STRUCTURAL STEEL FIRE PROTECTION

INTUMESCENT COATINGS IN THE 21ST CENTURY

Dr. Simon Jones
Technical Director
Nullifire, tremco illbruck Ltd.
OUR CREDENTIALS

Nullifire pioneered decorative intumescent coatings for the fire protection of structural steelwork

• First intumescent coating launched in the early 80’s

• First water-based coating (Nullifire S607) for steel protection in the early 90’s

• First hybrid technology SC900 series launched in 2013

• State of the art UK based production and testing facilities with first rate representation in Australia
WHY USE PASSIVE FIRE PROTECTION?

The Objectives

- The highest priority is to prevent building collapse allowing time for safe evacuation of people from the building.
- Make the building safer for the emergency services to carry out any rescue work and tackle the fire upon arrival.

The Passive Fire Protection Solution

- Passive fire protection delays the collapse of the structure through insulating the structural steel columns and beams that support the building fabric.
- Achieving specified fire resistance in terms of time.
WHY PROTECT STRUCTURAL STEEL?

• It does not burn, but…
• It does lose strength as it heats up, for example in a fire
• Using typical “cold design” rules steel will suffer structural failure at around 550°C
There are three common ways of protecting structural steel work:

• Cementitious coating is a portland cement with the addition of vermiculite or perlite

• Boarding systems based on calcium silicate or gypsum

• Intumescent coatings
WHAT IS AN INTUMESCENT COATING?

• An intumescent is a substance that swells as a result of heat exposure: increasing in volume and decreasing in density.
• The process provides a thick layer of ‘char’ which thermally insulates the substrate.
• Intumescent coatings are the most widely used structural fire protection solution worldwide.
• They are comprehensively tested and regulated to modern test standards and third party certification.
MARKET SHARE OF PASSIVE FIRE PROTECTION SYSTEMS FOR STEEL

Trends in structural fire protection 1992-2014

- **Boards**
- **Sprays**
- **Intumescent**
- **Other**

<table>
<thead>
<tr>
<th>Year</th>
<th>Market Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992</td>
<td>30%</td>
</tr>
<tr>
<td>1997</td>
<td>40%</td>
</tr>
<tr>
<td>2001</td>
<td>30%</td>
</tr>
<tr>
<td>2005</td>
<td>50%</td>
</tr>
<tr>
<td>2009</td>
<td>70%</td>
</tr>
<tr>
<td>2014</td>
<td>80%</td>
</tr>
</tbody>
</table>
HOW INTUMESCENCE WORKS

- Above 250°C, a process of char formation occurs
- Ammonium Polyphosphate decomposes to phosphoric acid

\[
\begin{align*}
\text{NH}_4\text{PO}_4 \rightarrow \text{H}_3\text{PO}_4 + \text{NH}_3
\end{align*}
\]

- Pentaerythritol reacts with the acid to form polyphosphoric acid esters

\[
\begin{align*}
\text{HO-CH}_2\text{CHOH-CH_2-OH} + n \text{H}_3\text{PO}_4 \rightarrow \text{HO-CH}_2\text{CHOH-CH_2-OH-PO}_4\text{H}_3 + n \text{H}_2\text{O}
\end{align*}
\]
HOW INTUMESCENCE WORKS

- Esters decompose to form a foamable carbon matrix, cross-linked through vinyl groups formed by the dehydration of the pentaerythritol esters
- Melamine decomposes liberating ammonia and nitrogen which blows the foam to form a stable, thermally-insulating char

\[
\begin{align*}
\text{NH}_2 \quad \rightarrow \quad \text{NH}_3 \\
\text{H}_2\text{N} \quad \text{N} \quad \text{N} \\
\text{N} \quad \text{N} \quad \text{NH}_2 \\
\end{align*}
\]

- Gradually carbon burns out to give an inorganic char based on phosphorous and titanium oxides. The insulating char protects the substrate from the heat of the fire
TEMPERATURE VS TIME

- Std Fire
- Uncoated Steel
- Coated Steel
HOW MUCH INTUMESCENT IS NEEDED?

- Size of steel and area exposed to fire (Hp/A)
- Function of structural section - beam or column
- Load: supporting Concrete Floor or Light Weight Roof
- Fire rating - 30, 60, 90 or 120 minutes
- Typical minimum of 0.2 mm for 30 minutes
- Or can be up to 5 mm for 2 hours
MARKET EVOLUTION

• 1980’s – the Solvent Based era
  ➢ Performance driven
  ➢ Very few suppliers, very specialist

• 1990’s – Water Based era
  ➢ Driven by cost, not “green” factors
  ➢ Becoming Applicator driven

• 2000’s – Commodity era
  ➢ Non-specialist, totally cost driven
  ➢ Quality under intense pressure
WHAT HAPPENS NEXT?

