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1	1	Cog.Eng. D.L. Oar, T3-28		1/18/95							
1	1	Cog. Mgr. L.T. Blackford, T3-28		1/18/95							
		QA				Central Files		18-04		3	
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Document Number: WHC-SD-CP-ANAL-010, REV.0

Document Title: Attachments for Fire Modeling for Building 221-T
T Plant Canyon Deck and Railroad Tunnel

Release Date: January 19, 1995

**This document was reviewed following the
procedures described in WHC-CM-3-4 and is:**

APPROVED FOR PUBLIC RELEASE

WHC Information Release Administration Specialist:

Kara M. Broz

January 19, 1995

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ATTACHMENTS

for

Fire Modeling for Building 221-T
T-Plant Canyon Deck and Railroad Tunnel

Prepared for

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2355 Stevens Drive
Richland, Washington 99325

Prepared by

Hughes Associates, Inc.
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September 29, 1994

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

PURPOSE

The purpose for this attachment is to provide historical information and documentation for Document No. WHC-SD-CP-ANAL-008 Rev 0, "Fire Modeling for Building 221-T--T Plant Canyon Deck and Railroad Tunnel", dated September 29, 1994.

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RESUMES

CRAIG L. BEYLER, Technical Director

EDUCATION:

Ph.D. in Engineering Science, Harvard University, 1983
 M.S. in Mechanical Engineering, Cornell University, 1980
 M.Sc. in Fire Safety Engineering, University of Edinburgh, 1978
 B.S. in Fire Protection Engineering, University of Maryland, 1976
 B.S. in Civil Engineering, Cornell University, 1975

PROFESSIONAL EXPERIENCE:

Technical Director, Hughes Associates, Inc., 1990-present. Responsible for technical quality of fire protection design, research, and development projects and professional development of engineering staff. Project manager for a variety of fire protection R&D/T&E programs. Development of methods for evaluating the fire growth properties and residual strength of composite materials. Development of mathematical fire models and modeling techniques for specialized applications, including zone and field models. Risk and hazard analysis for a wide range of specialized applications.

Principal, Fire Science Technologies, 1987-1990. Development of compartment fire models including computer-based models and simple correlationally-based models for ships and buildings. Preparation and presentation of a five-day short course for the HAZARD I hazard analysis package. Litigation support for a range of fire situations. Preparation of a draft of "Fire Dynamics and Chemistry: An Engineering Approach" for John Wiley and Sons.

Assistant Professor of Fire Protection Engineering and Mechanical Engineering, Worcester Polytechnic Institute, 1985-1987. Taught graduate courses in Combustion, Fire Dynamics, and Fire Chemistry. Advised MS thesis work for FPE graduate students. Research in fire dynamics including compartment fire growth, smoke movement, pool fire radiation as well as fault tree approaches to link fire growth predictions to performance based fire safety objectives. Chaired a committee to totally restructure the graduate courses in the FPE degree programs and instituted an ongoing seminar program.

Visiting Scientist, Fire Research Station at Borehamwood, England, 1984-1985. Conducted experimental and theoretical investigations of piloted ignition of solid fuels. Prepared a review paper of the state-of-the-art of knowledge of plume and ceiling jet flows.

Postdoctoral Fellow, Harvard University, 1983-1984. Conducted an extensive experimental program to study the effect of oxygen starvation effects on the generation of products of combustion, especially carbon monoxide, in a compartment fire environment. Experimental and theoretical studies of hot layer ignition in compartment fires.

Research Associate, University of Maryland, 1976-1977.

Engineer (part-time), Center for Fire Research, National Bureau of Standards, 1975-1976.

Security Clearance: DOD Secret
 DOE "Q"

CRAIG L. BEYLER, Technical Director

PROFESSIONAL STANDING:

Committees:

Member, Research Committee, Society of Fire Protection Engineers, 1988-present.

Member, Engineering Education Committee, Society of Fire Protection Engineers, 1983-present.

Member, Subcommittee on Fire Detection Design Methods, 72 EM, National Fire Protection Association, 1983-present.

Member, Furnishings and Contents Committee, National Fire Protection Association, 1992-present.

Member, Smoke Management Systems in Malls, Atria and Large Areas, NFPA 92B, 1992-present.

Society Memberships:

Member, Combustion Institute, 1980-present.

Member, Society of Fire Protection Engineers, 1983-present.

Member, International Association for Fire Safety Science, 1985-present.

Member, American Society for Testing and Materials, 1988-present.

Member, National Fire Protection Association, 1987-present.

Member, Salamander Honorary Fire Protection Engineering Society, 1977-present.

Technical Journals and Books:

Founding Editor, *Journal of Fire Protection Engineering*, 1988-1992.

Member, Editorial Advisory Board, *Fire Technology*, 1984-present.

Co-editor, *SFPE Handbook of Fire Protection Engineering*, Society of Fire Protection Engineers, 1984-present.

Reviewer, *Combustion and Flame*, 1987-present.

Fire Dynamics and Chemistry: An Engineering Approach, in preparation for John Wiley and Sons.

3/93

SELECTED PUBLICATIONS LIST

Craig L. Beyler

- Scheffey, J.L., Williams, F.W., Tatem, P.A., and Beyler, C.L., "Closure of Hatches during Pierside Fires on Submarines," NRL Ltr Rpt Ser 6180/399.2, October 28, 1993.
- Gottuk, D.T., Roby, R.J. and Beyler, C.L., "A Study of Carbon Monoxide and Smoke Yields from Compartment Fires," *Twenty-Fourth Symposium (International) on Combustion*, The Combustion Institute, Pittsburgh, PA., 1993.
- Gottuk, D.T., Roby, R.J., Peatross, M.J., and Beyler, C.L., "Carbon Monoxide Production in Compartment Fires," *Journal of Fire Protection Engineers*, 4 (4), 1992.
- Beyler, C.L., "A Unified Model of Fire Suppression," *Journal of Fire Protection Engineering*, 4 (1), 1992, pp. 5-16.
- DiNenno, P.J. and Beyler, C.L., "Fire Hazard Assessment of Composite Materials: The Use and Limitations of Current Hazard Analysis Methodology," *Fire Hazard and Fire Risk Assessment, ASTM STP 1150*, Marcelo H. Hirschler, Ed., American Society for Testing and Materials, Philadelphia, PA, 1992, pp. 87-99.
- Fitzgerald, R.W., Richards, R.C., and Beyler, C.L., "Firesafety Analysis of Polar Icebreaker Replacement Design," *Journal of Fire Protection Engineering*, 3 (4), 1991, pp. 137-150.
- Skelly, M.J., Roby, R.J., and Beyler, C.L., "An Experimental Investigation of Glass Breakage in Compartment Fires," *Journal of Fire Protection Engineering*, 3 (1), 1991, pp. 25-34.
- Beyler, C.L., "Analysis of Compartment Fires with Overhead Forced Ventilation," *Fire Safety Science—Proceedings from the Third International Symposium*, 1991, pp. 291-300.
- Deal, S., and Beyler, C.L., "Correlating Preflashover Room Fire Temperatures," *Journal of Fire Protection Engineering*, 2(2), 1990, pp. 33-48.
- Shokri, M., and Beyler, C.L., "Radiation from Large Pool Fires," *Journal of Fire Protection Engineering*, 1(4), 1989, pp. 141-149.
- Shanley, J., and Beyler, C.L., "Horizontal Vent Flow Modeling with Helium and Air," *Second International Symposium on Fire Safety Science*, Hemisphere Publishing Co., 1989, pp. 305-314.
- Beyler, C.L., "Thermal Decomposition of Polymers," *SFPE Handbook of Fire Protection Engineering*, NFPA, Quincy, MA, 1988, pp. 165-178.
- Beyler, C.L., "Flammability Limits of Premixed and Diffusion Flames," *SFPE Handbook of Fire Protection Engineering*, NFPA, Quincy, MA, 1988, pp. 286-297.
- Thomson, H.E., Drysdale, D.D. and Beyler, C.L., "An Experimental Evaluation of Critical Surface Temperature as a Criterion for Piloted Ignition of Solid Fuels," *Fire Safety Journal*, 13, 1988, p. 185.
- Beyler, C.L., "Fire Plumes and Ceiling Jets," *Fire Safety Journal*, 11, 1986, p. 53.
- Beyler, C.L., "Major Species Production by Solid Fuels in a Two Layer Compartment Fire Environment," *First International Symposium on Fire Safety Science*, Hemisphere Publishing Co., 1986, p. 431.

Selected Publications List

C.L. Beyler, Page Two

Beyler, C.L., "Major Species Production by Diffusion Flames in a Two Layer Compartment Fire Environment," *Fire Safety Journal*, 10, 1986, p. 47.

Beyler, C.L., "A Design Method for Flaming Fire Detection," *Fire Technology*, 20, No. 4, 1984, p. 5.

Beyler, C.L., "Ignition and Burning of a Layer of Incomplete Combustion Products," *Combustion Science and Technology*, 39, 1984, p. 287.

Beyler, C.L., and Gouldin, F.C., "Flame Structure in a Swirl Stabilized Combustor Inferred by Radiant Emission Measurements," *Eighteenth Symposium (International) on Combustion*, The Combustion Institute, 1981, p. 1011.

Beyler, C.L., "An Evaluation of Sprinkler Discharge Calculation Methods," *Fire Technology*, 13, No. 3, 1977, p. 185.

2/94

ERIC R. ROSENBAUM, P.E., Senior Engineer

EDUCATION:

M.S., Fire Protection Engineering, University of Maryland, (in progress)
B.S., Fire Protection Engineering, University of Maryland, 1985

PROFESSIONAL EXPERIENCE:

Senior Engineer, Hughes Associates, Inc., 1992-present. Analyzes code requirements and intent relating to the design of structures. Reviews design of structures and processes for fire safety. Structures evaluated include hazardous waste processing facilities, high hazard uses (explosion potential and flammable liquids), and conventional structures (e.g., dormitories and offices). Performs fire hazard analyses for DOE structures. This includes computational analysis and detailed review of processing to determine elements of hazard. Designs and reviews fire suppression systems. Provides statistical analysis of fire data (e.g., NFIRS) for correlations of information.

Fire Protection Engineer, Science Applications International Corporation (SAIC), 1991-1992. Acting lead Fire Protection Engineer for Department of Energy, Environmental Restoration and Waste Management Division (EM). Responsible for development and implementation of fire protection program. Reviews and recommends action on exemption requests for EM facilities. Project manager responsible for analysis of facilities for fire safety. Occupancies include nuclear reactors, radioactive material processing facilities and commercial properties such as hotels, offices and dormitories.

Consulting Fire Protection Engineer, Rolf Jensen & Associates, 1985-1991. Project manager responsible for the design of various types of suppression systems for different occupancies including flammable liquid storage and processing facilities, tire storage areas, department stores and embassies. Performs systems design for automatic sprinklers, Halon, fire alarm, detection and voice communication systems. Identifies code requirements that apply to the design of hospitals, mixed use high-rise buildings, atriums and industrial occupancies. Negotiates with code officials and develops variances. Performs fire protection and life safety surveys and recommends upgrades for industrial plants, prisons, college campuses, flammable liquid processing plants, factories, ordnance facilities, and high-rise buildings. Performs and manages pre-purchase evaluation surveys of shopping malls and office buildings.

Fire Protection Engineering Trainee, National Bureau of Standards, 1982-1985. Utilizes computer modeling to evaluate occupant safety and possible fire severity within a building. Evaluates fire conditions and activation time of suppression systems. Assists in the development of the Fire Safety Evaluation System program for health care and detention/correctional occupancies and produces a workbook aid. Inspects occupancies and proposes changes to achieve compliance with relevant code.

PROFESSIONAL STANDING:

Registered Professional Engineer in the States of Virginia, Massachusetts, North Carolina, and Maryland
Member, Society of Fire Protection Engineers (Co-chairman, SFPE Research Committee)
Member, National Fire Protection Association (Health Care Section Member)
Member, Salamander, Fire Protection Engineering Honorary Society
Member, Tau Beta Pi Association, National Engineering Honor Society
Recipient, Robert J. Taylor Academic Achievement Award

1/93

PRESENTATIONS AND PUBLICATIONS

Eric R. Rosenbaum, P.E.

Scheffey, J.L., Rosenbaum, E.R., and Hadley, J.J., "Alternative Approaches to Integrated Damage Control Systems (IDCS) for USCG Vessels," SBIR 1992 Phase I Final Report, prepared for the U.S. Coast Guard, April 29, 1993.

Rosenbaum, E.R., Hunt, S.P., Beyler, C.L., and DiNenno, P.J., "Code Study of Illuminated Plastic Signs," prepared for The Port Authority of New York and New Jersey, Hughes Associates, Inc., December 10, 1992.

Rosenbaum, E.R., Budnick, E.K., Hunt, S.P., Perrault, D.J., and Wong, J.T., "Waste System Evaporator Fire Risk Analysis in Building 374, Subcontract No. ASC 110621 NR/KE," prepared for EG&G Rocky Flats, Inc., Hughes Associates, Inc., September 18, 1992.

Rosenbaum, E., and O'Conner, D.J., "New Technologies and Research in Fire Protection," *SFPE Bulletin*, July/August 1992.

Rosenbaum, E., "Fire and Life Safety," American Institute of Architects, Washington Chapter, April 1991 and May 1992.

Rosenbaum, E., "A Fire Protection Engineering Case Study: The Pension Building," Architects and Engineers, Charlotte, North Carolina, May 1989.

Rosenbaum, E., "Computer Assisted Carbon Dioxide System Design," Society of Fire Protection Engineers, Adelphi, MD, January 1985.

5/93

NAEEM IQBAL, Junior Engineer

EDUCATION:

B.S., Mechanical Engineering, NED University of Engineering and Technology, Karachi, Pakistan, 1987
M.S., Fire Protection Engineering, University of Maryland, College Park, MD, 1993

PROFESSIONAL EXPERIENCE:

Junior Engineer, Hughes Associates, Inc., 1993 to present. Responsibilities include project support for fire modeling, hazard analysis, and risk assessment. Conduct tests on self-heating and spontaneous combustion.

Graduate Research Assistant, Department of Fire Protection Engineering, University of Maryland, College Park, 1992 - 1993. Developed analytical models of one-dimensional transient burning rate of thermoplastic materials. Worked on wall coverings flammability research project for American Textile Manufacturers Institute, Washington, DC. Fire hazard prediction for textile materials: Determining material ignition and flame spread properties (ASTM E1321). Worked on flooring material flammability research project for USACE. Fire hazard prediction for flooring material (carpet): Critical radiant heat flux of floor-covering systems using a radiant heat energy source (ASTM E648).

Computer Lab Assistant, College of Behavioral and Social Sciences, University of Maryland, College Park, 1992 - 1992. Assisted faculty and students using various software on a local area network of IBM PCs and Macintosh computers. Maintained, installed, and updated software.

Mechanical Engineer, Sallman and Associates, Palo Alto, CA, 1990 - 1991. Designed commercial and residential HVAC and mechanical systems.

Mechanical Engineer, Fahim, Nanji & de Souza, Karachi, Pakistan, 1987 - 1990. Designed heating, air conditioning, ventilation, and exhaust system. Worked on feasibility studies, analyzed HVAC projects needs, drawings, specifications, cost estimations, and energy conservation analyses. Developed selection data in accordance with ASHRAE and OSHA recommendations. Performed engineering calculations using HVAC software. Supervised the installation of commercial and industrial, mechanical, and HVAC systems. Coordinated activities with contractors and inspection agencies to ensure full compliance with drawings and specifications.

PROFESSIONAL STANDING:

Member, Society of Fire Protection Engineers
Member, National Fire Protection Association
Member, International Association for Fire Safety Science
Member, American Society of Mechanical Engineers
Member, American Society of Heating, Refrigerating, and Air Conditioning Engineers
Member, American Institute of Chemical Engineers
Member, The Construction Specifications Institute
Member, Salamander Honorary Fire Protection Engineering Fraternity, Beta Chapter

12/93

REVIEW AND COMMENT RECORD

REVIEW COMMENT RECORD (RCR)
Fire Modeling for Building 221-T
T-Plant Canyon Deck and Railroad Tunnel

Item	Comment	Disposition
1	Appendix A, Table A7, page XXIII, identifies the recommended fuel mass burned per filter, which causes filter failure. It is unclear how the mass of 5 kg/filter for flammable and combustible liquids was arrived at. Page VI indicates that for hazard analysis (presumably the bounding event), a dirty filter should be assumed (existing delta P of 4 inches of water prior to fire) therefore, the value of 3-4 kg from Nisio's work cited on page XXII (second paragraph seems more valid as the bounding case. Therefore, provide expanded explanation as to why 5 kg/filter is recommended.	The recommended 5 kg/filter (11 lb/filter) mass of flammable and combustible liquid is the average of lower limit of 7 and 3 kg/filter from Ballinger's and Nisio's work respectively. Explanation is provided in the main report on page XXII and XXIII (Table 19).
2	Information which identifies the mass of fuel needed to cause filter failure is presented in terms of mass fuel burned per filter. This information is found in Tables A6, and A7 on pages XXII and XXIII. Tables 19 and 20, page 69, (and Table 1 & 2, page xi) provide explicit limits for the materials allowed in a single area of T-Plant. This information is based on the quantity of combustibles that will lead to HEPA filter failure. Yet the actual size of the filters used in T-Plant are not identified. For the purposes of completeness and understanding, identify the size, location and number of HEPA filters that been assumed to exist at T-Plant.	The sizes, locations, and number of HEPA filter exist in T-Plant provided by Mr. David L. Oar on September 7, 1994 are as follows: Floor exhaust HEPA filter = 4 filters x 6' x 6' = 144 ft ² (13.38 m ²). Roof exhaust HEPA filter = 225 ft ² (21 m ²). Table, page xii and Table 19, page 69 summarizes mass of fuel burned which causes HEPA filter failure based on the existing filter area in terms of fuel packages in the single location of T-Plant.
3	Section 8.1, Tables 19 and 20 on page 69, identify quantities of combustibles that can cause HEPA filter failure. Explain the assumptions identified in Tables 19 and 20. (For example, that smoke aerosol accumulation/unit area of filter is assumed to be the same for each filter; That soot deposition is assumed to be uniformly distributed across each filter, etc.).	Explanation is provided on pages 69, Table 19, and page 70 Table 20

Item	Comment	Disposition
4	It appears that an increase or decrease in HEPA filter area directly correlated to an increase or decrease in the quantity of combustibles necessary to cause HEPA filter failure. Further it appears that this correlation was assumed in the analysis. This assumption should be stated (possibly in Section 8.1, HEPA filter clogging, page 67) and explained so the reader has a greater understanding of the analysis performed.	See Table 1, page xii, Table 19, page 69, and Table 20, page 70 for details.
5	Pages 11, 13, and 28 were missing from the Report provided for review. Provided these pages in the final report.	Provided in the final report.
6	The analysis performed have not been sufficiently documented within the report to validate their accuracy. Provide adequate documentation to substantiate the accuracy of the analysis that is presented. Sample Calculation Summary and Control Sheet, pages 1 and 2, are attached as an example of the level of detail and documentation that is being requested.	Provided in the enclosed packages.
7	Report documentation in accordance with Item 7 of the task order form has not been provided. Provide documentation in accordance with the task order form.	Provided in the enclosed package.
8	There are a number of grammatical errors throughout the report that require correction. Make all grammatical corrections prior to issuance of a final report.	Corrected in the final report
9	There appears to be a typo on page A-IX, bottom paragraph. The dimensions are 0.61 cm x 0.61 cm. Believe this should be 0.61 m x 0.61 m. Correct/modify as required.	Corrected in the final report.
10	For the purpose of clarity and understanding, all quantities and dimensions should be identified whenever possible in both English and metric units. English units may be identified in () s.	All the quantities and dimensions are presented as metric (English) units in the final report.

Item	Comment	Disposition
11	Table 10, page 43 identifies the radiative fraction that is used in calculating incident heat flux. A value of 0.35 is used for each fire source. Yet this value is never explained or justified. Provide explanatory information which substantiates the use of the value of 0.35 for each of the fire sources.	Most fuels have radiative fraction between 0.25 - 0.40. For reference see "Some Measurements of the Radiative Power Output of Diffusion Flames", Western States Section of the Combustion Institute, WSS/CI 81-15, 1981, by Bernard J. McCaffrey.
12	Table 12, page 46, and Table 13, page 51 as presented are not clearly separated from the text and is not readily distinguishable as a "Table". Placing the information within boundary lines is recommended.	Corrected in the final report.
13	The headings of Tables 2, page xi and Table 20, page 69 do not sufficiently describe the data that is presented. The numbers correlate to the number of fuel packages presented on the left side of the table. It is suggested that the table heading be similar to "Number of fuel package which can cause ventilation system failure".	Table 2, page xi and Table 20, page 69 are deleted. The new Tables 1 and 19 are on page xii and 69 with heading "Mass of fuel burned to cause HEPA filter failure in T-Plant exhaust ventilation system". These tables provides mass of fuel burned per floor and roof exhaust ventilation in terms of fuel packages.
14	Section 9.0, Summary, page 70, first paragraph and Section 1.0 Introduction page v, first paragraph states that "Hazard to the structure, exposure of the operating personnel and to the public are considered." Hazards relating to operating personnel are not explicitly address. Expand conclusions and explanations (possibly Section 7.6, page 67 and Section 9.0, page 70, and Section 10.0, page 71) to address these key concerns or delete the reference to "personnel and to the public..."	The new sentence states that "The results are presented in terms of the impact of fire on the building structure, contents, and ventilation system".
15	Page vi, paragraph (4) uses the term "low-level radioactive waste". The term "low-level" may not always apply and should be DELETED.	Corrected in the final report.

Wm. Rogers
9/29/94

SOFTWARE FILES

Fire Modeling for Building 221-T
T-Plant Canyon Deck and Rail Road Tunnel

Disk - 1 WordPerfect Files

Executive Summary
Report
Appendix - A

Input and Output Files: CFAST Version 2.0.1, 4 - 22 - 1994

Disk - 2 Steady State Fires Based on Exhaust Flow Rates

CFAST Input Data Files

TPL1a.dat 49 MW Fire 291-T Exhaust Fan On
TPL2a.dat 70 MW Fire 221-T-13 Exhaust Fan On
TPL3a.dat 120 MW Fire Both Exhaust Fan On

CFAST Output Files

Steady State Fires Based on Exhaust Flow Rates

TPL1a.fst 49 MW Fire 291-T Exhaust Fan On
TPL2a.fst 70 MW Fire 221-T-13 Exhaust Fan On
TPL3a.fst 120 MW Fire Both Exhaust Fan On

Disk - 3 Fire in the Canyon Based on Wood Pallet Heat Release Rate at location 13L

CFAST Input Data Files

TPL1b.dat 15,000 kW Fire 291-T Exhaust Fan On
TPL2b.dat 15,000 kW Fire 221-T-13 Exhaust Fan On
TPL3b.dat 15,000 kW Fire Both Exhaust Fan On

CFAST Output Files

TPL1b.fst 15,000 kW Fire 291-T Exhaust Fan On
TPL2b.fst 15,000 kW Fire 221-T-13 Exhaust Fan On
TPL3b.fst 15,000 kW Fire Both Exhaust Fan On

Disk - 4 Fire in the Canyon Based on Wood Pallet Heat Release Rate at location 3R

CFAST Input Data Files

TPL1c.dat 8,700 kW Fire 291-T Exhaust Fan On
TPL2c.dat 8,700 kW Fire 221-T-13 Exhaust Fan On
TPL3c.dat 8,700 kW Fire Both Exhaust Fan On

CFAST Output Files

TPL1c.fst 8,700 kW Fire 291-T Exhaust Fan On
TPL2c.fst 8,700 kW Fire 221-T-13 Exhaust Fan On
TPL3c.fst 8,700 kW Fire Both Exhaust Fan On

Disk 5 Fire in the Tunnel Based on Plywood Box Heat Release Rate

CFAST Input Data Files

TPL1v.dat 1,200 kW Fire 291-T Exhaust Fan On
TPL2v.dat 1,200 kW Fire 221-T-13 Exhaust Fan On
TPL3v.dat 1,200 kW Fire Both Exhaust Fan On

CFAST Output Files

TPL1v.fst 1,200 kW Fire 291-T Exhaust Fan On
TPL2v.fst 1,200 kW Fire 221-T-13 Exhaust Fan On
TPL3v.fst 1,200 kW Fire Both Exhaust Fan On

**Disk 6 Fire in the Tunnel Based on 55 Gallon Drum Filled with Oil Soaked Rags
Heat Release Rate**

CFAST Input Data Files

TPL1w.dat 3,520 kW Fire 291-T Exhaust Fan On
TPL2w.dat 3,520 kW Fire 221-T-13 Exhaust Fan On
TPL3w.dat 3,520 kW Fire Both Exhaust Fan On

CFAST Output Files

TPL1w.fst 3,520 kW Fire 291-T Exhaust Fan On
TPL2w.fst 3,520 kW Fire 221-T-13 Exhaust Fan On
TPL3w.fst 3,520 kW Fire Both Exhaust Fan On

**CFEAST VERSION 2.0.1 APRIL 22, 1994
INPUT AND OUTPUT FILES**

Fire Scenario	Peak Heat Release Rate Q (kW)	Time (s)		Mass Flow (kg/s)				Critical Hazard Parameters													
		Peak time (s)	Total Duration t _d (s)	Flow Out (kg/s)		Flow In (kg/s)		Canyon						Railroad Tunnel							
				Exhaust flow Canyon	Exhaust flow Tunnel	Vent flow Canyon	Vent flow Tunnel	Interface Position (m)	Differential Pressure (Pa)	O ₂ Concentration (%)	CO ₂ Concentration (%)	H ₂ O Concentration (%)	Smoke Layer Temperature (°C)		Interface Position (m)	Differential Pressure (Pa)	O ₂ Concentration (%)	CO ₂ Concentration (%)	H ₂ O Concentration (%)		
													Upper	Lower							
																				Upper	Lower
291-T exhaust system on only	40 × 10 ³	1050	3000	11.46	-	2.33	7.44	216	110	0.27	-5.30	0.44	5.28	28	85	30	6.2	-11	0.96	5	27
221-T-13 exhaust system on only	70 × 10 ³	1255	2400	16.38	-	3.46	8.20	236	86	0.25	-7.40	0.30	5.16	28	119	30	6.2	-13	0.80	5	27
Both exhaust system on	120 × 10 ³	1644	1800	25.45	-	7.3	10.80	283	145	0.25	-16.30	0.163	4.98	10	95	30	6.2	-23	0.68	5	2.0 × 10 ⁴

Calculated values of critical hazard parameters based on exhaust flow rates. Fire origin canyon

VERSN 2 TPL1A ONLY FLOOR EXHAUST FAN ON
 TIMES 3000 60 20 20 20
 TAMB 300. 101300. 0.
 EAMB 300. 101300. 0.
 HI/F 8.00 0.000
 WIDTH 245.00 64.00
 DEPTH 12.000 6.0000
 HEIGH 12.000 8.0000
 HVENT 1 3 1 1.00 2.0 0.00 0.000
 HVENT 2 3 1 20.0 0.3048 0.20 0.00 0.00
 VVENT 2 1 33.32 2
 CVENT 1 3 1 1.00 1.00 1.00 1.00
 CVENT 2 3 1 1.00 1.00 1.00 1.00
 MVOPN 1 3 H 1.00 3.50
 MVOPN 3 1 H 1.00 3.50
 MVDCT 3 2 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVFAN 2 1 0.00 300.00 0.140E+02 0.266E-01
 INELV 1 9.00 2 9.00 3 9.00
 CEILI CONCRETE CONCRETE
 WALLS CONCRETE CONCRETE
 FLOOR CONCRETE CONCRETE
 CHEMI 0. 0. 1.0 30000000. 300. 400. 0.000
 LFBO 1
 LFBT 2
 FPOS 4.55 3.05 0.00
 FTIME 10. 60. 200. 3000.
 FMASS 0.00 0.333 0.6666 1.6333 1.6333
 FHIGH 0.00 0.00 0.00 0.00 0.00
 FAREA 0.00 0.00 0.00 0.00 0.00
 FQDOT 0.00 1.00E+07 2.00E+07 4.90E+07 4.90E+07
 CJET OFF
 HCR 0.333 0.333 0.333 0.333 0.333 0.333
 STPMAX 5.00
 DUMPR TPL1A.HI
 DEVICE 1
 WINDOW 0 0. 0. 1279. 1023. 4095.


```

** CFAST Version 2.0.1 Run 7/27/94 **
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```

Time = 3000.0 seconds.

Compartment	Upper Temp. (K)	Lower Temp. (K)	Inter. Height (m)	Upper Vol. (m^3)	Pressure (Pa)	Ceiling Temp. (K)	Up wall Temp. (K)	Low wall Temp. (K)	Floor Temp. (K)
1	493.3	358.4	0.27	3.45E+04 (98%)	-5.33	392.7	389.1	345.2	372.2
2	382.9	302.7	6.2	6.87E+02 (22%)	-11.0	324.5	322.2	304.6	304.6

Compartment	Fire	Plume Flow (kg/s)	Pyrol Rate (kg/s)	Fire Size (W)	Fire in Upper (W)	Fire in Lower (W)	Vent Fire (W)	Convec. (W)	Radiat. (W)	On Target (W/m^2)
	Main	18.1	1.63	3.020E+07				3.020E+07	0.000	
1		18.1	1.63	3.020E+07	4.75	3.020E+07	0.000			2.883E+03
2		0.000	0.000	0.000	0.000	0.000	0.000			756.
Outside							3.147E+05			

Upper Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCL c (mg/m^2)	HCL f (mg/m^2)	HCL uw (mg/m^2)	HCL lw (mg/m^2)
1	63.3	0.442	5.28	0.000	0.000	0.000	2.70	28.3	0.000	0.000	0.000	0.000	0.000
2	63.9	0.966	5.16	0.000	0.000	0.000	2.35	27.7	0.000	0.000	0.000	0.000	0.000

Lower Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCL c (mg/m^2)	HCL f (mg/m^2)	HCL uw (mg/m^2)	HCL lw (mg/m^2)
1	72.5	12.0	2.29	0.000	0.000	0.000	1.00	12.3	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	9.341E-08	0.000	0.000	0.000	0.000	5.010E-07	0.000	0.000	0.000	0.000	0.000

Vent Flow (kg/s)

From	To	Number	Type	U->U	U->L->U	L->U->L	L->L	E->U	E->L
1	3	1	H		0.624				
2	3	1	H						
3	1	1	H			1.69	0.644		0.916
3	2	1	H				7.44		

