

A SPECIFIER'S GUIDE TO STRUCTURAL STEEL FIRE PROTECTION



INTRODUCTION

In recent years, steel framed construction has steadily gained momentum across Australia. Numerous large scale, multi-storey projects employing structural steel have already been completed around the country, and the University of Wollongong reports that we have only just begun to scratch the surface of steel frame technology.ⁱ The increasing popularity of the construction method is the result of many factors, but is mainly attributable to its durability, design flexibility, speed of construction, and resistance to rust, rot, and degradation over time.ⁱⁱ

As steel framed construction continues to gain ground, it is crucial that specifiers follow best practice with regard to its usage, particularly in terms of fire protection. As a consequence of the recent high profile Grenfell and Lacrosse tower disasters, the construction industry is acutely aware of the risk of fire in multi-storey developments. Although in both instances aluminium composite cladding panels were ultimately responsible for the fire, the cases nonetheless highlight the importance of ensuring that where required, all construction materials offer adequate protection against fire.

Where required in this whitepaper, we set out the fire protection considerations that must be taken into account when specifying steel for use in steel framed systems. We also provide an overview of three key passive fire protection systems: spray applied vermiculite sprays, board encasement systems, and intumescent coatings.

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UNDERSTANDING THE RISKS

In accordance with the Deemed to Satisfy provisions of Specification C1.1 of the National Construction Code (NCC), steel must meet the Fire Resistance Level (FRL) corresponding with the type and class of construction. The NCC divides construction into “Class 1” through to “Class 10” dependent on use, and Types A, B, and C dependent on height. FRLs may vary significantly between buildings of different classes and types. If you are unsure of the FRL required for your project, consult your building certifier or Authority Having Jurisdiction (AHJ).

The inclusion of fire performance requirements for steel in the NCC reflects the very real risk that fire presents to steel. Steel softens at temperatures of 1000°Cⁱⁱⁱ and begins to lose its design margin of safety at temperatures of around 550°C – this is problematic, since most high-rise fires tend to burn at around 593°C^{iv}.

As temperatures increase, the strength of steel decreases significantly. At 600°C, it has an effective yield strength factor of 0.47, whereas at 800°C it has an effective yield strength factor of 0.11. In practical terms, this means that failure to ensure the adequate fire protection of steel may lead to the collapse of a building in the event of a fire.





BEST PRACTICE FOR STEEL PROTECTION SPECIFICATION

While it is important to work closely with an experienced supplier who can provide guidance and, if necessary, a fit-for-purpose system that meets the relevant building code requirements, it is important to understand the basic principles entailed in specifying steel.

Key Considerations

The **critical temperature**, or 'default limiting temperature', of steel is the temperature at which the structural member will collapse due to the effects of fire.^v In Australia, the most commonly used default limiting temperatures are 550°C for 4-sided applications and 620°C for three-sided composite structures.^{vi} The higher the critical temperature, the lower the requirement for additional fire protection.

The **sizing** of structural members must also be taken into account. As a rule of thumb, larger steel members will require less protection than their smaller counterparts, offering significant cost and labour savings in terms of fire protection measures. For example, a 100 x 100 x 4mm steel hollow section will require an estimated 75% more protection than a steel hollow section with the dimensions 100 x 100 x 9mm.

The **section factor** of the steel must be calculated to facilitate specification of the correct material thickness required to achieve the given FRL. Essentially, it measures the speed at which a steel section heats up when exposed to flames and heat. Section factor can be calculated using one of two equations: Exposed Surface Area to Mass ratio (ESA/m) or Heated Perimeter over Area (Hp/A). The fire protection thickness requirement increases as ESA/m and Hp/A values rise.^{vii}

MINIMUM INFORMATION REQUIREMENTS FOR SPECIFICATION

Before specifying fire protection for steel, it is necessary to ascertain the following:

- The **steel serial size**, or the designated profile and dimensions of the member in question.
- The **number of exposed sides** that the member will have. For example, a freestanding column will have four exposed sides, whereas a beam topped by a concrete slab or abutted against a wall will have three sides.
- The **FRL** that must be met, in accordance with the classifications provided by the NCC.
- If available, the **critical temperature** or design load used by the structural engineer in their design.



