**NRC INSPECTION MANUAL**

APHB

INSPECTION MANUAL CHAPTER 0609 APPENDIX F ATTACHMENT 8

TABLES AND PLOTS SUPPORTING THE

PHASE 2 RISK QUANTIFICATION

TABLE OF CONTENTS

Overview of Attachment 8 1

Set A: Vertical and Radial ZOI A-1

Set B: Minimum HRR to Create a Damaging HGL B-1

Set C: HRR Profiles of Fires Involving Cable Trays for Different Ignition Sources C-1

Set D: Severity Factor versus Vertical Target Distance D-1

Set E: Severity Factor versus Radial Target Distance E-1

Set F: Failure Time versus Vertical Target Distance F-1

Set G: Failure Time versus Radial Target Distance G-1

Set H: Detector Actuation and Sprinkler Activation Times H-1

Overview of Attachment 8

This attachment consists of a collection of tables and plots that are used in support of a Phase 2 assessment. Various Fire Dynamics Tools (FDTs) from NUREG 1805 were used to generate the data that are presented in the tables and plots. To automate the process the FDT calculations were implemented in a series of spreadsheets. The assumptions and background for these calculations is discussed in Section 06.03 of IMC 0308, Attachment 3, Appendix F.

As an alternative to using the pre-calculated tables and plots, the analyst may choose to use the FDT spreadsheets supplied with NUREG-1805 to perform custom calculations. This approach would be useful to analyze cases for which the input parameters are outside the range of what was considered in the development of the tables and plots, or for which the assumptions may be either unconservative or overly conservative.

A total of eight sets of tables and plots (labeled A-H) were developed. The sets are briefly described below.

Set A - Vertical and Radial Zone of Influence (ZOI):

Table/plot set A provides the vertical and radial ZOI for fixed and transient ignition sources, and for confined liquid fuel pool fires and unconfined liquid fuel spill fires. It is used to screen ignition sources that cannot cause damage to components or cables in the fire area and that are not capable of causing fire to spread to secondary combustibles (Step 2.3.2), and to identify the damaged target set for a specified FDS 1 scenario (Step 2.5.1).

Set B - Minimum Heat Release Rate (HRR) to Create a Damaging Hot Gas Layer (HGL):

Table/plot set B provides the minimum HRR that is needed to create damaging HGL conditions for a range of compartment sizes and different target types. It is used to screen ignition sources that are not capable of generating a damaging HGL (Step 2.3.3), and to identify scenarios involving secondary combustibles that can cause development of a damaging HGL in the fire area (Step 2.5.2).

Set C - HRR Profiles of Fires Involving Cable Trays for Different Ignition Sources:

Table/plot set C provides the combined HRR of an ignition source and a vertical stack of between one and seven horizontal cable trays as a function of time for various ignition source-cable tray configurations. This set is used in conjunction with table/plot set B to determine if and when a fire scenario involving secondary combustibles will cause a damaging HGL in the fire area (Step 2.5.2).

Set D - Severity Factor versus Vertical Target Distance:

To develop table/plot set D, calculations were performed to determine the highest elevation at which a target will be damaged or a secondary combustible will ignite when the ignition source reaches the HRR that corresponds to a specified Severity Factor (SF). Each table and plot provides the elevations corresponding to SFs ranging from 0.02 to 0.95 for one of the fixed or transient ignition sources listed in Attachment 5, located either in the open or in a corner. Table/plot set D is used to conservatively estimate the SF for a target or secondary combustible located within the vertical ZOI based on its elevation above the ignition source (Step 2.6.1).

Set E - Severity Factor versus Radial Target Distance:

To develop table/plot set E, calculations were performed to determine the longest radial distance at which a target will be damaged or a secondary combustible will ignite when the ignition source reaches the HRR that corresponds to a specified SF. Each table and plot provides the radial distances corresponding to SFs ranging from 0.02 to 0.95 for one of the fixed or transient ignition sources listed in Attachment 5. Table/plot set E is used to conservatively estimate the SF for a target or secondary combustible located within the radial ZOI based on its distance from the ignition source (Step 2.6.1).

Set F - Failure Time versus Vertical Target Distance:

Table/plot set F is used to conservatively estimate the damage time of a target or the ignition time of a secondary combustible located within the vertical ZOI based on its elevation above the ignition source. This time is used in the calculation of the non-suppression probability (Step 2.7.1).

Set G - Failure Time versus Radial Target Distance:

Table/plot set G is used to conservatively estimate the damage time of a target or the ignition time of a secondary combustible located within the radial ZOI based on its radial distance from the ignition source. This time is used in the calculation of the non-suppression probability (Step 2.7.1).

Set H - Detector Actuation and Sprinkler Activation Times:

Table set H consists of three subsets:

* Tables to determine smoke detector actuation time as a function of the ceiling height above the fire and the radial distance between the detector and the fire (Step 2.7.2).
* Tables to determine sprinkler activation time for fixed and transient ignition source fires as a function of the ceiling height above the fire and the radial distance between the sprinkler head and the fire (Step 2.7.3).
* Tables to determine sprinkler activation time for fires with a priori unknown HRR profile as a function of the ceiling height above the fire and the radial distance between the sprinkler head and the fire (Step 2.7.3).

Appendix A. VERTICAL AND RADIAL ZONE OF INFLUENCE TABLES AND GRAPHS

TABLE OF CONTENTS

Set A: Overview and Assumptions A-2

Figure A.01: Vertical ZOI vs. Fixed or Transient Ignition Source HRR A-3

Figure A.02: Radial ZOI vs. Fixed or Transient Ignition Source HRR A-4

Figure A.03: Minimum Volume of Liquid Fuel Spill to Cover a Specified Area A-5

Figure A.04: Vertical ZOI of Confined Diesel Fuel and Fuel Oil Pool Fires A-6

Figure A.05: Vertical ZOI of Confined Lube and Mineral Oil Pool Fires A-7

Figure A.06: Vertical ZOI of Confined Silicone Fluid Pool Fires A-8

Figure A.07: Radial ZOI of Confined Diesel Fuel and Fuel Oil Pool Fires A-9

Figure A.08: Radial ZOI of Confined Lube and Mineral Oil Pool Fires A-10

Figure A.09: Radial ZOI of Confined Silicone Fluid Pool Fires A-11

Figure A.10: Vertical ZOI of Unconfined Diesel Fuel and Fuel Oil Spill Fires A-12

Figure A.11: Vertical ZOI of Unconfined Lube and Mineral Oil Spill Fires A-13

Figure A.12: Vertical ZOI of Unconfined Silicone Fluid Spill Fires A-14

Figure A.13: Radial ZOI of Unconfined Diesel Fuel and Fuel Oil Spill Fires A-15

Figure A.14: Radial ZOI of Unconfined Lube and Mineral Oil Spill Fires A-16

Figure A.15: Radial ZOI of Unconfined Silicone Fluid Spill Fires A-17

Set A: Overview and Assumptions

Table/plot set A provides the vertical and radial ZOI for fixed and transient ignition sources, and for confined liquid fuel pool fires and unconfined liquid fuel spill fires. It is used to screen ignition sources that cannot cause damage to components or cables in the fire area and that are not capable of causing fire to spread to secondary combustibles (Step 2.3.2), and to identify the damaged target set for a specified FDS 1 scenario (Step 2.5.1).

