

Highlights of Fire Experiments and Modeling, 2003-2018



Fire Model Verification and Validation

NUREG-1824

44 sets of experiments; 860 individual experiments; 5000+ point to point comparisons

NUREG-1824
Supplement 1

EPRI 3002002182

Verification and Validation of Selected Fire Models for Nuclear Power Plant Applications

Supplement 1

Draft Report for Comment

U.S. Nuclear Regulatory Commission
Office of Nuclear Regulatory Research
Washington, DC 20555-0001

Electric Power Research Institute
3420 Hillview Avenue
Palo Alto, CA 94303



Models Selected for NRC/EPRI V&V Study

Fire Dynamics Tools (FDTs)

FIVE-Rev1

Cons. Fire & Smoke Transport (CFAST)

MAGIC (EPRI/MOU)

Fire Dynamics Simulator (FDS)

NRC Spreadsheets

EPRI Spreadsheets

NIST zone model

Électricité de France zone model

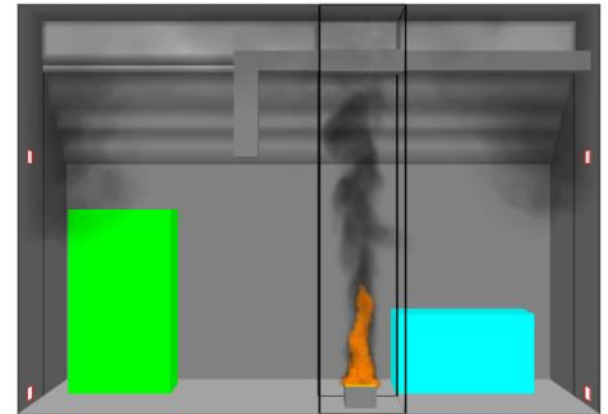
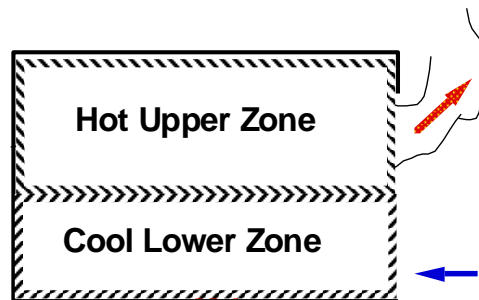
NIST CFD Model

Empirical Models

Zone Models

CFD Models

$$L_f = 0.23\dot{Q}^{2/5} - 1.02D$$



NUREG-1805: Fire Dynamics Tools

02_1_Temperature_NV_Sup1_Sl.xls [Compatibility Mode] - Excel

McGrattan, Kevin B. Dr. (Fed)

File Home Insert Page Layout Formulas Data Review View Add-ins ACROBAT Team Tell me

Clipboard Font Alignment Number Styles Cells Editing

SECURITY WARNING Some active content has been disabled. Click for more details. Enable Content

119

CHAPTER 2. PREDICTING HOT GAS LAYER TEMPERATURE AND SMOKE LAYER HEIGHT IN A ROOM FIRE WITH NATURAL VENTILATION WITH THERMALLY THICK/THIN BOUNDARIES Version 1805.1 (SI Units)

The following calculations estimate the hot gas layer temperature and smoke layer height in enclosure fire.

Parameters in YELLOW CELLS are Entered by the User.

Parameters in GREEN CELLS are Automatically Selected from the DROP DOWN MENU for the Material Selected.

All subsequent output values are calculated by the spreadsheet and based on values specified in the input parameters. This spreadsheet is protected and secure to avoid errors due to a wrong entry in a cell(s). The chapter in the NUREG should be read before an analysis is made.

Project / Inspection Title:

INPUT PARAMETERS

COMPARTMENT INFORMATION

Compartment Width (w_c)	<input type="text" value="3.70"/>	m
Compartment Length (l_c)	<input type="text" value="3.05"/>	m
Compartment Height (h_c)	<input type="text" value="2.44"/>	m
Vent Width (w_v)	<input type="text" value="0.91"/>	m
Vent Height (h_v)	<input type="text" value="1.22"/>	m
Top of Vent from Floor (V_T)	<input type="text" value="1.22"/>	m
Interior Lining Thickness (δ)	<input type="text" value="15.20"/>	cm

AMBIENT CONDITIONS

Temperature-NV

Ready Calculate



NUREG-1805
Supplement 1, Vol. 1

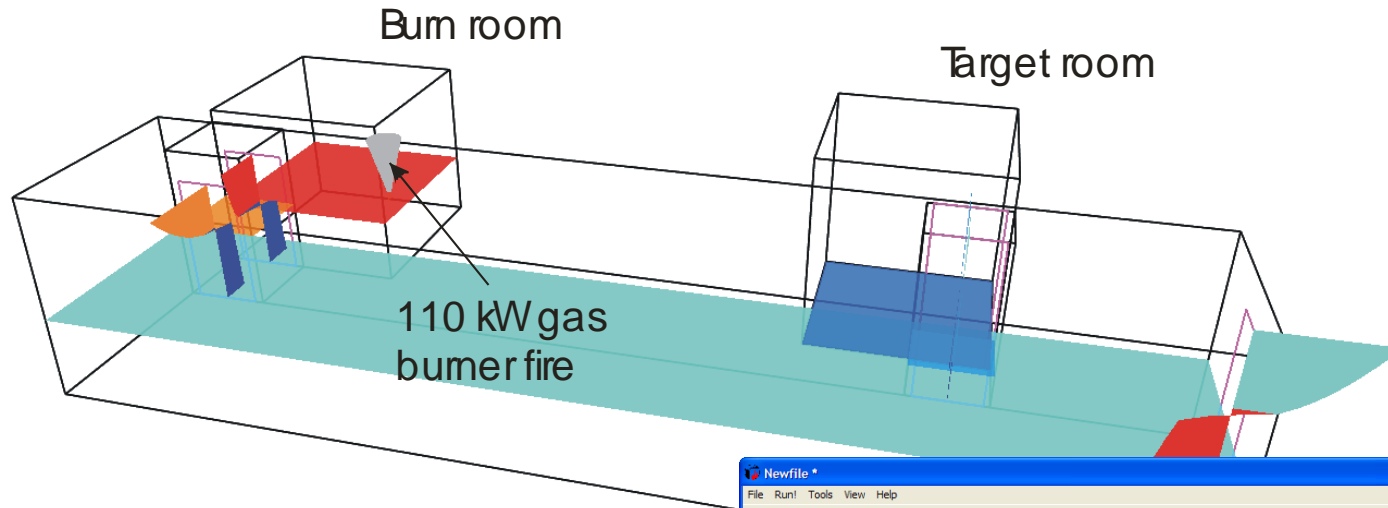
Fire Dynamics Tools (FDT^s) Quantitative Fire Hazard Analysis Methods for the U.S. Nuclear Regulatory Commission Fire Protection Inspection Program

Supplement 1

Office of Nuclear Regulatory Research

CFAST

Consolidated Fire And Smoke Transport



Newfile *

File Run! Tools View Help

Simulation Environment | Compartment Geometry | Horizontal Flow Vents | Vertical Flow Vents | Mechanical Flow Vents | Fires | Detection / Suppression | Targets | Surface Connections

