Fire Protection of Ductwork

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Morgan Advanced Materials

Morgan Advanced Materials
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Morgan Advanced Materials has a global presence with over 10,000 employees across 50 countries serving specialist markets in the energy, transport, healthcare, electronics, petrochemical and industrial sectors. It is listed on the London Stock Exchange in the engineering sector.
Topics

• The need for fire resisting ducts and the importance of identifying the duct function when assessing fire performance
• The fire testing standards currently used and how they compare
• The special considerations needed for kitchen extract and smoke extract ductwork
• Morgan’s approach in Qatar
Fire Protection of Ductwork

The need for fire protection and the importance of identifying the duct function
Control of fire spread within a building relies on compartmentation

Buildings are divided into fire-safe compartments within which a fire can be contained

These compartments must provide structural and insulation integrity during a fire to ensure the spread of fire does not occur
Ducts represent a risk to maintaining fire compartmentation

1. A fire in a duct can breach the integrity of a fire compartment if the duct is not capable of safely containing the fire

2. If the duct is in close proximity to combustible materials the external surface of the duct can be hot enough to ignite them

3. The type of duct is important in determining how the fire risk originates

4. Various fire testing standards have been developed to evaluate the fire performance of different duct types
## Methods to prevent fire spread through ducts

<table>
<thead>
<tr>
<th>Method</th>
<th>Concept</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fit a <strong>Fire Damper</strong></td>
<td>Fire damper closes during a fire and seals the duct at the point of penetration through a fire division</td>
<td>Fire dampers should not be installed within certain ductwork systems in buildings (e.g. kitchen extraction, staircase and lobby pressurisation, lift shaft ventilation, fresh air make up provision).</td>
</tr>
<tr>
<td>Enclose the duct in a protective shaft</td>
<td>A fire rated shaft is built around the duct to enclose it.</td>
<td>May still require fire dampers to be fitted depending on regulations and number of services in ducts. Although a common practice in the USA many constructions used have not been proven in fire tests!</td>
</tr>
<tr>
<td>Build a <strong>fire resisting duct</strong></td>
<td>The duct is insulated to ensure it can contain the fire. The insulation can be supplied within a pre-fabricated fire resisting duct assembly or secondary fitted on site to the duct</td>
<td>The duct design is also a key factor in its fire performance and of equal importance to the fire insulation system design. Duct steel thickness, flange design, stiffening and hanging arrangements should comply with what has been used in fire tests.</td>
</tr>
</tbody>
</table>
## Types of Duct – Function and Purpose of fire protection

<table>
<thead>
<tr>
<th>Type Of Duct</th>
<th>Purpose</th>
<th>Why fire protect?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ventilation</td>
<td>Provide HVAC in building</td>
<td>Due to the number of openings in HVAC ducts, the duct could have a fire “inside” and if it passes through multiple compartments in a building could be a source of fire spread unless it can contain any internal fire.</td>
</tr>
<tr>
<td>Pressurisation</td>
<td>Supply a positive pressure to critical areas to prevent smoke entering e.g. lobbies, corridors</td>
<td>The duct must function as a source of pressurisation when exposed to an external fire. Pressure loss via leakage due to deterioration of duct integrity in a fire is a concern.</td>
</tr>
<tr>
<td>Smoke Extraction</td>
<td>Extract smoke from a building</td>
<td>The duct must function as an extraction route for smoke. The duct must maintain sufficient sectional area when exposed to a fire to provide smoke extraction.</td>
</tr>
<tr>
<td>Kitchen Exhaust (Grease Extract)</td>
<td>Extract of cooking fumes from commercial kitchens</td>
<td>Combustible Materials inside the duct are potentially a source of fire and therefore the duct must be proven to contain the fire.</td>
</tr>
</tbody>
</table>

Ducts may have dual-function i.e. a ventilation duct may function as a fan assisted smoke extraction duct during a fire. Performance requirements in a fire may therefore be different than in normal use.
Fire resisting Ducts

Evolution of Fire Testing and Performance Classification
Global evolution of duct test and standards.

