Cable Heat Release, Ignition, and Spread in Tray Installations during Fire (CHRISTIFIRE) Phase I

Jason Dreisbach
U.S. Nuclear Regulatory Commission

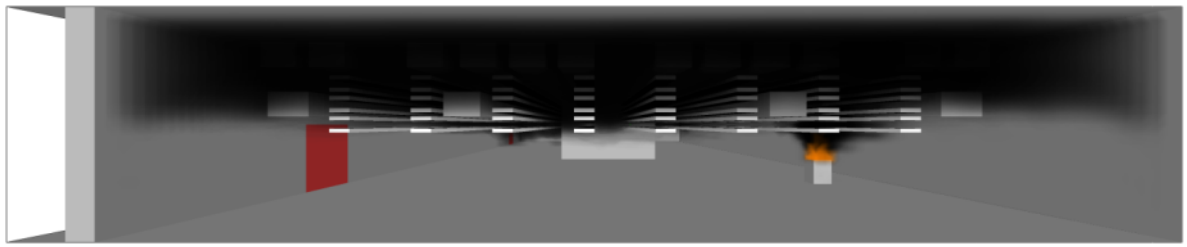
Kevin McGrattan, Andrew Lock, Nathan Marsh, Marc Nyden
National Institute of Standards and Technology

U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

NIST
National Institute of Standards and Technology
U.S. Department of Commerce

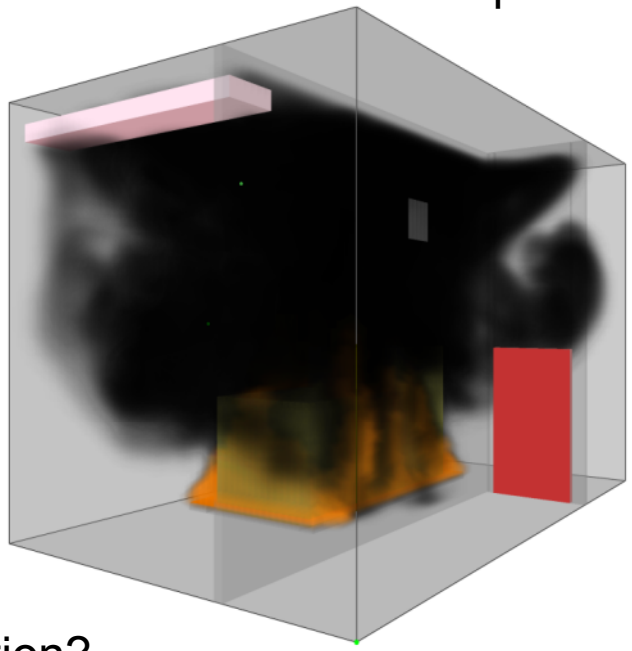
What's the Problem?

Answer: Very little useful information on cables for fire modeling

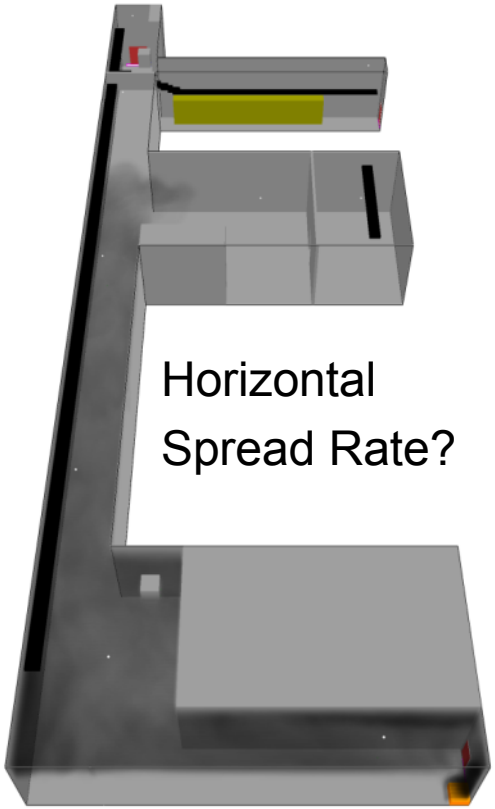


Tray to Tray Spread?

Effectiveness of Wraps?

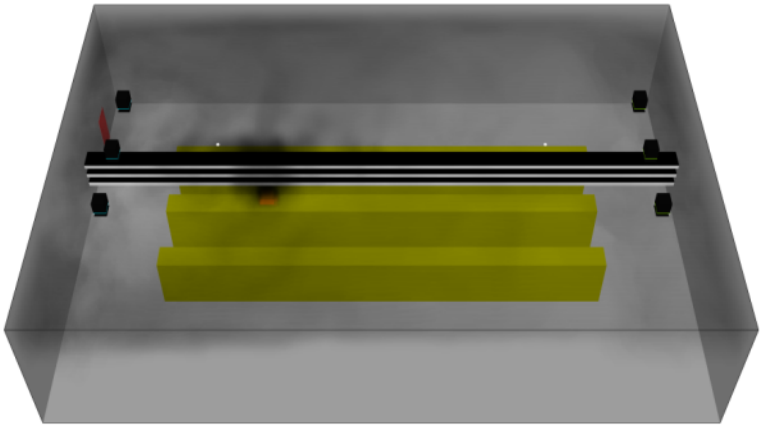


Vertical Spread Rate?

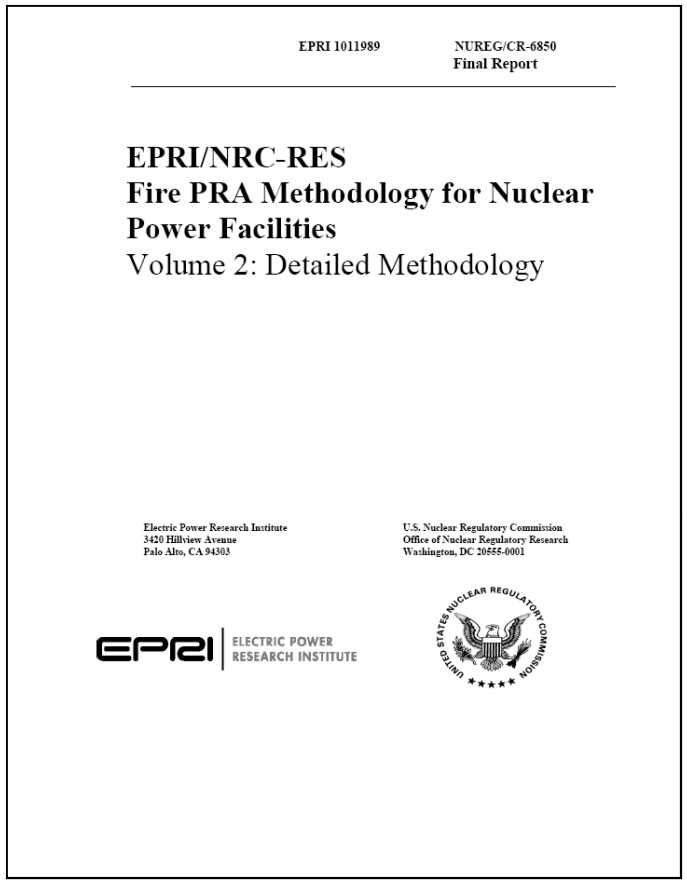


Horizontal
Spread Rate?

