High Challenge Warehouse Protection

Back to the Future

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Fire Scenarios/Description

“System” Performance Objectives

*** Save the building and as much of the contents as possible**

*** Ensure employee and fire fighter safety**

Rapid control < 5 minutes

Option: base performance objectives on the modeling results of compartment conditions and rack failure

Complete extinguishment without manual intervention

(ensures fire fighter safety)

Minimize fire damage

Target: 1 Pallet horizontally each direction, 1-2 vertically (1%)

Acceptable: 2 - 3 Pallets in any direction

Minimize collateral damage

System Selection (The good, the bad and the ugly)

System	Complexity	Cost	Collateral Damage	Suppression	Extinguishment
In-rack (ITA) and OH sprinklers	OK	OK	GOOD	OK-GOOD	OK-BAD
In-rack (deluge zoned)and OH sprinklers	BAD	BAD	GOOD	GOOD	GOOD
In-rack (deluge zoned) compressed air foam (deluge zoned) and OH sprinklers	BAD	BAD	GOOD	OK?	OK-BAD
Monitors and OH sprinklers	OK-BAD	OK	OK ?	OK-BAD	BAD
High expansion foam	GOOD	GOOD	OK-BAD ?	GOOD	GOOD
Water mist in-rack (deluge zoned) and OH sprinklers	BAD	BAD	GOOD	GOOD	OK-GOOD

In-rack real estate at a premium

In-rack ITA sprinklers/water mist nozzles have limited extinguishing capabilities

In-rack deluge sprinklers/water mist nozzles can extinguish the fire but rapidly becomes cost prohibitive do to zoning hardware (TA group release valve ?)

Monitors are cost effective but have limited extinguishing capabilities

High expansion foam can extinguish the fire but has zoning and collateral damage issues

Gaseous agents and aerosols are not applicable

System Selection/Conclusions

A lot of options for suppressing the fire

Limited cost effective options for extinguishing the fire

Most promising system : High Expansion Foam

First question: extinguishing capabilities

***Foam Fire Suppression for High Challenge Shipboard Spaces* - Scheffey et. al. SUPDET 2009**

Quadruple Threat

System	Extinguishment			
	Pool	Pallets	Cascade	Wood Crib Adjacent Space
Inside Air	0:43	1:30	1:36	10:16
Inside Air	0:36	0:48	1:06	2:06
Outside Air	0:28	0:46	1:21	1:43

High Expansion Foam System Development

Initial Considerations

Maximum Submergence Time 3-6 minutes per NFPA 11

Public water supply 800 gpm @ 20 psi

System/Hardware Characteristics

2-3% Foam concentration

Expansion Ratio : 500:1 delivered (higher ratios available)

(accuracy of published values, reduction due to fire conditions)

“Typical” Large Generator Parameters

(water motor drive generators)

