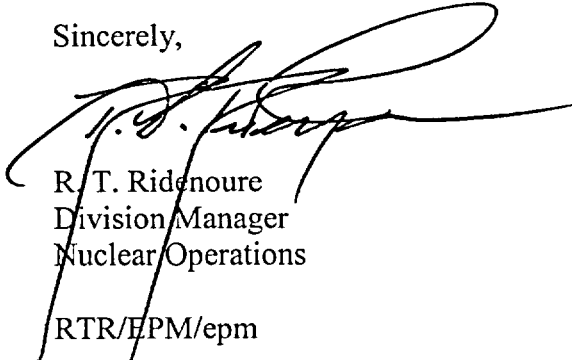
U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Reference: 1. Docket No. 50-285
2. Letter from OPPD (R. T. Ridenoure) to NRC (Document Control Desk)
Dated November 8, 2002 (LIC-02-0118)

SUBJECT: Omaha Public Power District (OPPD) Fire Modeling Analysis – Fire Area 32

As discussed on April 22, 2003, in a telephone conversation between G. R. Cavanaugh of the Fort Calhoun Station (FCS) and A. B. Wang of the Nuclear Regulatory Commission (NRC), OPPD is submitting the following sections from a technical analysis for Fire Area 32 for the FCS docket: Section 3 – Fire Scenarios, Section 5 – References, and Attachment B – Fire Modeling Worksheets. No commitments are made to the NRC in this letter.

Sincerely,



R. T. Ridenoure
Division Manager
Nuclear Operations

RTR/EPM/epm

Enclosure

c: E. W. Merschoff, NRC Regional Administrator, Region IV (w/o Enclosure)
A. B. Wang, NRC Project Manager (w/o enclosure)
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A006

SECTION 3 FIRE SCENARIOS

AFW pump FW-10 large oil fire.

18% conditional probability of large spill.

Unconfined spill results in high heat rate, but 10 second fire duration not credible.

Assumed fire duration is 2.5 minutes.

Adjust spill surface area to obtain 2.5 minute duration fire.

A bounding fire in this compartment would involve postulated failure of the systems identified above. This fire would result in unacceptable results. Therefore, fire modeling was performed to refine the analysis as discussed below.

In the discussions below, no differentiation is made between sections of a cable tray. Therefore, if a tray is partially within the fire zone of influence, all associated trays are assumed damaged.

1. Steam Driven AFW Pump FW-10 – Large Fire

A postulated 'large' auxiliary feedwater pump fire is assumed to occur with a conditional probability of 0.18. The fire was characterized as a spill of the entire oil inventory from the pump, 5.5 gallons. This fire has the potential to damage cable trays located directly above. The FIVE Inside Plume worksheet (Attachment B, Sheet "FW-10 Large – In-Plume") was used to determine whether target damage occurs. This situation was further evaluated using the Outside Plume and Radiant Exposure worksheets (Attachment B, Sheets "FW-10 Large – Out-Plume" and "FW-10 Large - Radiant", respectively).

Using the FIVE methodology, an unconfined large spill involving 5.5 gallons of oil would cover 660 sq.ft. and have a fire duration of 10 seconds. However, a credible fire event would require some time to ignite the oil spill, would involve a fire growth phase, then continued combustion until available fuel is depleted. Such a fire can be expected to burn for several minutes. For the purposes of the Fire Risk Analysis, it will be conservatively assumed that the minimum credible fire duration is 2.5 minutes. This 2.5 minute assumption is based on several parameters as discussed below.

In order to provide realistic results, the analysis considers a confined oil spill so that the fire duration can be extended. The selection of a 2.5 minute minimum fire duration is based on the following considerations.

1. A short fire duration is conservative. However, the 10 seconds associated with an ideal unconfined spill fire is unrealistic.
2. The Fire PRA Implementation Guide [5] indicates that ignition of IEEE 383 qualified cables would require fire exposure for 5 to 10 minutes.
3. A realistic oil pool fire can be expected to experience some degree of oxygen depletion which would reduce the overall combustion rate (longer fire duration). This reduction can be modeled by considering a smaller pool surface area.
4. The cable damage times (Appendix G of [5]) range from 2 to 19 minutes for temperatures of 700 °F and higher.

Using the 2.5 minute fire duration, the resulting fire characteristics are provided in Attachment B, Sheet "FW-10 Large = Fuel": The postulated 5.5 gallon oil spill fire has a fire intensity of 4528 Btu/s and a surface area of 45.7 sq. ft.

A number of physical parameters for the fire compartment are needed in order to assess the response of the 'nearest' target and the automatic fire suppression system. The determination of these parameters is based on the postulated oil spill originating from FW-10.

Trays 2S, 17S, and 18S potentially impacted.

The fire is of sufficient magnitude that damage to targets in the fire plume will occur. Therefore, an outside of plume worksheet was used to evaluate the extent of damage to targets beyond the fire plume.

Height to Target = 14.5 feet – The nearest target above FW-10 is cable tray 2S, which is 14.5 feet above the floor. Other trays above FW-10 include the following: 18S at 15.5 feet high; and 17S at 16.5 feet high and 8 feet laterally.

Trays 3S, 4S, 5S, 6S, 19S, and 20S are also near FW-10. However, the 1-hour radiant barrier partially surrounding FW-10 prevents the oil spill from spreading in their direction and provides some measure of shielding from the radiant heat effects.

Room Height = 20 feet – FCS Fire Hazards Analysis [2].

Floor Dimensions = 207.8 x 27 feet – This is based on a floor area of 5,610 ft² and an approximate room width of 27 feet near the pump.

Radial Distance to Targets = 7.6 feet – The postulated oil spill has a surface area of 45.7 ft². This equates to a diameter of 7.6 feet for a circular spill. Since the spill can occur anywhere around the pump, a 7.6 foot radius around the pump is assumed for determining potential targets impacted.

Fire Intensity = 4,528 Btu/s – the assumed fire intensity is based on the assumptions discussed earlier. Attachment B provides a worksheet which develops this value.

Fire Location Factor = 1 – the fire is assumed to be in the ‘center’ of the room.

Ambient Temperature = 90 °F – this assumed value is used for the maximum expected ambient temperature during normal plant operations.

*Outside of plume damage distance
– 4.8 feet.*

The outside of plume worksheet (Attachment B, Sheet “FW-10 Large – Out-Plume”) predicts a radial damage distance of 4.8 feet. Therefore, if a target is located in the jet region, but more than 4.8 feet from the fire plume, target damage is not expected.

*Radiant exposure damage distance
– 12 feet.*

Additionally, the radiant exposure worksheet (Attachment B, Sheet “FW-10 Large – Radiant”) predicts a critical radiant flux distance of 12 feet. The only critical component within this distance is FW-6, however it is separated from FW-10 by a 1-hour radiant barrier. Therefore, no additional targets are assumed to be damaged due to radiant effects.

This scenario was evaluated further to determine the target damage time versus suppression system actuation time. Successful actuation of the suppression system prior to the predicted target damage time would prevent such damage. The additional parameters needed for this analysis are discussed below.

Sprinklers approximately 8 feet above floor.

Targets greater than 11.5 feet above the pump will not be damaged if suppression is successful.

Height to Target = 11.5 feet – Although the actual target height is approximately 14.5 feet, the height used in the analysis was reduced to 11.5 feet, which is the lowest height which would yield a target damage time greater than the suppression system actuation time.

Radial Distance to Target = 0.1 feet – The target is conservatively assumed to be located above the fire source.

Fire Location Factor (Target) = 1 – The fire is assumed to be in the ‘center’ of the room.

Radiant Fraction = 0.40 - this value is based on guidance in FIVE [4].

Rated Detector Temperature = 165 °F - this value is based on the device setpoint [7].

Ambient Temperature = 75 °F – The assumed ambient temperature for this case is assumed to be 75 °F. This has the effect of increasing the detector response time.

Distance to Detector = 10 feet vertical, 1 foot horizontal – There are two sprinkler heads located directly above AFW pump FW-10, approximately 8 feet above the floor. Other detectors and sprinkler heads are located throughout the room. For conservatism, a vertical distance of 10 feet and a horizontal distance of 1 foot are assumed.

Fire Location Factor (Detector) = 1 - the fire is assumed to be in the ‘center’ of the room. This provides the most conservative result with respect to detector response.

Target Location = 1 (in-plume) - The targets are inside the postulated fire plume.

Target Thermal Response Parameter = 34 - This represents a nominal value for XPE/XPE cables with 0.43 inch diameter [4].

Detector Time Constant = 120 - this assumed value is based on the highest (slowest) detector in the reference tables [4].

The results of the suppression system actuation analysis are provided in Attachment B, Sheet “FW-10 Large – Suppression”. Assuming a ‘virtual’ target 11.5 feet above the pump and inside the fire plume, the analysis conservatively predicts a cable damage time of 7 seconds and a suppression system actuation time of 6.95 seconds. The expected damage time for the actual targets, since they are located higher than 11.5 feet, would be greater than 7 seconds.

Based on this analysis, it is concluded that successful actuation of the suppression system during a postulated large oil spill fire will limit damage in this fire compartment such that only the pump itself will be damaged.

AFW pump FW-10 small oil fire.

82% conditional probability of small spill.

Targets greater than 8.3 feet above the pump will not be damaged.

AFW pump FW-6 large oil fire.

18% conditional probability of large spill.

Unconfined spill results in high heat rate, but 10 second fire duration not credible.

2. Steam Driven AFW Pump FW-10 – Small Fire

A postulated 'small' auxiliary feedwater pump fire is assumed to occur with a conditional probability of 0.82. The fire was characterized as a spill of 10% of the entire oil inventory, or 0.55 gallons. This spill is assumed to occur with an 82% conditional probability [5]. The characterization of such a fire is based on the same fundamental parameters as that considered for the large oil spill fire. The resulting fire has a surface area of 4.6 sq.ft., a duration of 2.5 minutes, and an intensity of 453 Btu/s.

The analysis of this postulated fire was evaluated using the FIVE worksheets for the Inside Plume and Radiant exposure cases (Attachment B, Sheets "FW-10 Small – In-Plume" and "FW-10 Small - Radiant", respectively). The completed analysis worksheets are based on the same input parameters as the FW-10 large fire. The analysis shows that targets located 8.3 feet or more above the postulated fire would not be damaged.

The radiant exposure case performed using 1 Btu/s/ft² critical flux limit yields a critical flux distance of approximately 3.8 feet. Given the 1-hour radiant shield between FW-10 and FW-6, as well as the spacing between FW-10 and the air compressors, this heating mechanism is not a concern with respect to target damage.

Based on this analysis, a postulated small oil spill fire should be assumed to result in damage to only the pump itself.

3. Motor Driven AFW Pump FW-6 – Large Fire

A postulated 'large' auxiliary feedwater pump fire is assumed to occur with a conditional probability of 0.18. The fire was characterized as a spill of the entire oil inventory from the pump, 3.5 gallons. This fire has the potential to damage cable trays located directly above. The FIVE Inside Plume worksheet (Attachment B, Sheet "FW-6 Large – In-Plume") was used to determine whether target damage occurs. This situation was further evaluated using the Outside Plume and Radiant Exposure worksheets (Attachment B, Sheets "FW-6 Large – Out-Plume" and "FW-6 Large - Radiant", respectively).