Num	Compartment	Object	Type	Ignition by	At Value	X Position	Y Position	Z Position	Peak Q
1	Compartment 1	bunsen	Constrained	Time	0	1.8	1.2	0	350

Ceiling Jet: Ceiling & Walls

Lower Oxygen Limit: 10 %

Add Duplicate Remove

Fire 1

Compartment: Compartment 1

Type: Constrained Position, X: 1.8 m Position Y: 1.2 m Position Z: 0 m Ignition Criterion: Time

Normal, X: 0 Normal, Y: 0 Normal, Z: 1 Plume: McCaffrey Ignition Value: 0 s

Fire Object

Fire Object: bunsen Edit

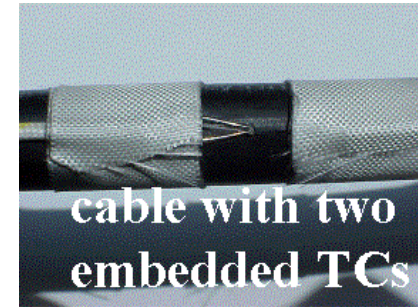
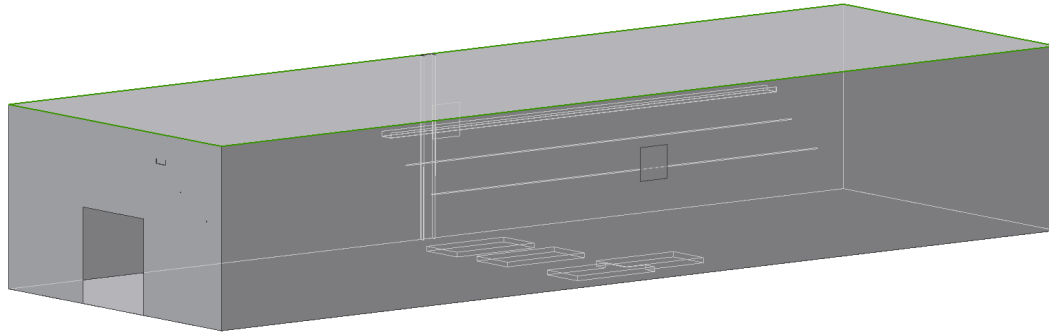
Material: Methane, a transparent gas (CH₄)

Length: 0.01 m
Width: 0.01 m
Thickness: 0.01 m
Molar Mass: 0.016 kg/mol
Total Mass: 10000 kg
Heat of Combustion: 50000 kJ/kg
Heat of Gasification: -0.001 kJ/kg
Volatilization Temperature: 26.85001 °C
Ignition Temperature: 219.85 °C
Radiative Fraction: 0.33

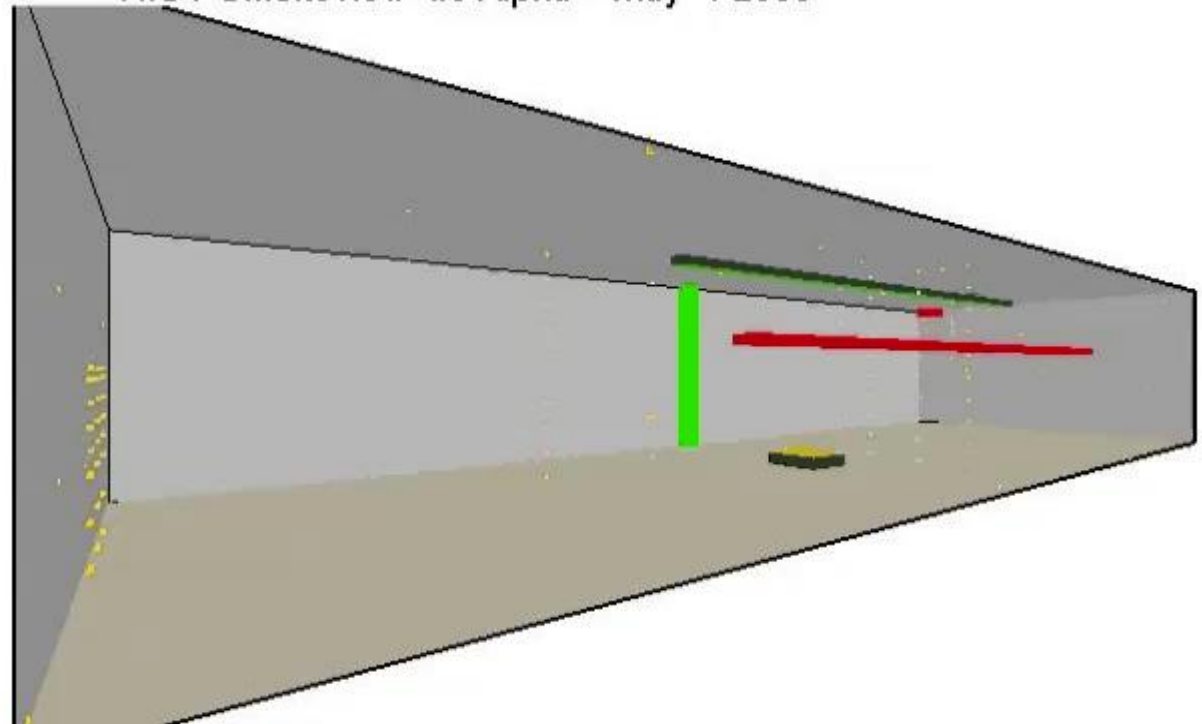
bunsen HRR

No Errors

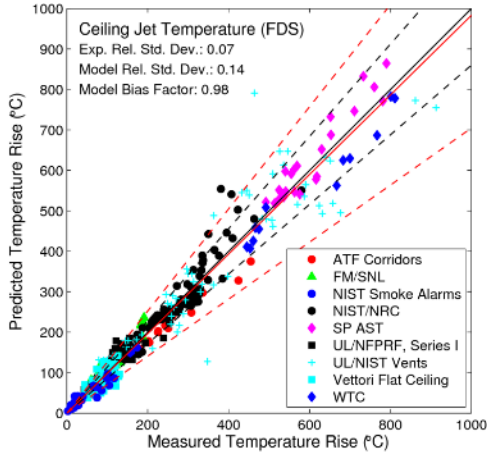
NIST/NRC Fire in a Switch Gear Room (2003)



