BRE FIRE CONFERENCE 2015

11th June 2015

Part of the BRE Trust
Why do design fires matter?

BRE Fire Conference 2015
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What is a design fire?

A design fire is a simplified approximation of a fire that is considered to be representative of a fire involving a specified hazard.

Not all fires are the same,
Some commonly heard phrases when describing fires:

“Smoldering fire”
“Flashed-over fire”

“Flash fire”
“Smokey fires”
Characterising a design fire
Factors which affect design fire characteristics

- Fuel type
- Orientation of fuel
- Ventilation
- Enclosure
- Location
- Suppression

- Growth rate
- Peak heat release rate
- Duration
- Smoke yield (visibility)
- Toxic yield
Idealised fire growth curves

Table 3: The four standard fire growth coefficients. Data from Chitty & Fraser-Mitchell

<table>
<thead>
<tr>
<th>Fire growth coefficient</th>
<th>Time to reach 1 MW (s)</th>
<th>Coefficient $\alpha_r$</th>
<th>Fire scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slow</td>
<td>600</td>
<td>0.00293</td>
<td>Densely packed paper</td>
</tr>
<tr>
<td>Medium</td>
<td>300</td>
<td>0.01172</td>
<td>Traditional mattress or armchair</td>
</tr>
<tr>
<td>Fast</td>
<td>150</td>
<td>0.0469</td>
<td>PU mattress or PE pallets</td>
</tr>
<tr>
<td>Ultra fast</td>
<td>75</td>
<td>0.1876</td>
<td>High rack storage</td>
</tr>
</tbody>
</table>
Structural fire testing

Standard fire curves

![Graph showing temperature over time for different fire scenarios: Hydrocarbon, ISO 834, External, and Real fire. The graph indicates assumed flashover at a certain time.]
Parametric curves

- fire load
- ventilation
- thermal characteristics
Time equivalence

ISO Fire

Temperature

Time

30

60

90
Why define a design fire?
## Guidance

### Table 4  Risk profiles

<table>
<thead>
<tr>
<th>Occancy characteristic (from Table 2)</th>
<th>Fire growth rate</th>
<th>Risk profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>A  (Occupants who are awake and familiar with the building)</td>
<td>1  Slow</td>
<td>A1</td>
</tr>
<tr>
<td></td>
<td>2  Medium</td>
<td>A2</td>
</tr>
<tr>
<td></td>
<td>3  Fast</td>
<td>A3</td>
</tr>
<tr>
<td></td>
<td>4  Ultra-fast</td>
<td>A4 (A)</td>
</tr>
<tr>
<td>B  (Occupants who are awake and unfamiliar with the building)</td>
<td>1  Slow</td>
<td>B1</td>
</tr>
<tr>
<td></td>
<td>2  Medium</td>
<td>B2</td>
</tr>
<tr>
<td></td>
<td>3  Fast</td>
<td>B3</td>
</tr>
<tr>
<td></td>
<td>4  Ultra-fast</td>
<td>B4 (A)</td>
</tr>
<tr>
<td>C  (Occupants who are likely to be asleep)</td>
<td>1  Slow</td>
<td>C1 (B)</td>
</tr>
<tr>
<td></td>
<td>2  Medium</td>
<td>C2 (B)</td>
</tr>
<tr>
<td></td>
<td>3  Fast</td>
<td>C3 (B, Q)</td>
</tr>
<tr>
<td></td>
<td>4  Ultra-fast</td>
<td>C4 (A, B)</td>
</tr>
</tbody>
</table>

### Occupancy Risk profile

- Administration office: A2
- Amusement arcade: B2
- Archive/library reading area: B3
- Art gallery: B1/B2
- Assembly hall: B2
- Banking hall: B1
Fire protection system design

- Smoke extract system
- Typically based on a steady state design fire
- Simple
- Onerous but not for all aspects (e.g. detection time)
Fire Engineering

For designers….

A need to define the hazard to occupants, property/business and firefighters in selecting what fire protection measures/performance are required to ensure a reasonable standard of safety is achieved.

Means of escape:

ASET vs RSET

Design fire dependent
PD7974

QDR ← Involvement of stakeholders

Fuel:
- Combustibility
- Flammability
- Surface spread of flame
- Fire load density
- Orientation
- Distribution

Environment:
- Insulation
- Ventilation (windows, vents, HVAC?)
- Location of fire
- Operation of the area

Assessment, experience and judgement
What is credible?

Need to establish a reasonable worst case design fire.

Arson – multiple seats of fire
Terrorist attack – Major conflagration

Typically outside the scope of most fire strategies but could be included

Accidental fires:

Should be credible and realistic but also robust, withstand scrutiny and include a suitable margin of safety.
What does guidance say?

BR368 – Unreasonable to base smoke extract design on the largest fire possible

- Average design fire unsuitable
- Available fire statistics
- Expert judgement

PD 7974 - In the UK, it is recommended that the 80% fractile value be taken as the fire load density for design.