Ignition?



Current Guidance for Modeling Cables



EPRI 1011989 NUREG/CR-6850
Final Report

EPRI/NRC-RES
Fire PRA Methodology for Nuclear Power Facilities
Volume 2: Detailed Methodology

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

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

EPRI ELECTRIC POWER RESEARCH INSTITUTE

Problems going from
"bench" to full-scale

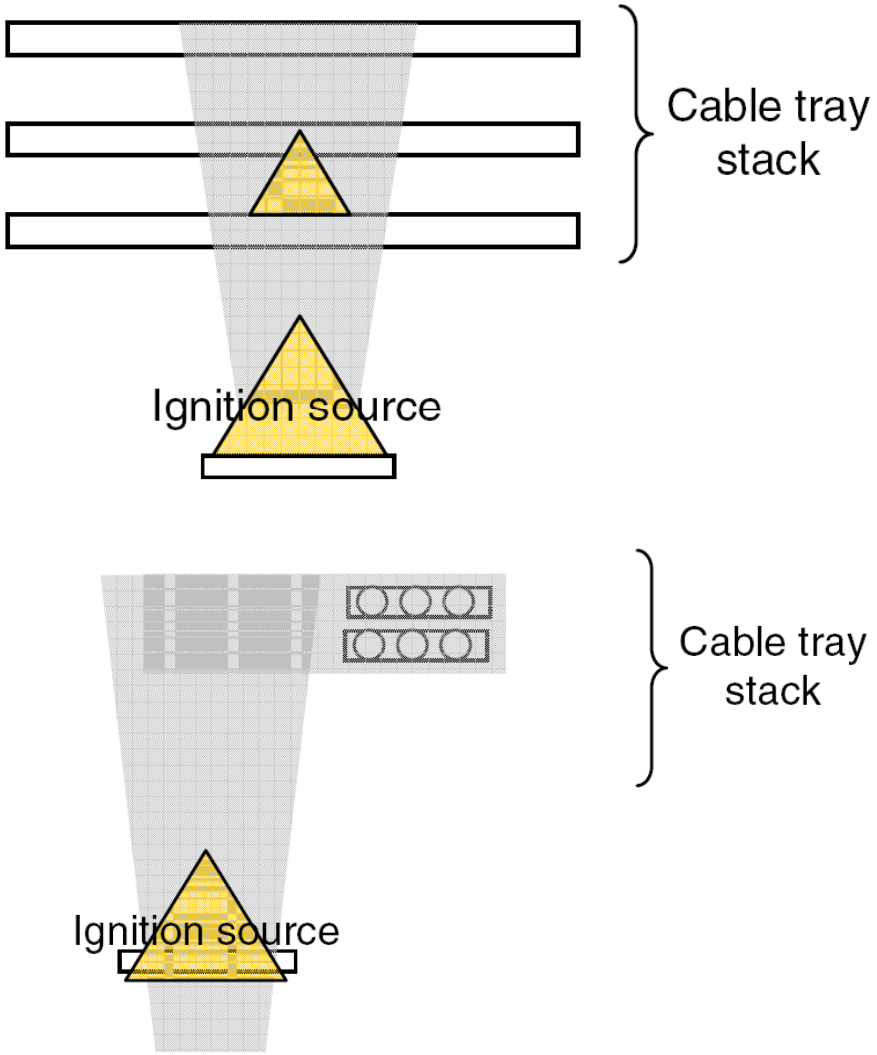
Table R-1
Bench Scale HRR Values Under a Heat Flux of 60 kW/m^2, q_{bs} [R-4]

Material	Bench Scale HRR [kW/m^2]
XPE/FRXPE	475
XPE/Neoprene	354
XPE/Neoprene	302
XPE/XPE	178
PE/PVC	395
PE/PVC	359
PE/PVC	312
PE/PVC	589
PE, Nylon/PVC, Nylon	231
PE, Nylon/PVC, Nylon	218

Which HRR to Use?

Similar guidance/info in
NUREG-1805 (FDTs)