NIST Smokeview 4.0 Alpha - May 1 2003



Summary of NRC/EPRI validation study



Quantities of Interest

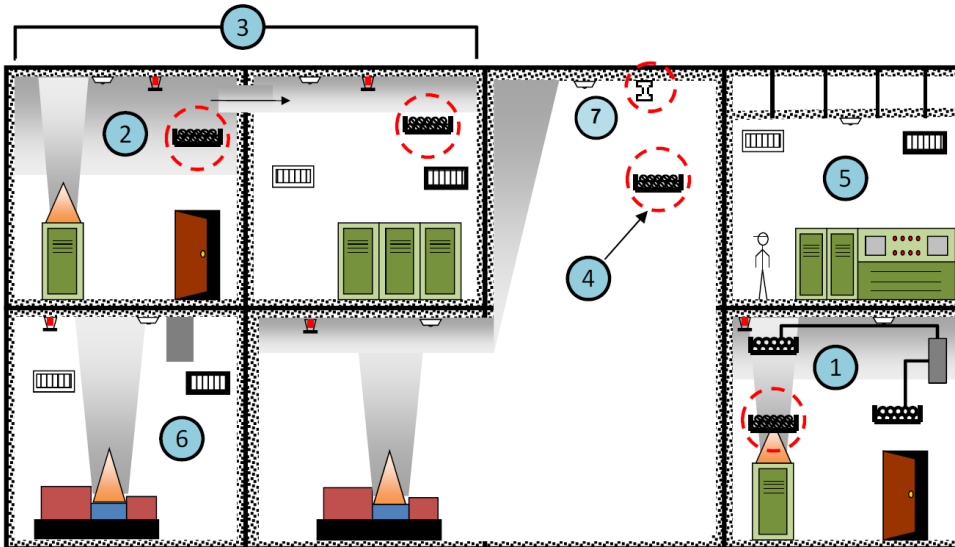
Models of Interest

Output Quantity	Empirical Correlations			CFAST		MAGIC		FDS		Exp
	Corr.	δ	$\tilde{\sigma}_M$	δ	$\tilde{\sigma}_M$	δ	$\tilde{\sigma}_M$	δ	$\tilde{\sigma}_M$	$\tilde{\sigma}_E$
HGL Temp. Rise, Natural	MQH	1.17	0.15	1.20	0.36	1.12	0.32	1.01	0.12	0.07
HGL Temp. Rise, Forced	FPA	1.29	0.32	1.15	0.20	1.08	0.17	1.21	0.22	0.07
	DB	1.18	0.25							
HGL Temp. Rise, Closed	Beyler	1.04	0.37	0.99	0.08	1.07	0.16	1.20	0.12	0.07
HGL Depth	ASET/YT	-	-	1.04	0.33	1.12	0.29	1.03	0.06	0.05
Ceiling Jet Temp. Rise	Alpert Unconfined	0.86	0.11	1.18	0.33	1.04	0.45	0.98	0.14	0.07
	Alpert Compartment	0.31	0.49							
Plume Temp. Rise	Heskestad	0.84	0.33	1.08	0.20	1.04	0.20	1.20	0.21	0.07
	McCaffrey	0.90	0.31							
Oxygen Concentration	N/A			1.00	0.15	0.93	0.22	1.01	0.11	0.08
Smoke Concentration	N/A			3.16	0.68	3.71	0.66	2.63	0.59	0.19
Pressure Rise	N/A			1.36	0.66	1.49	0.45	0.96	0.27	0.21
Target Temp. Rise	Steel	1.29	0.45	1.58	0.64	1.08	0.38	0.98	0.18	0.07
Target Heat Flux	Point Source	1.44	0.47	0.93	1.16	0.85	0.66	0.98	0.25	0.11
	Solid Flame	1.17	0.44							
Surface Temp. Rise	N/A			1.05	0.28	0.95	0.29	0.99	0.12	0.07
Surface Heat Flux	N/A			0.98	0.34	0.78	0.35	0.92	0.15	0.11
Cable Failure Time	THIEF	0.90	0.11	-	-	-	-	1.10	0.16	0.12
Sprinkler Activation Time	Sprinkler	1.11	0.41	0.80	0.21	0.93	0.20	0.93	0.15	0.06
Smoke Detector Activation Time	Temp. Rise	0.66	0.57	1.12	0.46	1.54	0.36	0.85	0.29	0.34
	Milke	0.65	0.60							
	Mowrer	0.11	0.50							

Nuclear Power Plant Fire Modeling Analysis Guidelines (FIRE MAG)

NUREG-1934
EPRI 1023259

November 2012



NUREG-1934

EPRI 1023259
Final Report

Nuclear Power Plant Fire Modeling Analysis Guidelines (NPP FIRE MAG)

Final Report

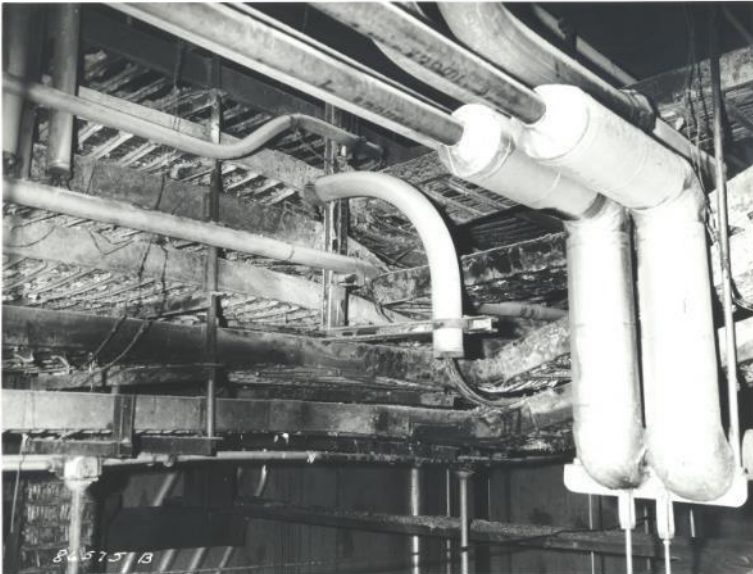
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Washington, D.C. 20555-0001

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Fire Modeling PIRT
(Phenomena Identification
and Ranking Table
November 2008
NUREG/CR-6978

What are the fire
modeling challenges?