Using the FIVE methodology, an unconfined large spill involving 3.5 gallons of oil would cover 420 sq.ft. and have a fire duration of 10 seconds. However, a credible fire event would require some time to ignite the oil spill, would involve a fire growth phase, then continued combustion until available fuel is depleted. Such a fire can be expected to burn for several minutes. For the purposes of the Fire Risk Analysis, it will be conservatively assumed that the minimum credible fire duration is 2.5 minutes. This 2.5 minute assumption is based on several parameters as discussed below.

Assumed fire duration is 2.5 minutes.

Adjust spill surface area to obtain 2.5 minute duration fire.

Trays 2S, 3S, 4S, 18S, and 19S potentially impacted.

In order to provide realistic results, the analysis considers a confined oil spill so that the fire duration can be extended. The selection of a 2.5 minute minimum fire duration is based on the following considerations.

1. A short fire duration is conservative. However, the 10 seconds associated with an ideal unconfined spill fire is unrealistic.
2. The Fire PRA Implementation Guide [5] indicates that ignition of IEEE 383 qualified cables would require fire exposure for 5 to 10 minutes.
3. A realistic oil pool fire can be expected to experience some degree of oxygen depletion which would reduce the overall combustion rate (longer fire duration). This reduction can be modeled by considering a smaller pool surface area.
4. The cable damage times (Appendix G of [5]) range from 2 to 19 minutes for temperatures of 700 °F and higher.

Using the 2.5 minute fire duration, the resulting fire characteristics are provided in Attachment B, Sheet "FW-6 Large – Fuel". The postulated 3.5 gallon oil spill fire has a fire intensity of 2882 Btu/s and a surface area of 29.1 sq. ft.

A number of physical parameters for the fire compartment are needed in order to assess the response of the 'nearest' target and the automatic fire suppression system. The determination of these parameters is based on the postulated oil spill originating from FW-6.

The fire is of sufficient magnitude that damage to targets in the fire plume will occur. Therefore, an outside of plume worksheet will be used to evaluate the extent of damage to targets beyond the fire plume.

Height to Target = 14.5 feet – The nearest target above FW-6 is cable tray 2S, which is 14.5 feet above the floor. Other trays above FW-6 include the following: 18S at 15.5 feet high; 19S at 14.5 feet high and 8 feet laterally; 3S at 18.5 feet high and 6.5 feet laterally; and 4S at 14.5 feet high and 11.5 feet laterally.

Room Height = 20 feet – FCS Fire Hazards Analysis [2].

Floor Dimensions = 207.8 x 27 feet – This is based on a floor area of 5,610 ft² and an approximate room width of 27 feet near the pump.

Radial Distance to Targets = 7.6 feet – The postulated oil spill has a surface area of 29.1 ft². This equates to a diameter of 6.1 feet for a circular spill. Since the spill can occur anywhere around the pump, a 6.1 foot radius around the pump is assumed for determining potential targets impacted.

Fire Intensity = 2,882 Btu/s – the assumed fire intensity is based on the assumptions discussed earlier. Attachment B provides a worksheet which develops this value.

Fire Location Factor = 1 – the fire is assumed to be in the 'center' of the room.

Ambient Temperature = 90 °F – this assumed value is used for the maximum expected ambient temperature during normal plant operations.

*Outside of plume damage distance
– 2.6 feet.*

The outside of plume worksheet (Attachment B, Sheet “FW-6 Large – Out-Plume”) predicts a radial damage distance of 2.6 feet. Therefore, if a target is located in the jet region, but more than 2.6 feet from the fire plume, target damage is not expected.

*Radiant exposure damage distance
–9.6 feet.*

Additionally, the radiant exposure worksheet (Attachment B, Sheet “FW-6 Large – Radiant”) predicts a critical radiant flux distance of 9.6 feet. The only critical component within this distance is FW-10, however it is separated from FW-6 by a 1-hour radiant barrier. Therefore, no additional targets are assumed to be damaged due to radiant effects.

This scenario was evaluated further to determine the target damage time versus suppression system actuation time. Successful actuation of the suppression system prior to the predicted target damage time would prevent such damage. The additional parameters needed for this analysis are discussed below.

Height to Target = 12.7 feet – Although the actual target height is approximately 14.5 feet, the height used in the analysis was reduced to 12.7 feet, which is the lowest height which would yield a target damage time greater than the suppression system actuation time.

Radial Distance to Target = 0.1 feet – The target is conservatively assumed to be located above the fire source.

Fire Location Factor (Target) = 1 – The fire is assumed to be in the ‘center’ of the room.

Radiant Fraction = 0.40 - this value is based on guidance in FIVE [4].

Rated Detector Temperature = 165 °F - this value is based on the device setpoint [7].

Ambient Temperature = 75 °F – The assumed ambient temperature for this case is assumed to be 75 °F. This has the effect of increasing the detector response time.

*Sprinklers assumed to be near
ceiling.*

Distance to Detector = 20 feet vertical, 1 foot horizontal – There are sprinkler heads located near the ceiling above AFW pump FW-6. Other detectors and sprinkler heads are located throughout the room. For conservatism, a vertical distance of 20 feet and a horizontal distance of 1 foot are assumed.

Fire Location Factor (Detector) = 1 - the fire is assumed to be in the ‘center’ of the room. – This provides the most conservative result with respect to detector response.

Target Location = 1 (in-plume) - The targets are inside the postulated fire plume.

Target Thermal Response Parameter = 34 - This represents a nominal value for XPE/XPE cables with 0.43 inch diameter [4].

Targets greater than 12.7 feet above the pump will not be damaged if suppression is successful.

AFW pump FW-6 small oil fire.

82% conditional probability of small spill.

Targets greater than 8.0 feet above the pump will not be damaged.

Air compressor large oil fire.

18% conditional probability of large spill.

Detector Time Constant = 120 - this assumed value is based on the highest (slowest) detector in the reference tables [4].

The results of the suppression system actuation analysis are provided in Attachment B, Sheet "FW-6 Large - Suppression". Assuming a 'virtual' target 12.7 feet above the pump and inside the fire plume, the analysis conservatively predicts a cable damage time of 26 seconds and a suppression system actuation time of 25.7 seconds. The expected damage time for the actual targets, since they are located higher than 12.7 feet, would be greater than 26 seconds.

Based on this analysis, it is concluded that successful actuation of the suppression system during a postulated large oil spill fire will limit damage in this fire compartment such that only the pump itself will be damaged.

4. Motor Driven AFW Pump FW-6 - Small Fire

A postulated 'small' auxiliary feedwater pump fire is assumed to occur with a conditional probability of 0.82. The fire was characterized as a spill of 10% of the entire oil inventory, or 2 quarts, whichever is greater. In this case, with an oil inventory of 3.5 gallons, a 2 quart spill is considered more limiting. This spill is assumed to occur with an 82% conditional probability [5]. The characterization of such a fire is based on the same fundamental parameters as that considered for the large oil spill fire. The resulting fire has a surface area of 4.2 sq.ft., a duration of 2.5 minutes, and an intensity of 412 Btu/s.

The analysis of this postulated fire was evaluated using the FIVE worksheets for the Inside Plume and Radiant exposure cases (Attachment B, Sheets "FW-6 Small - In-Plume" and "FW-6 Small - Radiant", respectively). The completed analysis worksheets are based on the same input parameters as the FW-6 large fire. The analysis shows that targets located 8.0 feet or more above the postulated fire would not be damaged.

The radiant exposure case performed using 1 Btu/s/ft² critical flux limit yields a critical flux distance of approximately 3.6 feet. Given the 1-hour radiant shield between FW-6 and potential targets, this heating mechanism is not a concern with respect to target damage.

Based on this analysis, a postulated small oil spill fire should be assumed to result in damage to only the pump itself.

5. Air Compressor Large Fire

A postulated 'large' air compressor fire is assumed to occur with a conditional probability of 0.18. The fire was characterized as a spill of the entire oil inventory from one compressor, 7 gallons. This fire has the potential to damage cable trays located directly above. The FIVE Inside Plume worksheet (Attachment B, Sheet "IA Large - In-Plume") was used to determine whether target damage occurs. This situation was further evaluated using the Outside Plume and Radiant Exposure worksheets (Attachment B, Sheets "IA Large - Out-Plume" and "IA Large - Radiant", respectively). Since the compressors are expected to have similar target impacts, only one scenario is developed for all three compressors.

Unconfined spill results in high heat rate, but 10 second fire duration not credible.

Assumed fire duration is 2.5 minutes.

Adjust spill surface area to obtain 2.5 minute duration fire.

Trays 1S, 16S, and 16S-1 potentially impacted.

Using the FIVE methodology, an unconfined large spill involving 7 gallons of oil would cover 840 sq.ft. and have a fire duration of 10 seconds. However, a credible fire event would require some time to ignite the oil spill, would involve a fire growth phase, then continued combustion until available fuel is depleted. Such a fire can be expected to burn for several minutes. For the purposes of the Fire Risk Analysis, it will be conservatively assumed that the minimum credible fire duration is 2.5 minutes. This 2.5 minute assumption is based on several parameters as discussed below.

In order to provide realistic results, the analysis considers a confined oil spill so that the fire duration can be extended. The selection of a 2.5 minute minimum fire duration is based on the following considerations.

1. A short fire duration is conservative. However, the 10 seconds associated with an ideal unconfined spill fire is unrealistic.
2. The Fire PRA Implementation Guide [5] indicates that ignition of IEEE 383 qualified cables would require fire exposure for 5 to 10 minutes.
3. A realistic oil pool fire can be expected to experience some degree of oxygen depletion which would reduce the overall combustion rate (longer fire duration). This reduction can be modeled by considering a smaller pool surface area.
4. The cable damage times (Appendix G of [5]) range from 2 to 19 minutes for temperatures of 700 °F and higher.

Using the 2.5 minute fire duration, the resulting fire characteristics are provided in Attachment B, Sheet "1A Large – Fuel". The postulated 7 gallon oil spill fire has a fire intensity of 5763 Btu/s and a surface area of 58.2 sq. ft.

A number of physical parameters for the fire compartment are needed in order to assess the response of the 'nearest' target and the automatic fire suppression system. The determination of these parameters is based on the postulated oil spill originating from the air compressor.

The fire is of sufficient magnitude that damage to targets in the fire plume will occur. Therefore, an outside of plume worksheet will be used to evaluate the extent of damage to targets beyond the fire plume.

Height to Target = 16.5 feet – The nearest target above the air compressors is cable tray 1S, which is 16.5 feet above the floor. Other trays near the compressors include 16S (16.5 feet high, 2 feet laterally) and 16S-1 (16.5 feet high, 2 feet laterally).

Room Height = 20 feet – FCS Fire Hazards Analysis [2].

Floor Dimensions = 207.8 x 27 feet – This is based on a floor area of 5,610 ft² and an approximate room width of 27 feet near the pump.

