SupDet 2013 Workshop: Suppression Research Charrette

1:00 p.m. – 5:00 p.m., February 27, 2013
Doubletree Orlando at SeaWorld, Orlando, FL

Workshop Summary

In 2010, the Foundation conducted a high hazard warehouse concept design challenge, where six leading engineering firms presented innovative concepts for protection of a high bay warehouse with a challenging commodity. The result was the generation of new ideas to address this challenge. Since then, the Foundation has continued to address this issue with a number of research projects focused on new commodities, configurations, and protection schemes. However, several research challenges remain unaddressed.

To begin to address these research challenges, the Foundation held a Research Charrette on Wednesday afternoon, February 27th, 2013 in Orlando Florida, in conjunction with SupDet 2013. The goal of the Charrette was to use the collective knowledge and experience of the fire protection leaders participating to take the first steps towards addressing each of the following challenges:

1) Topic 1: What do we need to know to determine **equivalencies between water mist and sprinkler protection** for selected suppression scenarios? **– lead Dan O'Connor, Aon Fire Protection Engineering**

2) Topic 2: How do we measure the impact of **high clearance of sprinklers over industrial (factory) operations? – lead Steve Wolin, Consultants, Inc.**

3) Topic 3: What more do we need to know to **apply the NFPA 13 obstruction rules for ESFR sprinklers**? **- lead Matt Klaus, National Fire Protection Association**

4) Topic 4: What are the validation priorities for new research underway on s**prinkler protection installed on sloped ceilings over storage? – lead Victoria Valentine, National Fire Sprinkler Association**

The agenda for the workshop is provided in Attachment A. The first part of the workshop was dedicated to the first topic related to the "equivalencies" between water mist and sprinkler protection. Dan O'Connor provided an overview of the design problem and then the workshop participants engaged in discussion on the issue.

For topics 2, 3, and 4, an initial statement of the design problem and existing data/research were presented by the leads listed above. Participants were divided into groups and were tasked to:

a) bound and put parameters on the design challenge
b) generate/prioritize candidate concept solutions
c) scope and prioritize additional research/studies that are needed to fill the knowledge gaps to validate these solutions

Then, each of the group leads provided a report out to the workshop participants. A list of participants is provided in Attachment B. This document summarizes the workshop discussions and provides the knowledge gaps that need to be addressed by research.

Topic 1: What do we need to know to determine equivalencies between water mist and sprinkler protection for selected suppression scenarios?

Background

There are two approaches to this issue. The first is to generally consider an occupancy approach toward equivalency. Currently, the primary interest is installing water mist in light and ordinary hazard occupancies as defined by NFPA 13, *Standard for the Installation of Sprinkler Systems*. There is also some demand for installation in residential occupancies. A light hazard listing for water mist systems is also available from FM Global, but FM defines light hazard a bit differently from NFPA 13 (Hazard Category 1). UL also lists water mist system for light, ordinary hazard 1 and ordinary hazard 2 occupancies using test methods that evolved from the tests used for listing sprinklers. The implication is that if a mist system is FM or UL listed for light or ordinary hazard, then it can be substituted for any light or ordinary hazard as traditionally listed in NFPA 13. (Note that the list of light and ordinary hazard occupancies is in the NFPA 13 annex not the code requirements; therefore, it is guidance). The concern is that given the differences between water mist systems and sprinkler systems – e.g. mechanisms of suppression, compartmentation effects, equipment design, operating pressures, etc. – is it appropriate to be able to substitute water mist systems for sprinkler systems for the wide variety of light and ordinary hazard occupancies as noted in NFPA 13.

Another approach would be to consider an application approach for water mist protection – similar to the approach taken in NFPA 13 for storage. In other words, water mist would be listed for specific occupancy or use applications based on full scale testing. Accordingly, there may need to be specific tests for office occupancy and theater seating areas although both are considered light hazard.

