Hot smoke tests

Verification tool for smoke ventilation systems

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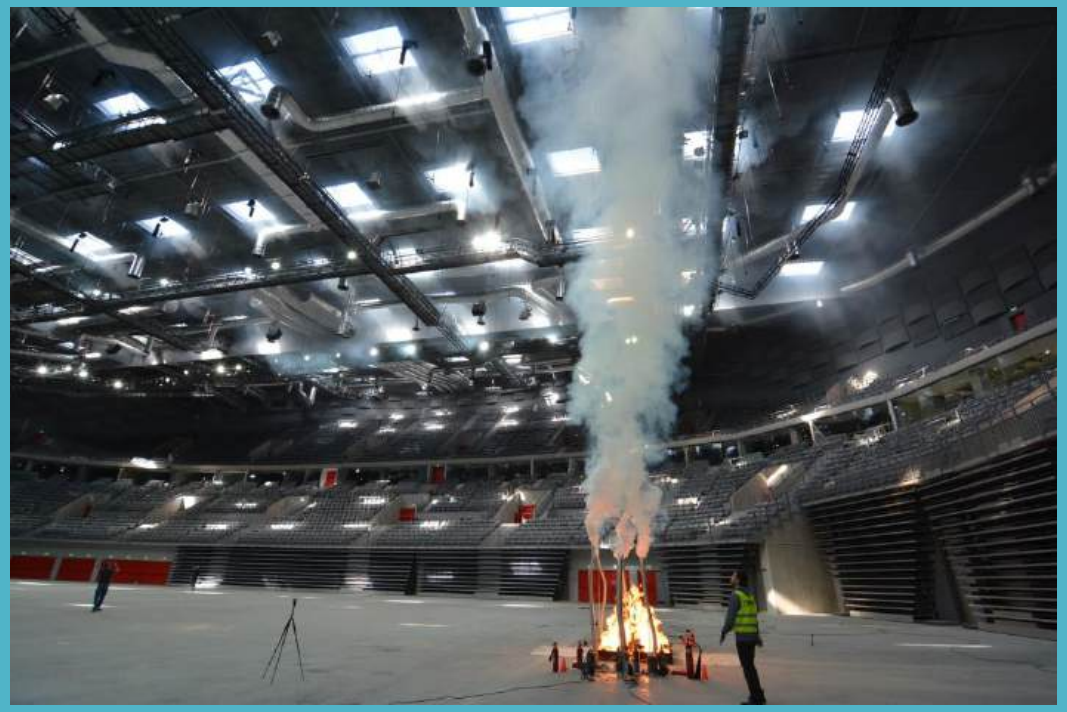
INBEPO

The Institution of Fire Engineers
Republic of Ireland Branch

Fire Safety Conference
Dublin, October 2024

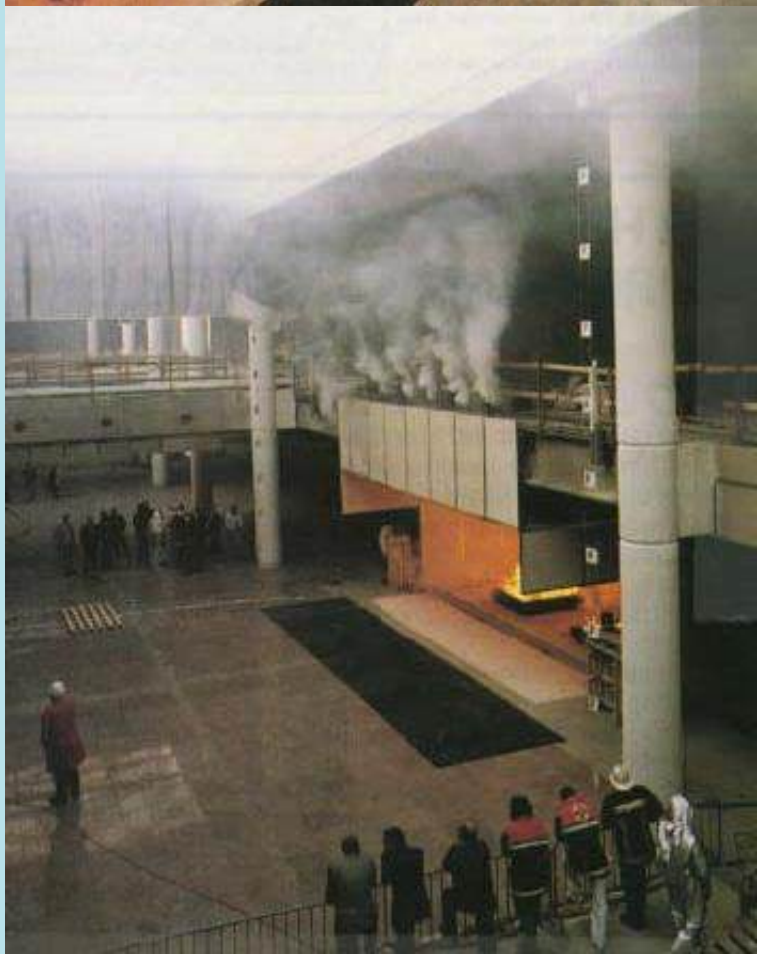


Hot smoke tests - introduction

Full scale smoke test are used to verify smoke ventilation systems in atrium buildings, shopping malls, underground car parks, tunnels and other similar structures.