Radial Distance to Targets = 8.6 feet – The postulated oil spill has a surface area of 58.2 ft². This equates to a diameter of 8.6 feet for a circular spill. Since the spill can occur anywhere around the compressor, a 8.6 foot radius around the compressor is assumed for determining potential targets impacted.

*Outside of plume damage distance
– 6.4 feet.*

*Radiant exposure damage distance
– 12 feet.*

*Sprinklers assumed to be near
ceiling.*

Fire Intensity = 5,763 Btu/s – the assumed fire intensity is based on the assumptions discussed earlier. Attachment B provides a worksheet which develops this value.

Fire Location Factor = 1 - the fire is assumed to be in the 'center' of the room.

Ambient Temperature = 90 °F - this assumed value is used for the maximum expected ambient temperature during normal plant operations.

The outside of plume worksheet (Attachment B, Sheet "IA Large – Out-Plume") predicts a radial damage distance of 6.4 feet. Therefore, if a target is located in the jet region, but more than 6.4 feet from the fire plume, target damage is not expected.

Additionally, the radiant exposure worksheet (Attachment B, Sheet "IA Large – Radiant") predicts a critical radiant flux distance of 13.5 feet. Depending on the compressor which is the source of the fire, two or three of the compressors may be damaged due to radiant effects. For conservatism, all three are assumed damaged.

This scenario was evaluated further to determine the target damage time versus suppression system actuation time. Successful actuation of the suppression system prior to the predicted target damage time would prevent such damage. The additional parameters needed for this analysis are discussed below.

Height to Target = 16 feet – Although the actual target height is approximately 16.5 feet, the height used in the analysis was reduced to 16 feet, which is the lowest height which would yield a target damage time greater than the suppression system actuation time.

Radial Distance to Target = 0.1 feet – The target is conservatively assumed to be located above the fire source.

Fire Location Factor (Target) = 1 – The fire is assumed to be in the 'center' of the room.

Radiant Fraction = 0.40 - this value is based on guidance in FIVE [4].

Rated Detector Temperature = 165 °F - this value is based on the device setpoint [7].

Ambient Temperature = 75 °F – The assumed ambient temperature for this case is assumed to be 75 °F. This has the effect of increasing the detector response time.

Distance to Detector = 20 feet vertical, 1 foot horizontal – There are sprinkler heads located near the ceiling above AFW pump FW-6. Other detectors and sprinkler heads are located throughout the room. For conservatism, a vertical distance of 20 feet and a horizontal distance of 1 foot are assumed.

Targets greater than 11.5 feet above the pump will not be damaged if suppression is successful.

AFW pump FW-10 small oil fire.

82% conditional probability of small spill.

Targets greater than 9.1 feet above the pump will not be damaged.

Fire Location Factor (Detector) = 1 - the fire is assumed to be in the 'center' of the room. This provides the most conservative result with respect to detector response.

Target Location = 1 (in-plume) - The targets are inside the postulated fire plume.

Target Thermal Response Parameter = 34 - This represents a nominal value for XPE/XPE cables with 0.43 inch diameter [4]

Detector Time Constant = 120 - this assumed value is based on the highest (slowest) detector in the reference tables [4]

The results of the suppression system actuation analysis are provided in Attachment B, Sheet "IA Large - Suppression". Assuming a 'virtual' target 16 feet above the pump and inside the fire plume, the analysis conservatively predicts a cable damage time of 16 seconds and a suppression system actuation time of 15.5 seconds. The expected damage time for the actual targets, since they are located higher than 16 feet, would be greater than 16 seconds.

Based on this analysis, it is concluded that successful actuation of the suppression system during a postulated large oil spill fire will limit damage in this fire compartment such that only the pump itself will be damaged.

6. Air Compressor Small Fire

A postulated 'small' air compressor fire is assumed to occur with a conditional probability of 0.82. The fire was characterized as a spill of 10% of the entire oil inventory, or 0.7 gallons. This spill is assumed to occur with an 82% conditional probability [5]. The characterization of such a fire is based on the same fundamental parameters as that considered for the large oil spill fire. The resulting fire has a surface area of 5.8 sq.ft., a duration of 2.5 minutes, and an intensity of 576 Btu/s.

The analysis of this postulated fire was evaluated using the FIVE worksheets for the Inside Plume and Radiant exposure cases (Attachment B, Sheets "IA Small - In-Plume" and "IA Small - Radiant", respectively). The completed analysis worksheets are based on the same input parameters as the air compressor large fire. The analysis shows that targets located 9.1 feet or more above the postulated fire would not be damaged.

The radiant exposure case performed using 1 Btu/s/ft² critical flux limit yields a critical flux distance of approximately 4.3 feet. Given the 8.6 foot spill radius, this radiant exposure distance is sufficient to potentially damage all three compressors.

Based on this analysis, a postulated small oil spill fire should be assumed to result in damage to only the three compressors.

SECTION 5 REFERENCES

1. "Safe Shutdown Analysis," EA-FC-89-055, Rev. 3.
2. Fire Hazards Analysis for Fort Calhoun Station, Rev. 6.
3. Individual Plant Examination of External Events for Fort Calhoun, Enclosure to LIC 95-0130.
4. EPRI Report TR-100370s, "Fire-Induced Vulnerability Evaluation (FIVE)", Final Report, April 1992
5. EPRI Report TR-105928, "EPRI Fire PRA Implementation Guide," Final report, December 1995.
6. Fire Compartment Close-out Strategy, Scenario No. GEN.
7. FCS Fire PRA Fire Modeling Analysis, 0139-00534-RPT-001, Rev. 0, VECTRA.

Attachment B

Fire Modeling Worksheets

OPPD - Fort Calhoun Station
Fire Risk Analysis Refinement Project
COMBUSTIBLE MATERIAL WORKSHEET

FUEL PROPERTIES - UNCONFINED SPILL

DESCRIPTION	
VOLUME (QUARTS)	22
NET HEAT OF COMBUSTION	17111
COMBUSTION EFFICIENCY	90%
UNIT HEAT RELEASE RATE	110
DENSITY	60

FLOW CHARACTERISTICS

DESCRIPTION		
SPECIFIC SPILL AREA	120.0	
SPILL AREA	660	SQ-FT
PEAK FIRE INTENSITY	65340	BTU/S
FIRE DURATION	10	SEC
	0.173	MIN

FUEL PROPERTIES - CONFINED SPILL

DESCRIPTION	
VOLUME (QUARTS)	22
NET HEAT OF COMBUSTION	17111
COMBUSTION EFFICIENCY	1
UNIT HEAT RELEASE RATE	110
DENSITY	60

FLOW CHARACTERISTICS

DESCRIPTION		
SPILL AREA	45.7	SQ-FT
PEAK FIRE INTENSITY	4528	BTU/S
FIRE DURATION	150	SEC
	2.500	MIN

COMMENTS

**OPPD - Fort Calhoun Station
Fire Risk Analysis Refinement Project**

FIXED COMBUSTIBLE / TARGET IN PLUME

ENGLISH UNITS VERSION

1	TARGET DAMAGE THRESHOLD TEMPERATURE (USE TABLE 1E FOR GUIDANCE)	700	F
2	HEIGHT OF TARGET ABOVE FIRE SOURCE (BASED ON SCENARIO GEOMETRY)	20	ft
3	HEIGHT FROM FIRE SOURCE TO CEILING (BASED ON SCENARIO GEOMETRY)	20	ft
3a	FLOOR DIMENSIONS - LENGTH	267.777778	ft
	- WIDTH	27	ft
3b	FLOOR AREA (LENGTH) X (WIDTH)	5610	ft ²
3c	ESTIMATED DURATION OF FIRE	2.5	min
4	PEAK FIRE INTENSITY USE TABLE 2E & FIGURES 4-5 FOR GUIDANCE)	4528.22374	Btu/s
5	FIRE LOCATION FACTOR (4 FOR CORNER, 2 FOR WALL, 1 FOR CENTER)	1	--
6	EFFECTIVE HEAT RELEASE RATE ([BOX 4] X [BOX 5])	4528.22374	Btu/s
7	PLUME TEMPERATURE RISE AT TARGET (LOOK UP VALUE FROM TABLE 5E)	631.51	F
8a	MAXIMUM AMBIENT TEMPERATURE	90	F
8b	CRITICAL TEMPERATURE RISE AT TARGET ([BOX 1] - MAXIMUM AMBIENT TEMPERATURE)	610	F
9	CRITICAL - PLUME TEMPERATURE RISE ([BOX 8] - [BOX 7])	-21.51	F
IF THE ENTRY IN BOX 9 IS <= 0, STOP. OTHERWISE CONTINUE TO CALCULATE THE CRITICAL COMBUSTIBLE LOAD NEEDED TO RAISE THE AVERAGE TEMPERATURE BY THIS AMOUNT			
10	Q _{net} /V TO ACHIEVE TEMP RISE IN BOX 9 (LOOK UP VALUE FROM TABLE 7E)	0.00	Btu/ft ³
11	CALCULATED ENCLOSURE VOLUME, V ([BOX 3] X FLOOR AREA OF SPACE)	0	ft ³
12	CALCULATED CRITICAL Q _{net} ([BOX 10] X [BOX 11])	0	Btu
13	ESTIMATED HEAT LOSS FRACTION (REPRESENTATIVE VALUE : 0.7)	0.7	--
14	ESTIMATE OF CRITICAL Q _{tot} ([BOX 12]/(1 - [BOX 13]))	0	Btu
15	ESTIMATE OF ACTUAL Q _{tot} ([HRR] X [TIME]) = [BOX 4] X [TIME]	0	Btu
IF THE ENTRY IN BOX 15 IS LESS THAN THE VALUE IN BOX 14, CRITICAL CONDITIONS ARE NOT INDICATED FOR THE SCENARIO BEING EVALUATED. OTHERWISE, THE SCENARIO DOES NOT PASS THIS SCREENING PROCEDURE. FURTHER ANALYSIS REQUIRED.			