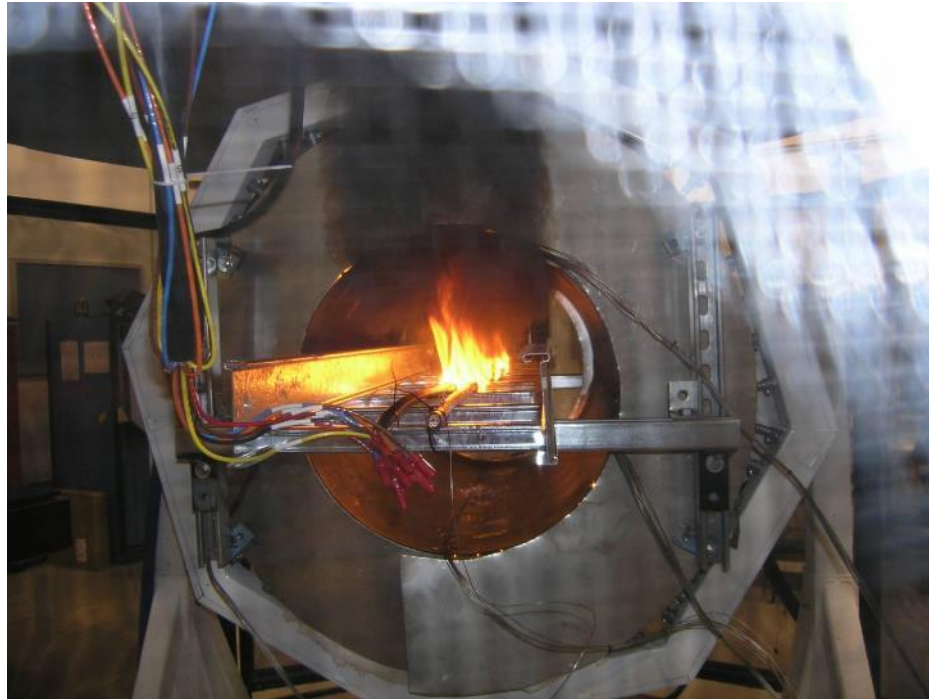
NUREG/CR-6978
SAND2008-3997P

**A Phenomena Identification and
Ranking Table (PIRT)
Exercise for Nuclear Power Plant
Fire Modeling Applications**

Office of Nuclear Regulatory Research



CAROLFIRE: Cable Response to Live Fire



 **U.S.NRC**
United States Nuclear Regulatory Commission
Protecting People and the Environment

NUREG/CR-6931, Vol. 1
SAND2007-6001V1

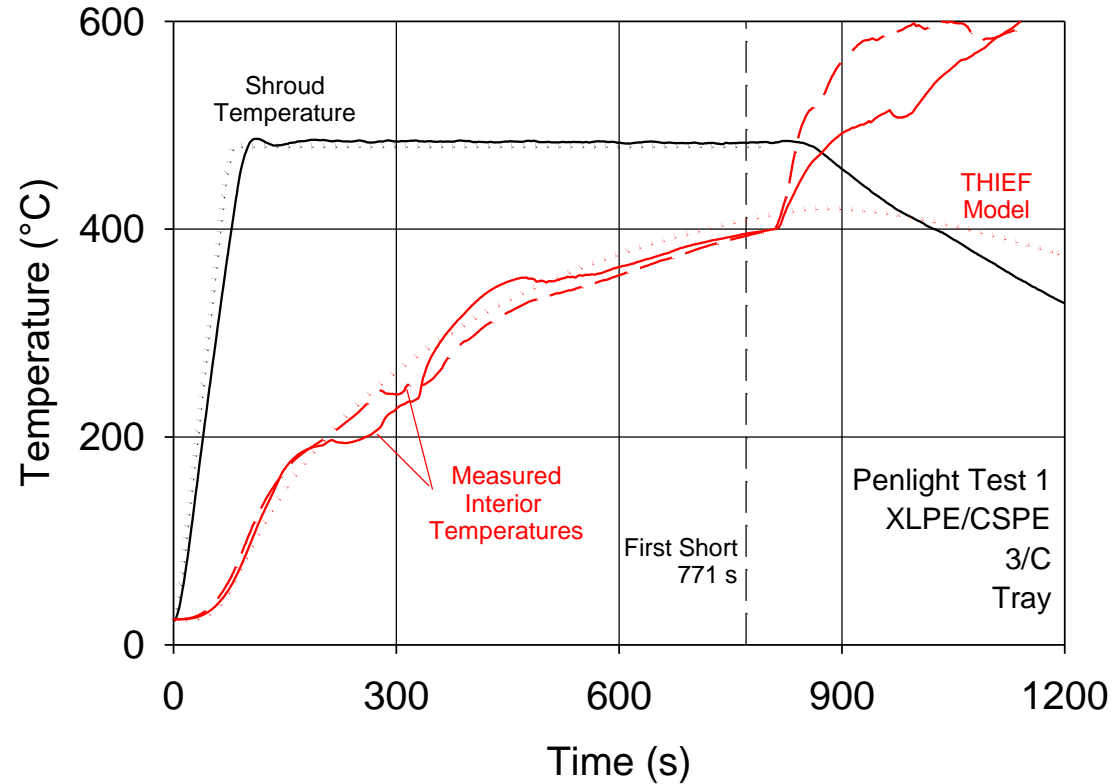
**Cable Response to
Live Fire (CAROLFIRE)
Volume 1: Test
Descriptions and Analysis
of Circuit Response Data**

**NUREG/CR-6931
Volume 1-3**

Office of Nuclear Regulatory Research

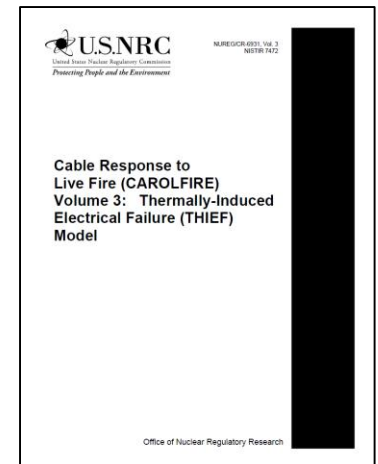


Thermally-Induced Electrical Failure (THIEF) Model



$$\rho c \frac{\partial T}{\partial t} = \frac{1}{r} \frac{\partial}{\partial r} k r \frac{\partial T}{\partial r}$$

NUREG/CR-6931
Volume 3



Cables used in CHRISTIFIRE

(Cable Heat Release, Ignition, Spread in Tray Installations in Fire)



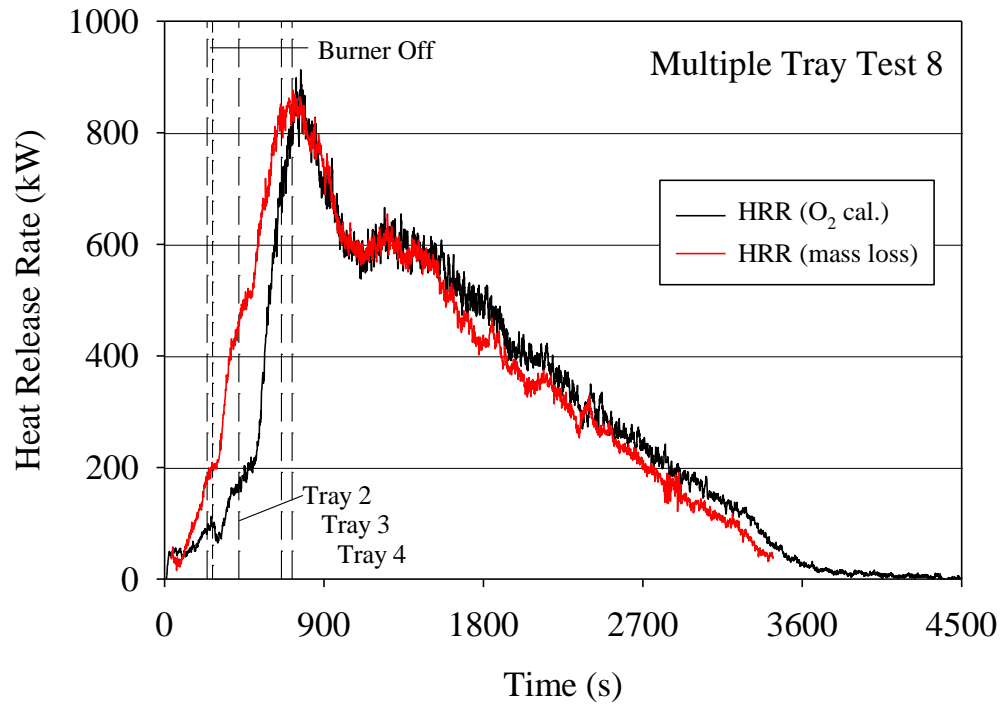
**Cable Heat Release,
Ignition, and Spread in
Tray Installations During
Fire (CHRISTIFIRE)
Phase 1: Horizontal Trays**