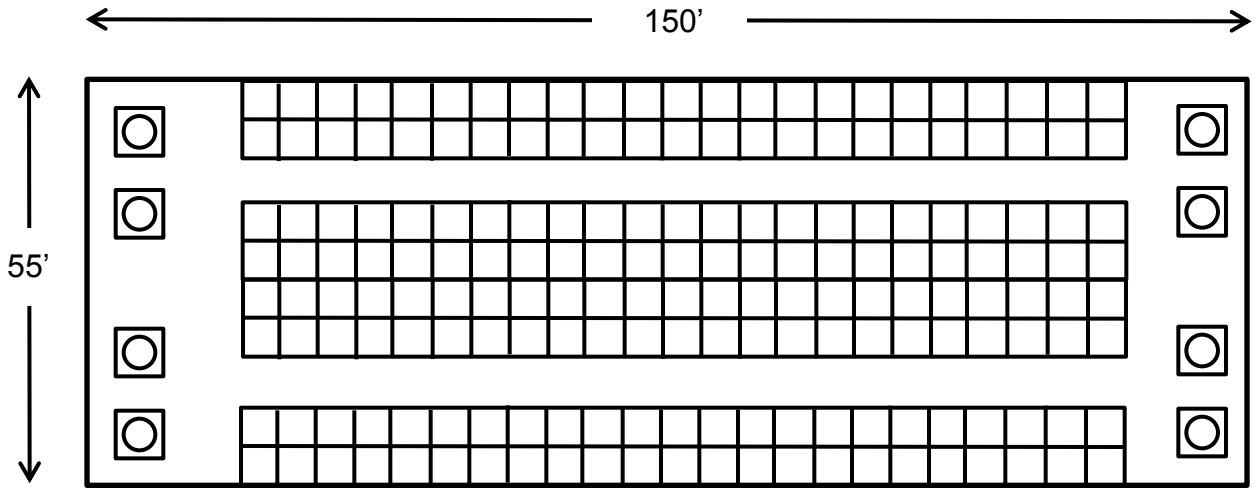
17,500 – 20,000 CFM in 500:1 range

250 - 300 gpm in the 50 psi – 75 psi range

Pendent or sidewall mounts available

Preliminary Design – Option 1 overhead

Designed with zoning in mind

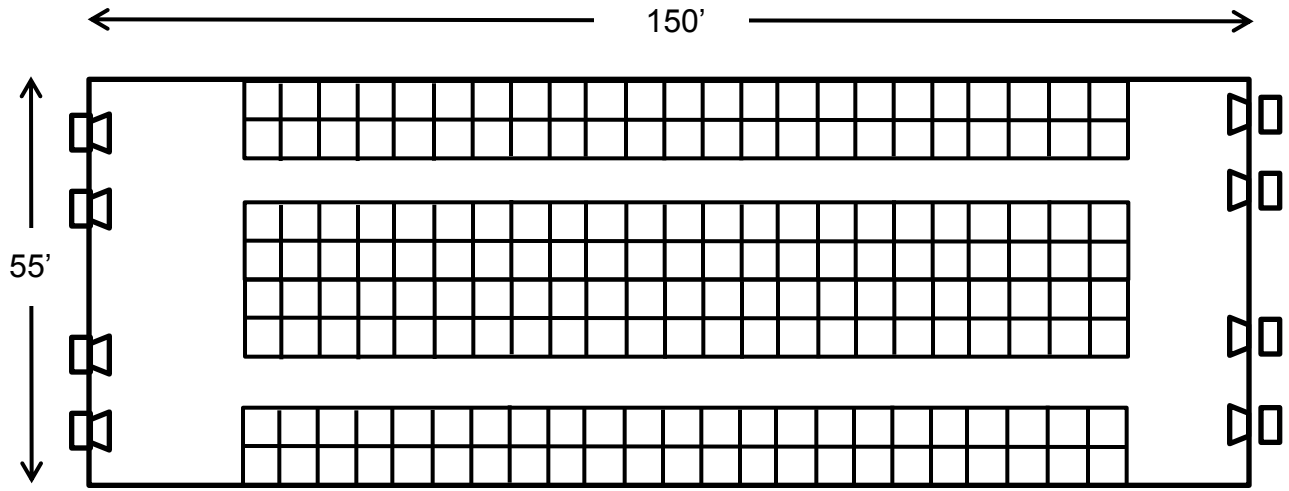


Ceiling Mounted Generator

Inadequate clearance in the overhead of aisle

Preliminary Design – Option 2 sidewall

Designed with zoning in mind



Wall Mounted Generator

Inadequate clearance in the overhead of aisle

Design Development

Objectives: Minimize system impact and cost

Design considerations/hurtles

Zoning will be required; partitions will need to be added

Zoning sizes

Minimize water supply issues

Minimize fill time (less than 3 minutes)