```

VERS 2 TPL2A ONLY ROOF EXHAUST FAN ON
TIMES 2400 60 20 20 20
TAMB 300. 101300. 0.
EAMB 300. 101300. 0.
HI/F 8.00 0.000
WIDTH 245.00 64.00
DEPTH 12.00 6.000
HEIGHT 12.00 8.00
HVENT 1 3 1 1.00 2.00 0.000 0.000
HVENT 2 3 1 20.0 0.3048 0.20 0.00 0.00
VVENT 2 1 33.32 2
VVENT 1 3 1 1.00 1.00 1.00 1.00
CVENT 2 3 1 1.00 1.00 1.00 1.00
CVENT 3 1 3 H 11.00 3.50
WOPN 1 3 H 11.00 3.50
WOPN 3 1 H 11.00 3.50
MVDCT 3 2 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
MVFAN 2 1 0.00 300.00 0.200E+02 0.266E-01
INELV 1 19.00 2 19.00 3 19.00
CELLI CONCRETE CONCRETE
WALLS CONCRETE CONCRETE
FLOOR CONCRETE CONCRETE
CHEMI 0. 1.0 30000000. 300. 400. 0.000
LEBO 1
LEBT 2
FPOS 4.55 3.05 0.00
FTIME 10. 60. 200. 2400.
FPASS 0.00 0.333 0.666 2.333 2.333
FHIGH 0.00 0.00 0.00 0.00 0.00
FAREA 0.00 0.00 0.00 0.00 0.00
FQDOT 0.00 1.00E+07 2.00E+07 7.00E+07 7.00E+07
CJET OFF
HCR 0.333 0.333 0.333 0.333 0.333
STPMAX 5.00
DUMPR TPL2A.HI
DEVICE 1
WINDOW 0 0. 0. 1279. 1023. 4095.

```

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Time = 2400.0 seconds.

Compartment	Upper Temp. (K)	Lower Temp. (K)	Inter. Height (m)	Upper Vol. (m^3)	Pressure (Pa)	Ceiling Temp. (K)	Up wall Temp. (K)	Low wall Temp. (K)	Floor Temp. (K)
1	509.1	361.1	0.25	3.45E+04 (98%)	-7.37	398.0	394.5	347.7	377.4
2	391.5	302.7	6.2	6.85E+02 (22%)	-13.4	325.0	322.6	304.7	304.7

Compartment	Fire	Plume Flow (kg/s)	Pyrol Rate (kg/s)	Fire Size (W)	Fire in Upper (W)	Fire in Lower (W)	Vent Fire (W)	Convec. (W)	Radiat. (W)	On Target (W/m^2)
	Main	21.4	2.33	3.581E+07				3.581E+07	0.000	
1		21.4	2.33	3.581E+07	0.317	3.581E+07	0.000			3.332E+03
2		0.000	0.000	0.000	0.000	0.000	0.000			868.
Outside							1.826E+05			

Upper Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCl c (mg/m^2)	HCl f (mg/m^2)	HCl uw (mg/m^2)	HCl lw (mg/m^2)
1	61.4	0.308	5.16	0.000	0.000	0.000	5.42	27.7	0.000	0.000	0.000	0.000	0.000
2	62.1	0.807	5.06	0.000	0.000	0.000	4.89	27.1	0.000	0.000	0.000	0.000	0.000

Lower Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCl c (mg/m^2)	HCl f (mg/m^2)	HCl uw (mg/m^2)	HCl lw (mg/m^2)
1	72.0	12.2	2.17	0.000	0.000	0.000	2.05	11.6	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	2.787E-07	0.000	0.000	0.000	0.000	1.494E-06	0.000	0.000	0.000	0.000	0.000

Vent Flow (kg/s)

From	To	Number	Type	U->U	U->L->U	L->U->L	L->L	E->U	E->L
1	3	1	H		0.179				
2	3	1	H						
3	1	1	H			2.74	0.722		1.08
3	2	1	H				8.20		

VERSN 2 TPL3A ONLY FLOOR EXHAUST FAN ON
 TIMES 1800 60 20 20 20
 TAMB 300. 101300. 0.
 EAMB 300. 101300. 0.
 HI/F 8.00 0.000
 WIDTH 245.00 64.00
 DEPTH 12.00 6.000
 HEIGH 12.00 8.000
 HVENT 1 3 1 1.00 2.00 0.000 0.000
 HVENT 2 3 1 20.0 0.3048 0.20 0.00 0.00
 VVENT 2 1 33.32 2
 CVENT 1 3 1 1.00 1.00 1.00 1.00
 CVENT 2 3 1 1.00 1.00 1.00 1.00
 MVOPN 1 3 H 11.00 3.50
 MVOPN 1 4 H 1.00 3.50
 MVOPN 3 1 H 11.00 3.50
 MVOPN 3 6 H 1.00 3.50
 MVDCT 3 2 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVDCT 4 5 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVFAN 2 1 0.00 300.00 0.200E+02 0.266E-01
 MVFAN 5 6 0.00 300.00 0.140E+02 0.266E-01
 INELV 1 19.00 2 19.00 3 19.00 4 9.00 5 9.00 6 9.00
 CEILI CONCRETE CONCRETE
 WALLS CONCRETE CONCRETE
 FLOOR CONCRETE CONCRETE
 CHEMI 0. 0. 1.0 30000000. 300. 400. 0.000
 LFBO 1
 LFBT 2
 FPOS 4.55 3.05 0.00
 FTIME 10. 60. 200. 1800.
 FMASS 0.00 0.333 0.666 4.00 4.00
 FHIGH 0.00 0.00 0.00 0.00 0.00
 FAREA 0.00 0.00 0.00 0.00 0.00
 FQDOT 0.00 1.00E+07 2.00E+07 1.20E+08 1.200E+08
 CJET OFF
 HCR 0.333 0.333 0.333 0.333 0.333 0.333
 STPMAX 5.00
 DUMPR TPL3A.HI
 DEVICE 1
 WINDOW 0 0. 0. 1279. 1023. 4095.

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Time = 1800.0 seconds.

Compartment	Upper Temp. (K)	Lower Temp. (K)	Inter. Height (m)	Upper Vol. (m^3)	Pressure (Pa)	Ceiling Temp. (K)	Up wall Temp. (K)	Low wall Temp. (K)	Floor Temp. (K)
1	555.8	367.5	0.25	3.45E+04 (98%)	-16.3	415.9	412.2	356.7	393.9
2	417.5	302.8	6.3	6.57E+02 (21%)	-23.1	328.8	326.0	305.5	305.4

Compartment	Fire	Plume Flow (kg/s)	Pyrol Rate (kg/s)	Fire Size (W)	Fire in Upper (W)	Fire in Lower (W)	Vent Fire (W)	Convec. (W)	Radiat. (W)	On Target (W/m^2)
	Main	31.0	4.00	5.513E+07				5.513E+07	0.000	
1		31.0	4.00	5.513E+07	1.388E-02	5.513E+07	0.000			4.925E+03
2		0.000	0.000	0.000	0.000	0.000	0.000			1.257E+03
Outside							0.000			

Upper Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCl c (mg/m^2)	HCl f (mg/m^2)	HCl uw (mg/m^2)	HCl lw (mg/m^2)
1	58.8	0.163	4.98	0.000	0.000	0.000	9.31	26.7	0.000	0.000	0.000	0.000	0.000
2	59.6	0.686	4.88	0.000	0.000	0.000	8.67	26.2	0.000	0.000	0.000	0.000	0.000

Lower Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCl c (mg/m^2)	HCl f (mg/m^2)	HCl uw (mg/m^2)	HCl lw (mg/m^2)
1	72.0	13.3	1.81	0.000	0.000	0.000	3.18	9.72	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	3.824E-07	0.000	0.000	0.000	0.000	2.050E-06	0.000	0.000	0.000	0.000	0.000

Vent Flow (kg/s)

From	To	Number	Type	U->U	U->L->U	L->U->L	L->L	E->U	E->L
1	3	1	H						
2	3	1	H						
3	1	1	H			6.22	1.08		1.20
3	2	1	H				10.8		

Fire Scenario	Peak Heat Release Rate Q (kW)	Time (s)		Mass Flow (kg/s)						Critical Hazard Parameters									
				Flow Out (kg/s)			Flow In (kg/s)			Canyon					Railroad Tunnel				
		Peak Time (s)	Total Duration t _b (s)	Exhaust flow Canyon	Exhaust flow Tunnel	Vent flow Canyon	Vent flow Tunnel	Interface Position (m)	Differential Pressure (Pa)	O ₂ Concentration (%)	CO ₂ Concentration (%)	H ₂ O Concentration (%)	Smoke Layer Temperature (°C)		Interface Position (m)	Differential Pressure (Pa)	O ₂ Concentration (%)	CO ₂ Concentration (%)	H ₂ O Concentration (%)
													Upper	Lower					
291-T exhaust system on only	15 x 10 ³	562	660	14.75	-	6.90	7.76	1.0	-11.0	19.0	0.48	2.80	27	27	6	-12.0	20.70	0	0
221-T-13 exhaust system on only	15 x 10 ³	562	660	20.60	-	8.10	9.80	3.0	-18.0	19.0	0.47	2.50	27	27	6	-19.0	20.70	0	0
Both exhaust system on	15 x 10 ³	562	660	35.0	-	16.50	17.30	3.0	-59.0	19.0	0.47	2.50	27	27	6	-59.30	20.70	0	0

Calculated values of critical hazard parameters based on wood pallet fire in the canyon at location 13L

VERSN 2 TPL1B ONLY FLOOR EXHAUST FAN ON FIRE IN THE CANYON
 TIMES 800 60 20 20 20
 TAMB 300. 101300. 0.
 EAMB 300. 101300. 0.
 HI/F 8.00 0.000
 WIDTH 245.00 64.00
 DEPTH 12.000 6.0000
 HEIGH 12.000 8.0000
 HVENT 1 3 1 1.00 2.00 0.000 0.000
 HVENT 2 3 1 20.0 0.3048 0.20 0.00 0.00
 VVENT 2 1 33.32 2
 CVENT 1 3 1 1.00 1.00 1.00 1.00
 CVENT 2 3 1 1.00 1.00 1.00 1.00
 MVOPN 1 3 H 1.00 3.50
 MVOPN 3 1 H 1.00 3.50
 MVDCT 3 2 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVFAN 2 1 0.00 300.00 0.140E+02 0.266E-01
 INELV 1 9.00 2 9.00 3 9.00
 CEILI CONCRETE CONCRETE
 WALLS CONCRETE CONCRETE
 FLOOR CONCRETE CONCRETE
 CHEMI 0. 0. 1.0 30000000. 300. 400. 0.000
 LFBO 1
 LFBT 2
 FPOS 4.55 3.05 0.00
 FTIME 60. 200. 582. 600. 800.
 FMASS 0.00 0.1666 0.266 0.5 0.5 0.1
 FHIGH 0.00 0.00 0.00 0.00 0.00
 FAREA 0.00 0.00 0.00 0.00 0.00
 FQDOT 0.00 5.00E+06 8.00E+06 15.0E+06 15.0E+06 3.0E+6
 CJET OFF
 HCR 0.333 0.333 0.333 0.333 0.333 0.333
 STPMAX 5.00
 DUMPR TPL1B.HI
 DEVICE 1
 WINDOW 0 0. 0. 1279. 1023. 4095.

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Time = 800.0 seconds.

Compartment	Upper Temp. (K)	Lower Temp. (K)	Inter. Height (m)	Upper Vol. (m^3)	Pressure (Pa)	Ceiling Temp. (K)	Up wall Temp. (K)	Low wall Temp. (K)	Floor Temp. (K)
1	367.9	306.9	1.2	3.18E+04 (90%)	-53.1	310.4	309.5	302.8	304.9
2	300.0	300.0	8.0	3.1 (0%)	-53.6	300.0	300.0	300.0	300.0

Compartment	Fire	Plume Flow (kg/s)	Pyrol Rate (kg/s)	Fire Size (W)	Fire in Upper (W)	Fire in Lower (W)	Vent Fire (W)	Convec. (W)	Radiat. (W)	On Target (W/m^2)
Main		5.92	0.100	3.000E+06				3.000E+06	0.000	
1		5.92	0.100	3.000E+06	0.000	3.000E+06	0.000			576.
2		0.000	0.000	0.000	0.000	0.000	0.000			0.000
Outside							0.000			

Upper Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (l/m)	HCL c (mg/m^2)	HCL f (mg/m^2)	HCL uw (mg/m^2)	HCL lw (mg/m^2)
1	77.9	18.7	0.537	0.000	0.000	0.000	0.000	2.88	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Lower Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (l/m)	HCL c (mg/m^2)	HCL f (mg/m^2)	HCL uw (mg/m^2)	HCL lw (mg/m^2)
1	79.2	20.7	1.131E-02	0.000	0.000	0.000	0.000	6.057E-02	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Vent Flow (kg/s)

From	To	Number	Type	U->U	U->L->U	L->U->L	L->L	E->U	E->L
1	3	1	H						
2	3	1	H						
3	1	1	H			6.30	9.20		0.746
3	2	1	H				16.4		

VERSN 2 TPL2B ONLY ROOF EXHAUST FAN ON FIRE IN THE CANYON
 TIMES 800 60 20 20 20
 TAMB 300. 101300. 0.
 EAMB 300. 101300. 0.
 HI/F 8.00 0.000
 WIDTH 245.00 64.00
 DEPTH 12.00 6.000
 HEIGH 12.00 8.00
 HVENT 1 3 1 1.00 2.00 0.000 0.000
 HVENT 2 3 1 20.0 0.3048 0.20 0.00 0.00
 VVENT 2 1 33.32 2
 CVENT 1 3 1 1.00 1.00 1.00 1.00
 CVENT 2 3 1 1.00 1.00 1.00 1.00
 MVOPN 1 3 H 11.00 3.50
 MVOPN 3 1 H 11.00 3.50
 MVDCT 3 2 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVFAN 2 1 0.00 300.00 0.200E+02 0.266E-01
 INELV 1 19.00 2 19.00 3 19.00
 CEILI CONCRETE CONCRETE
 WALLS CONCRETE CONCRETE
 FLOOR CONCRETE CONCRETE
 CHEMI 0. 0. 1.0 30000000. 300. 400. 0.000
 LFBO 1
 LFBT 2
 FPOS 4.55 3.05 0.00
 FTIME 60. 200. 582. 600. 800.
 FMASS 0.00 0.1666 0.266 0.5 0.5 0.1
 FHIGH 0.00 0.00 0.00 0.00 0.00
 FAREA 0.00 0.00 0.00 0.00 0.00
 PQDOT 0.00 5.00E+06 8.00E+06 15.0E+06 15.0E+06 3.0E+6
 CJET OFF
 HCR 0.333 0.333 0.333 0.333 0.333 0.333
 STPMAX 5.00
 DUMPR TPL2B.HI
 DEVICE 1
 WINDOW 0 0. 0. 1279. 1023. 4095.

** CFAST Version 2.0.1 Run 7/27/94 **
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CFAST Version 2.0.1 - created May 1, 1993 TPL2B.Fst

Time = 800.0 seconds.

Compartment	Upper Temp. (K)	Lower Temp. (K)	Inter. Height (m)	Upper Vol. (m^3)	Pressure (Pa)	Ceiling Temp. (K)	Up wall Temp. (K)	Low wall Temp. (K)	Floor Temp. (K)
1	366.5	307.8	3.4	2.53E+04 (72%)	-67.7	310.5	309.6	302.3	304.0
2	300.0	300.0	8.0	3.1 (0%)	-68.2	300.0	300.0	300.0	300.0

Compartment	Fire	Plume Flow (kg/s)	Pyrol Rate (kg/s)	Fire Size (W)	Fire in Upper (W)	Fire in Lower (W)	Vent Fire (W)	Convec. (W)	Radiat. (W)	On Target (W/m^2)
Main		13.0	0.100	3.000E+06				3.000E+06	0.000	
1		13.0	0.100	3.000E+06	0.000	3.000E+06	0.000			561.
2		0.000	0.000	0.000	0.000	0.000	0.000			0.000
Outside							0.000			

Upper Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCL c (mg/m^2)	HCL f (mg/m^2)	HCL uw (mg/m^2)	HCL lw (mg/m^2)
1	77.9	18.8	0.508	0.000	0.000	0.000	0.000	2.72	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Lower Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCL c (mg/m^2)	HCL f (mg/m^2)	HCL uw (mg/m^2)	HCL lw (mg/m^2)
1	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Vent Flow (kg/s)

From	To	Number	Type	U->U	U->L->U	L->U->L	L->L	E->U	E->L
1	3	1	H						
2	3	1	H						
3	1	1	H				17.6		
3	2	1	H				18.5		

VERSN 2 TPL3B BOTH EXHAUST FAN ON FIRE IN THE CANYON
 TIMES 800 60 20 20 20
 TAMB 300. 101300. 0.
 EAMB 300. 101300. 0.
 HI/F 8.00 0.000
 WIDTH 245.00 64.00
 DEPTH 12.00 6.000
 HEIGH 12.00 8.000
 HVENT 1 3 1 1.00 2.00 0.000 0.000
 HVENT 2 3 1 20.0 0.3048 0.20 0.00 0.00
 VVENT 2 1 33.32 2
 CVENT 1 3 1 1.00 1.00 1.00 1.00
 CVENT 2 3 1 1.00 1.00 1.00 1.00
 MVOPN 1 3 H 11.00 3.50
 MVOPN 1 4 H 1.00 3.50
 MVOPN 3 1 H 11.00 3.50
 MVOPN 3 6 H 1.00 3.50
 MVDCT 3 2 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVDCT 4 5 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVFAN 2 1 0.00 300.00 0.200E+02 0.266E-01
 MVFAN 5 6 0.00 300.00 0.140E+02 0.266E-01
 INELV 1 19.00 2 19.00 3 19.00 4 9.00 5 9.00 6 9.00
 CEILI CONCRETE CONCRETE
 WALLS CONCRETE CONCRETE
 FLOOR CONCRETE CONCRETE
 CHEMI 0. 0. 1.0 30000000. 300. 400. 0.000
 LFBO 1
 LFBT 2
 FPOS 4.55 3.05 0.00
 FTIME 60. 200. 582. 600. 800.
 FMASS 0.00 0.1666 0.266 0.5 0.5 0.1
 FHIGH 0.00 0.00 0.00 0.00 0.00
 FAREA 0.00 0.00 0.00 0.00 0.00
 FODOT 0.00 5.00E+06 8.00E+06 15.0E+06 15.0E+06 3.0E+6
 CJET OFF
 HCR 0.333 0.333 0.333 0.333 0.333 0.333
 STPMAX 5.00
 DUMPR TPL3B.HI
 DEVICE 1
 WINDOW 0 0. 0. 1279. 1023. 4095.

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Time = 800.0 seconds.

Compartment	Upper Temp. (K)	Lower Temp. (K)	Inter. Height (m)	Upper Vol. (m^3)	Pressure (Pa)	Ceiling Temp. (K)	Up wall Temp. (K)	Low wall Temp. (K)	Floor Temp. (K)
1	366.2	306.0	3.4	2.52E+04 (71%)	-171.	310.4	309.5	302.2	303.9
2	300.0	299.9	8.0	3.1 (0%)	-171.	300.0	300.0	300.0	300.0

Compartment	Fire	Plume Flow (kg/s)	Pyrol Rate (kg/s)	Fire Size (W)	Fire in Upper (W)	Fire in Lower (W)	Vent Fire (W)	Convec. (W)	Radiat. (W)	On Target (W/m^2)
	Main	13.1	0.100	3.000E+06				3.000E+06	0.000	
1		13.1	0.100	3.000E+06	0.000	3.000E+06	0.000			558.
2		0.000	0.000	0.000	0.000	0.000	0.000			0.000
Outside							0.000			

Upper Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (l/m)	HCL c (mg/m^2)	HCL f (mg/m^2)	HCL uw (mg/m^2)	HCL lw (mg/m^2)
1	77.9	18.8	0.507	0.000	0.000	0.000	0.000	2.72	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Lower Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (l/m)	HCL c (mg/m^2)	HCL f (mg/m^2)	HCL uw (mg/m^2)	HCL lw (mg/m^2)
1	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Vent Flow (kg/s)

From	To	Number	Type	U->U	U->L->U	L->U->L	L->L	E->U	E->L
1	3	1	H						
2	3	1	H						
3	1	1	H				28.0		
3	2	1	H				29.3		

Fire Scenario	Peak Heat Release Rate Q (kW)	Time (s)		Mass Flow (kg/s)				Critical Hazard Parameters													
		Peak t_{peak} (s)	Total Duration t_d (s)	Flow Out (kg/s)		Flow In (kg/s)		Canyon							Railroad Tunnel						
				Exhaust flow Canyon	Exhaust flow Tunnel	Vent flow Canyon	Vent flow Tunnel	Smoke Layer Temperature (°C)		Interface Position (m)	Differential Pressure (Pa)	O ₂ Concentration (%)	CO ₂ Concentration (%)	H ₂ O Concentration (%)	Smoke Layer Temperature (°C)		Interface Position (m)	Differential Pressure (Pa)	O ₂ Concentration (%)	CO ₂ Concentration (%)	H ₂ O Concentration (%)
								Upper	Lower						Upper	Lower					
201 - T exhaust system on only	8,700	442	660	15.60	-	5.45	6.0	87.0	33.0	2.30	-6.70	19.50	0.33	1.75	27	27	8	-7.30	20.70	0	0
221 - T-13 exhaust system on only	8,700	442	660	20.60	-	8.70	9.30	88.0	32.0	4.60	-16.50	19.50	0.33	1.75	27	27	8	-17.0	20.70	0	0
Both exhaust system on	8,700	442	660	38.40	-	16.50	17.20	88.0	32.0	4.60	-59.0	19.50	0.33	1.75	27	27	8	-59.0	20.70	0	0

Calculated values of critical hazard parameters based on wood pallet fire in the canyon at location 3R

VERSN 2 TPL1C ONLY FLOOR EXHAUST FAN ON FIRE IN THE CANYON
 TIMES 900 60 20 20 20
 TAMB 300. 101300. 0.
 EAMB 300. 101300. 0.
 HI/F 8.00 0.000
 WIDTH 245.00 64.00
 DEPTH 12.000 6.0000
 HEIGH 12.000 8.0000
 HVENT 1 3 1 1.00 2.00 0.000 0.000
 HVENT 2 3 1 20.0 0.3048 0.20 0.00 0.00
 VVENT 2 1 33.32 2
 CVENT 1 3 1 1.00 1.00 1.00 1.00
 CVENT 2 3 1 1.00 1.00 1.00 1.00
 MVOPN 1 3 H 1.00 3.50
 MVOPN 3 1 H 1.00 3.50
 MVDCT 3 2 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVFAN 2 1 0.00 300.00 0.140E+02 0.266E-01
 INELV 1 9.00 2 9.00 3 9.00
 CEILI CONCRETE CONCRETE
 WALLS CONCRETE CONCRETE
 FLOOR CONCRETE CONCRETE
 CHEMI 0. 0. 1.0 30000000. 300. 400. 0.000
 LFBO 1
 LFBT 2
 FPOS 4.55 3.05 0.00
 FTIME 60. 200. 442. 600. 900.
 FMASS 0.00 0.0666 0.1666 0.29 0.29 0.10
 FHIGH 0.00 0.00 0.00 0.00 0.00
 FAREA 0.00 0.00 0.00 0.00 0.00
 FQDOT 0.00 2.00E+06 5.00E+06 8.700E+06 8.700E+06 3.0E+6
 CJET OFF
 HCR 0.333 0.333 0.333 0.333 0.333 0.333
 STPMAX 5.00
 DUMPR TPL1C.HI
 DEVICE 1
 WINDOW 0 0. 0. 1279. 1023. 4095.

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Time = 900.0 seconds.

Compartment	Upper Temp. (K)	Lower Temp. (K)	Inter. Height (m)	Upper Vol. (m^3)	Pressure (Pa)	Ceiling Temp. (K)	Up wall Temp. (K)	Low wall Temp. (K)	Floor Temp. (K)
1	347.7	305.1	1.7	3.03E+04 (86%)	-24.8	307.3	306.6	301.8	303.1
2	300.0	300.0	8.0	3.1 (0%)	-25.4	300.0	300.0	300.0	300.0

Compartment	Fire	Plume Flow (kg/s)	Pyrol Rate (kg/s)	Fire Size (W)	Fire in Upper (W)	Fire in Lower (W)	Vent Fire (W)	Convec. (W)	Radiat. (W)	On Target (W/m^2)
Main		7.27	0.100	3.000E+06				3.000E+06	0.000	
1		7.27	0.100	3.000E+06	0.000	3.000E+06	0.000			368.
2		0.000	0.000	0.000	0.000	0.000	0.000			0.000
Outside							0.000			

Upper Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCL c (mg/m^2)	HCL f (mg/m^2)	HCL uw (mg/m^2)	HCL lw (mg/m^2)
1	78.3	19.3	0.388	0.000	0.000	0.000	0.000	2.08	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Lower Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCL c (mg/m^2)	HCL f (mg/m^2)	HCL uw (mg/m^2)	HCL lw (mg/m^2)
1	79.3	20.7	5.343E-04	0.000	0.000	0.000	0.000	2.866E-03	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Vent Flow (kg/s)

From	To	Number	Type	U->U	U->L->U	L->U->L	L->L	E->U	E->L
1	3	1	H						
2	3	1	H						
3	1	1	H			1.58	9.03		0.110
3	2	1	H				11.3		

VERSN 2 TPL2C ONLY ROOF EXHAUST FAN ON FIRE IN THE CANYON
 TIMES 900 60 20 20 20
 TAMB 300. 101300. 0.
 EAMB 300. 101300. 0.
 HI/F 8.00 0.000
 WIDTH 245.00 64.00
 DEPTH 12.00 6.000
 HEIGH 12.00 8.00
 HVENT 1 3 1 1.00 2.00 0.000 0.000
 HVENT 2 3 1 20.0 0.3048 0.20 0.00 0.00
 VVENT 2 1 33.32 2
 CVENT 1 3 1 1.00 1.00 1.00 1.00
 CVENT 2 3 1 1.00 1.00 1.00 1.00
 MVOPN 1 3 H 11.00 3.50
 MVOPN 3 1 H 11.00 3.50
 MVDCT 3 2 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVFAN 2 1 0.00 300.00 0.200E+02 0.266E-01
 INELV 1 19.00 2 19.00 3 19.00
 CEILI CONCRETE CONCRETE
 WALLS CONCRETE CONCRETE
 FLOOR CONCRETE CONCRETE
 CHEMI 0. 0. 1.0 30000000. 300. 400. 0.000
 LFBO 1
 LFBT 2
 FPOS 4.55 3.05 0.00
 FTIME 60. 200. 442. 600. 900.
 FMASS 0.00 0.0666 0.1666 0.29 0.29 0.10
 FHIGH 0.00 0.00 0.00 0.00 0.00
 FAREA 0.00 0.00 0.00 0.00 0.00
 FQDOT 0.00 2.00E+06 5.00E+06 8.700E+06 8.700E+06 3.0E+6
 CJET OFF
 HCR 0.333 0.333 0.333 0.333 0.333 0.333
 STPMAX 5.00
 DUMPR TPL2C.HI
 DEVICE 1
 WINDOW 0 0. 0. 1279. 1023. 4095.

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Time = 900.0 seconds.

Compartment	Upper Temp. (K)	Lower Temp. (K)	Inter. Height (m)	Upper Vol. (m^3)	Pressure (Pa)	Ceiling Temp. (K)	Up wall Temp. (K)	Low wall Temp. (K)	Floor Temp. (K)
1	346.5	305.4	4.6	2.19E+04 (62%)	-37.5	307.3	306.6	301.4	302.5
2	300.0	300.0	8.0	3.1 (0%)	-38.1	300.0	300.0	300.0	300.0

Compartment	Fire	Plume Flow (kg/s)	Pyrol Rate (kg/s)	Fire Size (W)	Fire in Upper (W)	Fire in Lower (W)	Vent Fire (W)	Convec. (W)	Radiat. (W)	On Target (W/m^2)
	Main	17.0	0.100	3.000E+06				3.000E+06	0.000	
1		17.0	0.100	3.000E+06	0.000	3.000E+06	0.000			357.
2		0.000	0.000	0.000	0.000	0.000	0.000			0.000
Outside							0.000			

Upper Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCL c (mg/m^2)	HCL f (mg/m^2)	HCL uw (mg/m^2)	HCL lw (mg/m^2)
1	78.3	19.4	0.364	0.000	0.000	0.000	0.000	1.95	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Lower Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCL c (mg/m^2)	HCL f (mg/m^2)	HCL uw (mg/m^2)	HCL lw (mg/m^2)
1	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Vent Flow (kg/s)

From	To	Number	Type	U->U	U->L->U	L->U->L	L->L	E->U	E->L
1	3	1	H						
2	3	1	H						
3	1	1	H				13.1		
3	2	1	H				13.8		

VERSN 2 TPL3C BOTH EXHAUST FAN ON FIRE IN THE CANYON
 TIMES 900 60 20 20 20
 TAMB 300. 101300. 0.
 EAMB 300. 101300. 0.
 HI/F 8.00 0.000
 WIDTH 245.00 64.00
 DEPTH 12.00 6.000
 HEIGH 12.00 8.000
 HVENT 1 3 1 1.00 2.00 0.000 0.000
 HVENT 2 3 1 20.0 0.3048 0.20 0.00 0.00
 VVENT 2 1 33.32 2
 CVENT 1 3 1 1.00 1.00 1.00 1.00
 CVENT 2 3 1 1.00 1.00 1.00 1.00
 MVOPN 1 3 H 11.00 3.50
 MVOPN 1 4 H 1.00 3.50
 MVOPN 3 1 H 11.00 3.50
 MVOPN 3 6 H 1.00 3.50
 MVDCT 3 2 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVDCT 4 5 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVFAN 2 1 0.00 300.00 0.200E+02 0.266E-01
 MVFAN 5 6 0.00 300.00 0.140E+02 0.266E-01
 INELV 1 19.00 2 19.00 3 19.00 4 9.00 5 9.00 6 9.00
 CEILI CONCRETE CONCRETE
 WALLS CONCRETE CONCRETE
 FLOOR CONCRETE CONCRETE
 CHEMI 0. 0. 1.0 30000000. 300. 400. 0.000
 LFBO 1
 LFBT 2
 FPOS 4.55 3.05 0.00
 FTIME 60. 200. 442. 600. 900.
 FMASS 0.00 0.0666 0.1666 0.29 0.29 0.10
 FHIGH 0.00 0.00 0.00 0.00 0.00
 FAREA 0.00 0.00 0.00 0.00 0.00
 FQDOT 0.00 2.00E+06 5.00E+06 8.700E+06 8.700E+06 3.0E+6
 CJET OFF
 HCR 0.333 0.333 0.333 0.333 0.333 0.333
 STPMAX 5.00
 DUMPR TPL3C.HI
 DEVICE 1
 WINDOW 0 0. 0. 1279. 1023. 4095.

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Time = 900.0 seconds.