The assumptions and background for the calculations performed to develop the tables and plots in set A are discussed in Section 06.03.01 of IMC 0308, Attachment 3, Appendix F. The principal assumptions are as follows:

1. Ambient air properties: It is assumed that Ta = 77°F. This is the default value in FDT 9.
2. Convective part of the HRR,: A convective fraction () of 0.70 is assumed, which is representative of transient fires and conservative for cable fires. This is the default value in FDT 9.
3. Radiative part of the HRR, : The radiative part of the HRR is equal to , where is the radiative fraction, and is the HRR. Theoretically the sum of the convective and radiative fractions is equal to one, implying that should be equal to 0.3 since = 0.7.
4. HRR, : Ignition source screening for electrical enclosures, motors, pumps and transients is based on the 98th percentile of the peak HRR, as recommended in NUREG/CR-6850, Volume 2. The HRRs that were used in the vertical ZOI calculations are the 98th percentile peak HRRs given in Table A5.1 in Attachment 5, combined with the 75th percentile HRR of small electrical enclosures (from NUREG-2178, Table 7-1). Tables and plots were created that provide the vertical and radial ZOI for the 12 HRRs. In addition, vertical and radial ZOI vs. HRR plots were developed that cover the entire range of HRRs. Tables and plots were also developed that show the ZOI as a function of fire diameter for confined pool fires involving selected liquid fuels. Similar tables and plots were developed for unconfined spill fires that show the ZOI as a function of the volume of the fuel spill.
5. Fire diameter, D: The fire diameter is determined based on the assumption that the Froude number is equal to one. This assumption leads to reasonably conservative (i.e., small) fire diameters, as shown in Table 6.2.8 of of IMC 0308, Attachment 3, Appendix F.
6. Fire elevation (z = 0): The following guidance is used to determine the elevation of the fire base:
   1. For electrical enclosures, the fire base is placed at 1 ft. below the top of the enclosure as determined from a walkdown.
   2. For motors and pumps it is recommended to place the fire base at the top of the ignition source as determined from a walkdown.
   3. For transients a height of 2 ft. is recommended, and the fire base is at the top.
   4. Confined liquid pool fires and unconfined liquid spill fires are placed on the floor.

The vertical ZOI tables and plots for electrical enclosures are based on the distance between the top of the enclosure and the target. Since the fire base is at the top of other fixed and transient ignition sources, the ZOI read from the plot in Figure A.01 shall be increased by 1 ft. for motor, pump, and transient fires.

1. Fire location effects: Vertical ZOI tables and plots for fixed and transient ignition sources were developed for fires away (> 2 ft.) from walls and corners (referred to as “free-burn”), and for fires within 2 ft. of a corner. At the discretion of the analyst, a fire within 2 ft. of a wall can be treated either as a corner or as a free-burn fire.

|  |
| --- |
|  |
| Figure A.01: Vertical ZOI vs. Fixed or Transient Ignition Source HRR |
| (Free-Burn & Corner Configurations, Thermoset & Thermoplastic Targets) |

|  |
| --- |
|  |
| Figure A.02**:**  Radial ZOI vs. Fixed or Transient Ignition Source HRR |

|  |
| --- |
|  |
| Figure A.03**:** Minimum Volume of a Liquid Fuel Spill to Cover a Specified Area |

|  |
| --- |
|  |
| Figure A.04: Vertical ZOI of Confined Diesel Fuel and Fuel Oil Pool Fires |

|  |
| --- |
|  |
| Figure A.05: Vertical ZOI of Confined Lube and Mineral Oil Pool Fires |

|  |
| --- |
|  |
| Figure A.06: Vertical ZOI of Confined Silicone Liquid Pool Fires |

|  |
| --- |
|  |
| Figure A.07: Radial ZOI of Confined Diesel Fuel and Fuel Oil Pool Fires |

|  |
| --- |
|  |
| Figure A.08: Radial ZOI of Confined Lube and Mineral Oil Pool Fires |

|  |
| --- |
|  |
| Figure A.09: Radial ZOI of Confined Silicone Liquid Pool Fires |

|  |
| --- |
|  |
| Figure A.10: Vertical ZOI of Unconfined Diesel Fuel and Fuel Oil Spill Fires |

|  |
| --- |
|  |
| Figure A.11: Vertical ZOI of Unconfined Lube and Mineral Oil Spill Fires |

|  |
| --- |
|  |
| Figure A.12: Vertical ZOI of Unconfined Silicone Liquid Spill Fires |

|  |
| --- |
|  |
| Figure A.13: Radial ZOI of Unconfined Diesel Fuel and Fuel Oil Spill Fires |

|  |
| --- |
|  |
| Figure A.14: Radial ZOI of Unconfined Lube and Mineral Oil Spill Fires |

|  |
| --- |
|  |
| Figure A.15: Radial ZOI of Unconfined Silicone Liquid Spill Fires |

Appendix B. HOT GAS LAYER TABLES AND GRAPHS

TABLE OF CONTENTS

Set B: Overview and Assumptions B-2

Figure B.01: Minimum HRR to Create a Damaging HGL (TS Targets) B-3

Figure B.02: Minimum HRR to Create a Damaging HGL (TP Targets) B-4

Figure B.03: Minimum HRR to Create a Damaging HGL (SE Targets) B-5

Set B: Overview and Assumptions

Table/plot set B provides the minimum HRR that is needed to create damaging HGL conditions for a range of compartment sizes and different target types. It is used to screen ignition sources that are not capable of generating a damaging HGL (Step 2.3.3), and to identify scenarios involving secondary combustibles that can cause development of a damaging HGL in the fire area (Step 2.5.2).

The assumptions and background for the calculations performed to develop the tables and plots in set B are discussed in Section 06.03.02 of IMC 0308, Attachment 3, Appendix F. The principal assumptions are as follows:

1. An important assumption is that the compartment has openings that are large enough to allow sufficient ventilation to support the fire, which justifies the use of the method of McCaffrey, Quintiere, and Harkleroad to calculate the HGL temperature over the methods for closed and mechanically-vented compartments that are described in Chapter 2 of NUREG-1805. In addition, the opening is assumed to be a standard 3 ft. wide, 7 ft. high open doorway. Several plants transitioning to NFPA 805 made the same assumptions, and the NRC review of the LAR submitted by these plants concluded that these assumptions and the exclusive use of the MQH method are acceptable.
2. The ambient air temperature, Ta, is assumed to be 77°F.
3. The minimum HRR to create damaging HGL conditions was calculated for floor areas ranging from 100 to 4900 ft2, and ceiling heights between 10 and 30 ft. It is unlikely that a HGL can develop in a compartment with a floor area and ceiling height outside the upper limit of those ranges.
4. The compartment boundaries (floor, walls, and ceiling) are assumed to be constructed of concrete with thermal properties taken from Table 2-3 in NUREG-1805, and a thickness of 1 ft.
5. The heat transfer coefficient, hT, (see Equation 14 in Section 06.03.02 of IMC 0308, Attachment 3, Appendix F) is calculated at t = 1800 s. This is conservative because, for 1 ft.-thick concrete boundaries, hT decreases as a function of time, and the minimum HRR to cause a damaging HGL is usually reached before 30 minutes have elapsed.