- Conventional technology has inherent limitations.
- Lowest DFT and lowest “can cost” does not benefit stakeholders.
- More significant to real “hand over cost”:
  - Applied cost per m²
  - At 120 min, labour & time dominate
- Robustness carries a real value
  - Tolerance of application conditions
  - Resistance to construction phase
  - Toughness and risk control
## INTUMESCENT TECHNOLOGIES

<table>
<thead>
<tr>
<th>TRADITIONAL</th>
<th>IDEAL</th>
<th>NEW TECHNOLOGY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Waterbased</strong></td>
<td><strong>Solvent based</strong></td>
<td><strong>Epoxy</strong></td>
</tr>
<tr>
<td>• Internal</td>
<td>• External</td>
<td>• Offshore</td>
</tr>
<tr>
<td>• On-site</td>
<td>• On &amp; Off-site</td>
<td>• Off-site</td>
</tr>
<tr>
<td>• No VOC</td>
<td>• High VOC</td>
<td>• Low VOC</td>
</tr>
<tr>
<td>• 8hr dry / coat</td>
<td>• 8hr dry / coat</td>
<td>• 24hr cure</td>
</tr>
<tr>
<td>• Multiple coats</td>
<td>• Multiple coats</td>
<td>• Durable &amp; tough</td>
</tr>
<tr>
<td>• No solvent odours</td>
<td>• Health concerns</td>
<td>• Premium</td>
</tr>
</tbody>
</table>
REAL MARKET NEEDS

✓ A high build, easy to apply material to save labour cost
✓ A rapid, fast-track system to minimise programme time
✓ High tolerance to weather and application conditions
✓ Reduce need to primer and topseal = one coat system
✓ Use existing spray equipment
✓ Increased damage resistance and simple and fast repairs
✓ Low VOC levels and low hazard
HYBRID TECHNOLOGY - THE CHEMISTRY

- Silane terminated Polyether or Polyurethane (STP or SPUR)

- Moisture curing system, crosslinked by using functional silanes, eg Amino-silanes
HYBRID TECHNOLOGY- THE CHEMISTRY

Water hydrolysates the alkoxy groups on the silicon atoms, creating hydroxyl groups that can condense to form a crosslinked network:

1. OR
   Si–OR + H₂O → Si–OH + ROH
   Step 1

2. OH catalyst
   Si–OH → Si–O Si–O
   Step 2
HYBRID TECHNOLOGY - THE BENEFITS

• Cured material is between Polyurethane and Silicone, a hybrid taking the best properties of each

• No Isocyanates

• No/low VOC formulations

• Overpainting possible

• Low hazard, low odour

• Curing is tolerant to temperature and humidity

• Very moisture resistant
### SC900 KEY BENEFITS

- Rapid Build > 7mm in a single application
- Dramatic savings in time and labour = lower costs
- Fast Cure = Short term weather resistance in 1 hour
- Ready to go on Day 2 – vs. Day 7
- Reduced Risk, reduced programme

<table>
<thead>
<tr>
<th>Traditional Off-Site application method</th>
<th>120 MINUTE FULL FIRE PROTECTION IN 7 DAYS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Day 1</td>
</tr>
<tr>
<td></td>
<td>MFT 1.2 cm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SC900I application method</th>
<th>120 MINUTE FULL FIRE PROTECTION IN 24 HOURS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Day 1</td>
</tr>
<tr>
<td></td>
<td>MFT 1.2 cm</td>
</tr>
</tbody>
</table>

With SC900I you **SAVE 60%+** on application and drying time, **ELIMINATE DELAYS** on site and **REDUCE COST** of application.
ON-SITE OR OFF-SITE

SC902
OPTIMISED FOR
ON-SITE APPLICATION

- Provides rapid completion of on-site fire protection
- Suitable for off-site applications as well
- Up to 120 minute fire protection in one coat
- Weather resistant in less than 1 hour, overnight cure
- Early fire protection offers peace of mind

SC902
OPTIMISED FOR
OFF-SITE APPLICATION

- Provides rapid completion of on-site fire protection
- Suitable for off-site applications as well
- Up to 120 minute fire protection in one coat
- Weather resistant in less than 1 hour, overnight cure
- Early fire protection offers peace of mind
FUTURE TRENDS

“Basic Market” - dry, internal 60 minute protection

- Economic water based is a good solution
- One coat application
- Hard to beat on cost

“Enhanced Market” – 2 hour +, fast-track, high risk, off-site

- 2k reactive products becoming valued for benefits
- Hand over cost beginning to win over cost per can
- Opportunity to deliver step change reduction in time, cost and risk
FUTURE “GAME-CHANGERS”? 

Simplicity and Hazard free
• 1k but 1 coat for 2 hr protection
• Solvent/hazard free

Very high durability
• New intumescent technology that is completely water resistant
• Very tough and damage resistant films
• Inherent corrosion protection
ANY QUESTIONS?

Dr. Simon Jones
Technical Director
Nullifire, Tremco illbruck Ltd.