OPPD - Fort Calhoun Station
Fire Risk Analysis Refinement Project

FIXED COMBUSTIBLE / TARGET OUTSIDE PLUME

ENGLISH UNITS VERSION

1	TARGET DAMAGE THRESHOLD TEMPERATURE (LOOK UP VALUE FROM TABLE 1E)	700	F
2	HEIGHT OF TARGET ABOVE FIRE SOURCE (BASED ON SCENARIO GEOMETRY)	18	ft
3	HEIGHT FROM FIRE SOURCE TO CEILING (BASED ON SCENARIO GEOMETRY)	20	ft
3a	FLOOR DIMENSIONS - LENGTH - WIDTH	207.77778 27	ft ft
3b	FLOOR AREA [LENGTH] X [WIDTH]	5610	ft ²
3c	ESTIMATED DURATION OF FIRE	2.5	min
4	RATIO OF TARGET HEIGHT/CEILING HEIGHT ((BOX2)/(BOX3))	0.90	--
IF THE VALUE IN BOX 4 IS > 0.85, COMPLETE BOXES 5-11; OTHERWISE, ENTER A VALUE OF 0 IN BOX 14 AND CONTINUE WITH BOX 15			
5	LONGITUDINAL DISTANCE FROM FIRE SOURCE TO TARGET, L (BASED ON SCENARIO GEOMETRY)	4.8	ft
6	LONGITUDINAL DISTANCE TO HEIGHT RATIO, L/H ((BOX 5)/(BOX 3))	0.24	--
7	ENCLOSURE WIDTH, W (BASED ON SCENARIO GEOMETRY)	27	ft
8	HEIGHT TO WIDTH RATIO, H/W ((BOX 3)/(BOX 7))	0.74	--
9	PEAK FIRE INTENSITY (USE TABLE 2E FOR GUIDANCE)	4528.2237	Btu/s
10	FIRE LOCATION FACTOR (4 FOR CORNER, 2 FOR WALL, 1 FOR CENTER)	1	--
11	EFFECTIVE HEAT RATE RELEASE ((BOX 9) X (BOX 10))	4528.2237	Btu/s
12	PLUME TEMPERATURE RISE AT CEILING (LOOK UP VALUE FROM TABLE 5E)	631.51	F
13	CEILING JET TEMPERATURE RISE FACTOR AT TARGET (IF [BOX 4] < 0.85, ENTER 0, ELSE LOOK UP VALUE FROM TABLE 6A OR 6B)	0.777	--
14	CEILING JET TEMPERATURE RISE AT TARGET ((BOX 12) X (BOX 13))	490.56	F
15a	MAXIMUM AMBIENT TEMPERATURE	90	F
15b	CRITICAL TEMPERATURE RISE AT TARGET ((BOX 1) - MAXIMUM AMBIENT TEMPERATURE)	610	F
16	CRITICAL - CEILING JET TEMP. RISE AT TARGET ((BOX 15) - (BOX 14))	119.44	F
IF THE ENTRY IN BOX 16 IS <= 0, STOP. OTHERWISE CONTINUE TO CALCULATE THE CRITICAL COMBUSTIBLE LOAD NEEDED TO RAISE THE AVERAGE TEMPERATURE BY THE AMOUNT INDICATED IN BOX 16			
17	Q _{net} /V TO ACHIEVE TEMP RISE IN BOX 16 (LOOK UP VALUE FROM TABLE 7E)	1.88	Btu/ft ³
18	CALCULATED ENCLOSURE VOLUME, V ((BOX 3B) X (BOX 3))	112,200	ft ³
19	CALCULATED CRITICAL Q _{net} ((BOX 17) X (BOX 18))	210,466	Btu
20	ESTIMATED HEAT LOSS FRACTION (RANGE: 0-1) (REPRESENTATIVE VALUE : 0.7)	0.7	--
21	ESTIMATE OF CRITICAL Q _{tot} ((BOX 19)/(1 - (BOX 20)))	701,554	Btu
22	ESTIMATE OF ACTUAL Q _{tot} (BASED ON ENERGY CONTENT OF FIRE SOURCE)	679,234	Btu
IF THE ENTRY IN BOX 22 IS LESS THAN THE VALUE IN BOX 21, CRITICAL CONDITIONS ARE NOT INDICATED FOR THE SCENARIO BEING EVALUATED. OTHERWISE, THE SCENARIO DOES NOT PASS THIS SCREENING PROCEDURE. FURTHER ANALYSIS REQUIRED.			

OPPD - Fort Calhoun Station
Fire Risk Analysis Refinement Project

FIXED COMBUSTIBLE / RADIANT EXPOSURE

ENGLISH UNITS VERSION

1	CRITICAL RADIANT FLUX TO TARGET (REPRESENTATIVE CONSERVATIVE VALUE = 1) (LOOK UP VALUE FROM TABLE 1E)	1	Btu/s/ft ²
2	PEAK FIRE INTENSITY (USE TABLE 2E FOR GUIDANCE)	4528.22374	Btu/s
3	RADIANT FRACTION OF HEAT RELEASE (REPRESENTATIVE VALUE = 0.4)	0.4	--
4	RADIANT HEAT RELEASE RATE ([BOX2]X[BOX3])	1811.2895	Btu/s
5	CRITICAL RADIANT FLUX DISTANCE (LOOK UP VALUE FROM TABLE 10E)	12.01	ft
6	ACTUAL DISTANCE BETWEEN SOURCE/TARGET (FROM FIRE COMPARTMENT CCDS)	0	ft
IF THE EXPOSURE FIRE IS LOCATED WITHIN THIS DISTANCE (INDICATED IN BOX 5) OF THE TARGET, CRITICAL CONDITIONS CAN OCCUR. OUTSIDE THIS RANGE, CRITICAL CONDITIONS ARE NOT INDICATED FOR THE SCENARIO UNDER CONSIDERATION.			

OPPD - Fort Calhoun Station
Fire Risk Analysis Refinement Project

SUPPRESSION
THERMALLY THICK TARGETS
ENGLISH UNITS VERSION

TARGET INFORMATION

1a	HEIGHT OF TARGET ABOVE FIRE SOURCE (BASED ON SCENARIO GEOMETRY)	11.5	ft
1b	RADIAL DISTANCE FROM FIRE SOURCE TO TARGET LINE OF SIGHT DISTANCE FROM FIRE SOURCE TO TARGET	0.1 11.50	ft ft
2	PEAK FIRE INTENSITY FROM BASIC SCREENING METHODOLOGY	4528.22374	Btu/s
3	FIRE LOCATION FACTOR (4 FOR CORNER, 2 FOR WALL, 1 FOR CENTER)	1	--
4	EFFECTIVE HEAT RELEASE RATE ((BOX 2) X (BOX 3))	4528.22374	Btu/s
6	MAXIMUM AMBIENT TEMPERATURE	75	F
7	PLUME TEMPERATURE RISE AT TARGET (LOOK UP VALUE FROM TABLE 5E)	1588.31	F
8	RADIANT FRACTION OF HEAT RELEASE (REPRESENTATIVE VALUE = 0.4)	0.4	--
9	RADIANT HEAT RELEASE RATE ((BOX 2) X (BOX 8))	1811.2895	Btu/s

DETECTOR INFORMATION

1	RATED ACTUATION TEMPERATURE OF DETECTOR (MANUFACTURERS DATA)	165	F
2	HEIGHT FROM FIRE SOURCE TO CEILING (BASED ON SCENARIO GEOMETRY)	10	ft
3	FLOOR DIMENSION - WIDTH	27	ft
4	LONGITUDINAL DISTANCE FROM FIRE SOURCE TO DETECTOR, L (BASED ON SCENARIO GEOMETRY)	1	ft
5	LONGITUDINAL DISTANCE TO HEIGHT RATIO, L/H ((BOX 4)/(BOX 2))	0.10	--
6	HEIGHT TO WIDTH RATIO, H/W ((BOX 2)/(BOX 3))	0.37	--
7	PEAK FIRE INTENSITY (USE TABLE 2E FOR GUIDANCE)	4528.22374	Btu/s
8	FIRE LOCATION FACTOR (4 FOR CORNER, 2 FOR WALL, 1 FOR CENTER)	1	--
9	EFFECTIVE FIRE INTENSITY ((BOX 7) X (BOX 8))	4528.22374	Btu/s
10	PLUME TEMPERATURE RISE AT CEILING (LOOK UP VALUE FROM TABLE 5E)	1600.00	F
11	CEILING JET TEMPERATURE RISE FACTOR AT DETECTOR (LOOK UP VALUE FROM TABLE 6A OR 6B)	1.00	--
12	CEILING JET TEMPERATURE RISE AT DETECTOR ((BOX 10) X (BOX 11))	1600.00	F

TIME TO TARGET DAMAGE

1	RADIATIVE HEAT FLUX AT TARGET (TABLE A-3E)	1.09	Btu/s/ft ²
2a	TARGET LOCATION IN-PLUME(1); OUT-PLUME (2)	1	
2b	CONVECTIVE HEAT FLUX AT TARGET (TABLES A-4E AND A-5)	10.27	Btu/s/ft ²
3	TOTAL HEAT FLUX AT TARGET ((BOX 1) + (BOX 2b))	11.36	Btu/s/ft ²
4	TARGET THERMAL RESPONSE PARAMETER (TABLE A-7E)	34	--
5	ESTIMATED TIME TO TARGET DAMAGE (TABLE A-2E)	7	s

TIME TO DETECTOR ACTUATION

6	DETECTION DEVICE RATED TEMPERATURE RISE	90	F
7	GAS TEMPERATURE RISE AT DETECTOR (USE BASIC SCREENING METHODOLOGY)	1600	F
8	DETECTOR TEMPERATURE RISE/GAS TEMPERATURE RISE ((BOX 6)/(BOX 7))	0.06	--
9	DIMENSIONLESS DETECTOR ACTUATION TIME (TABLE A-1)	0.06	--
10	TIME CONSTANT OF DETECTION DEVICE (TABLE A-6E OR MFG. DATA)	120	s
11	ESTIMATED TIME TO DETECTOR ACTUATION ((BOX 9) X (BOX 10))	6.95	s

OPPD - Fort Calhoun Station
Fire Risk Analysis Refinement Project
COMBUSTIBLE MATERIAL WORKSHEET

FUEL PROPERTIES - UNCONFINED SPILL

DESCRIPTION	
VOLUME (QUARTS)	2
NET HEAT OF COMBUSTION	17111
COMBUSTION EFFICIENCY	90%
UNIT HEAT RELEASE RATE	110
DENSITY	60

FLOW CHARACTERISTICS

DESCRIPTION		
SPECIFIC SPILL AREA	120.0	
SPILL AREA	66	SQ-FT
PEAK FIRE INTENSITY	6534	BTU/S
FIRE DURATION	10	SEC
	0.173	MIN

FUEL PROPERTIES - CONFINED SPILL

DESCRIPTION	
VOLUME (QUARTS)	2
NET HEAT OF COMBUSTION	17111
COMBUSTION EFFICIENCY	1
UNIT HEAT RELEASE RATE	110
DENSITY	60

