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MULTI-PHASE STUDY ON FIREFIGHTER SAFETY AND THE DEPLOYMENT OF RESOURCES

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Year 2 Progress Report

A Collaborative Effort by:



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MULTI-PHASE STUDY ON FIREFIGHTER SAFETY AND THE DEPLOYMENT OF RESOURCES

Year 2 Progress Report

Abstract

Over the past three decades, fire department response has expanded from fire prevention and fire suppression to include multiple other community risks such as emergency medical services, hazardous materials response, and special rescue. Today, service demands and public expectations placed upon local fire departments continue to rise as threats to communities from both natural and man-made disasters including terrorism reach new highs. A Multi-Phase Study on firefighter safety and the deployment of resources is being conducted under a grant from the Department of Homeland Security's Assistance to Firefighters grant program. During year 1, the project team performed a comprehensive literature review, assembled an expert technical panel, developed a robust theoretical model, designed and tested the survey instrument, and developed and implemented a statistically significant fire department sampling strategy. Over four hundred fire departments across the country have been invited to participate, have registered their participation in the study, and have submitted a completed departmental background survey. The goal of year 2 of this research is to collect data with adequate variance to be useful as a technical basis for modeling regression equations and to conduct field experiments that will provide a depth-of-understanding in deployment analysis. Year 3 of this research will be the capstone effort of the project focused on delivery of the results to the fire service community. Year three work will consist of software development, model verification and testing, model validation, documentation, and dissemination. The completion of this project will enable fire departments, cities, counties, and fire districts to design an acceptable level of resource deployment based upon community risks and service provision commitment. Following is the interim report for year 2 of the study.

Background

The fire service in the United States has a proud tradition of service to community and country dating back over 400 years (Hashagan 1998). While the nature of the fire service has changed dramatically in sophistication, techniques, and scope over the years, the fire service always remains committed to a core mission of protecting lives and property from the effects of fire. In 2007, U.S. municipal fire departments responded to an estimated 1,557,500 fires. These fires killed 3,430 civilians (non-firefighters) and contributed to 17,675 reported civilian fire injuries. Direct property damage was estimated at \$14.6 billion dollars. One hundred and two (102) firefighters died in the line-of-duty (Karter, 2007). In 2006, the total cost of fire in the United States was approximately \$280 billion (Hall, 2006). Every statistical analysis of the fire problem in the United States identifies residential structure fires as a key component in firefighter and non-firefighter deaths, as well as direct property loss.

It is a primary goal of the United States Fire Administration to achieve a 25% reduction in firefighter deaths in five years and a 50% reduction in firefighter fatalities in ten years (USFA, 2004). Firefighter fatalities occur during varied areas of the job including on scene operations, responding or returning from a call, training and other assigned tasks. Inherent to each of these arenas are notable risks that may be identifiable and preventable.

Further, the scope of fire service activity has increased in recent years. Notably, more fire department resources are committed to emergency medical service (EMS) calls every year. Though not considered in the current study, the fire service is often tasked to lead or contribute to the mitigation of natural disasters, hazardous materials incidents, and terrorism. Whether current resource allocations match existing service commitments remains unclear, due primarily to a lack of scientifically-based analytical tools.

Despite the magnitude of the fire problem in the United States, there are no scientifically-based tools available to community and fire service leaders to assess the effects of prevention, deployment, and staffing, decisions. Presently, community and fire service leaders have a qualitative understanding of the effect of certain resource allocation decisions. For example, as a decision to double the number of firehouses, apparatus, and firefighters would likely result in a decrease in community fire losses, while cutting the number of firehouses, apparatus, and firefighters would likely yield an increase in the community fire losses. However, decision-makers lack a sound basis for quantifying the total economic benefit of more fire resources or the number of firefighter and non-firefighter lives saved or injuries prevented.

Studies on adequate deployment of resources are needed to enable fire departments, cities, counties, and fire districts to design an acceptable level of resource deployment based upon community risks and service provision commitment. These studies will assist with strategic planning and municipal and state budget processes. Additionally, as resource studies refine data collection methods and measures, subsequent research and improvements to resource deployment models will have a sound scientific basis. Annual cost assessment indicates that

the cost benefit for this project will be \$33 per department or \$.88 per firefighter, based on fire department data from Karter (2006).

Purpose of the Study

This project in firefighter safety and deployment of resources seeks to enable fire departments and city/county managers to make sound decisions regarding optimal resource allocation and service based upon scientifically-based community risk assessment, safe, efficient and effective emergency response system design, and the local government's service commitment to the community.

Scope of Research

The scope of year one research on this project was focused on producing a scientifically-based resource allocation model based upon an international search of the published literature and expert elicitation. The model is useful for analysis of the impact of existing and alternative prevention and mitigation strategies at the station or fire department level. Model development was followed by the production and testing of web-based fire department surveys designed to collect data on the department level, the station level, and the incident level. Participating departments were selected using a two-stage stratified probability sampling methodology. Selected departments have signed onto the study and completed a department level survey. The reader should note that this report is a status report covering year two of a three-year, multi-phase study. As year two and year three research progresses, it is likely that some of the information contained within this report will change. The focus of year two is to generate survey data to provide the technical basis for modeling equations and to conduct field experiments to develop an in-depth understanding of deployment analysis. Year three will deliver the results to the fire service through software development, model verification and testing, documentation and dissemination.

Year Two Research Overview

The research in year two comprises four primary tasks: laboratory fire experiments, field tests for residential fire suppression, field tests for EMS ALS response and on scene intervention, and survey data analysis. This progress report will focus on recent developments with the experimental program. Future progress reports will document developments with the survey analysis as data becomes available.

Laboratory Experiments

The deployment and fire suppression experiments consist of two distinct phases: laboratory experiments and field experiments. The purpose of the laboratory experiments was to characterize the burning behavior of the wood pallets as a function of:

- number of pallets and the subsequent peak heat release rate,
- compartment effects on burning of wood pallets,
- effect of window ventilation on the fire, and
- effect on fire growth rate of excelsior loading configuration.

Design and Construction

Figure 1 shows the experimental configuration for the compartment pallet burns. Two identically-sized compartments (3.66 m x 4.88 m x 2.44 m) were connected by a hallway (4 m x 1 m x 2.4 m). At each end of the hallway, a single door connected the hallway to each of the compartments. In the burn compartment, a single window (3 m x 2 m) was initially closed with non-combustible board and opened at the end of each test to extinguish the remaining burning material and to remove any debris prior to the next test. In the second compartment, a single doorway connected the compartment to the rest of the test laboratory. It was kept open throughout the tests allowing the exhaust to flow into the main collection hood for measurement of heat release rate.