|  |
| --- |
|  |
| Figure B.01: Minimum HRR to Create a Damaging HGL (TS Targets) |
|  |

|  |
| --- |
|  |
| Figure B.02: Minimum HRR to Create a Damaging HGL (TP Targets) |
|  |

|  |
| --- |
|  |
| Figure B.03: Minimum HRR to Create a Damaging HGL (SE Targets) |

Appendix C. HEAT RELEASE RATE PROFILES OF FIRES INVOLVING HORIZONTAL CABLE TRAYS

TABLE OF CONTENTS

Set C: Overview and Assumptions C-3

Figure C.01.a: Table of HRRs of 1.5 ft. Cable Tray Fires C-4

Figure C.01.b: HRR Plots of 1.5 ft. TS Cable Tray Fires C-5

Figure C.01.c: HRR Plots of 1.5 ft. TP Cable Tray Fires C-5

Figure C.02.a: Table of HRRs of 3.0 ft. Cable Tray Fires C-6

Figure C.02.b: HRR Plots of 3.0 ft. TS Cable Tray Fires C-7

Figure C.02.c: HRR Plots of 3.0 ft. TP Cable Tray Fires C-7

Figure C.03.a: Table of HRRs of Motor & 1.5 ft. Cable Tray Fires C-8

Figure C.03.b: HRR Plots of Motor & 1.5 ft. TS Cable Tray Fires C-9

Figure C.03.c: HRR Plots of Motor & 1.5 ft. TP Cable Tray Fires C-9

Figure C.04.a: Table of HRRs of Motor & 3.0 ft. Cable Tray Fires C-10

Figure C.04.b: HRR Plots of Motor & 3.0 ft. TS Cable Tray Fires C-11

Figure C.04.c: HRR Plots of Motor & 3.0 ft. TP Cable Tray Fires C-11

Figure C.05.a: Table of HRRs of Pump & 1.5 ft. Cable Tray Fires C-12

Figure C.05.b: HRR Plots of Pump & 1.5 ft. TS Cable Tray Fires C-13

Figure C.05.c: HRR Plots of Pump & 1.5 ft. TP Cable Tray Fires C-13

Figure C.06.a: Table of HRRs of Pump & 3.0 ft. Cable Tray Fires C-14

Figure C.06.b: HRR Plots of Pump & 3.0 ft. TS Cable Tray Fires C-15

Figure C.06.c: HRR Plots of Pump & 3.0 ft. TP Cable Tray Fires C-15

Figure C.07.a: Table of HRRs of Loose Transient & 1.5 ft. Cable Tray Fires C-16

Figure C.07.b: HRR Plots of Loose Transient & 1.5 ft. TS Cable Tray Fires C-17

Figure C.07.c: HRR Plots of Loose Transient & 1.5 ft. TP Cable Tray Fires C-17

Figure C.08.a: Table of HRRs of Loose Transient & 3.0 ft. Cable Tray Fires C-18

Figure C.08.b: HRR Plots of Loose Transient & 3.0 ft. TS Cable Tray Fires C-19

Figure C.08.c: HRR Plots of Loose Transient & 3.0 ft. TP Cable Tray Fires C-19

Figure C.09.a: Table of HRRs of Contained Transient & 1.5 ft. Cable Tray Fires C-20

Figure C.09.b: HRR Plots of Contained Transient & 1.5 ft. TS Cable Tray Fires C-21

Figure C.09.c: HRR Plots of Contained Transient & 1.5 ft. TP Cable Tray Fires C-21

Figure C.10.a: Table of HRRs of Contained Transient & 3.0 ft. Cable Tray Fires C-22

Figure C.10.b: HRR Plots of Contained Transient & 3.0 ft. TS Cable Tray Fires C-23

Figure C.10.c: HRR Plots of Contained Transient & 3.0 ft. TP Cable Tray Fires C-23

Figure C.11.a: Table of HRRs of Small Enclosure & 1.5 ft. Cable Tray Fires C-24

Figure C.11.b: HRR Plots of Small Enclosure & 1.5 ft. TS Cable Tray Fires C-25

Figure C.11.c: HRR Plots of Small Enclosure & 1.5 ft. TP Cable Tray Fires C-25

Figure C.12.a: Table of HRRs of Small Enclosure & 3.0 ft. Cable Tray Fires C-26

Figure C.12.b: HRR Plots of Small Enclosure & 3.0 ft. TS Cable Tray Fires C-27

Figure C.12.c: HRR Plots of Small Enclosure & 3.0 ft. TP Cable Tray Fires C-27

Figure C.13.a: Table of HRRs of MCC/BC & 1.5 ft. Cable Tray Fires C-28

Figure C.13.b: HRR Plots of MCC/BC & 1.5 ft. TS Cable Tray Fires C-29

Figure C.13.c: HRR Plots of MCC/BC & 1.5 ft. TP Cable Tray Fires C-29

Figure C.14.a: Table of HRRs of MCC/BC & 3.0 ft. Cable Tray Fires C-30

Figure C.14.b: HRR Plots of MCC/BC & 3.0 ft. TS Cable Tray Fires C-31

Figure C.14.c: HRR Plots of MCC/BC & 3.0 ft. TP Cable Tray Fires C-31

Figure C.15.a: Table of HRRs of SWGR/LC & 1.5 ft. Cable Tray Fires C-32

Figure C.15.b: HRR Plots of SWGR/LC & 1.5 ft. TS Cable Tray Fires C-33

Figure C.15.c: HRR Plots of SWGR/LC & 1.5 ft. TP Cable Tray Fires C-33

Figure C.16.a: Table of HRRs of SWGR/LC & 3.0 ft. Cable Tray Fires C-34

Figure C.16.b: HRR Plots of SWGR/LC & 3.0 ft. TS Cable Tray Fires C-35

Figure C.16.c: HRR Plots of SWGR/LC & 3.0 ft. TP Cable Tray Fires C-35

Figure C.17.a: Table of HRRs of Power Inverter & 1.5 ft. Cable Tray Fires C-36

Figure C.17.b: HRR Plots of Power Inverter & 1.5 ft. TS Cable Tray Fires C-37

Figure C.17.c: HRR Plots of Power Inverter & 1.5 ft. TP Cable Tray Fires C-37

Figure C.18.a: Table of HRRs of Power Inverter & 3.0 ft. Cable Tray Fires C-38

Figure C.18.b: HRR Plots of Power Inverter & 3.0 ft. TS Cable Tray Fires C-39

Figure C.18.c: HRR Plots of Power Inverter & 3.0 ft. TP Cable Tray Fires C-39

Figure C.19.a: Table of HRRs of Closed Medium Enclosure & 1.5 ft. Cable Tray Fires C-40

Figure C.19.b: HRR Plots of Closed Medium Enclosure & 1.5 ft. TS Cable Tray Fires C-41

Figure C.19.c: HRR Plots of Closed Medium Enclosure & 1.5 ft. TP Cable Tray Fires C-41

Figure C.20.a: Table of HRRs of Closed Medium Enclosure & 3.0 ft. Cable Tray Fires C-42

Figure C.20.b: HRR Plots of Closed Medium Enclosure & 3.0 ft. TS Cable Tray Fires C-43

Figure C.20.c: HRR Plots of Closed Medium Enclosure & 3.0 ft. TP Cable Tray Fires C-43

