Atrium Hot Smoke Test at HKCEC (Ir Professor W.K. Chow)

Presented by Professor W.K. Chow
Chair Professor of Architectural Science and Fire Engineering
Director, Research Centre for Fire Engineering
Head of Department,
Department of Building Services Engineering
Leader, Area of Strength: Fire Safety Engineering
1. Introduction
Foyer A
Hong Kong Convention and Exhibition Centre – Expansion Project
(HKCEC Expansion Project)

★ To evaluate the performance of dynamic smoke exhaust systems in the HKCEC Expansion Project through the application of a hot smoke test
Hong Kong Convention and Exhibition Centre
The site
Testing procedure followed those in AS 4391-1999 as specified in the Fire Service Installations (FSI) Code. Test fire with a heat release rate of 2 MW will be used. This value satisfied the specification in FSI with heat release rate higher than 1 MW.

The main testing criterion is to demonstrate the acceptable performance of the proposed fire safety systems.

Evaluate the smoke hazard management performance in Foyer A with reference to the smoke layer height being maintained at a level above 2.8 m (see Appendix K for details). Other testing criteria listed in the FSI Code will be followed.

The air temperature criterion will be watched as roof sprinkler was installed for suppressing fire. Sprinkler heads at some positions will be thermally lagged. The smoke temperature is estimated to be in the order of 55°C (see Appendix K for details).
The test is conducted together with a team from the Harbin Engineering University

Leaders:  Professor Gao Ye

Professor Dong Hui
The team
2. Objectives of the Test
As specified in section 2.23 of the Fire Service Installations (FSI) Code 2005 as in Appendix A by the Fire Services Department (FSD), hot smoke tests (HST) are required as highlighted to evaluate the smoke extraction system for a wide range of premise classes and areas of special risks for compartments with

- Headroom of 12 m or more; or
- Irregular geometrical dimensions or extraordinary large size.

Reference of HST is made to the Australian Standard AS 4391.
Foyer A has a floor area 2,565 m²
The hall void volume is approximately 51,355 m³.
The smoke clear height for Foyer A is 2.8 m with a 7 MW design fire in FE Report.
Agreed to be 4.5 m with a 2 MW fire in hot smoke test.
To Phase 2

To Phase 1

Make-up air louvers

Make-up air flow

Remark: Extraction louvers uniformly distributed at the edge or under the slab of each level.

Zone A of Foyer
3. The Fire Source
As listed in section 2.2 on pool fire of the HST procedure, a 2 MW fire is proposed for the test.

The apparatus for the fire would follow AS 4391 with six A1-size fuel trays to give a 2 MW heat output.

In accordance with AS 4391, the test fire fuel shall be ‘Denatured Industrial Grade Methylated Spirit (Grade 95)’.

The fuel trays will sit in individual water baths with floor protection as detailed in AS 4391.
The quantities of fuel to be used shall follow those recommended in Table 2.7 of AS 4391. It should be sufficient for a steady burning time of about 10 minutes as stated in section 2.2.2 of the HST procedure.

Based on the mock-up tests at the PolyU/USTC Atrium and the first preliminary field test, approximately 96 litres of methylated spirit will be required for a 2 MW fire with 6 trays burning for over 10 minutes, with about 8 minutes of steady burning. Each tray will require about 10 litres of methylated spirit.
4. Hot Smoke Generation
As the test fire fuel selected will give clean combustion products, the smoke generated is not visible. Tracer smoke should be introduced by a smoke generator.

The Pepper Fog Smoke Generator Mark-XII-D previously used for Hot Smoke Tests at Langham Place and Mega Box.

The equipment is rented from the Fire Services Department, Hong Kong as in the first preliminary field test.
5. The Fire Chamber
A chamber is used to reduce thermal radiative effect to adjacent object.

There must be floor protection.

Sufficient hot air will be generated by this arrangement and more thoroughly-mixed hot smoke will be discharged out of the chamber.

This 2 MW test fire is demonstrated by the mock-up tests and the first preliminary field test to generate sufficient heat and buoyancy to transport the tracer smoke up.
Positions of the smoke generators in the FSD inspection test
**Top to Bottom**
1. 50mm Rockwool
2. 6mm Promtech Board
3. 3mm Plywood
4. 25mm Fibreglass
5. 3mm Plywood

---

**Floor Protection of the Fire Source**
Ignition of the pool fire
Smoke gun at top

New trial
6. Location of Temperature Sensors
Temperature sensors were placed as a thermocouple tree T1 above the cabin.

There should be 14 measuring points of thermocouples (or thermoresistors) at 0 m, 2 m, 4 m, 6 m, 8 m, 10 m, 12 m, 14 m, 16 m, 18 m, 20 m, 22 m, 24 m and 26 m above the floor and at the ceiling level.

Temperatures to be measured at 5 s intervals, with measurement started from 5 minutes before ignition and 5 minutes after burning.

Another tree T2 of temperature sensors is suggested to be placed.

(Added to check smoke layer temperature)
(a) Thermocouple trees

2 MW test fire

Make-up air louvers

Thermocouples on thermocouple trees

Make-up air flow

(b) A pictorial view

Remark: Extraction louvers uniformly distributed at the edge or under the slab of each level.

Location of thermocouples in zone A of Foyer
Plan view of zone A for Foyer with test setup

- Boundary of L2 for Zone A
- Boundary of L3 for Zone A
- Boundary of roof for Zone A at L5
- Boundary of roof for Zone A at L7

- 2 MW fire on floor
- Thermocouple trees hanging at high level down to floor
- Camera on floor
- Test control centre on floor

2.8 m height line scale attached to wall
Sectional view of zone A for Foyer with test setup
7. Testing Procedure
★ Set up the instrument as required.
★ Set up the chamber with smoke generators in positions.
★ Apply protective coatings to nearby glass and expensive equipment such as the escalators where appropriate. Note that the radiative heat flux at 1 m away from a 2 MW fire can be up to 6.62 kWm⁻² (8.86 kWm⁻² for a 5 MW fire!).
★ Cover sprinkler heads next to the thermocouple tree T1 by appropriate thermal lagging.

Safety aspects of the test will be observed with portable extinguishers for Class B fires at the ready.

Start the data acquisition system and let it run for 5 minutes.
★ Turn on the video recorder.

★ Set up the pool fires in the chamber by an ignition source.

★ Turn on the smoke generator.

★ Smoke generated would give a buoyancy-induced plume that would move up, divert horizontally as a ceiling jet, and then a smoke layer would be formed.

★ The whole operating sequence on detecting the fire, sounding the alarm, operating the smoke curtain, and turning on the fan will be tested.

The smoke layer should not descend to lower than the specified height of 2.8 m above the floor level.

★ Photographs on the transient positions of the smoke layer will be taken at different angles.
Observe whether the smoke layer can be kept above the specified smoke interface height of 5.0 m in foyer.

Turn off the smoke generator before methylated spirit in the pool fires is used up.

Test completed, keep the data acquisition unit running for another 5 minutes.

Turn off the video recorder.

Run the system for another 15 minutes to clear up the space.
8. Mock-up Tests
★ 2 June 2009
★ 3 June 2009
Spread to zone C
Another Test: Hall 3 Zone B
12 February 2009
Data recording
Fire Chamber
Smoke Layer
Smoke curtains drop to 3 m above floor level.

To phase 1

To phase 2

Zone A

Zone B

Make-up air louvers

Make-up air flow

Extraction louvers

Hall 3: Zone B
Hall 3 Zone B

Test on 12 February 2009

Smoke layer interface height by vertical air temperature profile