FLOW CHARACTERISTICS

DESCRIPTION		
SPILL AREA	4.6	SQ-FT
PEAK FIRE INTENSITY	453	BTU/S
FIRE DURATION	150	SEC
	2.500	MIN

COMMENTS

ENGLISH UNITS VERSION

1	TARGET DAMAGE THRESHOLD TEMPERATURE (USE TABLE 1E FOR GUIDANCE)	700	F
2	HEIGHT OF TARGET ABOVE FIRE SOURCE (BASED ON SCENARIO GEOMETRY)	8.3	ft
3	HEIGHT FROM FIRE SOURCE TO CEILING (BASED ON SCENARIO GEOMETRY)	20	ft
3a	FLOOR DIMENSIONS - LENGTH - WIDTH	207.777778 27	ft ft
3b	FLOOR AREA (LENGTH) X (WIDTH)	5610	ft ²
3c	ESTIMATED DURATION OF FIRE	2.5	min
4	PEAK FIRE INTENSITY USE TABLE 2E & FIGURES 4-5 FOR GUIDANCE)	452.912776	Btu/s
5	FIRE LOCATION FACTOR (4 FOR CORNER, 2 FOR WALL, 1 FOR CENTER)	1	--
6	EFFECTIVE HEAT RELEASE RATE ((BOX 4] X [BOX 5])	452.912776	Btu/s
7	PLUME TEMPERATURE RISE AT TARGET (LOOK UP VALUE FROM TABLE 5E)	589.33	F
8a	MAXIMUM AMBIENT TEMPERATURE	90	F
8b	CRITICAL TEMPERATURE RISE AT TARGET ([BOX 1] - MAXIMUM AMBIENT TEMPERATURE)	610	F
9	CRITICAL - PLUME TEMPERATURE RISE ([BOX 8] - [BOX 7])	20.67	F
IF THE ENTRY IN BOX 9 IS ≤ 0, STOP. OTHERWISE CONTINUE TO CALCULATE THE CRITICAL COMBUSTIBLE LOAD NEEDED TO RAISE THE AVERAGE TEMPERATURE BY THIS AMOUNT			
10	Qnet/V TO ACHIEVE TEMP RISE IN BOX 9 (LOOK UP VALUE FROM TABLE 7E)	0.35	Btu/ft ³
11	CALCULATED ENCLOSURE VOLUME, V ([BOX 3] X FLOOR AREA OF SPACE)	112200	ft ³
12	CALCULATED CRITICAL Qnet ([BOX 10] X [BOX 11])	39,513	Btu
13	ESTIMATED HEAT LOSS FRACTION (REPRESENTATIVE VALUE : 0.7)	0.7	--
14	ESTIMATE OF CRITICAL Qtot ([BOX 12]/(1 - [BOX 13]))	131,710	Btu
15	ESTIMATE OF ACTUAL Qtot ([HRR] X [TIME]) = [BOX 4] X [TIME]	67,937	Btu
IF THE ENTRY IN BOX 15 IS LESS THAN THE VALUE IN BOX 14, CRITICAL CONDITIONS ARE NOT INDICATED FOR THE SCENARIO BEING EVALUATED. OTHERWISE, THE SCENARIO DOES NOT PASS THIS SCREENING PROCEDURE. FURTHER ANALYSIS REQUIRED.			

OPPD - Fort Calhoun Station
Fire Risk Analysis Refinement Project

FIXED COMBUSTIBLE / RADIANT EXPOSURE

ENGLISH UNITS VERSION

1	CRITICAL RADIANT FLUX TO TARGET (REPRESENTATIVE CONSERVATIVE VALUE = 1) (LOOK UP VALUE FROM TABLE 1E)	1	Btu/s/ft ²
2	PEAK FIRE INTENSITY (USE TABLE 2E FOR GUIDANCE)	452.912776	Btu/s
3	RADIANT FRACTION OF HEAT RELEASE (REPRESENTATIVE VALUE = 0.4)	0.4	--
4	RADIANT HEAT RELEASE RATE ((BOX2)X(BOX3))	181.165111	Btu/s
5	CRITICAL RADIANT FLUX DISTANCE (LOOK UP VALUE FROM TABLE 10E)	3.80	ft
6	ACTUAL DISTANCE BETWEEN SOURCE/TARGET (FROM FIRE COMPARTMENT CCDS)	0	ft
IF THE EXPOSURE FIRE IS LOCATED WITHIN THIS DISTANCE (INDICATED IN BOX 5) OF THE TARGET, CRITICAL CONDITIONS CAN OCCUR. OUTSIDE THIS RANGE, CRITICAL CONDITIONS ARE NOT INDICATED FOR THE SCENARIO UNDER CONSIDERATION.			

OPPD - Fort Calhoun Station
Fire Risk Analysis Refinement Project
COMBUSTIBLE MATERIAL WORKSHEET

FUEL PROPERTIES - UNCONFINED SPILL

DESCRIPTION	
VOLUME (QUARTS)	14
NET HEAT OF COMBUSTION	17111
COMBUSTION EFFICIENCY	90%
UNIT HEAT RELEASE RATE	110
DENSITY	60

FLOW CHARACTERISTICS

DESCRIPTION		
SPECIFIC SPILL AREA	120.0	
SPILL AREA	420	SQ-FT
PEAK FIRE INTENSITY	41580	BTU/S
FIRE DURATION	10	SEC
	0.173	MIN

FUEL PROPERTIES - CONFINED SPILL

DESCRIPTION	
VOLUME (QUARTS)	14
NET HEAT OF COMBUSTION	17111
COMBUSTION EFFICIENCY	1
UNIT HEAT RELEASE RATE	110
DENSITY	60

FLOW CHARACTERISTICS

DESCRIPTION		
SPILL AREA	29.1	SQ-FT
PEAK FIRE INTENSITY	2882	BTU/S
FIRE DURATION	150	SEC
	2.500	MIN

COMMENTS

OPPD - Fort Calhoun Station
Fire Risk Analysis Refinement Project

FIXED COMBUSTIBLE / TARGET IN PLUME

ENGLISH UNITS VERSION

1	TARGET DAMAGE THRESHOLD TEMPERATURE (USE TABLE 1E FOR GUIDANCE)	700	F
2	HEIGHT OF TARGET ABOVE FIRE SOURCE (BASED ON SCENARIO GEOMETRY)	18.2	ft
3	HEIGHT FROM FIRE SOURCE TO CEILING (BASED ON SCENARIO GEOMETRY)	20	ft
3a	FLOOR DIMENSIONS - LENGTH	207.777778	ft
	- WIDTH	27	ft
3b	FLOOR AREA (LENGTH) X (WIDTH)	5610	ft ²
3c	ESTIMATED DURATION OF FIRE	2.5	min
4	PEAK FIRE INTENSITY (USE TABLE 2E & FIGURES 4-5 FOR GUIDANCE)	2882.3961	Btu/s
5	FIRE LOCATION FACTOR (4 FOR CORNER, 2 FOR WALL, 1 FOR CENTER)	1	—
6	EFFECTIVE HEAT RELEASE RATE ([BOX 4] X [BOX 5])	2882.3961	Btu/s
7	PLUME TEMPERATURE RISE AT TARGET (LOOK UP VALUE FROM TABLE 5E)	546.84	F
8a	MAXIMUM AMBIENT TEMPERATURE	90	F
8b	CRITICAL TEMPERATURE RISE AT TARGET ([BOX 1] - MAXIMUM AMBIENT TEMPERATURE)	610	F
9	CRITICAL - PLUME TEMPERATURE RISE ([BOX 8] - [BOX 7])	63.16	F
IF THE ENTRY IN BOX 9 IS ≤ 0 , STOP. OTHERWISE CONTINUE TO CALCULATE THE CRITICAL COMBUSTIBLE LOAD NEEDED TO RAISE THE AVERAGE TEMPERATURE BY THIS AMOUNT			
10	Q_{net}/V TO ACHIEVE TEMP RISE IN BOX 9 (LOOK UP VALUE FROM TABLE 7E)	1.04	Btu/ft ³
11	CALCULATED ENCLOSURE VOLUME, V ([BOX 3] X FLOOR AREA OF SPACE)	112200	ft ³
12	CALCULATED CRITICAL Q_{net} ([BOX 10] X [BOX 11])	116,421	Btu
13	ESTIMATED HEAT LOSS FRACTION (REPRESENTATIVE VALUE : 0.7)	0.7	--
14	ESTIMATE OF CRITICAL Q_{tot} ([BOX 12]/(1 - [BOX 13]))	388,070	Btu
15	ESTIMATE OF ACTUAL Q_{tot} ([HRR] X [TIME]) = [BOX 4] X [TIME]	432,359	Btu
IF THE ENTRY IN BOX 15 IS LESS THAN THE VALUE IN BOX 14, CRITICAL CONDITIONS ARE NOT INDICATED FOR THE SCENARIO BEING EVALUATED. OTHERWISE, THE SCENARIO DOES NOT PASS THIS SCREENING PROCEDURE. FURTHER ANALYSIS REQUIRED.			

OPPD - Fort Calhoun Station
Fire Risk Analysis Refinement Project

FIXED COMBUSTIBLE / TARGET OUTSIDE PLUME

ENGLISH UNITS VERSION

1	TARGET DAMAGE THRESHOLD TEMPERATURE (LOOK UP VALUE FROM TABLE 1E)	700	F
2	HEIGHT OF TARGET ABOVE FIRE SOURCE (BASED ON SCENARIO GEOMETRY)	18.2	ft
3	HEIGHT FROM FIRE SOURCE TO CEILING (BASED ON SCENARIO GEOMETRY)	20	ft
3a	FLOOR DIMENSIONS - LENGTH	207.77778	ft
	- WIDTH	27	ft
3b	FLOOR AREA [LENGTH] X [WIDTH]	5610	ft ²
3c	ESTIMATED DURATION OF FIRE	2.5	min
4	RATIO OF TARGET HEIGHT/CEILING HEIGHT ((BOX 2)/[BOX 3])	0.91	--
IF THE VALUE IN BOX 4 IS > 0.85, COMPLETE BOXES 5-11; OTHERWISE, ENTER A VALUE OF 0 IN BOX 14 AND CONTINUE WITH BOX 15.			
5	LONGITUDINAL DISTANCE FROM FIRE SOURCE TO TARGET, L (BASED ON SCENARIO GEOMETRY)	2.6	ft
6	LONGITUDINAL DISTANCE TO HEIGHT RATIO, L/H ((BOX 5)/[BOX 3])	0.13	--
7	ENCLOSURE WIDTH, W (BASED ON SCENARIO GEOMETRY)	27	ft
8	HEIGHT TO WIDTH RATIO, H/W ((BOX 3)/[BOX 7])	0.74	--
9	PEAK FIRE INTENSITY (USE TABLE 2E FOR GUIDANCE)	2882.3961	Btu/s
10	FIRE LOCATION FACTOR (4 FOR CORNER, 2 FOR WALL, 1 FOR CENTER)	1	--
11	EFFECTIVE HEAT RATE RELEASE ((BOX 9) X [BOX 10])	2882.3961	Btu/s
12	PLUME TEMPERATURE RISE AT CEILING (LOOK UP VALUE FROM TABLE 5E)	467.30	F
13	CEILING JET TEMPERATURE RISE FACTOR AT TARGET (IF [BOX 4] < 0.85, ENTER 0, ELSE LOOK UP VALUE FROM TABLE 6A OR 6B)	1.169	--
14	CEILING JET TEMPERATURE RISE AT TARGET ((BOX 12) X [BOX 13])	546.29	F
15a	MAXIMUM AMBIENT TEMPERATURE	90	F
15b	CRITICAL TEMPERATURE RISE AT TARGET ([BOX 1] - MAXIMUM AMBIENT TEMPERATURE)	610	F
16	CRITICAL - CEILING JET TEMP. RISE AT TARGET ([BOX 15] - [BOX 14])	63.71	F
IF THE ENTRY IN BOX 16 IS <= 0, STOP. OTHERWISE CONTINUE TO CALCULATE THE CRITICAL COMBUSTIBLE LOAD NEEDED TO RAISE THE AVERAGE TEMPERATURE BY THE AMOUNT INDICATED IN BOX 16.			
17	Q _{net} /V TO ACHIEVE TEMP RISE IN BOX 16 (LOOK UP VALUE FROM TABLE 7E)	1.05	Btu/ft ³
18	CALCULATED ENCLOSURE VOLUME, V ([BOX 3B] X [BOX 3])	112,200	ft ³
19	CALCULATED CRITICAL Q _{net} ([BOX 17] X [BOX 18])	117,385	Btu
20	ESTIMATED HEAT LOSS FRACTION (RANGE: 0-1) (REPRESENTATIVE VALUE : 0.7)	0.7	--
21	ESTIMATE OF CRITICAL Q _{tot} ([BOX 19]/(1 - [BOX 20]))	391,282	Btu
22	ESTIMATE OF ACTUAL Q _{tot} (BASED ON ENERGY CONTENT OF FIRE SOURCE)	432,359	Btu
IF THE ENTRY IN BOX 22 IS LESS THAN THE VALUE IN BOX 21, CRITICAL CONDITIONS ARE NOT INDICATED FOR THE SCENARIO BEING EVALUATED. OTHERWISE, THE SCENARIO DOES NOT PASS THIS SCREENING PROCEDURE. FURTHER ANALYSIS REQUIRED.			