(Local concentrations of fire load can exceed this value.)
When using experimental data:

Is the data representative?
– Similar fuel, composition, orientation etc?
– Have circumstances changed?
Case study
Example - Airport concourse

- Retail (adopts cabin principle, separated from concourse)
- Large area with minimal fixed fire loading
- Strict control of fire load by airport management
  - Seating
  - Small concessionaires
- Main fire load passenger luggage (uncontrolled content pre-security)
- Luggage generally individual and separated
- Occasionally baggage accumulated e.g. on trolleys
Fire growth

- Large area small isolated items of fire load
- Propensity for fire spread is low
How much fuel does a luggage trolley present?

Generally 23 kg free allowance but 30kg max
Groups share trolleys. How many people travel together?

CAA Passenger Survey Report 2013
Terminating passengers are passengers who arrive at or depart from an airport by surface modes of transport.

<table>
<thead>
<tr>
<th>Group size</th>
<th>UK Business</th>
<th>UK Leisure</th>
<th>Foreign Business</th>
<th>Foreign Leisure</th>
<th>All Passengers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travelling alone</td>
<td>83.0%</td>
<td>25.4%</td>
<td>84.2%</td>
<td>42.5%</td>
<td>36.8%</td>
</tr>
<tr>
<td>Travelling with one other</td>
<td>9.9%</td>
<td>42.0%</td>
<td>9.1%</td>
<td>34.5%</td>
<td>36.1%</td>
</tr>
<tr>
<td>Travelling with two others</td>
<td>1.8%</td>
<td>5.3%</td>
<td>1.6%</td>
<td>5.5%</td>
<td>4.9%</td>
</tr>
<tr>
<td>Travelling with three others</td>
<td>1.8%</td>
<td>10.1%</td>
<td>1.0%</td>
<td>9.9%</td>
<td>12.8%</td>
</tr>
<tr>
<td>Travelling with four others</td>
<td>0.6%</td>
<td>4.9%</td>
<td>0.3%</td>
<td>3.7%</td>
<td>3.7%</td>
</tr>
<tr>
<td>Travelling with five or more</td>
<td>3.0%</td>
<td>6.3%</td>
<td>3.8%</td>
<td>5.7%</td>
<td>5.6%</td>
</tr>
</tbody>
</table>

| Total                       | 100.0%      | 100.0%     | 100.0%           | 100.0%          | 100.0%         |
| Total Passengers (000s)     | 2,694       | 20,736     | 1,615            | 7,357           | 32,402         |

- 83.0% of business travellers travel alone
- 88.8% of leisure travellers travel in groups of up to four people
Weight of baggage per person

Checked baggage weights by gender and region; totals

<table>
<thead>
<tr>
<th>Airport</th>
<th>Mean</th>
<th>n</th>
<th>Std.dev</th>
<th>Accuracy (%)</th>
<th>Confidence range (95%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LGW</td>
<td>16.8</td>
<td>3,400</td>
<td>5.1</td>
<td>1.0</td>
<td>0.17</td>
</tr>
</tbody>
</table>
Weight of baggage being carried per group (on a trolley)

<table>
<thead>
<tr>
<th>People</th>
<th>LGW 2013 (%)</th>
<th>Total luggage weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>36.8</td>
<td>16.8</td>
</tr>
<tr>
<td>2</td>
<td>36.1</td>
<td>33.6</td>
</tr>
<tr>
<td>3</td>
<td>4.9</td>
<td>50.4</td>
</tr>
<tr>
<td>4</td>
<td>12.8</td>
<td>67.2</td>
</tr>
<tr>
<td>5</td>
<td>3.7</td>
<td>N/A</td>
</tr>
<tr>
<td>6</td>
<td>5.8</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Leisure 67kg (4 people)  
Business 33.6kg (2 people)

Terminal was business focused, most likely fire load was 33.6kg of baggage
Design fire

1.2MW peak heat release rate

Medium fire growth

1.2MW peak heat release rate
38kg
Added conservatism

Margin of safety

Allow future flexibility in terminal use
60kg
HRR not the only important characteristic...

- Primary tenability criteria is visibility
- Smoke yield

CFD as an example

<table>
<thead>
<tr>
<th>Material</th>
<th>Smoke conversion factor, $\varepsilon_{\text{smoke}}$ kg/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Flaming</td>
</tr>
<tr>
<td>Cellulosics</td>
<td>&lt; 0.01 to 0.025</td>
</tr>
<tr>
<td>Plastics</td>
<td>&lt; 0.01 to 0.17</td>
</tr>
</tbody>
</table>

Cellulosic = 0.02
Plastics = 0.1
CFD
CFD
After handover

Regulation 38 – ensure sufficient information is passed on to the building owner/manager. This includes the basis for the engineered analysis:

**The design fire**

What does 2.0MW mean to a general facilities or operations manager?

Or,

Combustible content should be restricted to 60kg of combustible material separated by distance of 5m.
Conclusion

- Design fires form a critical basis of engineered fire strategies
- Must ensure the design fire is accurate
- Must ensure the end user understands the basis for the design fire
- Need for further design fires:
  - Kiosks, displays/stands, buggies, wheelie bins
Thank you

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