The first well recorded examples of such tests in Europe are from the nineties (e.g. Brussels airport test in 1994, European Parliament test in Brussels in 1996).

Full-scale smoke test can be carried our as either cold (with no significant hear source present) or hot tests.



Source: Concept Smoke

Smoke tests with cold smoke

Source: LinkedIn

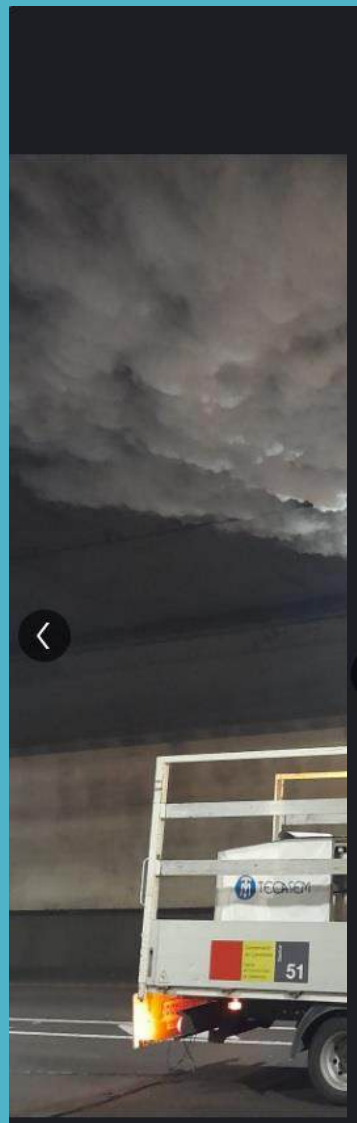
Hot smoke tests

In a hot smoke test heat and visible smoke can either be produced by a single source (e.g. burning diesel or heptane) or they can be generated separately.

The later method allows visible smoke (tracer) to be a clean, artificially generated aerosol, which does not leave any residue in the building after the test.

In either case the heat output of the test fire (heat source) will normally be much smaller than that of the design fire.

Source: CTP Projekt (LinkedIn)



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Successful smoke test in the Atrium LLF of the Children's Hospital Zurich. As part of this test, the 8 MRH 630s, each with a power consumption of 15 kW, which were installed on the roof, were put through their paces.

The MRH delivered have a total air volume of an impressive 255,000 m^3/h. This ensures fast and efficient evacuation of flue gases in the event of a fire or other emergency situation. The afterflow takes place via the automatically opened doors, which are controlled by the MRWA (smoke and heat exhaust ventilation system).

A thank you to all those involved for their support and successful cooperation.

Safety Technology#Children's Hospital#Systemair#MRWA#Smoke Extraction#Innovation

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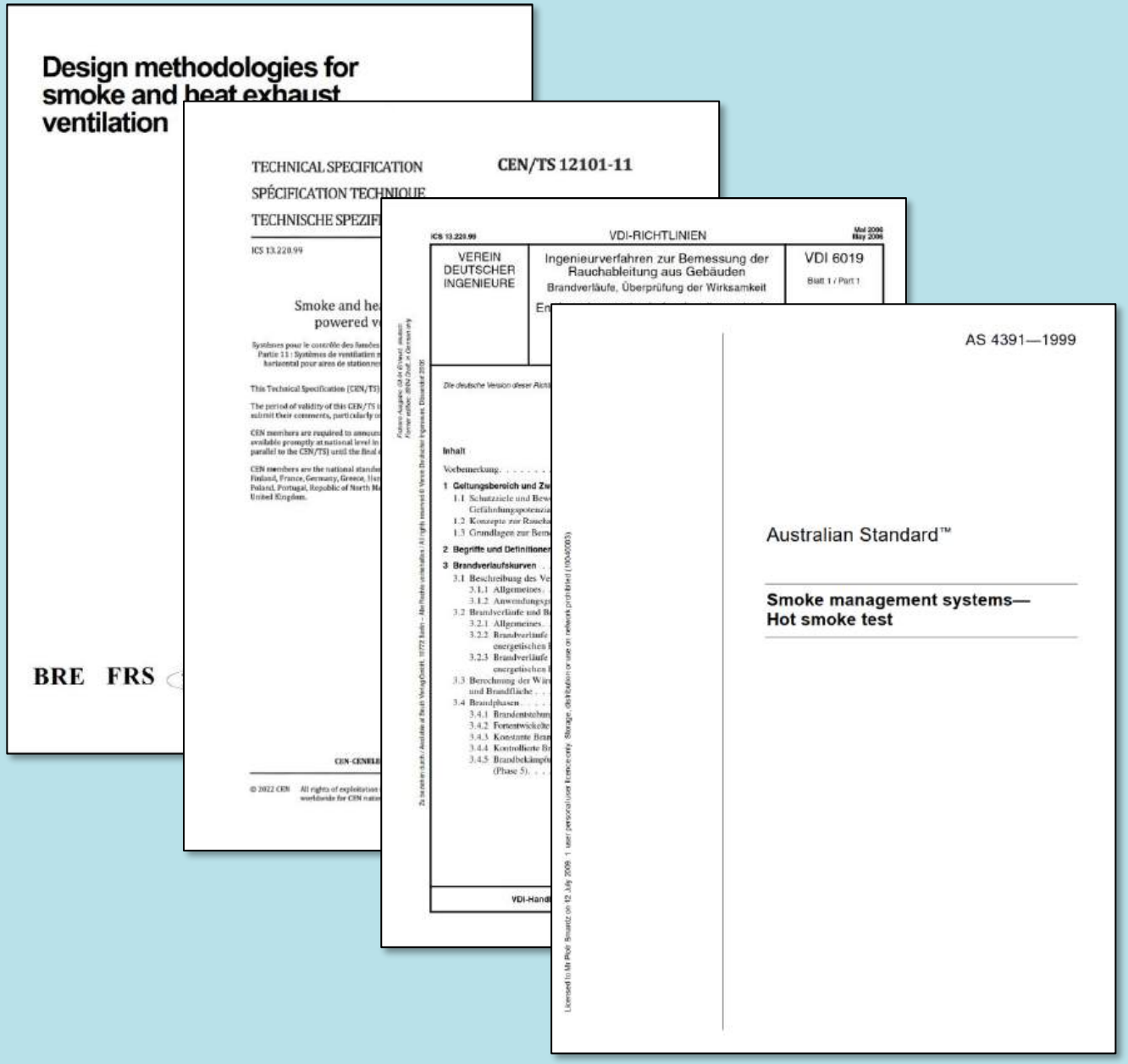
Source: LinkedIn

