FIRE TESTING FOR INSULATION

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OVERVIEW

- Non-Combustibility
- Surface Burning Characteristics
- Wall and Ceiling Finishes—Room Corner Test
- Fire Resistance Test Methods—Standard Time-Temperature Exposure
- Exterior Flame Propagation
- Fire Resistance—Rapid Temperature Rise (Hydrocarbon Fires)
- Jet Fire
NON-COMBUSTIBILITY

ASTM E136—Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C

- Code References in IBC, IRC, and IMC
NON-COMBUSTIBILITY

• 30-minute test (usually) per test run
• Four test runs required
  • Three of the four specimens required to meet the individual test specimen criteria below
• Weight Loss Criteria
• Temperature Rise Criteria
  • $\leq 30^\circ$C if weight loss $\leq 50\%$
  • None if weight loss $> 50\%$
• Flaming Criteria
  • None after 30s if weight loss $\leq 50\%$
  • No flaming if weight loss $> 50\%$

Option B – ASTM E136 using ASTM E2652 Apparatus
ASTM E84 STANDARD TEST METHOD FOR SURFACE BURNING CHARACTERISTICS OF BUILDING MATERIALS

• Code Requirement in the IBC, IRC, and IMC
• Flame Spread Index and Smoke Developed Index
  • Duct Insulation
  • Pipe Insulation
  • Foam Plastic Insulation
  • Material in Plenums
  • Etc.
ASTM E84 STANDARD TEST METHOD FOR SURFACE BURNING CHARACTERISTICS OF BUILDING MATERIALS
ASTM E84 (CONTINUED)

Heptane Pan for Smoke Calibration

Photometer System for Smoke Measurement
NFPA 286–ROOM CORNER TEST

• Room Size: 8 ft. tall x 8 ft. wide x 12 ft. deep

• Ignition source: Sand burner
  • 40 kW for 5 min. then 160 kW for 10 min.

• Flashover Conditions (when any two conditions below are met)
  • Heat release rate > 1 MW
  • Heat flux at floor > 20 kW/m²
  • Avg upper layer temp. > 600°C (1112°F)
  • Flame exits doorway
  • Paper target on floor auto-ignites
NFPA 286 IBC CLASS A ALTERNATIVE METHOD AND FOAM PLASTIC INSULATION SPECIAL APPROVAL CRITERIA

- Class A Interior Finish Alternative and Foam Plastic Insulation Special Approval
  - During 40 kW exposure, flame shall not reach ceiling
  - Flame spread does not reach outer extremities of walls or ceiling
  - No Flashover per NFPA 286
  - Peak heat release rate ≤ 800 kW
  - Total smoke ≤ 1,000 m²
FIRE RESISTANCE TEST METHODS—STANDARD TIME-TEMPERATURE EXPOSURE

- UL 263, Fire Tests of Building Construction and Materials

FIG. 1 Time-Temperature Curve
FIRE RESISTANCE TESTING—
STANDARD TIME-TEMPERATURE EXPOSURE
FIRE RESISTANCE TESTING—STANDARD TIME-TEMPERATURE EXPOSURE

• Test Standards for Specific Applications
  • IMO 2010 FTP Code Part 3 (ISO 834-1 Exposure) International Marine Applications
  • ASTM E1725: Fire-Resistive Barrier Systems for Electrical System Components
  • ASTM E814/UL 1479: Through-Penetration Firestops
  • ASTM E1966/UL 2079: Fire Rated Joint Systems
  • ASTM E2816: Fire Resistive Metallic HVAC Duct Systems
  • ASTM E2336: Fire Resistive Grease Duct Enclosure Systems
  • UL 2221: Fire Resistive Grease Duct Enclosure Assemblies
ASTM E2816 CONDITIONS

FIG. 5 Isometric View of Test Assembly Condition A – Horizontal HVAC Duct without Openings

FIG. 8 Isometric Views of Test Assembly Condition B – Vertical HVAC Duct without Openings
ASTM E2816 CONDITIONS

**FIG. 11 Isometric View of Test Assembly Condition C – Horizontal HVAC Duct with Openings**

- A = Horizontal Fire-Separating Element
- B = Vertical Fire-Separating Element
- C = Fire Side of Fire-Separating Elements
- D = Straight HVAC Duct
- E = HVAC Duct Joints
- F = HVAC End Cap

**FIG. 14 Isometric View of Test Assembly Condition D – Vertical HVAC Duct with Openings**

- A = Horizontal Fire-Separating Element
- B = No Vertical Fire-Separating Element
- C = Fire Side of Fire-Separating Elements
- D = Straight HVAC Duct
- E = HVAC Duct Joints
- F = HVAC End Cap

- G = Test Cap with Fan Connection
- H = Unprotected Opening
- I = Optional HVAC Duct Internal Reinforcement – Not Shown
- J = Supports
- K = Opening in Fire-Separating Element
GREASE DUCT TESTING

- Internal Fire Test (500°F for 4 hours followed by 30 minutes at 2000°F)
- 1 hr. to 2 hr. Fire Engulfment Test (usually 2 hr.)
NFPA 285—STANDARD FIRE TEST METHOD FOR EVALUATION OF FIRE PROPAGATION CHARACTERISTICS OF EXTERIOR WALL ASSEMBLIES CONTAINING COMBUSTIBLE COMPONENTS
NFPA 285 (CONTINUED)
NFPA 285 (CONTINUED)

