A Case Study in Utilizing an Existing High-Rise Building’s Fire Protection System Infrastructure for Fighting Exterior Façade Fires

Milosh Puchovsky, Worcester Polytechnic Institute
Zachary Magnone, Johnson Controls
Agenda

• Project Overview
• System Concept
• Fire Performance Evaluation Criteria
• Building Details
• Hydraulic Considerations
• Summary Results
Project Description & Overview

The purpose of the project was consider the hydraulic impact of an exterior fire suppression system installed on a conceptual existing 56-story high-rise building equipped with a standpipe system and an interior fire sprinkler system.
Project Description & Overview

• Graduate Student Independent Study Project during Summer / Fall 2018

• Completed by former WPI Graduate Students
  • Jenna Troio
  • Alex Riley

• Case study scenario and exterior fire suppression system product details provided by Johnson Controls Inc. (JCI)
Combustible cladding is a worldwide problem
Time is critical

Address Downtown Hotel, Dubai 1, January 2016
Fires can be difficult or impossible to access

- Fire reported to start on 20th floor, at approx. 200 ft
- Best equipped fire service can reach 200 ft
- External fires difficult to fight from the inside
- What about response time?

Address Downtown Hotel, Dubai, January 2016
Goal is rapid intervention at any height

1. **Speed** ➔ *address incipient fires in seconds!*
   - Fire service often takes minutes to respond and longer to become operational

2. **Fight fires at any height**
   - Fire service hose can reach ~200 ft

3. **Large coverage area**
   - At least 165 ft wide by 200 ft high (20 stories)

4. **Use a small amount of “agent”**
   - Utilize typical NFPA 14 standpipe water supply – e.g. 500 gpm @ 100 psi

5. **Minimize structural & architectural impact**
Autonomous Fire Suppression (AFS) system components

- Flame Detectors
  2x IR array flame detectors installed outside of the building.

- Robotic Monitor and Extension Boom
  An articulating robotic monitor mounted to an extension boom that automatically extends when in a fire scenario.

- Deluge Valve
  Remote resetting deluge valve to provide water.
AFS system configuration
AFS system operation

FIRE at $X^\circ, Y^\circ$

SPRAYSafe AFS

RELEASING PANEL
Autonomously detects up to four fires, dynamically locating the fires in three dimensions.

Within Seconds, extends Boom and autonomously directs a high volume of water onto the fire.

Goes into standby mode when flames are no longer detected, without any human intervention.
Overlapping layers of protection

Overlapping coverage areas
## Hydraulic design criteria

<table>
<thead>
<tr>
<th>Pressure (psi)</th>
<th>Orifice Size</th>
<th>Reference Flow (gpm)</th>
<th>HR (ft)</th>
<th>VUR (ft)</th>
<th>VDR (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>72.5</td>
<td>K26</td>
<td>221</td>
<td>65</td>
<td>65</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>K30</td>
<td>255</td>
<td>65</td>
<td>82</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>98</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>87</td>
<td>K26</td>
<td>243</td>
<td>75</td>
<td>72</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>K30</td>
<td>280</td>
<td>75</td>
<td>82</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>92</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>101.5</td>
<td>K26</td>
<td>262</td>
<td>89</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td></td>
<td>K30</td>
<td>302</td>
<td>89</td>
<td>82</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>108</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>116</td>
<td>K26</td>
<td>280</td>
<td>98</td>
<td>82</td>
<td></td>
</tr>
<tr>
<td></td>
<td>K30</td>
<td>323</td>
<td>98</td>
<td>82</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>115</td>
<td>65</td>
<td></td>
</tr>
</tbody>
</table>
Guidelines for integration in existing buildings

1. Design for 2 AFS systems operating for 30 minutes on adjacent levels of a building

2. Maintain full operational capability of existing sprinkler systems

3. Ensure a minimum of one standpipe hose flow is available, or as required
Building Description

• 4-sided building
• 56 stories in height with three basement levels (735 ft from grade)
• 27,225 sq ft per story (165 ft by 165 ft)
• Exterior siding consists of aluminum composite cladding
• Two exit stairwells
Existing Water-Based Systems

• Class I Standpipe System
  • Two 6-inch risers (one in each stair)
  • 2-1/2 inch outlets in each stair on each floor
  • 500 gpm (250 gpm at each outlet) at 100 psi for most remote riser
  • 250 gpm at 100 psi for remaining riser

