Structural Steel and Timber Fire Protection With Intumescent Coatings
World’s first intumescent coating system launched in the early 80’s by Nullifire U.K.

First water-based intumescent coating for steel protection began in the late 80’s.

First hybrid technology SC900 series launched in 2013.

State of the art UK based production and testing facilities in Coventry and Wigan.

Australian Distributor

permax
What is Passive Fire Protection System?

For all fire protection systems it is the same - Life Safety

- Passive Fire Protection (PFP) for structural steel is designed to protect the building fabric, slowing or preventing the building from collapsing. Allowing time for the emergency services to control/extinguish the fire.

- Aims to limit the amount of structural damage to the building.

- It ensures that the building maintains its FRL for Structural Adequacy/Integrity/Insulation.

- Passive Fire Protection Systems can be used in conjunction with Active Fire Protection Systems to achieve the best possible protection for the building.
Why is fire protection required?

- Protect people
- Asset Protection
- Compliance
  i.e. building code, insurance body
Fire Types & Severity

<table>
<thead>
<tr>
<th>Fire Condition</th>
<th>Cellulosic</th>
<th>Hydrocarbon</th>
<th>Jet Fire</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. Temperature</td>
<td>925°C (1697°F)</td>
<td>1100°C (2012°F)</td>
<td>→ 1400°C (2552°F)</td>
</tr>
<tr>
<td>Typical Heat Flux</td>
<td>100 kW/m²</td>
<td>200 kW/m²</td>
<td>300 kW/m²</td>
</tr>
<tr>
<td>Erosive Forces</td>
<td>Limited</td>
<td>Limited</td>
<td>Severe</td>
</tr>
</tbody>
</table>

Fire Test Curves

- Cellulosic
- Hydrocarbon Curve
- Jet Fire (Approx)
Choice of Material

- All commonly used building materials lose some strength when exposed to fire.
- Concrete - spalls to expose reinforcement.
- Wood - depletes charing to ash
- **Steel does not burn, BUT, it starts to lose its structural strength at temperatures above 400 °C.**
FRL – Fire Resistance Level
Adequacy Integrity Insulation
120 / 120 / 120
Structural Adequacy

Refers to the time in minutes before failure occurs for a structural member that is supporting a structural load.

Denoted by the first number in a Fire Resistance Level (FRL)

Structural Steel members can ONLY achieve Structural Adequacy

Eg. 30/---
   60/---
   90/---
   120/---
**Integrity**

Refers to the ability of a wall, ceiling or building component such as fire doors to prevent the passage of smoke and flames from the exposed space to the non-exposed space.

Denoted by the second number in a Fire Resistance Level (FRL)

Structural Steel columns and beams CANNOT achieve Integrity

**Insulation**

Refers to the ability of a building element to maintain a temperature difference between the exposed side and the non-exposed side below a specified limit.

Denoted by the third number in a Fire Resistance Level (FRL)
Vermiculite Spray is a plaster or cement based with the addition of vermiculite or perlite

Boarded systems are the oldest method

Intumescent coating systems are the latest addition to the family
Market Share of Passive Fire Protection Systems for Steel
An intumescent coating is a paint that swells when exposed to fire.

The name intumescent comes from the Latin word ‘INTUMÉSCERE’ meaning: ‘to swell’.

Conditions permitting, the char can swell up to **100 times** the Dry Film Thickness.

Intumescent coating char depth depends on the **type, coating thickness** and **temperature**.
Intumescent Char
Composite Wall Configuration

- Cladding in close proximity to intumescent protected structural steel elements may inhibit char formation.
- Sudden collapse of cladding may lead to thermal shock.
- Indicative fire tests of Nullifire hybrid SC900 Series coated steel with 13mm plasterboard fixed in close proximity did not hinder char expansion and did not degrade fire performance.
- Lightweight steel studs directly fixed to columns in a composite wall can also be sprayed with SC902 intumescent system to retain thermal insulation.
- We can assist with designing of composite wall configurations that will not compromise the passive fire protection.

May cause char failure due to sudden heat exposure
How to determine the thickness of a Intumescent Coating

Section Factor
(Hp/A, ksm A/V)

Structural Member Type
(Beam, Column, Bracing)

Structural Load - Floor Load or Light Weight Roof Load
(Critical Steel Temperature)

Not all steel sections and sizes can be fire protected.
There are options to achieve the required FRL
What is the Section Factor?

➢ **Hp/A** and **Ksm**, … are measurements of the heating rate of any structural steel section in a fire.

