BUILDING PERFORMANCE

Reaction to fire performance of aluminium composite panels

Issue date: 6 May 2016

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
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New Zealand Government

Contents

Use of this guide

This guide by the Ministry of Business, Innovation and Employment (the Ministry, or MBIE) has been written in accordance with section 175 of the Building Act 2004 (the Building Act), which relates to guidance published by the Ministry's Chief Executive. While the Ministry has taken every care in preparing this document, it should not be relied upon as establishing all the requirements of the Building Act. Readers should always refer to the Building Act and associated regulations as the source document and be aware that for specific situations or problems it may be necessary to seek independent legal advice. Note that all references to the Building Act in this guide are to the Building Act 2004 and all references to the Building Code, the Code or NZBC are to the Building Code (Schedule 1, Building Regulations 1992) in force at the time of writing.

About this guide

This guide outlines some of the Building Code requirements for the fire performance of aluminium composite panels (ACPs) used as external wall claddings and discusses ways to comply with these requirements. It will mainly be of interest to manufacturers, suppliers, specifiers and certifiers of these products.

Note that this guide focuses on Building Code clause C3: Fire affecting areas beyond the fire source; in particular the performance clauses C3.5 and C3.7. There may be other relevant clauses within Building Code clause C: Fire safety as well as other Building Code clauses that apply to the cladding or the building as a whole.

Fire testing measurements

Two of the key measurements in fire testing are an element or material's 'reaction to fire' and its 'fire resistance'.

This guide is mostly concerned with **reaction to fire**, which relates to an element or material's contribution to the fire hazard. This is usually by increasing a fire's growth, energy output or both.

Fire resistance is a three-part description of an element or material's ability to carry load under elevated temperatures, its ability to resist the passage of fire and smoke, and its ability to resist heat conduction. (Refer to Building Code clause A2 for the definition of an element's fire resistance rating, or FRR.)

Aluminium composite panels (ACPs)

ACPs are thin sandwich-type panels made from two sheets of aluminium bound to a core of insulating material. A common use for ACPs is as external claddings on multi-level buildings as they are relatively lightweight and sturdy, while the aluminium sheets can be painted any colour.

ACPs are combustible[1] (i.e. capable of catching fire). Other examples of combustible external cladding systems include exterior insulation finish systems, structural insulation finish systems, high pressure laminates and weather-resistive barriers.

The degree of combustibility of ACPs ranges from:

- products that are readily combustible (ACPs with cores that are 100% polyethylene, or PE, which melts at relatively low temperatures and is highly flammable), to
- products with a core of mineral fibre and some PE, which are less combustible, to
- products with a core of almost all mineral fibre plus a small amount of PE to bind this fibre to the aluminium, which have limited combustibility.

[1] The Building Code, Acceptable Solutions C/AS1-AS7 and Verification Method C/VM2 define building materials as being either combustible or non-combustible when tested to Standard Test Method AS 1530.1:1994 *Methods for fire tests on building materials, components and structures. Part 1: Combustibility test for materials.*

Note:

There have been a number of high-profile building fires internationally[2], including in Melbourne in November 2014 and Dubai in 2015, in which ACP claddings with a 100% PE core have contributed to rapid and extensive vertical fire spread.

Aluminium is a good thermal conductor and, as the aluminium skins of ACPs are very thin, heat from a fire source will conduct quickly to a PE core. The melting temperature of PE is very low and once this is reached the PE will drip and flow.

The ability of PE to act as a binding material will deteriorate as it melts and the aluminium skins will deform and delaminate. The molten PE can then become exposed to a fire source, particularly around joints and edges, and ignite. PE combusts vigorously.

Caution should be taken when using and specifying particular ACP products that they are appropriate for the intended use.

Building Code requirements: reaction to fire

ACPs used as external claddings must meet certain provisions of the Building Code which include, but are not limited to, those relating to their 'reaction to fire' performance.

In terms of fire performance the acceptable properties of external wall cladding systems depend on the building height, presence of sprinklers and the distance from the relevant boundary.

The most relevant requirements are in Building Code clause C3: Fire affecting areas beyond the fire source. The functional requirements of this clause are as follows:

Clause	Provision	Limit on application
C3.1	*Buildings must be designed and constructed so that there is a low probability of injury or illness to persons not in close proximity to a fire source.*	
C3.2	*Buildings with a building height greater than 10 m where upper floors contain sleeping uses or other property must be designed and constructed so that there is a low probability of external vertical fire spread to upper floors in the building.*	*Clause C3.2 does not apply to importance level 1 buildings.*
C3.3	*Buildings must be designed and constructed so that there is a low probability of fire spread to other property vertically or horizontally across a relevant boundary.*	

The performance requirements for clause C3 (i.e. how to satisfy the functional requirements) are set out in clauses C3.5 to 3.9. The most relevant of these for ACPs used as external claddings are the following:

[2] White, N., Delichatsios, M., Ahrens, M., & Kimball, A. (2013). *Fire hazards of exterior wall assemblies containing combustible components*. In MATEC Web of Conferences (Vol. 9, p. 02005). EDP Sciences

C3.5 *Buildings must be designed and constructed so that fire does not spread more than 3.5 m vertically from the fire source over the external cladding of multi-level buildings.*

C3.7 *External walls of buildings that are located closer than 1 m to the relevant boundary of the property on which the building stands must either:*

(a) be constructed from materials which are not combustible building materials, or

(b) for buildings in importance levels 3 and 4, be constructed from materials that, when subjected to a radiant flux of 30 kW/m^2, do not ignite for 30 minutes, or

(c) for buildings in Importance Levels 1 and 2, be constructed from materials that, when subjected to a radiant flux of 30 kW/m^2, do not ignite for 15 minutes.

