Fire Detection in Warehouse Facilities

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Impetus

- FPRF Workshops conducted in 2009 and 2010
- Increasing challenges presented by modern warehouse facilities
  - Increased storage heights and areas,
  - Automated storage and retrieval systems (ASRS),
  - Limitations in available water supplies, and
  - Changes in firefighting strategies.
- Sprinklers primary installed fire protection with fire service response
- Evaluate fire detection to augment suppression system and fire service response

Overview of Project – Objectives

- Objective: To provide technical information to aid in the development of guidelines and standards for the use of fire detection technologies for modern warehouse fire protection.
- Phase I goals:
  - Assess the potential role for fire detection in modern warehouse facilities.
  - Develop a research plan to implement the overall project objective.

Approach

- Perform a literature review of warehouse fire protection
  - Characterize warehouse facilities
  - Analyze fire loss incidents
  - Identify potential detection technologies
  - Review existing detection research
- Perform a hazard analysis
- Identify information gaps and recommend future work

Warehouse Facilities and Fires

- Vast array of facilities (>600,000 in US)
- US:
  - 70% < 10,000 ft^2 in storage area
  - Over 50,000 > 50,000 ft^2
  - 15% > 20,000 ft^2 but 26% of fires
  - Heights >30-40 ft over 576,000 ft^2
  - With ASRS, storage may exceed 100 ft
- Detection present in 20–40% of all warehouse fire incidents (most often smoke detection or sprinkler water flow alarms)
- Suppression systems in 30–40% of warehouse fire incidents.

Warehouse Facilities and Fires

- Common causes were arson (13%) and failure of electrical equipment (14%), often starting in storage and shipping areas.
- Wood, paper, plastic, and fabrics were the materials most commonly ignited and contributed to the large fire loss events.
- Limited injuries and deaths due to warehouse fire events, primarily a property value issue

Destructive Fire Incidents

- New Orleans, 1996
  - 1 million ft^2 warehouse with 72 ft ceiling
  - Wicker baskets, rugs, pillows, cardboard, towels, plastic chairs and packaging
  - Fully operational sprinkler systems provide water flow alarm to fire department
  - Sprinkler containment ineffective due to distance between ceiling and storage (>50 ft)
  - After fire extinguished, sprinkler valves were secured, and power restored to ASRS which arced and re-ignited fire with no suppression available
  - Fire uncontrollable after re-ignition and building total loss

Destructive Fire Incidents

- South Carolina, 2007
  - 165,00 ft^2 warehouse with 38 ft ceiling
  - Plastic Tupperware in rack storage
  - Fully compliant and operational sprinkler systems
  - Fire department arrive to limited visibility due to smoke and sprinkler systems
  - De-activated sprinkler and increase ventilation to improve visibility
  - Fire grew out of control w/o sprinkler system and resulted in total loss

Destructive Fire Incidents

- Montana Tire Warehouse - 2009
  - No detection or suppression
  - Fire reported by passerby
  - $2 million
- Wisconsin Stacked Cardboard - 2010
  - No detection or suppression
  - Smoke reported by neighbor
  - $3.5 million
- Illinois Palletized Plastic Bottles - 2011
  - Water flow switch not monitored
  - Delayed fire department response
  - $1.5 million

Destructive Fire Incidents

- Fire incidents demonstrate
  - Suppression systems have not prevented several large warehouse fire incidents
    - Failed system operation
    - Improperly reported water flow or other detection alarm
    - Failure to contain fire growth
  - Fire department response is limited when arriving at the scene of a rapidly developing fire
    - Smoke reducing visibility
    - Heat preventing entry
    - Warehouse property (floor area, height, storage configuration and density) limit potential tactics
    - Protection of property not worthy of risking lives to enter

Warehouse Facilities and Fires

- Evaluation of large fire incidents: early warning notification of fire is often not-present or fails to provide the proper response to fire departments.
- Early warning refers to an alert or indication of the fire condition prior to potential sprinkler activation.