OPPD - Fort Calhoun Station
Fire Risk Analysis Refinement Project

FIXED COMBUSTIBLE / RADIANT EXPOSURE

ENGLISH UNITS VERSION

1	CRITICAL RADIANT FLUX TO TARGET (REPRESENTATIVE CONSERVATIVE VALUE = 1) (LOOK UP VALUE FROM TABLE 1E)	1	Btu/s/ft ²
2	PEAK FIRE INTENSITY (USE TABLE 2E FOR GUIDANCE)	2882.3961	Btu/s
3	RADIANT FRACTION OF HEAT RELEASE (REPRESENTATIVE VALUE = 0.4)	0.4	--
4	RADIANT HEAT RELEASE RATE ((BOX2)X[BOX3])	1152.95844	Btu/s
5	CRITICAL RADIANT FLUX DISTANCE (LOOK UP VALUE FROM TABLE 10E)	9.58	ft
6	ACTUAL DISTANCE BETWEEN SOURCE/TARGET (FROM FIRE COMPARTMENT CCDS)	0	ft
IF THE EXPOSURE FIRE IS LOCATED WITHIN THIS DISTANCE (INDICATED IN BOX 5) OF THE TARGET, CRITICAL CONDITIONS CAN OCCUR. OUTSIDE THIS RANGE, CRITICAL CONDITIONS ARE NOT INDICATED FOR THE SCENARIO UNDER CONSIDERATION.			

OPPD - Fort Calhoun Station
Fire Risk Analysis Refinement Project

SUPPRESSION
THERMALLY THICK TARGETS

ENGLISH UNITS VERSION

TARGET INFORMATION

1a	HEIGHT OF TARGET ABOVE FIRE SOURCE (BASED ON SCENARIO GEOMETRY)	12.7	ft
1b	RADIAL DISTANCE FROM FIRE SOURCE TO TARGET LINE OF SIGHT DISTANCE FROM FIRE SOURCE TO TARGET	0.1 12.70	ft ft
2	PEAK FIRE INTENSITY FROM BASIC SCREENING METHODOLOGY	2882.3961	Btu/s
3	FIRE LOCATION FACTOR (4 FOR CORNER, 2 FOR WALL, 1 FOR CENTER)	1	--
4	EFFECTIVE HEAT RELEASE RATE ((BOX 2) X (BOX 3))	2882.3961	Btu/s
6	MAXIMUM AMBIENT TEMPERATURE	75	F
7	PLUME TEMPERATURE RISE AT TARGET (LOOK UP VALUE FROM TABLE 5E)	996.11	F
8	RADIANT FRACTION OF HEAT RELEASE (REPRESENTATIVE VALUE = 0.4)	0.4	--
9	RADIANT HEAT RELEASE RATE ((BOX 2) X (BOX 8))	1152.95844	Btu/s

DETECTOR INFORMATION

1	RATED ACTUATION TEMPERATURE OF DETECTOR (MANUFACTURERS DATA)	165	F
2	HEIGHT FROM FIRE SOURCE TO CEILING (BASED ON SCENARIO GEOMETRY)	20	ft
3	FLOOR DIMENSION - WIDTH	27	ft
4	LONGITUDINAL DISTANCE FROM FIRE SOURCE TO DETECTOR, L (BASED ON SCENARIO GEOMETRY)	1	ft
5	LONGITUDINAL DISTANCE TO HEIGHT RATIO, L/H ((BOX 4)/(BOX 2))	0.05	--
6	HEIGHT TO WIDTH RATIO, H/W ((BOX 2)/(BOX 3))	0.74	--
7	PEAK FIRE INTENSITY (USE TABLE 2E FOR GUIDANCE)	2882.3961	Btu/s
8	FIRE LOCATION FACTOR (4 FOR CORNER, 2 FOR WALL, 1 FOR CENTER)	1	--
9	EFFECTIVE FIRE INTENSITY ((BOX 7) X (BOX 8))	2882.3961	Btu/s
10	PLUME TEMPERATURE RISE AT CEILING (LOOK UP VALUE FROM TABLE 5E)	467.30	F
11	CEILING JET TEMPERATURE RISE FACTOR AT DETECTOR (LOOK UP VALUE FROM TABLE 6A OR 6B)	1.00	--
12	CEILING JET TEMPERATURE RISE AT DETECTOR ((BOX 10) X (BOX 11))	467.30	F

TIME TO TARGET DAMAGE

1	RADIATIVE HEAT FLUX AT TARGET (TABLE A-3E)	0.57	Btu/s/ft ²
2a	TARGET LOCATION IN-PLUME (1); OUT-PLUME (2)	1	
2b	CONVECTIVE HEAT FLUX AT TARGET (TABLES A-4E AND A-5)	5.36	Btu/s/ft ²
3	TOTAL HEAT FLUX AT TARGET ((BOX 1) + (BOX 2b))	5.93	Btu/s/ft ²
4	TARGET THERMAL RESPONSE PARAMETER (TABLE A-7E)	34	--
5	ESTIMATED TIME TO TARGET DAMAGE (TABLE A-2E)	26	s

TIME TO DETECTOR ACTUATION

6	DETECTION DEVICE RATED TEMPERATURE RISE	90	F
7	GAS TEMPERATURE RISE AT DETECTOR (USE BASIC SCREENING METHODOLOGY)	467	F
8	DETECTOR TEMPERATURE RISE/GAS TEMPERATURE RISE ((BOX 6)/(BOX 7))	0.19	--
9	DIMENSIONLESS DETECTOR ACTUATION TIME (TABLE A-1)	0.21	--
10	TIME CONSTANT OF DETECTION DEVICE (TABLE A-6E OR MFG. DATA)	120	s
11	ESTIMATED TIME TO DETECTOR ACTUATION ((BOX 9) X (BOX 10))	25.67	s

OPPD - Fort Calhoun Station
Fire Risk Analysis Refinement Project
COMBUSTIBLE MATERIAL WORKSHEET

FUEL PROPERTIES - UNCONFINED SPILL

DESCRIPTION	
VOLUME (QUARTS)	2
NET HEAT OF COMBUSTION	17111
COMBUSTION EFFICIENCY	90%
UNIT HEAT RELEASE RATE	110
DENSITY	60

FLOW CHARACTERISTICS

DESCRIPTION	
SPECIFIC SPILL AREA	120.0

SPILL AREA	60	SQ-FT
PEAK FIRE INTENSITY	5940	BTU/S
FIRE DURATION	10	SEC
	0.173	MIN

FUEL PROPERTIES - CONFINED SPILL

DESCRIPTION	
VOLUME (QUARTS)	2
NET HEAT OF COMBUSTION	17111
COMBUSTION EFFICIENCY	1
UNIT HEAT RELEASE RATE	110
DENSITY	60

FLOW CHARACTERISTICS

DESCRIPTION		
SPILL AREA	4.2	SQ-FT
PEAK FIRE INTENSITY	412	BTU/S
FIRE DURATION	150	SEC
	2.500	MIN

COMMENTS

OPPD - Fort Calhoun Station
Fire Risk Analysis Refinement Project

FIXED COMBUSTIBLE / TARGET IN PLUME

ENGLISH UNITS VERSION

1	TARGET DAMAGE THRESHOLD TEMPERATURE (USE TABLE 1E FOR GUIDANCE)	700	F
2	HEIGHT OF TARGET ABOVE FIRE SOURCE (BASED ON SCENARIO GEOMETRY)	8	ft
3	HEIGHT FROM FIRE SOURCE TO CEILING (BASED ON SCENARIO GEOMETRY)	20	ft
3a	FLOOR DIMENSIONS - LENGTH	207.777778	ft
	- WIDTH	27	ft
3b	FLOOR AREA (LENGTH) X (WIDTH)	5610	ft ²
3c	ESTIMATED DURATION OF FIRE	2.5	min
4	PEAK FIRE INTENSITY USE TABLE 2E & FIGURES 4-5 FOR GUIDANCE)	411.720064	Btu/s
5	FIRE LOCATION FACTOR (4 FOR CORNER, 2 FOR WALL, 1 FOR CENTER)	1	--
6	EFFECTIVE HEAT RELEASE RATE ([BOX 4] X [BOX 5])	411.720064	Btu/s
7	PLUME TEMPERATURE RISE AT TARGET (LOOK UP VALUE FROM TABLE 5E)	588.03	F
8a	MAXIMUM AMBIENT TEMPERATURE	90	F
8b	CRITICAL TEMPERATURE RISE AT TARGET ([BOX 1] - MAXIMUM AMBIENT TEMPERATURE)	610	F
9	CRITICAL - PLUME TEMPERATURE RISE ([BOX 8] - [BOX 7])	21.97	F
IF THE ENTRY IN BOX 9 IS ≤ 0 , STOP. OTHERWISE CONTINUE TO CALCULATE THE CRITICAL COMBUSTIBLE LOAD NEEDED TO RAISE THE AVERAGE TEMPERATURE BY THIS AMOUNT			
10	Q_{net}/V TO ACHIEVE TEMP RISE IN BOX 9 (LOOK UP VALUE FROM TABLE 7E)	0.37	Btu/ft ³
11	CALCULATED ENCLOSURE VOLUME, V ([BOX 3] X FLOOR AREA OF SPACE)	112200	ft ³
12	CALCULATED CRITICAL Q_{net} ([BOX 10] X [BOX 11])	41,956	Btu
13	ESTIMATED HEAT LOSS FRACTION (REPRESENTATIVE VALUE : 0.7)	0.7	--
14	ESTIMATE OF CRITICAL Q_{tot} ([BOX 12]/(1 - [BOX 13]))	139,854	Btu
15	ESTIMATE OF ACTUAL Q_{tot} ([HRR] X [TIME]) = [BOX 4] X [TIME]	61,758	Btu
IF THE ENTRY IN BOX 15 IS LESS THAN THE VALUE IN BOX 14, CRITICAL CONDITIONS ARE NOT INDICATED FOR THE SCENARIO BEING EVALUATED. OTHERWISE, THE SCENARIO DOES NOT PASS THIS SCREENING PROCEDURE. FURTHER ANALYSIS REQUIRED.			