Office of Nuclear Regulatory Research

**Cable Heat Release,
Ignition, and Spread in
Tray Installations During
Fire (CHRISTIFIRE)
Phase 2: Vertical Shafts
and Corridors**

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NUREG/CR-7010, Volumes 1 and 2



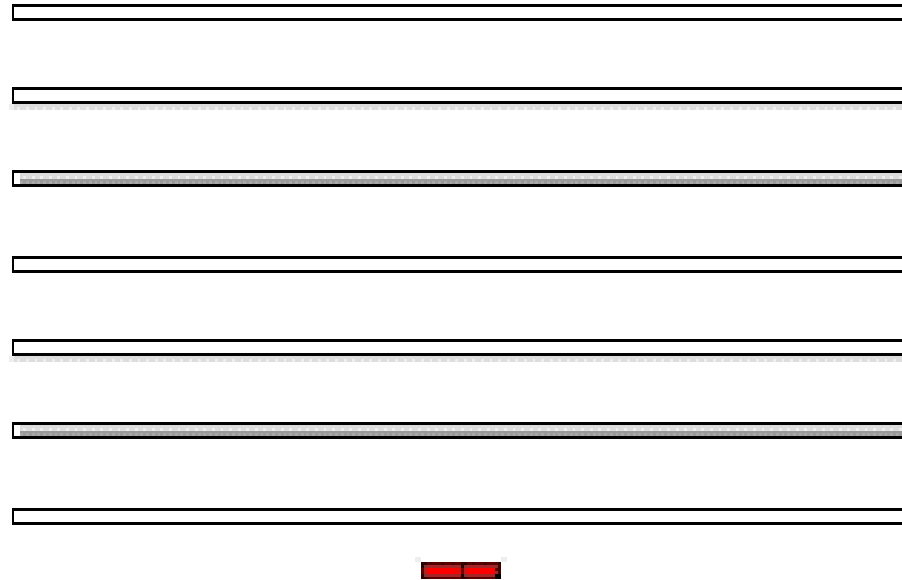
Thermoplastic Cable

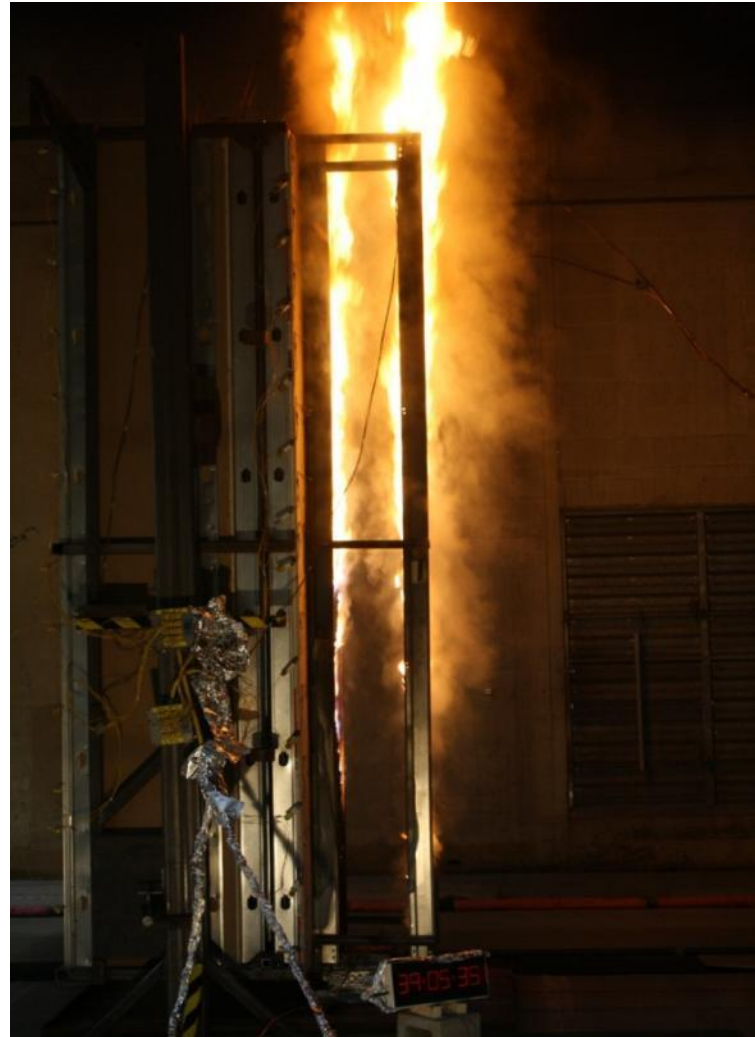


FLASH-CAT: Flame Spread in Horizontal Cable Trays

Multiple Tray Test 20

Time 00:10









NUREG/CR-7197

Heat Release Rates of Electrical Enclosure Fires (HELEN-FIRE)

Final Report

Office of Nuclear Regulatory Research

NUREG/CR-7197

NUREG-2178, Vol. 1

EPRI 3002005578

Refining And Characterizing Heat Release Rates From Electrical Enclosures During Fire (RACHELLE-FIRE)

Volume 1:
Peak Heat Release Rates and Effect of Obstructed Plume

Final Report

U.S. Nuclear Regulatory Commission
Office of Nuclear Regulatory Research
Washington, D.C. 20555-0001

Electric Power Research Institute
3420 Hillview Avenue
Palo Alto, CA 94304-1338



NUREG/CR-2178



Open electrical cabinet, 0.6 m by 0.6 m by 2.1 m
Thermoset cables placed on each side



Loose, unjacketed, thermoplastic insulated wire



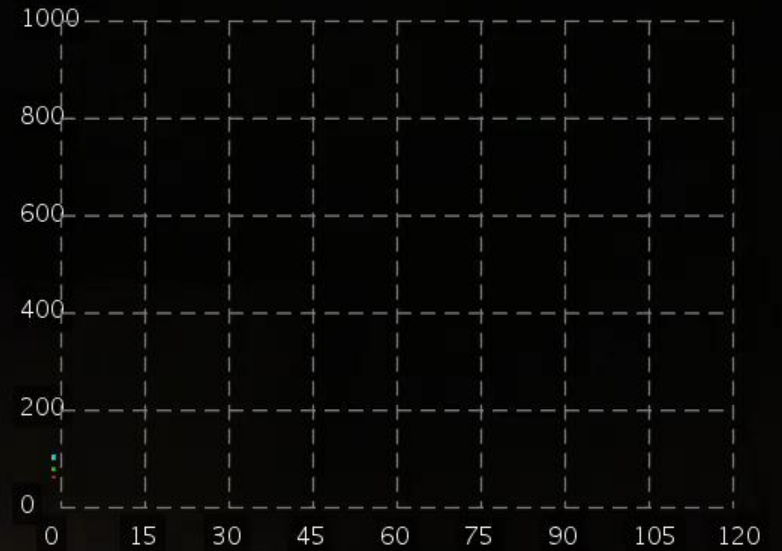
RACHELLE-FIRE Validation: Obstructed Plumes