➢ **Hp/A** depends on:
  a) The heated perimeter of the steel exposed to flames “Hp”
  b) The cross sectional area of the section “A”

➢ **Ksm** depends on:
  ➢ The exposed surface area to mass ratio in m²/tonne

➢ Generally, the sectional shape, size and mass of steel determines the exposed surface area to mass ratio or perimeter to cross sectional surface area.

High Hp + Low A = Fast Heating

Low Hp + High A = Slow Heating
The required Dry Film Thickness (DFT) to achieve a specified FRL is determined using AS4100-1998 Section 12.

SECTION 12  FIRE

12.1 REQUIREMENTS
This Section applies to steel building elements required to have a fire-resistance level (FRL).

For protected steel members and connections, the thickness of protection material \( h_1 \) shall be greater than or equal to that required to give a period of structural adequacy (PSA) equal to the required FRL.

For unprotected steel members and connections, the exposed surface area to mass ratio \( (k_{\text{sm}}) \) shall be less than or equal to that required to give a PSA equal to the required FRL.

The period of structural adequacy (PSA) shall be determined in accordance with Clause 12.3, using the variations of the mechanical properties of steel with temperature as specified in Clause 12.4.
Steel loses strength immediately upon heating, this becomes critical from a structural adequacy perspective starting from 300°C.

At a temperature of 550°C steel will retain approximately 50% of its room temperature load capacity.

Empirically, for steel supporting floor loads:

- 550°C is considered to be the failure temperature for structural steel columns exposed on 4 sides.
- 620°C for structural steel beams.

Empirically, steel supporting roof loads can have critical steel temperatures from 700°C.

Failure temperatures can be as high as 750°C or even higher for partially exposed members and/or under loaded sections.
Determining Load Ratios

\[ T_l = 905 - 690r_f \] where \[ r_f = \frac{N^r}{\varphi R_u} \]

Australian Fire Case Design Load = \( G + 0.4Q \)

\[ r_f = \frac{Member\ Capacity\ In\ A\ Fire\ Environment}{Member\ Capacity\ At\ Room\ Temperature} \]

Corresponding load ratio’s to typical critical steel temperatures:

<table>
<thead>
<tr>
<th>Load Ratio</th>
<th>( r_f )</th>
<th>Critical Steel Temp.</th>
<th>General Loading Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.51</td>
<td></td>
<td>550C</td>
<td>Columns- Concrete Floor Slab</td>
</tr>
<tr>
<td>0.41</td>
<td></td>
<td>620C</td>
<td>Beams- Concrete Floor Slab</td>
</tr>
<tr>
<td>0.3</td>
<td></td>
<td>700C</td>
<td>Columns &amp; Beams- Light Weight Roof Load</td>
</tr>
</tbody>
</table>

Obtaining accurate loading information from structural engineers will have a big impact on the quantity of intumescent required overall.
Determining DFT from Critical Steel Temperature

\[ T_l = 905 - 690r_f \] where \( r_f = \frac{N'}{\phi R_u} \)

- For a given load level, the temperature at which failure is expected to occur in a structural steel element is the critical steel temperature.

- **Load ratio** is used to determine the limiting steel temperature, \( T_l \) as specified in AS4100 Section 12 Cl. 12.5

- \( r_f \) is the ratio of design action on a member under a fire load case as specified in AS1170.1 to the design capacity of the member at room temperature.

- This limiting steel temperature is then used to determine the thickness of intumescent, \( h_I \) required using a regression analysis with regression coefficients determined by fire testing data.

12.6.2.1 Regression analysis

The relationship between temperature \( (T) \) and time \( (t) \) for a series of tests on a group shall be calculated by least-squares regression as follows:

\[ t = k_0 + k_1h + k_2\left(\frac{h}{k_{am}}\right) + k_3T + k_4hT + k_5\left(\frac{kT}{k_{am}}\right) + k_6\left(\frac{T}{k_{am}}\right) \]

where

- \( t \) = time from the start of the test, in minutes
- \( k_0 \) to \( k_6 \) = regression coefficients
- \( h \) = thickness of fire protection material, in millimetres
- \( T \) = steel temperature, in degrees Celsius, \( T > 250°C \)
- \( k_{am} \) = exposed surface area to mass ratio, in square metres/tonne

Part of the Construction Products Group – Australia
Why Detailed Design is Important