Figure C.21.a: Table of HRRs of Open Medium Enclosure & 1.5 ft. Cable Tray Fires C-44

Figure C.21.b: HRR Plots of Open Medium Enclosure & 1.5 ft. TS Cable Tray Fires C-45

Figure C.21.c: HRR Plots of Open Medium Enclosure & 1.5 ft. TP Cable Tray Fires C-45

Figure C.22.a: Table of HRRs of Open Medium Enclosure & 3.0 ft. Cable Tray Fires C-46

Figure C.22.b: HRR Plots of Open Medium Enclosure & 3.0 ft. TS Cable Tray Fires C-47

Figure C.22.c: HRR Plots of Open Medium Enclosure & 3.0 ft. TP Cable Tray Fires C-47

Figure C.23.a: Table of HRRs of Closed Large Enclosure & 1.5 ft. Cable Tray Fires C-48

Figure C.23.b: HRR Plots of Closed Large Enclosure & 1.5 ft. TS Cable Tray Fires C-49

Figure C.23.c: HRR Plots of Closed Large Enclosure & 1.5 ft. TP Cable Tray Fires C-49

Figure C.24.a: Table of HRRs of Closed Large Enclosure & 3.0 ft. Cable Tray Fires C-50

Figure C.24.b: HRR Plots of Closed Large Enclosure & 3.0 ft. TS Cable Tray Fires C-51

Figure C.24.c: HRR Plots of Closed Large Enclosure & 3.0 ft. TP Cable Tray Fires C-51

Figure C.25.a: Table of HRRs of Open Large Enclosure & 1.5 ft. Cable Tray Fires C-52

Figure C.25.b: HRR Plots of Open Large Enclosure & 1.5 ft. TS Cable Tray Fires C-53

Figure C.25.c: HRR Plots of Open Large Enclosure & 1.5 ft. TP Cable Tray Fires C-53

Figure C.26.a: Table of HRRs of Open Large Enclosure & 3.0 ft. Cable Tray Fires C-54

Figure C.26.b: HRR Plots of Open Large Enclosure & 3.0 ft. TS Cable Tray Fires C-55

Figure C.26.c: HRR Plots of Open Large Enclosure & 3.0 ft. TP Cable Tray Fires C-55

Set C: Overview and Assumptions

Table/plot set C provides the combined HRR of an ignition source and a vertical stack of between one and seven horizontal cable trays as a function of time for various ignition source-cable tray configurations. This set is used in conjunction with table/plot set B to determine if and when a fire scenario involving secondary combustibles will cause a damaging HGL in the fire area (Step 2.5.2).

The assumptions and background for the calculations performed to develop the tables and plots in set C are discussed in Section 06.03.03 of IMC 0308, Attachment 3, Appendix F. The principal assumptions are as follows:

1. The FLASH-CAT model was used to calculate the HRR of vertical stacks of horizontal cable trays. The model is described in Chapter 9 of NUREG/CR-7010, Vol. 1, and in Section 06.03.03 of IMC 0308, Attachment 3, Appendix F.
2. The HRR as a function of time for an ignition source in combination with a vertical stack of cable trays was calculated at 1 minute intervals for the following ignition source-cable tray configurations:
3. Ignition source-cable tray HRR tables and plots were developed for all fixed and transient ignition sources listed in Table A5.1 of Attachment 5.
4. In addition, HRR tables and plots were developed for cable tray fires without an ignition source. These tables and plots can be used to determine the HRR of cable trays fires that are ignited by a confined liquid fuel pool fire or an unconfined liquid fuel spill fire by adding the HRR of the confined liquid fuel pool fire or unconfined liquid fuel spill fire. The HRRs of confined liquid fuel pool fires and unconfined liquid fuel spill fires are tabulated in table/plot set A.
5. HRR tables and plots were developed for cable trays widths of 1.5 and 3 ft. The calculated HRR values for 1.5 ft. wide trays can be used for 1 ft. and 2 ft. wide trays. The calculated HRR values for 3.0 ft. wide trays can be used for single trays and multiple trays side-by-side with a total width greater than 2 ft.
6. The trays were assumed to be 24 ft. long and ignited at the center to ensure that it would take at least one hour for the flame to spread to the end of the trays.
7. The assumed spacing between trays was 1 ft.
8. HRR tables and plots were developed for stacks of one through seven trays filled with TS and TP cables. The HRR tables and plots for TS cables can also be used for Kerite cables.
9. The table/plot set C HRRs for TS cables were calculated assuming 75% of the trays are filled with cables that have the characteristics of cable #16 in NUREG/CR-7010, Vol. 1. This cable was chosen because, of all the TS cables that were tested, it results in the highest amount of active polymer in the trays. The tables and plots for TP cables were developed in the assumption that 75% of the trays are filled with cables that have the characteristics of cable #701 in NUREG/CR-7010, Vol. 1, which was the only true TP cable that was tested. The input parameters for the cable tray fire propagation model calculations are given in Section 06.03.03 of IMC 0308, Attachment 3, Appendix F (see Table 6.2.10).