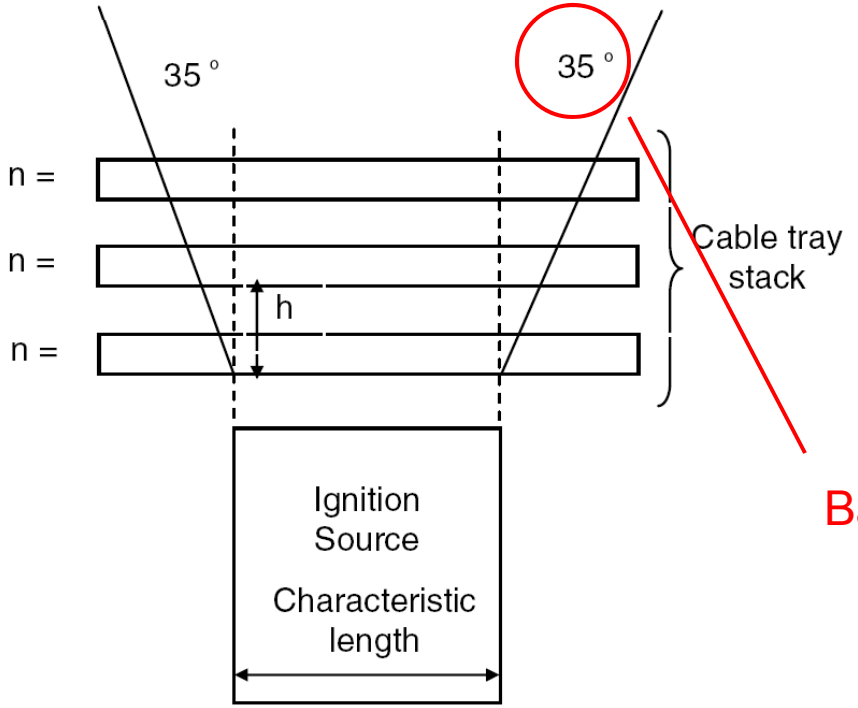
Current Guidance on Ignition

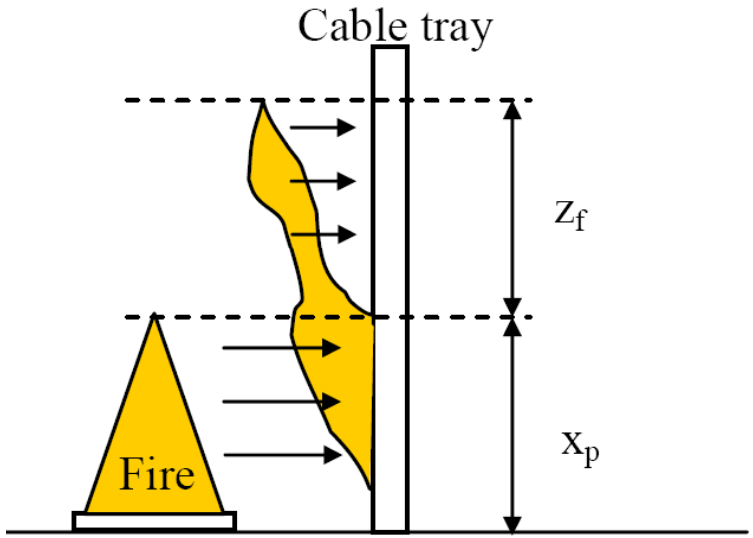


Current Guidance on Flame Spread

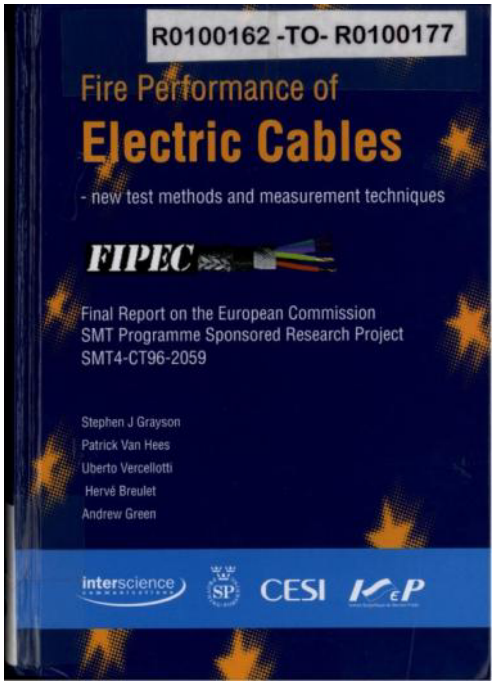
$$v = \frac{4\left(\dot{q}''_f\right)^2 \delta_f}{\pi (k\rho c)\left(T_{ig} - T_{amb}\right)^2}$$

Vague or ill-defined parameters





Based on only one experiment



Basic Outline of Experimental Program

Chemistry/Materials

- Tube Furnace testing for gaseous yields
- Microcalorimetry for thermal properties

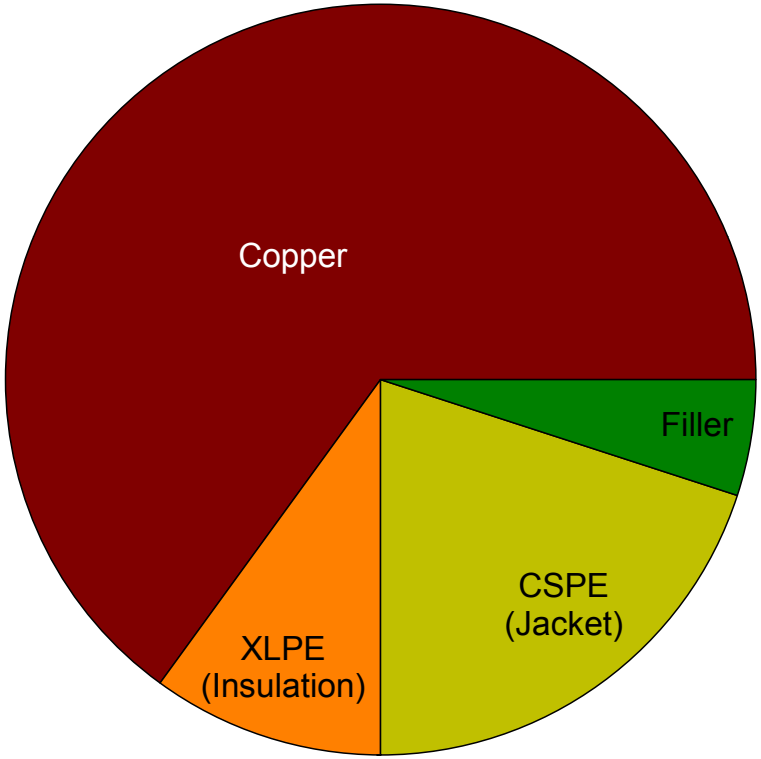
Heat Release and Spread Rates

- Cone Calorimetry (Bench-Scale)
- Radiant Panel Tests (Intermediate-Scale)
- Multiple Tray Tests (Large-Scale)

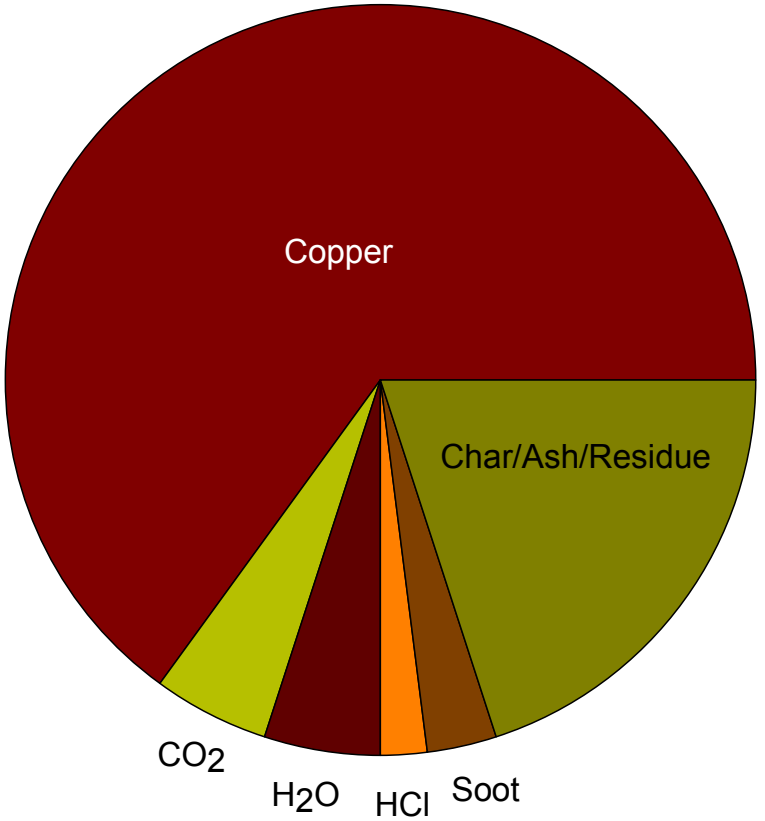
Cables used in CHRISTIFIRE

Basic Chemistry of Burning Cables

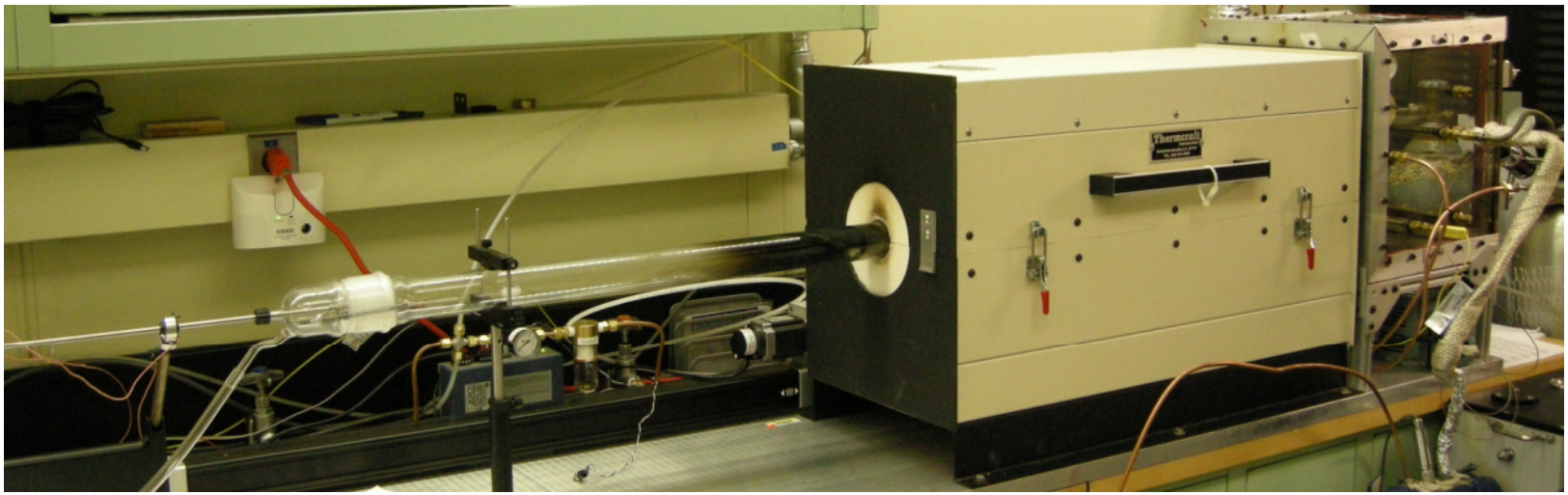
What we start with ...