NIST Technical Note 1984



RACHELLE-FIRE Validation: Corner Plumes

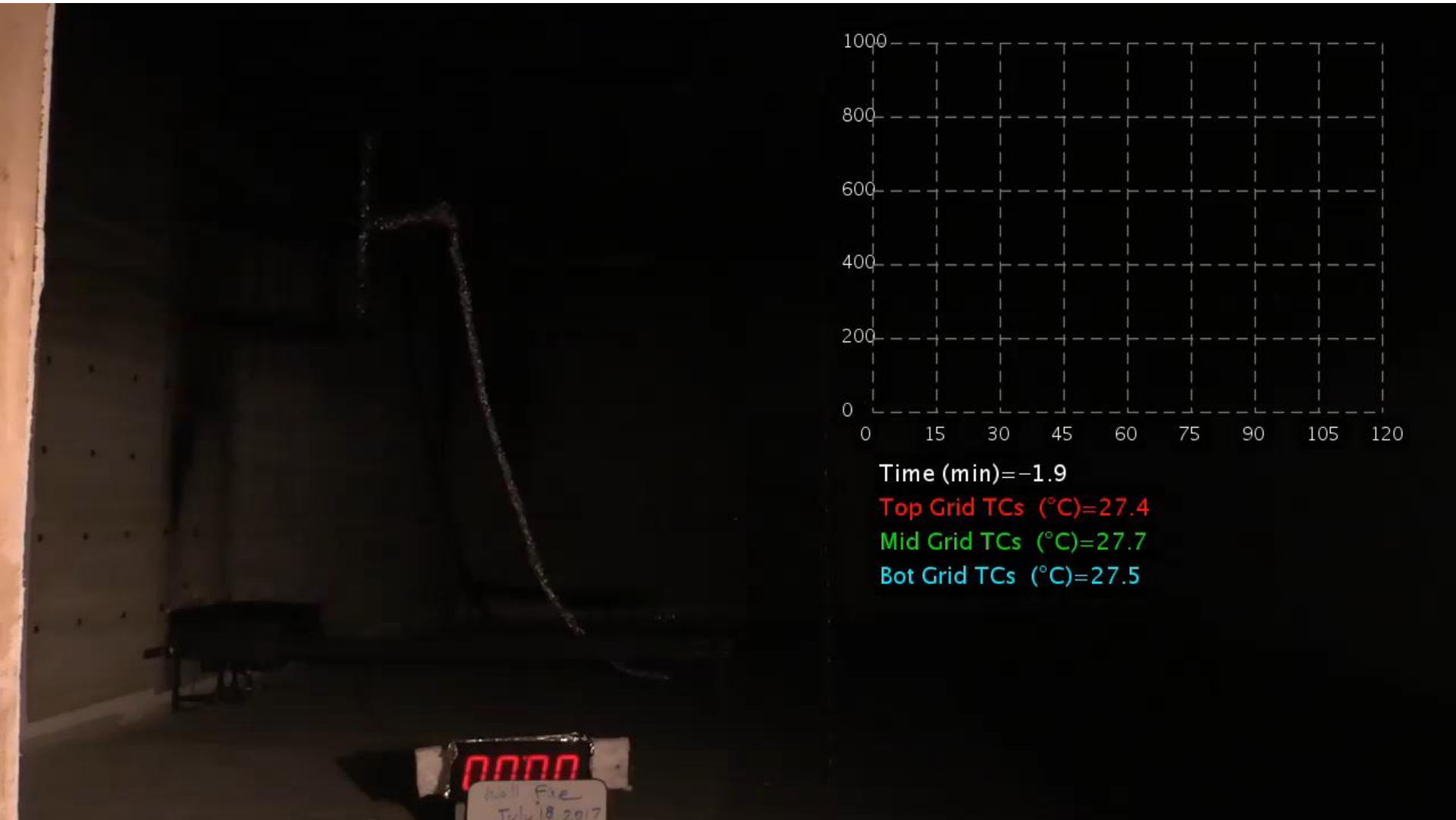
NIST Technical Note 1984



Time (min)=-1.35
Top Grid TCs (°C)=65.5
Mid Grid TCs (°C)=83.3
Bot Grid TCs (°C)=109.3

RACHELLE-FIRE Validation: Wall Plumes

NIST Technical Note 1984





NUREG/CR-XXXX Vol 2

Response Bias of Electrical Cable Coatings at Fire Conditions (REBECCA-FIRE)