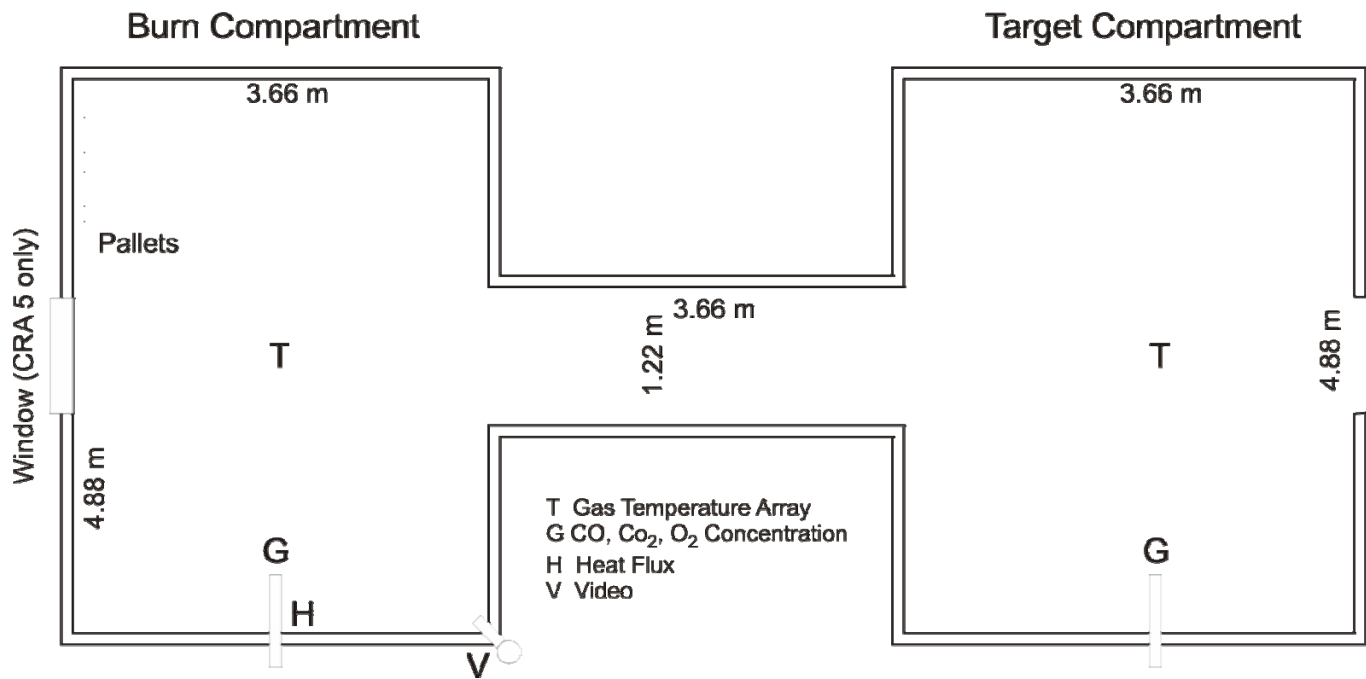


Figure 1. Compartment Configuration and Instrumentation for Pallet Tests

The structure was constructed of two layer of gypsum wallboard over steel studs. The floor of the structure was lined with two layers of gypsum wallboard directly over the concrete floor of the test facility. In the burn compartment, an additional lining of cement board was placed over the gypsum walls and ceiling surfaces near to the fire source to minimize fire damage to the structure after multiple fire experiments. A doorway 0.91 m wide by 1.92 m tall connected the burn compartment to the hallway and an opening 1 m by 2 m connected the hallway to the target compartment. Ceiling height was 2.41 m throughout the structure.

Fuel Source

The fuel source for all of the tests was recycled hardwood pallets constructed of several lengths of hardwood boards nominally 83 mm wide by 12.7 mm thick. Lengths of the individual boards ranged from nominally 1 m to 1.3 m. The finished size of a single pallet was approximately 1 m by 1.3 m by 0.11 m. Figure 2 shows the fuel source for one of the tests including six stacked pallets and excelsior ignition source. As an ignition source, excelsior (slender wood shavings typically used as packing material) was placed within the pallets, with the amount and location depending on the ignition scenario. Figure 3 shows the pallets prior to a slow and a fast ignition scenario fire. Table 1 details the total mass of pallets and excelsior for each of the free burn and compartment tests.

Experimental Conditions

The experiments were conducted in two series. In the first series, heat release measurements were made under free burn conditions beneath a 6 m by 6 m hood used to collect combustion gases and provide the HRR measurement. A second series of tests was conducted with the fire in a compartmented structure to assess environmental conditions within the structure during the fires and determine the effect of the compartment enclosure on the fire growth. A summary of the tests conducted is shown in Table 1.



Figure 2. Pallets and Excelsior Ignition Source Used as a Fuel Source

Table 1. Tests Conducted and Ambient Conditions at Beginning of Each Test

Test	Test Type	Number of Pallets	Ignition Scenario	Total Pallet Mass (kg)	Excelsior Mass (kg)	Ambient Temperature (°C)	Relative Humidity (%)
PAL 1	Free burn	4	Fast	79.3	8.1	13	<5
PAL 2	Free burn	6	Fast	118.8	15.1		
PAL 3	Free burn	8	Fast	146.7	16.2	13	13
PAL 4	Free burn	4	Slow	51.0	1.65	14	13
PAL 5	Free burn	6	Slow	160.3	0.85		
CRA 1	Compartment	6	Slow	114.0	0.83		
CRA 2	Compartment	4	Slow	69.7			
CRA 3	Compartment	4	Fast	71.1	0.8		
CRA 4	Compartment	4	Slow	73.9	0.83		
CRA 5	Compartment	4	Slow	73.8	0.85		



Figure 3. Fuel and Excelsior Source for Slow (left) and Fast (right) Ignition Scenarios

Measurements Conducted

Heat release rate was measured in all tests. HRR measurements were conducted under the 3 m by 3 m calorimeter at the NIST Large Fire Research Laboratory. The HRR measurement was based on the oxygen consumption calorimetry principle first proposed by Thornton¹ * and developed further by Huggett² and Parker³. This method assumes that a known amount of heat is released for each gram of oxygen consumed by a fire. The measurement of exhaust flow velocity and gas volume fractions (O₂, CO₂ and CO) were used to determine the HRR based on the formulation derived by Parker³ and Janssens⁴. The combined expanded relative uncertainty of the HRR measurements was estimated at $\pm 14\%$, based on a propagation of uncertainty analysis⁵.

For the compartment fire tests, gas temperature measurements were made in the burn compartment and in the target compartment connected by a hallway to the burn compartment using 24 gauge bare-bead chromel-alumel (type K) thermocouples positioned in vertical array. Thermocouples were located at the center of each compartment at locations 0.03 m, 0.30 m, 0.61 m, 0.91 m, 1.22 m, 1.52 m, 1.83 m, and 2.13 m from the ceiling. The expanded uncertainty associated with a type K thermocouple is approximately $\pm 4.4\text{ }^{\circ}\text{C}$ ⁶.

Gas species were continuously monitored in the burn compartment at a level 0.91 m from the ceiling at a location centered on the side wall of the compartment, 0.91 m from the wall. Oxygen was measured using paramagnetic analyzers. Carbon monoxide and carbon dioxide were measured using non-dispersive infrared (NDIR) analyzers. All analyzers were calibrated with nitrogen and a known concentration of gas prior to each test for a zero and span concentration calibration. The expanded relative uncertainty of each of the span gas molar fractions is estimated to be $\pm 1\%$.

Total heat flux was measured on the side wall of the enclosure at a location centered on the side wall, 0.61 m from the ceiling level. The heat flux gauges were 6.4 mm diameter Schmidt-Boelter type, water cooled gauges with embedded type-K thermocouples. The manufacturer reports a $\pm 3\%$ expanded uncertainty in the response calibration (the slope in $\text{kW}/\text{m}^2/\text{mV}$). Calibrations at the NIST facility have

* Numbers refer to literature references listed at the end of the document.

varied within an additional $\pm 3\%$ of manufacturer's calibration. For this study, an uncertainty of $\pm 6\%$ is estimated.

Results

Table 2 shows the peak HRR and time to peak HRR for the free-burn tests and for the compartment tests. Figure 4 includes images from the free-burn experiments near the time of peak HRR for each of the experiments. Figure 5 illustrates the progression of the fire from the exit doorway looking down the hallway to the burn compartment for one of the tests. Figure 6 to Figure 9 present graphs of the heat release rate for all of the tests. Figure 10 through Figure 14 shows the gas temperature, major gas species concentrations, and heat flux in the burn compartment and target compartment in the five compartment tests.

Table 2. Peak Heat Release Rate During Several Pallet Tests in Free-burn and in a Compartment

Test	Test Type	Number of Pallets	Ignition Scenario	Peak HRR (kW)	Time to Peak HRR (s)
PAL 1	Free burn	4	Fast	2144	205
PAL 2	Free burn	6	Fast	2961	320
PAL 3	Free burn	8	Fast	3551	301
PAL 4	Free burn	4	Slow	1889	385
PAL 5	Free burn	6	Slow	2410	986
CRA 1	Compartment	6	Slow	1705	1102
CRA 2	Compartment	4	Slow	1583	649
CRA 3	Compartment	4	Fast	1959	159
CRA 4	Compartment	4	Slow	1620	775
CRA 5	Compartment	4	Slow	1390	927