<table>
<thead>
<tr>
<th>Steel Size</th>
<th>FRL</th>
<th>Sides/Member</th>
<th>Hp/A</th>
<th>Critical Steel Temperature</th>
<th>WFT [mm]</th>
<th>DFT [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>410UB59.7</td>
<td>120</td>
<td>3 Sided Beam</td>
<td>175</td>
<td>620C</td>
<td>4.4</td>
<td>3.74</td>
</tr>
<tr>
<td>410UB59.7</td>
<td>90</td>
<td>3 Sided Beam</td>
<td>175</td>
<td>620C</td>
<td>2.5</td>
<td>2.14</td>
</tr>
<tr>
<td>410UB59.7</td>
<td>60</td>
<td>3 Sided Beam</td>
<td>175</td>
<td>620C</td>
<td>0.6</td>
<td>0.54</td>
</tr>
<tr>
<td>410UB59.7</td>
<td>120</td>
<td>4 Sided Column</td>
<td>198</td>
<td>550C</td>
<td>6.0</td>
<td>5.12</td>
</tr>
<tr>
<td>410UB59.7</td>
<td>90</td>
<td>4 Sided Column</td>
<td>198</td>
<td>550C</td>
<td>3.8</td>
<td>3.22</td>
</tr>
<tr>
<td>410UB59.7</td>
<td>60</td>
<td>4 Sided Column</td>
<td>198</td>
<td>550C</td>
<td>1.6</td>
<td>1.32</td>
</tr>
</tbody>
</table>

Builder ask: What is the m² rate?

$36/m² to $432/m²

E.g. DFT Range: 0.54mm to 5.12mm
When do you need to upgrade?

<table>
<thead>
<tr>
<th>Member Size</th>
<th>HPA</th>
<th>120 FRL</th>
<th>90 FRL</th>
</tr>
</thead>
<tbody>
<tr>
<td>310 UC 158</td>
<td>93</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>310 UC 137</td>
<td>106</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>310 UC 118</td>
<td>123</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>310 UC 96.8</td>
<td>148</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>250 UC 89.5</td>
<td>134</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>250 UC 72.9</td>
<td>162</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>200 UC 59.5</td>
<td>161</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>200 UC 52.2</td>
<td>183</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>200 UC 46.2</td>
<td>205</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>150 UC 37.2</td>
<td>196</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>150 UC 30.0</td>
<td>238</td>
<td>[UPGRADE]</td>
<td>✔️</td>
</tr>
<tr>
<td>150 UC 23.4</td>
<td>304</td>
<td>[UPGRADE]</td>
<td>✔️</td>
</tr>
<tr>
<td>100 UC 14.8</td>
<td>312</td>
<td>[UPGRADE]</td>
<td>✔️</td>
</tr>
</tbody>
</table>

Table 15: SC901/SC902 thickness (mm). Four Sided Protection: Universal Columns at 560°C or greater.
Optimising the Structural Steel Design

- At times, upgrading the steel can be more cost effective.
- That is why it is important to get us involved early.
Concrete Core Filling

**Core-Filling** is a viable solution to fire protect high Hp/A hollow section steel unable to achieve the desired FRL (usually 120 minutes).

Provides additional option between:
- Upgrading the steel size
- Lowering DFTs
- A grout or standard concrete mix (<40MPa) loosely packed concrete is adequate.
- Mix lowers the Hp/A of the steel member and justifies a significant reduction in required dry film thickness to meet high FRLs.

**Benefit's of core-filling hollow section steel:**
- Lowers the Hp/A value
- The mix adds thermal resistance to the structural steel
- Forms a composite column with higher compressive capacity
- Lower film builds can have aesthetic advantages in terms of level of finish
Core-filling Vs. Not Core-filling

4 Sided Column supporting a concrete floor load with a 550C critical steel temperature core-filled and not core-filled. Approximate cost of core filling included
## Intumescent Coating Technology Types

<table>
<thead>
<tr>
<th>Acrylic</th>
<th>Hybrid</th>
<th>Epoxy</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Internal</td>
<td>• Internal / External</td>
<td>• External</td>
</tr>
<tr>
<td>• On-site</td>
<td>• On &amp; Off-site</td>
<td>• Off-site</td>
</tr>
<tr>
<td>• Low VOC</td>
<td>• Low VOC</td>
<td>• Low VOC</td>
</tr>
<tr>
<td>• 6-8 hrs recoating</td>
<td>• 8 hour cure</td>
<td>• 18-24 hrs recoating</td>
</tr>
<tr>
<td>• Multiple coats</td>
<td>• One coat</td>
<td>• Multiple coats</td>
</tr>
<tr>
<td>• Basic</td>
<td>• Extremely Resilient</td>
<td>• Premium</td>
</tr>
</tbody>
</table>
Components of Intumescent Coating Systems

**Steel blasted to Sa2½**
Mill scale, rust paint and foreign matter is removed completely. Any remaining traces are visible only as slight stains or discoloration in the form of spots or stripes.

