Innovative Fire Protection for Concert Halls

Dipl.-Ing. Rüdiger Kopp
FOGTEC Fire Protection
ruediger.kopp@fogtec.com
Case Study Elbphilharmonie in Hamburg

- City of Hamburg aimed to build one of the world’s best concert houses
- Outstanding location at the Elbe river in the harbour of Hamburg
- New landmark of the city
- Extraordinary design by architects Herzog & de Meuron combining a brick stone building with glass facades
- Project is a PPP project by an investor, the city of Hamburg and donations by citizens of Hamburg
Case Study Elbphilharmonie in Hamburg

- Overall building floor area is 120,000 m$^2$ with an overall height of 110 m
- Beside the philharmonic concert hall the building houses a 5-star hotel, restaurants, bars, a plaza, residential apartments and parking areas
- Concert hall has 2200 seats and an overall height of 25 m
- Hotel, restaurants, bars, plaza, residential apartments and parking areas are protected by a conventional sprinkler system

⇒ Concert hall was a fire protection challenge
Protection of the concert hall

- A conventional sprinkler system could not be used due to the height of the area and due to the potential water damage when the system is activated.

- A gas fire fighting system could also not be used due to evacuation time of the audience.

→ Development of an innovative fire protection concept based on high pressure water mist technology.
- Since the fire load is concentrated to the floor and seating area the fire fighting agent preferably shall be present in this area

- Instead of overcoming the concert hall height of 25 m, a floor mounted system would be advantageous

- An rapid activation of the system after fire detection would increase the safety level

- Fire detection and fire fighting system must be jointly evaluated

→ Development of a protection concept in conjunction with fire consultants (HHP and DEKRA)
System Acceptance an Approval Process

- Full scale fire test scenario was developed by the fire consultants based on NFPA 750 and prCEN/TS 14972 standards

- Fire tests were defined as close to reality as possible including
  - Fire load
  - Arrangement of fire load
  - Ventilation conditions
  - Fire detection
Fire Tests for Concert Hall

Fire Test Arrangement

- Test field of 6 m x 6 m (6 rows of each 8 seats) in a test hall of 10 m x 15 m floor area
- Steps between 14 cm and 60 cm height / stage height of 2.4 m
- Ceiling at 5.5 m height with 1 m distance to wall
- Original ventilation conditions (6 ventilation openings with 60 m\(^3\)/h)
- Two fire scenarios (low and high level) each between 4 nozzles
Fire Tests for Concert Hall
Innovative Fire Protection for Concert Halls

Conference in London

Fire Tests for Concert Hall
Fire Tests for Concert Hall

Fire Load

- Seat as specified in prCEN/TS 14972 for office areas, but modified to represent the original seat of the concert hall

- Paper cushion as specified in DIN 5510-2 lying on the seat, lighted in all four corners as igniter

<table>
<thead>
<tr>
<th>Seat</th>
<th>Material</th>
<th>Size [mm]</th>
<th>Weight [kg]</th>
<th>HRR MJ/ material</th>
<th>HRR MJ total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original Seat</td>
<td>PU - Mattress 55 kg/m³</td>
<td>1000<em>400</em>60</td>
<td>1,3</td>
<td>60,0</td>
<td>60,0</td>
</tr>
<tr>
<td>Test Seat</td>
<td>Pine wood</td>
<td>950<em>570</em>50</td>
<td>6,0</td>
<td>97,2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PU - Mattress 33 kg/m³</td>
<td></td>
<td>0,8</td>
<td>22,3</td>
<td>136,2</td>
</tr>
<tr>
<td></td>
<td>Cotton - cover (140 g/m²)</td>
<td>1000<em>500</em>50</td>
<td>1,064</td>
<td></td>
<td>16,7</td>
</tr>
</tbody>
</table>
Fire Tests for Concert Hall

Detection System Fire Test

- Three different detection systems were tested at the low scenario [2], being more difficult to detect

  - Smoke Aspirating System (pipe above each step)

  - Linear Heat Detection System (cable above each step)

  - Optical Smoke Detection System (detectors at ceiling / original ceiling is 20 m higher)
## Fire Tests for Concert Hall

### Detection System Fire Test Results

- **Smoke Aspirating System:** Fire detection 5:30 min after ignition
- **Linear Heat Detection System:** Fire detection 1:51 min after ignition
- **Optical Smoke Detector:** Fire detection 1:31 min after ignition

➡️ Decision was made for the Linear Heat Detection System, since it was fast and can localise the fire precisely

➡️ Fire consultants defined the pre-burn time for all water mist fire tests to 3 min to ensure sufficient safety margin
Fire Tests for Concert Hall

Water Mist System Fire Test

- Fire tests were carried out at low and high scenario / high scenario [1] turned out to be more difficult

- Fire between 4 nozzles as most difficult scenario

- Additional test with one disabled nozzle

- Aim was fire control until manual intervention by the fire brigade

- Fire test duration 10 min

- Fire damage was evaluated after fire test
Fire Tests for Concert Hall

Temperature at ignited seat

081022-1 Brandherd 1 zwischen 4 Düsen mit Brandfall - Lüftung

Temperature at ignited seat

Feuer an Zündung

HDWN an

HDWN aus

TE 1 (°C)
TE 2 (°C)
TE 3 (°C)
TE 4 (°C)
TE 5 (°C)
Druck 1 (bar)
Fire Tests for Concert Hall

Water Mist System Fire Test Results

- Temperatures in direct vicinity of the fire were effectively controlled
- Fire spread was limited
- Ventilation system had minimal influence on the effectiveness of the system
- Fire damage was concentrated on the ignition area
Case Study Elbphilharmonie in Hamburg

- Fire tests have determined the position of nozzles and the flow rate (1.2 l/min/m²)
- Nozzle installation in the floor with a cover, having the same appearance as the floor
- Nozzles will be zoned in sections
- Pump capacity is designed to operate 3 adjacent sections
- Small bore pipework for installation
  ➡️ Minimal disturbance of the architecture
Case Study Elbphilharmonie in Hamburg

Reliability Tests for Nozzles

- Reliability of the lift-off of the cover was analysed

- No danger for audience by the cover

- Cover removes even if obstructed by an object, e.g. a bag
Case Study Elbphilharmonie in Hamburg

Nozzle Arrangement
Case Study Elbphilharmonie in Hamburg

Different Activation Zones
The presented protection concept for concert halls allows a safe and architecturally pleasant solution for this special environment.

System design must be integrated in the overall fire safety concept of a building and be evaluated by authorities having jurisdiction.
Thank you for your attention