PAL 1



PAL 2



PAL 3



PAL 4



PAL 5

Figure 4. Free-burn Experiments Near Time of Peak Burning



Figure 5. Example Fire Progression from Test CRA 1

Slow Ignition Scenario

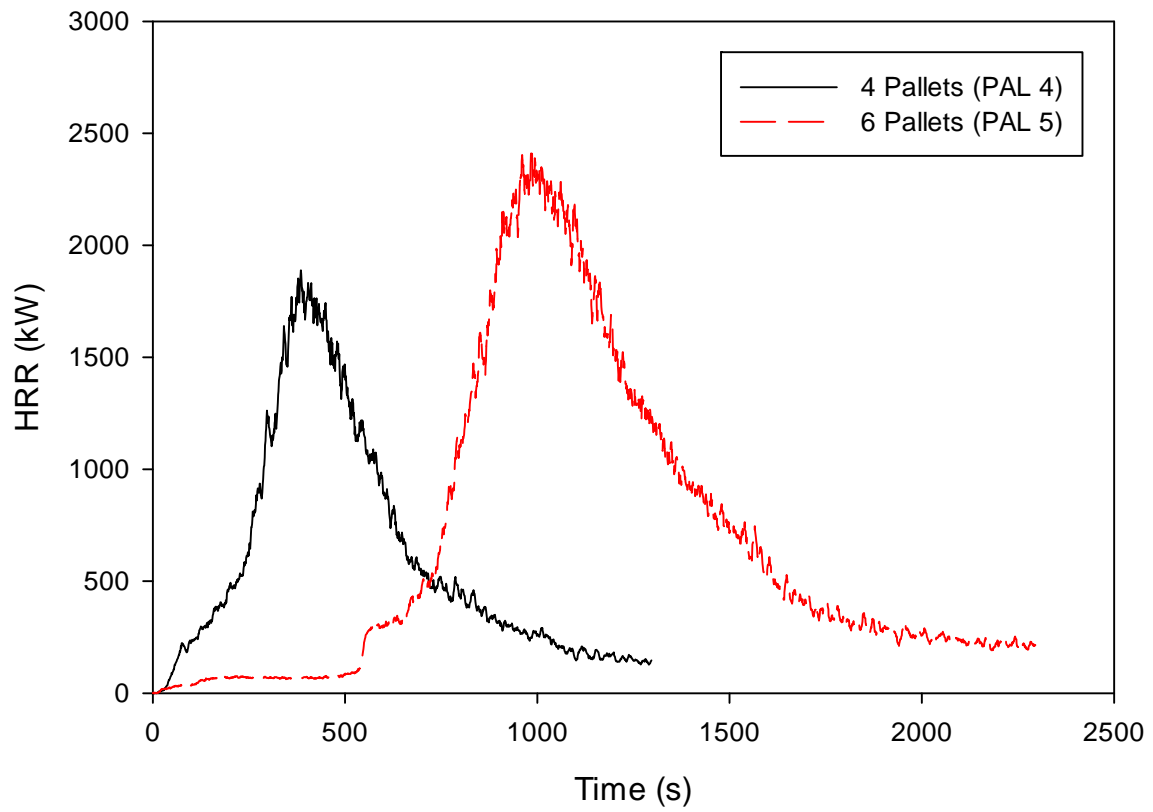


Figure 6. HRR, Slow Ignition, Free Burn Scenario

Fast Ignition Scenario

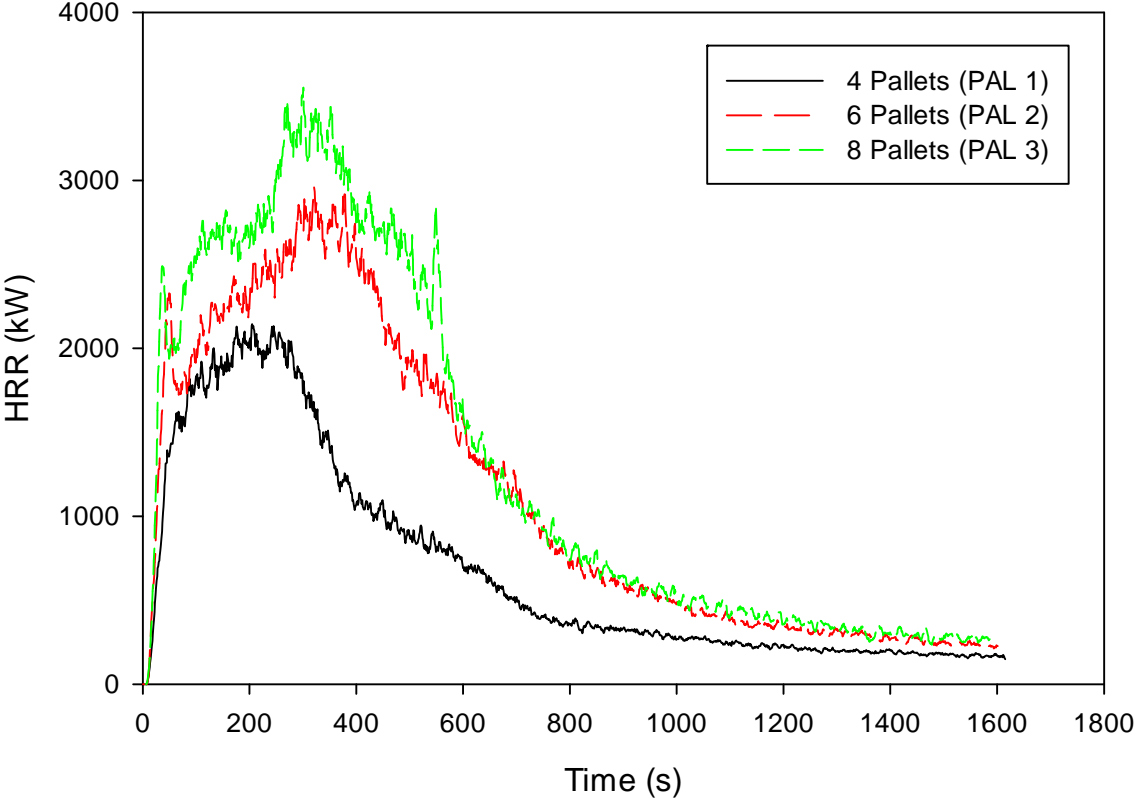


Figure 7. HRR, Fast Ignition, Free Burn Scenario