Heat sources in hot smoke tests

Source: Concept Smoke / LinkedIn

Internationally there are several guides, technical specifications and standards which refer to hot smoke tests in a varying degree of detail.

The most comprehensive test methodology is described in Australian Standard AS 4391:1999.



Test objectives (AS 4391:1999)

The objectives of the test shall be determined in consultation with the **relevant authority** to identify which parameters will demonstrate compliance of the system. The following minimum criteria shall also be achieved by the system under test:

a) The **automatic operation of the smoke control system** shall be in accordance with the agreed design requirements.

b) The performance of the system shall not be unduly affected by incomplete construction or other such defects in the building.

c) There shall not be evidence of partial or complete failure of any component of the smoke control system under test.

Test objectives (Annex E to CEN/TS 12101-11:2022)

The purpose of the hot smoke test is to validate the performance of horizontal ventilation system in conditions similar to a real fire, with particular consideration of:

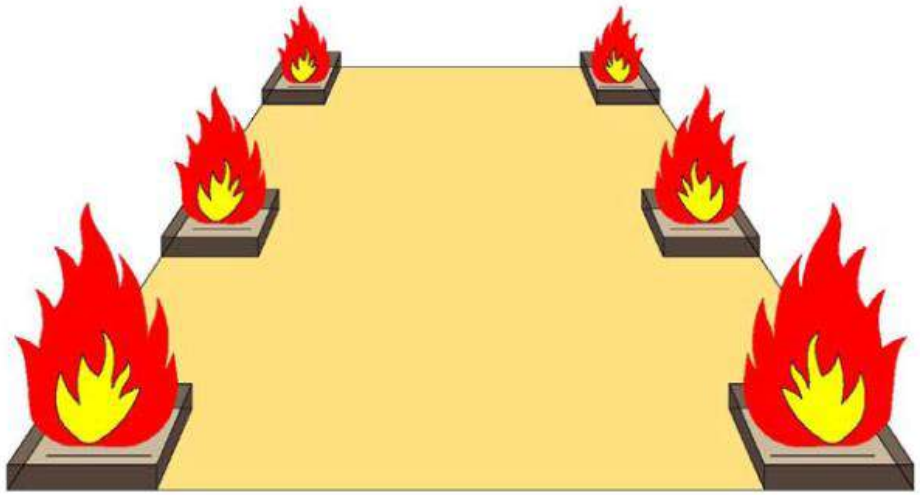
1) realization of **activation sequence**, including shut down of the day-to-day ventilation and start of the fire ventilation mode, as written in the activation sequence;
2) start of other ventilation systems that may interfere with horizontal flow ventilation system, such as pressure differentia systems within escape routes;
3) determining the time required to start the main system components, such as fire dampers, main exhaust and supply fans and the jet fans;
4) determining areas, in which mixing of smoke in the buoyant layer and incoming make-up air occurs, within the time of delay of jet fan activation;
5) an access path sufficiently clear of smoke is provided up to 15 meters from the fire.

What a hot smoke test can do for you?