- ASTM E2336
- ASTM E2816
- UL 2221
- BS 476 pt. 24
- EN 1366-1, 8, 9
- GB/T 17428 2009
- ISO 6944-1, 2
- AS 1530 pt. 4
- ASTM E2816
## Fire Test Standards Overview

<table>
<thead>
<tr>
<th>Region/Country</th>
<th>Standard</th>
<th>Duct Type</th>
<th>HVAC</th>
<th>Pressurisation</th>
<th>Smoke Extract</th>
<th>Kitchen/Grease</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>ASTM E2816</td>
<td>√</td>
<td>√</td>
<td>No specific reference</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td>ASTM E2336 (NFPA 96)</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td>UL 1978 (invalid since 2009)</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>EU</td>
<td>UL 2221 (test of enclosure systems for ducts)</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>EU</td>
<td>EN 1366-1:2014</td>
<td>√ Duct B</td>
<td>√ Duct A</td>
<td>x</td>
<td>√ currently via “ducts with combustible linings” scope but note new part 14 in preparation</td>
<td></td>
</tr>
<tr>
<td>EU</td>
<td>EN 1366-8:2004</td>
<td>x</td>
<td>x</td>
<td>√ Duct C (Multi-Compartment)</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>EU</td>
<td>EN 1366-9:2008</td>
<td>x</td>
<td>x</td>
<td>√ Single Compartment functioning up to 600°C</td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>
## Duct Fire Test Standards Overview

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</tr>
</thead>
<tbody>
<tr>
<td>International</td>
<td>ISO 6944-1: 2008</td>
<td>✓</td>
<td>✓</td>
<td>X</td>
<td>☑️ (must be used in conjunction with ISO 6944-2 2009)</td>
</tr>
<tr>
<td></td>
<td>NB: Replaces ISO 6944: 1985 which was a joint standard with BS 476 pt. 24</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ISO 6944-2: 2009</td>
<td>☑️ (duct B)</td>
<td></td>
<td></td>
<td></td>
<td>☑️ (duct A with additional requirement in test)</td>
</tr>
<tr>
<td>UK and ASIA</td>
<td>BS 476 part 24 (still referenced in some non-EU markets e.g. Hong Kong, Singapore but superseded by BS EN 1366-1,8 and 9 in UK)</td>
<td>✓</td>
<td>✓</td>
<td>☑️ (duct A with additional requirement in test)</td>
<td>☑️ (duct A with additional requirement in test), Non NFPA 96 compliant</td>
</tr>
</tbody>
</table>
General Requirements of Duct Fire Tests

- **Two distinct fire exposure conditions**
  - Fire exposure **outside only**
    - “Duct A”
  - Fire exposure **outside and inside** simultaneously
    - “Duct B”
- Duct is evaluated for **integrity, stability and “insulation”** performance
  - Insulation criterion of test is to ensure the duct surface does not cause ignition of combustibles in vicinity to its surface
  - Maximum surface temperature rise is specified that is not to be exceeded during the test duration
BS, EN, ISO and ASTM ventilation & pressurisation duct test standards test duct with (Type B) and without openings (Type A)

The test principles may be similar but there is considerable difference in detail on how the test is conducted which can lead to differences in test results.

Test standards for kitchen and smoke ducts are very different so will be discussed in more detail today.
Grease / Kitchen Extract Ducts
Structure Fires

- U.S. fire department structure fires - 3,520.
- Annual losses, civilian deaths- 09.
- Civilian injuries- 20.
- Property damage-$84 million.
- Cooking equipment – leading cause- **50% of fires in hotels**.
Eyewitnesses said that the fire was first spotted at the roof of Caravan restaurant and later spread to nearby eateries.
Grease / Kitchen Extract Ducts

• Fire risk is from ignition of accumulation of cooking oils within the duct over time
• Inspection and routine cleaning is not a complete safeguard for prevention of fires
• NFPA estimated in 2014 >U$100m annual direct property damage in the USA attributable to kitchen extract ducts
• Passive fire protection is fitted to ensure any fire can be contained within the duct
• The design of the fire protection system should consider the possible impact on the fire insulation of leaking grease from the duct
Severity of Grease Duct Fires

• Testing of extinguishing systems for kitchen extract hoods has provided some data on likely temperatures generated in grease fires
  • 1.5kg/m³ of animal fat coating the duct used
  • 225m/min air flow inside the duct prior to ignition of the fat
  • Ignition of fat with 20MJ/min external heat source

![Graph showing temperature over time]

Key

<table>
<thead>
<tr>
<th>X</th>
<th>time, expressed in seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>temperature, expressed in degrees Celsius</td>
</tr>
</tbody>
</table>

Data from:
- Location A, located 3.65 m from the ignition source
- Location B, located 6.09 m from the ignition source
3.3.50** Trained.** A person who has become proficient in performing a skill reliably and safely through instruction and practice/field experience acceptable to the AHJ.