Detection Technologies

- Smoke, heat, and flame detection
- Smoke can include spot type, beam detectors, aspiration smoke detection, and video image smoke detection.
- Smoke detection often provides earliest warning of fires (heights can be an issue).
- Heat (spot and linear)
- Flame (OFD and VID)

Hazard Analysis

- Goal: To determine the potential for using detection equipment to reduce property damages in warehouse fires
  - Develop a range of warehouse designs and fire scenarios
  - Determine potential for fire detection to improve fire department impact on fire control and extinguishment

Investigated Parameters

- Warehouse height (15, 40, and 100 ft)
- Large area warehouse (100,000 ft^2)
- Double row rack storage
- Fire location (Base of high racks, top of high racks, remote from high racks)
- Commodity types (Plastic and Class II (non-comb. in comb. packaging))
- Sprinkler system activation

Scenarios

Fire Scenario	Description	Potential Fire Growth		
		Incipient Period	Growth Rate	Max Size
F1	Intentional ignition at floor level in rack flue	Virtually none	Extremely rapid	Extremely large
F2	Top of rack ignition (light bulb)	Highly variable	Variable, potentially rapid	Extremely large
F3	Shipping and receiving ignition with spread to high rack	Highly variable	Variable, depending on geometric configuration and combustible materials	Extremely large
F4	Shipping and receiving ignition without spread to high rack	Highly variable	Variable depending on geometric configuration and combustible materials	Limited to available fuel in area
F5	Long incipient period from smoldering or overheat	Long, overheat fire condition with delayed transition to flaming	Variable	Variable

Conclusions

- Fire department response times and tactics (10-15 min. avg.)
  - Length significantly hinders effectiveness of detection to flaming fires in racks
  - Emphasizes need to detect during incipient phase of fire
- On-site trained personnel
  - 3 min. response
  - Detection has larger impact on a broader range of fire scenarios

Intentional Ignition at Floor Level in Rack Flue

- Fires grow rapidly – size proportional to height of storage
- No suppression (flaming ignition (e.g., arson))
  - Fire sizes over 100 MW, even for 15 ft tall warehouse
  - Develop in less time than typical fire department response
  - Little potential impact of detection
- Sprinklers activate quickly (1–2 minutes for flaming ignition)
  - Limit fires to less than 5 MW
  - Little potential for detection to significantly improve situation
- Incipient phase
  - Detection effective if 10–15 minutes before accelerated growth

Fires Ignited at Top of Racks

- Fire department extremely limited in ability to fight fires due to height in tall warehouses
  - Fire can grow quickly and become large (no suppression)
  - Fire detection limited value
- Incipient phase
  - Detection effective if 10–15 minutes before accelerated growth
- Quick sprinkler activation after fire growth due to proximity to ceiling
  - Limited potential for detection unless during incipient phase

Fires Ignited Outside of Racks

- Sprinkler activation can be delayed or may not occur for tall warehouses
  - 100 ft building requires fire greater than 20 MW
  - Detection can have an effective impact
- Fires may spread to high rack storage
  - Preheating may pose risk of sprinkler system being overwhelmed
  - Detection effective if 10–15 minutes before racks involved
- Incipient phase
  - Detection effective (no suppression)
  - Detection effective if 10–15 minutes before accelerated growth (with effective suppression)

Conclusions

- All scenarios: impact of fire detection directly related to duration of the incipient stage before accelerated fire growth.
- Regardless of suppression system activation or location of the fire, if detection is able to provide a warning 10 to 15 minutes before the end of the incipient stage, the fire department should be able to limit damage.
- On-site trained personnel
  - Detection must provide warning more than 3 minutes before the end of the incipient stage
  - Detection has larger impact on a broader range of fire scenarios

Phase II

- Potential impact of detection is directly correlated to the duration of the incipient fire growth phase of warehouse fires
  - Develop representative warehouse fire scenarios
    - Ignition Source
    - Ignited Materials
    - Ignition Geometry
  - Characterize fire development over time
    - Heat release rate
    - Smoke development
    - Radiant heat output

Phase II

- Evaluate detection system performance for characterized design fires and representative warehouse conditions.
  - Large floor areas and ceiling height
  - Open and obstructed viewing conditions
  - Ambient temperature or ventilation conditions
- Determine potential impact of detection to provide sufficient response prior to rapid fire growth for:
  - Firefighters (<10 minutes)
  - On-site responders (<3 minutes)

Questions and Input

Full Report:

Dinaburg, J. and Gottuk, D.T., “Fire Detection in Warehouse Facilities,” The Fire Protection Research Foundation, Quincy, MA, January, 2012.

http://www.nfpa.org/assets/files//Research%20Foundation/RFWarehouseFireProtection.pdf