|  |
| --- |
|  |
| Figure C.01.a: Table of HRRs of 1.5 ft. Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.01.b: HRR Plots of 1.5 ft. TS Cable Tray Fires |
|  |
| Figure C.01.c: HRR Plots of 1.5 ft. TP Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.02.a: Table of HRRs of 3.0 ft. Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.02.b: HRR Plots of 3.0 ft. TS Cable Tray Fires |
|  |
| Figure C.02.c: HRR Plots of 3.0 ft. TP Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.03.a: Table of HRRs of Motor & 1.5 ft. Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.03.b: HRR Plots of Motor & 1.5 ft. TS Cable Tray Fires |
|  |
| Figure C.03.c: HRR Plots of Motor & 1.5 ft. TP Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.04.a: Table of HRRs of Motor & 3.0 ft. Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.04.b: HRR Plots of Motor & 3.0 ft. TS Cable Tray Fires |
|  |
| Figure C.04.c: HRR Plots of Motor & 3.0 ft. TP Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.05.a: Table of HRRs of Pump & 1.5 ft. Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.05.b: HRR Plots of Pump & 1.5 ft. TS Cable Tray Fires |
|  |
| Figure C.05.c: HRR Plots of Pump & 1.5 ft. TP Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.06.a: Table of HRRs of Pump & 3.0 ft. Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.06.b: HRR Plots of Pump & 3.0 ft. TS Cable Tray Fires |
|  |
| Figure C.06.c: HRR Plots of Pump & 3.0 ft. TP Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.07.a: Table of HRRs of Loose Transient & 1.5 ft. Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.07.b: HRR Plots of Loose Transient & 1.5 ft. TS Cable Tray Fires |
|  |
| Figure C.07.c: HRR Plots of Loose Transient & 1.5 ft. TP Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.08.a: Table of HRRs of Loose Transient & 3.0 ft. Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.08.b: HRR Plots of Loose Transient & 3.0 ft. TS Cable Tray Fires |
|  |
| Figure C.08.c: HRR Plots of Loose Transient & 3.0 ft. TP Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.09.a: Table of HRRs of Contained Transient & 1.5 ft. Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.09.b: HRR Plots of Contained Transient & 1.5 ft. TS Cable Tray Fires |
|  |
| Figure C.09.c: HRR Plots of Contained Transient & 1.5 ft. TP Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.10.a: Table of HRRs of Contained Transient & 3.0 ft. Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.10.b: HRR Plots of Contained Transient & 3.0 ft. TS Cable Tray Fires |
|  |
| Figure C.10.c: HRR Plots of Contained Transient & 3.0 ft. TP Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.11.a: Table of HRRs of Small Enclosure & 1.5 ft. Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.11.b: HRR Plots of Small Enclosure & 1.5 ft. TS Cable Tray Fires |
|  |
| Figure C.11.c: HRR Plots of Small Enclosure & 1.5 ft. TP Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.12.a: Table of HRRs of Small Enclosure & 3.0 ft. Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.12.b: HRR Plots of Small Enclosure & 3.0 ft. TS Cable Tray Fires |
|  |
| Figure C.12.c: HRR Plots of Small Enclosure & 3.0 ft. TP Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.13.a: Table of HRRs of MCC/Battery Charger & 1.5 ft. Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.13.b: HRR Plots of MCC/Battery Charger & 1.5 ft. TS Cable Tray Fires |
|  |
| Figure C.13.c: HRR Plots of MCC/Battery Charger & 1.5 ft. TP Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.14.a: Table of HRRs of MCC/Battery Charger & 3.0 ft. Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.14.b: HRR Plots of MCC/Battery Charger & 3.0 ft. TS Cable Tray Fires |
|  |
| Figure C.14.c: HRR Plots of MCC/Battery Charger & 3.0 ft. TP Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.15.a: Table of HRRs of Switchgear/Load Center & 1.5 ft. Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.15.b: HRR Plots of Switchgear/Load Center & 1.5 ft. TS Cable Tray Fires |
|  |
| Figure C.15.c: HRR Plots of Switchgear/Load Center & 1.5 ft. TP Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.16.a: Table of HRRs of Switchgear/Load Center & 3.0 ft. Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.16.b: HRR Plots of Switchgear/Load Center & 3.0 ft. TS Cable Tray Fires |
|  |
| Figure C.16.c: HRR Plots of Switchgear/Load Center & 3.0 ft. TP Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.17.a: Table of HRRs of Power Inverter & 1.5 ft. Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.17.b: HRR Plots of Power Inverter & 1.5 ft. TS Cable Tray Fires |
|  |
| Figure C.17.c: HRR Plots of Power Inverter & 1.5 ft. TP Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.18.a: Table of HRRs of Power Inverter & 3.0 ft. Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.18.b: HRR Plots of Power Inverter & 3.0 ft. TS Cable Tray Fires |
|  |
| Figure C.18.c: HRR Plots of Power Inverter & 3.0 ft. TP Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.19.a: Table of HRRs of Closed Medium Enclosure & 1.5 ft. Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.19.b: HRR Plots of Closed Medium Enclosure & 1.5 ft. TS Cable Tray Fires |
|  |
| Figure C.19.c: HRR Plots of Closed Medium Enclosure & 1.5 ft. TP Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.20.a: Table of HRRs of Closed Medium Enclosure & 3.0 ft. Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.20.b: HRR Plots of Closed Medium Enclosure & 3.0 ft. TS Cable Tray Fires |
|  |
| Figure C.20.c: HRR Plots of Closed Medium Enclosure & 3.0 ft. TP Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.21.a: Table of HRRs of Open Medium Enclosure & 1.5 ft. Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.21.b: HRR Plots of Open Medium Enclosure & 1.5 ft. TS Cable Tray Fires |
|  |
| Figure C.21.c: HRR Plots of Open Medium Enclosure & 1.5 ft. TP Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.22.a: Table of HRRs of Open Medium Enclosure & 3.0 ft. Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.22.b: HRR Plots of Open Medium Enclosure & 3.0 ft. TS Cable Tray Fires |
|  |
| Figure C.22.c: HRR Plots of Open Medium Enclosure & 3.0 ft. TP Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.23.a: Table of HRRs of Closed Large Enclosure & 1.5 ft. Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.23.b: HRR Plots of Closed Large Enclosure & 1.5 ft. TS Cable Tray Fires |
|  |
| Figure C.23.c: HRR Plots of Closed Large Enclosure & 1.5 ft. TP Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.24.a: Table of HRRs of Closed Large Enclosure & 3.0 ft. Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.24.b: HRR Plots of Closed Large Enclosure & 3.0 ft. TS Cable Tray Fires |
|  |
| Figure C.24.c: HRR Plots of Closed Large Enclosure & 3.0 ft. TP Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.25.a: Table of HRRs of Open Large Enclosure & 1.5 ft. Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.25.b: HRR Plots of Open Large Enclosure & 1.5 ft. TS Cable Tray Fires |
|  |
| Figure C.25.c: HRR Plots of Open Large Enclosure & 1.5 ft. TP Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.26.a: Table of HRRs of Open Large Enclosure & 3.0 ft. Cable Tray Fires |

|  |
| --- |
|  |
| Figure C.26.b: HRR Plots of Open Large Enclosure & 3.0 ft. TS Cable Tray Fires |
|  |
| Figure C.26.c: HRR Plots of Open Large Enclosure & 3.0 ft. TP Cable Tray Fires |

Appendix D. SEVERITY FACTOR VS. VERTICAL DISTANCE TO TARGET ABOVE IGNTION SOURCE

TABLE OF CONTENTS

Set D: Overview and Assumptions D-2

Figure D.01: Motor, Pump, and Transient Fires (Free-Burn Configuration, TS Targets) D-3

Figure D.02: Motor, Pump, and Transient Fires (Corner Configuration, TS Targets) D-4

Figure D.03: Motor, Pump, and Transient Fires (Free-Burn Configuration, TP Targets) D-5

Figure D.04: Motor, Pump, and Transient Fires (Corner Configuration, TP Targets) D-6

Figure D.05: Electrical Enclosure Set 1 (Free-Burn Configuration, TS Targets) D-7

Figure D.06: Electrical Enclosure Set 1 (Corner Configuration, TS Targets) D-8

Figure D.07: Electrical Enclosure Set 1 (Free-Burn Configuration, TP Targets) D-9

Figure D.08: Electrical Enclosure Set 1 (Corner Configuration, TP Targets) D-10

Figure D.09: Electrical Enclosure Set 2 (Free-Burn Configuration, TS Targets) D-11

Figure D.10: Electrical Enclosure Set 2 (Corner Configuration, TS Targets) D-12

Figure D.11: Electrical Enclosure Set 2 (Free-Burn Configuration, TP Targets) D-13

Figure D.12: Electrical Enclosure Set 2 (Corner Configuration, TP Targets) D-14

Set D: Overview and Assumptions

To develop table/plot set D, calculations were performed to determine the highest elevation at which a target will be damaged or a secondary combustible will ignite when the ignition source reaches the HRR that corresponds to a specified Severity Factor (SF). Each table and plot provides the elevations corresponding to SFs ranging from 0.02 to 0.95 for one of the fixed or transient ignition sources listed in Attachment 5, located either in the open or in a corner. Table/plot set D is used to conservatively estimate the SF for a target or secondary combustible located within the vertical ZOI based on its elevation above the ignition source (Step 2.6.1).