**Primer**
Protects the steel from corrosion

**Intumescent coating (Basecoat)**
In a thickness appropriate to the level of protection required
Appropriate to the steelwork being protected
Applied in multiple coats over multiple days

**Topcoat**
Optional for internal environments (waterborne/solvent)
Required for external environments (solvent-borne)
Extends life to the next maintenance cycle
Considerations when Specifying a Coating System

Corrosivity Category
AS2312 / ISO 12944

Category C1 - Very low

Category C2 – Low

Category C3 – Medium

Category C4 – High

Category C5 - Very high (C5-1: Industrial, C5-M: Marine)

Category Cx – Extreme

Category T – Inland Tropical
Specifications

Nullifire / Permax have a highly trained and knowledgeable team that would be happy to provide a tailored specification for your project. It is important to provide all the correct information, including any plans, so that the specification is correctly detailed.

Correct specifications should include the following:

- Client Details
- Project Details
- Corrosivity Category
- Member Types and Sizes
- FRL
- Steel critical failure temperature
- Intumescent Finish Required
- Steel Preparation Required
- Top Seal Required
- Product Technical Data Sheet Attached
- Any other requirements such as core-filling or meshing
Intumescent System Finishes

**Basic Finish (Standard)**
Reasonably smooth and even, orange peel, other texture, minor runs, similar minor defects are acceptable

**Normal Decorative Finish (Commercial)**
A good standard of cosmetic finish generally when viewed from a distance of 5m or more
Minor orange peel or other texture is usually acceptable

**High Decorative Finish (Architectural)**
A high standard of evenness, smoothness and gloss when viewed from a distance of 2 m or more
Warranties

Warranties are generally based on the project, taking into consideration the following variables:

- Exposure (external/internal) Corrosivity Category (e.g. C1,C3,C4)
- Steel Preparation (Primed or Unprimed steel, Galvanized)
- Top Seal (Quality of the Top Seal)
- Maintenance Schedule (Accessibility and frequency)
- Traffic etc

If you are requesting warranty documents for a project, ask before the project starts
Contractors

All products are installed by contractors who are able to demonstrate their competencies in the application of intumescent coating systems.

Be able to provide the necessary documentation to certify that the fire protection system has been installed in accordance with the product loading schedule, manufacturer’s product specifications.

Carry out their own environment measurement processes (Dewpoint), wet and dry film thickness surveys as required

Be able to verify that the installed product system meets the relevant Australian Standard with regards to fire testing compliance.

Third party inspection: although adding to the cost of the project, could greatly reduce the costly remedial work later down the project life.
Failed Intumescent

Waterborne Intumescent

Epoxy Intumescent
Considerations when Specifying a Coating System
Final Versus Construction Environment
Sydney Crown Casino
TED Building Monash University
The Coliseum Theatre Sydney NSW
Auckland International Convention Centre
Bond University QLD
Bond University QLD
Concrete Fire Engineered Solution Case-Study

Brisbane City Hall Heritage Upgrade
- Heritage building built in the 1920’s requiring upgrades to meet modern safety regulations, waterproofing, fire and electrical issues.

Existing Structure
- Masonry walled with concrete framed floor system.
- 20 MPa concrete strength
- Cover as low as 20mm in some areas with thick paint under the coffer ceilings

Fire Rating Problem
- Sprinkler failure scenario required FRL 45/45/45 for the slab.
- Intumescent paint, Nullifire S707-60 was tested first by Exova Warrington fire in accordance to AS1530.4-2005

Fire Testing & Solution
- Slab system spanned 1800mm between deep floor beams. 644 microns of S707-60 was applied.
- Structural adequacy of intumescent protected the slab and render for 51 minutes before detachment
- There was no integrity or insulation failure for 60 minutes.
- Testing carried out with Exova Warrington fire
80 Pitt St - Sydney CBD

- 13 story office tower, heritage building from the 1930's

Existing Structure

- 75 mm minimum waffle slab to be protected with Nullifire SC902

Fire Rating Problem

- Existing structural fire performance was confirmed as 75/75/55 FRL
- Sprinklers installed as risk protection.
- Evaluate a SC902 system to achieve fire rating for FER - 90/90/90 or DfS 120/120/120

Fire Testing & Solution

- Design option required for total sprinkler failure scenario
- As current design provided 55 min protection intumescent was designed to achieve 60 FRL and 90 FRL before slab failure
- One dimensional thermal transfer model used by fire engineers at FERM engineering
- Temperature profile of exposed surface and reinforcement was matched to a suitable steel element with SC902 steel protection
- Steel temperature of 400°C used as concrete does not yield at this temperature but deflection occurs.
- Exova Warrington fire witnessed fire testing carried out with Nullifire UK.