OPPD - Fort Calhoun Station
Fire Risk Analysis Refinement Project

FIXED COMBUSTIBLE / RADIANT EXPOSURE

ENGLISH UNITS VERSION

1	CRITICAL RADIANT FLUX TO TARGET (REPRESENTATIVE CONSERVATIVE VALUE = 1) (LOOK UP VALUE FROM TABLE 1E)	1	Btu/s/ft ²
2	PEAK FIRE INTENSITY (USE TABLE 2E FOR GUIDANCE)	411.720064	Btu/s
3	RADIANT FRACTION OF HEAT RELEASE (REPRESENTATIVE VALUE = 0.4)	0.4	--
4	RADIANT HEAT RELEASE RATE ([BOX2]X[BOX3])	164.688026	Btu/s
5	CRITICAL RADIANT FLUX DISTANCE (LOOK UP VALUE FROM TABLE 10E)	3.62	ft
6	ACTUAL DISTANCE BETWEEN SOURCE/TARGET (FROM FIRE COMPARTMENT CCDS)	0	ft
IF THE EXPOSURE FIRE IS LOCATED WITHIN THIS DISTANCE (INDICATED IN BOX 5) OF THE TARGET, CRITICAL CONDITIONS CAN OCCUR. OUTSIDE THIS RANGE, CRITICAL CONDITIONS ARE NOT INDICATED FOR THE SCENARIO UNDER CONSIDERATION.			

OPPD - Fort Calhoun Station
Fire Risk Analysis Refinement Project

COMBUSTIBLE MATERIAL WORKSHEET

FUEL PROPERTIES - UNCONFINED SPILL

DESCRIPTION	
VOLUME (QUARTS)	28
NET HEAT OF COMBUSTION	17111
COMBUSTION EFFICIENCY	90%
UNIT HEAT RELEASE RATE	110
DENSITY	60

FLOW CHARACTERISTICS

DESCRIPTION	
SPECIFIC SPILL AREA	120.0

SPILL AREA	840	SQ-FT
PEAK FIRE INTENSITY	83160	BTU/S
FIRE DURATION	10	SEC
	0.173	MIN

FUEL PROPERTIES - CONFINED SPILL

DESCRIPTION	
VOLUME (QUARTS)	28
NET HEAT OF COMBUSTION	17111
COMBUSTION EFFICIENCY	1
UNIT HEAT RELEASE RATE	110
DENSITY	60

FLOW CHARACTERISTICS

DESCRIPTION		
SPILL AREA	58.2	SQ-FT
PEAK FIRE INTENSITY	5763	BTU/S
FIRE DURATION	150	SEC
	2.500	MIN

COMMENTS

**OPPD - Fort Calhoun Station
Fire Risk Analysis Refinement Project**

FIXED COMBUSTIBLE / TARGET IN PLUME

ENGLISH UNITS VERSION

1	TARGET DAMAGE THRESHOLD TEMPERATURE (USE TABLE 1E FOR GUIDANCE)	700	F
2	HEIGHT OF TARGET ABOVE FIRE SOURCE (BASED ON SCENARIO GEOMETRY)	20	ft
3	HEIGHT FROM FIRE SOURCE TO CEILING (BASED ON SCENARIO GEOMETRY)	20	ft
3a	FLOOR DIMENSIONS - LENGTH - WIDTH	207.777778 27	ft ft
3b	FLOOR AREA (LENGTH) X (WIDTH)	5610	ft ²
3c	ESTIMATED DURATION OF FIRE	2.5	min
4	PEAK FIRE INTENSITY (USE TABLE 2E & FIGURES 4-5 FOR GUIDANCE)	5763.48787	Btu/s
5	FIRE LOCATION FACTOR (4 FOR CORNER, 2 FOR WALL, 1 FOR CENTER)	1	--
6	EFFECTIVE HEAT RELEASE RATE ([BOX 4] X [BOX 5])	5763.48787	Btu/s
7	PLUME TEMPERATURE RISE AT TARGET (LOOK UP VALUE FROM TABLE 5E)	741.68	F
8a	MAXIMUM AMBIENT TEMPERATURE	90	F
8b	CRITICAL TEMPERATURE RISE AT TARGET ([BOX 1] - MAXIMUM AMBIENT TEMPERATURE)	610	F
9	CRITICAL - PLUME TEMPERATURE RISE ([BOX 8] - [BOX 7])	-131.68	F
IF THE ENTRY IN BOX 9 IS <= 0, STOP. OTHERWISE CONTINUE TO CALCULATE THE CRITICAL COMBUSTIBLE LOAD NEEDED TO RAISE THE AVERAGE TEMPERATURE BY THIS AMOUNT			
10	Q _{net} /V TO ACHIEVE TEMP RISE IN BOX 9 (LOOK UP VALUE FROM TABLE 7E)	0.00	Btu/ft ³
11	CALCULATED ENCLOSURE VOLUME, V ([BOX 3] X FLOOR AREA OF SPACE)	0	ft ³
12	CALCULATED CRITICAL Q _{net} ([BOX 10] X [BOX 11])	0	Btu
13	ESTIMATED HEAT LOSS FRACTION (REPRESENTATIVE VALUE : 0.7)	0.7	--
14	ESTIMATE OF CRITICAL Q _{tot} ([BOX 12]/(1 - [BOX 13]))	0	Btu
15	ESTIMATE OF ACTUAL Q _{tot} ([HRR] X [TIME]) = [BOX 4] X [TIME]	0	Btu
IF THE ENTRY IN BOX 15 IS LESS THAN THE VALUE IN BOX 14, CRITICAL CONDITIONS ARE NOT INDICATED FOR THE SCENARIO BEING EVALUATED. OTHERWISE, THE SCENARIO DOES NOT PASS THIS SCREENING PROCEDURE. FURTHER ANALYSIS REQUIRED.			

OPPD - Fort Calhoun Station
Fire Risk Analysis Refinement Project

FIXED COMBUSTIBLE / TARGET OUTSIDE PLUME

ENGLISH UNITS VERSION

1	TARGET DAMAGE THRESHOLD TEMPERATURE (LOOK UP VALUE FROM TABLE 1E)	700	F
2	HEIGHT OF TARGET ABOVE FIRE SOURCE (BASED ON SCENARIO GEOMETRY)	18	ft
3	HEIGHT FROM FIRE SOURCE TO CEILING (BASED ON SCENARIO GEOMETRY)	20	ft
3a	FLOOR DIMENSIONS - LENGTH	207.77778	ft
	- WIDTH	27	ft
3b	FLOOR AREA [LENGTH] X [WIDTH]	5610	ft ²
3c	ESTIMATED DURATION OF FIRE	2.5	min
4	RATIO OF TARGET HEIGHT/CEILING HEIGHT ((BOX 2)/[BOX 3])	0.90	--
IF THE VALUE IN BOX 4 IS > 0.85, COMPLETE BOXES 5-11; OTHERWISE, ENTER A VALUE OF 0 IN BOX 14 AND CONTINUE WITH BOX 15.			
5	LONGITUDINAL DISTANCE FROM FIRE SOURCE TO TARGET, L (BASED ON SCENARIO GEOMETRY)	6.4	ft
6	LONGITUDINAL DISTANCE TO HEIGHT RATIO, L/H ((BOX 5)/[BOX 3])	0.32	--
7	ENCLOSURE WIDTH, W (BASED ON SCENARIO GEOMETRY)	27	ft
8	HEIGHT TO WIDTH RATIO, H/W ([BOX 3]/[BOX 7])	0.74	--
9	PEAK FIRE INTENSITY (USE TABLE 2E FOR GUIDANCE)	5763.4879	Btu/s
10	FIRE LOCATION FACTOR (4 FOR CORNER, 2 FOR WALL, 1 FOR CENTER)	1	--
11	EFFECTIVE HEAT RATE RELEASE ((BOX 9) X [BOX 10])	5763.4879	Btu/s
12	PLUME TEMPERATURE RISE AT CEILING (LOOK UP VALUE FROM TABLE 5E)	741.68	F
13	CEILING JET TEMPERATURE RISE FACTOR AT TARGET (IF [BOX 4] < 0.85, ENTER 0, ELSE LOOK UP VALUE FROM TABLE 6A OR 6B)	0.641	--
14	CEILING JET TEMPERATURE RISE AT TARGET ((BOX 12) X [BOX 13])	475.60	F
15a	MAXIMUM AMBIENT TEMPERATURE	90	F
15b	CRITICAL TEMPERATURE RISE AT TARGET ([BOX 1] - MAXIMUM AMBIENT TEMPERATURE)	610	F
16	CRITICAL - CEILING JET TEMP. RISE AT TARGET ([BOX 15] - [BOX 14])	134.40	F
IF THE ENTRY IN BOX 16 IS <= 0, STOP. OTHERWISE CONTINUE TO CALCULATE THE CRITICAL COMBUSTIBLE LOAD NEEDED TO RAISE THE AVERAGE TEMPERATURE BY THE AMOUNT INDICATED IN BOX 16.			
17	Q _{net} /V TO ACHIEVE TEMP RISE IN BOX 16 (LOOK UP VALUE FROM TABLE 7E)	2.09	Btu/ft ³
18	CALCULATED ENCLOSURE VOLUME, V ([BOX 3B] X [BOX 3])	112,200	ft ³
19	CALCULATED CRITICAL Q _{net} ([BOX 17] X [BOX 18])	234,141	Btu
20	ESTIMATED HEAT LOSS FRACTION (RANGE: 0-1) (REPRESENTATIVE VALUE : 0.7)	0.7	--
21	ESTIMATE OF CRITICAL Q _{tot} ([BOX 19]/(1 - [BOX 20]))	780,471	Btu
22	ESTIMATE OF ACTUAL Q _{tot} (BASED ON ENERGY CONTENT OF FIRE SOURCE)	864,523	Btu
IF THE ENTRY IN BOX 22 IS LESS THAN THE VALUE IN BOX 21, CRITICAL CONDITIONS ARE NOT INDICATED FOR THE SCENARIO BEING EVALUATED. OTHERWISE, THE SCENARIO DOES NOT PASS THIS SCREENING PROCEDURE. FURTHER ANALYSIS REQUIRED.			