NFPA 750, *Standard on Water Mist Fire Protection Systems*, appears to be going in the direction of developing a framework for occupancy-based protection while also stating that systems should be installed only in areas listed in the manufacturer's installation manual. It is currently considering a list of occupancies similar to NFPA 13 in the next draft of the document in the revisions cycle. The intent is to establish a framework for use of water mist in areas where tested/proven. To what extent can engineers and AHJs rely on the specific tests for listed light hazard and ordinary hazard mist systems with the expectation that a proposed mist system will substitute and provide capability and reliability the fire community has come to expect from NFPA 13 compliant sprinkler systems?

Extrapolating from listing tests

How far out are we willing to extrapolate from tests to expand the application of results to other applications? A bench scale test (analogous to UMD research on sprinklers) could quantify a sprays ability to penetrate a plume to benchmark against sprinklers. Full scale tests would still be needed, but bench scale testing could act as a screening method.

What is the goal of water mist protection? Sprinklers control the fire; the current objective of water mist is suppression. We need to align engineering objectives of these systems.

Could we develop a testing methodology based on high, medium and low pressure systems (get away from pre-engineered systems)? Nozzles have specific performance characteristics but if we look at spray performance we may be able to categorize performance. Until we can do this, broad application of water mist will be difficult because there are many general installation rules that need to be applied to all systems (e.g. obstruction, concealed spaces, etc).

Knowledge gaps

The following knowledge gaps were identified during the discussion:

- Information from manufacturers:
    - What types of tests are being done?
    - In what types of applications is water mist being used?
    - What is the success rate?
    - What occupancies or applications is a mist system capable of substituting for a sprinkler system?
- System Capabilities and Reliability
    - Pump systems and integration with standpipe or hose systems and fire department connections
    - Lots of data on sprinkler performance and failures, but not any meaningful data on mist systems
- General installation rules/guidance must be developed on the impact of the following on water mist systems:
    - high airflows,
    - high ceilings,
    - obstructions,
    - shadow areas,
    - narrow combustible concealed spaces, etc.

Topic 2: How do we measure the impact of high clearance of sprinklers over industrial (factory) operations?

Background

Buildings housing industrial operations like factories are getting taller, which can cause a high clearance of sprinklers from the fire. This is partly due to re-use of existing buildings for industrial operations. The increased clearance leads to increased fire sizes and fire spread at sprinkler activation and the possibility of activating too many sprinklers (or skipping). There is not a lot of loss history, but maximum clearance of these types of occupancies is not currently addressed in NFPA 13, *Standard for the Installation of Sprinkler Systems*.

If used properly, we have models that can predict activation of first sprinkler if fire size is known. The challenge is estimating the fire size based on the anticipated combustibles in the building.

Parameters and Candidate Solutions

In most cases, the sprinkler systems in industrial spaces are not intended to be life safety systems. The goal is to make sure that the fire is controlled and that the roof structure remains intact, so the parameters that need to be defined include the number of design sprinklers and the maximum allowable roof temperature.

Other parameters associated with this design challenge are ceiling height, density of fuel load, and geometry of the space. These facilities have typical ceiling heights of 65 feet and smaller, so the focus of research should be in this range.

Some of the possible solutions for this problem include using large orifice sprinkler heads and extending the spacing between sprinklers to reduce skipping.

Knowledge gaps

In industrial spaces with ceiling heights up to 65 feet, what should the maximum allowable clearance between sprinklers and fuel packages be? To answer this question, typical ranges of the following need to be determined first:

- fuel package density,
- fuel types, and
- geometry.

One possible solution to the question posed above is to extend the spacing between sprinklers, but this needs to be quantified.

Also, what about applications where there is a mezzanine in a high ceiling space with high clearance over other areas? How should the system be designed?

Topic 3: What more do we need to know to apply the NFPA 13 obstruction rules for ESFR sprinklers?