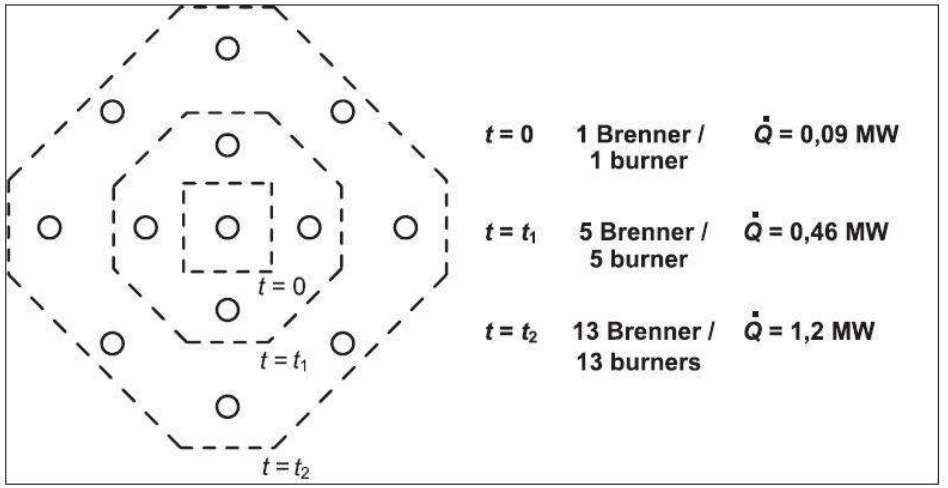
1) provide a realistic visualisation of smoke flow with buoyant plume and buoyant smoke layer
2) challenge the detection system with smoke activating multiple detectors (potentially also outside the initial smoke detection / smoke control zone)
3) indicate smoke leakage paths through gaps between construction, smoke curtains etc.
4) provide qualitative indication of smoke control system performance
5) highlight potentially detrimental influence of wind and excessive air flow velocities on the performance of the smoke ventilation system

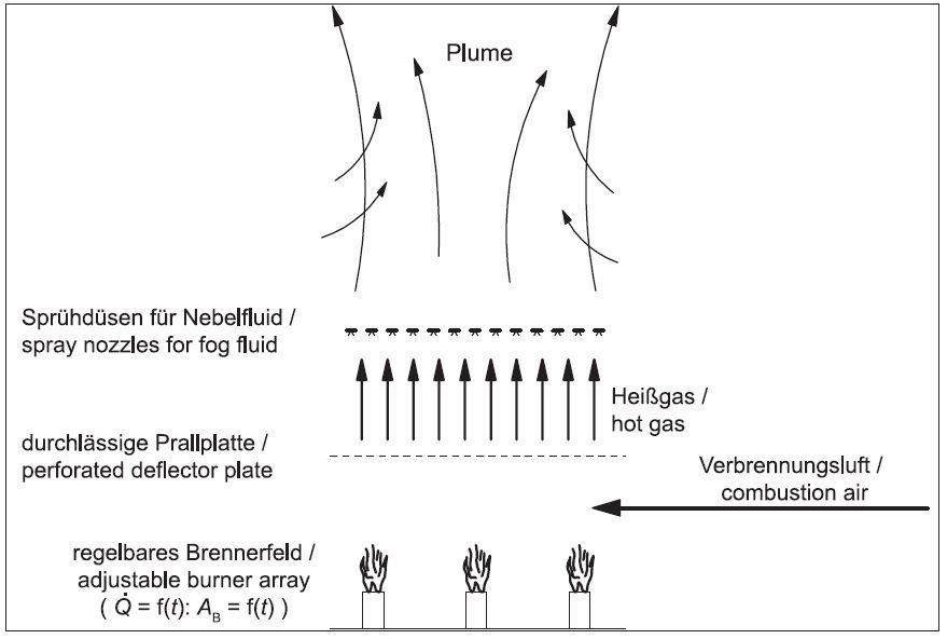
What it cannot do?

1) fully replicate the effects of the design fire – for safety reasons the heat output during a test is normally an order of magnitude lower than that of the design fire
2) be a measure of smoke control system efficiency in preventing certain phenomena such as back-layering (in a real fire)
3) provide meaningful information about smoke layer temperature and visibility through smoke in the real (design fire) scenario



