THE FIRE PROTECTION RESEARCH FOUNDATION

PROJECT SUMMARY

Obstructions and ESFR Sprinklers – Phase 2

5 November 2014

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 standard-spray sprinklers, obstructions near the sprinkler heads can greatly affect the distribution of water. NFPA 13, Standard for the Installation of Sprinkler Systems, generally allows the following obstructions in Sections 8.12.5.1, 8.12.5.2, and 8.12.5.3:

- Sprinklers installed per the allowable distances from near or at ceiling obstructions in Table 8.12.5.1.1
- Isolated obstructions less than 2 feet wide and 1 foot or greater horizontally from sprinkler
- Isolated and continuous obstructions less than 2 inches wide and 2 feet or greater below deflector or 1 foot or greater horizontally from sprinkler
- Continuous obstructions 1 foot or less in width and located 1 foot horizontally from sprinkler
- Continuous obstructions 2 feet of less in width and located 2 feet horizontally from sprinkler
- Bottom chords of bar joists or open trusses located 1 foot or greater horizontally from sprinkler (upright sprinklers can be installed over the bottom chords of bar joists or open trusses that are up to 4 inches wide)

Two methods are available in NFPA 13 to resolve obstructions that do not fall into the categories above: eliminating the obstruction or adding sprinklers underneath the obstruction. However, there have been some successful tests that have been conducted with obstructions that are not allowable by NFPA 13 without taking these measures. The information from these tests as well as information gathered from further testing could help inform revisions to the NFPA 13 requirements.

Research Goal: The overall goal of the project is to develop a tool that can be used for providing reliable analysis of the impact of obstructions on ESFR sprinklers based on existing data and develop technical basis to the NFPA 13 Technical Committees for new requirements and guidance. The objective of this Phase 2 project is to implement the test plan developed in Phase 1 to fill the knowledge gaps identified.

Project Tasks:

Task 1: Finalize Test Plan - Develop final experimental test plan based on the research plan documented the Phase 1 report with feedback from the Project Technical Panel and sponsors.

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Task 2: ADD Testing - The difference in the performance of the various ESFR sprinkler models needs to be understood such that the results of the testing program will not be product specific. ADD testing will be conducted, both with and without obstructions, to explore this issue. Twenty ADD tests are planned. From this work, the appropriate ESFR sprinkler model will be selected for use in the full scale testing. This data will also be compared to previous data to measure the repeatability of the ADD testing.

Task 3: Conduct Full Scale Tests - Full-scale testing will be used to validate sprinkler performance. The full-scale testing will begin with double-row rack storage of Standard Group A Plastic commodity stored to a height of 30 feet with a 40-foot ceiling. Use of the 40-foot ceiling and 30-foot storage coincides with survey data regarding most common ceiling height and is the highest storage array K-17 ESFR sprinklers can protect without rack sprinklers. The results of these tests will be applicable to lower ceiling and storage arrangements as well as larger orifice ESFR sprinklers.

Standard 6-inch transverse and longitudinal flue spaces will be provided at rack uprights and between unit loads. The sprinkler system will consist of K-17 ESFR sprinklers positioned at the ceiling with 14-inch clearance between the ceiling and the deflector. The K-17 sprinkler has the highest pressure and smallest droplet size of the ESFR sprinklers allowed or listed to protect 40- foot high buildings. The use of the K-17 sprinkler is considered the reasonable worst-case condition; therefore, allowing application of these results to the larger K factor ESFR sprinklers.

The sprinkler spacing will be 10 feet by 10 feet with an operating pressure of 52 psi. Ignition will be centered under one sprinkler, at the intersection of the transverse and longitudinal flue spaces. Standard igniters will be used. Specific igniter locations will be determined later.

> **Task 3a: Full-Scale Test Series – Bar Joist Obstructions** - Based on literature review and information provided by manufacturers of structural members, the depth of bar joists commonly used in warehouses is 30 inches, followed by 22 inches and 36 inches. For the 22-inch and 30-inch deep joists, bottom chords consist of 2-inch by 2-inch double angles. The bottom chord of the 36-inch deep joist consists of 2½-inch by 2½-inch double angles.
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> The scenario with the bottom chord of the joist located directly underneath the sprinkler deflector (i.e., the sprinkler located within the web of the joist) was eliminated because the ADD testing resulted in an extremely challenging scenario. The data showed an ADD percentage reduction of 50 percent or greater for all three joist depths in the four center pans.
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> In order to establish parameters for obstructions, the initial test will consist of a joist depth of 22 inches with a horizontal offset of 3 inches. ADD data showed a consistent improvement in percent reduction of the ADD as the horizontal offsets increased and the joist depth increased. All sprinklers over the test array will be obstructed.
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> The result of Test 1 will determine the path of future tests. If Test 1 passes, the scenarios will include different joist depths with the same horizontal offset. If Test 1 fails, the horizontal offset will be increased to 6 inches followed by an increase in joist depth.

Task 3b: Full-Scale Test Series – Bridging Member Obstructions - The bridging members will consist of 1½-inch by 1½-inch angles. The vertical offset distances of the bridging member to the sprinkler deflector used in the previously completed test series were 8, 16, and 22 inches, the proposed full-scale testing will locate the bridging members within the bar joist. The bridging members will be secured to the top of the double angles that make-up the bottom chord. This will cause the bridging member vertical offset from the sprinkler deflector to differ from the previous testing. For a 22-inch deep bar joist the vertical offset for the bridging member from the deflector will be 6 inches, for a 30-inch deep joist the vertical offset will be 14 inches, and a 36-inch deep joist will have a vertical offset of 19½ inches.

The results from the bar joist obstruction testing will dictate the testing arrangements of the bridging member. The most rigorous successful bar joist depth and offset will be used in the initial bridging member test arrangement. The bridging member will be located on the bar joist with variable offsets that increase if the test results in a failure.

The bridging members will have an initial offset from the sprinkler of 0 inches that can be increased to 3, 6, and 9 inches. After the 9-inch bridging member offset has been tested or the test results in a pass, the next bar joist depth will be used, until the bar joist depth of 36 inches is tested. If a 22-inch deep bar joist is selected, the initial bridging member offset will be 3 inches (the 0-inch offset will have been eliminated due to prior testing).

Implementation: This research program will be conducted under the auspices of the Fire Protection Research Foundation in accordance with Foundation Policies and will be guided by a Project Technical Panel who will provide input to the project, recommend contractor selection, review periodic reports of progress and research results, and review the final project report.

Schedule: The final report will be available in June 2015.