Minimize interferences

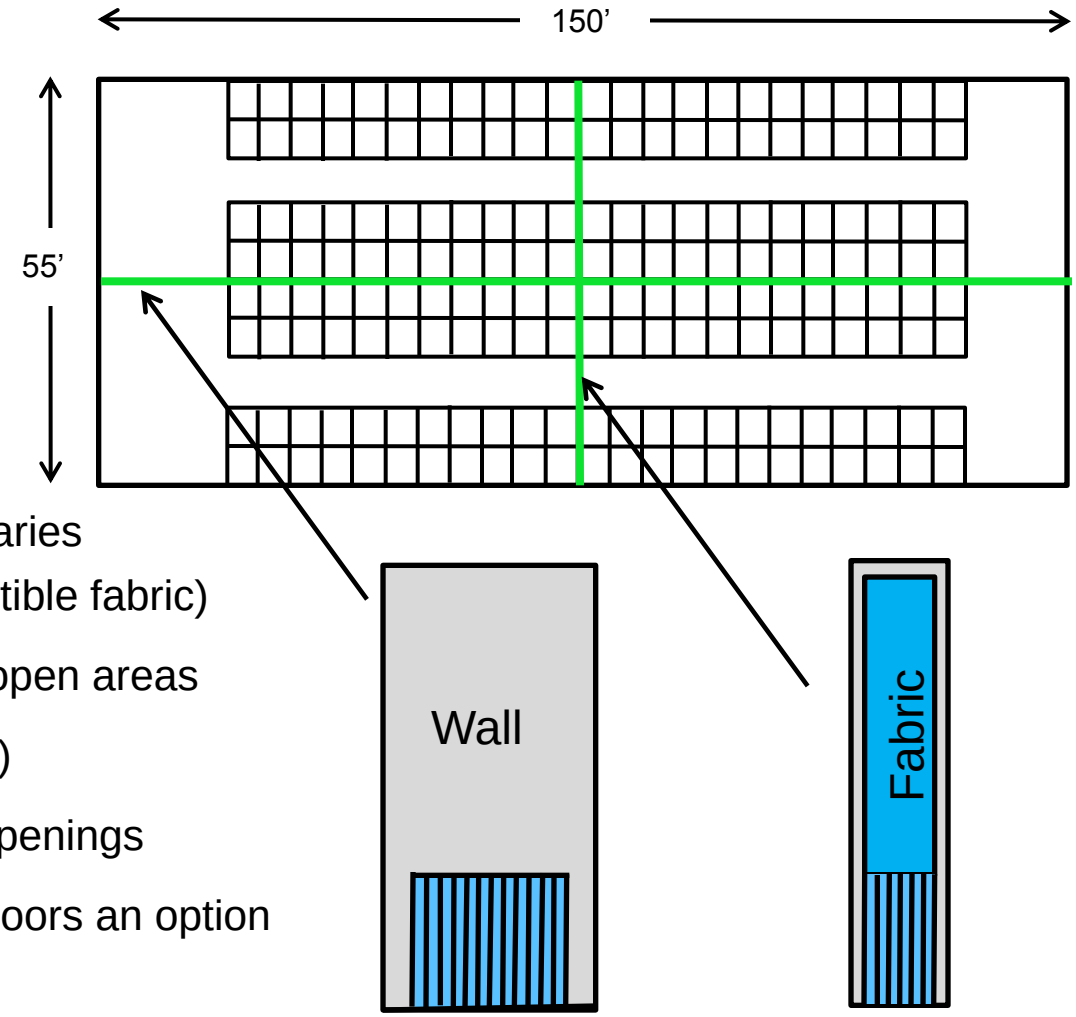
Zones	Zone Volume (ft^3)	No. Generators	Flow Rate (gpm)	3 % - 30 min. Concentrate (gal)
1	530,000	8	2400	2160
2	265,000	4	1200	1080
4	132500	2	600	540

System designed for 3 minute fill time

Flow rate of generators @ 75 psi (125 psi @ pump)

Concentrate greater than NFPA 11 requirements of 25 minutes – fill 4 times

Zoning Configuration and Partitions



Rasbash and Langford 1965

Dividers in racks at zone boundaries (sheet metal, wood, noncombustible fabric)

Light construction walls across open areas

Aisle partition (most challenging)