Compartment	Upper Temp. (K)	Lower Temp. (K)	Inter. Height (m)	Upper Vol. (m^3)	Pressure (Pa)	Ceiling Temp. (K)	Up wall Temp. (K)	Low wall Temp. (K)	Floor Temp. (K)
1	346.3	304.2	4.6	2.17E+04 (62%)	-110.	307.2	306.6	301.4	302.4
2	300.0	300.0	8.0	3.1 (0%)	-110.	300.0	300.0	300.0	300.0

Compartment	Fire	Plume Flow (kg/s)	Pyrol Rate (kg/s)	Fire Size (W)	Fire in Upper (W)	Fire in Lower (W)	Vent Fire (W)	Convec. (W)	Radiat. (W)	On Target (W/m^2)
	Main	17.1	0.100	3.000E+06				3.000E+06	0.000	
1		17.1	0.100	3.000E+06	0.000	3.000E+06	0.000			355.
2		0.000	0.000	0.000	0.000	0.000	0.000			0.000
Outside							0.000			

Upper Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCL c (mg/m^2)	HCL f (mg/m^2)	HCL uw (mg/m^2)	HCL lw (mg/m^2)
1	78.3	19.4	0.363	0.000	0.000	0.000	0.000	1.95	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Lower Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCL c (mg/m^2)	HCL f (mg/m^2)	HCL uw (mg/m^2)	HCL lw (mg/m^2)
1	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Vent Flow (kg/s)

From	To	Number	Type	U->U	U->L->U	L->U->L	L->L	E->U	E->L
1	3	1	H						
2	3	1	H						
3	1	1	H				22.4		
3	2	1	H				23.5		

2 TPLIC ONLY FLOOR EXHAUST FAN ON FIRE IN THE CANYON
 VERSN 900 50 20 20
 TIMES 300. 101300. 0.
 TAMB 300. 101300. 0.
 EMB 8.00 0.000
 HI/F 245.00 64.00
 WIDTH 12.000 8.0000
 DEPTH 12.000 6.0000
 HEIGHT 12.000 8.0000
 HVENT 1 3 1 1.00 2.00 0.000 0.000
 HVENT 2 3 1 20.0 0.3048 0.20 0.00 0.00
 VVENT 2 1 33.32 2
 CVENT 1 3 1 1.00 1.00 1.00 1.00
 CVENT 2 3 1 1.00 1.00 1.00 1.00
 MVOPN 1 3 H 1.00 3.50
 MVOPN 3 1 H 1.00 3.50
 MVDCT 3 2 8.00 2.00.00000 0.00 3.0000 0.00 3.000
 MVDCT 2 1 0.00 300.00 0.140E+02 0.266E-01
 MVDCT 2 1 0.00 2 9.00 3 9.00
 INELV 1 9.00 2 9.00 3 9.00
 CEILI CONCRETE CONCRETE
 WALLS CONCRETE CONCRETE
 FLOOR CONCRETE CONCRETE
 CHEMI 0. 0. 1.0 30000000. 300. 400. 0.000
 LFBG 1
 LFBG 2 4.55 3.05 0.00
 FPOS 60. 200. 442. 600. 900.
 FTIME 0.00 0.0666 0.1666 0.29 0.29 0.10
 FMASS 0.00 0.00 0.00 0.00 0.00
 FHIGH 0.00 0.00 0.00 0.00 0.00
 FAREA 0.00 0.00 0.00 0.00 0.00
 FQDOT 0.00 2.00E+06 5.00E+06 8.700E+06 8.700E+06 3.0E+6
 CUET OFF
 HCR 0.333 0.333 0.333 0.333 0.333 0.333
 STPMAX 5.00
 DOWER TPLIC.HI
 DEVICE 1
 WINDOW 0 0. 0. 1279. 1023. 4095.

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Time = 900.0 seconds.

Compartment	Upper Temp. (K)	Lower Temp. (K)	Inter. Height (m)	Upper Vol. (m^3)	Pressure (Pa)	Ceiling Temp. (K)	Up wall Temp. (K)	Low wall Temp. (K)	Floor Temp. (K)
1	347.7	305.1	1.7	3.03E+04	-24.8	307.3	306.6	301.8	303.1
2	300.0	300.0	8.0	3.1	-25.4	300.0	300.0	300.0	300.0

Compartment	Fire	Plume Flow (kg/s)	Pyrol Rate (kg/s)	Fire Size (W)	Fire in Upper (W)	Fire in Lower (W)	Vent Fire (W)	Convec. (W)	Radiat. (W)	On Target (W/m^2)
	Main	7.27	0.100	3.000E+06				3.000E+06	0.000	
1		7.27	0.100	3.000E+06	0.000	3.000E+06	0.000			368.
2		0.000	0.000	0.000	0.000	0.000	0.000			0.000
Outside							0.000			

Upper Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (l/m)	HCl c (mg/m^2)	HCl f (mg/m^2)	HCl uw (mg/m^2)	HCl lw (mg/m^2)
1	78.3	19.3	0.388	0.000	0.000	0.000	0.000	2.08	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Lower Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (l/m)	HCl c (mg/m^2)	HCl f (mg/m^2)	HCl uw (mg/m^2)	HCl lw (mg/m^2)
1	79.3	20.7	5.343E-04	0.000	0.000	0.000	0.000	2.866E-03	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Vent Flow (kg/s)

From	To	Number	Type	U->U	U->L->U	L->U->L	L->L	E->U	E->L
1	3	1	H						
2	3	1	H						
3	1	1	H			1.58	9.03		0.110
3	2	1	H				11.3		

Calculated values of critical hazard parameters based on plywood box fire in the railroad tunnel

Fire Scenario	Peak Heat Release Rate (kW)	Time (s)	Flow Out (kg/s)		Mass Flow (kg/s)		Critical Hazard Parameters												Railroad Tunnel	
			Exhaust Flow Canyon	Exhaust Flow Tunnel	Vent Flow Canyon	Vent Flow Tunnel	Smoke Layer Temperature (°C)	Interface Position (m)	Differential Pressure (Pa)	O ₂ Concentration (%)	CO ₂ Concentration (%)	H ₂ O Concentration (%)	Smoke Layer Temperature (°C)		Interface Position (m)	Differential Pressure (Pa)	O ₂ Concentration (%)	CO ₂ Concentration (%)	H ₂ O Concentration (%)	
													Upper	Lower						
291-T exhaust system on only	1,200	165	1200	18.36	-	7.16	9.0	35.0	27.2	5.50	-11.2	20.2	0.15	67.0	28.0	5.0	-16.0	20.20	0.13	0.60
221-T exhaust system on only	1,200	165	1200	23.40	-	11.0	12.50	39.0	27.2	11.0	-26.30	20.2	0.10	65.0	28.0	5.20	-31.0	20.20	0.174	0.75
Both exhaust system on	1,200	165	1200	39.76	-	21.30	22.70	36.0	27.2	9.10	-103.0	20.2	7.5 x 10 ⁻⁴	63.0	28.0	5.70	-99.0	20.20	0.12	0.62

VERSN 2 TPLIV ONLY FLOOR EXHAUST FAN ON FIRE IN THE TUNNEL
 TIMES 1200 60 20 20 20
 TAMB 300. 101300. 0.
 EAMB 300. 101300. 0.
 HI/F 8.00 0.000
 WIDTH 245.00 64.00
 DEPTH 12.000 6.0000
 HEIGH 12.000 8.0000
 HVENT 1 3 1 1.00 2.00 0.000 0.000
 HVENT 2 3 1 20.0 0.3048 0.200 0.000
 VVENT 2 1 33.32 2
 CVENT 1 3 1 1.00 1.00 1.00 1.00
 CVENT 2 3 1 1.00 1.00 1.00 1.00
 MVOPN 1 3 H 1.00 3.50
 MVOPN 3 1 H 1.00 3.50
 MVDCT 3 2 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVFAN 2 1 0.00 300.00 0.140E+02 0.266E-01
 INELV 1 9.00 2 9.00 3 9.00
 CEILI CONCRETE CONCRETE
 WALLS CONCRETE CONCRETE
 FLOOR CONCRETE CONCRETE
 CHEMI 0. 0. 1.0 30000000. 300. 400. 0.000
 LFBO 2
 LFBT 2
 FPOS 4.55 3.05 0.00
 FTIME 60. 110. 165. 200. 1200.
 FMASS 0.00 0.00133 0.0133 0.040 0.040 0.031
 FHIGH 0.00 0.00 0.00 0.00 0.00
 FAREA 0.00 0.00 0.00 0.00 0.00
 FQDOT 0.00 4.0E+04 40.0E+04 12.0E+05 12.0E+05 9.50E+05
 CJET OFF
 HCR 0.333 0.333 0.333 0.333 0.333 0.333
 STPMAX 5.00
 DUMPR TPLIV.HI
 DEVICE 1
 WINDOW 0 0. 0. 1279. 1023. 4095.

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Time = 1200.0 seconds.

Compartment	Upper Temp. (K)	Lower Temp. (K)	Inter. Height (m)	Upper Vol. (m ³)	Pressure (Pa)	Ceiling Temp. (K)	Up wall Temp. (K)	Low wall Temp. (K)	Floor Temp. (K)
1	307.5	300.3	5.5	1.91E+04 (54%)	-11.2	301.0	300.9	300.2	300.2
2	339.5	301.0	5.0	1.15E+03 (38%)	-16.0	306.6	306.2	301.2	301.5

Compartment	Fire	Plume Flow (kg/s)	Pyrol Rate (kg/s)	Fire Size (W)	Fire in Upper (W)	Fire in Lower (W)	Vent Fire (W)	Convec. (W)	Radiat. (W)	On Target (W/m ²)
Main		14.2	3.100E-02	9.500E+05				9.500E+05	0.000	
1		0.000	0.000	0.000	0.000	0.000	0.000			47.9
2		14.2	3.100E-02	9.500E+05	0.000	9.500E+05	0.000			292.
Outside							0.000			

Upper Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (l/m)	HCl c (mg/m ²)	HCl f (mg/m ²)	HCl uw (mg/m ²)	HCl lw (mg/m ²)
1	79.0	20.3	0.113	0.000	0.000	0.000	0.000	0.595	0.000	0.000	0.000	0.000	0.000
2	78.9	20.2	0.156	0.000	0.000	0.000	0.000	0.803	0.000	0.000	0.000	0.000	0.000

Lower Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (l/m)	HCl c (mg/m ²)	HCl f (mg/m ²)	HCl uw (mg/m ²)	HCl lw (mg/m ²)
1	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	1.441E-03	0.000	0.000	0.000	0.000	7.591E-03	0.000	0.000	0.000	0.000	0.000

Vent Flow (kg/s)

From	To	Number	Type	U->U	U->L->U	L->U->L	L->L	E->U	E->L
1	3	1	H						
2	3	1	H						
3	1	1	H				7.16		
3	2	1	H				8.97		

VERSN 2 TPL2V ONLY ROOF EXHAUST FAN ON FIRE IN THE TUNNEL
 TIMES 1200 60 20 20 20
 TAMB 300. 101300. 0.
 EAMB 300. 101300. 0.
 HI/F 8.00 0.00
 WIDTH 245.00 64.00
 DEPTH 12.00 6.00
 HEIGH 12.00 8.00
 HVENT 1 3 1 1.000 2.000 0.000 0.000
 HVENT 2 3 1 20.0 0.3048 0.200 0.000
 VVENT 2 1 33.32 2
 CVENT 1 3 1 1.00 1.00 1.00 1.00 1.00
 CVENT 2 3 1 1.00 1.00 1.00 1.00 1.00
 MVOPN 1 3 H 11.00 3.50
 MVOPN 3 1 H 11.00 3.50
 MVDCT 3 2 8.00 2.00 .00000 0.00 1.0000 0.00 1.0000
 MVFAN 2 1 0.00 300.00 0.200E+02 0.266E-01
 INELV 1 11.00 2 19.00 3 19.00
 CEILI CONCRETE CONCRETE
 WALLS CONCRETE CONCRETE
 FLOOR CONCRETE CONCRETE
 CHEMI 0. 0. 1.0 30000000. 300. 400. 0.000
 LFBO 2
 LFBT 2
 FPOS 4.55 3.05 0.00
 FTIME 60. 110. 165. 200. 1200.
 FMASS 0.00 0.00133 0.0133 0.040 0.040 0.031
 FHIGH 0.00 0.00 0.00 0.00 0.00
 FAREA 0.00 0.00 0.00 0.00 0.00
 FQDOT 0.00 4.0E+04 40.0E+04 12.0E+05 12.0E+05 9.50E+05
 CJET OFF
 HCR 0.333 0.333 0.333 0.333 0.333
 STPMAX 5.00
 DUMPR TPL2V.HI
 DEVICE 1
 WINDOW 0 0. 0. 1279. 1023. 4095.

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Time = 1200.0 seconds.

Compartment	Upper Temp. (K)	Lower Temp. (K)	Inter. Height (m)	Upper Vol. (m^3)	Pressure (Pa)	Ceiling Temp. (K)	Up wall Temp. (K)	Low wall Temp. (K)	Floor Temp. (K)
1	311.6	300.2	11.	3.18E+03 (9%)	-26.3	301.1	300.9	300.1	300.1
2	338.2	300.7	5.2	1.07E+03 (35%)	-30.6	306.4	306.0	301.1	301.4

Compartment	Fire	Plume Flow (kg/s)	Pyrol Rate (kg/s)	Fire Size (W)	Fire in Upper (W)	Fire in Lower (W)	Vent Fire (W)	Convec. (W)	Radiat. (W)	On Target (W/m^2)
Main		15.3	3.100E-02	9.500E+05				9.500E+05	0.000	
1		0.000	0.000	0.000	0.000	0.000	0.000			75.2
2		15.3	3.100E-02	9.500E+05	0.000	9.500E+05	0.000			281.
Outside							0.000			

Upper Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCL c (mg/m^2)	HCL f (mg/m^2)	HCL uw (mg/m^2)	HCL lw (mg/m^2)
1	79.0	20.3	0.103	0.000	0.000	0.000	0.000	0.537	0.000	0.000	0.000	0.000	0.000
2	78.9	20.2	0.144	0.000	0.000	0.000	0.000	0.740	0.000	0.000	0.000	0.000	0.000

Lower Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCL c (mg/m^2)	HCL f (mg/m^2)	HCL uw (mg/m^2)	HCL lw (mg/m^2)
1	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Vent Flow (kg/s)

From	To	Number	Type	U->U	U->L->U	L->U->L	L->L	E->U	E->L
1	3	1	H						
2	3	1	H						
3	1	1	H				11.0		
3	2	1	H				12.4		

VERSN 2 TPL3V BOTH EXHAUST FAN ON FIRE IN THE TUNNEL
 TIMES 1200 60 20 20 20
 TAMB 300. 101300. 0.
 EAMB 300. 101300. 0.
 HI/F 8.00 0.000
 WIDTH 245.00 64.00
 DEPTH 12.00 6.000
 HEIGH 12.00 8.000
 HVENT 1 3 1 1.00 2.00 0.000 0.000
 HVENT 2 3 1 20.0 0.3048 0.200 0.00
 VVENT 2 1 33.32 2
 CVENT 1 3 1 1.00 1.00 1.00 1.00
 CVENT 2 3 1 1.00 1.00 1.00 1.00
 MVOPN 1 3 H 11.0 3.50
 MVOPN 1 4 H 1.00 3.50
 MVOPN 3 1 H 11.0 3.50
 MVOPN 3 6 H 1.00 3.50
 MVDCT 3 2 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVDCT 4 5 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVFAN 2 1 0.00 300.00 0.200E+02 0.266E-01
 MVFAN 5 6 0.00 300.00 0.140E+02 0.266E-01
 INELV 1 19.00 2 19.00 3 19.00 4 9.00 5 9.00 6 9.00
 CEILI CONCRETE CONCRETE
 WALLS CONCRETE CONCRETE
 FLOOR CONCRETE CONCRETE
 CHEMI 0. 0. 1.0 30000000. 300. 400. 0.000
 LFBO 2
 LFBT 2
 FPOS 4.55 3.05 0.00
 FTIME 60. 110. 165. 200. 1200.
 FMASS 0.00 0.00133 0.0133 0.040 0.040 0.031
 FHIGH 0.00 0.00 0.00 0.00 0.00
 FAREA 0.00 0.00 0.00 0.00 0.00
 FQDOT 0.00 4.0E+04 40.0E+04 12.0E+05 12.0E+05 9.50E+05
 CJET OFF
 HCR 0.333 0.333 0.333 0.333 0.333 0.333
 STPMAX 5.00
 DUMPR TPL3V.HI
 DEVICE 1
 WINDOW 0 0. 0. 1279. 1023. 4095.

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Time = 1200.0 seconds.

Compartment	Upper Temp. (K)	Lower Temp. (K)	Inter. Height (m)	Upper Vol. (m^3)	Pressure (Pa)	Ceiling Temp. (K)	Up wall Temp. (K)	Low wall Temp. (K)	Floor Temp. (K)
1	308.7	300.2	9.1	8.56E+03 (24%)	-99.3	301.0	300.9	300.2	300.2
2	335.4	300.5	5.7	8.97E+02 (29%)	-103.	305.8	305.5	301.0	301.1

Compartment	Fire	Plume Flow (kg/s)	Pyrol Rate (kg/s)	Fire Size (W)	Fire in Upper (W)	Fire in Lower (W)	Vent Fire (W)	Convec. (W)	Radiat. (W)	On Target (W/m^2)
	Main	18.0	3.100E-02	9.500E+05				9.500E+05	0.000	
1		0.000	0.000	0.000	0.000	0.000	0.000			55.7
2		18.0	3.100E-02	9.500E+05	0.000	9.500E+05	0.000			257.
Outside							0.000			

Upper Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCL c (mg/m^2)	HCL f (mg/m^2)	HCL uw (mg/m^2)	HCL lw (mg/m^2)
1	79.1	20.4	7.480E-02	0.000	0.000	0.000	0.000	0.389	0.000	0.000	0.000	0.000	0.000
2	79.0	20.3	0.122	0.000	0.000	0.000	0.000	0.628	0.000	0.000	0.000	0.000	0.000

Lower Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCL c (mg/m^2)	HCL f (mg/m^2)	HCL uw (mg/m^2)	HCL lw (mg/m^2)
1	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Vent Flow (kg/s)

From	To	Number	Type	U->U	U->L->U	L->U->L	L->L	E->U	E->L
1	3	1	H						
2	3	1	H						
3	1	1	H				21.3		
3	2	1	H				22.7		

Fire Scenario	Peak Heat Release Rate $\dot{Q}$ (kW)	Time (s)		Mass Flow (kg/s)				Critical Hazard Parameters											
				Flow Out (kg/s)		Flow In (kg/s)		Canyon						Railroad Tunnel					
		Peak time (s)	Total Duration t_b (s)	Exhaust flow Canyon	Exhaust flow Tunnel	Vent flow Canyon	Vent flow Tunnel	Interface Position (m)	Differential Pressure (Pa)	O_2 Concentration (%)	CO_2 Concentration (%)	H_2O Concentration (%)	Smoke Layer Temperature (°C)		Interface Position (m)	Differential Pressure (Pa)	O_2 Concentration (%)	CO_2 Concentration (%)	H_2O Concentration (%)
													Upper	Lower					
201 - T exhaust system on only	3,520	202	1000	16.38	-	9.11	5.81	5.50	-7.50	20.0	0.25	1.30	48.0	28.0	5.50	-16.50	19.40	0.35	1.90
221 - F-13 exhaust system on only	3,520	202	1000	23.40	-	9.70	12.10	9.80	-20.50	20.0	0.25	1.35	52.0	28.0	5.10	-29.0	19.50	0.33	1.80
Both exhaust system on	3,520	202	1000	39.78	-	19.60	21.40	8.20	-20.0	20.0	0.20	1.0	48.0	28.0	5.50	-91.0	19.60	0.30	1.50

Calculated values of critical hazard parameters based on 55 gallon drum filled with flammable liquid soaked fire in the railroad tunnel

VERSN 2 TPL1W ONLY FLOOR EXHAUST FAN ON FIRE IN THE TUNNEL
 TIMES 1000 60 20 20 20
 TAMB 300. 101300. 0.
 EAMB 300. 101300. 0.
 HI/F 8.00 0.000
 WIDTH 245.00 64.00
 DEPTH 12.000 6.0000
 HEIGH 12.000 8.0000
 HVENT 1 3 1 1.00 2.00 0.000 0.000
 HVENT 2 3 1 20.0 0.3048 0.200 0.000
 VVENT 2 1 33.32 2
 CVENT 1 3 1 1.00 1.00 1.00 1.00
 CVENT 2 3 1 1.00 1.00 1.00 1.00
 MVOPN 1 3 H 1.00 3.50
 MVOPN 3 1 H 1.00 3.50
 MVDCT 3 2 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVFAN 2 1 0.00 300.00 0.140E+02 0.266E-01
 INELV 1 9.00 2 9.00 3 9.00
 CEILI CONCRETE CONCRETE
 WALLS CONCRETE CONCRETE
 FLOOR CONCRETE CONCRETE
 CHEMI 0. 0. 1.0 30000000. 300. 400. 0.000
 LFBO 2
 LFBT 2
 FPOS 4.55 3.05 0.00
 FTIME 60. 180. 282. 350. 1000.
 FMASS 0.00 0.00133 0.0133 0.117 0.117 0.093
 FHIGH 0.00 0.00 0.00 0.00 0.00
 FAREA 0.00 0.00 0.00 0.00 0.00
 FQDOT 0.00 4.0E+04 40.0E+04 3.520E+06 3.520E+06 2.800E+06
 CJET OFF
 HCR 0.333 0.333 0.333 0.333 0.333 0.333
 STPMAX 5.00
 DUMPR TPL1W.HI
 DEVICE 1
 WINDOW 0 0. 0. 1279. 1023. 4095.

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Time = 1000.0 seconds.

Compartment	Upper Temp. (K)	Lower Temp. (K)	Inter. Height (m)	Upper Vol. (m^3)	Pressure (Pa)	Ceiling Temp. (K)	Up wall Temp. (K)	Low wall Temp. (K)	Floor Temp. (K)
1	319.1	300.7	5.5	1.92E+04 (54%)	-7.40	302.4	302.2	300.6	300.6
2	391.2	302.5	5.0	1.17E+03 (38%)	-16.5	315.7	314.7	302.9	303.7

Compartment	Fire	Plume Flow (kg/s)	Pyrol Rate (kg/s)	Fire Size (W)	Fire in Upper (W)	Fire in Lower (W)	Vent Fire (W)	Convec. (W)	Radiat. (W)	On Target (W/m^2)
	Main	18.1	9.300E-02	2.800E+06				2.800E+06	0.000	
1		0.000	0.000	0.000	0.000	0.000	0.000			129.
2		18.1	9.300E-02	2.800E+06	0.000	2.800E+06	0.000			864.
Outside							0.000			

Upper Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCl c (mg/m^2)	HCl f (mg/m^2)	HCl uw (mg/m^2)	HCl lw (mg/m^2)
1	78.6	19.8	0.249	0.000	0.000	0.000	0.000	1.33	0.000	0.000	0.000	0.000	0.000
2	78.4	19.4	0.354	0.000	0.000	0.000	0.000	1.88	0.000	0.000	0.000	0.000	0.000

Lower Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCl c (mg/m^2)	HCl f (mg/m^2)	HCl uw (mg/m^2)	HCl lw (mg/m^2)
1	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	4.313E-03	0.000	0.000	0.000	0.000	2.298E-02	0.000	0.000	0.000	0.000	0.000

Vent Flow (kg/s)

From	To	Number	Type	U->U	U->L->U	L->U->L	L->L	E->U	E->L
1	3	1	H						
2	3	1	H						
3	1	1	H				5.81		
3	2	1	H				9.11		

VERSN 2 TPL2W ONLY ROOF EXHAUST FAN ON FIRE IN THE TUNNEL
 TIMES 1000 60 20 20 20
 TAMB 300. 101300. 0.
 EAMB 300. 101300. 0.
 HI/F 8.00 0.00
 WIDTH 245.00 64.00
 DEPTH 12.00 6.00
 HEIGH 12.00 8.00
 HVENT 1 3 1 1.000 2.000 0.000 0.000
 HVENT 2 3 1 20.0 0.3048 0.200 0.000
 VVENT 2 1 33.32 2
 CVENT 1 3 1 1.00 1.00 1.00 1.00
 CVENT 2 3 1 1.00 1.00 1.00 1.00
 MVOPN 1 3 H 11.00 3.50
 MVOPN 3 1 H 11.00 3.50
 MVDCT 3 2 8.00 2.00 .00000 0.00 1.0000 0.00 1.0000
 MVFAN 2 1 0.00 300.00 0.200E+02 0.266E-01
 INELV 1 11.00 2 19.00 3 19.00
 CEILI CONCRETE CONCRETE
 WALLS CONCRETE CONCRETE
 FLOOR CONCRETE CONCRETE
 CHEMI 0. 0. 1.0 30000000. 300. 400. 0.000
 LFBO 2
 LFBT 2
 FPOS 4.55 3.05 0.00
 FTIME 60. 180. 282. 350. 1000.
 FMASS 0.00 0.00133 0.0133 0.117 0.117 0.093
 FHIGH 0.00 0.00 0.00 0.00 0.00
 FAREA 0.00 0.00 0.00 0.00 0.00
 FQDOT 0.00 4.0E+04 40.0E+04 3.520E+06 3.520E+06 2.800E+06
 CJET OFF
 HCR 0.333 0.333 0.333 0.333 0.333
 STEMAX 5.00
 DUMPR TPL2W.HI
 DEVICE 1
 WINDOW 0 0. 0. 1279. 1023. 4095.

** CFAST Version 2.0.1 Run 7/27/94 **
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CFAST Version 2.0.1 - created May 1, 1993 TPL2W.Fat

Time = 1000.0 seconds.

Compartment	Upper Temp. (K)	Lower Temp. (K)	Inter. Height (m)	Upper Vol. (m^3)	Pressure (Pa)	Ceiling Temp. (K)	Up wall Temp. (K)	Low wall Temp. (K)	Floor Temp. (K)
1	324.2	300.6	9.8	6.49E+03 (18%)	-20.6	302.7	302.3	300.4	300.4
2	389.1	301.9	5.1	1.11E+03 (36%)	-29.0	315.3	314.4	302.8	303.5

Compartment	Fire	Plume Flow (kg/s)	Pyrol Rate (kg/s)	Fire Size (W)	Fire in Upper (W)	Fire in Lower (W)	Vent Fire (W)	Convec. (W)	Radiat. (W)	On Target (W/m^2)
	Main	19.1	9.300E-02	2.800E+06				2.800E+06	0.000	
1		0.000	0.000	0.000	0.000	0.000	0.000			166.
2		19.1	9.300E-02	2.800E+06	0.000	2.800E+06	0.000			836.
Outside							0.000			

Upper Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCL c (mg/m^2)	HCL f (mg/m^2)	HCL uw (mg/m^2)	HCL lw (mg/m^2)
1	78.6	19.8	0.252	0.000	0.000	0.000	0.000	1.35	0.000	0.000	0.000	0.000	0.000
2	78.4	19.5	0.332	0.000	0.000	0.000	0.000	1.77	0.000	0.000	0.000	0.000	0.000

Lower Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCL c (mg/m^2)	HCL f (mg/m^2)	HCL uw (mg/m^2)	HCL lw (mg/m^2)
1	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Vent Flow (kg/s)

From	To	Number	Type	U->U	U->L->U	L->U->L	L->L	E->U	E->L
1	3	1	H						
2	3	1	H						
3	1	1	H				9.70		
3	2	1	H				12.1		

VERSN 2 TPL3W BOTH EXHAUST FAN ON FIRE IN THE TUNNEL
 TIMES 1000 60 20 20 20
 TAMB 300. 101300. 0.
 EAMB 300. 101300. 0.
 HI/F 8.00 0.000
 WIDTH 245.00 64.00
 DEPTH 12.00 6.000
 HEIGH 12.00 8.000
 HVENT 1 3 1 1.00 2.00 0.000 0.000
 HVENT 2 3 1 20.0 0.3048 0.200 0.00
 VVENT 2 1 33.32 2
 CVENT 1 3 1 1.00 1.00 1.00 1.00
 CVENT 2 3 1 1.00 1.00 1.00 1.00
 MVOFN 1 3 H 11.0 3.50
 MVOFN 1 4 H 1.00 3.50
 MVOFN 3 1 H 11.0 3.50
 MVOFN 3 6 H 1.00 3.50
 MVDCT 3 2 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVDCT 4 5 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVFAN 2 1 0.00 300.00 0.200E+02 0.266E-01
 MVFAN 5 6 0.00 300.00 0.140E+02 0.266E-01
 INELV 1 19.00 2 19.00 3 19.00 4 9.00 5 9.00 6 9.00
 CEILI CONCRETE CONCRETE
 WALLS CONCRETE CONCRETE
 FLOOR CONCRETE CONCRETE
 CHEMI 0. 0. 1.0 30000000. 300. 400. 0.000
 LFBO 2
 LFBT 2
 FPOS 4.55 3.05 0.00
 FTIME 60. 180. 282. 350. 1000.
 FMASS 0.00 0.00133 0.0133 0.117 0.117 0.093
 FHIGH 0.00 0.00 0.00 0.00 0.00
 FAREA 0.00 0.00 0.00 0.00 0.00
 PQDOT 0.00 4.0E+04 40.0E+04 3.520E+06 3.520E+06 2.800E+06
 CJET OFF
 HCR 0.333 0.333 0.333 0.333 0.333 0.333
 STPMAX 5.00
 DUMPR TPL3W.HI
 DEVICE 1
 WINDOW 0 0. 0. 1279. 1023. 4095.

** CFAST Version 2.0.1 Run 7/27/94 **
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CFAST Version 2.0.1 - created May 1, 1993 TPL3W.Fst

Time = 1000.0 seconds.

Compartment	Upper Temp. (K)	Lower Temp. (K)	Inter. Height (m)	Upper Vol. (m^3)	Pressure (Pa)	Ceiling Temp. (K)	Up wall Temp. (K)	Low wall Temp. (K)	Floor Temp. (K)
1	321.0	300.6	8.2	1.12E+04 (32%)	-84.1	302.5	302.2	300.5	300.5
2	384.2	301.4	5.5	9.74E+02 (32%)	-90.9	314.2	313.5	302.5	302.9

Compartment	Fire	Plume Flow (kg/s)	Pyrol Rate (kg/s)	Fire Size (W)	Fire in Upper (W)	Fire in Lower (W)	Vent Fire (W)	Convec. (W)	Radiat. (W)	On Target (W/m^2)
	Main	21.8	9.300E-02	2.800E+06				2.800E+06	0.000	
1		0.000	0.000	0.000	0.000	0.000	0.000			142.
2		21.8	9.300E-02	2.800E+06	0.000	2.800E+06	0.000			772.
Outside							0.000			

Upper Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (l/m)	HCl c (mg/m^2)	HCl f (mg/m^2)	HCl uw (mg/m^2)	HCl lw (mg/m^2)
1	78.8	20.0	0.195	0.000	0.000	0.000	0.000	1.04	0.000	0.000	0.000	0.000	0.000
2	78.5	19.6	0.291	0.000	0.000	0.000	0.000	1.55	0.000	0.000	0.000	0.000	0.000

Lower Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (l/m)	HCl c (mg/m^2)	HCl f (mg/m^2)	HCl uw (mg/m^2)	HCl lw (mg/m^2)
1	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Vent Flow (kg/s)

From	To	Number	Type	U->U	U->L->U	L->U->L	L->L	E->U	E->L