Slow Ignition Scenario

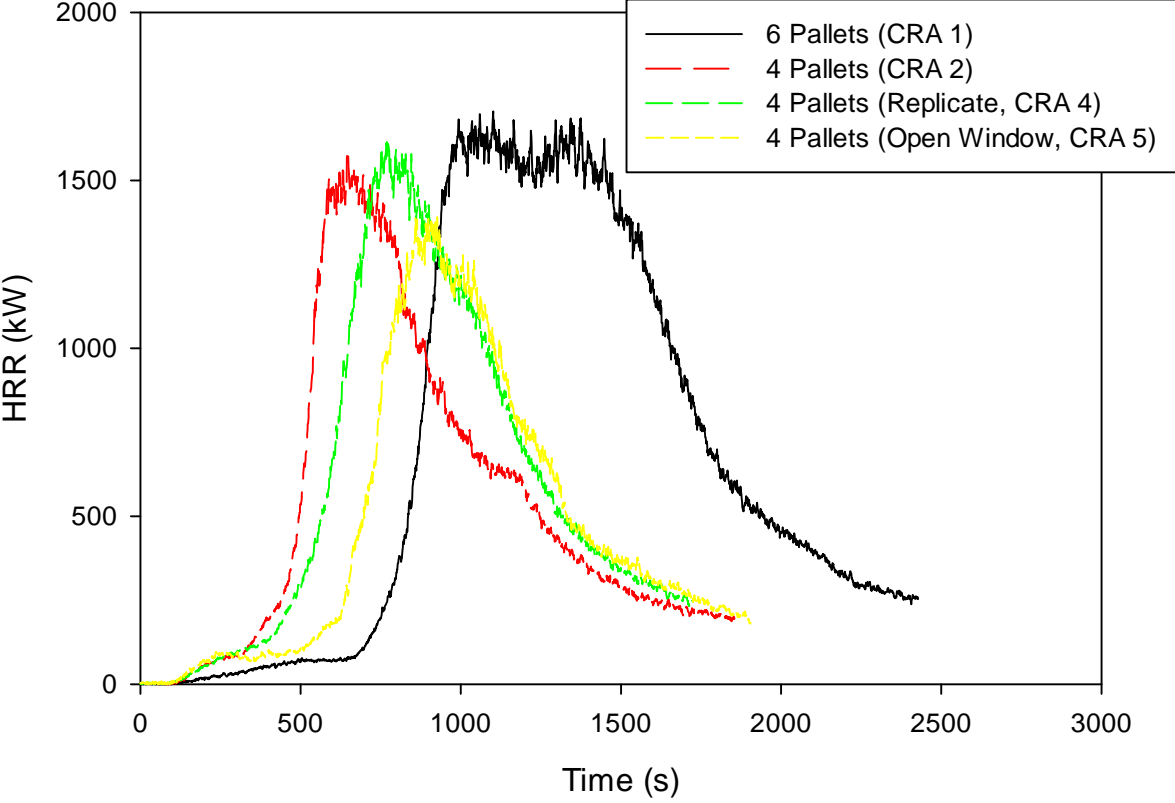


Figure 8. HRR, Slow Ignition, Compartment Test

Fast Ignition Scenario

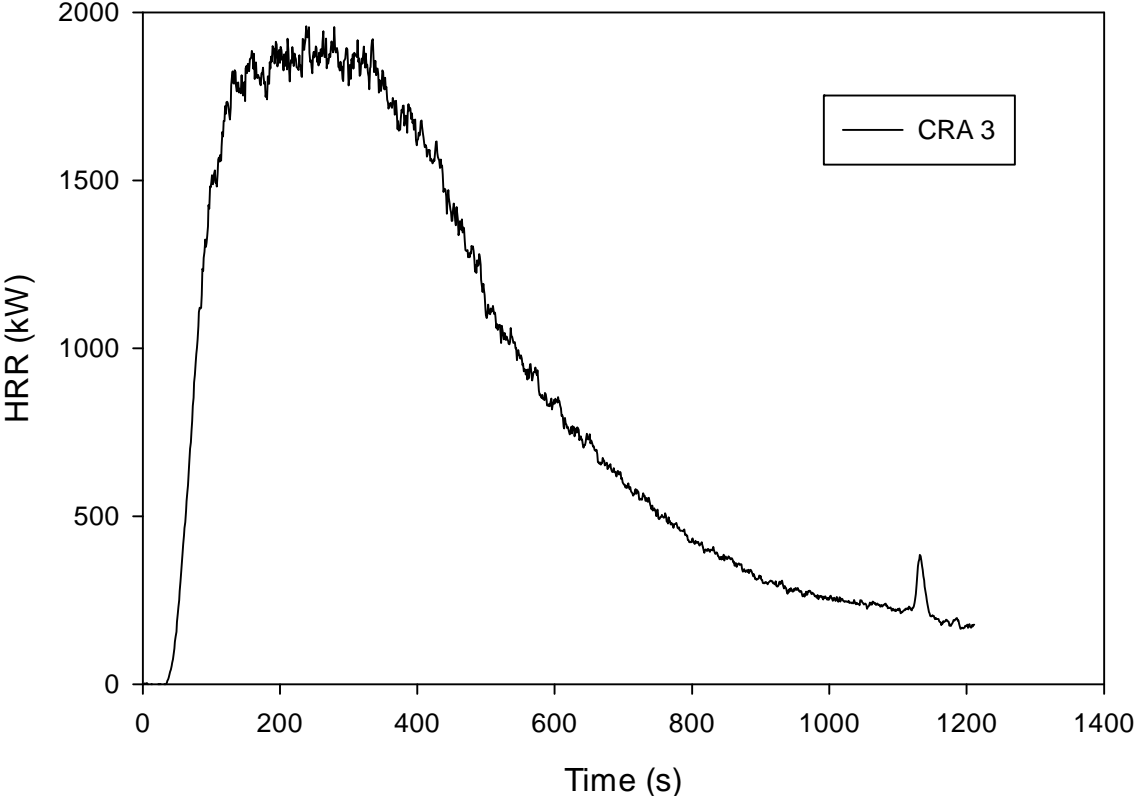


Figure 9. HRR, Fast Ignition, Compartment Test

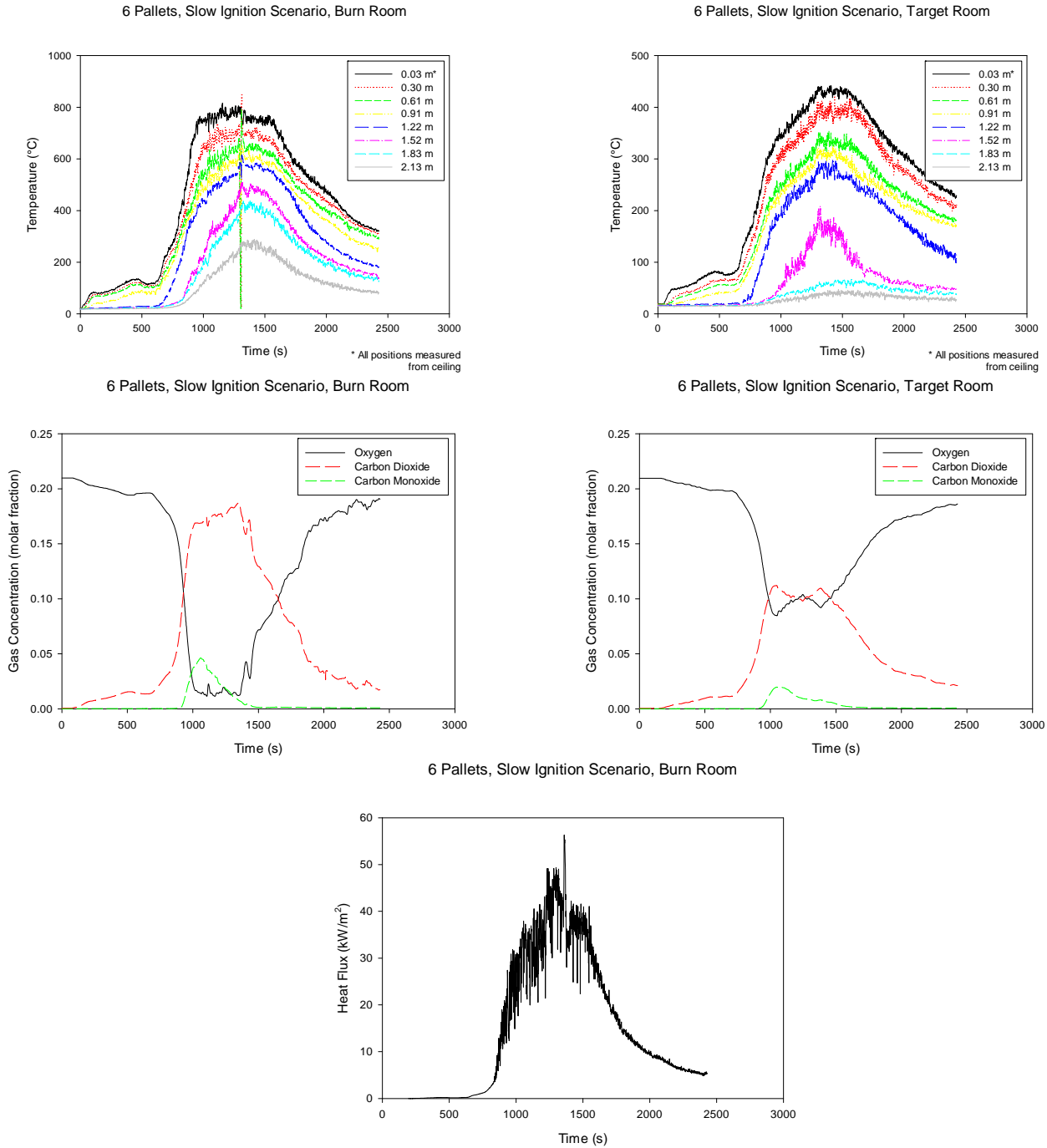


Figure 10. Temperature, Gas Concentration, and Heat Flux During Test CRA 1, 6 Pallets, Slow Ignition Scenario