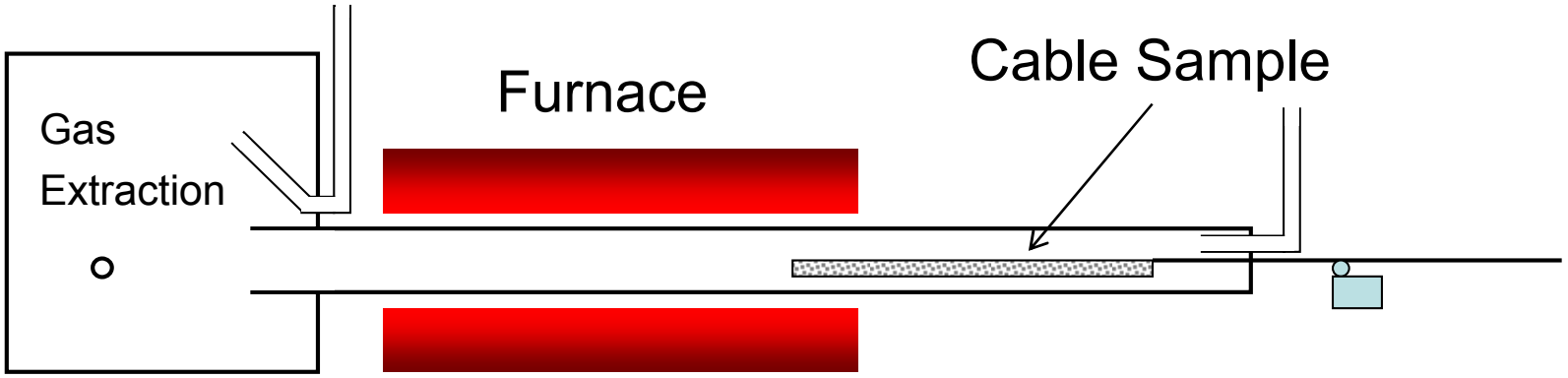


... and what we get.