Source: Morgan & De Smedt





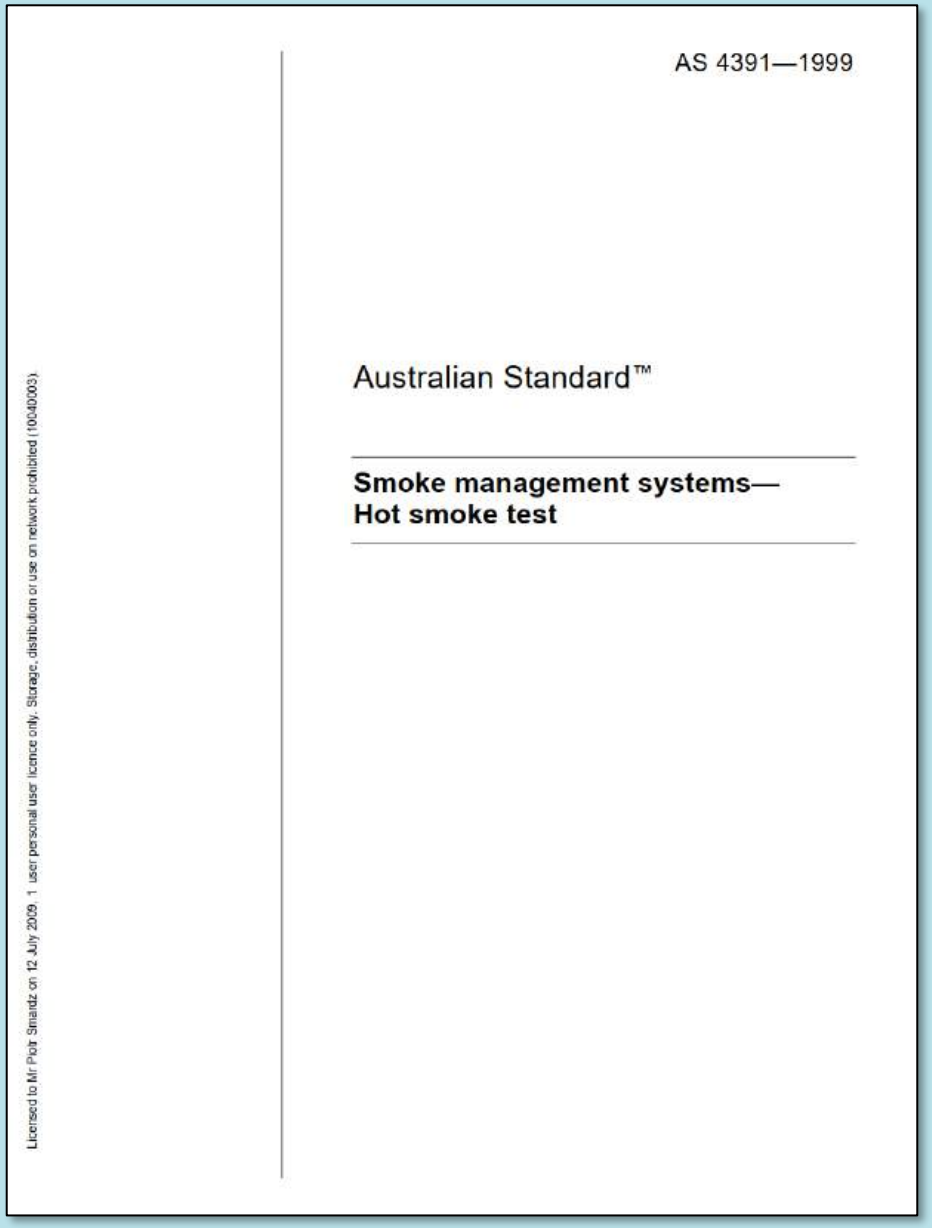
Source: VDI 6019

Hot smoke tests – AS 4391 methodology

Australian Standard AS 4391-1999 is the only internationally recognized reference document comprehensively prescribing the methodology for hot smoke tests.

The document covers:

- Test apparatus
- Test procedures
- Life and asset safety requirements
- Recording equipment
- Test preparation and reporting


AS 4391—1999

Australian Standard™

Smoke management systems—
Hot smoke test

The principle of the test is described in section I of AS 4391:

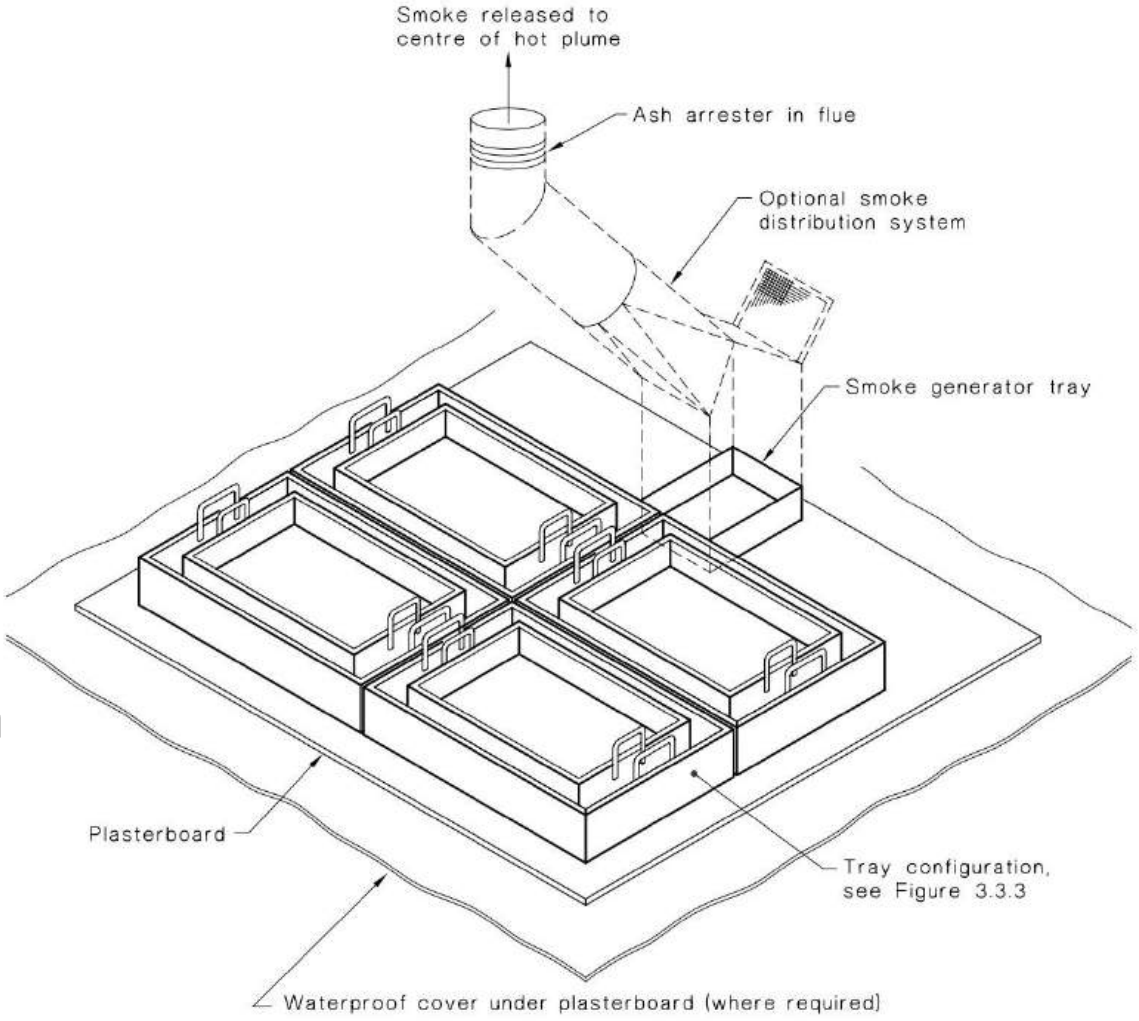
„A pool of methylated spirit is ignited to create a plume of hot air which is then charged with a tracer smoke. This plume activates the smoke control system, the performance of which is monitored to compare with the system as approved by the regulatory authority.”

The fuel in the test is industrial grade methylated spirit (ethanol).

Fuel is burned in standardized steel tray (or trays). Dimensions of the trays are based on ISO paper sizes A5 to A1.

The test allows for up to 4 A1 trays to be placed together, resulting in the maximum test fire area of 2 m^2 and the maximum heat output of 1.5 MW.

Each tray with fuel is placed in a water bath – larger metal trays (B5 to B1).



AS 4391 Figure 2.1 – Test apparatus

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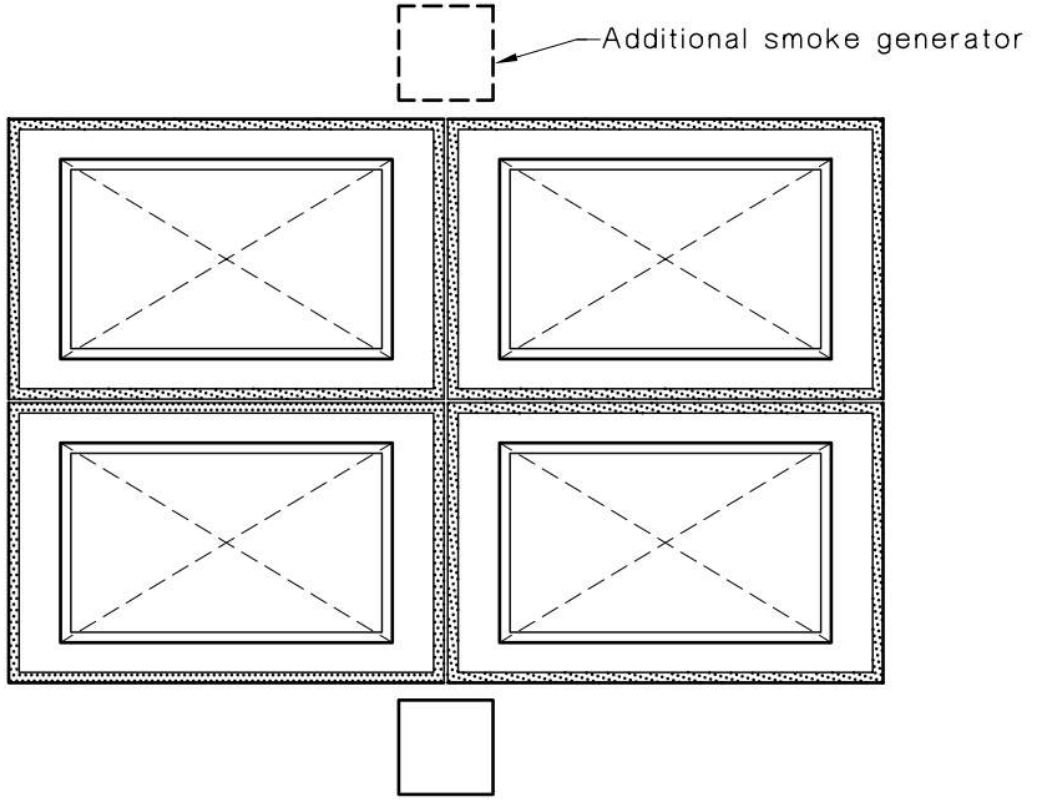


