SPECIFYING FIRE-RATED BUILDING SYSTEMS

Fire resistance

Fires affecting dwellings and places of business cause losses ranging from property and structural damage to injuries and loss of life. In 2018, 4,595,102 fires were reported worldwide, resulting in 51,351 fire-related injuries and 30,812 fire-related deaths. In some cases, these tragic outcomes might have been avoided or mitigated by using better designs, materials and systems.

By understanding how fires work, as well as what standards and fire-rated systems exist, architects can design and build structures that reduce the spread of fire, preventing future injuries and potential deaths.

This whitepaper explores fire elements of the National Construction Code (NCC) that relate to the design of wall and ceiling systems.

Basic principles of fire

There are three conditions needed for a fire to start, known as the fire triangle. This includes fuel, oxygen gas (O2) and a heat source. If one element is missing, a fire cannot start. Likewise, if one element is removed, the fire goes out.

Fire itself is the visible combustion reaction of flame and smoke. Smoke refers to the collection of airborne solid and liquid particles and gases emitted when a material undergoes combustion and occurs when there is not enough oxygen or incomplete combustion. Smoke is toxic and smoke inhalation is the primary cause of death in victims of indoor fires.

Factors that can impact the spread of fire include conduction, convection and radiation, as well as flammability of surrounding products and equipment, ventilation conditions and building design.

- Conduction is the direct contact of heat, such as hot sand forcing beachgoers into a run.
- Convection is circulation of hot-to-cold achieved when warm areas of gas rise to cooler areas. Boiling water is a good example of convection, as the steam is being transferred into the cooler air.
- Radiation is the transfer of heat through empty space with no physical contact needed. For example, when the sun warms the skin on a sunny day, or a magnifying glass is used to singe the grass.

Stages of fire

Three stages of ignition occur before a fire becomes fully established. These are ignition, growth, and flashover.

- In the ignition stage, fuel, oxygen, and heat join together. At this stage, a fire extinguisher can control the fire.
- In the growth stage, additional fuel ignites, and convection and radiation ignite more surfaces. As the fire reaches the ceiling, hot gases are collected, bringing all fuels in the room simultaneously closer to ignition.
- The flashover stage occurs when the fire is fully developed and has spread across most or all available fuel, with temperatures reaching their peak.
- Finally, decay or burnout occurs when the fire has consumed all available fuel, temperatures decrease and the fire becomes less intense.

Fire regulations

Building codes and relevant government and industry standards exist to prevent and minimise damage in the event of a fire. Building designers and architects must consider the appropriate building design to keep people safe. This includes compartments, smoke, extraction, and escape routes. Additionally, to limit the possibility of risk extension and consequence, construction products and systems must be correctly classified.

The NCC provides the minimum necessary requirements for safety and health, amenity and accessibility, and sustainability in the design, construction, performance and liveability of new buildings (and new building work in existing buildings) throughout Australia.

The NCC fire resistance requirements offer a framework for testing and compartmentation to:

- Safeguard people from illness or injury due to a fire in a building
- Safeguard occupants from illness or injury while evacuating a building during a fire
- Facilitate the activities of emergency services personnel
- Avoid the spread of fire between buildings
- Protect other property from physical damage caused by structural failure of a building as a result of fire.

Reaction to fire versus fire resistance

Testing a material's reaction to fire, or how it degenerates when exposed to fire under specific conditions, requires an evaluation into product behaviour regarding ignitability, propagation and surface spread of flame. These tests are conducted on basic materials only.

Fire resistance is a system's ability to fulfil, for a stated time, the required structural adequacy, and/or integrity, and/or insulation specified in a standard fire resistance test.

There are three specific standards that can measure this:

1. AS/NZS 1530.1: Combustibility test for materials
2. AS/NZS 3837: Method of test for heat smoke release rates for materials
3. AS/NZS 1530.4: Fire resistance tests on elements of construction

Fire resistance level (FRL)

A fire resistance level (FRL) is comprised of structural adequacy, integrity and insulation.

Structural adequacy is the time it takes before the specimen can no longer carry its load. If a building system can no longer do its job structurally, the occupants would be in danger. For example, a falling structure could crush the occupant or block the exit path.

Integrity is the time it takes before cracks and openings appear, allowing passage for flames and/or hot gases. Smoke and flames pose a hazard to building occupants.

Insulation is the ability to maintain a temperature on the unexposed face not rising by more than 140 degrees Celsius on average, or 180 degrees for a single point.

For example, if a load-bearing system achieved a minimum of 60 minutes in load-bearing capacity; 60 minutes in integrity; and 60 minutes in insulation, then it would be classified as FRL 60/60/60.

If a non-load bearing system achieved a minimum of 60 minutes in integrity and 60 minutes in insulation, then it would be classified as FRL -/60/60.

There are two main factors that affect a required FRL:

1. Class of building: determined by the building purpose.
2. Type of construction - the type of construction is determined based on rise in storeys and fire compartment size

Structural Testing

Fire rated lightweight wall systems must meet structural Specification C1.8 (Structural tests for lightweight construction) of the NCC. The two main test methods are resistance to static pressure and resistance to impact.

Resistance to static pressure

For a wall to meet compliance, it must resist static pressure. A wall does not pass a structural test when it collapses or the rate of deflection exceeds 20mm for lift shaft, or 30mm for a standard wall.