- Visual—10 ft. above top of window, laterally outside of burn room
- 1000°F on thermocouples located 10 ft. above top of window
- Combustible components (thermocouples inside wall)
- Assembly dependent
- Either 1000°F or 750°F
HYDROCARBON FIRE TESTS

• Pool Fires
• UL 1709
• H-Class
• MIL-STD-3020
• Transportation Tunnels
• Jet Fires
POOL FIRE TESTS

• Transportation Industry
  • 49 CFR 571.304–Compressed Natural Gas Fuel Container
  • 10 CFR 71.73–Nuclear Shipping Containers

• Fire Suppression Testing

• Very high heat flux

• ASTM E1529–Standard Test Methods for Determining Effects of Large Hydrocarbon Pool Fires on Structural Members and Assemblies
POOL FIRE TESTS

• ASTM E1529—Standard Test Methods for Determining Effects of Large Hydrocarbon Pool Fires on Structural Members and Assemblies
  • Uses same furnaces as ASTM E119 and UL 263
  • Furnace controlled to 158 kW/m² (1850 to 2150°F)
  • Accelerated Weathering and Aging
  • Method A—Columns
    • Loaded—Maintain Load
    • Unloaded—1000°F Limit on Average, 1200°F on Individual
  • Method B—Beams
    • Loaded—Maintain Load
    • Unloaded—1000°F Limit on Average, 1200°F on Individual
POOL FIRE TESTS (ASTM E1529 CONTINUED)

- Method C—Walls
  - Steel—(Bulkhead)
  - No Passage of Flame
  - 250°F Rise for Average and 325°F Rise for Individual
UL 1709—STANDARD FOR SAFETY RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

• Uses same furnaces as ASTM E119 and UL 263
• Furnaces controlled to 204 kW/m² (~2000°F)
• Environmental Performance
  • UL 2431
  • Material Classification Category 1-A: Outdoor, Heavy Industrial
• 1000°F Limit on Average, 1200°F on Individual
• Supplemental Beam Test
  • *Assesses materials performance with significant deflection in the beam*
  • Furnace temperature of 2000°F
  • Test a loaded beam and an unloaded beam side by side
  • Deflection limited to \((L^2)/(400d)\) total **AND** a rate of \((L^2)/(9000d)\)
  • Assessed temperature not specified by the standard
    • \(T\) for the average
    • \(1.2T\) for the individual
  • Correction Factor calculated from the loaded and unloaded beam
H-CLASS

• Variation of IMO Part 3—Test for “A,” “B,” and “F” Class Divisions
• Standardized Steel Bulkhead and Deck
• Insulation and Integrity Criteria
  • No flaming
  • Limited to 250°F Rise on Average and 325°F Rise on Individual
• Uses a Hydrocarbon Furnace Environment (2000°F by 5 min.)
  • IMO Furnace Environment
    • 1070°F at 5 min.
    • 1250°F at 10 min.
    • 1550°F at 30 min.
    • 1730°F at 60 min.
H-CLASS (CONTINUED)

• Can Extend Beyond 60 min.

• Applicable to Other Components
  • Windows
  • Doors
  • Dampers
  • Penetrations
TABLE 1 Tunnel Fire Test Time-Temperature Curve for Control of Fire Tests

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>Temperature [°C (°F)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>20 (68)</td>
</tr>
<tr>
<td>3</td>
<td>891 (1935)</td>
</tr>
<tr>
<td>5</td>
<td>1141 (2085)</td>
</tr>
<tr>
<td>10</td>
<td>1199 (2190)</td>
</tr>
<tr>
<td>30</td>
<td>1299 (2370)</td>
</tr>
<tr>
<td>60</td>
<td>1349 (2640)</td>
</tr>
<tr>
<td>90</td>
<td>1299 (2370)</td>
</tr>
<tr>
<td>≥120</td>
<td>1199 (2190)</td>
</tr>
</tbody>
</table>

RWS Furnace Curve
Time vs. Temperature

Time of Desired Rating

Cooling Phase Shifts According to Desired Rating
• Flame Spread Limitations
• Environmental tests
• Spalling
• Limit temperatures of reinforcing steel to 482°F
• Insulation concrete interface limited to 716°F
MIL-STD-3020—FIRE RESISTANCE OF U.S. NAVAL SURFACE SHIPS

• Similar to H-Class
  • Bulkhead and Deck Construction
  • Thermocouple Requirements

• Furnace Controlled to 204 kW/m² (~2000 °F)

• 30-min. Duration

• Criteria
  • Integrity–No Flaming
  • Insulation–Limited to 250°F Rise on Average and 325°F Rise on Individual

• Other Requirements
  • Shock and Vibration
  • Smoke and Toxicity
ISO 22899—DETERMINATION OF THE RESISTANCE TO JET FIRES OF PASSIVE FIRE PROTECTION MATERIALS

• Originally OTI 95-634
• Propane at 0.30 kg/s
• Heat Fluxes up to 350 kW/m²
• Recirculation Chamber and Back Box
• ~1.5 m x 1.5 m Test Area
• Panels, Tubular Sections, Structural Steel, Penetrations
QUESTIONS AND CONTACT INFORMATION

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