### Fire Testing & Solution

<table>
<thead>
<tr>
<th>Component</th>
<th>90/90/90 FRL</th>
<th>120/120/120 FRL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor Segment 75mm</td>
<td>Adding 60 min FRL 1.2mm SC902</td>
<td>Adding 90 min FRL 1.8mm SC902</td>
</tr>
<tr>
<td>Floor Beam 120mm</td>
<td>Adding 60 min FRL 1.6mm SC902</td>
<td>Adding 90 min FRL 2.6mm SC902</td>
</tr>
</tbody>
</table>
Indicative Fire Testing - Concrete

<table>
<thead>
<tr>
<th>Slab Type</th>
<th>Slab Depth</th>
<th>Bottom Cover</th>
<th>Slab Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reinforced Concrete</td>
<td>75mm</td>
<td>20</td>
<td>SL82 mesh reinforcement, 20 mPa and 10mm aggregate.</td>
</tr>
<tr>
<td>Reinforced Concrete</td>
<td>125mm</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Reinforced Concrete</td>
<td>150mm</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

75mm Thick Slab

Performance (whole minutes and FRL)
Specimen: a 75mm thick concrete slab with Nullifire SC912 applied to 50% of the surface.

<table>
<thead>
<tr>
<th>Test Results – Uncoated Side</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural adequacy</td>
</tr>
<tr>
<td>Integrity</td>
</tr>
<tr>
<td>Insulation</td>
</tr>
<tr>
<td>FRL</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test Results – Coated Side</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural adequacy</td>
</tr>
<tr>
<td>Integrity</td>
</tr>
<tr>
<td>Insulation</td>
</tr>
<tr>
<td>FRL</td>
</tr>
</tbody>
</table>

Configurations of the thermocouples on slab surface and within slab. 20mm cover on each slab. First thermocouple was at reinforcement depth.
Indicative Fire Testing - Concrete

75mm Thick Slab

Coated Slab

Uncoated Slab

Insulation Failure at 93 minutes.

Insulation Failure at 69 minutes.
Always Use Third Party Tested and Accredited Products

Fire protection is too important to take shortcuts

Ensure your Fire Protection System is Fully Compliant to AS/NZ Standards

- Products should satisfy the NCC Building Code of Australia compliance in regards to fire testing and assessment – AS1530.4-2005 and AS4100-1998

- In the NCC (BCA) 2014 (as current) Volume One, Specification A2.3, clause 2(d)(i) references AS4100 as a method of determining the FRL of steel structures.

- AS 4100, Section 12 further specifies a method of calculating the FRL of structural steel elements based on analytical methods using test results from tests which include AS1530.4.
How We Can Help

- Through all the steps of your project from initial specification to installation

- Optimise structural steel selection to ensure compliant fire protection.

- Use of multi-temperature analysis data via to enable optimisation of critical steel temperatures within the range of 400°C to 750 °C.

- Project specific fire testing to assist with performance based fire engineered solutions.

- The earlier engagement with Nullifire / Permax team the higher project cost savings
Thank you for your time

Questions?

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Intumescent Fire Protection to Structural Timber

permax

Australian Distributor of AITHON
Overview

Introduction to Permax

Passive Fire Protection in Timber structures

Intumescent on Timber

Structural Adequacy in Fire Event- AS1720.4

PV33 FRL Fire Protection

Structural Adequacy Protected Timber

PV33 Durability & Maintenance

Timber Linings & Coverings

Fire Protected timber- CLT

Certification & Specifying
Introduction to Permax

• Providing passive fire protection solutions for more than 10 years.

• Australian distributor of:
  • Nullifire Intumescents for Structural Steel (Cellulosic)
  • Typhoon Intumescent bolt caps
  • Flexichar Intumescent for Structural Steel (Hydrocarbon)
  • Nullifire and Aithon Intumescent for Concrete
Timber Structures

- Technology advances/sustainable construction
- Applications:
  - Cladding
  - Floors/Ceilings
  - Walls
  - Columns & Beams
- Physical and mechanical properties
- Weakness = Fire safety.
Passive Fire Safety of Timber Structures

- Designing timber for fire
  - Structural Adequacy?
  - Fire Hazard Properties?
  - Non Combustible/Fire Spread?