Background

ESFR sprinklers are often installed in warehouses to avoid installation of in-rack sprinklers. However, since the discharge pattern of ESFR sprinklers is different from regular sprinklers, obstructions near the sprinkler heads can greatly affect the distribution of water. NFPA 13, *Standard for the Installation of Sprinkler Systems*, allows the following related to obstructions and ESFR sprinklers:

- Items less than 2 inches wide and 2 feet or greater below deflector
- Items one foot or less in width and located 1 foot horizontally from sprinkler
- Items two feet of less in width and located 2 feet horizontally from sprinkler

However, there are some successful tests that have been conducted with obstructions outside of these requirements. The information from these tests as well as information gathered from further testing could help inform the NFPA 13 requirements.

Parameters

Some of the parameters associated with this design challenge are ceiling height, storage height, and type of commodity being stored.

In addition to the parameters listed above, the following related to the sprinkler and the obstructions are key parameters:

- Size of obstruction
- Shape of the obstruction
- Location of the obstruction in relation to the sprinkler deflector
- Type of sprinkler (K factor)
- Sprinkler spacing

Testing completed at FM Global has identified that bridging ¾ inch to 1 inch wide can cause failures depending on the location of the obstruction, so small obstructions should be investigated as well as larger obstructions.

Knowledge gaps

There has been testing completed related to ESFR sprinklers and obstructions (including XL GAPS and FM Global). Therefore, the first step for research should be a literature review of available information and test data on the topic.

The literature review should identify the knowledge gaps that still exist. The next step should be a model validation study. Spray distribution testing of various real-scale configurations of ESFR sprinklers and obstructions should be completed to compare discharge distribution and obstruction impact with model predictions. Tests should include both passing and failing configuration and one of these configurations should be a "cable tray" scenario. Validated model(s) should then be used to simulate other configurations to fill the gaps from testing.

Some additional topics that should be investigated related to this issue are multiple obstructions and the impact of sprinkler heads installed under obstructions in addition to sprinklers installed on the ceiling (e.g. how do these additional sprinklers impact spacing and activation of ceiling sprinklers?).

Topic 4: What are the validation priorities for new research underway on sprinkler protection installed on sloped ceilings over storage?

Background

There is a limited prior research related to protection of storage under ceilings with slopes steeper than 2/12. Two prior research projects in this arena were small scale testing done by Gunner Heskestad at FM Global (then Factory Mutual Research Corp.) in November 1988 on ESFR sprinkler response under ceilings with slopes of 0/12, 1/12, and 2/12 ("Model Study of ESFR Sprinkler Response Under Sloped Ceilings". Another study was conducted in February 2013 by Andre Marshall at the University of Maryland and Custom Spray Solutions that analyzed the impact of sloped ceilings and sprinkler orientation on delivered density ("Analysis of Sloped Ceiling and Sprinkler Orientation Impact on Delivered Density"). This research investigated slopes of 0/12, 2/12, 4/12, and 6/12.

Additionally, the Fire Protection Research Foundation completed a combined experimental and computational study to assess the performance of residential sprinklers installed on sloped ceilings (as well as sloped ceilings with beams) in 2010 ("Analysis of the Performance of Residential Sprinkler Systems with Sloped or Sloped and Beamed Ceilings").

Parameters

There are many different parameters related to this design challenge. Some of the key parameters include the slope of the ceiling, the commodity being stored, types of sprinklers (including ESFRs), and sprinkler spacing. Another key parameter is the clearance to the storage, but it is unclear how this should be measured: at the low point of the ceiling, at the high point of the ceiling?

The configuration of sprinkler piping is another parameter to be considered. Are there pressure losses along the slope? Do they impact any type of configuration (i.e. tree, loop, gridded) more than the others?

Other parameters that should be considered are whether the effect of obstructions is amplified with slope and different types of roofs (i.e. sawtooth, domes, purlin).

Some possible solutions to the problem are to use higher densities, larger calculation areas, or specific types of sprinklers. A possible solution to prevent cold soldering of sprinklers would be to install baffles. However, the best orientation of baffles is not known. Should they be installed perpendicular to roof or to the floor?