1	3	1	H						
2	3	1	H						
3	1	1	H				19.6		
3	2	1	H				21.4		

CALCULATION CONTROL SHEETS

CALCULATION CONTROL SHEET HUGHES ASSOCIATES, INC.

PROJECT TITLE:	<u>Fire Modeling for Building 221-T</u>
CALCULATION TITLE:	<u>Estimating Potential Fire Exposure</u>
COMPLETED BY:	<u>Naeem Iqbal</u>
CHECKED BY:	<u>Clara Boyle</u> <u>[Signature]</u>
APPROVED BY:	<u>E. R. R.</u>
DATE:	<u>9/29/94</u>
PROBLEM/OBJECTIVE:	<u>Radiative heat flux to target fuel.</u> <u>Repackaging area railroad tunnel. Target fuel - Repackaged (RMW)</u>
ASSUMPTIONS:	<u>Point source radiative heat transfer model</u> <u>10 kW/m² needed for ignition CS</u>
CALCULATIONS:	<p>Heat release from 55 gallon drum filled with flammable liquid Soaked rags = $Q = 440 \text{ kW}$ (fire heat release rate)</p> <p>Approximate distance from center of fire to target = 1 m (0.3048)</p> <p>Assume radiative fraction = $\gamma_r = 0.35$</p> <p>Radiative flux at any distance from the fire source given by</p> $\dot{q}'' = \frac{\gamma_r Q}{4\pi R^2} \quad (\text{Point Source heat transfer model})$ $\dot{q}'' = \frac{0.35 \times 440}{4 \times \pi (1)^2} = 12 \text{ kW/m}^2$ <p>Ignition is possible in this location.</p> <p>Total heat release rate - $8 \times 440 = 3520 \text{ kW}$</p> <p style="text-align: center;"> $\swarrow$ from 1 drum CS $\swarrow$ 8 drums CS </p>
RESULT:	$\dot{q}'' = 12 \text{ kW/m}^2$, $Q = 3520 \text{ kW}$
REFERENCES:	<u>Modak A (1977) "Thermal Radiation from Pool Fires" Combustion and Flame, Vol. 29 pp 177-192 - 1977</u>

CALCULATION CONTROL SHEET HUGHES ASSOCIATES, INC.

PROJECT TITLE: Fire Modeling for Building 221-T
 CALCULATION TITLE: Steady State Heat Release Rate Based on Exhaust Flow Rate
 COMPLETED BY: Napem Iqbal
 CHECKED BY: Craig Beyler Tom Beyler
 APPROVED BY: R. R. L.
 DATE: 9/29/94

PROBLEM/OBJECTIVE: Heat release rate calculations based on exhaust flow from the Canyon clock.

ASSUMPTIONS: T² fire growth - fast fire

CALCULATIONS:

The energy release rate produces the maximum thermal effect to the structure is given by:

$$\dot{Q} = \dot{V} \rho_{air} \Delta H_{rai}$$

Exhaust flow rate = $\dot{V} = 30,000 \text{ gpm} = 14 \text{ m}^3/\text{sec}$ - 291-T exhaust system only
 $\dot{V} = 42,000 \text{ gpm} = 20 \text{ m}^3/\text{sec}$ - 221-T-13 exhaust system only
 $\dot{V} = 72,000 \text{ gpm} = 36 \text{ m}^3/\text{sec}$ - Both exhaust systems on.

Density of air = $\rho_{air} = 1.17 \text{ Kg/m}^3$

Heat of reaction for air = $\Delta H_{rai} = 3 \times 10^3 \text{ KJ/Kg}$

$$\begin{aligned}\dot{Q} &= 14 \times 1.17 \times 3 \times 10^3 = 49 \times 10^3 \text{ KW} = 49 \text{ MW} = 47 \times 10^3 \text{ Btu/sec} \\ \dot{Q} &= 20 \times 1.17 \times 3 \times 10^3 = 70 \times 10^3 \text{ KW} = 70 \text{ MW} = 67 \times 10^3 \text{ Btu/sec} \\ \dot{Q} &= 36 \times 1.17 \times 3 \times 10^3 = 120 \times 10^3 \text{ KW} = 120 \text{ MW} = 116 \times 10^3 \text{ Btu/sec}\end{aligned}$$

RESULT: The maximum heat release rate possible in the building is 120 MW.

REFERENCES: Table 3, P. 26 in main report.

CALCULATION CONTROL SHEET
HUGHES ASSOCIATES, INC.

PROJECT TITLE: Fire Modeling for Building 221-T
 CALCULATION TITLE: Heat Release Rate from Burning Wood Pallet
 COMPLETED BY: Nasim Iqbal
 CHECKED BY: Craig Byler Craig Byler
 APPROVED BY: E. D. R.
 DATE: 9/29/94

PROBLEM/OBJECTIVE: Heat release rate for 4' high wood pallet stack.

ASSUMPTIONS: HRR based on test data (Krasner 1988)

CALCULATIONS:

Peak HRR based on fast growth rate approximation
 $Q = 3.750 \text{ KW} \quad (3556 \text{ Btu/Sec})$
 Time to peak heat release - 300 Sec
 (See Figure 12. in main report)

RESULT: $Q = 3750 \text{ KW} @ 300 \text{ Sec. for one stack of wood pallet}$

REFERENCES: Babrowskas 1988 SFPE Handbook Chapter 2, P. 4

CALCULATION CONTROL SHEET
HUGHES ASSOCIATES, INC.

PROJECT TITLE: Fire Modeling for Building 221-T
 CALCULATION TITLE: Heat Release Rate from Plywood Box Filled with 227 Kg (500 lbs) Ordinary Combustibles.
 COMPLETED BY: Vacem Tsal
 CHECKED BY: Gary Bayler [Signature]
 APPROVED BY: E R RL
 DATE: 9/29/94

PROBLEM/OBJECTIVE: Heat release rate for burning 1.22m x 1.22m x 2.43m Plywood box.

ASSUMPTIONS: Reduction based on mail bags heat release test data

CALCULATIONS:

Area of plywood box = 2.97 m^2
 Volume " " " = 3.63 m^3
 Mass of Combustible = 227 Kg
 Ass. filling density of Combustible = 62 Kg/m^3
 From Table 2-1.12 P.2-13 SFPE Handbook
 Mail bags, filled, stored 1.5m high
 Peak HRR Per unit floor area = $400 \frac{\text{KW}}{\text{m}^2}$
 Peak HRR for Plywood box = 1200 KW
 $Q = 1200 \text{ KW (1138 Btu/Sec)}$
 Time to reach peak heat release = $170 \text{ Sec (T-fast fire)}$

RESULT: $Q = 1200 \text{ KW (1138 Btu/Sec)}$ $t = 170 \text{ Sec}$

REFERENCES: Babrauskas 1988 SFPE Handbook, Chapter 2 P.13

CALCULATION CONTROL SHEET HUGHES ASSOCIATES, INC.

PROJECT TITLE: Fire Modeling for Building 221-T
 CALCULATION TITLE: Heat Release Rate from Burning 55 Gallon Drum Filled with Maximum 91 Kg (200 lb) Flammable Liquid Rags
 COMPLETED BY: Naseem Iqbal
 CHECKED BY: Craig Bayler Naseem Iqbal
 APPROVED BY: S R PL
 DATE: 9/29/94

PROBLEM/OBJECTIVE: Pool fire heat release rate

ASSUMPTIONS: Prediction of HRR is based on top surface of 55 gallon drum involved in the fire. Assume Kerosene Pool fire.

CALCULATIONS:

Diameter of 55 gallon drum = 0.57 m

$$A = \frac{\pi}{4} D^2 = 0.26 \text{ m}^2$$

Heat of Combustion of Kerosene = $\Delta h_c = 43.7 \times 10^3 \text{ KJ/Kg}$

Burning rate = $\dot{m}'' = 0.039 \text{ Kg/m}^2 \cdot \text{Sec}$

The peak heat release rate for the vaporizing liquid is given by:

$$Q_{\text{pool}} = \Delta h_c \dot{m}'' A_{\text{pool}}$$

$$Q_{\text{pool}} = 43.7 \times 10^3 \times 0.039 \times 0.26$$

$$Q \approx 440 \text{ KW}$$

Time to reach Peak heat release, $t = 100 \text{ Sec}$
 (T² fast fire)

RESULT: $Q \approx 440 \text{ (418 Btu/Sec)}, t = 100 \text{ Sec}$

REFERENCES: Bobrauskas 1983 Estimating Large Pool Fire Burning Rate in Fire Technology Vol 19, NO 4 PP 251-261, 1983

CALCULATION CONTROL SHEET HUGHES ASSOCIATES, INC.

PROJECT TITLE: Fire Modeling for Building 221-T
 CALCULATION TITLE: Estimating Potential Fire Exposure
 COMPLETED BY: Noam Idan
 CHECKED BY: Craig Beyler Noam Beyler
 APPROVED BY: E. R. R.
 DATE: 9/29/94

PROBLEM/OBJECTIVE: Radiative heat flux to target fuel.
Canyon Location: 13L: Target fuel: wood Pallets

ASSUMPTIONS: Point Source radiative heat transfer model.

CALCULATIONS:

Heat release rate from one stack of wood pallets

3,750 KW (fire source)

approximate distance from center of fire to target = 2m (6.4 ft)

Assume radiative fraction = 0.35

Radiative flux at any distance from the fire source given by:

$$q'' = \frac{Q}{4\pi R^2}$$

$$q'' = \frac{0.35 \times 3750}{4\pi (2)^2} = 26 \text{ KW/m}^2$$

Ignition is possible in this location.

Total heat release rate: 15,000 KW burning 9 ft. stack of wood pallet.

for 1 stack CB

4 x stack CB

RESULT: $q'' = 26 \text{ KW/m}^2$ Total 3 stacks = 15,000 KW

REFERENCES: Modrak, A. (1977) Thermal Radiation from Pool Fires II: Convective and Flame
167-29 DP-177-192 1977.

CALCULATION CONTROL SHEET HUGHES ASSOCIATES, INC.

PROJECT TITLE: Fire Modeling for Building 221-T
 CALCULATION TITLE: Estimating Potential Fire Exposure
 COMPLETED BY: Niccom Iqbal
 CHECKED BY: Craig Deyler
 APPROVED BY: E RRL
 DATE: 9/29/94

PROBLEM/OBJECTIVE: Radiative heat flux to target faces
Constr: location 13L Target fuel: Drum.

ASSUMPTIONS: Point Source radiative heat transfer model.
10 kW/m² needed for ignition CB

CALCULATIONS:

Heat release rate from one stack of wood pallet.

$$\dot{Q} = 3.750 \text{ KW (fire source)}$$

Approximate distance from center of fire to target = 3.5m (11.50ft)

Assume radiative fraction = $f_r = 0.35$

Radiative flux at any distance from the fire source given by:

$$q'' = \frac{f_r \dot{Q}}{4\pi R^2}$$

$$q'' = \frac{0.35 \times 3750}{4\pi (3.5)^2} = 9 \text{ KW/m}^2$$

Ignition not possible in this location to drum

RESULT:

$$q'' = 9 \text{ KW/m}^2$$

REFERENCES:

Modak, A (1977) "Thermal Radiation from Pool Fires: Convection & Flame
Vol. 29 pp. 177-192 1977

**CALCULATION CONTROL SHEET
HUGHES ASSOCIATES, INC.**

PROJECT TITLE: Fire Modeling for Building 221-T
 CALCULATION TITLE: Estimating Potential Fire Exposure
 COMPLETED BY: Naceem Iqbal
 CHECKED BY: Craig Beale Alan Gyle
 APPROVED BY: E. D. RL
 DATE: 9/29/94

PROBLEM/OBJECTIVE: Radiative heat flux to target fuel
Conj. for: Location 3R. Target fuel: Plywood box.

ASSUMPTIONS: Point source radiative heat transfer model.
10 kW/m² needed for ignition CB

CALCULATIONS:

Heat release from one stack of wood pallet.
Q = 3750 kW (fire source)
Approximate distance from source to fire to target: 2m (6.5 ft)
Assume radiation fraction: $f_r = 0.35$
Radiative flux to any distance from the fire source given by:

$$\dot{q}'' = \frac{f_r Q}{4\pi R^2}$$

$$\dot{q}'' = \frac{0.35 \times 3750}{4\pi (2)^2} = 26 \text{ kW/m}^2$$

Ignition is possible in this location to plywood box.
Heat release rate = 1200 kW

RESULT: $\dot{q}'' = 26 \text{ kW/m}^2$, $Q = 1200 \text{ kW}$

REFERENCES: McCormack, A. (1972) "Thermal Radiation from Pool Fires" Combustion & Flame"
Vol. 29, pp. 172-192, 1972

CALCULATION CONTROL SHEET
HUGHES ASSOCIATES, INC.

PROJECT TITLE:

Fire Modeling for Building 221-T

CALCULATION TITLE:

Estimating Potential Fire Exposure

COMPLETED BY:

Nasim Iqbal

CHECKED BY:

Greg Kaylor

APPROVED BY:

ERL

DATE:

9/29/94

PROBLEM/OBJECTIVE:

Radiative heat flux to target fuel.

System: Location: 3R

Target: fuel, wood pallet.

ASSUMPTIONS:

Point source radiative heat transfer model.
10 kW/m² needed to burn wood.

CALCULATIONS:

Heat release rate from one shell of wood pallet.

$$Q = 3,750 \text{ kW}$$

Approximate distance from center of fire to target = 3m (10 ft)
Assume radiative fraction = $\gamma = 0.35$

Radiative flux to any distance from the fire source is given by:

$$q'' = \frac{\gamma Q}{4\pi R^2} \quad (\text{Point source heat transfer model})$$

$$q'' = \frac{0.35 \times 3750}{4\pi (3)^2} = 12 \text{ kW/m}^2$$

Ignition - Possible in this location to wood pallet.
Total heat release rate = $Q = 7500 \text{ kW}$

RESULT:

$$q'' = 12 \text{ kW/m}^2, \quad Q = 7500 \text{ kW}$$

REFERENCES:

Nat. Bur. of Standards (1973) Thermal Radiation from Pool Fires, Combustion & Flame
Vol. 29, pp 177-192
1973

CALCULATION CONTROL SHEET HUGHES ASSOCIATES, INC.

PROJECT TITLE: Fire Modeling for Building 221-T
 CALCULATION TITLE: Estimating Potential Fire Exposure
 COMPLETED BY: Naeem Iqbal
 CHECKED BY: Craig Beyler James Beyler
 APPROVED BY: LRH
 DATE: 9/29/94

PROBLEM/OBJECTIVE: Radiative heat flux to target fuel.
Repackaging area railroad tunnel Target fuel Repacked (UW)

ASSUMPTIONS: Point source radiative heat transfer model.
10 kW/m² needed for ignition

CALCULATIONS:

Heat release rate from plywood box filled with materials
 $Q = 1200 \text{ kW}$ fire source.
 Approximate distance from fire source to target fuel (10 ft)
 Assume radiative fraction: $\gamma_r = 0.35$
 Radiative flux at any distance from the fire source is given by:

$$q'' = \frac{\gamma_r Q}{4\pi R^2} \quad (\text{Point source heat transfer model})$$

$$q'' = \frac{0.35 \times 1200}{4\pi (3)^2} \approx 4 \text{ kW/m}^2$$

Ignition not possible in this location

RESULT: $q'' = 4 \text{ kW/m}^2$

REFERENCES: Modak, R. (1972) Thermal Radiation from Fire. Fire Engineering, 107, 29 pp. 1972-1977

CALCULATION CONTROL SHEET HUGHES ASSOCIATES, INC.

PROJECT TITLE: Fire Modeling for Building 221-T
 CALCULATION TITLE: Estimating heat release rate for sprinkler activation

COMPLETED BY: Naeem Iqbal

CHECKED BY: Craig Byler John Byler

APPROVED BY: E R L

DATE: 9/29/94

PROBLEM/OBJECTIVE: Calculation of heat release rate at sprinkler activation temp 71°C (160°F)

ASSUMPTIONS:

CALCULATIONS:

The prediction of heat release rate for the steady fire at given gas temperature from by Ceiling jet Correlation developed by Alpert/Evans 1988]

$$T - T_{\infty} = \frac{16.9 \dot{Q}^{2/3}}{H^{5/3}} \text{ for } \frac{r}{H} \leq 0.18$$

$$\frac{r}{H} = \frac{2.15}{12} = 0.179$$

$$T = 71^{\circ}\text{C}$$

$$T_{\infty} = 25^{\circ}\text{C}$$

$$H = 12\text{m}$$

$$r = 2.15\text{m}$$

$$71 - 25 = \frac{16.9 \dot{Q}^{2/3}}{(12)^{5/3}}$$

$$\dot{Q} = 2240 \text{ kW} \longrightarrow *$$

verified in DETACT CASE also - CB

RESULT: $\dot{Q} = 2240 \text{ kW}$ to rise gas temp 71°C (160°F)

REFERENCES: Evans, D.D. (1988) "Ceiling Jet Flows," SFPE Handbook, Section 1 Chapter 9, P. 1-139, 1994

**CALCULATION CONTROL SHEET
HUGHES ASSOCIATES, INC.**

PROJECT TITLE: Fire Modeling for Building 221-T

CALCULATION TITLE: Steady State Fire Based - Evaporative Flow Rates

COMPLETED BY: Nasim Zaidi

CHECKED BY: Carm Beyle [Signature]

APPROVED BY: EPR

DATE: 9/29/94

PROBLEM/OBJECTIVE: To NW Fire in the Canyon, 221-T-13 Exhaust Fan on only

ASSUMPTIONS: Fire source is assumed to be maximum - 4,271 release potential in the uniting

CALCULATIONS:

See CASE 7.2.0.1 Input file TPL2A-Def
and output file "TPL2A-Fst"

RESULT: At 2400 sec Canyon Evap = 250.457F) 1014 m³/sec at 0.25m (0.8271)
Horizontal = 1188.12457F) 1014 m³/sec at 0.25m (2.44)

REFERENCES:

Time = 2400.0 seconds.

Compartment	Upper Temp. (K)	Lower Temp. (K)	Inter. Height (m)	Upper Vol. (m^3)	Pressure (Pa)	Ceiling Temp. (K)	Up wall Temp. (K)	Low wall Temp. (K)	Floor Temp. (K)
1	509.1	361.1	0.25	3.45E+04 (98%)	-7.37	398.0	394.5	347.7	377.4
2	391.5	302.7	6.2	6.85E+02 (22%)	-13.4	325.0	322.6	304.7	304.7

Compartment	Fire	Plume Flow (kg/s)	Pyrol Rate (kg/s)	Fire Size (W)	Fire in Upper (W)	Fire in Lower (W)	Vent Fire (W)	Convec. (W)	Radiat. (W)	On Target (W/m^2)
	Main	21.4	2.33	3.581E+07				3.581E+07	0.000	
1		21.4	2.33	3.581E+07	0.317	3.581E+07	0.000			3.332E+03
2		0.000	0.000	0.000	0.000	0.000	0.000			868.
Outside							1.826E+05			

Upper Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCL c (mg/m^2)	HCL f (mg/m^2)	HCL uw (mg/m^2)	HCL lw (mg/m^2)
1	61.4	0.308	5.16	0.000	0.000	0.000	5.42	27.7	0.000	0.000	0.000	0.000	0.000
2	62.1	0.807	5.06	0.000	0.000	0.000	4.89	27.1	0.000	0.000	0.000	0.000	0.000

Lower Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCL c (mg/m^2)	HCL f (mg/m^2)	HCL uw (mg/m^2)	HCL lw (mg/m^2)
1	72.0	12.2	2.17	0.000	0.000	0.000	2.05	11.6	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	2.787E-07	0.000	0.000	0.000	0.000	1.494E-06	0.000	0.000	0.000	0.000	0.000

Vent Flow (kg/s)

From	To	Number	Type	U->U	U->L->U	L->U->L	L->L	E->U	E->L
1	3	1	H		0.179				
2	3	1	H						
3	1	1	H			2.74	0.722		1.08
3	2	1	H				8.20		

VERSN 2 TPL2A ONLY ROOF EXHAUST FAN ON
 TIMES 2400 60 20 20 20
 TAMB 300. 101300. 0.
 EAMB 300. 101300. 0.
 HI/F 8.00 0.000
 WIDTH 245.00 64.00
 DEPTH 12.00 6.000
 HEIGH 12.00 8.00
 HVENT 1 3 1 1.00 2.00 0.000 0.000
 HVENT 2 3 1 20.0 0.3048 0.20 0.00 0.00
 VVENT 2 1 33.32 2
 CVENT 1 3 1 1.00 1.00 1.00 1.00
 CVENT 2 3 1 1.00 1.00 1.00 1.00
 MVOPN 1 3 H 11.00 3.50
 MVOPN 3 1 H 11.00 3.50
 MVDCT 3 2 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVFAN 2 1 0.00 300.00 0.200E+02 0.266E-01
 INELV 1 19.00 2 19.00 3 19.00
 CEILI CONCRETE CONCRETE
 WALLS CONCRETE CONCRETE
 FLOOR CONCRETE CONCRETE
 CHEMI 0. 0. 1.0 30000000. 300. 400. 0.000
 LFBO 1
 LFBT 2
 FPOS 4.55 3.05 0.00
 FTIME 10. 60. 200. 2400.
 FMASS 0.00 0.333 0.666 2.333 2.333
 FHIGH 0.00 0.00 0.00 0.00 0.00
 FAREA 0.00 0.00 0.00 0.00 0.00
 FQDOT 0.00 1.00E+07 2.00E+07 7.00E+07 7.00E+07
 CJET OFF
 HCR 0.333 0.333 0.333 0.333 0.333 0.333
 STPMAX 5.00
 DUMPR TPL2A.HI
 DEVICE 1
 WINDOW 0 0. 0. 1279. 1023. 4095.

CALCULATION CONTROL SHEET
HUGHES ASSOCIATES, INC.

PROJECT TITLE: Fire Modeling for Building 221-T

CALCULATION TITLE: Steady State Fire Based on Exhaust Flow Rates

COMPLETED BY: Naeem Iqbal

CHECKED BY: _____

APPROVED BY: _____

DATE: _____

PROBLEM/OBJECTIVE: 20 MW fire in the Canyon Both Exhaust System ON.

ASSUMPTIONS: Fire Scenario considered the maximum fire, as release possible in the building.

CALCULATIONS:

See CFAST 1.2.0.1 Input file "TBL-3A-Def" and output file "TBL-3A-Est."

RESULT: At 1800 Sec. Temp. at height 2.822 (541°F) with interface at 6.25m (20.5ft) and smoke layer at 11.6 (38.1ft). At 2000 Sec. at 6.3m (21ft).

REFERENCES:

Time = 1800.0 seconds.

Compartment	Upper Temp. (K)	Lower Temp. (K)	Inter. Height (m)	Upper Vol. (m^3)	Pressure (Pa)	Ceiling Temp. (K)	Up wall Temp. (K)	Low wall Temp. (K)	Floor Temp. (K)
1	555.8	367.5	0.25	3.45E+04 (98%)	-16.3	415.9	412.2	356.7	393.9
2	417.5	302.8	6.3	6.57E+02 (21%)	-23.1	328.8	326.0	305.5	305.4

Compartment	Fire	Plume Flow (kg/s)	Pyrol Rate (kg/s)	Fire Size (W)	Fire in Upper (W)	Fire in Lower (W)	Vent Fire (W)	Convec. (W)	Radiat. (W)	On Target (W/m^2)
	Main	31.0	4.00	5.513E+07				5.513E+07	0.000	
1		31.0	4.00	5.513E+07	1.388E-02	5.513E+07	0.000			4.925E+03
2		0.000	0.000	0.000	0.000	0.000	0.000			1.257E+03
Outside							0.000			

Upper Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (l/m)	HCl c (mg/m^2)	HCl f (mg/m^2)	HCl uw (mg/m^2)	HCl lw (mg/m^2)
1	58.8	0.163	4.98	0.000	0.000	0.000	9.31	26.7	0.000	0.000	0.000	0.000	0.000
2	59.6	0.686	4.88	0.000	0.000	0.000	8.67	26.2	0.000	0.000	0.000	0.000	0.000

Lower Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (l/m)	HCl c (mg/m^2)	HCl f (mg/m^2)	HCl uw (mg/m^2)	HCl lw (mg/m^2)
1	72.0	13.3	1.81	0.000	0.000	0.000	3.18	9.72	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	3.824E-07	0.000	0.000	0.000	0.000	2.050E-06	0.000	0.000	0.000	0.000	0.000

Vent Flow (kg/s)

From	To	Number	Type	U->U	U->L->U	L->U->L	L->L	E->U	E->L
1	3	1	H						
2	3	1	H						
3	1	1	H			6.22	1.08		1.20
3	2	1	H				10.8		

VERSN 2 TPL3A ONLY FLOOR EXHAUST FAN ON
 TIMES 1800 60 20 20 20
 TAMB 300. 101300. 0.
 EAMB 300. 101300. 0.
 HI/F 8.00 0.000
 WIDTH 245.00 64.00
 DEPTH 12.00 6.000
 HEIGH 12.00 8.000
 HVENT 1 3 1 1.00 2.00 0.000 0.000
 HVENT 2 3 1 20.0 0.3048 0.20 0.00 0.00
 VVENT 2 1 33.32 2
 CVENT 1 3 1 1.00 1.00 1.00 1.00
 CVENT 2 3 1 1.00 1.00 1.00 1.00
 MVOFN 1 3 H 11.00 3.50
 MVOFN 1 4 H 1.00 3.50
 MVOFN 3 1 H 11.00 3.50
 MVOFN 3 6 H 1.00 3.50
 MVDCT 3 2 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVDCT 4 5 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVFAN 2 1 0.00 300.00 0.200E+02 0.266E-01
 MVFAN 5 6 0.00 300.00 0.140E+02 0.266E-01
 INELV 1 19.00 2 19.00 3 19.00 4 9.00 5 9.00 6 9.00
 CEILI CONCRETE CONCRETE
 WALLS CONCRETE CONCRETE
 FLOOR CONCRETE CONCRETE
 CHEMI 0. 0. 1.0 30000000. 300. 400. 0.000
 LFBO 1
 LFBT 2
 FPOS 4.55 3.05 0.00
 FTIME 10. 60. 200. 1800.
 FMASS 0.00 0.333 0.666 4.00 4.00
 FHIGH 0.00 0.00 0.00 0.00 0.00
 FAREA 0.00 0.00 0.00 0.00 0.00
 FQDOT 0.00 1.00E+07 2.00E+07 1.20E+08 1.200E+08
 CJET OFF
 HCR 0.333 0.333 0.333 0.333 0.333 0.333
 STPMAX 5.00
 DUMPR TPL3A.HI
 DEVICE 1
 WINDOW 0 0. 0. 1279. 1023. 4095.

CALCULATION CONTROL SHEET HUGHES ASSOCIATES, INC.	
PROJECT TITLE:	<i>Fire Modeling for Building 221-T</i>
CALCULATION TITLE:	<i>Steady State Fire Load on Exhaust Flow Rates</i>
COMPLETED BY:	<i>Vacuum Exhaust</i>
CHECKED BY:	<i>Craws Beyler</i> <i>Ann Beyler</i>
APPROVED BY:	<i>E RRL</i>
DATE:	<i>9/29/94</i>
PROBLEM/OBJECTIVE:	<i>49 MW Fire in 4 Canyon: 291-T Exhaust Fan on only.</i>
ASSUMPTIONS:	<i>Fire Scenario ignored - maximum fire load possible in the building.</i>
CALCULATIONS:	<i>See CFAST v. 2.0.1 Input file "TPL1A.dat" and output file "TPL1A.Est."</i>
<p><i>Complete input/output files provided on disk - CS</i></p>	
RESULT:	<i>At 300 sec - Canyon Temp 220°C (428°F) with max. HCC 0.27m (1.38ft) Tunnel Temp 119°C (228°F) with max. HCC 6.2m (20.3ft)</i>
REFERENCES:	

CFAST 2.0.1 APRIL 22, 1994
Disk - 2 STEADY STATE FIRES BASED ON EXHAUST FLOW RATES

VERSN 2 TPL1A ONLY FLOOR EXHAUST FAN ON
 TIMES 3000 60 20 20 20
 TAMB 300. 101300. 0.
 EAMB 300. 101300. 0.
 HI/F 8.00 0.000
 WIDTH 245.00 64.00
 DEPTH 12.000 6.0000
 HEIGH 12.000 8.0000
 HVENT 1 3 1 1.00 2.0 0.00 0.000
 HVENT 2 3 1 20.0 0.3048 0.20 0.00 0.00
 VVENT 2 1 33.32 2
 CVENT 1 3 1 1.00 1.00 1.00 1.00
 CVENT 2 3 1 1.00 1.00 1.00 1.00
 MVOFN 1 3 H 1.00 3.50
 MVOFN 3 1 H 1.00 3.50
 MVDCT 3 2 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVFAN 2 1 0.00 300.00 0.140E+02 0.266E-01
