REACTION-TO-FIRE PROPERTIES FOR CONSTRUCTION AND FINISHING OF MULTI-STOREY TIMBER BUILDINGS IN NEW ZEALAND

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This information sheet discusses New Zealand Building Code requirements relating to the reaction-to-fire or flame spread properties of timber used in interior floors, walls or ceilings or as external cladding.

Performance requirements for the fire properties of materials used in interior floors, walls or ceilings or as external cladding are published by the Department of Building and Housing[1] in NZBC Code Clause C3. The requirements also appear in the Verification Method C/VM2 and in the Acceptable Solutions C/AS1 to C/AS7 (DBH, 2012) edited to suit the scope of each of the Compliance Documents. Compliance with any of these compliance documents means guaranteed acceptance by Building Consent Authorities and compliance with the New Zealand Building Code.

Alternative Solutions can be proposed but they may be subject to negotiation with the Building Consent Authority and must be shown to meet the performance requirements of the Building Code. Given that quantitative reaction to fire performance requirements are included in the Code Clauses C3, Alternative Solutions demonstrating equivalency would be expected to be quite rare and unusual and would at least require the services of a suitably qualified fire engineer.

This information sheet discusses requirements of the Code Clause C3 only.

What is the difference between 'Reaction-to-Fire' and 'Fire Resistance'?

'Reaction-to-Fire' describes how materials behave when exposed to the radiant heat from small growing fires, and the degree to which they are able to support flame spread and contribute smoke and heat to the fire. 'Fire Resistance' refers to the degree (usually expressed as a time duration) to which building assemblies or elements can withstand large fully developed fire preventing structural collapse or performing as barriers to limit the fire spreading through the building.

Interior Walls and Ceilings

What are Group Numbers?

Group Numbers are derived from testing to either ISO 5660 (cone calorimeter test) or ISO 9705 (room-corner test) and are used in NZBC Code Clause C3.4 to control the reaction-to-fire properties of interior wall and ceiling linings. The detailed procedure for determining the Group Number using fire test data is given in C/VM2 Appendix A. Group Numbers are measured on a scale of 1 (good) to 4 (bad). A Group Number of 4 is indicative of rapid flame spread potential and is not permitted in areas of buildings subject to reaction to fire controls.

Why are there two test methods for determining Group Numbers?

The Group Number is associated with the time to flashover in a small room (i.e. total fire involvement with everything burning). Time to flashover is a good measure of the fire hazard since the longer it takes for this to occur, the more time available for occupants to escape from the building. The ISO 9705 test measures this time directly because it is a full-scale fire test in a room where the walls and ceiling are lined with the product to be evaluated.

In the ISO 9705 test, time to flashover (TFO) is taken as the time at which the measured rate of heat release reaches 1 MW, and is related to the Group Number as follows:

TFO < 2 min	(Group Number 4)
2 ≤ TFO < 10 min	(Group Number 3)
10 ≤ TFO < 20 min	(Group Number 2)
No flashover in 20 min	(Group Number 1)

[1]Name has changed to Building and Housing Group, Ministry of Business, Innovation & Employment.

However, since the ISO 9705 test requires a large amount of test material and is expensive to carry out, there is an alternative fire test ISO 5660 which requires only small samples of the test product measuring 100 mm x 100 mm in area. Burning rate data from the ISO 5660 test is used in a calculation that predicts the Group Number. This is a less expensive and more convenient means of obtaining a Group Number. In most, but not necessarily all cases, the Group Number assignment obtained from each test will be the same. Where there is a difference usually the Group Number is more conservative (higher) using ISO 5660 compared to ISO 9705.

Group Numbers of timber depend on the species, density and thickness of the material. In New Zealand, materials must be evaluated with any applied coatings or finishes included. Group Numbers of timber may be improved with the use of fire-retardant treatments or coatings.

What about Smoke Production?

In some locations in buildings not protected with an automatic fire sprinkler system, the NZBC Clause C3.4 requires, in addition to a Group Number classification, the rate of smoke production to be less than 250 m2/kg in the ISO 5660 test or less than 5 m2/s in the ISO 9705 test. When these limits are required to be met the Group Number is appended with a '-S'. (e.g. Group Number 1-S).

In any location where NZBC Clause C3.4 permits a Group Number 3, or in any location in a building protected with an automatic fire sprinkler system, there are no limits placed on the smoke production rate.

