STRUCTURAL STEEL FIRE PROTECTION
INTUMESCENT COATINGS SYSTEMS

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Passive Fire Protection Specialist
AkzoNobel – International Paint
AGENDA

The types of fires and their behaviour

Types of passive fire protection

How an intumescent coating works

Regulation and legislation

Coating types and finishes

Specification guidelines
AkzoNobel is globally the largest paint company in the world and is a diversified multicultural group with actives in Coatings and Chemicals.

In 2014 we had consolidated revenue of €15.7 billion and more than 57,200 employees in over 80 countries.

AkzoNobel coatings divisions include:
- Architectural / Decorative
- Marine & Protective
- Yacht
- Powder
- Automotive
- Aerospace coatings
Choice of material

- ALL COMMONLY USED BUILDING MATERIALS LOSE SOME STRENGTH WHEN EXPOSED TO FIRE.
- CONCRETE - SPALLS TO EXPOSE REINFORCEMENT.
- WOOD - DEPLETES BURNING TO ASH
- STEEL DOES NOT BURN, BUT, IT STARTS TO LOSE ITS STRUCTURAL STRENGTH AT TEMPERATURES ABOVE 400 °C.
Material properties of steel

- Steel Loses 40% of its strength at 550°C

Design Strength $p_y$

Temperature °C

Strength factor

0 0.2 0.4 0.6 0.8 1

0 200 400 600 800 1000

550°C
RESULT OF AN ACTUAL FIRE

Unprotected steel columns in the upper section of the building collapsed.

In the lower section of building, protection prevented collapse. However, in the stages where protection is incomplete, steel profiles are crooked and twisted, while protected ones look fine.
INTERNATIONAL FIRE CURVES

Protective Coatings

1 = Cellulosic ISO Curve
2 = Hydrocarbon Curve
3 = RABT-ZTV Curve
4 = HCM Curve
5 = RWS Curve
Methods of Fire Protection

Building Requires Fire Protection

Passive Fire Protection
- Compartmentation
- Structural FP

Active Fire Protection
- Fire Engineering
  - Boarding
  - Cementitious
  - Intumescent

- Sprinklers
- Detection and Alarm
- Smoke Control
- Foam, gas suppression
Applied fire protection aims to keep steel sufficiently cool for the required fire resistance period.

This extra time allows people to evacuate.
Intumescent Coating System

• Can be applied off site
• Aesthetically very appealing
• More damage resistant
• Thin film, light weight
• Fast to apply
• Good lifetime cost
• Space saving
• Set and forget Solution
The Intumescent Mechanism
(Intumescent = to swell up)

Steel Component “I” beam

Intumescent coating

Swell to form insulating char
Intumescent paint activated
Char forms to insulate the steel

- epoxy
  Very compact, black and rigid
- epoxy
  Voids, large expansion
- acrylic
  Voids, large expansion, very fragile
A SYSTEM not a product

Surface Preparation: Blast cleaned Sa 2.5
Compatible primer as per the intumescent assessment

Intumescent used is dependant upon the final environment

Internal Environment
Acrylic Solvent or Water based

External Environment (weatherproof)
Epoxy solvent free 100% volume solids

Compatible Topcoat
Acrylic, Polyurethane, Polysiloxane etc.
Understanding of both fire and corrosion

- **Fire Protection**
  - Passive fire protection

- **Steelwork**
  - Anticorrosive products

- **Cosmetic Finishes**
  - For high aesthetic impact and long-term durability

- **Storage Tanks**
  - Tank-lining systems

- **Interior structural steel**
  - Modified Epoxy Dry Fall Coatings

- **Underwater Structures**
  - Nontoxic foul-release systems

- **Passive Fire Protection**
  - Intumescent fireproofing

- **Resistant Coatings for Chemical Environments**

- **Heat and Cycling**
  - Temperature-resistant coatings

- **Abrasion Surfaces**
  - Water Based Low VOC Epoxy Coatings
3.3 Steel Preparation
Before applying the Interchar 2060, all steel work must be prepared as follows and use the following primers and topcoats:

Surface Preparation
Blot clean Sa2.5 – sharp angular medium profile – 50 microns

3.4 Primers and Topcoats
Based on information supplied by the client in M&PC RD&I Fire & Insulation Coating Laboratory documents the following primers and topcoats given in Table 1 and Table 2 respectively may be used without being detrimental to the fire resistance performance of structural elements protected with Interchar 2060.