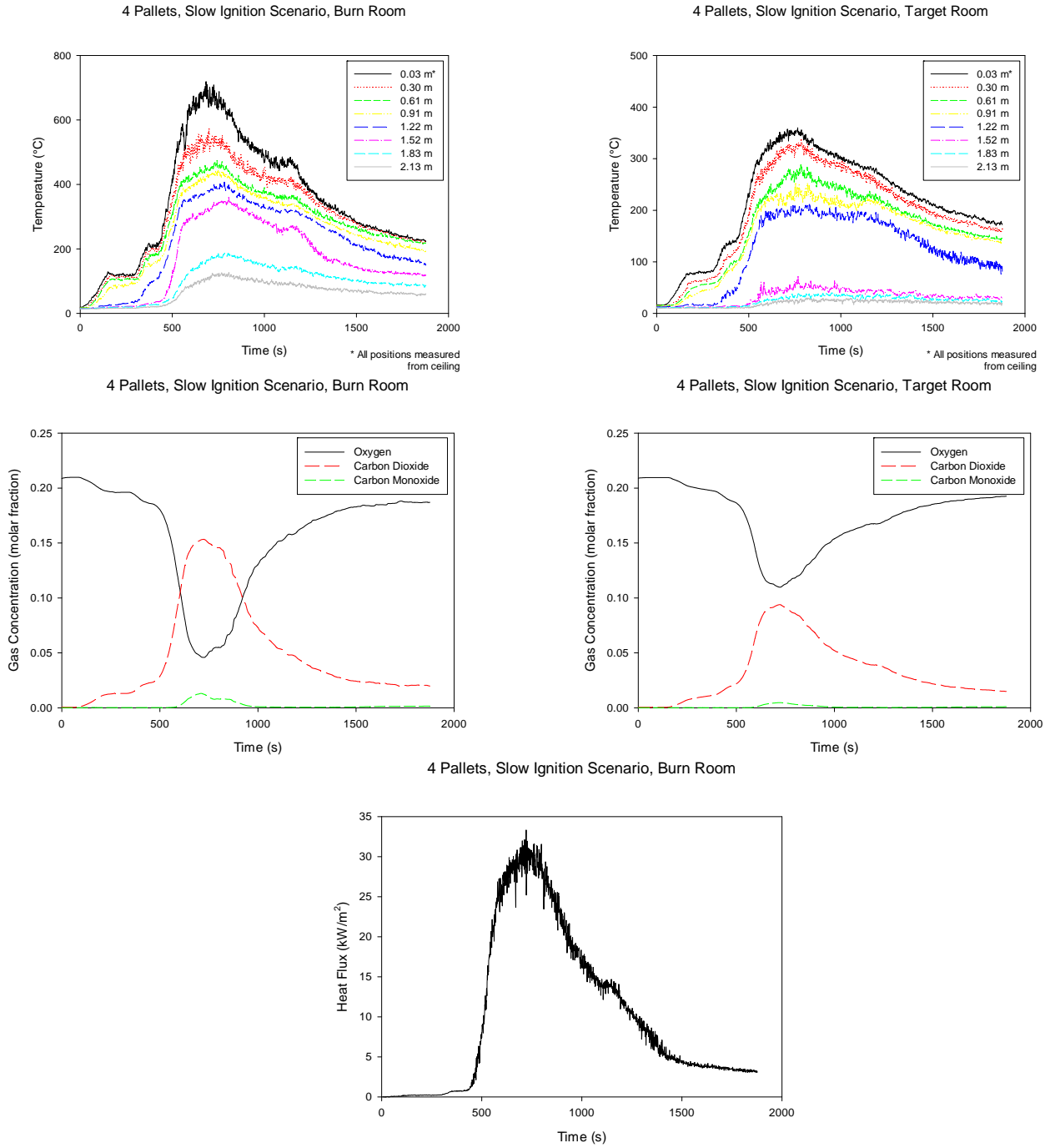
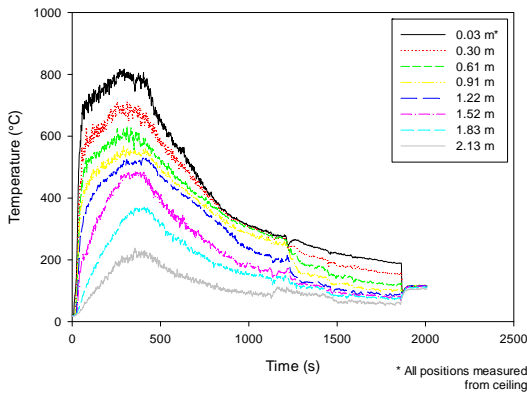
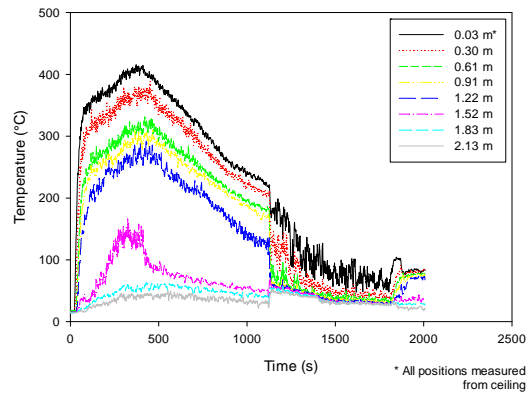


Figure 11. Temperature, Gas Concentration, and Heat Flux During Test CRA 2, 4 Pallets, Slow Ignition Scenario

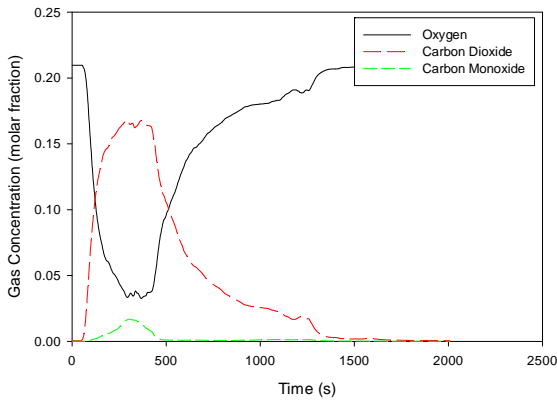
4 Pallets, Fast Ignition Scenario, Burn Room



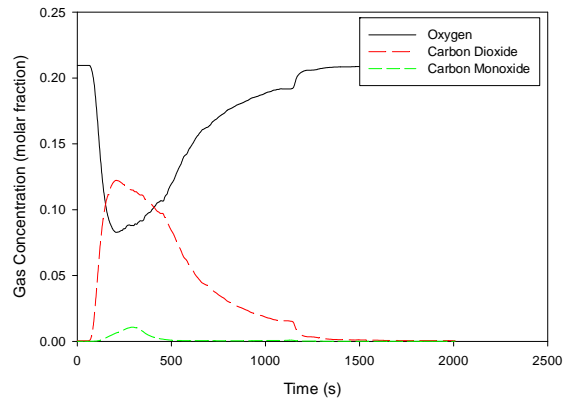
4 Pallets, Fast Ignition Scenario, Target Room



4 Pallets, Fast Ignition Scenario, Burn Room



4 Pallets, Fast Ignition Scenario, Target Room



4 Pallets, Fast Ignition Scenario, Burn Room

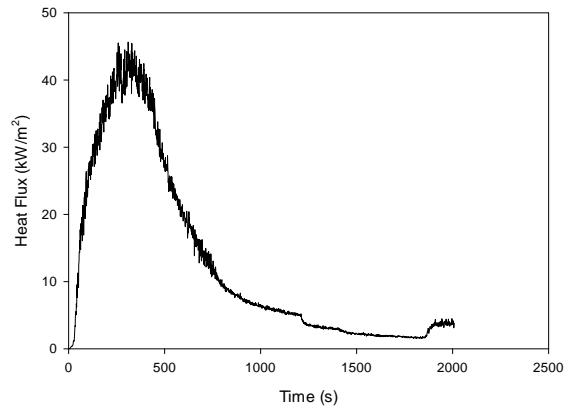
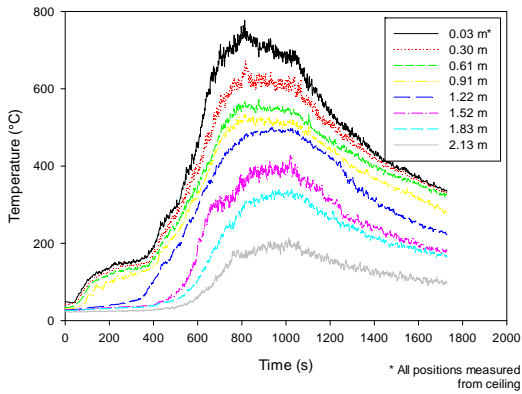
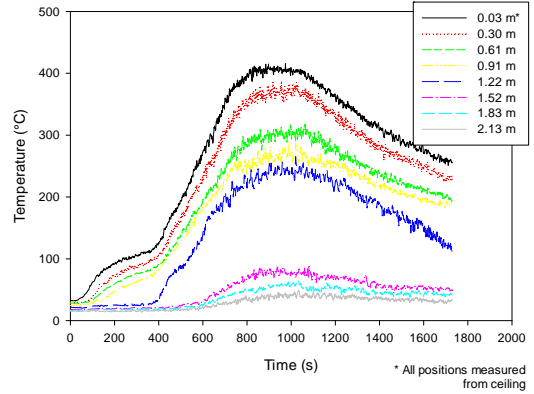


Figure 12. Temperature, Gas Concentration, and Heat Flux During Test CRA 3, 4 Pallets, Fast Ignition Scenario