• Sprinkler System
  • Light Hazard and Ordinary Hazard Group 1 Occupancies

• Independent Risers for standpipe and sprinkler systems
Existing Water-Based Systems

• Water Tanks
  • Low Zone - 60,759 gallon (230000 liters) on 5\textsuperscript{th} floor
  • High Zone - 30,379 gallon (115000 liters) on 35\textsuperscript{th} floor – break tank

• Fire Pumps
  • Low Zone – 1000 gpm @ 264 psi (serve basement through 29\textsuperscript{th} floor)
  • High Zone – 1000 gpm @ 250 psi (serve 30\textsuperscript{th} through 56\textsuperscript{th} floor)
  • Primary, back-up and jockey pumps in both locations
Pump and Tank Arrangement
High Zone
Standpipe System
Arrangement
Standpipe Hydraulic Demand – High Zone

827 gpm @ 226 psi

827 gpm x 30 minutes = 24810 gal
AFS System Considerations

• Number and location of fires?
• Single fire either on the interior or exterior of the building
• Exterior fire on one side of the building
• Exterior fire on the corner of the building (affecting two sides)?
AFS Design Basis

• Minimum discharge from each AFS nozzle – 250 gpm @ 87 psi (to be determined based on manufacturer’s design specifications)

• AFS nozzles to be positioned on each side of the building the 10th, 20th, 35th and 50th floors.

• Each nozzle supplied by alternating standpipes (one standpipe serves floors 10 and 35, and the other standpipe serves floors 20 and 50)
Hydraulic Scenarios Considered

1. Single AFS nozzle operating on the 50th floor
2. Single AFS nozzle operating on the 35th floor
3. Single AFS nozzle operating on the 20th floor
4. Single AFS nozzle operating on the 10th floor
5. Two AFS nozzles operating on the 10th and 20th floors
6. Two AFS nozzles operating on the 50th and 35th floors
7. Two AFS nozzles operating on the 20th and 10th floors*
8. Two AFS nozzles operating on the 50th and 35th floors*

*All scenarios considered a 750 gpm @ 100 psi standpipe demand except for scenarios 7 & * which considered a 500 gpm @ 100 psi standpipe demand
Hydraulic Performance of AFS nozzle on 35th and 50th story with 750 gpm @ 100 psi standpipe demand

Figure 17: Upper Standpipe Zone - Single SpraySafe Nozzle Operation
### Summary Results of Hydraulic Analysis

<table>
<thead>
<tr>
<th>AFS Nozzle Location</th>
<th>Available Flow and Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standpipe Demand @ 100 psi</td>
</tr>
<tr>
<td>10th Floor</td>
<td>257.78 PSI @ 1132.7 GPM</td>
</tr>
<tr>
<td>750 GPM</td>
<td>252.61 PSI @ 1132.7 GPM</td>
</tr>
<tr>
<td>20th Floor</td>
<td>259.90 PSI @ 1088.9 GPM</td>
</tr>
<tr>
<td>750 GPM</td>
<td>257.97 PSI @ 1088.9 GPM</td>
</tr>
<tr>
<td>30th Floor</td>
<td>242.36 PSI @ 1144.2 GPM</td>
</tr>
<tr>
<td>750 GPM</td>
<td>233.22 PSI @ 1144.2 GPM</td>
</tr>
<tr>
<td>50th Floor</td>
<td>246.50 PSI @ 1068.2 GPM</td>
</tr>
<tr>
<td>750 GPM</td>
<td>237.23 PSI @ 1068.2 GPM</td>
</tr>
<tr>
<td>10th and 20th Floor</td>
<td>239.32 PSI @ 1465.7 GPM</td>
</tr>
<tr>
<td>750 GPM</td>
<td>265.61 PSI @ 1465.7 GPM</td>
</tr>
<tr>
<td>30th and 50th Floor</td>
<td>222.93 PSI @ 1455.5 GPM</td>
</tr>
<tr>
<td>750 GPM</td>
<td>243.67 PSI @ 1455.5 GPM</td>
</tr>
<tr>
<td>10th and 20th Floor</td>
<td>254.63 PSI @ 1195.1 GPM</td>
</tr>
<tr>
<td>500 GPM</td>
<td>254.05 PSI @ 1195.1 GPM</td>
</tr>
<tr>
<td>30th and 50th Floor</td>
<td>255.01 PSI @ 1187.6 GPM</td>
</tr>
<tr>
<td>500 GPM</td>
<td>235.34 PSI @ 1187.6 GPM</td>
</tr>
</tbody>
</table>
Thank You