3.4.1 Primers

<table>
<thead>
<tr>
<th>Table 1: Approved International Protective Coatings Primers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interzinc 2280 + Intergard 269</td>
</tr>
<tr>
<td>Interzinc 42</td>
</tr>
<tr>
<td>Interzinc 52</td>
</tr>
<tr>
<td>Interprime 198</td>
</tr>
<tr>
<td>Intercure 200</td>
</tr>
</tbody>
</table>

3.4.2 Topcoats

<table>
<thead>
<tr>
<th>Table 2: Approved International Protective Coatings Topcoats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interthane 870</td>
</tr>
<tr>
<td>Interthane 990</td>
</tr>
<tr>
<td>Interfine 629</td>
</tr>
</tbody>
</table>

Note: * Polysiloane based topcoats will require a tie-coat which are Intergard 269, Intergard 276, Interthane 870 and Interthane 990.
## How is the thickness determined?

<table>
<thead>
<tr>
<th><strong>Mass</strong></th>
<th>Size and shape of individual steel sections - I or Hollow (open or closed) Hp/A (6mm for 1 or 2 hours hollow sections)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exposure</strong></td>
<td>Number of faces, is it a column, composite beam, hollow section (one assessment does not fit all section types)</td>
</tr>
<tr>
<td><strong>Critical Failure temperature</strong></td>
<td>550 c for columns 620 c for beams</td>
</tr>
<tr>
<td><strong>Duration</strong></td>
<td>The level of protection required i.e. 60 minutes, 90 minutes 2 hours, up to 4 hours</td>
</tr>
<tr>
<td><strong>Test Standards and Approvals</strong></td>
<td>British Standard BS 476 Australian Standard AS1530.4-2005 Australian Standard AS 4100-1998 Regression analysis Class Societies Lloyds, ABS, DNV etc.</td>
</tr>
</tbody>
</table>
12.6.2.1 REGRESSION ANALYSIS USED FOR INTERPOLATION WITHIN THE WINDOW OF APPLICABILITY

\[ T = k_0 + k_1 H + k_2 (H/KSM) + k_3 T + k_4 HIT + (HIT/KSM) + k_6 (T/KSM) \]

12.6.2.2 LIMITATIONS AND CONDITIONS OF USE

(A) STEEL MEMBERS SHALL BE PROTECTED WITH BOARD, SPRAYED BLANKET OR SIMILAR INSULATION MATERIALS HAVING A DRY DENSITY LESS THAN 1000 KG / M3.

NOTE: STANDARDS AUSTRALIA IS NOT PREPARED TO MAKE ANY RECOMMENDATIONS ON INTERPOLATION FOR MEMBERS PROTECTED WITH OTHER MATERIALS SUCH AS INTUMESCENT COATINGS.

AS 4100 AMENDMENT MARCH 2012

12.6.2.2 EXPERIENCE HAS SHOWN THAT THE ABOVE REGRESSION METHOD CAN ALSO BE USED FOR MATERIALS SUCH AS INTUMESCENT AND ABLATIVE COATINGS SUBJECT TO THE COEFFICIENT OF CORRELATION EXCEEDING 0.9

12.6.1 ALTERNATIVELY, RECOGNIZED METHODS OF ASSESSMENT IN ACCORDANCE WITH ENV 13381-4 AND EN 13381-8 MAY BE USED.
Fire Duration & Certification

Thicknesses are a function of:

Member type
- I Section (open section)
- Hollow Section (CHS/SHS/RHS)

Orientation
- Beam (Bending)
- Column (Compression)
Section Factor

beam or column cross section (4 sided)

$$\text{Section Factor} = \frac{H_p}{A}$$ (units $m^{-1}$)

- $A = \text{Area (A) of cross section} - m^2$
- $H_p = \text{Heated Perimeter (Hp) of cross section} - m$

In mainland Europe, it is often calculated as $A/V$: Exposed Surface Area $\div$ Volume
Section Factor

Large heated perimeter (Hp) Small cross sectional area (A)

= High Hp/A (section factor)
= Heats up **QUICKER**

Small heated perimeter (Hp) Large cross sectional area (A)