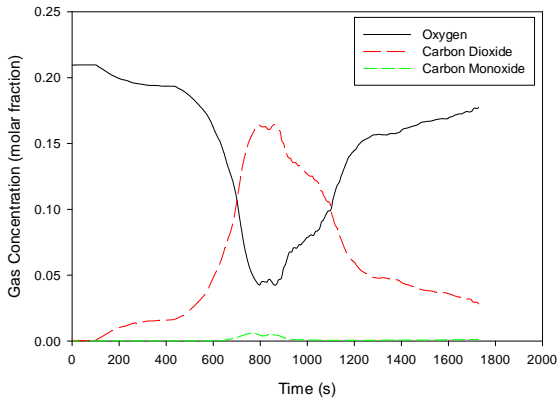
4 Pallets, Slow Ignition Scenario, Burn Room
(Replicate)



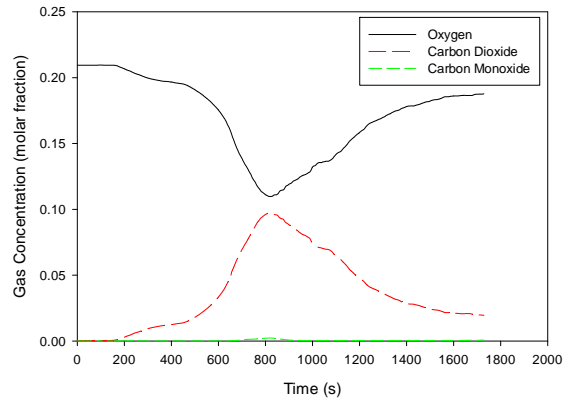
4 Pallets, Slow Ignition Scenario, Target Room
(Replicate)



4 Pallets, Slow Ignition Scenario, Burn Room
(Replicate)



4 Pallets, Slow Ignition Scenario, Target Room
(Replicate)



4 Pallets, Slow Ignition Scenario, Burn Room
(Replicate)

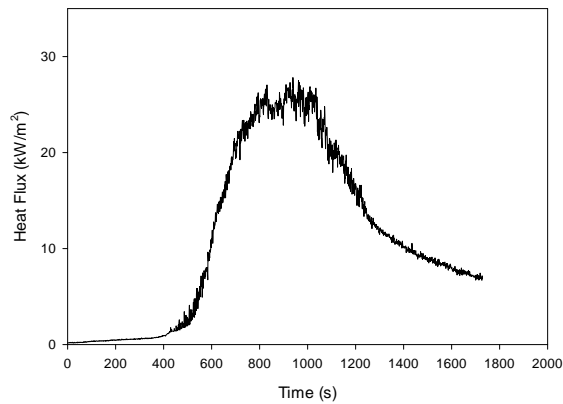
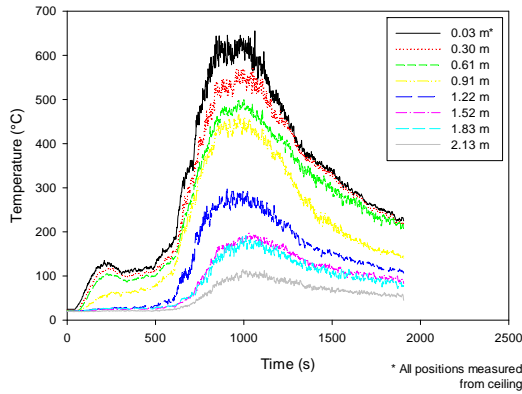
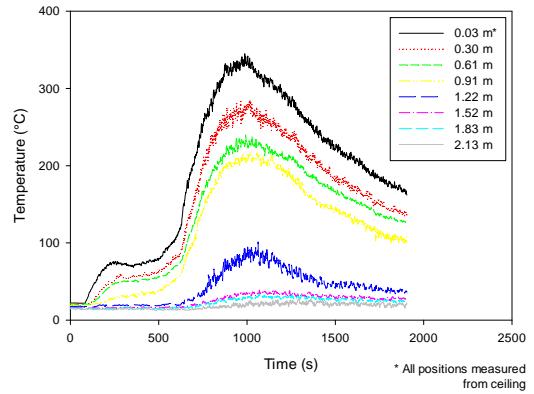


Figure 13. Temperature, Gas Concentration, and Heat Flux During Test CRA 4, 4 Pallets, Slow Ignition Scenario (Replicate)

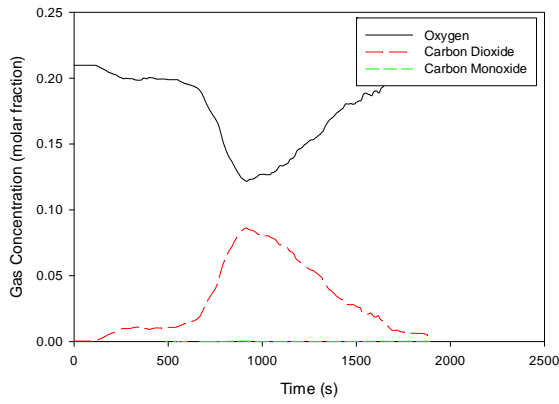
4 Pallets, Slow Ignition Scenario, Burn Room
(Open Window Venting)



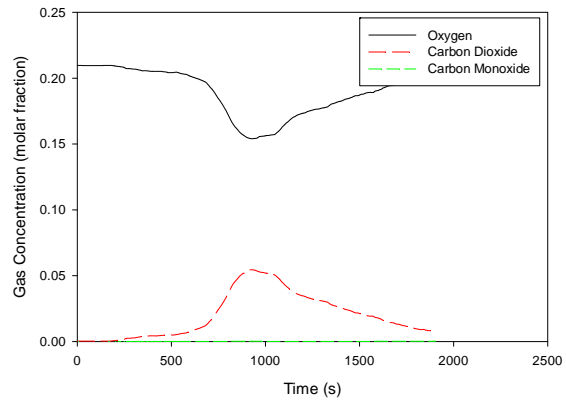
4 Pallets, Slow Ignition Scenario, Target Room
(Open Window Venting)



4 Pallets, Slow Ignition Scenario, Burn Room
(Open Window Venting)



4 Pallets, Slow Ignition Scenario, Target Room
(Open Window Venting)



4 Pallets, Slow Ignition Scenario, Burn Room
(Open Window Venting)

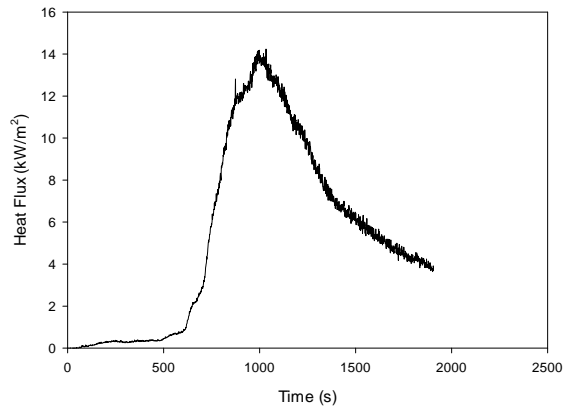


Figure 14. Temperature, Gas Concentration, and Heat Flux During Test CRA 5, 4 Pallets, Slow Ignition Scenario (Open Window Venting)

Fire Modeling

Based upon the results of the laboratory experiments, the project team determined that four pallets would provide both a realistic fire scenario, as well as a repeatable and well-characterized fuel source. Varying the placement and quantity of excelsior provided significant variance in the rate of fire growth. Prior to finalization of the fuel package and construction specifications, modeling was used to ensure that the combination of fuel and residential geometry would result in untenable conditions throughout the structure without subjecting the fire service participants to unsafe testing conditions. Therefore, CFAST (the consolidated fire and smoke transport model⁷) and FDS (fire dynamics simulator model⁸) were used to predict the temperatures and toxic species within the structure as a function of the experimentally-determined heat release rates. The results summarized below confirmed that the building geometry and fuel package produced adequate variation in tenability conditions in the residential structure, ensured that the room of origin would not reach flashover conditions (a key provision of NFPA 1403.⁹

Tenability Assessment

Fire department response has two primary objectives: preservation of life and property. The field experiments will evaluate the effectiveness of different response configurations on both of these objectives, with particular focus on the interior tenability conditions within an NFPA 1710-style residential structure.¹⁰ See the section entitled *Field Experiments* for a further discussion of the temporary burn prop.

Design of the fire field experiments requires a balance between two competing objectives: potential to create untenable conditions throughout the structure while ensuring the environment does not create undue hazard to the firefighters. Therefore, NIST used the Fire Dynamics Simulator model to simulate the thermal and gaseous conditions throughout the residential structure as a function of the fires determined in the Large Fire Laboratory experiments described above.