 INELV 1 9.00 2 9.00 3 9.00
 CEILI CONCRETE CONCRETE
 WALLS CONCRETE CONCRETE
 FLOOR CONCRETE CONCRETE
 CHEMI 0. 0. 1.0 30000000. 300. 400. 0.000
 LFBO 1.
 LFBT 2
 FPOS 4.55 3.05 0.00
 FTIME 10. 60. 200. 3000.
 FMASS 0.00 0.333 0.6666 1.6333 1.6333
 FHIGH 0.00 0.00 0.00 0.00 0.00
 FAREA 0.00 0.00 0.00 0.00 0.00
 FQDOT 0.00 1.00E+07 2.00E+07 4.90E+07 4.90E+07
 CJET OFF
 HCR 0.333 0.333 0.333 0.333 0.333 0.333
 STPMAX 5.00
 DUMPR TPL1A.HI
 DEVICE 1
 WINDOW 0 0. 0. 1279. 1023. 4095.

Time = 3000.0 seconds.

Compartment	Upper Temp. (K)	Lower Temp. (K)	Inter. Height (m)	Upper Vol. (m^3)	Pressure (Pa)	Ceiling Temp. (K)	Up wall Temp. (K)	Low wall Temp. (K)	Floor Temp. (K)
1	493.3	358.4	0.27	3.45E+04 (98%)	-5.33	392.7	389.1	345.2	372.2
2	382.9	302.7	6.2	6.87E+02 (22%)	-11.0	324.5	322.2	304.6	304.6

Compartment	Fire	Plume Flow (kg/s)	Pyrol Rate (kg/s)	Fire Size (W)	Fire in Upper (W)	Fire in Lower (W)	Vent Fire (W)	Convec. (W)	Radiat. (W)	On Target (W/m^2)
	Main	18.1	1.63	3.020E+07				3.020E+07	0.000	
1		18.1	1.63	3.020E+07	4.75	3.020E+07	0.000			2.883E+03
2		0.000	0.000	0.000	0.000	0.000	0.000			756.
Outside							3.147E+05			

Upper Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (l/m)	HCL c (mg/m^2)	HCL f (mg/m^2)	HCL uw (mg/m^2)	HCL lw (mg/m^2)
1	63.3	0.442	5.28	0.000	0.000	0.000	2.70	28.3	0.000	0.000	0.000	0.000	0.000
2	63.9	0.966	5.16	0.000	0.000	0.000	2.35	27.7	0.000	0.000	0.000	0.000	0.000

Lower Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (l/m)	HCL c (mg/m^2)	HCL f (mg/m^2)	HCL uw (mg/m^2)	HCL lw (mg/m^2)
1	72.5	12.0	2.29	0.000	0.000	0.000	1.00	12.3	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	9.341E-08	0.000	0.000	0.000	0.000	5.010E-07	0.000	0.000	0.000	0.000	0.000

Vent Flow (kg/s)

From	To	Number	Type	U->U	U->L->U	L->U->L	L->L	E->U	E->L
1	3	1	H		0.624				
2	3	1	H						
3	1	1	H			1.69	0.644		0.916
3	2	1	H				7.44		

CALCULATION CONTROL SHEET

HUGHES ASSOCIATES, INC.

PROJECT TITLE:

Fire Modeling for Building 251-T

CALCULATION TITLE:

Find in the Canyon. Based on Wood & Galt: PR at '36

COMPLETED BY:

Naam: Isabel

CHECKED BY:

Craig Butler *[Signature]*

APPROVED BY:

9. 2. 22

DATE:

9/29/94

PROBLEM/OBJECTIVE:

ASSUMPTIONS:

15000 W. 54-F-13 Extension to road.

CALCULATIONS:

See CFAST. Input file "TPE=V.dat" and
out-Dat file "TPE=V.Est"

Complete files on disk-CB

RESULT:

At 600-m. Canyon Temp 73.5 C (162 F) and 100 m. at 600 m. Altitude
Tunnel Temp 3.5 to 10.5 C (38 to 50 F) and 100 m. at 600 m. Altitude

REFERENCES:

VERSN 2 TPL2B ONLY ROOF EXHAUST FAN ON FIRE IN THE CANYON
 TIMES 800 60 20 20 20
 TAMB 300. 101300. 0.
 EAMB 300. 101300. 0.
 HI/F 8.00 0.000
 WIDTH 245.00 64.00
 DEPTH 12.00 6.000
 HEIGH 12.00 8.00
 HVENT 1 3 1 1.00 2.00 0.000 0.000
 HVENT 2 3 1 20.0 0.3048 0.20 0.00 0.00
 VVENT 2 1 33.32 2
 CVENT 1 3 1 1.00 1.00 1.00 1.00
 CVENT 2 3 1 1.00 1.00 1.00 1.00
 MVOPN 1 3 H 11.00 3.50
 MVOPN 3 1 H 11.00 3.50
 MVDCT 3 2 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVFAN 2 1 0.00 300.00 0.200E+02 0.266E-01
 INELV 1 19.00 2 19.00 3 19.00
 CEILI CONCRETE CONCRETE
 WALLS CONCRETE CONCRETE
 FLOOR CONCRETE CONCRETE
 CHEMI 0. 0. 1.0 30000000. 300. 400. 0.000
 LFBO 1
 LFBT 2
 FPOS 4.55 3.05 0.00
 FTIME 60. 200. 582. 600. 800.
 FMASS 0.00 0.1666 0.266 0.5 0.5 0.1
 FHIGH 0.00 0.00 0.00 0.00 0.00
 FAREA 0.00 0.00 0.00 0.00 0.00
 FQDOT 0.00 5.00E+06 8.00E+06 15.0E+06 15.0E+06 3.0E+6
 CJET OFF
 HCR 0.333 0.333 0.333 0.333 0.333 0.333
 STPMAX 5.00
 DUMPR TPL2B.HI
 DEVICE 1
 WINDOW 0 0. 0. 1279. 1023. 4095.

Time = 800.0 seconds.

Compartment	Upper Temp. (K)	Lower Temp. (K)	Inter. Height (m)	Upper Vol. (m ³)	Pressure (Pa)	Ceiling Temp. (K)	Up wall Temp. (K)	Low wall Temp. (K)	Floor Temp. (K)
1	366.5	307.8	3.4	2.53E+04 (72%)	-67.7	310.5	309.6	302.3	304.0
2	300.0	300.0	8.0	3.1 (0%)	-68.2	300.0	300.0	300.0	300.0

Compartment	Fire	Plume Flow (kg/s)	Pyrol Rate (kg/s)	Fire Size (W)	Fire in Upper (W)	Fire in Lower (W)	Vent Fire (W)	Convec. (W)	Radiat. (W)	On Target (W/m ²)
	Main	13.0	0.100	3.000E+06				3.000E+06	0.000	
1		13.0	0.100	3.000E+06	0.000	3.000E+06	0.000			561.
2		0.000	0.000	0.000	0.000	0.000	0.000			0.000
Outside							0.000			

Upper Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCl c (mg/m ²)	HCl f (mg/m ²)	HCl uw (mg/m ²)	HCl lw (mg/m ²)
1	77.9	18.8	0.508	0.000	0.000	0.000	0.000	2.72	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Lower Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCl c (mg/m ²)	HCl f (mg/m ²)	HCl uw (mg/m ²)	HCl lw (mg/m ²)
1	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Vent Flow (kg/s)

From	To	Number	Type	U->U	U->L->U	L->U->L	L->L	E->U	E->L
1	3	1	H						
2	3	1	H						
3	1	1	H				17.6		
3	2	1	H				18.5		

CALCULATION CONTROL SHEET HUGHES ASSOCIATES, INC.

PROJECT TITLE: Fire Modeling for Building 291-T
 CALCULATION TITLE: Fire in the Canyon Based on Wood Pallet HRR at 13L
 COMPLETED BY: Vacant
 CHECKED BY: Craig Byler Alan Doyle
 APPROVED BY: E L R
 DATE: 9/29/94
 PROBLEM/OBJECTIVE: 15,000 KWh Fire, 291-T Exhaust fan on only.

ASSUMPTIONS:

CALCULATIONS:

See FAST input file "TL1B.dat"
and output file "TL1B.out"

Complete files on disk - C B

RESULT: at 600 sec tunnel temperature 1500 (203°F) with smoke at 1.2m (4ft)
tunnel temperature 270 (500°F) with smoke at 1.2m (4ft)

REFERENCES:

CEAST 2.0.1 APRIL 22, 1994
Disk - 3 FIRE IN THE CANYON BASED ON WOOD PALLET HEAT RELEASE RATE AT LOCATION 13L

VERSN 2 TPL1B ONLY FLOOR EXHAUST FAN ON FIRE IN THE CANYON
 TIMES 800 60 20 20 20
 TAMB 300. 101300. 0.
 EAMB 300. 101300. 0.
 HI/F 8.00 0.000
 WIDTH 245.00 64.00
 DEPTH 12.000 6.0000
 HEIGH 12.000 8.0000
 HVENT 1 3 1 1.00 2.00 0.000 0.000
 HVENT 2 3 1 20.0 0.3048 0.20 0.00 0.00
 VVENT 2 1 33.32 2
 CVENT 1 3 1 1.00 1.00 1.00 1.00
 CVENT 2 3 1 1.00 1.00 1.00 1.00
 MVOPN 1 3 H 1.00 3.50
 MVOPN 3 1 H 1.00 3.50
 MVDCT 3 2 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVFAN 2 1 0.00 300.00 0.140E+02 0.266E-01
 INELV 1 9.00 2 9.00 3 9.00
 CEILI CONCRETE CONCRETE
 WALLS CONCRETE CONCRETE
 FLOOR CONCRETE CONCRETE
 CHEMI 0. 0. 1.0 30000000. 300. 400. 0.000
 LFBO 1
 LFBT 2
 FPOS 4.55 3.05 0.00
 FTIME 60. 200. 582. 600. 800.
 FMASS 0.00 0.1666 0.266 0.5 0.5 0.1
 FHIGH 0.00 0.00 0.00 0.00 0.00
 FAREA 0.00 0.00 0.00 0.00 0.00
 FQDOT 0.00 5.00E+06 8.00E+06 15.0E+06 15.0E+06 3.0E+6
 CJET OFF
 HCR 0.333 0.333 0.333 0.333 0.333 0.333
 STPMAX 5.00
 DUMPR TPL1B.HI
 DEVICE 1
 WINDOW 0 0. 0. 1279. 1023. 4095.

Time = 800.0 seconds.

Compartment	Upper Temp. (K)	Lower Temp. (K)	Inter. Height (m)	Upper Vol. (m^3)	Pressure (Pa)	Ceiling Temp. (K)	Up wall Temp. (K)	Low wall Temp. (K)	Floor Temp. (K)
1	367.9	306.9	1.2	3.18E+04 (90%)	-53.1	310.4	309.5	302.8	304.9
2	300.0	300.0	8.0	3.1 (0%)	-53.6	300.0	300.0	300.0	300.0

Compartment	Fire	Plume Flow (kg/s)	Pyrol Rate (kg/s)	Fire Size (W)	Fire in Upper (W)	Fire in Lower (W)	Vent Fire (W)	Convec. (W)	Radiat. (W)	On Target (W/m^2)
	Main	5.92	0.100	3.000E+06				3.000E+06	0.000	
1		5.92	0.100	3.000E+06	0.000	3.000E+06	0.000			576.
2		0.000	0.000	0.000	0.000	0.000	0.000			0.000
Outside							0.000			

Upper Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCL c (mg/m^2)	HCL f (mg/m^2)	HCL uw (mg/m^2)	HCL lw (mg/m^2)
1	77.9	18.7	0.537	0.000	0.000	0.000	0.000	2.88	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Lower Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCL c (mg/m^2)	HCL f (mg/m^2)	HCL uw (mg/m^2)	HCL lw (mg/m^2)
1	79.2	20.7	1.131E-02	0.000	0.000	0.000	0.000	6.057E-02	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Vent Flow (kg/s)

From	To	Number	Type	U->U	U->L->U	L->U->L	L->L	E->U	E->L
1	3	1	H						
2	3	1	H						
3	1	1	H			6.30	9.20		0.746
3	2	1	H				16.4		

CALCULATION CONTROL SHEET HUGHES ASSOCIATES, INC.

PROJECT TITLE: Fire Modeling for Building 221-T
 CALCULATION TITLE: Fire in the Canyon Based on Wood Pile-FRP at Location 51
 COMPLETED BY: Naeem Iqbal
 CHECKED BY: Craig Byler Steve Byler
 APPROVED BY: E. R. R.
 DATE: 9/29/94
 PROBLEM/OBJECTIVE: 15000 Btu-Fire 38th Exhaust System 51.

ASSUMPTIONS:

CALCULATIONS:

See "FAS" input file "TPL30.dat" and
output file "TPL30.Fst"

Complete files on disk

RESULT: At 800 sec Canyon Temp. 93 & 149F with interface at 24mm (11 in.)
Tunnel temp. 12.27C (50F) with interface at 24mm (2.5 in.)

REFERENCES:

VERSN 2 TPL3B BOTH EXHAUST FAN ON FIRE IN THE CANYON
 TIMES 800 60 20 20 20
 TAMB 300. 101300. 0.
 EAMB 300. 101300. 0.
 HI/F 8.00 0.000
 WIDTH 245.00 64.00
 DEPTH 12.00 6.000
 HEIGH 12.00 8.000
 HVENT 1 3 1 1.00 2.00 0.000 0.000
 HVENT 2 3 1 20.0 0.3048 0.20 0.00 0.00
 VVENT 2 1 33.32 2
 CVENT 1 3 1 1.00 1.00 1.00 1.00
 CVENT 2 3 1 1.00 1.00 1.00 1.00
 MVOPN 1 3 H 11.00 3.50
 MVOPN 1 4 H 1.00 3.50
 MVOPN 3 1 H 11.00 3.50
 MVOPN 3 6 H 1.00 3.50
 MVDCT 3 2 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVDCT 4 5 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVFAN 2 1 0.00 300.00 0.200E+02 0.266E-01
 MVFAN 5 6 0.00 300.00 0.140E+02 0.266E-01
 INELV 1 19.00 2 19.00 3 19.00 4 9.00 5 9.00 6 9.00
 CEILI CONCRETE CONCRETE
 WALLS CONCRETE CONCRETE
 FLOOR CONCRETE CONCRETE
 CHEMI 0. 0. 1.0 30000000. 300. 400. 0.000
 LFBO 1
 LFBT 2
 FPOS 4.55 3.05 0.00
 FTIME 60. 200. 582. 600. 800.
 FMASS 0.00 0.1666 0.266 0.5 0.5 0.1
 FHIGH 0.00 0.00 0.00 0.00 0.00
 FAREA 0.00 0.00 0.00 0.00 0.00
 PQDOT 0.00 5.00E+06 8.00E+06 15.0E+06 15.0E+06 3.0E+6
 CJET OFF
 HCR 0.333 0.333 0.333 0.333 0.333 0.333
 STPMAX 5.00
 DUMPR TPL3B.HI
 DEVICE 1
 WINDOW 0 0. 0. 1279. 1023. 4095.

Time = 800.0 seconds.

Compartment	Upper Temp. (K)	Lower Temp. (K)	Inter. Height (m)	Upper Vol. (m^3)	Pressure (Pa)	Ceiling Temp. (K)	Up wall Temp. (K)	Low wall Temp. (K)	Floor Temp. (K)
1	366.2	306.0	3.4	2.52E+04 (71%)	-171.	310.4	309.5	302.2	303.9
2	300.0	299.9	8.0	3.1 (0%)	-171.	300.0	300.0	300.0	300.0

Compartment	Fire	Plume Flow (kg/s)	Pyrol Rate (kg/s)	Fire Size (W)	Fire in Upper (W)	Fire in Lower (W)	Vent Fire (W)	Convec. (W)	Radiat. (W)	On Target (W/m^2)
	Main	13.1	0.100	3.000E+06				3.000E+06	0.000	
1		13.1	0.100	3.000E+06	0.000	3.000E+06	0.000			558.
2		0.000	0.000	0.000	0.000	0.000	0.000			0.000
Outside							0.000			

Upper Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCL c (mg/m^2)	HCL f (mg/m^2)	HCL uw (mg/m^2)	HCL lw (mg/m^2)
1	77.9	18.8	0.507	0.000	0.000	0.000	0.000	2.72	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Lower Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCL c (mg/m^2)	HCL f (mg/m^2)	HCL uw (mg/m^2)	HCL lw (mg/m^2)
1	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Vent Flow (kg/s)

From	To	Number	Type	U->U	U->L->U	L->U->L	L->L	E->U	E->L
1	3	1	H						
2	3	1	H						
3	1	1	H				28.0		
3	2	1	H				29.3		

CALCULATION CONTROL SHEET HUGHES ASSOCIATES, INC.

PROJECT TITLE: Env Modeling for Building 221-T
 CALCULATION TITLE: Env Modeling Based on Wood 1/16/94 at 221-T
 COMPLETED BY: Vacuum, J. et al
 CHECKED BY: Cary Doyle Ken Lofgren
 APPROVED BY: E. R. R.
 DATE: 9/29/94
 PROBLEM/OBJECTIVE: 2700 P.M. Env. 221-T-13 Exhaust Fan on 221-T

ASSUMPTIONS:

CALCULATIONS:

See "AS Input file" "PLSC.dat" and
output file "PLSC.Est"

Complete files on diskette

RESULT:

REFERENCES:

VERSN 2 TPL2C ONLY ROOF EXHAUST FAN ON FIRE IN THE CANYON
 TIMES 900 60 20 20 20
 TAMB 300. 101300. 0.
 EAMB 300. 101300. 0.
 HI/F 8.00 0.000
 WIDTH 245.00 64.00
 DEPTH 12.00 6.000
 HEIGH 12.00 8.00
 HVENT 1 3 1 1.00 2.00 0.000 0.000
 HVENT 2 3 1 20.0 0.3048 0.20 0.00 0.00
 VVENT 2 1 33.32 2
 CVENT 1 3 1 1.00 1.00 1.00 1.00
 CVENT 2 3 1 1.00 1.00 1.00 1.00
 MVOPN 1 3 H 11.00 3.50
 MVOPN 3 1 H 11.00 3.50
 MVDCT 3 2 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVFAN 2 1 0.00 300.00 0.200E+02 0.266E-01
 INELV 1 19.00 2 19.00 3 19.00
 CEILI CONCRETE CONCRETE
 WALLS CONCRETE CONCRETE
 FLOOR CONCRETE CONCRETE
 CHEMI 0. 0. 1.0 30000000. 300. 400. 0.000
 LFBO 1
 LFBT 2
 FPOS 4.55 3.05 0.00
 FTIME 60. 200. 442. 600. 900.
 FMASS 0.00 0.0666 0.1666 0.29 0.29 0.10
 FHIGH 0.00 0.00 0.00 0.00 0.00
 FAREA 0.00 0.00 0.00 0.00 0.00
 FQDOT 0.00 2.00E+06 5.00E+06 8.700E+06 8.700E+06 3.0E+6
 CJET OFF
 HCR 0.333 0.333 0.333 0.333 0.333 0.333
 STPMAX 5.00
 DUMPR TPL2C.HI
 DEVICE 1
 WINDOW 0 0. 0. 1279. 1023. 4095.

Time = 900.0 seconds.

Compartment	Upper Temp. (K)	Lower Temp. (K)	Inter. Height (m)	Upper Vol. (m ³)	Pressure (Pa)	Ceiling Temp. (K)	Up wall Temp. (K)	Low wall Temp. (K)	Floor Temp. (K)				
1	346.5	305.4	4.6	2.19E+04 (62%)	-37.5	307.3	306.6	301.4	302.5				
2	300.0	300.0	8.0	3.1 (0%)	-38.1	300.0	300.0	300.0	300.0				
Compartment	Fire	Plume Flow (kg/s)	Pyrol Rate (kg/s)	Fire Size (W)	Fire in Upper (W)	Fire in Lower (W)	Vent Fire (W)	Convec. (W)	Radiat. (W)	On Target (W/m ²)			
Main													
1		17.0	0.100	3.000E+06	3.000E+06	0.000	0.000	3.000E+06	0.000	357.0000			
2		0.000	0.000	0.000	0.000	0.000	0.000						
Outside													
Upper Layer Species													
Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	CO (1/m)	HCL C (mg/m ²)	HCL F (mg/m ²)	HCL uw (mg/m ²)	HCL lw (mg/m ²)
1	78.3	19.4	0.364	0.000	0.000	0.000	0.000	1.95	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Lower Layer Species													
Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	CO (1/m)	HCL C (mg/m ²)	HCL F (mg/m ²)	HCL uw (mg/m ²)	HCL lw (mg/m ²)
1	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Vent Flow (kg/s)													
From	To	Number	Type	U->U	U->L->U	L->U->L	E->U	E->L					
1	3	1	H										
2	3	1	H										
3	1	1	H										
3	2	1	H										

Vent Flow (kg/s)

From	To	Number	Type	U->U	U->L->U	L->U->L	L->L	E->U	E->L
1	3	1	H						
2	3	1	H						
3	1	1	H				13.1		
3	2	1	H				13.8		

CALCULATION CONTROL SHEET

HUGHES ASSOCIATES, INC.

PROJECT TITLE: Fire Modeling for Building 221-T

CALCULATION TITLE: Fire in the Cotton Section Warehouse on 12/28

COMPLETED BY: Noor, Iqbal

CHECKED BY: Gary Byles, Gary Byles

APPROVED BY: E. R. R.

DATE: 9/29/94

PROBLEM/OBJECTIVE: 3,700 KW Fire 291-T Exhaust Fan on only

ASSUMPTIONS:

CALCULATIONS:

See *input* file "PIC.dat" and
output file "PIC.Fst"

Complete files on disk - CDS

RESULT: At Goose Canyon, D. 710 46 F, water temperature 18 m (5.5 ft) 22°C (72 F) water temperature at 5 m (26 ft)

REFERENCES:

CEAST 2.0.1 APRIL 22, 1994
Disk - 4 FIRE IN THE CANYON BASED ON WOOD PALLET HEAT RELEASE RATE AT LOCATION 3R

VERSN 2 TPL1C ONLY FLOOR EXHAUST FAN ON FIRE IN THE CANYON
 TIMES 900 60 20 20 20
 TAMB 300. 101300. 0.
 EAMB 300. 101300. 0.
 HI/F 8.00 0.000
 WIDTH 245.00 64.00
 DEPTH 12.000 6.0000
 HEIGH 12.000 8.0000
 HVENT 1 3 1 1.00 2.00 0.000 0.000
 HVENT 2 3 1 20.0 0.3048 0.20 0.00 0.00
 VVENT 2 1 33.32 2
 CVENT 1 3 1 1.00 1.00 1.00 1.00
 CVENT 2 3 1 1.00 1.00 1.00 1.00
 MVOPN 1 3 H 1.00 3.50
 MVOPN 3 1 H 1.00 3.50
 MVDCT 3 2 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVFAN 2 1 0.00 300.00 0.140E+02 0.266E-01
 INELV 1 9.00 2 9.00 3 9.00
 CEILI CONCRETE CONCRETE
 WALLS CONCRETE CONCRETE
 FLOOR CONCRETE CONCRETE
 CHEMI 0. 0. 1.0 30000000. 300. 400. 0.000
 LFBO 1
 LFBT 2
 FPOS 4.55 3.05 0.00
 FTIME 60. 200. 442. 600. 900.
 FMASS 0.00 0.0666 0.1666 0.29 0.29 0.10
 FHIGH 0.00 0.00 0.00 0.00 0.00
 FAREA 0.00 0.00 0.00 0.00 0.00
 FQDOT 0.00 2.00E+06 5.00E+06 8.700E+06 8.700E+06 3.0E+6
 CJET OFF
 HCR 0.333 0.333 0.333 0.333 0.333 0.333
 STPMAX 5.00
 DUMPR TPL1C.HI
 DEVICE 1
 WINDOW 0 0. 0. 1279. 1023. 4095.

Time = 900.0 seconds.

Compartment	Upper Temp. (K)	Lower Temp. (K)	Inter. Height (m)	Upper Vol. (m^3)	Pressure (Pa)	Ceiling Temp. (K)	Up wall Temp. (K)	Low wall Temp. (K)	Floor Temp. (K)
1	347.7	305.1	1.7	3.03E+04 (86%)	-24.8	307.3	306.6	301.8	303.1
2	300.0	300.0	8.0	3.1 (0%)	-25.4	300.0	300.0	300.0	300.0

Compartment	Fire	Plume Flow (kg/s)	Pyrol Rate (kg/s)	Fire Size (W)	Fire in Upper (W)	Fire in Lower (W)	Vent Fire (W)	Convec. (W)	Radiat. (W)	On Target (W/m^2)
	Main	7.27	0.100	3.000E+06				3.000E+06	0.000	
1		7.27	0.100	3.000E+06	0.000	3.000E+06	0.000			368.
2		0.000	0.000	0.000	0.000	0.000	0.000			0.000
Outside							0.000			

Upper Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCl c (mg/m^2)	HCl f (mg/m^2)	HCl uw (mg/m^2)	HCl lw (mg/m^2)
1	78.3	19.3	0.388	0.000	0.000	0.000	0.000	2.08	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Lower Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCl c (mg/m^2)	HCl f (mg/m^2)	HCl uw (mg/m^2)	HCl lw (mg/m^2)
1	79.3	20.7	5.343E-04	0.000	0.000	0.000	0.000	2.866E-03	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Vent Flow (kg/s)

From	To	Number	Type	U->U	U->L->U	L->U->L	L->L	E->U	E->L
1	3	1	H						
2	3	1	H						
3	1	1	H			1.58	9.03		0.110
3	2	1	H				11.3		

CALCULATION CONTROL SHEET

HUGHES ASSOCIATES, INC.

PROJECT TITLE: Five models for providing services

CALCULATION TITLE: From the early 1980s to the early 1990s

COMPLETED BY: John J. G. J.

CHECKED BY: Craig Boyer Mr. J. J.

APPROVED BY: E. R. R.

DATE: 9/29/94

PROBLEM/OBJECTIVE: 5,700 and five years of service to the community.

ASSUMPTIONS:

CALCULATIONS:

See CFAST Input file "TML3C.dat" and
output file "TML3C.Fst"

Complete files on disk - CN3

RESULT: At 900-re. depth temperature 72.1 deg. with 100 ft. interval
Tunnel 3 1/2 ft. 200 ft. 1 ft. 2 ft. 10 ft. 100 ft. 1000 ft.

REFERENCES:

VERSN 2 TPL3C BOTH EXHAUST FAN ON FIRE IN THE CANYON
 TIMES 900 60 20 20 20
 TAMB 300. 101300. 0.
 EAMB 300. 101300. 0.
 HI/F 8.00 0.000
 WIDTH 245.00 64.00
 DEPTH 12.00 6.000
 HEIGH 12.00 8.000
 HVENT 1 3 1 1.00 2.00 0.000 0.000
 HVENT 2 3 1 20.0 0.3048 0.20 0.00 0.00
 VVENT 2 1 33.32 2
 CVENT 1 3 1 1.00 1.00 1.00 1.00
 CVENT 2 3 1 1.00 1.00 1.00 1.00
 MVOPN 1 3 H 11.00 3.50
 MVOPN 1 4 H 1.00 3.50
 MVOPN 3 1 H 11.00 3.50
 MVOPN 3 6 H 1.00 3.50
 MVDCT 3 2 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVDCT 4 5 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVFAN 2 1 0.00 300.00 0.200E+02 0.266E-01
 MVFAN 5 6 0.00 300.00 0.140E+02 0.266E-01
 INELV 1 19.00 2 19.00 3 19.00 4 9.00 5 9.00 6 9.00
 CEILI CONCRETE CONCRETE
 WALLS CONCRETE CONCRETE
 FLOOR CONCRETE CONCRETE
 CHEMI 0. 0. 1.0 30000000. 300. 400. 0.000
 LFBO 1
 LFBT 2
 FPOS 4.55 3.05 0.00
 FTIME 60. 200. 442. 600. 900.
 FMASS 0.00 0.0666 0.1666 0.29 0.29 0.10
 FHIGH 0.00 0.00 0.00 0.00 0.00
 FAREA 0.00 0.00 0.00 0.00 0.00
 FQDOT 0.00 2.00E+06 5.00E+06 8.700E+06 8.700E+06 3.0E+6
 CJET OFF
 HCR 0.333 0.333 0.333 0.333 0.333 0.333
 STPMAX 5.00
 DUMPR TPL3C.HI
 DEVICE 1
 WINDOW 0 0. 0. 1279. 1023. 4095.

Time = 900.0 seconds.

Compartment	Upper Temp. (K)	Lower Temp. (K)	Inter. Height (m)	Upper Vol. (m^3)	Pressure (Pa)	Ceiling Temp. (K)	Up wall Temp. (K)	Low wall Temp. (K)	Floor Temp. (K)
1	346.3	304.2	4.6	2.17E+04 (62%)	-110.	307.2	306.6	301.4	302.4
2	300.0	300.0	8.0	3.1 (0%)	-110.	300.0	300.0	300.0	300.0

Compartment	Fire	Plume Flow (kg/s)	Pyrol Rate (kg/s)	Fire Size (W)	Fire in Upper (W)	Fire in Lower (W)	Vent Fire (W)	Convec. (W)	Radiat. (W)	On Target (W/m^2)
	Main	17.1	0.100	3.000E+06				3.000E+06	0.000	
1		17.1	0.100	3.000E+06	0.000	3.000E+06	0.000			355.
2		0.000	0.000	0.000	0.000	0.000	0.000			0.000
Outside							0.000			

Upper Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCl c (mg/m^2)	HCl f (mg/m^2)	HCl uw (mg/m^2)	HCl lw (mg/m^2)
1	78.3	19.4	0.363	0.000	0.000	0.000	0.000	1.95	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Lower Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCl c (mg/m^2)	HCl f (mg/m^2)	HCl uw (mg/m^2)	HCl lw (mg/m^2)
1	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Vent Flow (kg/s)

From	To	Number	Type	U->U	U->L->U	L->U->L	L->L	E->U	E->L
1	3	1	H						
2	3	1	H						
3	1	1	H				22.4		
3	2	1	H				23.5		

CALCULATION CONTROL SHEET HUGHES ASSOCIATES, INC.

PROJECT TITLE: Fire Modeling for Building 221-T
 CALCULATION TITLE: Fire in 40 Tunnel Based on Physical Data 1992
 COMPLETED BY: Alison Ideal
 CHECKED BY: Clary Beyer Tom Beyer
 APPROVED BY: R. R. R.
 DATE: 9/29/94
 PROBLEM/OBJECTIVE: 1200 KW Fire, 221-T-13 Exhaust Fan on only.

ASSUMPTIONS:

CALCULATIONS:

See CFAST Input file TPL2V.dat and
output file "TPL2V.1.Fst."

Complete files on disk-03

RESULT: At 1200 KW Tunnel temp. 650 (149F) with interface 5 m (17ft)
Curtop temp. 38.6°C (101.5F) with interface at 11m (36ft)

REFERENCES:

VERSN 2 TPL2V ONLY ROOF EXHAUST FAN ON FIRE IN THE TUNNEL
 TIMES 1200 60 20 20 20
 TAMB 300. 101300. 0.