The assumptions and background for the calculations performed to develop the tables and plots in set D are discussed in Section 06.03.04 of IMC 0308, Attachment 3, Appendix F. Since these calculations were based on FDT 9, the same assumptions were made as in the development of the tables and plots for the vertical ZOI of fixed and transient ignition sources in set A, with one exception. More specifically, the fire diameter for a given ignition source was assumed to be constant during the t2 growth stage and equal to that assumed in the development of the tables and plots in set A, except during the period when the HRR is below one fifth of the 98th percentile of the peak HRR. When the HRR is smaller than one fifth of the peak HRR, the fire diameter was reduced to keep the Froude number at 0.2, which is the lower limit of the validated range reported in NUREG-1824 Supplement 1.

|  |
| --- |
|  |
| Figure D.01: Severity Factor vs. Vertical Target Distance for Motor, Pump and Transient Fires |
| (Free-Burn Configuration, TS Cable Targets) |
|  |
| Figure D.02: Severity Factor vs. Vertical Target Distance for Motor, Pump and Transient Fires |
| (Corner Configuration, TS Cable Targets) |
|  |
| Figure D.03: Severity Factor vs. Vertical Target Distance for Motor, Pump and Transient Fires |
| (Free-Burn Configuration, TP Cable Targets) |
|  |
| Figure D.04: Severity Factor vs. Vertical Target Distance for Motor, Pump and Transient Fires |
| (Corner Configuration, TP Cable Targets) |
|  |
| Figure D.05: Severity Factor vs. Vertical Target Distance for Electrical Enclosures (Set 1) |
| (Free-Burn Configuration, TS Cable Targets) |

|  |
| --- |
|  |
| Figure D.06: Severity Factor vs. Vertical Target Distance for Electrical Enclosures (Set 1) |
| (Corner Configuration, TS Cable Targets) |

|  |
| --- |
|  |
| Figure D.07: Severity Factor vs. Vertical Target Distance for Electrical Enclosures (Set 1) |
| (Free-Burn Configuration, TP Cable Targets) |

|  |
| --- |
|  |
| Figure D.08: Severity Factor vs. Vertical Target Distance for Electrical Enclosures (Set 1) |
| (Corner Configuration, TP Cable Targets) |

|  |
| --- |
|  |
| Figure D.09: Severity Factor vs. Vertical Target Distance for Electrical Enclosures (Set 2) |
| (Free-Burn Configuration, TS Cable Targets) |

|  |
| --- |
|  |
| Figure D.10: Severity Factor vs. Vertical Target Distance for Electrical Enclosures (Set 2) |
| (Corner Configuration, TS Cable Targets) |

|  |
| --- |
|  |
| Figure D.11: Severity Factor vs. Vertical Target Distance for Electrical Enclosures (Set 2) |
| (Free-Burn Configuration, TP Cable Targets) |

|  |
| --- |
|  |
| Figure D.12: Severity Factor vs. Vertical Target Distance for Electrical Enclosures (Set 2) |
| (Corner Configuration, TP Cable Targets) |

Appendix E. SEVERITY FACTOR VS. RADIAL DISTANCE FROM IGNTION SOURCE TO TARGET

TABLE OF CONTENTS

Set E: Overview and Assumptions E-2

Figure E.01: Motor, Pump, and Transient Fires (TS Cable Targets) E-3

Figure E.02: Motor, Pump, and Transient Fires (TP Cable Targets) E-4

Figure E.03: Motor, Pump, and Transient Fires (SE Targets) E-5

Figure E.04: Electrical Enclosure Set 1 (TS Cable Targets) E-6

Figure E.05: Electrical Enclosure Set 1 (TP Cable Targets) E-7

Figure E.06: Electrical Enclosure Set 1 (SE Targets) E-8

Figure E.07: Electrical Enclosure Set 2 (TS Cable Targets) E-9

Figure E.08: Electrical Enclosure Set 2 (TP Cable Targets) E-10

Figure E.09: Electrical Enclosure Set 2 (SE Targets) E-11

Set E: Overview and Assumptions

To develop table/plot set E, calculations were performed to determine the longest radial distance at which a target will be damaged or a secondary combustible will ignite when the ignition source reaches the HRR that corresponds to a specified SF. Each table and plot provides the radial distances corresponding to SFs ranging from 0.02 to 0.95 for one of the fixed or transient ignition sources listed in Attachment 5. Table/plot set E is used to conservatively estimate the SF for a target or secondary combustible located within the radial ZOI based on its distance from the ignition source (Step 2.6.1).

The assumptions and background for the calculations performed to develop the tables and plots in set E are discussed in Section 06.03.05 of IMC 0308, Attachment 3, Appendix F. Since these calculations were based on FDT 5 (Point Source Model), the same assumptions were made as in the development of the tables and plots for the radial ZOI of fixed and transient ignition sources in set A.

|  |
| --- |
|  |
| Figure E.01: Severity Factor vs. Radial Target Distance for Motor, Pump and Transient Fires |
| (TS Cable Targets) |

|  |
| --- |
|  |
| Figure E.02: Severity Factor vs. Radial Target Distance for Motor, Pump and Transient Fires |
| (TP Cable Targets) |

|  |
| --- |
|  |
| Figure E.03: Severity Factor vs. Radial Target Distance for Motor, Pump and Transient Fires |
| (SE Targets) |

|  |
| --- |
|  |
| Figure E.04: Severity Factor vs. Radial Target Distance for Electrical Enclosures (Set 1) |
| (TS Cable Targets) |

|  |
| --- |
|  |
| Figure E.05: Severity Factor vs. Radial Target Distance for Electrical Enclosures (Set 1) |
| (TP Cable Targets) |

|  |
| --- |
|  |
| Figure E.06: Severity Factor vs. Radial Target Distance for Electrical Enclosures (Set 1) |
| (SE Targets) |

|  |
| --- |
|  |
| Figure E.07: Severity Factor vs. Radial Target Distance for Electrical Enclosures (Set 2) |
| (TS Cable Targets) |

|  |
| --- |
|  |
| Figure E.08: Severity Factor vs. Radial Target Distance for Electrical Enclosures (Set 2) |
| (TP Cable Targets) |

|  |
| --- |
|  |
| Figure E.09: Severity Factor vs. Radial Target Distance for Electrical Enclosures (Set 2) |
| (SE Targets) |

Appendix F. FAILURE TIME VS. VERTICAL DISTANCE TO TARGET ABOVE IGNTION SOURCE

TABLE OF CONTENTS

Set F: Overview and Assumptions F-2

Figure F.01: Motor, Pump, and Transient Fires (Free-Burn Configuration, TS Targets) F-3

Figure F.02: Motor, Pump, and Transient Fires (Corner Configuration, TS Targets) F-4

Figure F.03: Motor, Pump, and Transient Fires (Free-Burn Configuration, TP Targets) F-5

Figure F.04: Motor, Pump, and Transient Fires (Corner Configuration, TP Targets) F-6

Figure F.05: Electrical Enclosure Set 1 (Free-Burn Configuration, TS Targets) F-7

Figure F.06: Electrical Enclosure Set 1 (Corner Configuration, TS Targets) F-8

Figure F.07: Electrical Enclosure Set 1 (Free-Burn Configuration, TP Targets) F-9

Figure F.08: Electrical Enclosure Set 1 (Corner Configuration, TP Targets) F-10

Figure F.09: Electrical Enclosure Set 2 (Free-Burn Configuration, TS Targets) F-11

Figure F.10: Electrical Enclosure Set 2 (Corner Configuration, TS Targets) F-12

Figure F.11: Electrical Enclosure Set 2 (Free-Burn Configuration, TP Targets) F-13

Figure F.12: Electrical Enclosure Set 2 (Corner Configuration, TP Targets) F-14

Set F: Overview and Assumptions

Table/plot set F is used to conservatively estimate the damage time of a target or the ignition time of a secondary combustible located within the vertical ZOI based on its elevation above the ignition source. This time is used in the calculation of the non-suppression probability (Step 2.7.1).