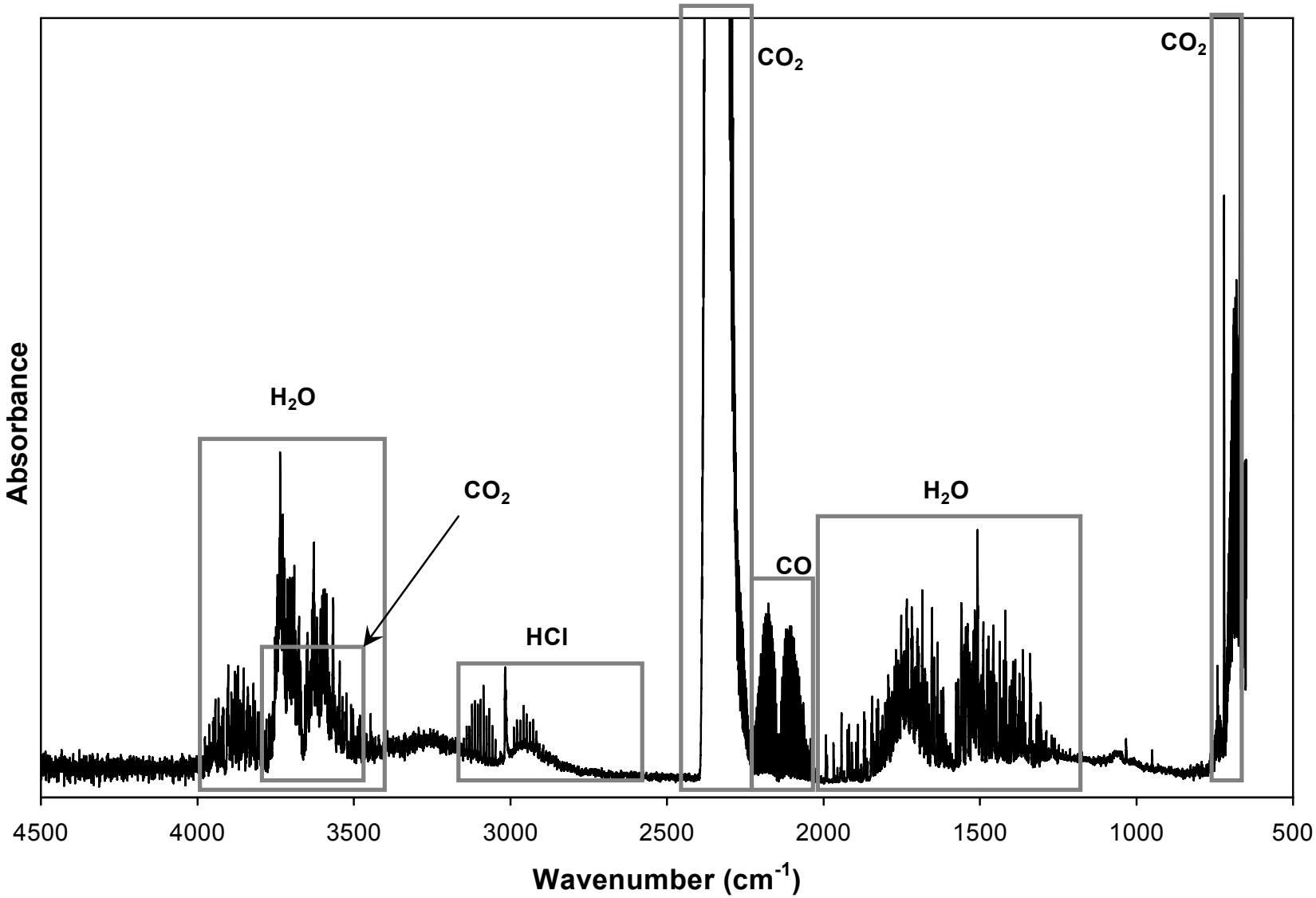


ISO/TS 19700 Tube Furnace

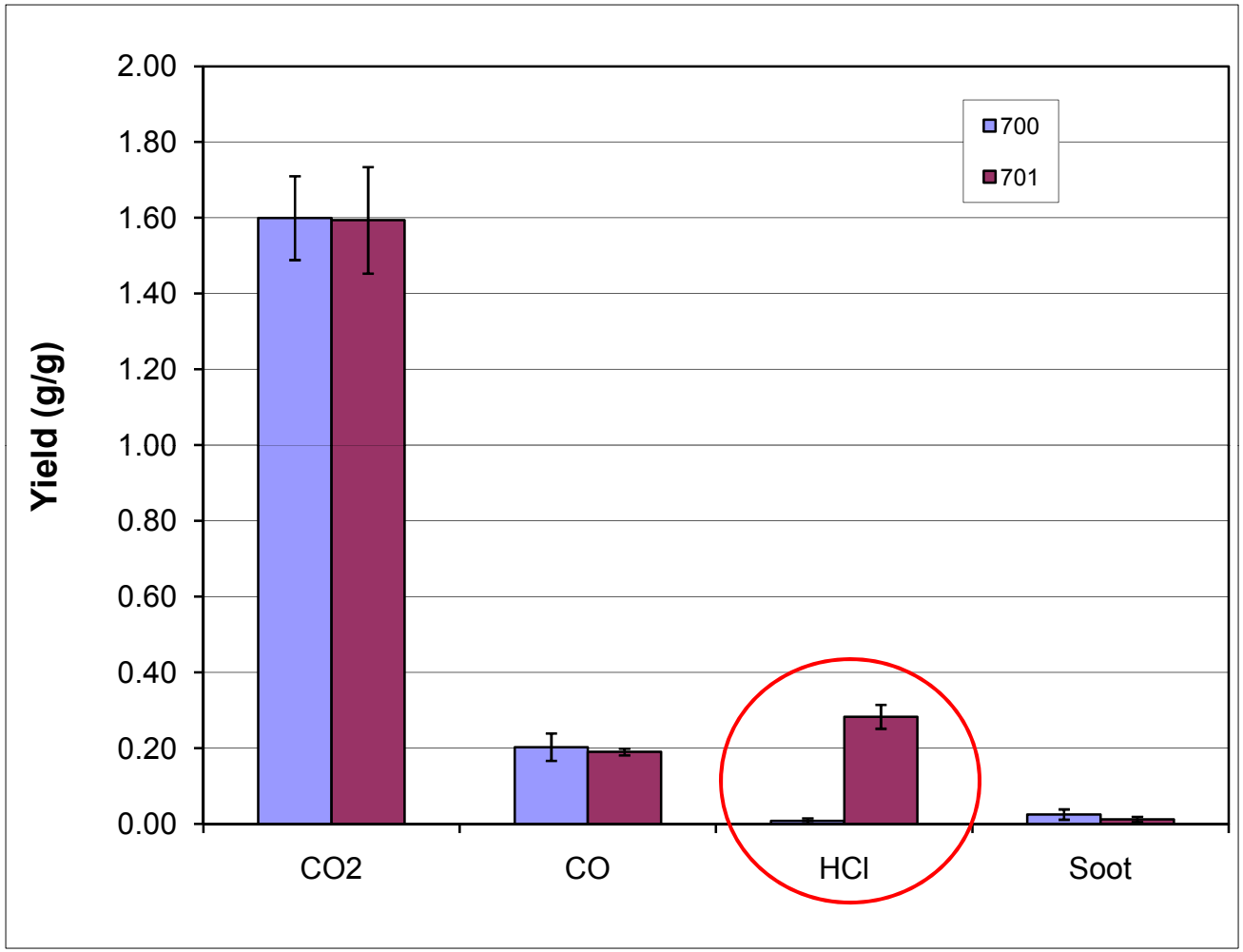




Absorption Spectra of Cable Effluent



Yields of Various Gases from Two Cables



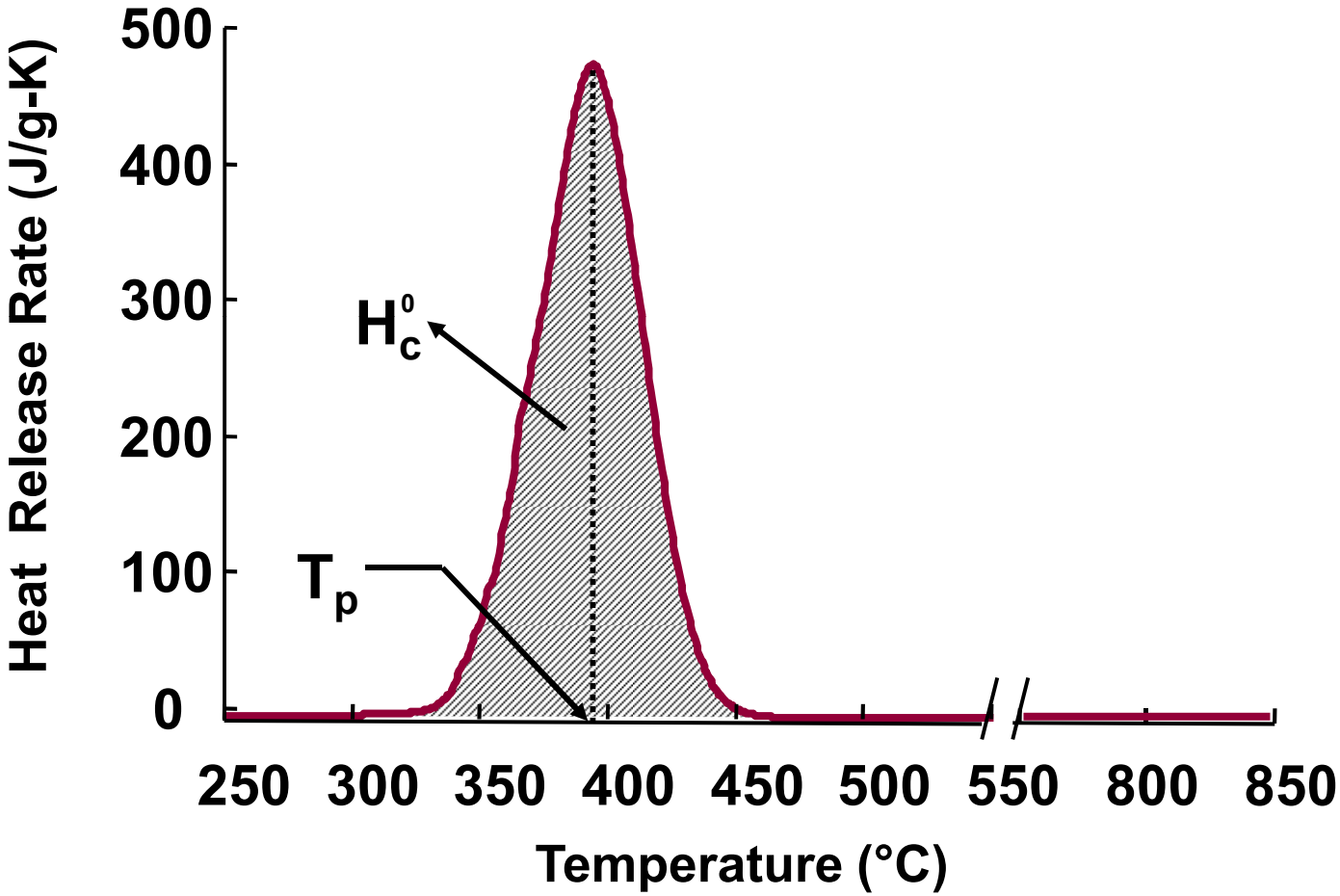
PVC produces alot of HCl

Microcalorimetry

Standard Test Method for Measuring Flammability Properties of Plastics and Other Solid Materials Using Microscale Combustion Calorimetry, ASTM D 7309, ASTM International,