What are typical Group Numbers and Smoke Production Rates achieved by timber surfaces?

Untreated, unfinished timber typically achieves a Group Number of 3 depending on species and thickness of the wood. However it is possible that some high density timbers may achieve a lesser value whereas some very low density timbers may be higher. Therefore, unless the material fits the generic specification given in Table 1, the relevant technical data should be requested from the manufacturer or supplier of the product.

Smoke production rates for exposed timber are typically less than 250 m2/kg in the ISO 5660 test and less than 5 m2/s in the ISO 9705 test. Both the Group Number and smoke production rate can change when coatings are applied to the surface of the timber. For compliance with the NZBC, the Group Numbers and smoke production rates must be supported by fire test results unless the material fits the generic specification given in Table 1 for a Group Number 3 classification. Test data when required should be requested from the manufacturer or supplier of the product or coating.

Table 1

Coating **(coating in good condition and well adhered to substrate)**	**Substrate**	**Performance (with or without coating)**
Waterborne or solvent borne paint coatings, varnish or stain ≤ 0.4mm thick ≤ 100 g/m^2	Solid wood or wood product ≥ 9.0 mm thick ≥ 600 kg/m3 for particle boards, or ≥ 400 kg/m3 for all other wood and wood products	G3

Can I use timber products for surface linings within individual household units of residential buildings?

Yes, the NZBC Clause 3.4 allows wood products to be used anywhere within household units in detached dwellings e.g (houses) and also within household units in residential flats or apartment buildings. The household units may be single level or multi-level and Group Numbers for wood products are not required. However, this exemption does not include any exit stairs or corridors in these buildings that are used by more than one household unit.

Are there any parts of buildings that are exempt from meeting the reaction-to-fire requirements?

Yes, handrails and general decorative trim (i.e. architraves, skirting, window reveals etc) are exempt from reaction-to-fire requirements. In addition, small areas of non-conforming product within a space with a total aggregate surface area of not more than 5.0 m2 are permitted.

Also exempt are individual doorsets and continuous areas of permanently installed openable wall partitions not more than 3 m high and having a surface

area not more than 25% of the divided room floor area or 5 m2 (whichever is less).

Timber joinery and structural timber building elements (such as heavy timber columns, beams, portals and shear walls not more than 3 m wide) constructed from solid wood, glulam or laminated veneer lumber are exempt from reaction-to-fire requirements. These elements may still be required to achieve certain fire resistance ratings so they continue to support loads during and after fire depending on the building use and their location in the building.

Exposed timber or permanent formwork on the underside of floor/ceiling systems should be treated as a ceiling and are not exempt from reaction-to-fire requirements.

Are there any benefits from installing a fire sprinkler system?

Yes, the main benefit for timber linings (achieving Group Number 3) providing the building has an approved automatic fire sprinkler system, is that timber can be used as a wall surface material in crowd and sleeping use areas (excluding where occupants are under care or detention).

What types of buildings require the walls and ceiling to meet surface finish requirements?

With the exception of the examples given above, the wall and ceiling surfaces in all other buildings are required to have finishes that meet maximum Group Number classifications and in some cases smoke production rates. There are four general groupings with different levels of performance required. These are summarised here as:

1. Stairs or corridors that are designated 'exitways' or 'safe paths' or sleeping spaces in facilities where occupants are under care or are being detained (e.g. hospitals, rest-homes, prisons). Also included are all occupied spaces in buildings designated an Importance Level of 4.

   In these locations the Group Number shall be no greater than 1-S if unsprinklered, or 2 if sprinklered. Wood products as wall or ceilings could typically only be used in these locations if fire retardant treatments have been applied and the relevant fire test data is available to demonstrate compliance. Some proprietary prefinished plywood products are known to achieve this level of performance.

2. Parts of buildings used for crowd/assembly uses including classrooms, meeting rooms, public halls, gymnasiums, shops, cinemas or similar types of spaces. Also parts of buildings used for sleeping uses (excluding household units, under care or detention).

   In these locations the Group Number for ceilings shall be no greater than 2-S if unsprinklered, or 2 if sprinklered, and the Group Number for walls shall be no greater than 2-S if unsprinklered, or 3 if sprinklered.

   With the exception of walls in sprinklered spaces, most wood products as wall or ceilings can only be used in these locations if fire retardant treatments have been applied and the fire test data is available to demonstrate compliance.