- Encapsulating thermal barriers are common solution to improve fire performance.
  - Benefits:
    - Decrease the temperature rise in the timber
    - Slow down or prevent char of timber elements
  - Methods:
    - Plasterboard
    - Intumescent
Intumescent coatings

- Innovative way to do deal with fire protection

- Benefits:
  - Attractive architectural appearance
  - Can be applied off-site or on-site, internal and external

- Fire Performance:
  - Forms a thick porous carbonaceous layer of char
  - Low density and low thermal conductivity
Intumescent Coatings on Timber

- Delay in time to ignition
- Reduction of heat release rate during combustion
- Flame spread & reduced smoke emission
- No ignition can occur too

**Expanded intumescent can:**
- Provide a thermal barrier to reduce & delay temperature rise
- Delay onset of charring rate within timber elements
- Provide a physical barrier to limit the pyrolysis gasses and access of oxygen within timber.
Design of Timber for Fire

1. FRL for Structural Adequacy

- 60/--/--, 90/--/--, 120/--/--?
- AS1720.4
- Timber Columns & Beams

2. Fire Hazard Property/Group Number

3. Fire Protected Timber for Incipient Spread of Flame
Structural Adequacy

Refers to the time in minutes before failure occurs for a structural member that is supporting a structural load.

Structural members are ONLY required to achieve structural adequacy as per DtS.

- 30/-/-
- 60/-/-
- 90/-/-
- 120/-/-
Unprotected Structural Timber

AS1720.4-2006 Timber Structures- Fire resistance for Structural Adequacy of Timber Members

SECTION 1  SCOPE AND GENERAL

1.1 SCOPE

This Standard provides a computational method for determining the fire resistance for structural adequacy of solid, plywood, laminated veneer lumber (LVL), and glued-laminated structural timber members as an alternative to the test specified in AS 1530.4.

This Standard also provides methods for protecting metal connectors from the effects of fire.

NOTES:

1  This Standard is not relevant to the determination of the early fire hazard properties of materials for which a method of assessment is given in AS/NZS 1530.3.

2  This Standard is not relevant to structural accreditation through furnace testing for which the appropriate Standard is AS 1530.4.

Notional charring rate depends on the timber density at a moisture content of 12% in kg/m$^3$. 

Timber Forms Natural Char
Example:
Solid Timber Column
700 \( \text{kg/m}^3 \)
Cross Section Size = 200mm by 200mm

**Step 1:** Calculate notional charring rate \( c \) (mm/mins)

\[
c = 0.4 + \left( \frac{280}{\delta} \right)^2
\]

\( \delta = \text{timber density (Kg/m}^3 \)\)

Notional charring rate \( c \) (mm/mins)

\[
c = 0.4 + \left( \frac{280}{700} \right)^2 = 0.56 \text{ mm/min}
\]
Example:
Solid Timber Column
700 kg/m³
Cross Section Size= 200mm by 200mm

Step 2:
Calculate effective depth of charring (mm)

\[ d_c = c_t + 7.5 \]

60 FRL =>

\[ d_c = 0.6 \times 60 + 7.5 = 41.1 \text{ mm} \]

Step 3:
Determine the Effective Residual Cross Section
200mm - 41.1mm - 41.1mm = 117.8mm

Step 4:
Structural load capacity of effective residual section

Greater Than

Design load on member under a fire load case as per AS1170.0
Aithon PV33 Fire Protection

- 60 FRL
- Aithon PV33 Clear water borne intumescent for internal timber.
- Aithon F3A is low sheen clear water based top coat.
- Aithon TB15 primer- Softwoods with open grains.

Application:
- At below 70% Humidity, temperatures 5C to 30C
- Timber moisture content below 12%
- Normal application is sprayed, can be brushed and rolled
PV33 Char Behaviour

- Acts at the surface
- At a 60 FRL- 1050C, PV33 carbon char is converted to gas
- Achieving higher FRL require mineral char (pigmented fillers)
**Applicability of Aithon PV33**

### Description of Assessment Product
- Fire tested to ENV13381-7-2002 and EN 1363-1-1999.
- Assessed to AS 1530.4:2014 and AS1720.4:2006 for timber density is greater than 550kg/m³
- Solid, Plywood, Laminated Veneer Lumber (LVL) & Glue Laminated Timber beams and columns only

### Description of Fire Test
- Two loaded beams fire tested. One with max PV33 coverage and one with min PV33 Coverage
- Coated beam test compared to uncoated beam to quantify affects of timber intumescent.

### Fire Resistant Level Applicability
- Applicable to fire resistance levels of 15, 30, 45 and 60 minutes for structural adequacy.
Fire Assessment

- FAS190031 R2.0 - Char Depth Determination of Timber Beams and Columns
Structural Adequacy for Protected Timber

- Charring rate of the protected timber determined based on the Char Depth (mm) and Time (mins).
- Each FRL has a different effective depth of charring calculation for PV33 protected timber.
- Minimum $h = 300 \text{ g/m}^2$
- Maximum $h = 1150 \text{ g/m}^2$

FAS190031 R2.0- Char Depth Determination of Timber Beams and Columns

The char depth given below is the equivalent effective depth of charring, $d_e$, as given in AS 1720.4:2006 which includes the 7.5mm zero strength layer.