3.3.51 Trap. A cuplike or U-shaped configuration located on the inside of a duct system component where liquids can accumulate.

### Chapter 4  General Requirements

#### 4.1 General.

**4.1.1 Cooking equipment used in processes** producing smoke or grease-laden vapors shall be equipped with an exhaust system that complies with all the equipment and performance requirements of this standard.

**4.1.1.1** Cooking equipment that has been listed in accordance with ANSI/UL 197 or an equivalent standard for reduced emissions shall not be required to be provided with an exhaust system.

**4.1.1.2** The listing evaluation of cooking equipment covered by 4.1.1.1 shall demonstrate that the grease discharge at the exhaust duct of a test hood placed over the appliance shall not exceed 5 mg/m³ (0.00018 oz/ft³) when operated with a total airflow of 0.236 m³/s (500 cfm).

**4.1.2** All such equipment and its performance shall be maintained in accordance with the requirements of this standard during all periods of operation of the cooking equipment.

#### 4.2** Clearance.

**4.2.1** Where enclosures are not required, hoods, grease removal devices, exhaust fans, and ducts shall have a clearance of at least 457 mm (18 in.) to combustible material, 76 mm (3 in.) to limited-combustible material, and 0 mm (0 in.) to noncombustible material.

**4.2.2** Where a hood, duct, or grease removal device is listed for clearances less than those required in 4.2.1, the listing requirements shall be permitted.

#### 4.2.3** Clearance Reduction.

**4.2.3.1** Where a clearance reduction system consisting of 0.33 mm (0.013 in.) (28 gauge) sheet metal spaced out 25 mm (1 in.) on noncombustible spacers is provided, there shall be a minimum of 229 mm (9 in.) clearance to combustible material.

**4.2.3.2** Where a clearance reduction system consisting of 0.69 mm (0.027 in.) (22 gauge) sheet metal on 25 mm (1 in.) mineral wool batts or ceramic fiber blanket reinforced with wire mesh or equivalent spaced 25 mm (1 in.) on noncombustible spacers is provided, there shall be a minimum of 76 mm (3 in.) clearance to combustible material.

**4.2.3.3** Where a clearance reduction system consisting of a listed and labeled field-applied grease duct enclosure material, system, product, or method of construction specifically evaluated for such purpose in accordance with ASTM E 2336, the required clearance shall be in accordance with the listing.
QCS 2014- separate fire requirements for kitchen.

6.1.2 References

1. The following standards are referred to in this Part:

- **BS 476**..............Fire tests on building materials and structures
- **BS 1449**...............Steel plate, sheet and strip
- **BS 1470**...............Wrought aluminium and aluminium alloys for general engineering purposes
- **BS 1474**...............Wrought aluminium and aluminium alloys for general engineering purposes; bars extruded round tubes and sections
- **BS CP 352**.............Mechanical ventilation and air conditioning in buildings
- **NFPA 90A**.............Installation of Air Conditioning and Ventilating Facilities
- **NFPA 96**.............Ventilation Control and Fire Protection of Commercial Cooking Operation
- **SMACNA**.............Ductwork design and installation
Fire protection general guidelines for hotel projects - Qatar Civil defense.

Duct fire protection: NFPA 90 A for 2 hrs/ ISO 6944
Smoke ducts-Accepted for 2 hrs as per BS476part 24, ISO 6944 and NFPA 92 A and NFPA 92 B.
Kitchen Extract- NFPA 96 for kitchen for 2 hr fireprotection.
ASTM E 2336 for NFPA 96 compliance

ASTM E2336 requires compliance to 5 fire tests:

1. Section 16.1 requires non-combustibility to ASTM E136
2. Section 16.2 requires a 2 Hour ASTM E119 Wall Panel Test – this defines the insulation rating
3. Section 16.3 requires a durability test modelled after ASTM C518
4. Section 16.4 requires an internal grease duct fire test to demonstrate performance during long term exposure to service conditions (500°F/260°C for 4 hours), and exposure to a standardized internal grease fire (2000°F/1093°C for 30 minutes)
5. Section 16.5 requires a fire engulfment test run to the ASTM E119 fire curve, which tests the capability of the duct and enclosure system to resist external fires, tests the integrity of the enclosure fastening system, and tests the through penetration insulation performance of the system for time period requested by system manufacturer
6. Duct construction should meet NFPA 96 standard

INTERNAL FIRE TEST
• Heat furnace from ambient to 240° C & hold at this temperature for 4 hrs
• External temperature of duct must not rise by more than 65° C
• Afterwards increase in temperature to 1093° C for 30 minutes. Normal average and maximum limits for temperature rise apply (181° C/139° C).
The different approach of other codes..