   For a design using Acceptable Solution C/AS4, a further concession is allowed for classrooms, passageways and corridors (but not safe paths or exitways) of unsprinklered educational buildings provided the occupant load in the firecell is less than 250 people, the firecell is at ground level and served by at least two exitways or final exits. In this case, surfaces 1.2 m or higher above floor level must have a Group Number no greater than 2-S while wall surfaces within 1.2 m of floor level must have Group Number no greater than 3.

3. Everywhere else

   In locations other than noted under items 1 and 2 above, the Group Number shall be not more than 3. Most untreated wood products as walls or ceilings are compliant and can be used. The Group Number should be obtained from timber or paint finish suppliers or from the generic specification given in Table 1 above.

The reaction-to-fire requirements for interior surface finishes of wall and ceilings are given in Figure 1. This is a summary flow chart only based NZBC Clause 3.4 and associated information contained in the compliance documents, which should be consulted for further clarification.

Flooring and Floor Coverings

Flooring includes flexible finishes such as carpets, vinyl sheet or tiles, and finished or unfinished floor surfaces. Fire properties of floor surfaces are evaluated using ISO 9239-1:2010 (floor radiant panel test). Minimum requirements in all buildings excluding household units is a critical radiant flux (CRF) of not less than

1.2 kW/m2.

A critical radiant flux (CRF) of not less than 2.2 kW/m2 is required in the following locations:

- Unsprinklered firecells with an occupant load more than 50 people;
- Sleeping areas in sprinklered buildings where care or detention is provided
- all exitways (except as below)

A critical radiant flux (CRF) of not less than 4.5 kW/m2 is required in the following location:

- Sleeping areas and exitways in unsprinklered buildings where care or detention is provided

Exposed solid wood flooring can generally achieve a critical radiant flux of at least 2.2 kW/m2 and some species can achieve higher than 4.5 kW/m2. Specific performance will depend on the timber species and thickness. Table 2 can be used without proof of performance, otherwise supporting fire test data should be requested from the manufacturer or supplier of the flooring material.

Table 2

Flooring Material	Critical Radiant Flux (CRF)
Concrete[2], brick, ceramic or porcelain tile	4.5 kW/M^2
Wood Products, Plywood or Solid Timber[1,2] ≥ 12 mm thick; and ≥ 400 kg/m^3	2.2 kW/M^2
Note 1. Some timber species and thicknesses and with/without applied coatings when tested may achieve a higher CRF. When a greater CRF is required to meet Clause C3.4 (b) than given in this table, supporting test data to ISO 9239-1:2010 for the product is required. 2. May include waterborne or solvent borne applied surface coatings not more than 0.4 mm thick and not more than 100 g/m^2.	

Exterior Wall Claddings

NZBC Clause C3 restricts the fire properties of exterior wall cladding materials in order to limit vertical fire spread over the surface of the material, and to reduce the likelihood of external fire spread to upper floors in multi-storey buildings.

There are several options available for demonstrating compliance, which include full-scale facade tests to NFPA 285, however small-scale fire testing to ISO 5660 Part 1 is the usual method and may provide a more conservative assessment. The peak rate of heat release and total energy release for the cladding material is measured in ISO 5660. Non fire-retardant treated timber can be considered acceptable only in locations where there are no restrictions.

Timber claddings which have a fire retardant treatment or coating incorporated in or applied to them are required to be subjected to the regime of accelerated weathering described in ASTM D 2898 Method B prior to fire testing.

Detailed requirements can be found in Paragraph 5.8 and Appendix C7.1 of Acceptable Solutions C/AS1 to C/AS7.

When is it acceptable to use non fire-retardant timber[2] as exterior wall cladding?

	Distance to Relevant Boundary		
	Less than 1m	1m or more	
Building Height	All buildings	Sleeping uses on an upper floor	All other uses on an upper floor
Up to 7m	No	Yes	
Up to 10m		Yes, only if sprinklered	
Up to 25m		No	Yes, only if sprinklered
Over 25m			No

[2] The fire performance of untreated timber may be improved through application of fire-retardants, however, durability of the treatments in exterior environments must be considered as well as its reaction-to-fire properties.

The acceptability of timber cladding materials for different building height, building use and distance to the boundary is summarised in the table above. In these locations, it is not necessary to provide supporting fire test data.

