CONCRETE FIREPROOFING
ANALYSIS, EVALUATION AND
REPAIR STRATEGIES

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Fireproofing Purpose

- Maintaining structural stability and integrity of steel members and vessel/pipe supports for a defined period of time when exposed to a fire

Protection

Active  Passive

Picture Courtesy of Refinery Terminal Fire Company (RTFC)
Fireproofing Basics

- Material minimum thickness
- Restrict heat transfer rate
- Protected element
- Acceptable steel core temperature at the end of fire exposure to avoid collapse/buckling
Comparison of Typical ‘Hydrocarbon’ and ‘Cellulose’ Time-Temperature Curves

- **Hydrocarbon**
  - Within 4 minutes

- **Cellulose**
  - Within 4 minutes

Degrees Fahrenheit (°F) vs. Minutes

Degrees Celsius (°C)
Effect Of Temperature On Strength Of Structural Steel

- 50% reduction @ 1000 °F
Fire And Explosion Behavior

- Resistance to thermal and erosive forces
- Surface temperature of substrate
- Non-combustible
- Withstand effects of explosion and subsequent drag pressures
Pre-Fire Durability

- Weather cycling and chemical tolerance
- Vapor permeability and low porosity
- Vibration resistance - compressive, tensile and flexural strength
- Hardness value and impact resistance
- Abrasion and erosion resistance
- Bonding strength
- Wash-down resistance
Passive Fireproofing Materials

CEMENTITIOUS

- Lightweight
- Dense
- Heat absorbers
- Hard and durable
- Economic
- Easy to install and repair

INTUMESCENT

- Epoxy based
- React under fire and emit gases
- Form a low density carbonaceous char

FIBROUS

- Boards
- Blankets
- Can provide thermal insulation
- Absorb water
- Indoor applications

COMPOSITES

- Composite Panels
- Sandwich of metallic cladding, cementitious board, and mineral or ceramic fibers
- Not economically feasible
Cementitious Concrete Materials

- Made with Portland cement or modified fire-resistant cements
- Specific weights
  - Dense concrete - 140 to 150 lb./ft³
  - Lightweight concrete - 25 to 80 lb./ft³
- Thermal conductivity tends to be inversely proportional to specific weight
- Capable of withstanding direct flame impingement up to 2000°F (1100°C)
- Alkaline passive film protects the embedded steel
Intumescent Epoxy Coatings

- Intumescent coatings react to flame or heat at around 300° Fahrenheit (149° C) by expanding into a thick multicellular insulating blanket. This intumescent carbonaceous foam sharply limits the spread of flame and insulates the steel.

- Washable, aesthetically pleasing, mark resistant surface like traditional paint

- Provide protection from corrosion

- Require expertise in application and controlled conditions

- Comparatively higher cost to cementitious materials
Fireproofing Rating

A function of:

- Time and ease of evacuation
- Fire hazard posed by substance
- Fire suppression capabilities

2 inches (50 mm) of cementitious products will provide a 2-hour rating (BS476 & ASTM E-119)
Concrete Fireproofing In Processing Units

Multilevel Equipment Structures

Pipe Racks
Fireproofing Deterioration

Risk Of Loss Of Fire Protection

Corrosion

Efflorescence

Cracking

Fire Damage
Embedded Structural Steel Corrosion Exposed During Fireproofing Inspection Process
Rust Stains Emerging From Fireproofing Indicating Early Evidence Of Steel Member Corrosion

Failed Fireproofing Due To Embedded Structural Steel Member Corrosion
Improperly Detailed Cementitious Fireproofing, Notice No Mesh Reinforcement
Severely Corroded Embedded Wire Mesh And Corroding Structural Steel Member Flanges

Severely Corroded Embedded Wire Mesh And Corroding Structural Steel Members & Connections
Fireproofing Deterioration Mechanism

- Delamination/Spalling
- Corrosion Products
- Corrosion-Induced Cracking
- Structural Steel Beam/Column
- Shrinkage Cracking
- Cementitious Fireproofing
- Surface Corrosion Products
Fireproofing Deterioration Mechanism (cont.)

- Structural Steel Beam/Column
- Preformed Inorganic Panel Fireproofing
- Corrosion Products
- Open Areas Within The “Boxed” Structural Member Fills With Moisture And Promotes Corrosion
Prior Repair
Shrinkage Cracked
And Pipe Slide
Shoe “Seized” By
Corrosion
Fireproofing Deterioration Mechanism (cont.)

- Structural Steel Corrosion
- Cementitious Fireproofing
- Corrosion Build-Up Frozen Slide
- Rotation
- Structural Steel Beam/Column

PIPELINE
Condition Survey And Evaluation

- Assess the condition of concrete fireproofing
- Evaluate causes of concrete/steel distress
- Provide conceptual repair recommendations
Need For Fireproofing Restoration

- **Safety**
  - Possible structural collapse
  - Reduced fire protection/lower expected performance
  - Personnel at risk due to falling debris

- **Insurance costs**

- **Aesthetics of damaged/falling fireproofing**
Visual Inspection And Mapping

Note: Excavation at crack location
Excavation Geometry

- Structural Steel element
- Reinforcing wire mesh
- Fireproofing

Structural Steel Beam
Fireproofing
Ultrasonic Thickness Measurements

- Ultrasonic Thickness Meter
- Structural steel pipes, webs and beams flanges
- Access one side of steel member
Measurement Analysis

<table>
<thead>
<tr>
<th>Wide Flange Shape</th>
<th>Flange Thickness $t_f$</th>
<th>Section Loss (%)</th>
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<td>Theoretical vs Measured</td>
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If critical, remedial actions needed before...
Conceptual Fireproofing Repair

- Assemble scaffolding for elevated regions of distressed fireproofing
- Remove deteriorated concrete fireproofing and wire mesh avoiding damage to structural steel members
- Clean exposed embedded structural steel members of corrosion products
- Inspect members and connections for structural integrity
- Coat exposed structural steel section
Fireproofing Repair (Cont.)

- Install wire mesh
- Assemble mortar-tight cavity formwork
- Re-establish the cementitious fireproofing section by using “form and pour” placement techniques
- Remove formwork after curing period and surface grind cementitious repairs to match original fireproofing surface contours
Valuable Repair Aspects

- Turnkey investigation
- Attention to details
- Budgeting capabilities
- Corrosion protection to steel
- Production rates
- Adjustable crew size with qualified personnel
- High quality repair materials
- Observe standard industry practices