Resistance to soft body impact

This test requires a bag filled by 27kg of dry sand to be dropped on a wall. The wall must not deflect more than 20mm for a lift shaft or 30mm for a standard wall.

Fire resistance tests

Wall

A standard full-scale wall test is 3m x 3m in size. Performance depends on the entire wall system, including the plasterboard, framing, sealants, accessories, mounting and fixing.

Thermocouples are placed on the unexposed face of plasterboard wall to measure temperature increases. A burning cotton pad is one of the methods used to determine if a wall system fails integrity, along with gap gauges and sustained flaming. Also, sustained flaming on the surface on the unexposed face for 10 seconds or longer is considered an integrity failure. All testing must be carried out according to the AS1530.4 for the results to be valid and to meet the NCC requirements.

Ceiling

A standard full-scale ceiling test is 4m x 3m in size. Performance depends on the entire ceiling system, including materials such as plasterboard, framing, roof material or flooring. Resistance to incipient spread of fire (RISF) is also measured with temperatures recorded on the unexposed side of the plasterboard linings.

Structural element

In many types of buildings, structural steel will need to be fire protected. This is because structural steel has a low melting point and while steel will not melt, it will be weakened and compromise the integrity of a building, causing it to collapse.

The main concern is the capacity for the steel to carry a load. Protecting steel with plasterboard can be done by individually wrapping structural steel or containing it within a wall.

Fire resistance properties: gypsum board

The face and back of plasterboard is 100 per cent recycled paper, regardless of board type, with colour being the only difference. A fire-rated plasterboard has pink-coloured paper face.

Board density will vary from 500 kg/m^3 up to 1000 kg/m^3. Sound-rated, impact-rated, and fire-rated plasterboards are closer to 1000 kg/m^3.

Glass fibre content varies from zero up to 0.5 per cent. Some board types don't contain glass fibres such as regular or sound-rated boards. All fire-rated boards will contain glass fibres within the core of the board, and high-impact boards will have a fibreglass mat embedded within the back of the board.

A plasterboard contains generally 50% by volume of chemically combined water. During a fire, the water in the board becomes a vapour, and the vapourisation keeps the plasterboard cool while absorbing the heat of the fire. This is known as the endothermic effect.

Additionally, fire rated gypsum boards contain vermiculite, that works to counter act the shrinkage of the boards when exposed to a heat source.

Glass fibres create core cohesion in the gypsum boards when heated. As the board shrinks due to heat, the vermiculite expands and the fibreglass within the core keeps the board together.

Fire compartmentation

Compartmentation is the division of a building into cells, using construction materials that will prevent the passage of fire from one cell to another for a given period of time. This is particularly relevant in high rise residential buildings, where each unit is treated as its own cell to prevent the spread of fire between units. Depending on the size of the unit, additional fire separation within may be required to protect the occupants' means of escape.

Any structure required to support a fire-rated system must have a FRL of at least that of that a fire-rated system. This includes vertical and lateral support.

Structural members should not penetrate or pass over the top of a fire wall, as the failure of these members may damage or bring down the wall prematurely. This can be prevented through good design, by giving consideration to the following:

- Fire-rating the ceiling
- Fire-protecting the structural member
- Ensuring the partition can carry the load of the fire-affected member by including columns in the wall
- Providing support for both sides of the wall.

Next steps: Continuing Professional Development

Architects and specifiers need to be across the fire-related requirements set out in the NCC so that they can design and build structures that maintain public health and safety. As requirements, materials, and techniques continue to evolve, it's essential for professionals to stay up to date on the latest information.

Knauf now offers a continuing professional development (CPD) webinar presentation on specifying fire-rated building systems that is certified by the Australian Institute of Architects (AIA).

The webinar is one hour in length and is worth one informal CPD point. On completion of the post-webinar learning outcomes questionnaire, participants can receive one formal CPD point. Participation is free via online registrations and more information can be found at: www.knaufapac.com/au/cpd

About Knauf

Knauf is a leading manufacturer and supplier of plasterboard, ceiling tiles and suspension systems, metal framing, jointing compounds and industrial plasters across Australia. The company's main brand names include Knauf, Sheetrock®, Fiberock® and DONN® DX – the world's most widely specified and installed ceiling suspension system.

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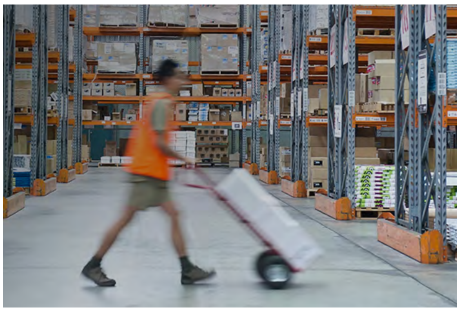
Our National TecASSIST™ helpline is available to answer technical questions and provide free advice to builders, contractors, architects, engineers and home owners throughout Australia.

There are many variables that can influence construction projects, which affect whether a particular construction technique is appropriate. Before proceeding with any project, we recommend you obtain professional advice to ascertain the appropriate construction techniques to suit the particular circumstances of your project. We recommend
you use qualified tradespersons to install this system.

The technical information contained in this manual was correct at the time of printing. Building systems, details and product availability are, however, subject to change. To ensure the information you are using is current, Knauf recommends you review the latest building information available on the Knauf website.

For further information, contact TecASSIST™ or your nearest Knauf sales office.



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