This information sheet summarises the requirements of NZBC Code Clause 3, Verification Method C/VM2 (including Amendment 3 dated Dec 2013) and Acceptable Solutions C/AS1 to C/AS7 however the exact wording in the compliance documents should always be referred to for a definitive interpretation.

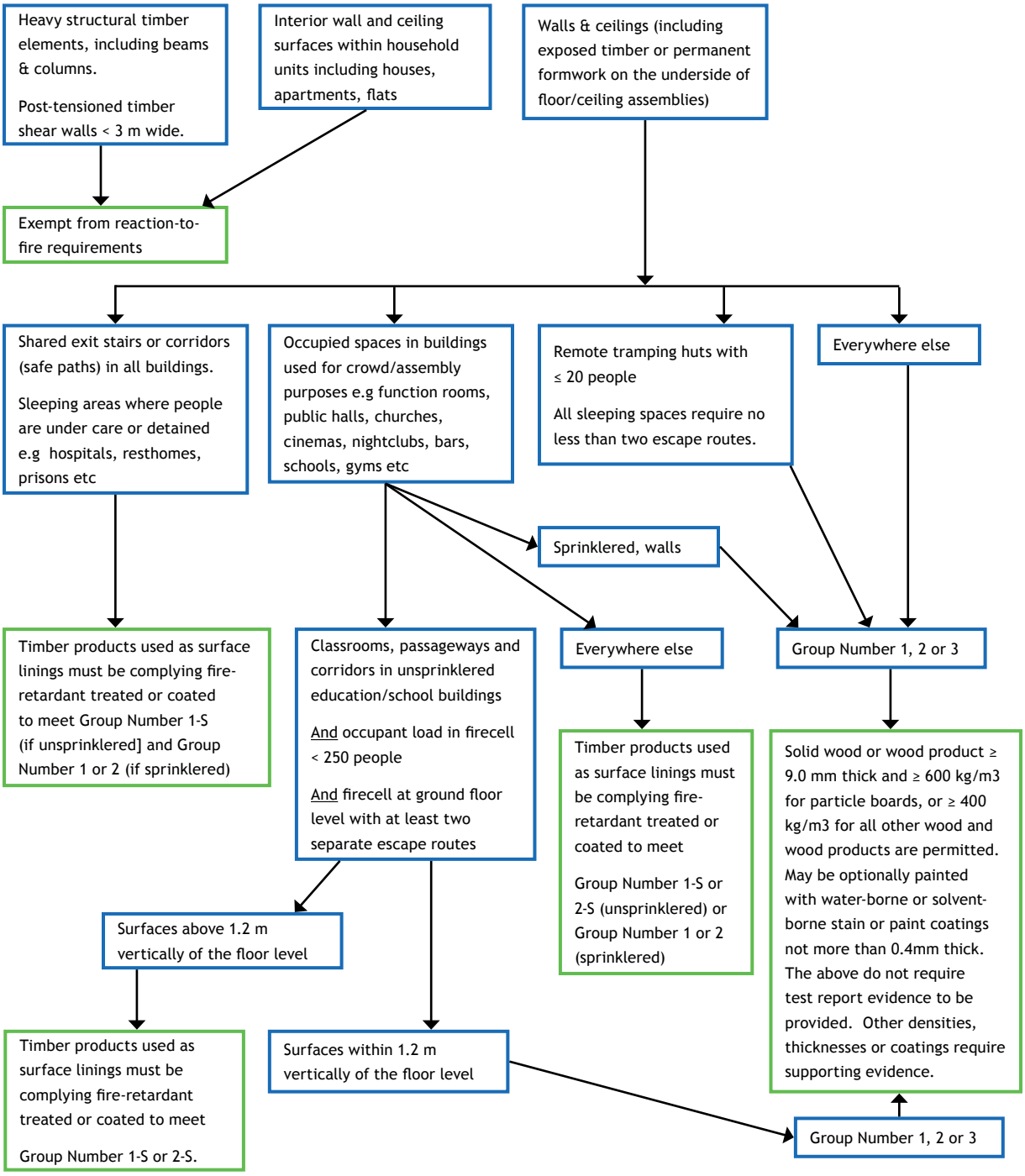

Figure 1: *Summary of reaction-to-fire requirements for use of interior timber (on wall and ceilings) - based on NZBC Clause C3.4 and Compliance Documents*