 EAMB 300. 101300. 0.
 HI/F 8.00 0.00
 WIDTH 245.00 64.00
 DEPTH 12.00 6.00
 HEIGH 12.00 8.00
 HVENT 1 3 1 1.000 2.000 0.000 0.000
 HVENT 2 3 1 20.0 0.3048 0.200 0.000
 VVENT 2 1 33.32 2
 CVENT 1 3 1 1.00 1.00 1.00 1.00 1.00
 CVENT 2 3 1 1.00 1.00 1.00 1.00 1.00
 MVOPN 1 3 H 11.00 3.50
 MVOPN 3 1 H 11.00 3.50
 MVDCT 3 2 8.00 2.00 .00000 0.00 1.0000 0.00 1.0000
 MVFAN 2 1 0.00 300.00 0.200E+02 0.266E-01
 INELV 1 11.00 2 19.00 3 19.00
 CEILI CONCRETE CONCRETE
 WALLS CONCRETE CONCRETE
 FLOOR CONCRETE CONCRETE
 CHEMI 0. 0. 1.0 30000000. 300. 400. 0.000
 LFBO 2
 LFBT 2
 FPOS 4.55 3.05 0.00
 FTIME 60. 110. 165. 200. 1200.
 FMASS 0.00 0.00133 0.0133 0.040 0.040 0.031
 FHIGH 0.00 0.00 0.00 0.00 0.00
 FAREA 0.00 0.00 0.00 0.00 0.00
 FODOT 0.00 4.0E+04 40.0E+04 12.0E+05 12.0E+05 9.50E+05
 CJET OFF
 HCR 0.333 0.333 0.333 0.333 0.333
 STEPMAX 5.00
 DUMPR TPL2V.HI
 DEVICE 1
 WINDOW 0 0. 0. 1279. 1023. 4095.

Time = 1200.0 seconds.

Compartment	Upper Temp. (K)	Lower Temp. (K)	Inter. Height (m)	Upper Vol. (m ³)	Pressure (Pa)	Ceiling Temp. (K)	Up wall Temp. (K)	Low wall Temp. (K)	Floor Temp. (K)
1	311.6	300.2	11.	3.18E+03 (9%)	-26.3	301.1	300.9	300.1	300.1
2	338.2	300.7	5.2	1.07E+03 (35%)	-30.6	306.4	306.0	301.1	301.4

Compartment	Fire	Plume Flow (kg/s)	Pyrol Rate (kg/s)	Fire Size (W)	Fire in Upper (W)	Fire in Lower (W)	Vent Fire (W)	Convec. (W)	Radiat. (W)	On Target (W/m ²)
	Main	15.3	3.100E-02	9.500E+05				9.500E+05	0.000	
1		0.000	0.000	0.000	0.000	0.000	0.000			75.2
2		15.3	3.100E-02	9.500E+05	0.000	9.500E+05	0.000			281.
Outside							0.000			

Upper Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (l/m)	HCl c (mg/m ²)	HCl f (mg/m ²)	HCl uw (mg/m ²)	HCl lw (mg/m ²)
1	79.0	20.3	0.103	0.000	0.000	0.000	0.000	0.537	0.000	0.000	0.000	0.000	0.000
2	78.9	20.2	0.144	0.000	0.000	0.000	0.000	0.740	0.000	0.000	0.000	0.000	0.000

Lower Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (l/m)	HCl c (mg/m ²)	HCl f (mg/m ²)	HCl uw (mg/m ²)	HCl lw (mg/m ²)
1	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Vent Flow (kg/s)

From	To	Number	Type	U->U	U->L->U	L->U->L	L->L	E->U	E->L
1	3	1	H						
2	3	1	H						
3	1	1	H				11.0		
3	2	1	H				12.4		

CALCULATION CONTROL SHEET
HUGHES ASSOCIATES, INC.

PROJECT TITLE: Fire Modeling of Tunnel 221-T
 CALCULATION TITLE: Fire in the Tunnel Based on Planned Sec. 22
 COMPLETED BY: Nacorn Iqbal
 CHECKED BY: Craig Boyler Ann. Boyler
 APPROVED BY: R. RRL
 DATE: 9/29/94

PROBLEM/OBJECTIVE: 12,00 kW fire, 221-T Exhaust Fan on high
1200 cfm

ASSUMPTIONS:

CALCULATIONS:

*See CFAST Input file "TPL1V.dat" and
 output file "TPL1V.Fst"*

Complete files on disk - CD

RESULT: At 1200 sec tunnel temp 65.5°C (152°F) with interface at 5.0m (16ft)
Carton temp. 34.5°C (94°F) with interface at 5.3m (17.4ft)

REFERENCES:

CFAST 2.0.1 APRIL 22, 1994
Disk - 5 FIRE IN THE TUNNEL BASED ON PLYWOOD BOX HEAT RELEASE RATE

VERSN 2 TPLIV ONLY FLOOR EXHAUST FAN ON FIRE IN THE TUNNEL
 TIMES 1200 60 20 20 20
 TAMB 300. 101300. 0.
 EAMB 300. 101300. 0.
 HI/F 8.00 0.000
 WIDTH 245.00 64.00
 DEPTH 12.000 6.0000
 HEIGH 12.000 8.0000
 HVENT 1 3 1 1.00 2.00 0.000 0.000
 HVENT 2 3 1 20.0 0.3048 0.200 0.000
 VVENT 2 1 33.32 2
 CVENT 1 3 1 1.00 1.00 1.00 1.00
 CVENT 2 3 1 1.00 1.00 1.00 1.00
 MVOPN 1 3 H 1.00 3.50
 MVOPN 3 1 H 1.00 3.50
 MVDCT 3 2 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVFAN 2 1 0.00 300.00 0.140E+02 0.266E-01
 INELV 1 9.00 2 9.00 3 9.00
 CEILI CONCRETE CONCRETE
 WALLS CONCRETE CONCRETE
 FLOOR CONCRETE CONCRETE
 CHEMI 0. 0. 1.0 30000000. 300. 400. 0.000
 LFBO 2
 LFBT 2
 FPOS 4.55 3.05 0.00
 FTIME 60. 110. 165. 200. 1200.
 FMASS 0.00 0.00133 0.0133 0.040 0.031
 FHIGH 0.00 0.00 0.00 0.00 0.00
 FAREA 0.00 0.00 0.00 0.00 0.00
 FQDOT 0.00 4.0E+04 40.0E+04 12.0E+05 12.0E+05 9.50E+05
 CJET OFF
 HCR 0.333 0.333 0.333 0.333 0.333 0.333
 STEPMAX 5.00
 DUMPR TPLIV.HI
 DEVICE 1
 WINDOW 0 0. 0. 1279. 1023. 4095.

Time = 1200.0 seconds.

Compartment	Upper Temp. (K)	Lower Temp. (K)	Inter. Height (m)	Upper Vol. (m^3)	Pressure (Pa)	Ceiling Temp. (K)	Up wall Temp. (K)	Low wall Temp. (K)	Floor Temp. (K)
1	307.5	300.3	5.5	1.91E+04 (54%)	-11.2	301.0	300.9	300.2	300.2
2	339.5	301.0	5.0	1.15E+03 (38%)	-16.0	306.6	306.2	301.2	301.5

Compartment	Fire	Plume Flow (kg/s)	Pyrol Rate (kg/s)	Fire Size (W)	Fire in Upper (W)	Fire in Lower (W)	Vent Fire (W)	Convec. (W)	Radiat. (W)	On Target (W/m^2)
Main		14.2	3.100E-02	9.500E+05				9.500E+05	0.000	
1		0.000	0.000	0.000	0.000	0.000	0.000			47.9
2		14.2	3.100E-02	9.500E+05	0.000	9.500E+05	0.000			292.
Outside							0.000			

Upper Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	CO (l/m)	HCL c (mg/m^2)	HCL f (mg/m^2)	HCL uw (mg/m^2)	HCL lw (mg/m^2)
1	79.0	20.3	0.113	0.000	0.000	0.000	0.000	0.595	0.000	0.000	0.000	0.000	0.000
2	78.9	20.2	0.156	0.000	0.000	0.000	0.000	0.803	0.000	0.000	0.000	0.000	0.000

Lower Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	CO (l/m)	HCL c (mg/m^2)	HCL f (mg/m^2)	HCL uw (mg/m^2)	HCL lw (mg/m^2)
1	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	1.441E-03	0.000	0.000	0.000	0.000	7.591E-03	0.000	0.000	0.000	0.000	0.000

Vent Flow (kg/s)

From	To	Number	Type	U->U	U->L->U	L->U->L	L->L	E->U	E->L
1	3	1	H						
2	3	1	H						
3	1	1	H				7.16		
3	2	1	H				8.97		

**CALCULATION CONTROL SHEET
HUGHES ASSOCIATES, INC.**

PROJECT TITLE: Fire modeling for Building 2-4-7

CALCULATION TITLE: Fire in the Tunnel Based on Physical Data FPR

COMPLETED BY: Joan Izal

CHECKED BY: Gary Bayler Joan Bayler

APPROVED BY: R. R. RL

DATE: 9/29/94

PROBLEM/OBJECTIVE: 1200 K10 Fire 201.5 m/s Fire in tunnel
1200 cs

ASSUMPTIONS:

CALCULATIONS:

See CFAST Input file "TPL3V.dat" and
output file "TPL3V.lst."

Complete files on disk- cs

RESULT: At 1200 sec Tunnel temp. 62.48 (141F), 501.2 K (468.0 C) at 5.7m (19ft)
and on wall 35.27 (96F) with fire at 9.1m (30ft)

REFERENCES:

VERSN 2 TPL3V BOTH EXHAUST FAN ON FIRE IN THE TUNNEL
 TIMES 1200 60 20 20 20
 TAMB 300. 101300. 0.
 EAMB 300. 101300. 0.
 HI/F 8.00 0.000
 WIDTH 245.00 64.00
 DEPTH 12.00 6.000
 HEIGH 12.00 8.000
 HVENT 1 3 1 1.00 2.00 0.000 0.000
 HVENT 2 3 1 20.0 0.3048 0.200 0.00
 VVENT 2 1 33.32 2
 CVENT 1 3 1 1.00 1.00 1.00 1.00
 CVENT 2 3 1 1.00 1.00 1.00 1.00
 MVOPN 1 3 H 11.0 3.50
 MVOPN 1 4 H 1.00 3.50
 MVOPN 3 1 H 11.0 3.50
 MVOPN 3 6 H 1.00 3.50
 MVDCT 3 2 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVDCT 4 5 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVFAN 2 1 0.00 300.00 0.200E+02 0.266E-01
 MVFAN 5 6 0.00 300.00 0.140E+02 0.266E-01
 INELV 1 19.00 2 19.00 3 19.00 4 9.00 5 9.00 6 9.00
 CEILI CONCRETE CONCRETE
 WALLS CONCRETE CONCRETE
 FLOOR CONCRETE CONCRETE
 CHEMI 0. 0. 1.0 30000000. 300. 400. 0.000
 LFBO 2
 LFBT 2
 FPOS 4.55 3.05 0.00
 FTIME 60. 110. 165. 200. 1200.
 FMASS 0.00 0.00133 0.0133 0.040 0.040 0.031
 FHIGH 0.00 0.00 0.00 0.00 0.00
 FAREA 0.00 0.00 0.00 0.00 0.00
 FQDOT 0.00 4.0E+04 40.0E+04 12.0E+05 12.0E+05 9.50E+05
 CJET OFF
 HCR 0.333 0.333 0.333 0.333 0.333 0.333
 STPMAX 5.00
 DUMPR TPL3V.HI
 DEVICE 1
 WINDOW 0 0. 0. 1279. 1023. 4095.

Time = 1200.0 seconds.

Compartment	Upper Temp. (K)	Lower Temp. (K)	Inter. Height (m)	Upper Vol. (m ³)	Pressure (Pa)	Ceiling Temp. (K)	Up wall Temp. (K)	Low wall Temp. (K)	Floor Temp. (K)
1	308.7	300.2	9.1	8.56E+03 (24%)	-99.3	301.0	300.9	300.2	300.2
2	335.4	300.5	5.7	8.97E+02 (29%)	-103.	305.8	305.5	301.0	301.1

Compartment	Fire	Plume Flow (kg/s)	Pyrol Rate (kg/s)	Fire Size (W)	Fire in Upper (W)	Fire in Lower (W)	Vent Fire (W)	Convec. (W)	Radiat. (W)	On Target (W/m ²)
	Main	18.0	3.100E-02	9.500E+05				9.500E+05	0.000	
1		0.000	0.000	0.000	0.000	0.000	0.000			55.7
2		18.0	3.100E-02	9.500E+05	0.000	9.500E+05	0.000			257.
Outside							0.000			

Upper Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	THC (%)	H2O (%)	OD (1/m)	HCL c (mg/m ²)	HCL f (mg/m ²)	HCL uw (mg/m ²)	HCL lw (mg/m ²)
1	79.1	20.4	7.480E-02	0.000	0.000	0.000	0.000	0.389	0.000	0.000	0.000	0.000	0.000
2	79.0	20.3	0.122	0.000	0.000	0.000	0.000	0.628	0.000	0.000	0.000	0.000	0.000

Lower Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	THC (%)	H2O (%)	OD (1/m)	HCL c (mg/m ²)	HCL f (mg/m ²)	HCL uw (mg/m ²)	HCL lw (mg/m ²)
1	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Vent Flow (kg/s)

From	To	Number	Type	U->U	U->L->U	L->U->L	L->L	E->U	E->L
1	3	1	H						
2	3	1	H						
3	1	1	H				21.3		
3	2	1	H				22.7		

CALCULATION CONTROL SHEET
HUGHES ASSOCIATES, INC.

PROJECT TITLE: Fire Modeling for Tunnel 221-T
 CALCULATION TITLE: Fire in the Tunnel Based on 500 kW fire with oil soaked floor FRR
 COMPLETED BY: Naeem Iqbal
 CHECKED BY: Cory Beyler Jim Byles
 APPROVED BY: E R R
 DATE: 9/29/94

PROBLEM/OBJECTIVE: 3,520 kW Fire. 221-T-13 Exhaust Fan on.

ASSUMPTIONS:

CALCULATIONS:

See CFAST Input file TPL2W.dai and
output file TPL2W.Fst.

Complete files on disk - CB

RESULT: At 1000 sec Tunnel Temp. 118°C (244°F) with interface at 5.1m (17ft)
Confinement Temp 51°C (124°F) with interface at 9.8m (32ft)

REFERENCES:

VERSN 2 TPL2W ONLY ROOF EXHAUST FAN ON FIRE IN THE TUNNEL
 TIMES 1000 60 20 20 20
 TAMB 300. 101300. 0.
 EAMB 300. 101300. 0.
 HI/F 8.00 0.00
 WIDTH 245.00 64.00
 DEPTH 12.00 6.00
 HEIGH 12.00 8.00
 HVENT 1 3 1 1.000 2.000 0.000 0.000
 HVENT 2 3 1 20.0 0.3048 0.200 0.000
 VVENT 2 1 33.32 2
 CVENT 1 3 1 1.00 1.00 1.00 1.00
 CVENT 2 3 1 1.00 1.00 1.00 1.00
 MVOPN 1 3 H 11.00 3.50
 MVOPN 3 1 H 11.00 3.50
 MVDCT 3 2 8.00 2.00 .00000 0.00 1.0000 0.00 1.0000
 MVFAN 2 1 0.00 300.00 0.200E+02 0.266E-01
 INELV 1 11.00 2 19.00 3 19.00
 CEILI CONCRETE CONCRETE
 WALLS CONCRETE CONCRETE
 FLOOR CONCRETE CONCRETE
 CHEMI 0. 0. 1.0 30000000. 300. 400. 0.000
 LFBO 2
 LFBT 2
 FPOS 4.55 3.05 0.00
 FTIME 60. 180. 282. 350. 1000.
 FMASS 0.00 0.00133 0.0133 0.117 0.117 0.093
 FHIGH 0.00 0.00 0.00 0.00 0.00
 FAREA 0.00 0.00 0.00 0.00 0.00
 FQDOT 0.00 4.0E+04 40.0E+04 3.520E+06 3.520E+06 2.800E+06
 CJET OFF
 HCR 0.333 0.333 0.333 0.333 0.333
 STPMAX 5.00
 DUMPR TPL2W.HI
 DEVICE 1
 WINDOW 0 0. 0. 1279. 1023. 4095.

Time = 1000.0 seconds.

Compartment	Upper Temp. (K)	Lower Temp. (K)	Inter. Height (m)	Upper Vol. (m ³)	Pressure (Pa)	Ceiling Temp. (K)	Up wall Temp. (K)	Low wall Temp. (K)	Floor Temp. (K)
1	324.2	300.6	9.8	6.49E+03 (18%)	-20.6	302.7	302.3	300.4	300.4
2	389.1	301.9	5.1	1.11E+03 (36%)	-29.0	315.3	314.4	302.8	303.5

Compartment	Fire	Plume Flow (kg/s)	Pyrol Rate (kg/s)	Fire Size (W)	Fire in Upper (W)	Fire in Lower (W)	Vent Fire (W)	Convec. (W)	Radiat. (W)	On Target (W/m ²)
	Main	19.1	9.300E-02	2.800E+06				2.800E+06	0.000	
1		0.000	0.000	0.000	0.000	0.000	0.000			166.
2		19.1	9.300E-02	2.800E+06	0.000	2.800E+06	0.000			836.
Outside							0.000			

Upper Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (l/m)	HCl c (mg/m ²)	HCl f (mg/m ²)	HCl uw (mg/m ²)	HCl lw (mg/m ²)
1	78.6	19.8	0.252	0.000	0.000	0.000	0.000	1.35	0.000	0.000	0.000	0.000	0.000
2	78.4	19.5	0.332	0.000	0.000	0.000	0.000	1.77	0.000	0.000	0.000	0.000	0.000

Lower Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (l/m)	HCl c (mg/m ²)	HCl f (mg/m ²)	HCl uw (mg/m ²)	HCl lw (mg/m ²)
1	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Vent Flow (kg/s)

From	To	Number	Type	U->U	U->L->U	L->U->L	L->L	E->U	E->L
1	3	1	H						
2	3	1	H						
3	1	1	H				9.70		
3	2	1	H				12.1		

CALCULATION CONTROL SHEET
HUGHES ASSOCIATES, INC.

PROJECT TITLE: Fire Model - Tunnel - Incident 921 -
 CALCULATION TITLE: Fire in the Tunnel Based on 55 Gallon Drum Filled
With Oil Coated Rotor HRR
 COMPLETED BY: Naeem Iqbal
 CHECKED BY: Craig Byler Tom Byler
 APPROVED BY: E. L. Road
 DATE: 9/29/94
 PROBLEM/OBJECTIVE: 5,520 kW Fire 271-T. Exhaust Fan on opposite

ASSUMPTIONS:

CALCULATIONS:

*See CFAST Input file TPL1w.dat and
 output file TPL1w.Fst*

Complete files on disk - CB

RESULT: At 1000 sec Tunnel temp 1180 (486°F) with Interface at 5.0m (16 ft)
Canyon temp 467 (115°F) with Interface at 5.5m (18 ft)

REFERENCES:

CEAST 2.0.1 APRIL 22, 1994
Disk - 6 FIRE IN THE TUNNEL BASED ON 55 GALLON DRUM FILLED WITH FLAMMABLE OIL SOAKED RAGS
HEAT RELEASE RATE

VERSN 2 TPL1W ONLY FLOOR EXHAUST FAN ON FIRE IN THE TUNNEL
 TIMES 1000 60 20 20 20
 TAMB 300. 101300. 0.
 EAMB 300. 101300. 0.
 HI/F 8.00 0.000
 WIDTH 245.00 64.00
 DEPTH 12.000 6.0000
 HEIGH 12.000 8.0000
 HVENT 1 3 1 1.00 2.00 0.000 0.000
 HVENT 2 3 1 20.0 0.3048 0.200 0.000
 VVENT 2 1 33.32 2
 CVENT 1 3 1 1.00 1.00 1.00 1.00
 CVENT 2 3 1 1.00 1.00 1.00 1.00
 MVOPN 1 3 H 1.00 3.50
 MVOPN 3 1 H 1.00 3.50
 MVDCT 3 2 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVFAN 2 1 0.00 300.00 0.140E+02 0.266E-01
 INELV 1 9.00 2 9.00 3 9.00
 CEILI CONCRETE CONCRETE
 WALLS CONCRETE CONCRETE
 FLOOR CONCRETE CONCRETE
 CHEMI 0. 0. 1.0 30000000. 300. 400. 0.000
 LFBO 2
 LFBT 2
 FPOS 4.55 3.05 0.00
 FTIME 60. 180. 282. 350. 1000.
 FMASS 0.00 0.00133 0.0133 0.117 0.117 0.093
 FHIGH 0.00 0.00 0.00 0.00 0.00
 FAREA 0.00 0.00 0.00 0.00 0.00
 FQDOT 0.00 4.0E+04 40.0E+04 3.520E+06 3.520E+06 2.800E+06
 CJET OFF
 HCR 0.333 0.333 0.333 0.333 0.333 0.333
 STEPMAX 5.00
 DUMPR TPL1W.HI
 DEVICE 1
 WINDOW 0 0. 0. 1279. 1023. 4095.

Time = 1000.0 seconds.

Compartment	Upper Temp. (K)	Lower Temp. (K)	Inter. Height (m)	Upper Vol. (m^3)	Pressure (Pa)	Ceiling Temp. (K)	Up wall Temp. (K)	Low wall Temp. (K)	Floor Temp. (K)
1	319.1	300.7	5.5	1.92E+04 (54%)	-7.40	302.4	302.2	300.6	300.6
2	391.2	302.5	5.0	1.17E+03 (38%)	-16.5	315.7	314.7	302.9	303.7

Compartment	Fire	Plume Flow (kg/s)	Pyrol Rate (kg/s)	Fire Size (W)	Fire in Upper (W)	Fire in Lower (W)	Vent Fire (W)	Convec. (W)	Radiat. (W)	On Target (W/m^2)
	Main	18.1	9.300E-02	2.800E+06				2.800E+06	0.000	
1		0.000	0.000	0.000	0.000	0.000	0.000			129.
2		18.1	9.300E-02	2.800E+06	0.000	2.800E+06	0.000			864.
Outside							0.000			

Upper Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCL c (mg/m^2)	HCL f (mg/m^2)	HCL uw (mg/m^2)	HCL lw (mg/m^2)
1	78.6	19.8	0.249	0.000	0.000	0.000	0.000	1.33	0.000	0.000	0.000	0.000	0.000
2	78.4	19.4	0.354	0.000	0.000	0.000	0.000	1.88	0.000	0.000	0.000	0.000	0.000

Lower Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCL c (mg/m^2)	HCL f (mg/m^2)	HCL uw (mg/m^2)	HCL lw (mg/m^2)
1	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	4.313E-03	0.000	0.000	0.000	0.000	2.298E-02	0.000	0.000	0.000	0.000	0.000

Vent Flow (kg/s)

From	To	Number	Type	U->U	U->L->U	L->U->L	L->L	E->U	E->L
1	3	1	H						
2	3	1	H						
3	1	1	H				5.81		
3	2	1	H				9.11		

CALCULATION CONTROL SHEET
HUGHES ASSOCIATES, INC.

PROJECT TITLE: Fire Modeling for Building 221-T
 CALCULATION TITLE: Fire in the Tunnel Based on 55 Gallon Drum Filled with Oil Soaked Rags H/R.
 COMPLETED BY: Nacorn IgSal
 CHECKED BY: Craig Bayler Don Bayler
 APPROVED BY: E R RL
 DATE: 9/29/94
 PROBLEM/OBJECTIVE: 3520 KW Fire. Both Exhaust System on

ASSUMPTIONS:

CALCULATIONS:

*See CIPAS Input file TPL3W.dat and
 output file TPL3W.Fst.*

Complete File on Disk - 03

RESULT: *At 1800 Sec Tunnel temp 111°C (232°F) with Interface at 5.5m (18ft)
 Canyon temp 48°C (118°F) with Interface at 8.2m (27ft)*

REFERENCES:

VERSN 2 TPL3W BOTH EXHAUST FAN ON FIRE IN THE TUNNEL
 TIMES 1000 60 20 20 20
 TAMB 300. 101300. 0.
 EAMB 300. 101300. 0.
 HI/F 8.00 0.000
 WIDTH 245.00 64.00
 DEPTH 12.00 6.000
 HEIGH 12.00 8.000
 HVENT 1 3 1 1.00 2.00 0.000 0.000
 HVENT 2 3 1 20.0 0.3048 0.200 0.00
 VVENT 2 1 33.32 2
 CVENT 1 3 1 1.00 1.00 1.00 1.00
 CVENT 2 3 1 1.00 1.00 1.00 1.00
 MVOPN 1 3 H 11.0 3.50
 MVOPN 1 4 H 1.00 3.50
 MVOPN 3 1 H 11.0 3.50
 MVOPN 3 6 H 1.00 3.50
 MVDCT 3 2 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVDCT 4 5 8.00 2.00 .00000 0.00 3.0000 0.00 3.000
 MVFAN 2 1 0.00 300.00 0.200E+02 0.266E-01
 MVFAN 5 6 0.00 300.00 0.140E+02 0.266E-01
 INELV 1 19.00 2 19.00 3 19.00 4 9.00 5 9.00 6 9.00
 CEILI CONCRETE CONCRETE
 WALLS CONCRETE CONCRETE
 FLOOR CONCRETE CONCRETE
 CHEMI 0. 0. 1.0 30000000. 300. 400. 0.000
 LFBO 2
 LFBT 2
 FPOS 4.55 3.05 0.00
 FTIME 60. 180. 282. 350. 1000.
 FMASS 0.00 0.00133 0.0133 0.117 0.117 0.093
 FHIGH 0.00 0.00 0.00 0.00 0.00
 FAREA 0.00 0.00 0.00 0.00 0.00
 FQDOT 0.00 4.0E+04 40.0E+04 3.520E+06 3.520E+06 2.800E+06
 CJET OFF
 HCR 0.333 0.333 0.333 0.333 0.333 0.333
 STPMAX 5.00
 DUMPR TPL3W.HI
 DEVICE 1
 WINDOW 0 0. 0. 1279. 1023. 4095.

Time = 1000.0 seconds.

Compartment	Upper Temp. (K)	Lower Temp. (K)	Inter. Height (m)	Upper Vol. (m ³)	Pressure (Pa)	Ceiling Temp. (K)	Up wall Temp. (K)	Low wall Temp. (K)	Floor Temp. (K)
1	321.0	300.6	8.2	1.12E+04 (32%)	-84.1	302.5	302.2	300.5	300.5
2	384.2	301.4	5.5	9.74E+02 (32%)	-90.9	314.2	313.5	302.5	302.9

Compartment	Fire	Plume Flow (kg/s)	Pyrol Rate (kg/s)	Fire Size (W)	Fire in Upper (W)	Fire in Lower (W)	Vent Fire (W)	Convec. (W)	Radiat. (W)	On Target (W/m ²)
	Main	21.8	9.300E-02	2.800E+06				2.800E+06	0.000	
1		0.000	0.000	0.000	0.000	0.000	0.000			142.
2		21.8	9.300E-02	2.800E+06	0.000	2.800E+06	0.000			772.
Outside							0.000			

Upper Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCL c (mg/m ²)	HCL f (mg/m ²)	HCL uw (mg/m ²)	HCL lw (mg/m ²)
1	78.8	20.0	0.195	0.000	0.000	0.000	0.000	1.04	0.000	0.000	0.000	0.000	0.000
2	78.5	19.6	0.291	0.000	0.000	0.000	0.000	1.55	0.000	0.000	0.000	0.000	0.000

Lower Layer Species

Compartment	N2 (%)	O2 (%)	CO2 (%)	CO (ppm)	HCN (ppm)	HCL (ppm)	TUHC (%)	H2O (%)	OD (1/m)	HCL c (mg/m ²)	HCL f (mg/m ²)	HCL uw (mg/m ²)	HCL lw (mg/m ²)
1	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	79.3	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Vent Flow (kg/s)

From	To	Number	Type	U->U	U->L->U	L->U->L	L->L	E->U	E->L
1	3	1	H						
2	3	1	H						
3	1	1	H				19.6		
3	2	1	H				21.4		

**CALCULATION CONTROL SHEET
HUGHES ASSOCIATES, INC.**

PROJECT TITLE: Fire Modeling for Building 221-T

CALCULATION TITLE: Estimating Sprinkler activation time.

COMPLETED BY: Naeem Iqbal

CHECKED BY: Craig Beyler Sam Beyler

APPROVED BY: E R RL

DATE: 9/29/94

PROBLEM/OBJECTIVE: Response time for fixed temperature sprinkler,
head in the Canyon and railroad tunnel.

ASSUMPTIONS:

CALCULATIONS:

Input and output files of FPEtool
Computer model

RESULT: Response time in the Canyon is 289 sec (min), and in the tunnel is 239 sec (min)

REFERENCES:

Estimating Sprinkler Actuation Time in the Canyon and Railroad Tunnel

The analysis using DETAC-QS, as included in FPEtool (Nelson, 1990) is used to estimate the sprinkler response time.

Ambient temperature - 25 °C (77 °F)

Sprinkler spacing - 3.04 m (10 ft)

Distance of sprinkler from axis of fire - 2.15 m (7.07 ft)

Sprinkler actuation temperature - 71 °C (160 °F)

T² fire growth - Fast fire

Sprinkler type and location	Time to sprinkler activation (sec)	Fire size (kW)	Mass Loss Rate kg/m ² sec	Smoke layer temperature (°C)	Sprinkler actuation temperature (°C)
Canyon Conventional type RTI-165 (m/s) ^{1/2}	219	2235	0.125	71	52
	289	3865	0.216	91	71
Tunnel Conventional type RTI-165 (m/s) ^{1/2}	162	1223	0.068	71	45
	239	2662	0.149	102	71

Heat Release Rate Required to Activate Sprinkler in the Canyon

To determine the potential of a sprinkler being swept by the fire plume, an analysis is performed to evaluate the minimum heat release of a fire in the canyon 12 m below the ceiling needed to raise the temperature of the gas 71 °C (160 °F) at a distance 2.15 (7.07 ft) from the axis of a fire.

Alpert has developed correlations based on measurements collected during test burns of fuel arrays of wood and plastic pallets, cardboard boxes, plastic materials in cardboard boxes, and liquid fuels with energy release rates ranging from 668 kW to 98 MW under ceiling heights from 4.6 to 15.5 m. The correlations developed by Alpert are:

$$T_g - T_o = \frac{16.9 Q^{2/3}}{H^{5/3}} \quad \text{for } \frac{r}{H} \leq 0.18 \quad (1)$$

$$T_g - T_o = \frac{16.9 \left(\frac{Q}{r}\right)^{2/3}}{H} \quad \text{for } \frac{r}{H} > 0.18 \quad (2)$$

where:

T_g - gas temperature

T_o - ambient temperature

Q - heat release rate

H - ceiling height

r - distance of sprinkler head from axis of fire

$T_g = 71$ °C, $T_o = 25$ °C, $H = 12$ m, and $r = 2.15$ m

For the condition $r/H < 0.18$ ($0.179 < 0.18$) so correlation (Equation 1) is used to evaluate the heat release rate required to activate the sprinkler head at 71 °C (160 °F) in the canyon