= Low Hp/A (section factor)
= Heats up **SLOWER**
LOADING TABLES (DERIVED BY TESTING) ARE USED TO CALCULATE REQUIRED THICKNESSES OF INTUMESCENT

ORIENTATION – STANDARD – FIRE DURATION: 120 M
SECTIONS FACTOR (A/V): 100 M⁻¹
LIMITING TEMPERATURE (CCT): 550°C
DFT: 1.957MM

AKZONOBEL HAVE CALCULATORS TO AUTOMATE THIS PROCESS
## Protective Coatings

### 1 hour versus 2 hour comparison

<table>
<thead>
<tr>
<th>HpA Beams 600 DegC</th>
<th>30 MIN</th>
<th>60 Min</th>
<th>120 Min Internal</th>
<th>120 Min External</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>0.20</td>
<td>0.37</td>
<td>2.40</td>
<td>3.86</td>
</tr>
<tr>
<td>150</td>
<td>0.20</td>
<td>0.56</td>
<td>2.85</td>
<td>5.70</td>
</tr>
<tr>
<td>200</td>
<td>0.20</td>
<td>0.68</td>
<td>3.49</td>
<td>6.85</td>
</tr>
<tr>
<td>245</td>
<td>0.20</td>
<td>0.83</td>
<td>3.85</td>
<td>7.75</td>
</tr>
</tbody>
</table>

TYPICAL DATA PLEASE CONSULT MANUFACTURER BEFORE USE
<table>
<thead>
<tr>
<th>Steel Size</th>
<th>60/-/- 550 Deg C</th>
<th>90/-/- 550 Deg C</th>
<th>120/-/- 550 Deg C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hollow Sections</td>
<td>Wall thickness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5mm</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>6mm</td>
<td>1.12</td>
<td>3.61</td>
<td>7.42</td>
</tr>
<tr>
<td>9mm</td>
<td>0.57</td>
<td>2.56</td>
<td>5.54</td>
</tr>
<tr>
<td>5mm concrete filled</td>
<td>0.31</td>
<td>1.28</td>
<td>2.56</td>
</tr>
<tr>
<td>6mm concrete filled</td>
<td>0.31</td>
<td>1.28</td>
<td>2.56</td>
</tr>
<tr>
<td>9mm concrete filled</td>
<td>0.31</td>
<td>1.28</td>
<td>2.56</td>
</tr>
</tbody>
</table>
TYPICAL DATA PLEASE CONSULT MANUFACTURER BEFORE USE

Need for specifying failure temperature

<table>
<thead>
<tr>
<th>Deg C</th>
<th>350</th>
<th>400</th>
<th>450</th>
<th>500</th>
<th>550</th>
<th>600</th>
<th>650</th>
<th>700</th>
<th>750</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
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<td>1 hour</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I section</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>column</td>
<td></td>
<td>x</td>
<td>1.08</td>
<td>0.88</td>
<td>0.71</td>
<td>0.55</td>
<td>0.40</td>
<td>0.27</td>
<td>0.25</td>
</tr>
<tr>
<td>Hpa150</td>
<td></td>
<td>6.00</td>
<td>4.74</td>
<td>3.90</td>
<td>3.30</td>
<td>2.89</td>
<td>2.37</td>
<td>1.85</td>
<td>1.51</td>
</tr>
<tr>
<td>2 hour</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I section</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>column</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hpa150</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Stress in Structural Members

**Structural Capacity of a Beam in Bending**

A beam has a design capacity in terms of structural load that can be applied at ambient condition.

**Scenario A**
Beam loaded to 50% of its ambient design capacity

Failure temperature = 695°C (1284°F)
Indicative thickness of intumescent:

**Scenario B**
Beam loaded to 100% of its ambient design capacity

Failure temperature = 580°C (1077°F)
Indicative thickness of intumescent:
Bolted Connections

• Understanding of fundamental connection and bolt behaviour has increased recently

• Protection options are available including novel approaches

• No specific fire test standard but supported by industry guidance and ad-hoc testing

• Importance of connections in whole frame behaviour
  – Performance-based design
  – Robust designs should at check connection behaviour in fire (and cooling)
Bolted Connections