Table 3: Time dependent temperature contours in field structure with fast growth fire

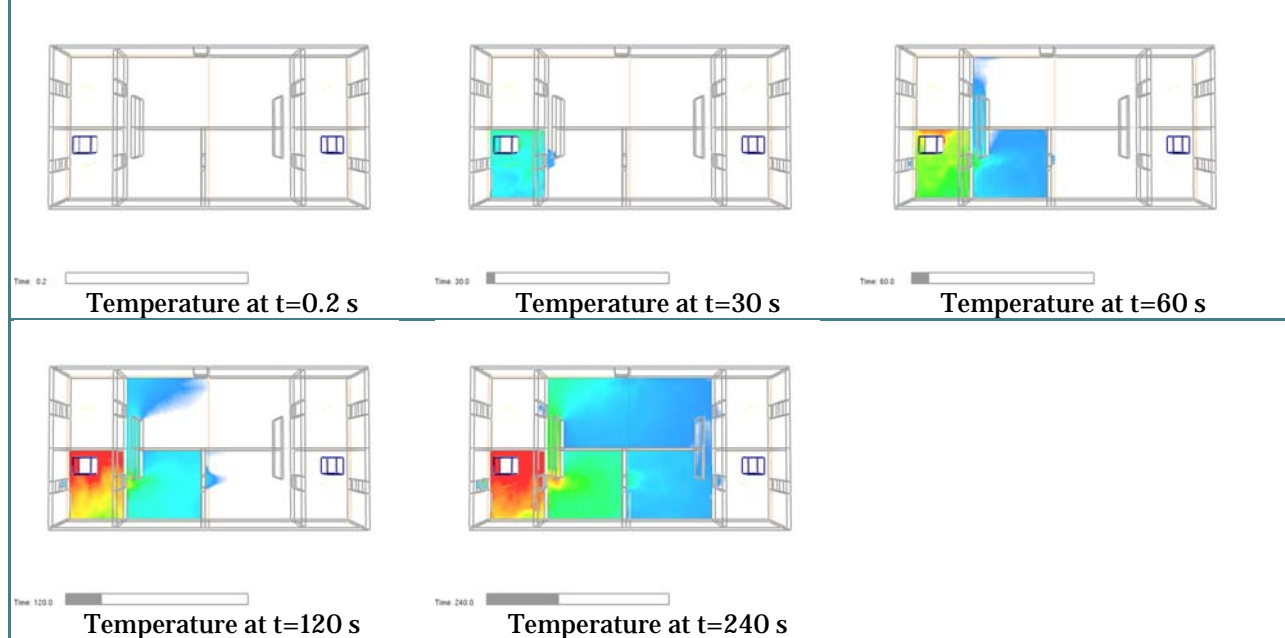
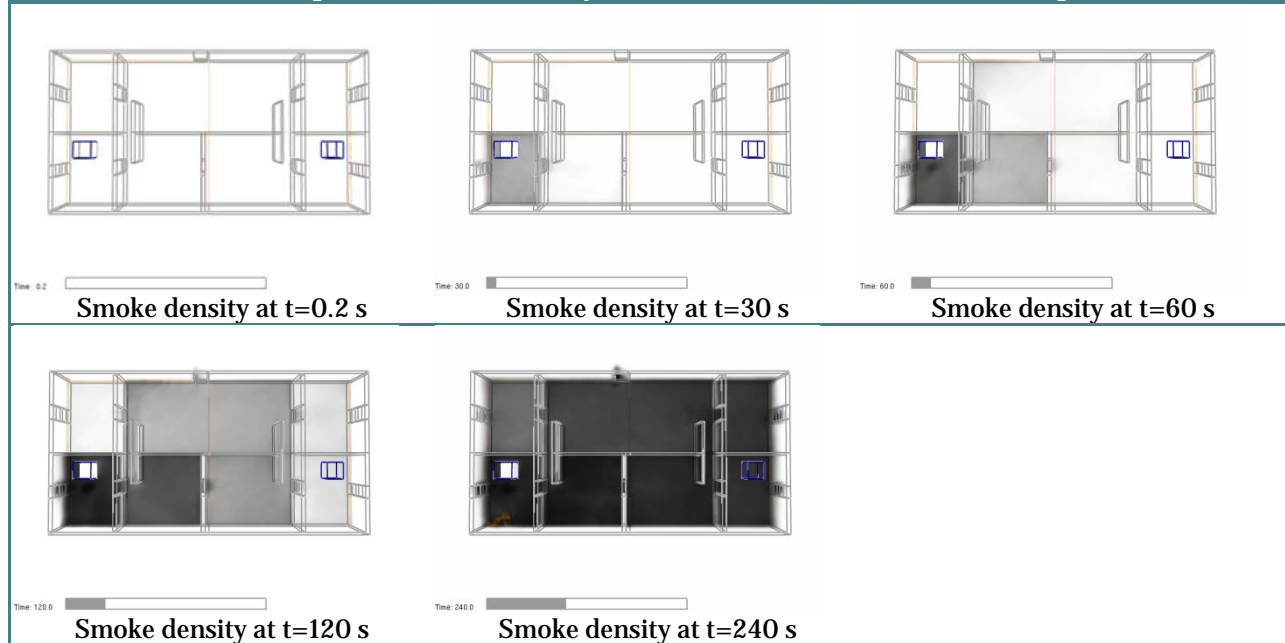


Table 4: Time dependent smoke density contours in field structure with fast growth fire



The results of the fire modeling indicate development of untenable conditions in the field experiments between 5 and 15 minutes, depending upon several factors: fire growth rate, ventilation conditions, and the total leakage of heat into the building and through leakage paths. This time frame will allow differentiation of the effectiveness of various fire department response characteristics.

Field Experiments

The temporary burn prop is a typical single-level, two-thousand square foot detached residential building. As shown in Figure 15, there are four bedrooms, each 12 ft by 16 ft. In the center of the structure are living and dining areas, as well as a kitchen.

The building has bilateral symmetry about the short axis in order to allow two tests per day to be conducted by allowing clean up from the first test to occur simultaneous to the preparations for the second test. This will also help to ensure that the firefighters will not know that the fire is always located in a single room within the structure.

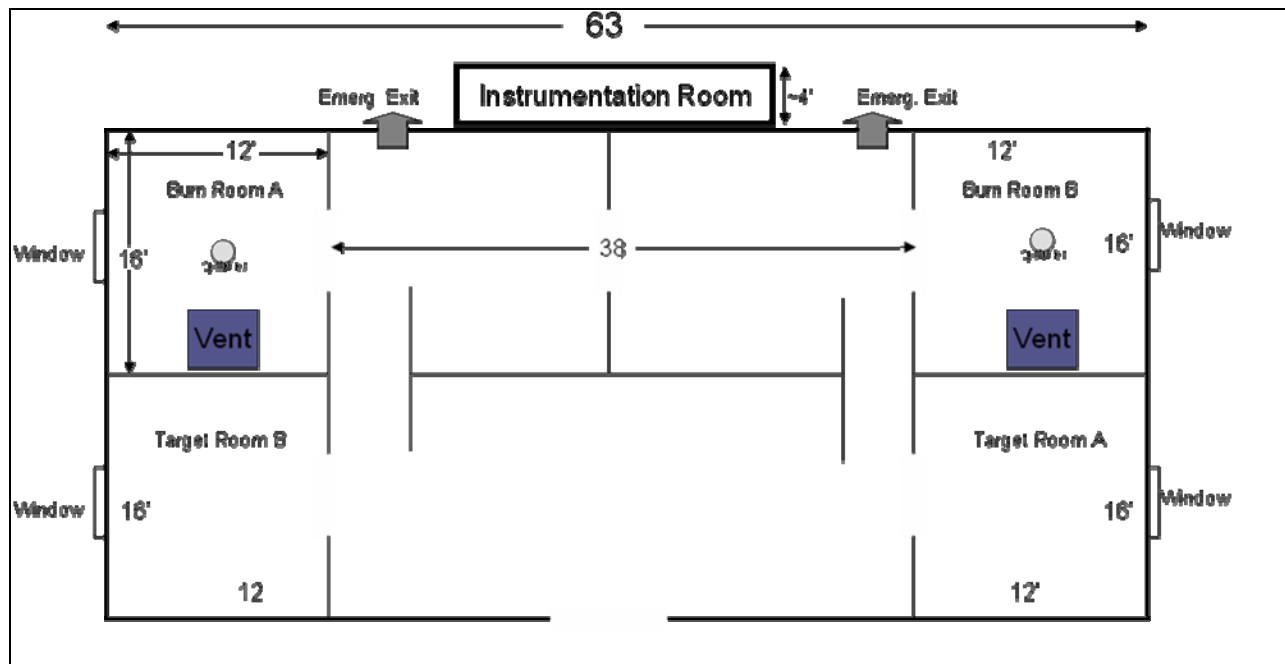


Figure 15: Schematic of the temporary burn prop

Field Site

Through the generosity of the Montgomery County (MD) Fire and Rescue Department, a field site was donated at the Montgomery County Fire and Rescue Training Facility in Montgomery County, MD. A temporary burn prop is presently under construction near an existing live fire training building. The selected site has ready access to all necessary water, electrical, and support facilities.