The assumptions and background for the calculations performed to develop the tables and plots in set F are discussed in Section 06.03.06 of IMC 0308, Attachment 3, Appendix F. Since the failure times were obtained as part of the Severity Factor calculations, the assumption were the same as for table/plot set D.

|  |
| --- |
|  |
| Figure F.01: Failure Time vs. Vertical Target Distance for Motor, Pump and Transient Fires |
| (Free-Burn Configuration, TS Cable Targets) |

|  |
| --- |
|  |
| Figure F.02: Failure Time vs. Vertical Target Distance for Motor, Pump and Transient Fires |
| (Corner Configuration, TS Cable Targets) |

|  |
| --- |
|  |
| Figure F.03: Failure Time vs. Vertical Target Distance for Motor, Pump and Transient Fires |
| (Free-Burn Configuration, TP Cable Targets) |

|  |
| --- |
|  |
| Figure F.04: Failure Time vs. Vertical Target Distance for Motor, Pump and Transient Fires |
| (Corner Configuration, TP Cable Targets) |

|  |
| --- |
|  |
| Figure F.05: Failure Time vs. Vertical Target Distance for Electrical Enclosures (Set 1) |
| (Free-Burn Configuration, TS Cable Targets) |

|  |
| --- |
|  |
| Figure F.06: Failure Time vs. Vertical Target Distance for Electrical Enclosures (Set 1) |
| (Corner Configuration, TS Cable Targets) |

|  |
| --- |
|  |
| Figure F.07: Failure Time vs. Vertical Target Distance for Electrical Enclosures (Set 1) |
| (Free-Burn Configuration, TP Cable Targets) |

|  |
| --- |
|  |
| Figure F.08: Failure Time vs. Vertical Target Distance for Electrical Enclosures (Set 1) |
| (Corner Configuration, TP Cable Targets) |

|  |
| --- |
|  |
| Figure F.09: Failure Time vs. Vertical Target Distance for Electrical Enclosures (Set 2) |
| (Free-Burn Configuration, TS Cable Targets) |

|  |
| --- |
|  |
| Figure F.10: Failure Time vs. Vertical Target Distance for Electrical Enclosures (Set 2) |
| (Corner Configuration, TS Cable Targets) |

|  |
| --- |
|  |
| Figure F.11: Failure Time vs. Vertical Target Distance for Electrical Enclosures (Set 2) |
| (Free-Burn Configuration, TP Cable Targets) |

|  |
| --- |
|  |
| Figure F.12: Failure Time vs. Vertical Target Distance for Electrical Enclosures (Set 2) |
| (Corner Configuration, TP Cable Targets) |

Appendix G. FAILURE TIME VS. RADIAL DISTANCE FROM IGNTION SOURCE TO TARGET

TABLE OF CONTENTS

Set G: Overview and Assumptions G-2

Figure G.01: Motor, Pump, and Transient Fires (TS Cable Targets) G-3

Figure G.02: Motor, Pump, and Transient Fires (TP Cable Targets) G-4

Figure G.03: Motor, Pump, and Transient Fires (SE Targets) G-5

Figure G.04: Electrical Enclosure Set 1 (TS Cable Targets) G-6

Figure G.05: Electrical Enclosure Set 1 (TP Cable Targets) G-7

Figure G.06: Electrical Enclosure Set 1 (SE Targets) G-8

Figure G.07: Electrical Enclosure Set 2 (TS Cable Targets) G-9

Figure G.08: Electrical Enclosure Set 2 (TP Cable Targets) G-10

Figure G.09: Electrical Enclosure Set 2 (SE Targets) G-11

Set G: Overview and Assumptions

Table/plot set G is used to conservatively estimate the damage time of a target or the ignition time of a secondary combustible located within the radial ZOI based on its radial distance from the ignition source. This time is used in the calculation of the non-suppression probability (Step 2.7.1).

The assumptions and background for the calculations performed to develop the tables and plots in set G are discussed in Section 06.03.07 of IMC 0308, Attachment 3, Appendix F. Since the failure times were obtained as part of the Severity Factor calculations, the assumption were the same as for table/plot set E.

|  |
| --- |
|  |
| Figure G.01: Failure Time vs. Radial Target Distance for Motor, Pump and Transient Fires |
| (TS Cable Targets) |

|  |
| --- |
|  |
| Figure G.02: Failure Time vs. Radial Target Distance for Motor, Pump and Transient Fires |
| (TP Cable Targets) |

|  |
| --- |
|  |
| Figure G.03: Failure Time vs. Radial Target Distance for Motor, Pump and Transient Fires |
| (SE Targets) |

|  |
| --- |
|  |
| Figure G.04: Failure Time vs. Radial Target Distance for Electrical Enclosures (Set 1) |
| (TS Cable Targets) |

|  |
| --- |
|  |
| Figure G.05: Failure Time vs. Radial Target Distance for Electrical Enclosures (Set 1) |
| (TP Cable Targets) |

|  |
| --- |
|  |
| Figure G.06: Failure Time vs. Radial Target Distance for Electrical Enclosures (Set 1) |
| (SE Targets) |

|  |
| --- |
|  |
| Figure G.07: Failure Time vs. Radial Target Distance for Electrical Enclosures (Set 2) |
| (TS Cable Targets) |

|  |
| --- |
|  |
| Figure G.08: Failure Time vs. Radial Target Distance for Electrical Enclosures (Set 2) |
| (TP Cable Targets) |

|  |
| --- |
|  |
| Figure G.09: Failure Time vs. Radial Target Distance for Electrical Enclosures (Set 2) |
| (SE Targets) |

AppendixH. DETECTOR ACTUATION AND SPRINKLER ACTIVATION TIMES

TABLE OF CONTENTS

Set H: Overview and Assumptions H-2

Figure H.01: t2 HRR Growth Profile for Various Ignition Sources H-3

Figure H.02: Minimum HRR for Detector Actuation vs. H and R (R Range: 0-15 ft.) H-4

Figure H.03: Minimum HRR for Detector Actuation vs. H and R (R Range: 16-30 ft.) H-5

Figure H.04: Total Lag and Response Time vs. H and R (R Range: 0-15 ft.) H-6

Figure H.05: Total Lag and Response Time vs. H and R (R Range: 16-30 ft.) H-7

Figure H.06: Time to Sprinkler Activation vs. H and R (Motor Fires) H-8

Figure H.07: Time to Sprinkler Activation vs. H and R (Pump Fires) H-9

Figure H.08: Time to Sprinkler Activation vs. H and R (Loose Transient Fires) H-10

Figure H.09: Time to Sprinkler Activation vs. H and R (Contained Transient Fires) H-11

Figure H.10: Time to Sprinkler Activation vs. H and R (Small Enclosure Fires) H-12