**Char depth of timber beams and columns with a density greater than 700 kg/m$^3$**

- Char depth for 15 minutes FRL ($d_{c,15}$) = $14.20 - 5.823 \times 10^{-3}h$
- Char depth for 30 minutes FRL ($d_{c,30}$) = $22.74 - 4.011 \times 10^{-3}h$
- Char depth for 45 minutes FRL ($d_{c,45}$) = $31.52 - 3.941 \times 10^{-3}h$
- Char depth for 60 minutes FRL ($d_{c,60}$) = $40.15 - 4.544 \times 10^{-3}h$

$h$ is the thickness of AITHON PV33 given in $\text{g/m}^2$.

**Char depth of timber beams and columns with a density greater than 550 kg/m$^3$ and less than 700 kg/m$^3$**

- Char depth for 15 minutes FRL ($d_{c,15}$) = $15.41 - 6.872 \times 10^{-3}h$
- Char depth for 30 minutes FRL ($d_{c,30}$) = $25.48 - 4.731 \times 10^{-3}h$
- Char depth for 45 minutes FRL ($d_{c,45}$) = $35.85 - 4.649 \times 10^{-3}h$
- Char depth for 60 minutes FRL ($d_{c,60}$) = $46.03 - 5.362 \times 10^{-3}h$

$h$ is the thickness of AITHON PV33 given in $\text{g/m}^2$. 
Example:
Solid Timber Column
700 kg/m³
Cross Section Size= 200mm by 200mm
Fire protected with PV33

Calculate effective depth of charring (mm)

\[
d_c = 46.03 - 5.362 \times 10^{-3} h
\]
Protected Vs. Unprotected Timber

Effective Depth of Charring for 700 kg/m² Density

- **Unprotected Timber**
- **1150 g/m² Protected Timber**
- **800 g/m² Protected Timber**
- **300 g/m² Protected Timber**
PV33 undergone durability testing equivalent to 5 years external exposure and then fire tested to see its performance.

Achieved a X-class rating for external exposure. Shows good resistant to UV damages.

Regardless PV33 is still only recommended for semi-exposed and indoor environments.

Top coat is first line of defence.

Detailed repair and maintenance guide available.
Timber Intumescent Components

Surface Preparation

- Proper sandblasting is often not possible due to ambient restrictions
- The entire surface needs to be carefully cleaned using a 150 or 180 grade sand paper

Primer TB15

- Provides a tannin blocking effect, reduces absorption of softwoods and improves adhesion of the clear intumescent coating.

Intumescent PV33

- In a thickness appropriate to the level of the timber protection required
- Applied in multiple coats over multiple days

Topcoat F3A

- For internal environments (waterborne/solvent)
- Extends life to the next maintenance cycle
Design of Timber for Fire

1. FRL for Structural Adequacy

2. Fire Hazard Property/Group Number
   - Group Number 1 or 2?
   - BCA Spec C1.10 Fire Hazard Properties- AS5637.1
   - Wall/Floor/Ceiling linings and coverings

3. Fire Protected Timber for Incipient Spread of Flame
BCA Spec C1.10 Fire Hazard Properties: Table 3- Wall and Ceiling Lining Materials

- C1.10 (b) Paint or fire-retardant coatings must not be used in order to make a material comply with a required fire hazard property.

Test Standard:

- AS5637.1- Determination of fire hazard properties; this standard determines smoke growth rate index or average specific extinction area in terms of ISO 9705 or prediction method in terms of ISO 5660-1 (AS3837).

New PV33 formulation undergoing testing to achieve a group number rating on timber linings.
Design of Timber for Fire

1. FRL for Structural Adequacy

2. Fire Hazard Property/Group Number

3. Fire Protected Timber for Incipient Spread of Flame
   - Limit timber and protective covering interface temperature to 300C.
   - BCA Spec C1.13a Fire-Protected Timber
   - Timber walls and ceilings (CLT)
C1.13a- Fire Protected Timber

Design Failure Criteria BCA 2019 C1.13a:
Temperature at interface between protection system and timber does not exceed 300°C.

Test Standard:
- AS1530.4- Methods for fire tests on building materials.

Benefits of Intumescent Over Plasterboard
- Clear intumescent saves the natural look of timber texture
- Reduces weight of board within structure
- Fire performance doesn’t depend on fixing method
- Off-site application helps in further reducing costs and minimizing disruptions for other trades.