Protective Coatings
SECONDARY MEMBER PROTECTION

Protective Coatings
Intumescent Coating Specification

- Steelwork shall be blast cleaned Sa2.5 ISO 8501-1:2007
- All materials, Primer, Intumescent and Topcoats shall be obtained from one manufacturer (i.e. International Paints)
- All materials used shall be documented in the independent Nata laboratory assessment (i.e. BRANZ)
- The intumescent coating shall have been tested and assessed to the relevant local standards
- The Intumescent Coating shall have 3rd Party Certification (i.e. Certifier, LPCB)
- Critical failure Temp i.e. 550 Deg C or load utilisation
- Applicators must be able to demonstrate competence and experience in the application of intumescent paints
- Any external exposed steelwork shall be protected using a two component epoxy intumescent
Wrong Specification Application ???

Protective Coatings
Castellated Beams

Protective Coatings
School Projects – 2 hours visible steel

Protective Coatings
Onslow Modular Apartments

Protective Coatings
Level of finish – Not always the same
Anzac Bridge

Protective Coatings
Hospital Project
Latest Product Developments

2 HOURS

Product A - 1.35 mm

Product B - 0.84 mm

40% reduction in material
## Latest Product Developments

<table>
<thead>
<tr>
<th>Steel Size single sided plate</th>
<th>HpA</th>
<th>CCT Deg C</th>
<th>Product A 90/-/- mm dft</th>
<th>Product B 90/-/- mm dft</th>
<th>Product A 120/-/- mm dft</th>
<th>Product B 120/-/- mm dft</th>
</tr>
</thead>
<tbody>
<tr>
<td>10mm</td>
<td>100</td>
<td>620</td>
<td>0.59</td>
<td>1.19</td>
<td>0.90</td>
<td>2.06</td>
</tr>
<tr>
<td>12mm</td>
<td>85</td>
<td>620</td>
<td>0.52</td>
<td>0.99</td>
<td>0.80</td>
<td>1.76</td>
</tr>
<tr>
<td>14mm</td>
<td>70</td>
<td>620</td>
<td>0.49</td>
<td>0.92</td>
<td>0.77</td>
<td>1.66</td>
</tr>
</tbody>
</table>

OVER 50% REDUCTION IN MATERIAL COST
## Latest Product Developments

### Protective Coatings

<table>
<thead>
<tr>
<th>Steel Size</th>
<th>Product A</th>
<th>Product B</th>
</tr>
</thead>
<tbody>
<tr>
<td>200X12 EA</td>
<td>2.03 mm</td>
<td>0.98 mm</td>
</tr>
<tr>
<td>800WB146</td>
<td>1.76 mm</td>
<td>0.84 mm</td>
</tr>
<tr>
<td>200UC59</td>
<td>1.90 mm</td>
<td>0.91 mm</td>
</tr>
<tr>
<td>400WC212</td>
<td>1.24 mm</td>
<td>0.62 mm</td>
</tr>
<tr>
<td>310UC97</td>
<td>1.76 mm</td>
<td>0.84 mm</td>
</tr>
<tr>
<td>350WC280</td>
<td>1.02 mm</td>
<td>0.62 mm</td>
</tr>
</tbody>
</table>

50 % reduction in material
Latest Product Developments

Mixture of 60 and 120 minute protection

Original Product offer mix
Product A 10,000 Litres
Product B 5,000 Litres

Latest Product offer mix
Product A 1120 5,500 Litres
Product C 1260 5,500 Litres

40 % reduction in material

Protective Coatings
## Latest Product Developments

<table>
<thead>
<tr>
<th>Steel Size</th>
<th>Product A</th>
<th>Product B</th>
</tr>
</thead>
<tbody>
<tr>
<td>120/-/-</td>
<td>mm dft</td>
<td>Mm dft</td>
</tr>
<tr>
<td>700WB173</td>
<td>2.03</td>
<td>1.00</td>
</tr>
</tbody>
</table>

50% reduction in material
Conclusions

COMPLETE SYSTEMS NOT PRODUCTS
THANK YOU

Intumescent Coatings
Protecting Lives - Protecting Assets

Oil and Gas Refinery
Melbourne Airport Structural Steel Internal
International Fire Lab Furnace Falling, UK
New York Times Building Structural Steel External