West Conshohocken, PA, USA (2007)

Thermal Combustion Properties From Microcalorimeter Experiment

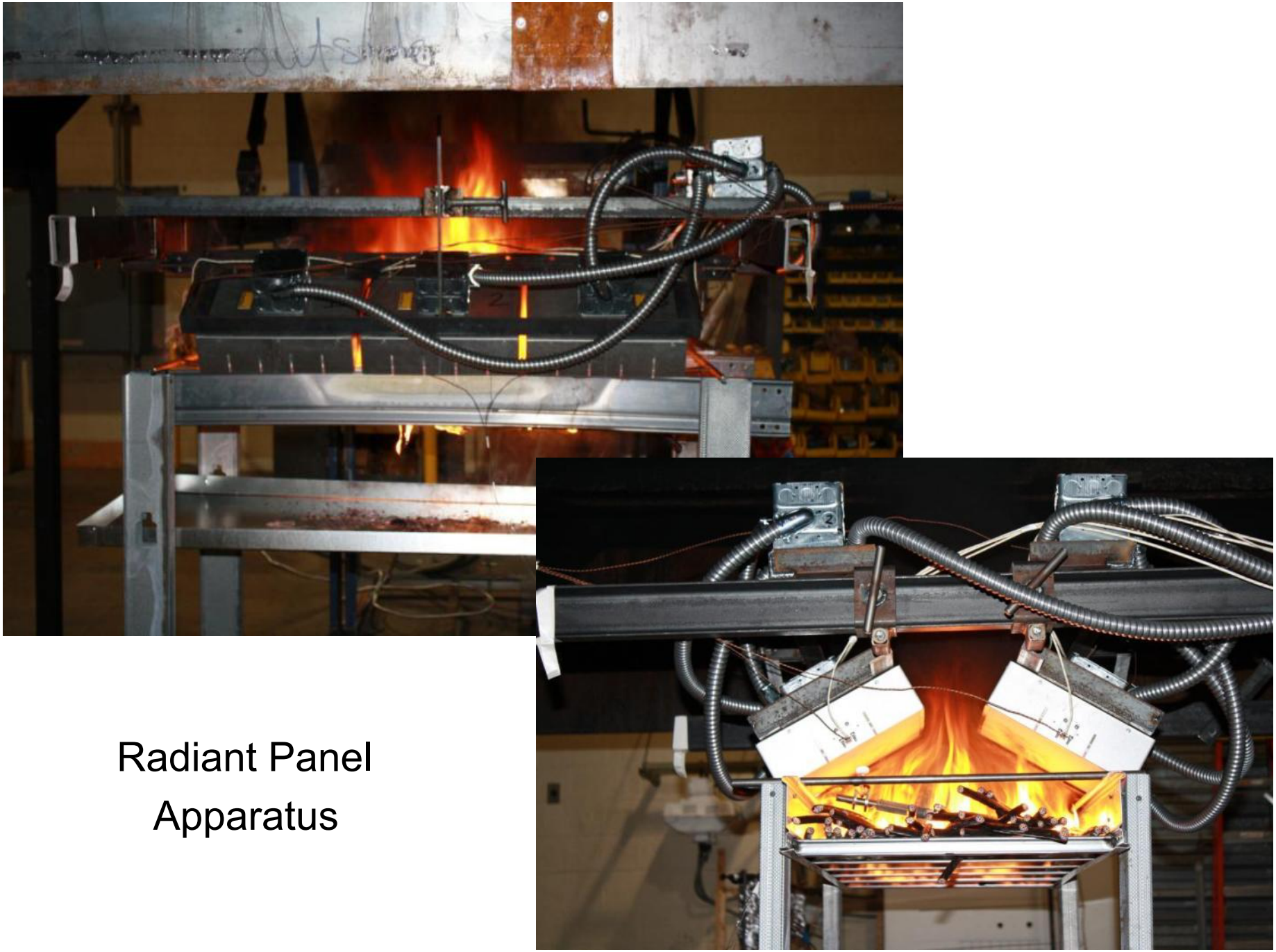


Preliminary Results ONLY

Do not cite

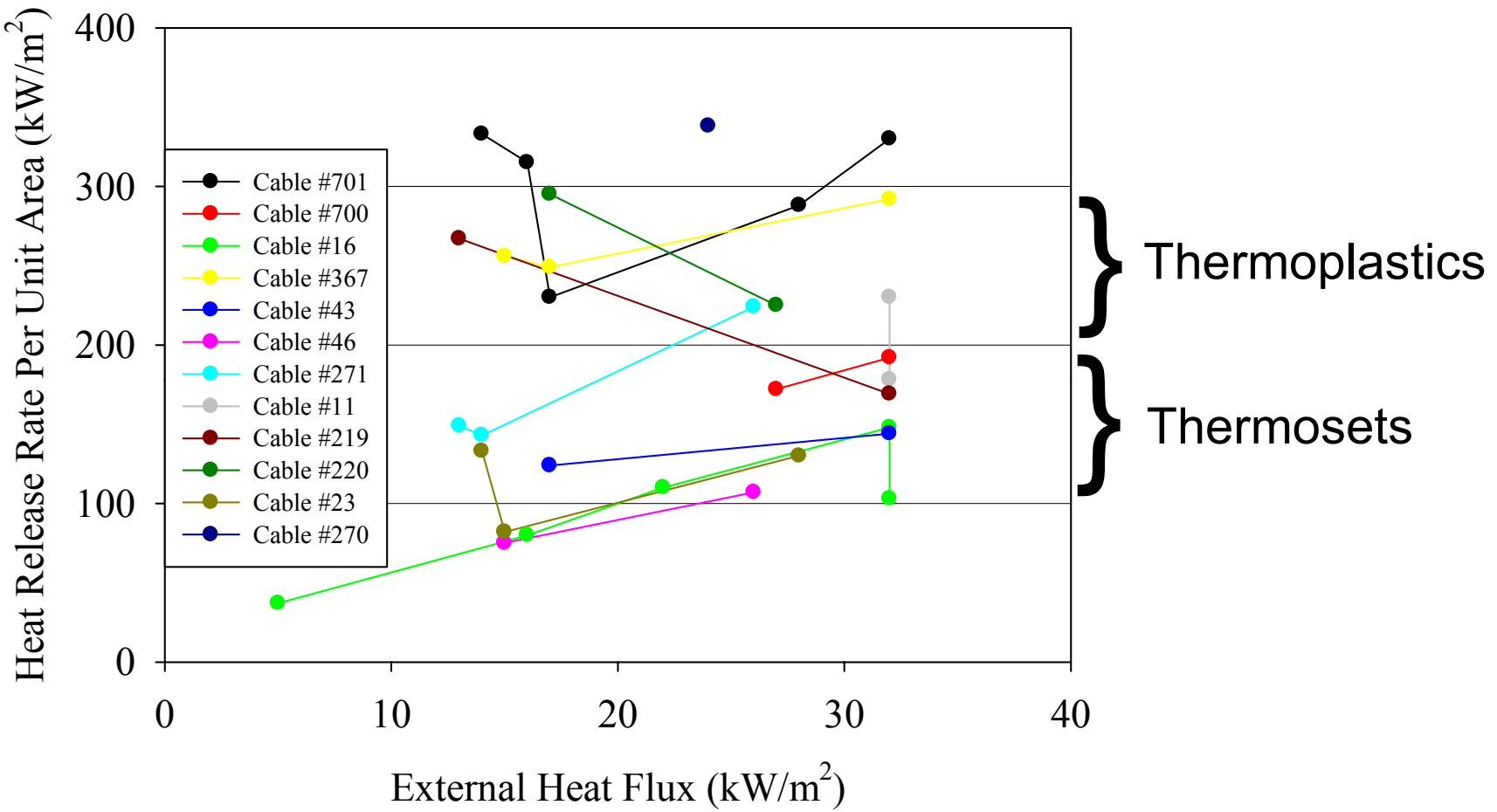
Cable Material	Peak HRR (kJ/kg/K)	Heat of Combustion (MJ/kg)	Pyrolysis Temperature (°C)
XLPE Jacket	290	14.9	470
XLPE Insulators	475	23.7	485
PVC Jacket	215	13.8	305
PE Insulators	260	13.1	300