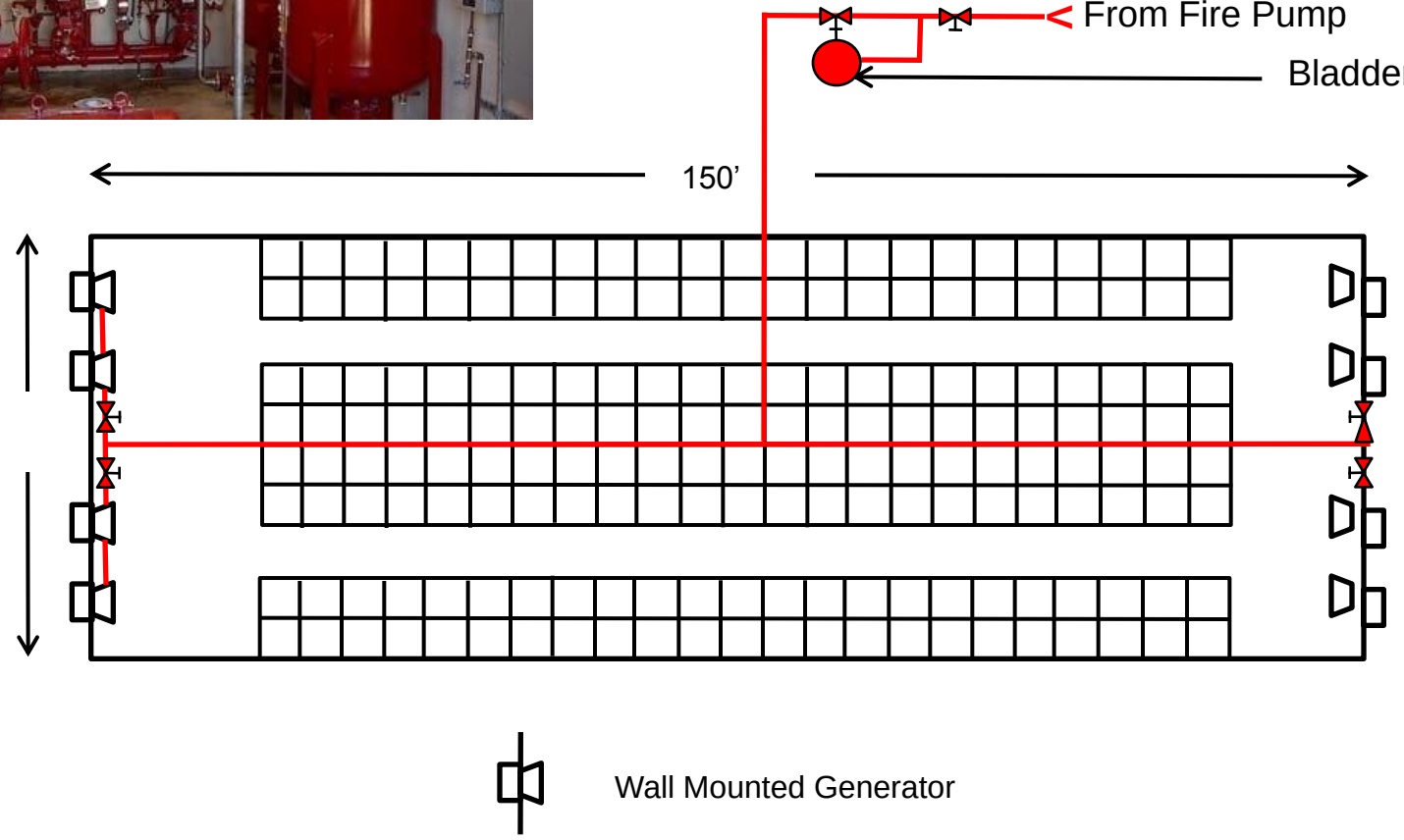
Need to address loading dock openings

Curtains preferred; automated doors an option

Curtain correlation developed during USN tests

System Components

(fairly simple system)



System Enhancements

Techniques to extend submergence time

Objective: extend 30 minutes to hours

Automatic variable discharge

- **(e.g. 10 minutes continuous followed by timed on/off cycles)**

Manual control/override

- **Video monitoring of foam depth**
- **Manually controlled discharges**
- **Selectable discharge modes**