<table>
<thead>
<tr>
<th>Application</th>
<th>Time – without timber interface exceeding 300°C (mins)</th>
<th>Minimum thickness of fire-grade plasterboard (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inside a fire-isolated stairway or lift shaft</td>
<td>20</td>
<td>13</td>
</tr>
<tr>
<td>External walls within 1 m of an allotment boundary or 2 m of a building on the same allotment</td>
<td>45</td>
<td>2 x 13</td>
</tr>
<tr>
<td>All other applications</td>
<td>30</td>
<td>16</td>
</tr>
</tbody>
</table>
Experimental investigation

- 200x200x100 mm Cross-Laminated Timber (CLT) block
- Heating conditions: constant incident heat flux of 50 kW/m²
## Indicative Fire Testing - Spec C1.13a (CLT)

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Applied Thin Intumescent Coating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WFT [mm]</td>
</tr>
<tr>
<td>S00-A</td>
<td>n/a</td>
</tr>
<tr>
<td>S00-B</td>
<td>0.60</td>
</tr>
<tr>
<td>S00-C</td>
<td>1.60</td>
</tr>
<tr>
<td>S06-A</td>
<td>1.60</td>
</tr>
<tr>
<td>S06-B</td>
<td>2.50</td>
</tr>
<tr>
<td>S06-C</td>
<td>2.50</td>
</tr>
<tr>
<td>S16-A</td>
<td>2.50</td>
</tr>
<tr>
<td>S16-B</td>
<td>2.50</td>
</tr>
<tr>
<td>S16-C</td>
<td>2.50</td>
</tr>
<tr>
<td>S25-A</td>
<td>2.50</td>
</tr>
<tr>
<td>S25-B</td>
<td>2.50</td>
</tr>
<tr>
<td>S25-C</td>
<td>2.50</td>
</tr>
</tbody>
</table>
Indicative Fire Testing - Spec C1.13a (CLT)
In-depth thermocouples evolution

Thermocouple @ 2mm
## Results – Timber charring final depth

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Final Charring Depth [mm]</th>
<th>Charring Rate [mm/min]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Visual</td>
<td>300°C Isotherm</td>
</tr>
<tr>
<td>S00-A</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>S00-B</td>
<td>55</td>
<td>36</td>
</tr>
<tr>
<td>S00-C</td>
<td>60</td>
<td>59</td>
</tr>
<tr>
<td>S06-A</td>
<td>21</td>
<td>17</td>
</tr>
<tr>
<td>S06-B</td>
<td>22</td>
<td>17.5</td>
</tr>
<tr>
<td>S06-C</td>
<td>22</td>
<td>16.5</td>
</tr>
<tr>
<td>S16-A</td>
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<td>11</td>
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<tr>
<td>S16-B</td>
<td>14</td>
<td>10</td>
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<tr>
<td>S16-C</td>
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<td>S25-A</td>
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<td>5.5</td>
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<tr>
<td>S25-B</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>S25-C</td>
<td>5</td>
<td>&lt; 2</td>
</tr>
</tbody>
</table>
### Considerations when Specifying a Coating System

<table>
<thead>
<tr>
<th>Factors affecting quality of finishes</th>
<th>Factors affect fire performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substrate</td>
<td>Species</td>
</tr>
<tr>
<td>Ambient Temperature</td>
<td>Density</td>
</tr>
<tr>
<td>Maintenance Schedule</td>
<td>Moisture</td>
</tr>
<tr>
<td>Pre-treatment</td>
<td>Building Design</td>
</tr>
<tr>
<td>Application Procedure</td>
<td>System Choice</td>
</tr>
</tbody>
</table>

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Contractors

Recommended that all products are installed by contractors who are able to demonstrate their competencies in the application of intumescent coating systems.
Compliance

- Maintain detailed records of the work – ITP sheets

- Timber Moisture Content, WFT & DFT Measurements.

- Be able to provide the necessary documentation to certify that the fire protection system has been installed in accordance with the product loading schedule, manufacturer’s product specifications.

- Be able to verify that the installed product system meets the relevant Australian Standard with regards to fire testing compliance.

- Third party inspection: although adding to the cost of the project, could greatly reduce the costly remedial work later down the project life.
Always Use Third Party Tested and Accredited Products

Ensure your Fire Protection System is Fully Compliant to AS/NZ Standards

Test reports must be issued by accredited testing authorities.

Products should satisfy the NCC Building Code of Australia compliance in regards to fire testing and assessment – AS1530.4:2014 and AS1720.4:2006.

AS 1720.4, Section 2 further specifies a method of calculating the FRL of structural steel elements based on analytical methods using test results from tests which include AS1530.4.
THANK YOU FOR YOUR TIME
ANY QUESTIONS?

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