$$71 - 25 = \frac{16.9 Q^{2/3}}{12^{5/3}} \quad \text{for } \frac{r}{H} \leq 0.18$$

$$Q = 171.20^{3/2}$$

$$Q = 2240 \text{ kW}$$

The corresponding energy release of a fire rise a gas temperature 71 °C (160 °F) is 2240 kW.

Reference

Nelson, H.E., (1990), "FPEtool: Fire Protection Engineering Tools for Hazard Estimation", NISTIR 4380, National Institute of Standard and Technology, Gaithersburg, Maryland, 1990.

Evans, D.D., (1988), "Ceiling Jet Flow", Section 1, Chapter 9, SFPE Handbook of Fire Protection Engineering, P.J. DiNenno, Editor-in-Chief, National Fire Protection Association, Quincy, 1988.

CANYON

09-20-1994

Fire to
ceiling

Detector
axial dist.

Room
temp.

Device
rating

RTI
(metric)

m
12

m
2.15

C
25

C
71

165

Minimum heat release rate necessary to activate the
detector at the location described is 2,240 kW

Time(Sec)	RHR(kw)	Jet (C)	Head/det (C)
Time(Sec)	RHR(kw)	Jet (C)	Head/det. (C)
0	0	25	25
1	0	25	25
2	0	25	25
3	0	25	25
4	1	25	25
5	1	25	25
6	2	25	25
7	2	25	25
8	3	25	25
9	4	26	25
10	5	26	25
11	6	26	25
12	7	26	25
13	8	26	25
14	9	26	25
15	10	26	25
16	12	26	25
17	13	26	25
18	15	27	25
19	17	27	25
20	19	27	25
21	21	27	25
22	23	27	25
23	25	27	25
24	27	27	25
25	29	27	25
26	32	28	25
27	34	28	25
28	37	28	25
29	39	28	25
30	42	28	25
31	45	28	25
32	48	28	25
33	51	29	25
34	54	29	25
35	57	29	25
36	60	29	25
37	64	29	25
38	67	29	25
39	71	29	25
40	75	30	25
41	79	31	26
42	83	31	26
43	87	31	26
44	91	31	26
45	95	31	26
46	99	31	26
47	103	31	26
48	107	31	26
49	111	31	26
50	115	31	26
51	121	31	26
52	127	31	26
53	133	31	26
54	139	31	26
55	145	31	26
56	151	31	26
57	157	31	26
58	163	31	26
59	169	31	26
60	175	31	26
61	181	31	26
62	187	31	26
63	193	31	26
64	199	31	26
65	205	31	26
66	211	31	26
67	217	31	26
68	223	31	26
69	229	31	26
70	235	31	26
71	241	31	26
72	247	31	26
73	253	31	26
74	259	31	26
75	265	31	26
76	271	31	26
77	277	31	26
78	283	31	26
79	289	31	26
80	295	31	26
81	301	31	26
82	307	31	26
83	313	31	26
84	319	31	26
85	325	31	26
86	331	31	26
87	337	31	26
88	343	31	26
89	349	31	26
90	355	31	26
91	361	31	26
92	367	31	26
93	373	31	26
94	379	31	26
95	385	31	26
96	391	31	26
97	397	31	26
98	403	31	26
99	409	31	26
100	415	31	26
101	421	31	26
102	427	31	26
103	433	31	26
104	439	31	26
105	445	31	26
106	451	31	26
107	457	31	26
108	463	31	26
109	469	31	26
110	475	31	26
111	481	31	26
112	487	31	26
113	493	31	26
114	499	31	26
115	505	31	26
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117	517	31	26
118	523	31	26
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121	541	31	26
122	547	31	26
123	553	31	26
124	559	31	26
125	565	31	26
126	571	31	26
127	577	31	26
128	583	31	26
129	589	31	26
130	595	31	26
131	601	31	26
132	607	31	26
133	613	31	26
134	619	31	26
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141	661	31	26
142	667	31	26
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149	709	31	26
150	715	31	26
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154	739	31	26
155	745	31	26
156	751	31	26
157	757	31	26
158	763	31	26
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160	775	31	26
161	781	31	26
162	787	31	26
163	793	31	26
164	799	31	26
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166	811	31	26
167	817	31	26
168	823	31	26
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170	835	31	26
171	841	31	26
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173	853	31	26
174	859	31	26
175	865	31	26
176	871	31	26
177	877	31	26
178	883	31	26
179	889	31	26
180	895	31	26
181	901	31	26
182	907	31	26
183	913	31	26
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185	925	31	26
186	931	31	26
187	937	31	26
188	943	31	26
189	949	31	26
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194	979	31	26
195	985	31	26
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210	1075	31	26
211	1081	31	26
212	1087	31	26
213	1093	31	26
214	1099	31	26
215	1105	31	26
216	1111	31	26
217	1117	31	26
218	1123	31	26
219	1129	31	26
220	1135	31	26
221	1141	31	26
222	1147	31	26
223	1153	31	26
224	1159	31	26
225	1165	31	26
226	1171	31	26
227	1177	31	26
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111	574	43	31
112	585	44	31
113	595	44	31
114	606	44	31
115	616	44	32
116	627	44	32
117	638	45	32
118	649	45	32

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187	1630	62	45
188	1647	62	45
189	1665	62	45
190	1682	63	45
191	1700	63	45
192	1718	63	46
193	1736	64	46
194	1754	64	46
195	1772	64	46
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197	1808	65	47
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200	1864	65	47
201	1883	66	48
202	1901	66	48
203	1920	66	48
204	1939	67	48
205	1958	67	49
206	1978	67	49
207	1997	67	49
208	2016	68	49
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210	2055	68	50
211	2075	68	50
212	2094	69	50
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215	2154	70	51
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217	2194	70	52
218	2215	70	52
219	2235	71	52
220	2255	71	52
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224	2338	72	53
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226	2380	73	54
227	2401	73	54
228	2422	73	54
229	2444	73	55
230	2465	74	55
231	2487	74	55
232	2508	74	55
233	2530	75	56
234	2552	75	56
235	2573	75	56
236	2595	75	56
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244	2774	78	58
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247	2843	79	59
248	2866	79	59
249	2889	79	60
250	2912	80	60
251	2935	80	61
252	2958	80	61
253	2983	80	61
254	3006	81	61

255	3037	81	62
257	3078	82	62
258	3102	82	62
259	3126	82	62
260	3150	82	63
261	3174	83	63
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264	3248	84	64
265	3272	84	64
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267	3322	85	65
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269	3372	85	65
270	3397	85	66
271	3422	86	66
272	3448	86	66
273	3473	86	66
274	3499	87	67
275	3524	87	67
276	3550	87	67
277	3576	88	68
278	3601	88	68
279	3627	88	68
280	3653	88	68
281	3680	89	69
282	3706	89	69
283	3732	89	69
284	3759	90	70
285	3785	90	70
286	3812	90	70
287	3838	91	70
288	3865	91	71

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---- Detector activation at 289.0 seconds ----

Time(Sec)	RHR(kW)	Jet (C)	Head/det (C)
287	3838	91	70
288	3865	91	71

Time(Sec)	RHR(kW)	Jet (xC)	Head/det (
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---- Detector actuation at 288.95 seconds -----

RTI = 165

Height (m) = 12

Dist. - fire axis (m) = 2.15

Do you want to see the graph of the calculation? (Y/N)

Sparged fire

Fire Size	
Time (Sec)	Time (min)
60	500
150	1000
210	2000
240	3000
300	3750
600	3750
900	3750
1200	3400

$$= 300 \left(\frac{84}{500} \right)^{\frac{1}{2}}$$

CANYON	09-20-1994
Fire to ceiling	Detector axial dist. m
12	2.15
	Room temp. C
	25
	Device rating C
	71
	RTI (metric)
	165
Minimum heat release rate necessary to activate the detector at the location described is 2,240 kW	

CANYON	09-20-1994
Fire to ceiling	Detector axial dist. m
12	2.15
	Room temp. C
	25
	Device rating C
	71
	RTI (metric)
	165

Minimum heat release rate necessary to activate the detector at the location described is 2,240 kW

Time (Sec)	RHR (kW)	Jet (C)	Head/det. (C)	Head/det (C)
0	167	25	25	
5	194	34	25	
10	222	35	26	
15	250	36	26	
20	278	37	27	
25	306	38	28	
30	333	38	28	
35	361	39	29	
40	417	40	29	
45	444	41	30	
50	472	41	30	
55	500	42	31	
60	528	42	31	
65	556	43	32	
70	583	44	32	
75	611	44	33	
80	639	45	34	
85	667	45	34	
90	694	46	35	
95	722	47	35	
100	750	47	36	
105	800	48	37	
110	833	49	38	
120				

Do you want to see the graph of the calculation? (Y/N)

Height (m) = 12
Dist. -- fire axis (m) = 2.15

R11 = 165

Detector activation at 284.34 seconds

Time(Sec)	RHR(kW)	Jet (XC)	Head/det (XC)
280	3500	87	70
275	3438	86	69
Time(Sec)	RHR(kW)	Jet (C)	Head/det (C)

280	3500	87	70
275	3438	86	69
270	3375	85	68
265	3313	85	66
260	3250	84	65
255	3188	83	64
250	3125	82	62
245	3063	82	61
240	3000	80	59
235	2833	78	58
230	2667	76	56
225	2500	74	55
220	2333	72	54
215	2167	70	53
210	2000	67	52
205	1917	66	51
200	1833	65	50
195	1750	64	49
190	1667	63	48
185	1583	61	47
180	1500	60	46
175	1417	59	45
170	1333	57	44
165	1250	56	44
160	1167	54	43
155	1083	53	42
150	1000	52	42
145	972	51	41
140	944	51	40
135	917	50	40
130	889	50	39
125	861	49	39

Detector activation at 284.3 seconds

TUNNEL 09-20-1994

Fire to ceiling	Detector axial dist.	Room temp.	Device rating	RTI
m	m	C	C	(metric)
8	2.15	25	71	165

Minimum heat release rate necessary to activate the detector at the location described is 1,216 kW

Time (Sec)	RHR (kW)	Jet (C)	Head/det (C)
Time (Sec)	RHR (kW)	Jet (C)	Head/det. (C)
0	0	25	25
1	0	25	25
2	0	25	25
3	0	25	25
4	1	25	25
5	1	25	25
6	2	25	25
7	2	26	25
8	3	26	25
9	4	26	25
10	5	26	25
11	6	26	25
12	7	26	25
13	8	26	25
14	9	27	25
15	10	27	25
16	12	27	25
17	13	27	25
18	15	27	25
19	17	27	25
20	19	28	25
21	21	28	25
22	23	28	25
23	25	28	25
24	27	28	25
25	29	29	25
26	32	29	25
27	34	29	25
28	37	29	25
29	39	29	25
30	42	29	25
31	45	30	25
32	48	30	25
33	51	30	25
34	54	31	25
35	57	31	25
36	60	31	25
37	64	31	26
38	67	31	26
39	71	32	26
40	75	32	26
41	78	32	26
42	82	32	26
43	86	33	26
44	90	33	26
45	94	33	26
46	99	33	26
47	103	34	26
48	107	34	26
49	112	34	26
50	117	34	26
51	121	35	26

54	136	35	26
55	141	36	26
56	146	36	27
57	151	36	27
58	157	36	27
59	162	37	27
60	168	37	27
61	173	37	27
62	179	38	27
63	185	38	27
64	191	38	27
65	197	38	27
66	203	39	27
67	209	39	27
68	215	39	28
69	222	40	28
70	228	40	28
71	235	40	28
72	242	40	28
73	248	41	28
74	255	41	28
75	262	41	28
76	269	42	28
77	276	42	28
78	284	42	29
79	291	42	29
80	298	43	29
81	306	43	29
82	313	43	29
83	321	44	29
84	329	44	29
85	337	44	29
86	345	45	30
87	353	45	30
88	361	45	30
89	369	45	30
90	377	46	30
91	386	46	30
92	394	46	30
93	403	47	31
94	412	47	31
95	421	47	31
96	429	48	31
97	438	48	31
98	448	48	31
99	457	49	31
100	466	49	32
101	475	49	32
102	485	50	32
103	494	50	32
104	504	50	32
105	514	51	32
106	524	51	33
107	534	51	33
108	544	52	33
109	554	52	33
110	564	52	33
111	574	53	33
112	585	53	34
113	595	53	34
114	606	54	34
115	616	54	34
116	626	55	35
120	671	56	35
121	682	56	35

123	705	57	36
124	717	57	36
125	728	57	36
126	740	58	36
127	752	58	37
128	763	58	37
129	775	59	37
130	788	59	37
131	800	59	38
132	812	60	38
133	824	60	38
134	837	60	38
135	849	61	38
136	862	61	39
137	875	62	39
138	887	62	39
139	900	62	39
140	913	63	40
141	926	63	40
142	940	63	40
143	953	64	40
144	966	64	41
145	980	64	41
146	993	65	41
147	1007	65	41
148	1021	66	42
149	1035	66	42
150	1049	66	42
151	1063	67	42
152	1077	67	43
153	1091	67	43
154	1105	68	43
155	1120	68	43
156	1134	69	44
157	1149	69	44
158	1163	69	44
159	1178	70	44
160	1193	70	45
161	1208	70	45
162	1223	71	45
163	1238	71	46
164	1253	72	46
165	1269	72	46
166	1284	72	46
167	1300	73	47
168	1315	73	47
169	1331	73	47
170	1347	74	48
171	1363	74	48
172	1379	75	48
173	1395	75	48
174	1411	75	49
175	1427	76	49
176	1443	76	49
177	1460	77	50
178	1476	77	50
179	1493	77	50
180	1510	78	50
181	1527	78	51
182	1544	79	51
183	1561	79	51
184	1578	79	52
185	1595	80	52
186	1612	80	52
187	1630	81	53

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190	1682	82	54
191	1700	82	54
192	1718	83	55
193	1736	83	55
194	1754	83	55
195	1772	84	55
196	1790	84	56
197	1808	85	56
198	1827	85	56
199	1845	85	57
200	1864	86	57
201	1883	86	57
202	1901	87	58
203	1920	87	58
204	1939	87	58
205	1958	88	59
206	1978	88	59
207	1997	89	59
208	2016	89	60
209	2036	89	60
210	2055	90	60
211	2075	90	61
212	2094	91	61
213	2114	91	61
214	2134	92	62
215	2154	92	62
216	2174	92	62
217	2194	93	63
218	2215	93	63
219	2235	94	64
220	2255	94	64
221	2276	94	64
222	2297	95	65
223	2317	95	65
224	2338	96	65
225	2359	96	66
226	2380	97	66
227	2401	97	66
228	2422	97	67
229	2444	98	67
230	2465	98	68
231	2487	99	68
232	2508	99	68
233	2530	100	69
234	2552	100	69
235	2573	100	69
236	2595	101	70
237	2617	101	70
238	2640	102	71
239	2662	102	71

----- Detector activation at 239.1 seconds -----

Time(Sec)	RHR(kw)	Jet (C)	Head/det (C)
238	2640	102	71
239	2662	102	71

Time(Sec) RHR(kw) Jet (C) Head/det

----- Detector actuation at 239.13 seconds -----

Height (m) = 8
Dist. - fire axis (m) = 2.15

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Do you want to see the graph of the calculation? (Y/N)

**ESTIMATING SPRINKLER ACTUATION TIME
IN THE
CANYON AND RAILROAD TUNNEL**

Estimating Sprinkler Actuation Time in the Canyon and Railroad Tunnel

Ambient temperature - 25 °C (77 °F)

Sprinkler spacing - 3.04 m (10 ft)

Distance of sprinkler from axis of fire - 2.15 m (7.07 ft)

Sprinkler actuation temperature - 71 °C (160 °F)

T² fire growth - Fast fire

Sprinkler type and location	Sprinkler response time index (RTI) (m/sec) ^{1/2}	Time to sprinkler activation (sec)	Fire size (kW)	Smoke layer temperature (°C)
Canyon Conventional type	50	231	2487	74
	130	276	3524	87
	150	283.5	3653	88
	200	301	4194	95
	250	317	4624	99
	300	331.5	5075	104
Tunnel Conventional type	50	176	1443	76
	130	226	2359	96
	150	234	2465	98
	200	251	2913	107
	250	266.5	3272	114
	300	280	3653	120

Reference

Nelson, H.E., (1990), "FPETOOL: Fire Protection Engineering Tools for Hazard Estimation", NISTIR 4380, National Institute of Standard and Technology, Gaithersburg, Maryland, 1990.

CANYON 09-20-1994

Fire to ceiling	Detector axial dist.	Room temp.	Device rating	1011
m	m	C	C	
12	2.15	25	71	1.30

Minimum heat release rate necessary to activate the detector at the location described is 2,240 kW

Time (Sec)	RHR (kW)	Jet (C)	Head/det. (C)
0	0	25	25
5	1	25	25
10	5	26	25
15	10	26	25
20	19	27	25
25	29	27	25
30	42	28	25
35	57	29	25
40	75	30	26
45	94	30	26
50	117	31	26
55	141	32	26
60	168	33	27
65	197	34	27
70	228	35	27
75	262	36	28
80	298	37	28
85	337	38	29
90	377	39	29
95	421	40	30
100	466	41	31
105	514	42	31
110	564	43	32
115	616	44	33
120	671	45	34
125	728	47	34
130	788	48	35
135	849	49	36
140	913	50	37
145	980	51	38
150	1049	52	39
155	1120	54	40
160	1193	55	41
165	1269	56	42
170	1347	58	43
175	1427	59	44
180	1510	60	46
185	1595	61	47
190	1682	63	48
195	1772	64	49
200	1864	65	50
205	1958	67	52
210	2055	68	53
215	2154	70	54
220	2255	72	55
230			
240	2684	77	61
245	2797	78	62
250	2913	80	64

255	3030	81	65
260	3150	82	66
265	3272	84	68
270	3397	85	71
275	3524	87	71

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---- Detector activation at 276.0 seconds ----

Time(Sec)	RHR(kW)	Jet (C)	Head/det (C)
270	3397	85	69
275	3524	<u>87</u>	71

Time(Sec)	RHR(kW)	Jet (xC)	Head/det
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---- Detector actuation at 275.96 seconds -----

RTI = 130

Height (m) = 12

Dist. - fire axis (m) = 2.15

Do you want to see the graph of the calculation? (Y/N)

CANYON 09-20-1994

Fire to ceiling	Detector axial dist.	Room temp.	Device rating	RTI
m	m	C	C	(metric)
12	2.15	25	71	150

Minimum heat release rate necessary to activate the
detector at the location described is 2,240 kW

Time (Sec)	RHR (kW)	Jet (C)	Head/det (C)
0	0	25	25
5	1	25	25
10	5	26	25
15	10	26	25
20	19	27	25
25	29	27	25
30	42	28	25
35	57	29	25
40	75	30	26
45	94	30	26
50	117	31	26
55	141	32	26
60	168	33	26
65	197	34	27
70	228	35	27
75	262	36	28
80	298	37	28
85	337	38	28
90	377	39	29
95	421	40	30
100	466	41	30
105	514	42	31
110	564	43	31
115	616	44	32
120	671	45	33
125	728	47	34
130	788	48	34
135	849	49	35
140	913	50	36
145	980	51	37
150	1049	52	38
155	1120	54	39
160	1193	55	40
165	1269	56	41
170	1347	58	42
175	1427	59	43
180	1510	60	44
185	1595	61	45
190	1682	63	46
195	1772	64	47
200	1864	65	48
205	1958	66	49
210	2053	67	50
215	2150	68	51
220	2240	69	52
225	2330	70	53
230	2420	71	54
235	2510	72	55
240	2600	73	56
245	2690	74	57
250	2780	75	58
255	2870	76	59
260	2960	77	60
265	3050	78	61
270	3140	79	62
275	3230	80	63
280	3320	81	64
285	3410	82	65
290	3500	83	66
295	3590	84	67
300	3680	85	68
305	3770	86	69
310	3860	87	70
315	3950	88	71
320	4040	89	72
325	4130	90	73
330	4220	91	74
335	4310	92	75
340	4400	93	76
345	4490	94	77
350	4580	95	78
355	4670	96	79
360	4760	97	80
365	4850	98	81
370	4940	99	82
375	5030	100	83
380	5120	101	84
385	5210	102	85
390	5300	103	86
395	5390	104	87
400	5480	105	88
405	5570	106	89
410	5660	107	90
415	5750	108	91
420	5840	109	92
425	5930	110	93
430	6020	111	94
435	6110	112	95
440	6200	113	96
445	6290	114	97
450	6380	115	98
455	6470	116	99
460	6560	117	100
465	6650	118	101
470	6740	119	102
475	6830	120	103
480	6920	121	104
485	7010	122	105
490	7100	123	106
495	7190	124	107
500	7280	125	108
505	7370	126	109
510	7460	127	110
515	7550	128	111
520	7640	129	112
525	7730	130	113
530	7820	131	114
535	7910	132	115
540	8000	133	116
545	8090	134	117
550	8180	135	118
555	8270	136	119
560	8360	137	120
565	8450	138	121
570	8540	139	122
575	8630	140	123
580	8720	141	124
585	8810	142	125
590	8900	143	126
595	8990	144	127
600	9080	145	128
605	9170	146	129
610	9260	147	130
615	9350	148	131
620	9440	149	132
625	9530	150	133
630	9620	151	134
635	9710	152	135
640	9800	153	136
645	9890	154	137
650	9980	155	138
655	10070	156	139
660	10160	157	140
665	10250	158	141
670	10340	159	142
675	10430	160	143
680	10520	161	144
685	10610	162	145
690	10700	163	146
695	10790	164	147
700	10880	165	148
705	10970	166	149
710	11060	167	150
715	11150	168	151
720	11240	169	152
725	11330	170	153
730	11420	171	154
735	11510	172	155
740	11600	173	156
745	11690	174	157
750	11780	175	158
755	11870	176	159
760	11960	177	160
765	12050	178	161
770	12140	179	162
775	12230	180	163
780	12320	181	164
785	12410	182	165
790	12500	183	166
795	12590	184	167
800	12680	185	168
805	12770	186	169
810	12860	187	170
815	12950	188	171
820	13040	189	172
825	13130	190	173
830	13220	191	174
835	13310	192	175
840	13400	193	176
845	13490	194	177
850	13580	195	178
855	13670	196	179
860	13760	197	180
865	13850	198	181
870	13940	199	182
875	14030	200	183
880	14120	201	184
885	14210	202	185
890	14300	203	186
895	14390	204	187
900	14480	205	188
905	14570	206	189
910	14660	207	190
915	14750	208	191
920	14840	209	192
925	14930	210	193
930	15020	211	194
935	15110	212	195
940	15200	213	196
945	15290	214	197
950	15380	215	198
955	15470	216	199
960	15560	217	200
965	15650	218	201
970	15740	219	202
975	15830	220	203
980	15920	221	204
985	16010	222	205
990	16100	223	206
995	16190	224	207
1000	16280	225	208
1005	16370	226	209
1010	16460	227	210
1015	16550	228	211
1020	16640	229	212
1025	16730	230	213
1030	16820	231	214
1035	16910	232	215
1040	17000	233	216
1045	17090	234	217
1050	17180	235	218
1055	17270	236	219
1060	17360	237	220
1065	17450	238	221
1070	17540	239	222
1075	17630	240	223
1080	17720	241	224
1085	17810	242	225
1090	17900	243	226
1095	17990	244	227
1100	18080	245	228
1105	18170	246	229
1110	18260	247	230
1115	18350	248	231
1120	18440	249	232
1125	18530	250	233
1130	18620	251	234
1135	18710	252	235
1140	18800	253	236
1145	18890	254	237
1150	18980	255	238
1155	19070	256	239
1160	19160	257	240
1165	19250	258	241
1170	19340	259	242
1175	19430	260	243
1180	19520	261	244
1185	19610	262	245
1190	19700	263	246
1195	19790	264	247
1200	19880	265	248
1205	19970	266	249
1210	20060	267	250
1215	20150	268	251
1220	20240	269	252
1225	20330	270	253
1230	20420	271	254
1235	20510	272	255
1240	20600	273	256
1245	20690	274	257
1250	20780	275	258
1255	20870	276	259
1260	20960	277	260
1265	21050	278	261
1270	21140	279	262
1275	21230	280	263
1280	21320	281	264
1285	21410	282	265
1290	21500	283	266
1295	21590	284	267
1300	21680	285	268
1305	21770	286	269
1310	21860	287	270
1315	21950	288	271
1320	22040	289	272
1325	22130	290	273
1330	22220	291	274
1335	22310	292	275
1340	22400	293	276
1345	22490	294	277
1350	22580	295	278
1355	22670	296	279
1360	22760	297	280
1365	22850	298	281
1370	22940	299	282
1375	23030	300	283
1380	23120	301	284
1385	23210	302	285
1390	23300	303	286
1395	23390	304	287
1400	23480	305	288
1405	23570	306	289
1410	23660	307	290
1415	23750	308	291
1420	23840	309	292
1425	23930	310	293
1430	24020	311	294
1435	24110	312	295
1440	24200	313	296
1445	24290	314	297
1450	24380	315	298
1455	24470	316	299
1460	24560	317	300
1465	24650	318	301
1470	24740	319	302
1475	24830	320	303
1480	24920	321	304
1485	25010	322	305
1490	25100	323	306
1495	25190	324	307
1500	25280	325	308
1505	25370	326	309
1510	25460	327	310
1515	25550	328	311
1520	25640	329	312
1525	25730	330	313
1530	25820	331	314
1535	25910	332	315