AS 4391 Figure 3.3.3 – Tray configuration 4xA1

Fuel tray size	Amount of fuel for 10 minutes of steady state burn, L	Approximate heat release rate, kW/m^2	Approximate heat output, kW	Temperature rise at 3 m above the trays, °C	Volume flow in the plume at 3 m above the trays, m^3/s
4 x A1	4 x 16 = 64	751	1 500	236	9.2
2 x A1	4 x 15 = 32	696	700	166	5.4
A1	13,0	678	340	117	3.2
A2	5,5	566	140	69	2.0
A3	2,5	471	60	41	1.3

Test fire characteristics based on table 2.7 and table A1 of AS 4391

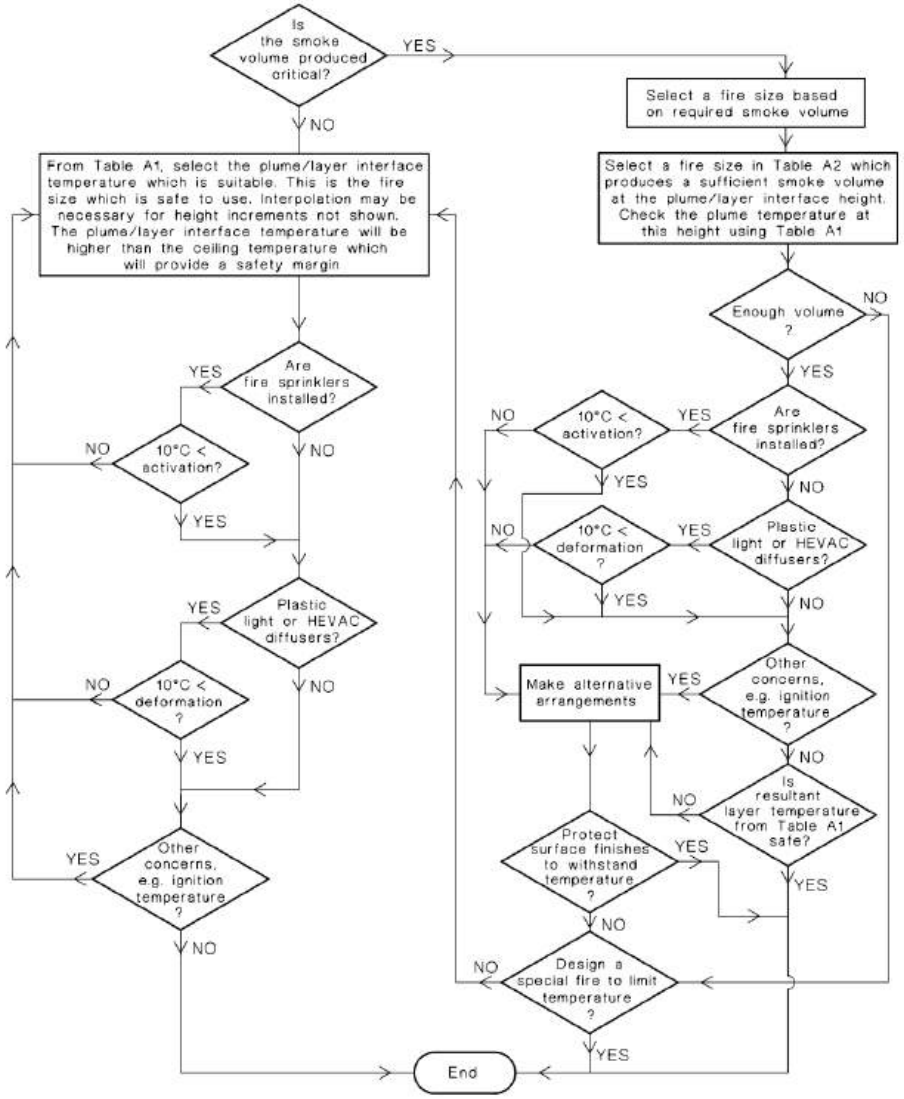

INBEPO
PRÓBY DYMOWE
INBEPO
RAMIRENT
TS26 53 NAWA WSCH
INBEPO
INŻYNIERIA BEZPIECZEŃSTWA POŻAROWEGO
PRÓBA DYMOWA NR: 1
DATA: 02.07.2024