Instrumentation

Inside the burn structure, the focus of the data collection instrumentation will be to measure the tenability of the environment throughout the structure. The occupants can be injured thermally (temperature or heat flux injuries), by inhalation of toxic gases (oxygen depletion or elevated carbon monoxide or carbon dioxide), or loss of visibility due to the concentration of smoke particulate. Table 5 identifies the measurement techniques which will be used to assess tenability within the burn structure. As shown

in Figure 15, each of these conditions will be monitored in the burn room as well as a remote target room in order to assess the likelihood of occupants surviving the particular fire and fire department response scenario.

Table 5: Measurement methods for fire field experiments

Tenability Parameter	Measurement Method
Temperature	Thermocouples (Type K)
Oxygen	Paramagnetic analyzer
Carbon Monoxide	Non-dispersive infrared analyzer
Carbon Dioxide	Non-dispersive infrared analyzer
Smoke	Laser attenuation
Heat flux	Schmidt-Boelter type heat flux gauge

External to the burn structure, the primary variable of interest is the arrival and movement of fire department personnel. Fire department personnel will be recorded by video using several high-mounted video cameras which will allow analysis of the fire scene from a ‘birds-eye’ perspective. Time to task for individuals will be captured by experimental personnel trained to observe and records specific actions. The video will provide redundant quality-control mechanism. Floor-level video water-cooled cameras will also be located inside the structure in order to capture primary search and rescue, as well as suppression activities.

Safety Protocols

Firefighter safety is the primary goal of both the research program, as well as the experimental protocols. Fairfax County, VA and Montgomery County, MD department officers have provided copies of the safety protocols under which they conduct live fire testing for their staff and recruits, each compliant with the provisions of NFPA 1403.

Several safety features have been built-in to the field structure to complement the requirements of NFPA 1403. Remotely-activated roof vents in the room of fire origin will enable the site commander to vent heat and smoke quickly. A deluge sprinkler system oriented to the known location of the fuel package can be remotely activated for rapid fire suppression. All rooms are provided with direct access to the exterior of the building through either doors or windows.

Field Experiment: Basic Assumptions as Determined by Technical Advisors

Following are the assumptions to be used for all fire suppression field experiments.

- Personnel will don full SCBA with integrated PASS device prior to entering an IDLH atmosphere.
- Personnel will wear Full Protective Clothing while in an IDLH atmosphere.

- First arriving company officers will provide on-scene report
- All field experiments will comply with NFPA 1403 and relevant OSHA regulations including '2-in-2-out' regulation.
- A 'GONG' mechanism will be put in place for any unsafe behavior during the exercise.
- A 'Mayday' procedure will be established for actual mishap
- The environment will be a one story single family residential dwelling approximately 2000 sq. ft. in size.
- There will be no victim during the exercise therefore NO notification of life-safety issue.
- The experiments will be for fire suppression and extend until 'fire knock-down'. There will be no salvage or overhaul operation.
- No thermal imaging cameras will be used.
- The Pump operator must remain at the engine when flowing water.
- Safety officer will be assigned within the study pursuant to NFPA 1710 An additional 'Study' Safety Officer will be established to monitor the study overall and will not be part of the study tasks. (pursuant to NFPA 1403)
- All vehicles and props used in the experiments will have specific positioning to assure consistency in the experiments
- Training Protocols and study briefing will be standardized for all participants.
- Equipment will be standardized on all responding apparatus for the tasks that are to be completed for the experiment.
- Maintain fire in room of origin for all experiments.
- Company response and scene arrival will be staggered based on geographical information system (GIS) assessment of actual departments that deploy companies of the sizes under study. Study companies will be deployed according to response intervals calculated in GIS assessment.

Master Task List (On Scene Arrival)

- 1) Assume Command and provide on-scene report
- 2) Establish uninterrupted water supply (400GPM minimum)
- 3) 4 inch supply line for each evolution
- 4) Establish Initial RIT Team (2 out)
- 5) Deploy and extend attack line (size and length)
- 6) Gain Entry/Secure Egress (ground ladders considered for egress)
- 7) Initial Fire Attack
- 8) Search & Rescue
 - Primary
 - Secondary
- 9) Ventilation
 - Natural
 - Forced
- 10) Deploy and extend Backup Line
- 11) Secure and control Utilities
- 12) Check for Fire Extension

Detailed Master Task List

- 1) Assume Command, Provide an Initial On-scene Size Up Report
 - Arrive at scene
 - Conduct size-up @ scene
 - Transmit an initial on scene size up report and establish command
 - Develop and communicate an Incident Action Plan
 - Instruct Crew members concerning tasks
 - Maintain continuous command (see notes on first arriving engine)
- 2) Provide uninterrupted water supply (400 GPM minimum – this is for attack 150 and 2.5 inch back up 250) A single 4 inch water supply meets this objective for supply. An 1 ¾ will be used for the initial attack line and a 2 inch back up
- 3) Stop apparatus just past hydrant
 - Pull 4” supply line and gear
 - the first driver just stops and wraps the line and then moves to the fire... NO FF gets off engine and the walks to the fire... the driver on the second engine connects supply line
 - Drive truck to tactical position – spot engine
 - Connect supply line to hydrant & charge
 - Clamp then break supply line off back of truck –
 - Connect supply line to intake on engine
 - Driver puts pump in gear (prior to leaving the seat)
 - Deploy and extend Attack Line
 - Pull
 - Flake
 - Charge
 - Bleed

- Enter when IRIT established
 - Locate fire and extend line
 - Officer gives status report
 - Scan search in fire area
 - Apply fire stream to fire
- 4) Establish initial RIT team (simultaneous with #5 below)
- Officer & Nozzle person are attack team
 - Pump operator & second FF available
 - Identify two people to be IRIT (dedicated)
 - (Proper PPE)
- 5) Gain Entry (simultaneous with 3,4 above)
- Establish (confirm) attack crew ready
 - Determine access capability
 - Obtain proper tools (if necessary)
 - Force (if necessary)
 - Secure egress
- 6) Search & Rescue (Primary)
- Complete primary search (as specified)
 - Complete search
 - Conduct secondary search

7) Ventilation

- Coordinate ventilation w/attack team
- Personnel takeout designated windows
- Follow up 2/ mechanical ventilation (2 persons)
 - Exhaust
 - Positive Pressure

8) Extend B/U Line -Pull B/U line from forward engine

- Flake
- Charge
- Bleed
- Enter at direction of IC (this line is left unattended but ready and will be available for the RIT/RIC or other crew)

9) Control Utilities

- Identify location of electricity/gas
- Eliminate flow of electricity/gas (if necessary)

POST KNOCKDOWN

10) Check Fire Extension

- Check Rooms/walls
- Pull Ceiling
- Check Attic

Conclusions

Overall, the year two project is making steady progress and is within budget. The laboratory experiments characterizing the fuel packages for the field experiments are complete. The planning, construction, and procurement process for the fire department deployment and suppression experiments is nearly complete. The schedule for the remaining work is shown below.

Schedule

Year two experimental tasks are on schedule to be completed in 2008. A report of tests will be released in early 2009, with a full report, including analysis, findings, and conclusions, to be released in summer 2009.

The EMS field experiments are presently scheduled to be completed in early 2009. Details of these experiments will be provided in a future progress report. A full report of these tests will be released in summer 2009, with a final report by September 30, 2009.

Details of the fire department survey work will be provided in a future progress report.

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⁵ Bryant, R. A., et al. *The NIST 3 Megawatt Quantitative Heat Release Rate Facility - Description and Procedure*. s.l. : Natl. Inst. Stand. Technol., 2004. NIST IR 7052.

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⁹ *NFPA 1403: Standard on Live Fire Training Evolutions*. National Fire Protection Association, Quincy, MA. 2007.

¹⁰ *NFPA 1710: Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments*. National Fire Protection Association, Quincy, MA. 2004.