1540	26000	333	316
1545	26090	334	317
1550	26180	335	318
1555	26270	336	319
1560	26360	337	320

270	3397	85	67
275	3524	87	69
280	3653	88	70

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---- Detector activation at 283.5 seconds ----

Time(Sec)	RHR(kW)	Jet (C)	Head/det (C)
275	3524	87	69
280	3653	88	70

Time(Sec)	RHR(kW)	Jet (xC)	Head/det ()
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---- Detector actuation at 283.5 seconds -----

RTI = 150

Height (m) = 12

Dist. - fire axis (m) = 2.15

Do you want to see the graph of the calculation? (Y/N)

CANYON 09-20-1994

Fire to ceiling	Detector axial dist.	Room temp.	Device rating	RTI
m	m	C	C	(metric)
12	2.15	25	71	200

Minimum heat release rate necessary to activate the detector at the location described is 2,240 kW

Time (Sec)	RHR (kW)	Jet (C)	Head/det (C)
0	0	25	25
5	1	25	25
10	5	26	25
15	10	26	25
20	19	27	25
25	29	27	25
30	42	28	25
35	57	29	25
40	75	30	25
45	94	30	26
50	117	31	26
55	141	32	26
60	168	33	26
65	197	34	26
70	228	35	27
75	262	36	27
80	298	37	27
85	337	38	28
90	377	39	28
95	421	40	29
100	466	41	29
105	514	42	30
110	564	43	30
115	616	44	31
120	671	45	31
125	728	47	32
130	788	48	33
135	849	49	33
140	913	50	34
145	980	51	35
150	1049	52	36
155	1120	54	36
160	1193	55	37
165	1269	56	38
170	1347	58	39
175	1427	59	40
180	1510	60	41
185	1595	61	42
190	1682	63	43
195	1772	64	44
200	1864	65	45
205	1958	67	46
210	2055	68	47
215	2154	70	48
220	2255	71	50
225	2355	71	50
230	2455	71	50
235	2555	71	50
240	2655	71	50
245	2755	71	50
250	2855	71	50
255	2955	71	50
260	3055	71	50
265	3155	71	50
270	3255	71	50
275	3355	71	50
280	3455	71	50
285	3555	71	50
290	3655	71	50
295	3755	71	50
300	3855	71	50

Time (Sec) Detector RHR (kW) Jet (C) Head/det (C)

300 4194 139 95 71

Time(Sec)

RHR(kW)

Jet (x°C)

Head/det (

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---- Detector actuation at 301.03 seconds -----

RTI = 200

Height (m) = 12

Dist. - fire axis (m) = 2.15

Do you want to see the graph of the calculation? (Y/N)

Time(Sec)

RHR(kW)

Jet (C)

Head/det (C)

295

4055

93

69

300

4194

95

71

Time(Sec)

RHR(kW)

Jet (x°C)

Head/det (

---- Detector actuation at 301.03 seconds -----

RTI = 200

Height (m) = 12

Dist. - fire axis (m) = 2.15

Do you want to see the graph of the calculation? (Y/N)

CANYON 09-20-1994

Fire to ceiling	Detector axial dist.	Room temp.	Device rating	RTI
m	m	C	C	(metric)
12	2.15	25	71	250

Minimum heat release rate necessary to activate the detector at the location described is 2,240 kW

Time(Sec)	RHR(kW)	Jet (C)	Head/det (C)
0	0	25	25
5	1	25	25
10	5	26	25
15	10	26	25
20	19	27	25
25	29	27	25
30	42	28	25
35	57	29	25
40	75	30	25
45	94	30	25
50	117	31	26
55	141	32	26
60	168	33	26
65	197	34	26
70	228	35	26
75	262	36	27
80	298	37	27
85	337	38	27
90	377	39	28
95	421	40	28
100	466	41	28
105	514	42	29
110	564	43	29
115	616	44	30
120	671	45	30
125	728	47	31
130	788	48	31
135	849	49	32
140	913	50	33
145	980	51	33
150	1049	52	34
155	1120	54	35
160	1193	55	36
165	1269	56	36
170	1347	58	37
175	1427	59	38
180	1510	60	39
185	1595	61	40
190	1682	63	41
195	1772	64	42
200	1864	65	43
205	1958	67	43
210	2055	68	44
215	2154	70	46
220	2255	71	47
225	2359	72	48
230	2465	74	49
235	2573	75	50
240	2684	77	51

250	2913	80	53
255	3030	81	55
260	3150	82	57
265	3272	84	58
270	3397	85	60
275	3524	87	61
280	3653	88	62
285	3785	90	64
290	3919	91	65
295	4055	93	66
300	4194	95	68
305	4335	96	69
310	4478	98	70
315	4624	99	

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---- Detector activation at 316.9 seconds ----

Time (Sec)	RHR (kW)	Jet (C)	Head/det (C)
310	4478	98	69
315	4624	99	70

Time (Sec)	RHR (kW)	Jet (xC)	Head/det (xC)
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---- Detector actuation at 316.93 seconds -----

RTI = 250

Height (m) = 12

Dist. - fire axis (m) = 2.15

Do you want to see the graph of the calculation? (Y/N)

CANYON 09-20-1994

Fire to ceiling	Detector axial dist.	Room temp.	Device rating	RTI
m	m	C	C	(metric)
12	2.15	25	71	300

Minimum heat release rate necessary to activate the detector at the location described is 2,240 kW

Time (Sec)	RHR (kW)	Jet (C)	Head/det (C)
0	0	25	25
5	1	25	25
10	5	26	25
15	10	26	25
20	19	27	25
25	29	27	25
30	42	28	25
35	57	29	25
40	75	30	25
45	94	30	25
50	117	31	25
55	141	32	26
60	168	33	26
65	197	34	26
70	228	35	26
75	262	36	26
80	298	37	27
85	337	38	27
90	377	39	27
95	421	40	28
100	466	41	28
105	514	42	28
110	564	43	29
115	616	44	29
120	671	45	30
125	728	47	30
130	788	48	31
135	849	49	31
140	913	50	32
145	980	51	32
150	1049	52	33
155	1120	54	34
160	1193	55	34
165	1269	56	35
170	1347	58	36
175	1427	59	36
180	1510	60	37
185	1595	61	38
190	1682	63	39
195	1772	64	40
200	1864	65	40
205	1958	67	41
210	2055	68	41
215	2154	70	43

225	2359	72	45
230	2465	74	46
235	2573	75	47
240	2684	77	48
245	2797	78	49
250	2913	80	50
255	3030	81	52
260	3150	82	53
265	3272	84	54
270	3397	85	55
275	3524	87	56
280	3653	88	57
285	3785	90	59
290	3919	91	60
295	4055	93	61
300	4194	95	62
305	4335	96	64
310	4478	98	65
315	4624	99	66
320	4772	101	68
325	4922	102	69
330	5075	104	71

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---- Detector activation at 331.5 seconds ----

Time(Sec)	RHR(kW)	Jet (C)	Head/det (C)
325	4922	102	69
330	5075	104	71

Time(Sec)	RHR(kW)	Jet (xC)	Head/det (xC)
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---- Detector actuation at 331.5 seconds -----

RTI = 300

Height (m) = 12

Dist. - fire axis (m) = 2.15

Do you want to see the graph of the calculation? (Y/N)

TUNNEL 09-20-1994

Fire to ceiling	Detector axial dist.	Room temp.	Device rating	RTI
m	m	C	C	(metric)
8	2.15	25	71	130

Minimum heat release rate necessary to activate the detector at the location described is 1,216 kW

Time (Sec)	RHR (kW)	Jet (C)	Head/det (C)
0	0	25	25
5	1	25	25
10	5	26	25
15	10	27	25
20	19	28	25
25	29	29	25
30	42	30	25
35	57	31	26
40	75	32	26
45	94	33	26
50	117	34	26
55	141	36	27
60	168	37	27
65	197	38	28
70	228	40	28
75	262	41	29
80	298	43	30
85	337	44	30
90	377	46	31
95	421	47	32
100	466	49	33
105	514	51	34
110	564	52	35
115	616	54	36
120	671	56	37
125	728	57	38
130	788	59	40
135	849	61	41
140	913	63	42
145	980	64	43
150	1049	66	45
155	1120	68	46
160	1193	70	48
165	1269	72	49
170	1347	74	51
175	1427	76	53
180	1510	78	54
185	1595	80	56
190	1682	84	59
200	1864	86	61
205	1958	88	63

215	2154	92	67
220	2255	94	69
225	2359	96	71

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---- Detector activation at 226.0 seconds ----

Time(Sec)	RHR(kW)	Jet (C)	Head/det (C)
220	2255	94	69
225	2359	96	71

Time(Sec)	RHR(kW)	Jet (xC)	Head/det (xC)
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---- Detector actuation at 225.98 seconds -----

RTI = 130

Height (m) = 8

Dist. - fire axis (m) = 2.15

Do you want to see the graph of the calculation? (Y/N)

TUNNEL 09-20-1994

Fire to ceiling	Detector axial dist.	Room temp.	Device rating	RTI
m	m	C	C	(metric)
8	2.15	25	71	150

Minimum heat release rate necessary to activate the detector at the location described is 1,216 kW

Time (Sec)	RHR (kW)	Jet (C)	Head/det (C)
0	0	25	25
5	1	25	25
10	5	26	25
15	10	27	25
20	19	28	25
25	29	29	25
30	42	30	25
35	57	31	25
40	75	32	26
45	94	33	26
50	117	34	26
55	141	36	27
60	168	37	27
65	197	38	27
70	228	40	28
75	262	41	29
80	298	43	29
85	337	44	30
90	377	46	31
95	421	47	31
100	466	49	32
105	514	51	33
110	564	52	34
115	616	54	35
120	671	56	36
125	728	57	37
130	788	59	38
135	849	61	39
140	913	63	41
145	980	64	42
150	1049	66	43
155	1120	68	45
160	1193	70	46
165	1269	72	47
170	1347	74	49
175	1427	76	50
180	1510	78	52
185	1595	80	54
190	1682	82	55
195	1772	84	57
200	1864	86	59
205	1958	88	60
210	2055	90	62
215	2154	92	64
220	2255	94	66
225	2359	96	68

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Time(Sec)	RHR(kW)	Jet (C)	Head/det (C)
225	2359	96	68
230	2465	98	70

Time(Sec)	RHR(kW)	Jet (xC)	Head/det (xC)
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---- Detector actuation at 233.66 seconds -----

RTI = 150

Height (m) = 8

Dist. - fire axis (m) = 2.15

Do you want to see the graph of the calculation? (Y/N)

TUNNEL 09-20-1994

Fire to ceiling	Detector axial dist.	Room temp.	Device rating	RTI
m	m	C	C	(metric)
8	2.15	25	71	200

Minimum heat release rate necessary to activate the detector at the location described is 1,216 kW

Time (Sec)	RHR (kW)	Jet (C)	Head/det (C)
0	0	25	25
5	1	25	25
10	5	26	25
15	10	27	25
20	19	28	25
25	29	29	25
30	42	30	25
35	57	31	25
40	75	32	26
45	94	33	26
50	117	34	26
55	141	36	26
60	168	37	27
65	197	38	27
70	228	40	27
75	262	41	28
80	298	43	28
85	337	44	29
90	377	46	29
95	421	47	30
100	466	49	31
105	514	51	31
110	564	52	32
115	616	54	33
120	671	56	34
125	728	57	35
130	788	59	36
135	849	61	37
140	913	63	38
145	980	64	39
150	1049	66	40
155	1120	68	41
160	1193	70	42
165	1269	72	44
170	1347	74	45
175	1427	76	46
180	1510	78	48
185	1595	80	49
190	1682	82	50
195	1772	84	52
200	1858	86	53
220	2255	94	60
225	2359	96	62

235	2573	100	65
240	2684	103	67
245	2797	105	69
250	2913	107	71

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---- Detector activation at 251.1 seconds ----

Time(Sec)	RHR(kW)	Jet (C)	Head/det (C)
245	2797	105	69
250	2913	107	71

Time(Sec)	RHR(kW)	Jet (xC)	Head/det (xC)
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---- Detector actuation at 251.06 seconds -----

RTI = 200

Height (m) = 8

Dist. - fire axis (m) = 2.15

Do you want to see the graph of the calculation? (Y/N)

TUNNEL 09-20-1994

Fire to ceiling	Detector axial dist.	Room temp.	Device rating	RTI
m	m	C	C	(metric)
8	2.15	25	71	250

Minimum heat release rate necessary to activate the detector at the location described is 1,216 kW

Time (Sec)	RHR (kW)	Jet (C)	Head/det (C)
0	0	25	25
5	1	25	25
10	5	26	25
15	10	27	25
20	19	28	25
25	29	29	25
30	42	30	25
35	57	31	25
40	75	32	25
45	94	33	26
50	117	34	26
55	141	36	26
60	168	37	26
65	197	38	27
70	228	40	27
75	262	41	27
80	298	43	28
85	337	44	28
90	377	46	29
95	421	47	29
100	466	49	30
105	514	51	30
110	564	52	31
115	616	54	32
120	671	56	32
125	728	57	33
130	788	59	34
135	849	61	35
140	913	63	36
145	980	64	37
150	1049	66	38
155	1120	68	39
160	1193	70	40
165	1269	72	41
170	1347	74	42
175	1427	76	43
180	1510	78	44
185	1595	80	46
190	1682	82	47
195	1772	84	48
200	1864	86	50
205	1958	88	52
210	2054	90	54
215	2152	92	56
220	2252	94	58
225	2354	96	60
230	2465	98	62

240	2684	103	62
245	2797	105	63
250	2913	107	65
255	3030	109	67
260	3150	111	69
265	3272	114	70

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---- Detector activation at 266.5 seconds ----

Time(Sec)	RHR(kW)	Jet (C)	Head/det (C)
260	3150	111	69
265	3272	114	70

Time(Sec)	RHR(kW)	Jet (xC)	Head/det (x)
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---- Detector actuation at 266.46 seconds -----

RTI = 250

Height (m) = 8

Dist. - fire axis (m) = 2.15

Do you want to see the graph of the calculation? (Y/N)

TUNNEL 09-20-1994

Fire to ceiling	Detector axial dist.	Room temp.	Device rating	RTI
m	m	C	C	(metric)
8	2.15	25	71	300

Minimum heat release rate necessary to activate the detector at the location described is 1,216 kW

Time (Sec)	RHR (kW)	Jet (C)	Head/det (C)
0	0	25	25
5	1	25	25
10	5	26	25
15	10	27	25
20	19	28	25
25	29	29	25
30	42	30	25
35	57	31	25
40	75	32	25
45	94	33	25
50	117	34	26
55	141	36	26
60	168	37	26
65	197	38	26
70	228	40	27
75	262	41	27
80	298	43	27
85	337	44	28
90	377	46	28
95	421	47	29
100	466	49	29
105	514	51	30
110	564	52	30
115	616	54	31
120	671	56	31
125	728	57	32
130	788	59	33
135	849	61	33
140	913	63	34
145	980	64	35
150	1049	66	36
155	1120	68	37
160	1193	70	38
165	1269	72	39
170	1347	74	40
175	1427	76	41
180	1510	78	42
185	1595	80	43
190	1682	82	44
195	1771	84	45
200	1862	86	46
205	1955	88	47
210	2050	90	48
215	2154	92	51
220	2255	94	52

230	2465	98	55
235	2573	100	56
240	2684	103	58
245	2797	105	59
250	2913	107	61
255	3030	109	62
260	3150	111	64
265	3272	114	66
270	3397	116	67
275	3524	118	69
280	3653	120	71

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---- Detector activation at 280.4 seconds ----

Time(Sec)	RHR(kW)	Jet (C)	Head/det (C)
275	3524	118	69
280	3653	120	71

Time(Sec)	RHR(kW)	Jet (xC)	Head/det (xC)
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---- Detector actuation at 280.36 seconds -----

RTI = 300

Height (m) = 8

Dist. - fire axis (m) = 2.15

Do you want to see the graph of the calculation? (Y/N)

Estimating Sprinkler Actuation Time in the Canyon and Railroad Tunnel

Sprinkler are normally located near the ceiling of a space and are heated by the ceiling jet of hot gases spreading from the rising fire plume. The calculations discussed in the following section are the activation time of the sprinkler head and fire development in the canyon and rail road tunnel.

The analysis using DETAC-QS, as included in FPETOOL (Nelson, 1990) is used to estimate the response times, accompanying rate of heat release and smoke layer temperature that would be expected if the plum reaches the sprinklers.

Ambient temperature - 25 °C (77 °F)

Sprinkler spacing - 3.04 m (10 ft)

Distance of sprinkler from axis of fire - 2.15 m (7.07 ft)

Sprinkler actuation temperature - 71 °C (160 °F)

Sprinkler response index RTI - 25 (m/sec)^{1/2}

T² fire growth - Fast fire

Location	Sprinkler type	Time to sprinkler activation (sec)	Fire size (kW)	Smoke layer temperature (°C)
Canyon	Conventional	231	2487	74
Tunnel	Conventional	176	1443	76

Based on this calculation, the response conditions for a sprinkler in the canyon and rail road tunnel is as follows:

Canyon sprinkler actuation time, 231 seconds (3.85 minutes); fire size 2487 kW (2359 Btu/sec); smoke layer temperature, 74 °C (165 °F);

Tunnel Sprinkler actuation time, 176 seconds (2.93 minutes); fire size 1443 kW (1369 Btu/sec); smoke layer temperature, 76 °C (169 °F);

Reference

Nelson, H.E., (1990), "FPETOOL: Fire Protection Engineering Tools for Hazard Estimation", NISTIR 4380, National Institute of Standard and Technology, Gaithersburg, Maryland, 1990.

Fire to ceiling	Detector axial dist.	Room temp.	Device rating	RTI
m	m	C	C	(metric)
8	2.15	25	71	25

Time (Sec)	RHR (kW)	Jet (C)	Head/det
0	0	25	25
1	0	25	25
2	0	25	25
3	0	25	25
4	1	25	25
5	1	25	25
6	2	25	25
7	2	26	25
8	3	26	25
9	4	26	25
10	5	26	25
11	6	26	25
12	7	26	25
13	8	26	25
14	9	27	25
15	10	27	25
16	12	27	25

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SD-C

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86	345	45	39
87	353	45	40
88	361	45	40
89	369	45	40
90	377	46	41
91	386	46	41
92	394	46	41
93	403	47	41
94	412	47	42
95	421	47	42
96	429	48	42
97	438	48	43
98	448	48	43
99	457	49	43
100	466	49	44
101	475	49	44
102	485	50	44
103	494	50	45
104	504	50	45
105	514	51	45
106	524	51	46
107	534	51	46
108	544	52	46
109	554	52	47
110	564	52	47
111	574	53	47
112	585	53	48
113	595	53	48
114	606	54	48
115	616	54	49
116	627	54	49
117	638	55	49
118	649	55	50
119	660	55	50
120	671	56	50
121	682	56	51
122	694	56	51
123	705	57	51
124	717	57	52
125	728	57	52
126	740	58	52
127	752	58	53
128	763	58	53
129	775	59	53
130	788	59	54
131	800	59	54
132	812	60	54
133	824	60	55
134	837	60	55
135	849	61	56
136	862	61	56
137	875	62	56
138	887	62	57
139	900	62	57
140	913	63	57
141	926	63	58
142	940	63	58
143	953	64	58
144	966	64	59
145	980	64	59
146	993	65	60
147	1007	65	60
148	1021	66	60
149	1035	66	61
150	1049	66	61

152	1077	67	62
153	1091	67	62
154	1105	68	62
155	1120	68	63
156	1134	69	63
157	1149	69	64
158	1163	69	64
159	1178	70	64
160	1193	70	65
161	1208	70	65
162	1223	71	65
163	1238	71	66
164	1253	72	66
165	1269	72	67
166	1284	72	67
167	1300	73	67
168	1315	73	68
169	1331	73	68
170	1347	74	69
171	1363	74	69
172	1379	75	69
173	1395	75	70
174	1411	75	70
175	1427	76	70
176	1443	76	71

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---- Detector activation at 176.3 seconds ----

Time(Sec)	RHR(kW)	Jet (C)	Head/det (C)
175	1427	76	70
176	1443	76	71

Time(Sec)	RHR(kW)	Jet (xC)	Head/det (xC)
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---- Detector actuation at 176.34 seconds -----

RTI = 25

Height (m) = 8

Dist. - fire axis (m) = 2.15

Do you want to see the graph of the calculation? (Y/N)

CANYON 09-19-1994

Time (Sec)	RHR (kW)	Jet (C)	Head/det (C)
0	0	25	25
1	0	25	25
2	0	25	25
3	0	25	25
4	1	25	25
5	1	25	25
6	2	25	25
7	2	25	25
8	3	25	25
9	4	26	25
10	5	26	25
11	6	26	25
12	7	26	25
13	8	26	25
14	9	26	25
15	10	26	25
16	12	26	25
17	13	26	25
18	15	27	25
19	17	27	25
20	19	27	25

22	23	27	26
23	25	27	26
24	27	27	26
25	29	27	26
26	32	28	26
27	34	28	26
28	37	28	26
29	39	28	26
30	42	28	26
31	45	28	26
32	48	28	26
33	51	29	26
34	54	29	27
35	57	29	27
36	60	29	27
37	64	29	27
38	67	29	27
39	71	29	27
40	75	30	27
41	78	30	27
42	82	30	27
43	86	30	28
44	90	30	28
45	94	30	28
46	99	31	28
47	103	31	28
48	107	31	28
49	112	31	28
50	117	31	29
51	121	31	29
52	126	32	29
53	131	32	29
54	136	32	29
55	141	32	29
56	146	32	29
57	151	32	30
58	157	33	30
59	162	33	30
60	168	33	30
61	173	33	30
62	179	33	30
63	185	34	31
64	191	34	31
65	197	34	31
66	203	34	31
67	209	34	31
68	215	34	31
69	222	35	32
70	228	35	32
71	235	35	32
72	242	35	32
73	248	35	32
74	255	36	33
75	262	36	33
76	269	36	33
77	276	36	33
78	284	36	33
79	291	37	33
80	298	37	34
81	306	37	34
82	313	37	34
83	321	37	34
84	329	38	34
85	337	38	35
86	345	38	35
	---	38	35

89	367	37	36
90	377	39	36
91	386	39	36
92	394	39	36
93	403	39	37
94	412	40	37
95	421	40	37
96	429	40	37
97	438	40	37
98	448	41	37
99	457	41	38
100	466	41	38
101	475	41	38
102	485	41	38
103	494	42	38
104	504	42	39
105	514	42	39
106	524	42	39
107	534	42	39
108	544	43	39
109	554	43	40
110	564	43	40
111	574	43	40
112	585	44	40
113	595	44	41
114	606	44	41
115	616	44	41
116	627	44	41
117	638	45	42
118	649	45	42
119	660	45	42
120	671	45	42
121	682	46	42
122	694	46	43
123	705	46	43
124	717	46	43
125	728	47	43
126	740	47	44
127	752	47	44
128	763	47	44
129	775	47	44
130	788	48	44
131	800	48	45
132	812	48	45
133	824	48	45
134	837	49	45
135	849	49	46
136	862	49	46
137	875	49	46
138	887	50	46
139	900	50	47
140	913	50	47
141	926	50	47
142	940	51	47
143	953	51	48
144	966	51	48
145	980	51	48
146	993	52	48
147	1007	52	49
148	1021	52	49
149	1035	52	49
150	1049	52	49
151	1063	53	50
152	1077	53	50
153	1091	53	50
154	1105	53	50

155	1120	54	51
156	1134	54	51
157	1149	54	51
158	1163	54	52
159	1178	55	52
160	1193	55	52
161	1208	55	52
162	1223	55	52
163	1238	56	53
164	1253	56	53
165	1269	56	53
166	1284	56	53
167	1300	57	54
168	1315	57	54
169	1331	57	54
170	1347	58	54
171	1363	58	55
172	1379	58	55
173	1395	58	55
174	1411	59	55
175	1427	59	56
176	1443	59	56
177	1460	59	56
178	1476	60	56
179	1493	60	57
180	1510	60	57
181	1527	60	57
182	1544	61	57
183	1561	61	58
184	1578	61	58
185	1595	61	58
186	1612	62	58
187	1630	62	59
188	1647	62	59
189	1665	62	59
190	1682	63	60
191	1700	63	60
192	1718	63	60
193	1736	64	60
194	1754	64	61
195	1772	64	61
196	1790	64	61
197	1808	65	61
198	1827	65	62
199	1845	65	62
200	1864	65	62
201	1883	66	63
202	1901	66	63
203	1920	66	63
204	1939	67	63
205	1958	67	64
206	1978	67	64
207	1997	67	64
208	2016	68	64
209	2036	68	65
210	2055	68	65
211	2075	68	65
212	2094	69	66
213	2114	69	66
214	2134	69	66
215	2154	70	66
216	2174	70	67
217	2194	70	67
218	2214	71	68
219	2234	71	68
220	2254	71	68
221	2274	71	68
222	2294	71	68
223	2314	71	68
224	2334	71	68
225	2354	71	68
226	2374	71	68
227	2394	71	68
228	2414	71	68
229	2434	71	68
230	2454	71	68
231	2487	74	71

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---- Detector activation at 231.6 seconds ----

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Time(Sec)	RHR(kW)	Jet (C)	Head/det (C)
230	2465	74	71
231	2487	74	71

Time(Sec)	RHR(kW)	Jet (xC)	Head/det (xC)
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---- Detector actuation at 231.57 seconds -----

RTI = 25

Height (m) = 12

Dist. - fire axis (m) = 2.15

Do you want to see the graph of the calculation? (Y/N)

[illegible]

RTI — 300 ($\text{g}^{1/2}/\text{sec}^2$)
RTI 130 — 350 (m^2/sec^2)

*Carleton
New England
fort fine*

[illegible]

1.414

202

A hand-drawn diagram of a triangle. The two sides forming the vertex at the top are labeled '100'.

14.

14, 14

2.15m

$$300 \left(\frac{1}{2} \sqrt{\frac{1}{2}} \right) \left(\frac{1}{2} \sqrt{\frac{1}{2}} \right)$$