Figure H.11: Time to Sprinkler Activation vs. H and R (MCC & Battery Charger Fires) H-13

Figure H.12: Time to Sprinkler Activation vs. H and R (Switchgear & Load Center Fires) H-14

Figure H.13: Time to Sprinkler Activation vs. H and R (Power Inverter Fires) H-15

Figure H.14: Time to Sprinkler Activation vs. H and R (Closed Medium Enclosure Fires) H-16

Figure H.15: Time to Sprinkler Activation vs. H and R (Open Medium Enclosure Fires) H-17

Figure H.16: Time to Sprinkler Activation vs. H and R (Closed Large Enclosure Fires) H-18

Figure H.17: Time to Sprinkler Activation vs. H and R (Open Large Enclosure Fires) H-19

Figure H.18: Steady HRR for Sprinkler Activation in 1 Minute vs. H and R H-20

Figure H.19: Steady HRR for Sprinkler Activation in 2 Minutes vs. H and R H-21

Figure H.20: Steady HRR for Sprinkler Activation in 3 Minutes vs. H and R H-22

Figure H.21: Steady HRR for Sprinkler Activation in 4 Minutes vs. H and R H-23

Figure H.22: Steady HRR for Sprinkler Activation in 5 Minutes vs. H and R H-24

Figure H.23: Steady HRR for Sprinkler Activation in 6 Minutes vs. H and R H-25

Set H: Overview and Assumptions

Table set H consists of three subsets:

* Tables to determine smoke detector actuation time as a function of the ceiling height above the fire and the radial distance between the detector and the fire (Step 2.7.2).
* Tables to determine sprinkler activation time for fixed and transient ignition source fires as a function of the ceiling height above the fire and the radial distance between the sprinkler head and the fire (Step 2.7.3).
* Tables to determine sprinkler activation time for fires with a priori unknown HRR profile as a function of the ceiling height above the fire and the radial distance between the sprinkler head and the fire (Step 2.7.3).

The assumptions and background for the calculations performed to develop the tables and plots in set A are discussed in Section 06.03.08 of IMC 0308, Attachment 3, Appendix F. The primary assumptions are as follows:

1. To determine response time, smoke detectors are modeled as sprinkler heads with an RTI of 5 (m⋅s)0.5 and an activation temperature 9°F above ambient (86°F). The assumed RTI and activation temperature are identical to those that are used in the sample FDT 11 calculations in NUREG 1805.
2. For the sprinkler activation calculations, sprinkler heads were assumed to have an activation temperature of 165°F and an RTI of 130 (m⋅s)0.5. These values were used in the fire modeling supporting the LAR of several plants transitioning to NFPA 805.

|  |
| --- |
|  |
| Figure H.01: t2 HRR Growth Profile for Various Ignition Sources |

|  |
| --- |
|  |
| Figure H.02: Minimum HRR for Detector Actuation vs. H and R (R Range: 0-15 ft.) |

|  |
| --- |
|  |
| Figure H.03: Minimum HRR for Detector Actuation vs. H and R (R Range: 16-30 ft.) |

|  |
| --- |
|  |
| Figure H.04: Total Lag and Response Time vs. H and R (R Range: 0-15 ft.) |

|  |
| --- |
|  |
| Figure H.05: Total Lag and Response Time vs. H and R (R Range: 16-30 ft.) |

|  |
| --- |
|  |
| Figure H.06: Time to Sprinkler Activation vs. H and R (Motor Fires) |

|  |
| --- |
|  |
| Figure H.07: Time to Sprinkler Activation vs. H and R (Pump Fires) |

|  |
| --- |
|  |
| Figure H.08: Time to Sprinkler Activation vs. H and R (Loose Transient Fires) |

|  |
| --- |
|  |
| Figure H.09: Time to Sprinkler Activation vs. H and R (Contained Transient Fires) |

|  |
| --- |
|  |
| Figure H.10: Time to Sprinkler Activation vs. H and R (Small Enclosure Fires) |

|  |
| --- |
|  |
| Figure H.11: Time to Sprinkler Activation vs. H and R (MCC & Battery Charger Fires) |

|  |
| --- |
|  |
| Figure H.12: Time to Sprinkler Activation vs. H and R (Switchgear & Load Center Fires) |

|  |
| --- |
|  |
| Figure H.13: Time to Sprinkler Activation vs. H and R (Power Inverter Fires) |

|  |
| --- |
|  |
| Figure H.14: Time to Sprinkler Activation vs. H and R (Closed Medium Enclosure Fires) |

|  |
| --- |
|  |
| Figure H.15: Time to Sprinkler Activation vs. H and R (Open Medium Enclosure Fires) |

|  |
| --- |
|  |
| Figure H.16: Time to Sprinkler Activation vs. H and R (Closed Large Enclosure Fires) |

|  |
| --- |
|  |
| Figure H.17: Time to Sprinkler Activation vs. H and R (Open Large Enclosure Fires) |

|  |
| --- |
|  |
| Figure H.18: Steady HRR for Sprinkler Activation in 1 Minute vs. H and R |

|  |
| --- |
|  |
| Figure H.19: Steady HRR for Sprinkler Activation in 2 Minutes vs. H and R |

|  |
| --- |
|  |
| Figure H.20: Steady HRR for Sprinkler Activation in 3 Minutes vs. H and R |

|  |
| --- |
|  |
| Figure H.21: Steady HRR for Sprinkler Activation in 4 Minutes vs. H and R |

|  |
| --- |
|  |
| Figure H.22: Steady HRR for Sprinkler Activation in 5 Minutes vs. H and R |

|  |
| --- |
|  |
| Figure H.23: Steady HRR for Sprinkler Activation in 6 Minutes vs. H and R |

ATTACHMENT 1

Revision History for IMC 0609, Appendix F, Attachment 8

| Commitment Tracking Number | Accession Number  Issue Date  Change Notice | Description of Change | Description of Training Required and Completion Date | Comment Resolution and Closed Feedback Form Accession Number (Pre-Decisional, Non-Public) |
| --- | --- | --- | --- | --- |
|  | 05/28/2004  CN 04-016 | IMC 0609, App F, Att 8 “Guidance for Fire Non-Suppression Probability Analysis,” is added to provide guidance for fire non-suppression analysis. |  |  |
|  | 02/28/2005  CN 05-007 | IMC 0609, App F, Att 8 “Guidance for Fire Non-Suppression Probability Analysis,” is revised to correct the mathematical signs within the last bullet before Manual fire suppression on page F8-9. |  |  |
|  | ML17089A411  DRAFT  CN 17-XXX | IMC 0609, App F, Att 8 “Guidance for Fire Non-Suppression Probability Analysis,” is moved to IMC 0609, App F, Att 7. Attachment 8 is replaced with sets of pre-solved tables and plots that are used in the revised Phase 2 to replace the use of the Fire Dynamics Tools Spreadsheets.  CA Note sent 7/18/17 for information only, ML17191A681.  Issued 10/11/17 as a draft publically available document to allow for public comments. | November 2017 | ML17093A189 |
|  | ML18087A413  05/02/18  CN 18-010 | Re-issued with new accession number in order to issue as an official revision after receipt of public comments. | Gap training covering changes to the procedure completed November 2017 | ML17093A189 |