Knowledge Gaps

There are many knowledge gaps related to this challenge. To start, it should be clarified what is happening globally related to storage under sloped ceilings:

- What are the fire losses in storage facilities with sloped ceilings?
- What code requirements are there outside the US in relation to this issue?

The next step in this research should be fire modeling of ceiling jets and fire plumes and how they spread in these types of facilities. This will help estimate how many sprinklers may activate in certain situations and predict the impact of baffles on smoke spread to determine the best orientation.

An analysis could be completed to determine the effect of different types of sprinkler piping configurations and what pressure losses along the ceiling slope are.

The information learned in the previous steps should be applied to large scale distribution testing under slopes of 2/12, 4/12, and 6/12. Various sprinkler types and deflector orientations should be considered. The use of ESFR sprinklers should also be considered with respect to spacing and obstructions to determine if the slope intensifies the impact of obstructions.

Other issues to consider are:

- Different construction types (i.e. sawtooth, domes, purlin)
- Use of dry pipe sprinkler system

Due to the number of unknowns related to this issue, the research should be staged so that completed work can inform later stages.

Attachment A: Workshop Agenda

THE FIRE PROTECTION RESEARCH FOUNDATION

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AGENDA

1:00pm	Introduction – Purpose and Ground Rules	Amanda Kimball, Fire Protection Research Foundation
1:10pm	Topic 1: Equivalencies between water mist and sprinkler protection 1. Problem Statement (10 minutes) 2. Work session a. Define set of occupancies where equivalency is sought/bound the design challenge b. Discuss fire scenarios and performance criteria c. Identify knowledge gaps and scope additional needed research/studies 3. Wrap up/summary (10 minutes)	Lead: Dan O'Connor, Aon Fire Protection Engineering
2:40pm	Break	
3:00pm	Problem Statements for Topics 2 – 4	
3:00pm	Topic 2: High clearance of sprinklers over industrial (factory) operations	Lead: Steve Wolin, Code Consultants, Inc.
3:10pm	Topic 3: NFPA 13 guidance on obstruction of ESFR sprinklers	Lead: Matt Klaus, NFPA
3:20pm	Topic 4: Sprinkler protection installed on sloped ceilings over storage	Lead: Victoria Valentine, National Fire Sprinkler Association
3:30pm	Breakout groups for Topics 2 – 4 (participants select one topic) 1. bound and put parameters on the design challenge 2. generate/prioritize candidate concept solutions 3. scope additional research/studies that are needed to fill the knowledge gaps to	

	validate these solutions	
4:30pm	Report Outcomes for Topics 2 – 4 (10 minutes each)	Leaders
5:00pm	Wrap Up/Next Steps	Amanda Kimball, Fire Protection Research Foundation

Outcome

Statements will be synthesized and compiled and will become part of the Foundation's research priority portfolio for future implementation. An article on the Charrette outcome will be publicized in the NFPA community.

Attachment B: List of Participants

Dan O’Connor, Facilitator
Matt Klaus, Facilitator
Victoria Valentine, Facilitator
Steve Wolin, Facilitator

Wayne Aho
Adnan Ansari
Wes Baker
Kerry Bell
Tracey Bellamy
Liv Astrid Bergsager
Scott Bryant
Matt Cannavale
Thierry Carriere
Paul Clarke
Shane M. Clary
Med Colket
Michael DeVore
Mike Edwards
Dan Finnegan
Christina Francis
Scott Franson
Mitch Freeman
Scott Futrell
Dave Gough
Jeff Harrington
Lance Harry
Ronald Hein
Akshay Jain
Stephen Jordan
Michael Kroneder
Felix Kuemmerlen
Zachary Magnone
Andre Marshall
Rodney McPhee
Jim Mongeau
Gaétan Morinville
Matt Osburn
Eduardo Padilla
Tom Parrish
Tom Pedersen
Raymond Quenneville
William Reilly
Ernesto Rodriguez
Steven Scandaliato
Bob Schifiliti
Lawrence Shudak
Michael Sides
George Stanley
Brian Stumm
Peter Thomas
Mike Widdekind