Collateral Damage

Packaging will be wetted in the activated zone

Contents should not be damaged

Worst case water usage 18,000 gallons

Potential Failure Modes

Openings between zones

Ample foam capacity/ foam stiffness

Fire located at edge of zone (i.e. Damages zone boundary/partition)

System designed to activate only one zone

(zone where fire was first detected)

Ample foam capacity/ foam stiffness

Zones	Zone Volume (ft^3)	No	Flow Rate (gpm)	Concentrate (gal)	Capacity No. of fills
1	530,000	8	2400	2160	9.1
2	265,000	4	1200	1080	4.5
4	132500	2	600	540	2.3

Detection

“System” performance objectives are to save the building and ensure fire fighter safety

Detection System Desired Attributes

Early warning to initiate a manned response
(i.e. fires where total flooding is not required)

Automatic Activation of the fire suppression system
(i.e. growing/flaming fire within the racks)
Target ~ 100 kW or so

Identify the fire location (and graphic display)

Detection System Selection (The good, the bad and the ugly)

Detection System	Complexity & Cost	Fire location capability	Effectiveness
In-rack spot smoke (photo and ion)	BAD	GOOD	GOOD
OH Spot Smoke (photo and ion)	OK	BAD	BAD
In-rack Aspirated Smoke	GOOD	BAD	GOOD
OH Aspirated Smoke	GOOD	BAD	OK-BAD
In-rack Spot Heat (fixed temp. and rate of rise)	BAD	GOOD	GOOD
OH Spot Heat (fixed temp. and rate of rise)	GOOD	BAD	BAD
In-rack Linear heat (twisted pair)	GOOD	OK-BAD	GOOD
OH Linear heat (twisted pair)	GOOD	BAD	BAD
In-rack Linear heat (fiber optic)	GOOD	GOOD	GOOD
OH Linear heat (fiber optic)	GOOD	GOOD	BAD
Flame	GOOD	BAD	OK-BAD

- In-rack real estate at a premium
- In-rack spot detectors are susceptible to damage and are not cost effective (due to No.)
- OH detectors are not effective until the fire becomes large

Selected system

Linear heat detectors (LHDs) in the racks

Flame detectors in open areas and down aisles for early warning

Detection System Preliminary Design

In-rack detectors – Linear Heat – EW & Automatic Activation

Fiber Optic (laser light scattering)

Capabilities fire location/resolution programmable alarm setting

Installed in or near flue space between pallets (staggered between levels)

Open areas and aisle detectors – Flame Detectors – EW

VID system recommended; can potentially detect flaming and smoldering fires

Capabilities – small fire detection – EW – manual response

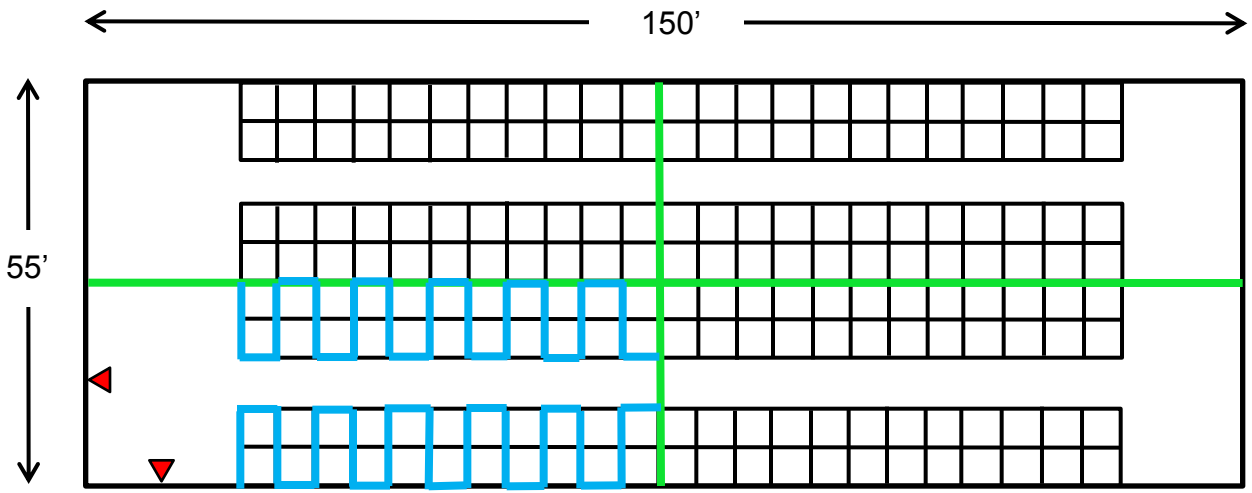
One viewing open area at end of aisle - (installed above pallet level)