4
5
CO2

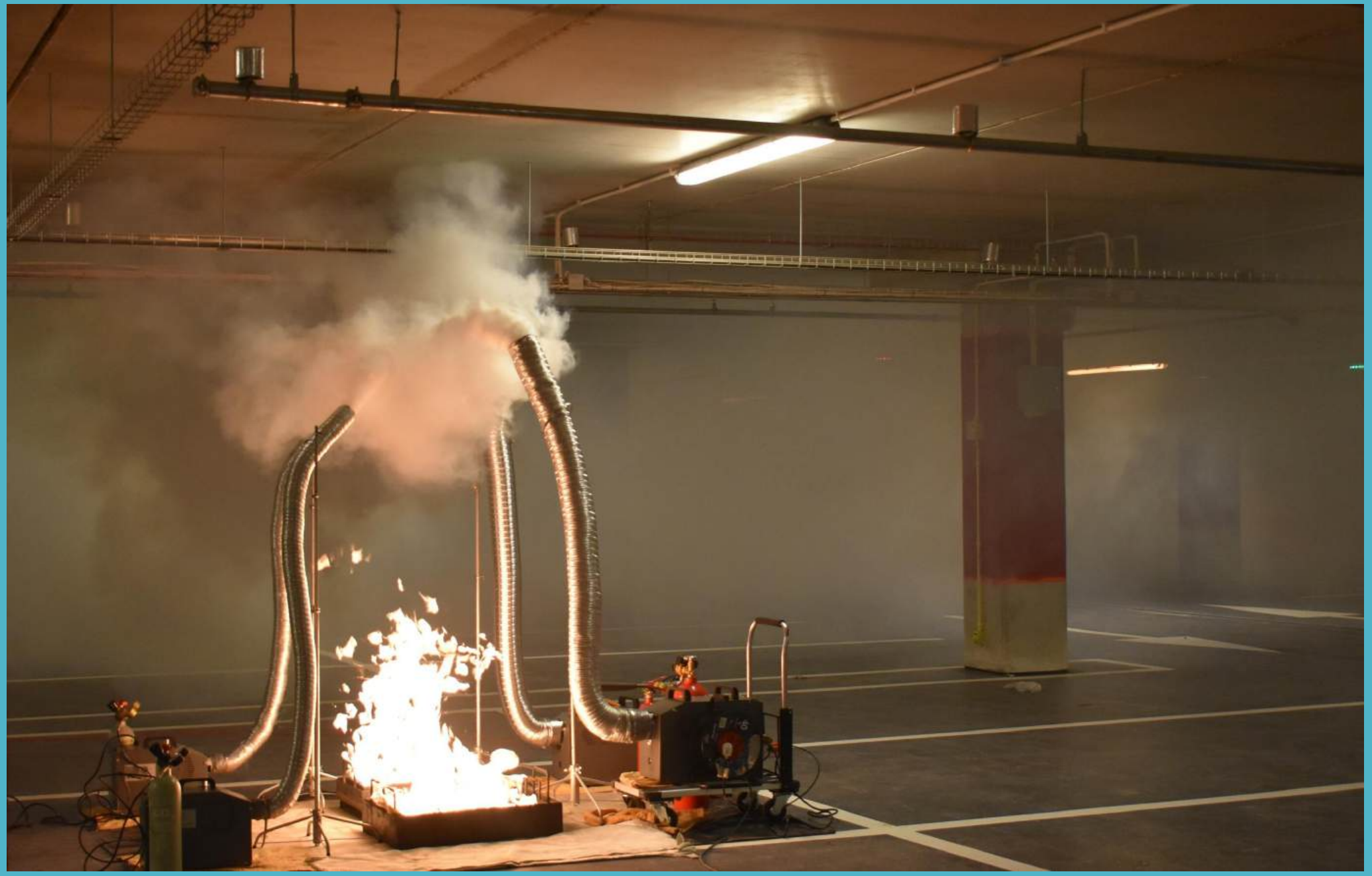
Safety considerations

The standard (appendix B) provides a methodology for selection of a safe test fire size.

The choice is strongly influenced by the height / volume of the space and by presence of sprinklers, plastic pipes, light fittings, cables and other similar objects which can be damaged by high temperature.



AS 4391 Figure B1 – Safe fire size selection proccess



Examples of hot smoke tests

Shopping centres


DEKRA

Sport halls


L
K

Enclosed car parks


032
027


04

Tunnels


VI-COUNT
COMPACT
TS26 53
NAWA
ZACH
INBEPO
INŻYNIERIA BEZPIECZEŃSTWA POŻAROWEGO
PRÓBA DYMOWA NR: 3
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TU-GRAZ

What problems can we identify?

Resources:

- AS 4391-1999 Smoke management systems – hot smoke tests
- VDI 6019-1:2014 Engineering methods for the dimensioning of systems for the removal of smoke from buildings
- CEN/TS 12101-11:2022 Smoke and heat control systems – Part 11: Horizontal flow powered ventilation systems for enclosed car parks (Annex E)
- Morgan H.P., de Smedt J.-C., Hot Smoke Tests: Testing the Design Performance of Smoke and Heat Ventilation Systems and of Impulse Ventilation Systems, „International Journal Eng. Performance-Based Fire Codes”, 6/2004, p. 7–18.
- RVS 09.02.31 Tunnel Ventilation – Basic Principles, 2008
- Methodological guide on safety exercises in road tunnels, CETU 2017
- Smardz P., Paliszek J., Hot smoke tests – lessons for better design of fire protection systems, INTERFLAM 2019
- www.firescienceshow.com (episode 33)

THANK YOU

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