- **BESA DW 172 Specification for kitchen ventilation systems**
  - D6 Section states compliance with **Duct B** fire test insulation and integrity when it passes through a fire compartment
  - In addition a **Duct A** test with extra requirements for combustible linings is required
BS 476 pt. 24 EN 1366-1: “Ducts with combustible linings”
Not the same as NFPA 96 requirements

- Use the ventilation/pressurisation duct test method with additional requirements.
- Ducts A and B can be considered:
  - A – prevent ignition of a combustible lining by an external fire
  - B – representing fully developed fire inside a duct which could be a grease fire

- **Duct A Test**
  - 4 thermocouples measure the *internal surface* of the duct *inside the fire test furnace*
  - Maximum temperature rise allowed is 180°C
  - Average rise of all 4 thermocouples not to exceed 140°C

- **Duct B test**
  - Does not use the rapid rise fire scenario used in ASTM E 2336
Smoke Extraction Ducts
Fire Testing Standards for Smoke Extraction Ducts

- BS 476 pt. 24 requires 75% of the duct cross section is retained
- EN 1366
  - **Part 8** for smoke extract ducts passing through multi-compartments, requires no more than 10% reduction in cross section.
  - Maximum leakage limits must not be exceeded
  - **Part 9** for smoke ducts contained within a single compartment and assuming pre-flashover functionality only is required i.e. temperature exposure of 600 °C.
- ASTM test methods do not consider smoke extract ducting.
• Maximum exhaust temperatures for smoke ducts can be specified as much lower than a standard fire test temperature e.g. 400°C
• Non-standard fire tests following the same principles as BS 476 pt. 24 but with low temperature exposure can be used in such cases
• Where any of these ducts penetrates a fire rated division then the duct must be tested fully to BS 476 pt. 24
Morgan Advanced Materials FastWrap XL Fire Resisting Duct Systems in Qatar
Morgan FireMaster FastWrap XL

### System details
- Alkaline Earth Silicate blanket classified at 1200° C, complete FSK encapsulated. Made in USA.
- Wrapped to duct with Stainless steel bands.
- Fire tested access door
- UL, Omega and Intertek listing for ducts up to or 2 Hrs.
- NFPA 96 compliance, ISO-6944,BS476 pt. 24, EN 1366-1

### Features
- UL listing for DUCT A, Duct B and Grease duct.
- Applus listed for Smoke low temperature duct test.
- Max product usage temperature of 1200°C.
- Binder-Free insulation
- Removable jacketing type installation, Easy to inspected duct.
- Excellent acoustic absorption.
- Tested systems for most types of penetration.
- Fire, Heat and sound insulation with 1 system.

### Morgan EDGE
- **Technical training:** Manufacturer’s training and certification to the installers
- **Technical services:** Periodic visits to site to assess the quality of work and recommend solutions.
- **Engineering Judgement:** Expert advice from the global team.
Major projects:

1. AL Bayt stadium smoke and kitchen extract - 2018.
2. Doha Metro - Qatar - 2017
3. Hamad international Airport - Qatar - 2011 onwards.
4. Mall of Qatar - Qatar - 2015
5. Hilton Riyadh - Qatar - 2016
Morgan FireMaster FastWrap installation

Doha Metro 2017
Morgan FireMaster FastWrap installation

Doha Metro 2017

NDIA 2016

NDIA 2015
2018 Smoke extract duct (400°C). 1 x layer x 25mm FireMaster FastWrap XL

1995 Kitchen extract duct work. 2 x layers x 38mm
Tomorrow: Morgan-Jersey Qatar Association-Made in Qatar.

• Fire Resisting Ductwork is more than a fire insulation material
• The Duct Design, Fire Insulation Specification and Penetration Sealing System are all part of a **system**
• Manufactured by M/s Khalid Manufacturing Company, with 40 years of manufacturing experience in Air outlets.
Thank You