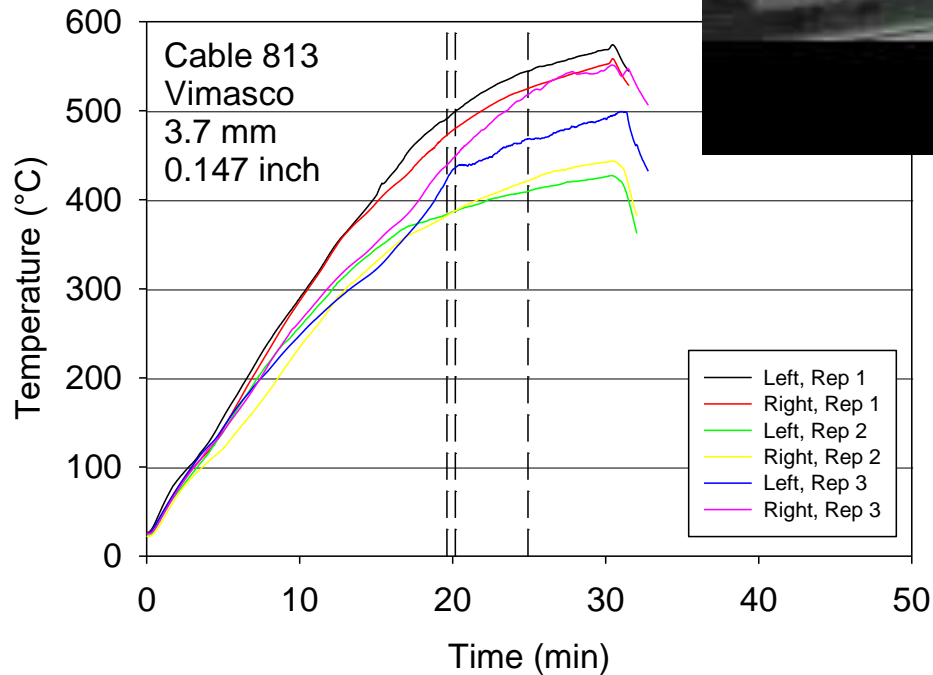
Office of Research

To be published
as a NUREG/CR

IEC* 60331-11

Tests for Electric Cables under Fire Conditions – Circuit Integrity

*International Electrotechnical
Commission



Vertical Tray of Unqualified Electrical Cables



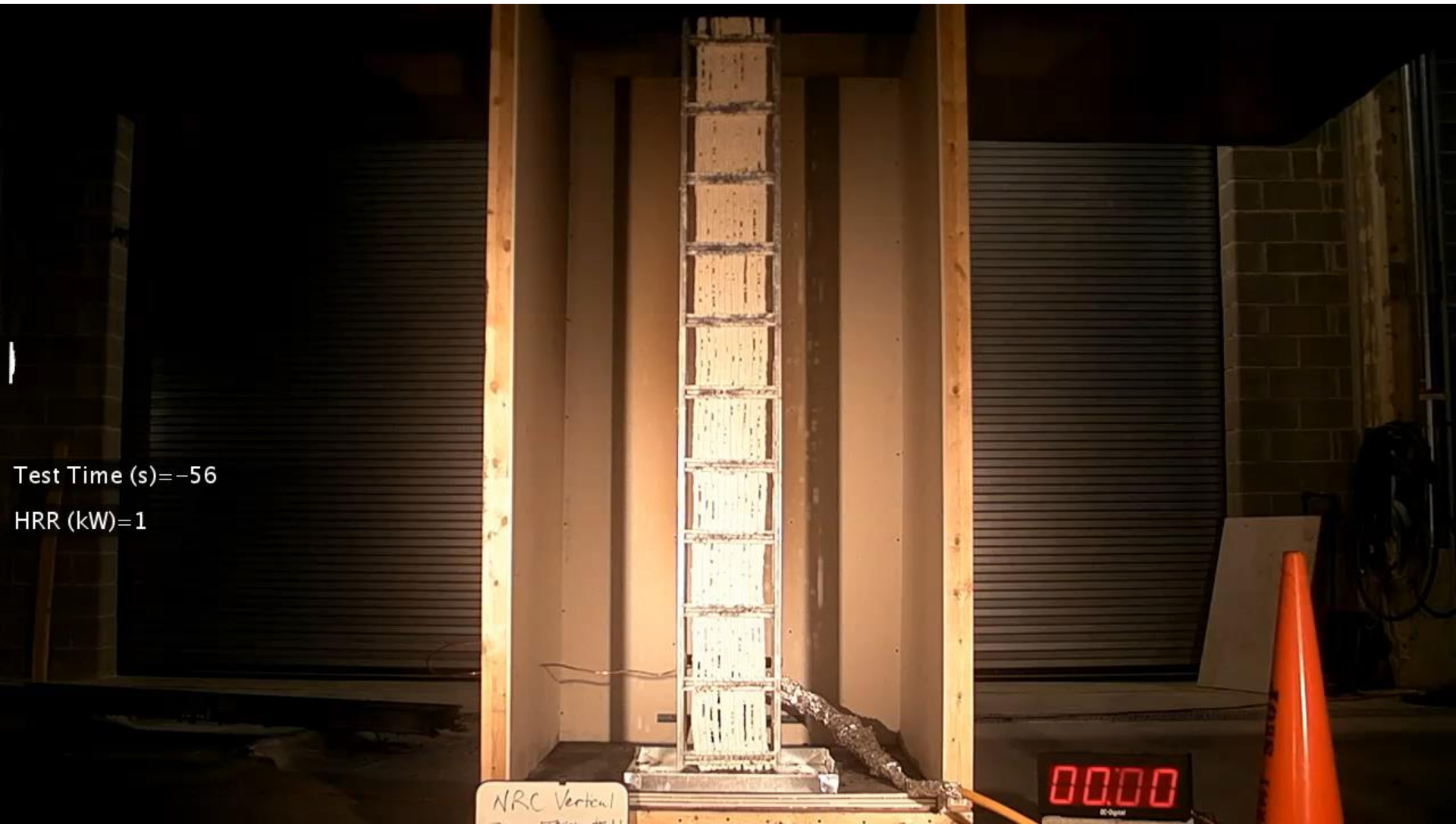
Test Time (s)=-33

HRR (kW)=-2

NRC Vertical

00:00

Vertical Tray of Unqualified Electrical Cables, Coated



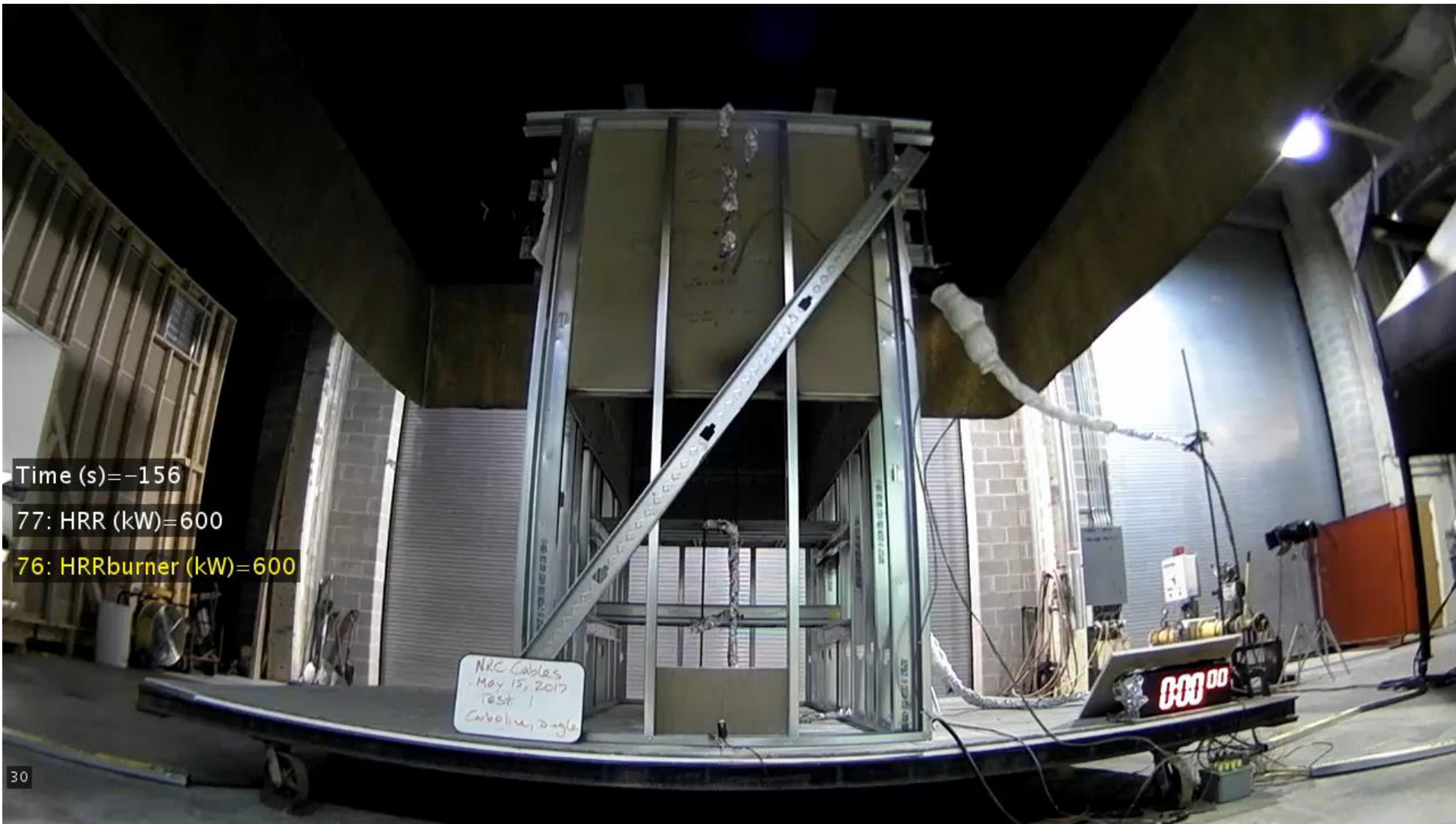
Test Time (s)=-56

HRR (kW)=1

NRC Vertical
Test #11

0000
0000

Coated and Uncoated Cables within the Fire, Fire Plume, and Hot Gas Layer



Time (s)=-156

77: HRR (kW)=600

76: HRRburner (kW)=600

NRC Cables
- May 15, 2017
Test 1
Cable line, angle

000.00

NUREG/CR-6886, Rev. 1
PNNL-15313