PASSIVE FIRE STEEL PROTECTION

There are three main types of passive fire steel protection, a category of fire protection that contains a fire at its point of origin and prevents it from spreading. The three types, which are given below, may be used separately, though certain environments will require a combination of two or more.

Spray applied vermiculite sprays are cost effective protective coatings that can be applied rapidly by specialist applicators. The coatings have a low grade, off-the-gun finish and are thus ideal for situations that do not require an architectural finish and where cost and speed are critical. Spray applied vermiculite sprays can meet FRL requirements up to 240/-/-.

Board encasement systems are a type of fireproof cladding that completely encloses structural steel members and allows for the installation of windows, doors, and walls directly adjacent to encased members. Ideal for achieving a high quality, architectural grade finish, board encasement systems facilitate perfect colour matching with surrounding ceiling and wall surfaces. As they are factory manufactured, fireproof boards ensure uniform thickness and thus adequate protection, unlike intumescent paints and vermiculite sprays, which may be susceptible to user error in terms of uneven or inadequate application of product.

They are more costly than vermiculite sprays, but can be used to meet FRL requirements up to 240/-/-.

Intumescent coating systems are fire-rated coating systems that can be applied directly to properly prepared steel structural members. The systems comprises a primer, intumescent, and top coat and all three layers need to be compatible with each other and with the final environment in which they will be located. They can be used to achieve a high degree of finish where the exposure of structural steel is required. Extremely cost efficient, intumescent paint can achieve an FRL up to 60/-/- in just one or two coats, depending on the accuracy of calculations and the exposure of the member in question. Higher FRLs up to 120/-/- can also be achieved with the application of extra coats.

Intumescent coatings work by expanding when heat is applied to them. The expanding paint forms an insulating layer of fire resistant char which in turn keeps the temperature of the steel down. This expansion is critical to the performance of the system, so while the initial installation of the product is very thin, there does need to be space around the member to allow for this expansion. This can mean that for certain types of installation – such as where window frames or walls will abut the member – an intumescent coating will not be suitable.





CONCLUSION

For over six decades, Promat has been a global leader in sophisticated fire science technologies. In Australia, the Promat brand is synonymous with reliable, outstanding fire performance for a breadth of sectors and project types and is considered an expert in passive fire protection. Promat's drive for innovation is paired with a world-leading research and development department that harnesses design expertise and the latest technology to develop cutting edge solutions for protection against fire, smoke, fumes, and heat.

A strong focus on environmental, health, and safety (EHS) has endured throughout the company's history, and informs everything from creating a safe working environment for all employees to measuring, monitoring, and improving on EHS performance.

Promat has developed solutions in each of the three major passive fire steel protection categories, and has processes for seamlessly interfacing two or more into one project.

CAFCO vermiculite sprays are favoured around the world for their reliability and durability. Globally, they have protected more than 4 million square metres of steel from fire, and are a popular and well-established system in Australia for their rapid, straightforward application process. The low-density sprays add minimal load to steel structures and are highly cost

efficient when correctly applied. Choose CAFCO® 300 for internal applications and CAFCO FENDOLITE® MII for outdoor use or other harsh environments that are exposed to moisture, chemicals, blasts, or jetfire.

PROMATECT board encasement systems are ideal for maximising space in compact installation environments. Offering a sleek single layer, frameless system, PROMATECT® 250 combines a streamlined contemporary style with high functionality.

PROMATECT's smooth surface finish can be skimmed and painted to the highest level of finish, granting designers a degree of flexibility unmatched by other fire protection methods. The economical board significantly reduces material and labour costs compared with competing products, and is suitable for achieving FRLs up to 120/-/-. For higher FRLs, PROMATECT® L is recommended.

CAFCO SPRAYFILM intumescent coatings have a proven track record around the world. A popular choice thanks to its cost efficiency and versatility, CAFCO SPRAYFILM® WB3 combined with Dulux Protective Coatings provide a fully warranted and compatible system with enhanced performance and aesthetic characteristics by way of corrosion protection and decorative and protective topcoats.

REFERENCES

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