Noticeable difference between Thermoset and Thermoplastic materials

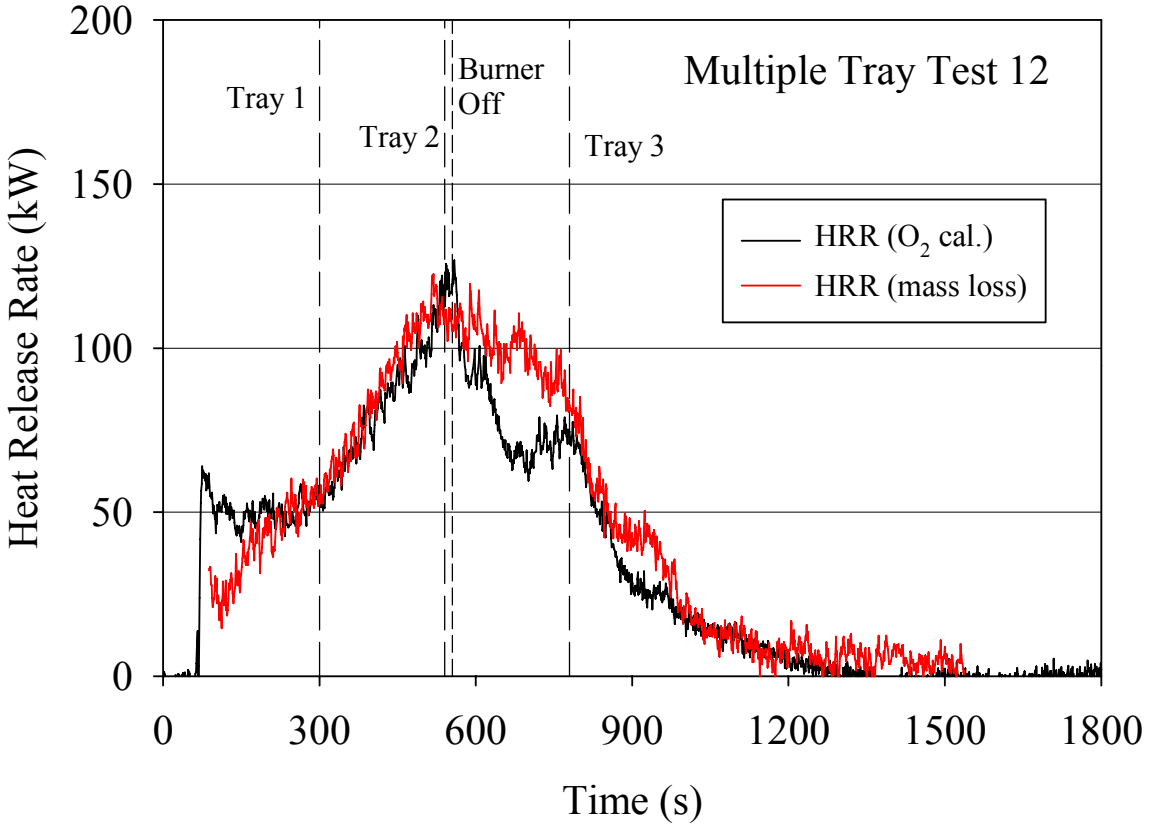


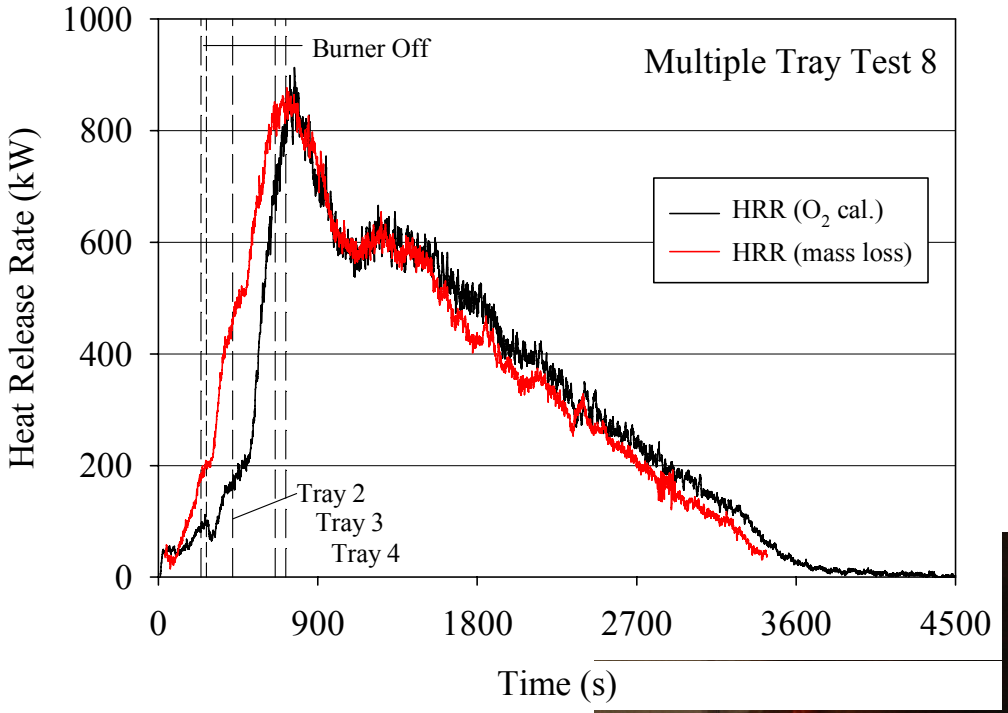
Radiant Panel
Apparatus

Results of Radiant Panel Experiments

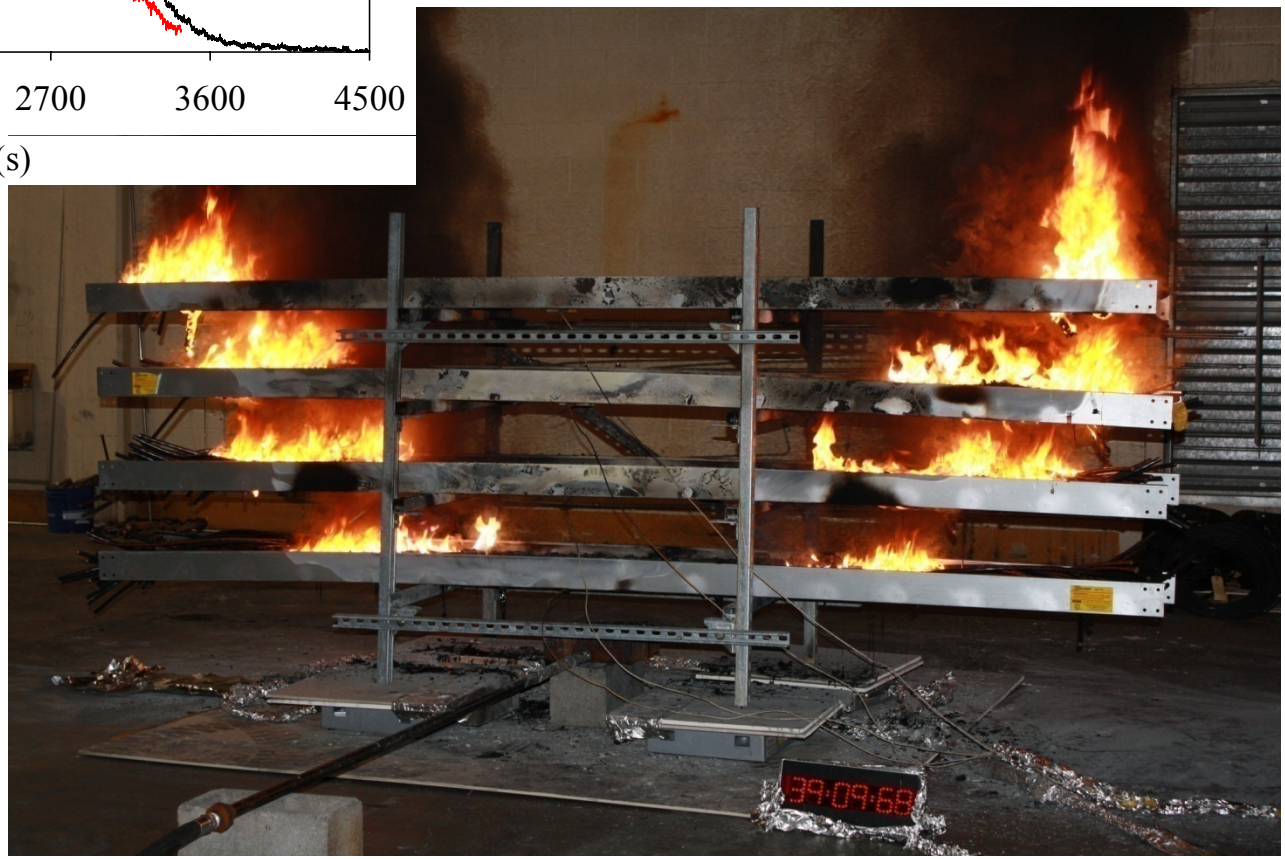


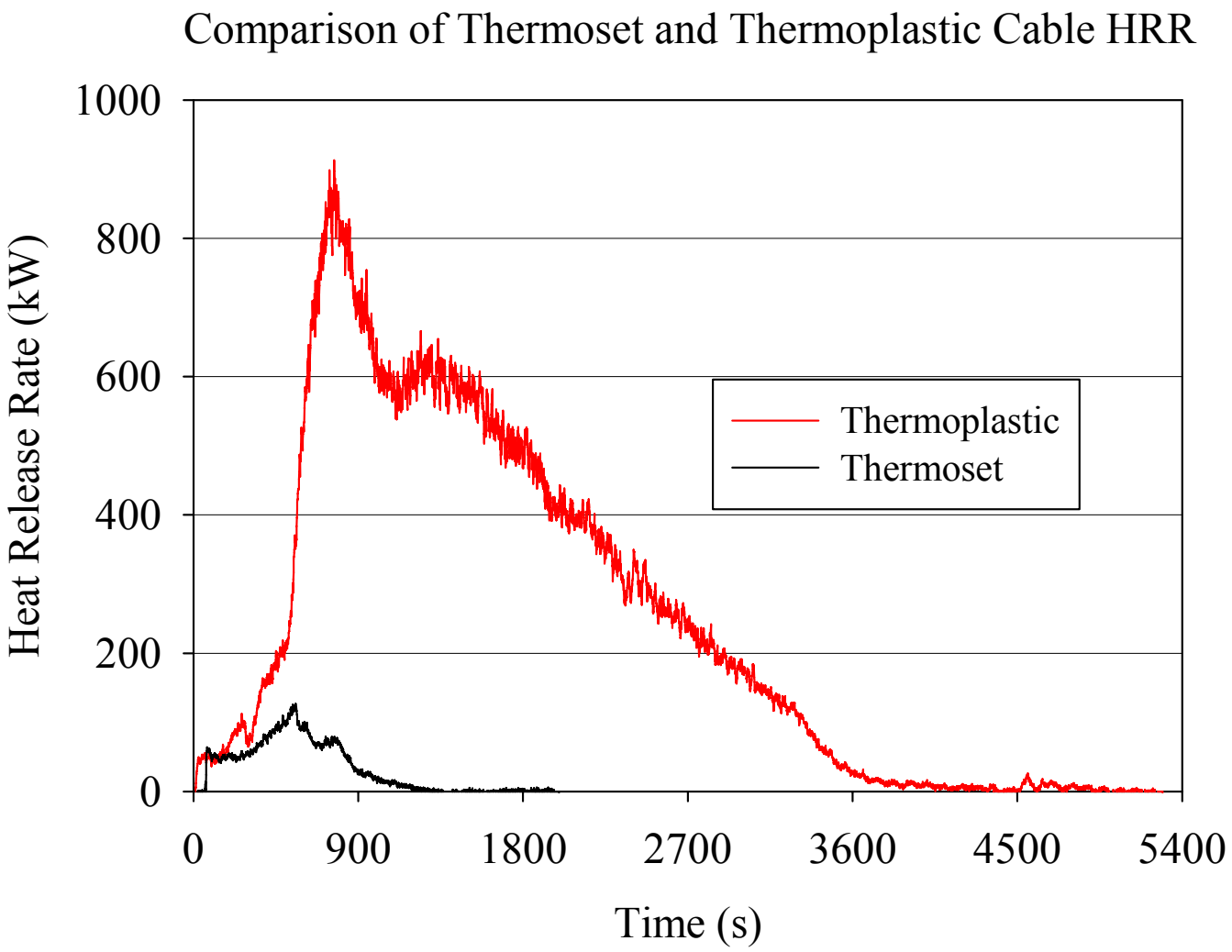
Thermoset Cable





Thermoplastic Cable




Comparison of Thermoset and Thermoplastic Cable HRR
Heat Release Rate (kW)
1000
800
600
400
200
0
0
900
1800
2700
3600
4500
5400
Time (s)
Thermoplastic
Thermoset

Current Status of Project

Full-Scale tests completed

Tube Furnace and Microcalorimetry results are being analyzed

Cone Calorimetry to begin September 2009

Additional full-scale testing is scheduled for Spring 2010

Phase I report, Summer 2010

Phase II – Vertical trays and other configurations (2010)

Proposed Phase III – Cable coatings and tray covers (2011)

Proposed Phase IV – Ventilation effects