Spent Fuel Transportation Package Response to the Baltimore Tunnel Fire Scenario



Final Report



Pacific Northwest National Laboratory

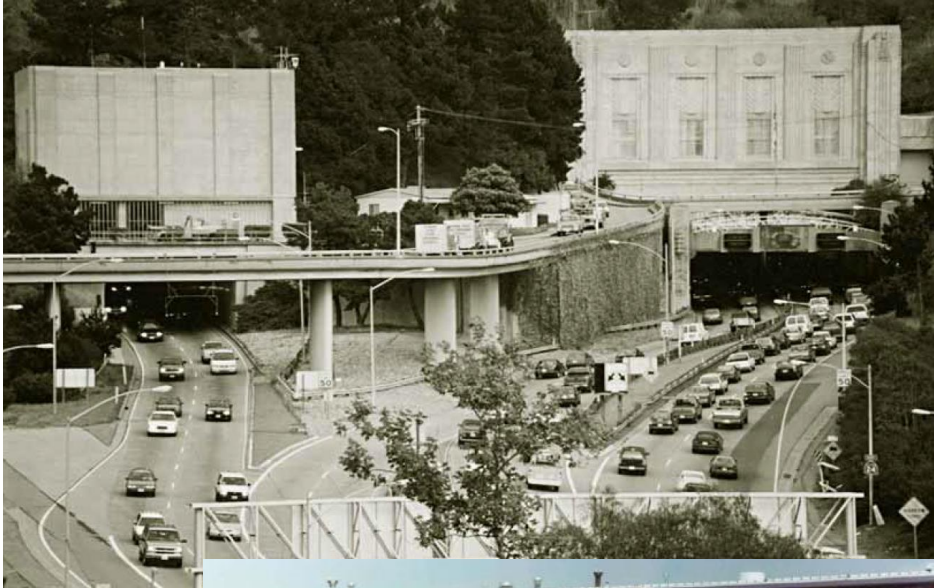


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Office of Nuclear Material Safety and Safeguards
Washington, DC 20555-0001



NUREG/CR-6886, Revision 1

Caldecott Tunnel Fire Oakland, California April 7, 1982



NUREG/CR-6894, Rev. 1
PNNL-15346



Spent Fuel Transportation Package Response to the Caldecott Tunnel Fire Scenario



Pacific Northwest National Laboratory

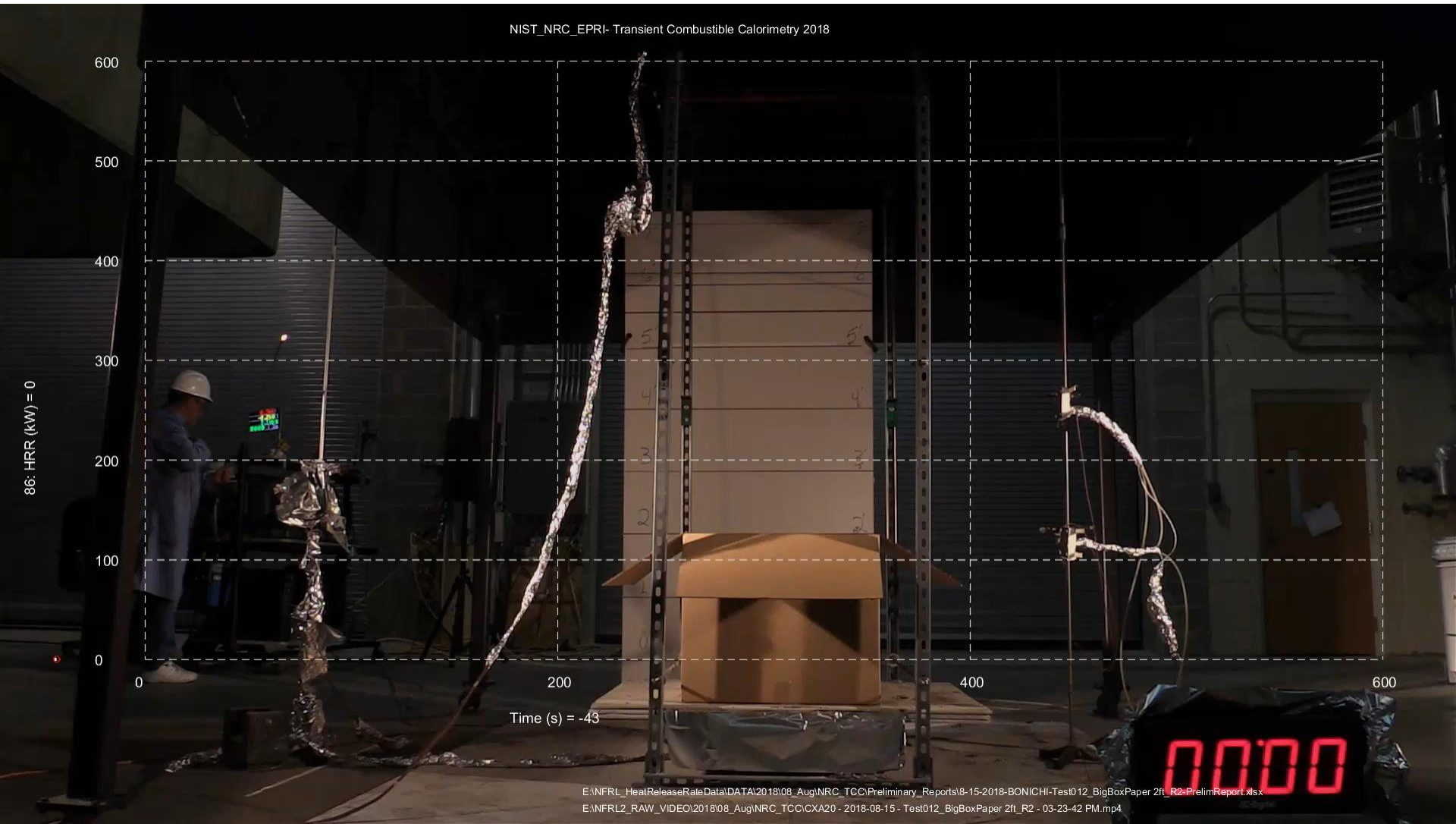


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NUREG/CR-6894, Revision 1

Recent Activity: Heat Release Rate of Transient Combustibles



Plastic work cart with printer and laptop computer