OPPD - Fort Calhoun Station
Fire Risk Analysis Refinement Project

FIXED COMBUSTIBLE / RADIANT EXPOSURE

ENGLISH UNITS VERSION

1	CRITICAL RADIANT FLUX TO TARGET (REPRESENTATIVE CONSERVATIVE VALUE = 1) (LOOK UP VALUE FROM TABLE 1E)	1	Btu/s/ft ²
2	PEAK FIRE INTENSITY (USE TABLE 2E FOR GUIDANCE)	5763.48787	Btu/s
3	RADIANT FRACTION OF HEAT RELEASE (REPRESENTATIVE VALUE = 0.4)	0.4	--
4	RADIANT HEAT RELEASE RATE ([BOX2]X[BOX3])	2305.39515	Btu/s
5	CRITICAL RADIANT FLUX DISTANCE (LOOK UP VALUE FROM TABLE 10E)	13.54	ft
6	ACTUAL DISTANCE BETWEEN SOURCE/TARGET (FROM FIRE COMPARTMENT CCDS)	0	ft
IF THE EXPOSURE FIRE IS LOCATED WITHIN THIS DISTANCE (INDICATED IN BOX 5) OF THE TARGET, CRITICAL CONDITIONS CAN OCCUR. OUTSIDE THIS RANGE, CRITICAL CONDITIONS ARE NOT INDICATED FOR THE SCENARIO UNDER CONSIDERATION.			

OPPD - Fort Calhoun Station
Fire Risk Analysis Refinement Project

SUPPRESSION
THERMALLY THICK TARGETS

ENGLISH UNITS VERSION

TARGET INFORMATION

1a	HEIGHT OF TARGET ABOVE FIRE SOURCE (BASED ON SCENARIO GEOMETRY)	16	ft
1b	RADIAL DISTANCE FROM FIRE SOURCE TO TARGET LINE OF SIGHT DISTANCE FROM FIRE SOURCE TO TARGET	0.1 16.00	ft
2	PEAK FIRE INTENSITY FROM BASIC SCREENING METHODOLOGY	5763.48787	Btu/s
3	FIRE LOCATION FACTOR (4 FOR CORNER, 2 FOR WALL, 1 FOR CENTER)	1	--
4	EFFECTIVE HEAT RELEASE RATE ((BOX 2) X (BOX 3))	5763.48787	Btu/s
6	MAXIMUM AMBIENT TEMPERATURE	75	F
7	PLUME TEMPERATURE RISE AT TARGET (LOOK UP VALUE FROM TABLE 5E)	1075.81	F
8	RADIANT FRACTION OF HEAT RELEASE (REPRESENTATIVE VALUE = 0.4)	0.4	--
9	RADIANT HEAT RELEASE RATE ((BOX 2) X (BOX 8))	2305.39515	Btu/s

DETECTOR INFORMATION

1	RATED ACTUATION TEMPERATURE OF DETECTOR (MANUFACTURERS DATA)	165	F
2	HEIGHT FROM FIRE SOURCE TO CEILING (BASED ON SCENARIO GEOMETRY)	20	ft
3	FLOOR DIMENSION - WIDTH	27	ft
4	LONGITUDINAL DISTANCE FROM FIRE SOURCE TO DETECTOR, L (BASED ON SCENARIO GEOMETRY)	1	ft
5	LONGITUDINAL DISTANCE TO HEIGHT RATIO, L/H ((BOX 4)/(BOX 2))	0.05	--
6	HEIGHT TO WIDTH RATIO, H/W ((BOX 2)/(BOX 3))	0.74	--
7	PEAK FIRE INTENSITY (USE TABLE 2E FOR GUIDANCE)	5763.48787	Btu/s
8	FIRE LOCATION FACTOR (4 FOR CORNER, 2 FOR WALL, 1 FOR CENTER)	1	--
9	EFFECTIVE FIRE INTENSITY ((BOX 7) X (BOX 8))	5763.48787	Btu/s
10	PLUME TEMPERATURE RISE AT CEILING (LOOK UP VALUE FROM TABLE 5E)	741.68	F
11	CEILING JET TEMPERATURE RISE FACTOR AT DETECTOR (LOOK UP VALUE FROM TABLE 6A OR 6B)	1.00	--
12	CEILING JET TEMPERATURE RISE AT DETECTOR ((BOX 10) X (BOX 11))	741.68	F

TIME TO TARGET DAMAGE

1	RADIATIVE HEAT FLUX AT TARGET (TABLE A-3E)	0.72	Btu/s/ft2
2a	TARGET LOCATION IN-PLUME(1), OUT-PLUME (2)	1	
2b	CONVECTIVE HEAT FLUX AT TARGET (TABLES A-4E AND A-5)	6.75	Btu/s/ft2
3	TOTAL HEAT FLUX AT TARGET ((BOX 1) + (BOX 2b))	7.47	Btu/s/ft2
4	TARGET THERMAL RESPONSE PARAMETER (TABLE A-7E)	34	--
5	ESTIMATED TIME TO TARGET DAMAGE (TABLE A-2E)	16	s

TIME TO DETECTOR ACTUATION

6	DETECTION DEVICE RATED TEMPERATURE RISE	90	F
7	GAS TEMPERATURE RISE AT DETECTOR (USE BASIC SCREENING METHODOLOGY)	742	F
8	DETECTOR TEMPERATURE RISE/GAS TEMPERATURE RISE ((BOX 6)/(BOX 7))	0.12	--
9	DIMENSIONLESS DETECTOR ACTUATION TIME (TABLE A-1)	0.13	--
10	TIME CONSTANT OF DETECTION DEVICE (TABLE A-6E OR MFG. DATA)	120	s
11	ESTIMATED TIME TO DETECTOR ACTUATION ((BOX 9) X (BOX 10))	15.52	s

OPPD - Fort Calhoun Station
Fire Risk Analysis Refinement Project
COMBUSTIBLE MATERIAL WORKSHEET

FUEL PROPERTIES - UNCONFINED SPILL

DESCRIPTION	
VOLUME (QUARTS)	3
NET HEAT OF COMBUSTION	17111
COMBUSTION EFFICIENCY	90%
UNIT HEAT RELEASE RATE	110
DENSITY	60

FLOW CHARACTERISTICS

DESCRIPTION		
SPECIFIC SPILL AREA	120.0	
SPILL AREA	84	SQ-FT
PEAK FIRE INTENSITY	8316	BTU/S
FIRE DURATION	10	SEC
	0.173	MIN

FUEL PROPERTIES - CONFINED SPILL

DESCRIPTION	
VOLUME (QUARTS)	3
NET HEAT OF COMBUSTION	17111
COMBUSTION EFFICIENCY	1
UNIT HEAT RELEASE RATE	110
DENSITY	60

FLOW CHARACTERISTICS

DESCRIPTION		
SPILL AREA	5.8	SQ-FT
PEAK FIRE INTENSITY	576	BTU/S
FIRE DURATION	150	SEC
	2.500	MIN

COMMENTS

OPPD - Fort Calhoun Station
Fire Risk Analysis Refinement Project

FIXED COMBUSTIBLE / TARGET IN PLUME

ENGLISH UNITS VERSION

1	TARGET DAMAGE THRESHOLD TEMPERATURE (USE TABLE 1E FOR GUIDANCE)	700	F
2	HEIGHT OF TARGET ABOVE FIRE SOURCE (BASED ON SCENARIO GEOMETRY)	9.1	ft
3	HEIGHT FROM FIRE SOURCE TO CEILING (BASED ON SCENARIO GEOMETRY)	20	ft
3a	FLOOR DIMENSIONS - LENGTH - WIDTH	207.777778 27	ft ft
3b	FLOOR AREA (LENGTH) X (WIDTH)	5610	ft ²
3c	ESTIMATED DURATION OF FIRE	2.5	min
4	PEAK FIRE INTENSITY USE TABLE 2E & FIGURES 4-5 FOR GUIDANCE)	576.401067	Btu/s
5	FIRE LOCATION FACTOR (4 FOR CORNER, 2 FOR WALL, 1 FOR CENTER)	1	--
6	EFFECTIVE HEAT RELEASE RATE ([BOX 4] X [BOX 5])	576.401067	Btu/s
7	PLUME TEMPERATURE RISE AT TARGET (LOOK UP VALUE FROM TABLE 5E)	593.69	F
8a	MAXIMUM AMBIENT TEMPERATURE	90	F
8b	CRITICAL TEMPERATURE RISE AT TARGET ([BOX 1] - MAXIMUM AMBIENT TEMPERATURE)	610	F
9	CRITICAL - PLUME TEMPERATURE RISE ([BOX 8] - [BOX 7])	16.31	F
IF THE ENTRY IN BOX 9 IS ≤ 0 , STOP. OTHERWISE CONTINUE TO CALCULATE THE CRITICAL COMBUSTIBLE LOAD NEEDED TO RAISE THE AVERAGE TEMPERATURE BY THIS AMOUNT			
10	Q_{net}/V TO ACHIEVE TEMP RISE IN BOX 9 (LOOK UP VALUE FROM TABLE 7E)	0.28	Btu/ft ³
11	CALCULATED ENCLOSURE VOLUME, V ([BOX 3] X FLOOR AREA OF SPACE)	112200	ft ³
12	CALCULATED CRITICAL Q_{net} ([BOX 10] X [BOX 11])	31,299	Btu
13	ESTIMATED HEAT LOSS FRACTION (REPRESENTATIVE VALUE : 0.7)	0.7	--
14	ESTIMATE OF CRITICAL Q_{tot} ([BOX 12]/(1 - [BOX 13]))	104,329	Btu
15	ESTIMATE OF ACTUAL Q_{tot} ([HRR] X [TIME]) = [BOX 4] X [TIME]	86,460	Btu
IF THE ENTRY IN BOX 15 IS LESS THAN THE VALUE IN BOX 14, CRITICAL CONDITIONS ARE NOT INDICATED FOR THE SCENARIO BEING EVALUATED. OTHERWISE, THE SCENARIO DOES NOT PASS THIS SCREENING PROCEDURE. FURTHER ANALYSIS REQUIRED.			

OPPD - Fort Calhoun Station
Fire Risk Analysis Refinement Project

FIXED COMBUSTIBLE / RADIANT EXPOSURE

ENGLISH UNITS VERSION

1	CRITICAL RADIANT FLUX TO TARGET (REPRESENTATIVE CONSERVATIVE VALUE = 1) (LOOK UP VALUE FROM TABLE 1E)	1	Btu/s/ft ²
2	PEAK FIRE INTENSITY (USE TABLE 2E FOR GUIDANCE)	576.401067	Btu/s
3	RADIANT FRACTION OF HEAT RELEASE (REPRESENTATIVE VALUE = 0.4)	0.4	--
4	RADIANT HEAT RELEASE RATE ((BOX2)X[BOX3])	230.560427	Btu/s
5	CRITICAL RADIANT FLUX DISTANCE (LOOK UP VALUE FROM TABLE 10E)	4.28	ft
6	ACTUAL DISTANCE BETWEEN SOURCE/TARGET (FROM FIRE COMPARTMENT CCDS)	0	ft
IF THE EXPOSURE FIRE IS LOCATED WITHIN THIS DISTANCE (INDICATED IN BOX 5) OF THE TARGET, CRITICAL CONDITIONS CAN OCCUR. OUTSIDE THIS RANGE, CRITICAL CONDITIONS ARE NOT INDICATED FOR THE SCENARIO UNDER CONSIDERATION.			