Two - three looking down aisle - (installed at different elevations to ensure complete coverage and reduce the likelihood for obstruction (redundancy)

Output - Graphic display showing fire location (maximum damage?)

Interface/control of pallet handling system

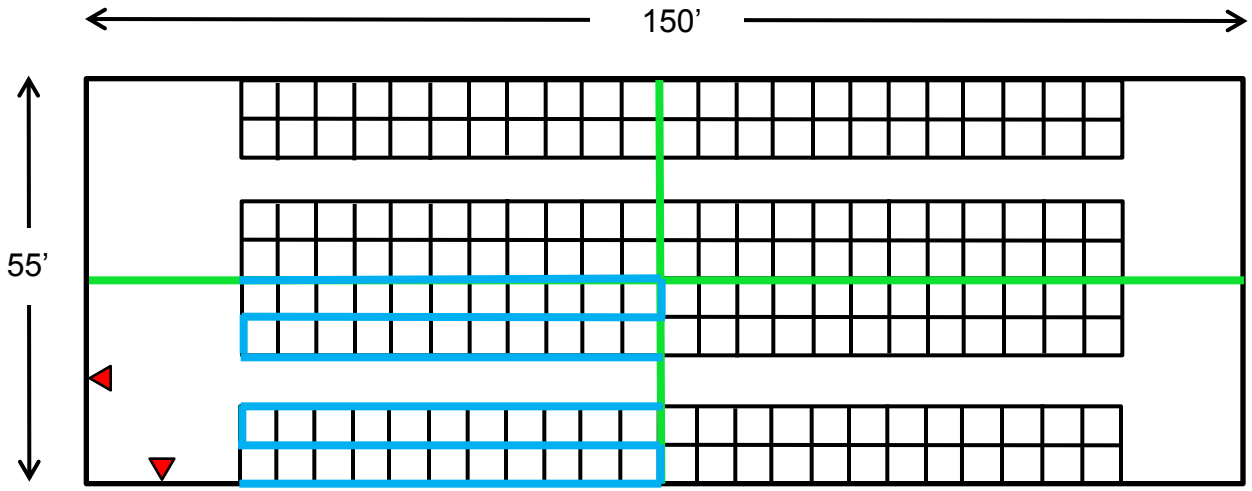
Detection Preliminary Design



Linear Heat Detectors
Odd Number Levels

Flame Detectors

Odd number levels



Linear Heat Detectors
Even Number Levels

Flame Detectors

Even number levels

Supplemental Systems

Interface detection system with pallet handling system

Option 1: EW Alarm have pallet handling system pickup a fire suppression pallet

The fire suppression pallet will be equipped with a wireless camera (fire status)

The fire suppression pallet will be equipped with a self contained extinguishing system (e.g. a large fire extinguisher with a remote controlled nozzle or more sophisticated)

Option 2: Have the pallet handling system remove the pallets around the fire to reduce fuel loading along growth path and aid in suppression

Option 3: Have the pallet handling system investigate fire after extinguishment and remove pallets in and around the fire area

Summary

High Expansion Foam is a Viable Alternative

- High Expansion Foam can meet the performance requires of this application; save the building and ensure fire fighter safety.
- The system is cost effective and can be designed to use the available water supply.
- There are issues associated with zoning and partitions that can be resolved.
- Supplemental systems can increase system effectiveness and potentially reduce collateral damage.

See you in the future