The building importance levels referred to in these clauses are defined in Building Code clause A3 and summarised in Table 1.

Table 1: Building importance levels (from Building Code clause A3)

IL	Description
1	Buildings posing low risk to human life or the environment, or a low economic cost, should the building fail (typically small non-habitable buildings)
2	Buildings posing normal risk to human life or the environment, or a normal economic cost, should the building fail (typical residential, commercial, and industrial buildings)
3	Buildings of a higher level of societal benefit or importance, or with higher levels of risk-significant factors to building occupants
4	Buildings essential to post-disaster recovery or associated with hazardous facilities
5	Buildings whose failure poses catastrophic risk to a large area (e.g. 100 km^2) or a large number of people (e.g. 100,000)

Demonstrating compliance

Acceptable Solutions, Verification Methods and alternative solutions

Options for showing that ACPs, when used in building work, comply with the relevant fire performance requirements of the Building Code include following the relevant sections of the:

- Acceptable Solutions (one of C/AS1 to C/AS7, depending on the type of building the product will be used on) or
- Verification Method C/VM2.

These compliance pathways must be accepted by building consent authorities (BCAs) when the product is used as specified.

If you cannot follow the relevant Acceptable Solution or the Verification Method fully you can present an alternative solution. This is the term used to describe any other way you choose to show Building Code compliance. It can include other relevant testing, appraisals, in-service history, compliance with a standard, or a combination of these. It is up to the BCA to decide whether to accept this as sufficient evidence.

These compliance pathways are described in more detail later in this guide, followed by a description of the standard fire test methods and other testing options.

Technical information and evidence

Because you can choose how to demonstrate Building Code compliance there is theoretically no restriction on what information you use to do so. However, your claims of compliance with the Building Code must be backed up with suitable technical information and evidence.

The further your design departs from a relevant Acceptable Solution or Verification Method, the more evidence BCAs are likely to look for.

Product certification

Another way to demonstrate compliance with the Building Code when applying for a building consent is to provide a product certificate.

BCAs must accept a product certificate as proof of compliance with the Building Code clauses listed on that certificate (as long as the product's proposed use is within the certificate's scope of use and any limitations or conditions). The BCA cannot require you to provide further evidence of compliance.

If you are an ACP manufacturer or supplier you can obtain product certification by applying to a product certification body and providing enough evidence to satisfy that organisation (via test methods and the like) that either:

- you can follow the relevant Acceptable Solutions or Verification Method or
- you have a suitable alternative solution.

Obtaining product certification also involves an assessment of your quality management systems, plus factory and site audits to ensure that compliance is being achieved and can be maintained.

Find out more

Product certification is a voluntary scheme established by the Building Act to provide an easily understood and robust way to show compliance with the Building Code. The current product certification scheme is CodeMark.

Go to www.building.govt.nz/product-certification for more details, including a list of current product certificates and product certification bodies.

Following an Acceptable Solution

To demonstrate compliance with clauses C3.5 and C3.7 first select the appropriate Acceptable Solution from C/AS1 to C/AS7. This will depend on what type of building the ACPs will be used on. Table 2 provides a brief description of these and Part 1 of each Acceptable Solution provides more detail of what is in or outside its scope.

Note that the Acceptable Solutions do not cover all types of buildings. For example, buildings over 20 storeys are excluded.

Table 2: Acceptable Solutions C/AS1 to C/AS7 and corresponding risk groups

Acceptable Solution	Risk group	Description
C/AS1	SH	Buildings with sleeping (residential) and outbuildings
C/AS2	SM	Buildings with sleeping (non-institutional)
C/AS3	SI	Buildings where care or detention is provided
C/AS4	CA	Buildings with public access and educational facilities
C/AS5	WB	Buildings used for business, commercial and low level storage
C/AS6	WS	Buildings used for high level storage and other high risks
C/AS7	VP	Buildings used for vehicle storage and parking

Next, follow the relevant requirements of the Acceptable Solution Part 5: Control of external fire spread (and any other requirements that may be relevant for Building Code compliance).

These Acceptable Solutions refer to either or both of the following standard test methods:

- ISO 5660.1:2002 (a small scale test) and
- NFPA 285:2012 (a full scale test).

These are described further in Fire test methods page 12.

The following diagram illustrates the compliance pathway using these Acceptable Solutions.

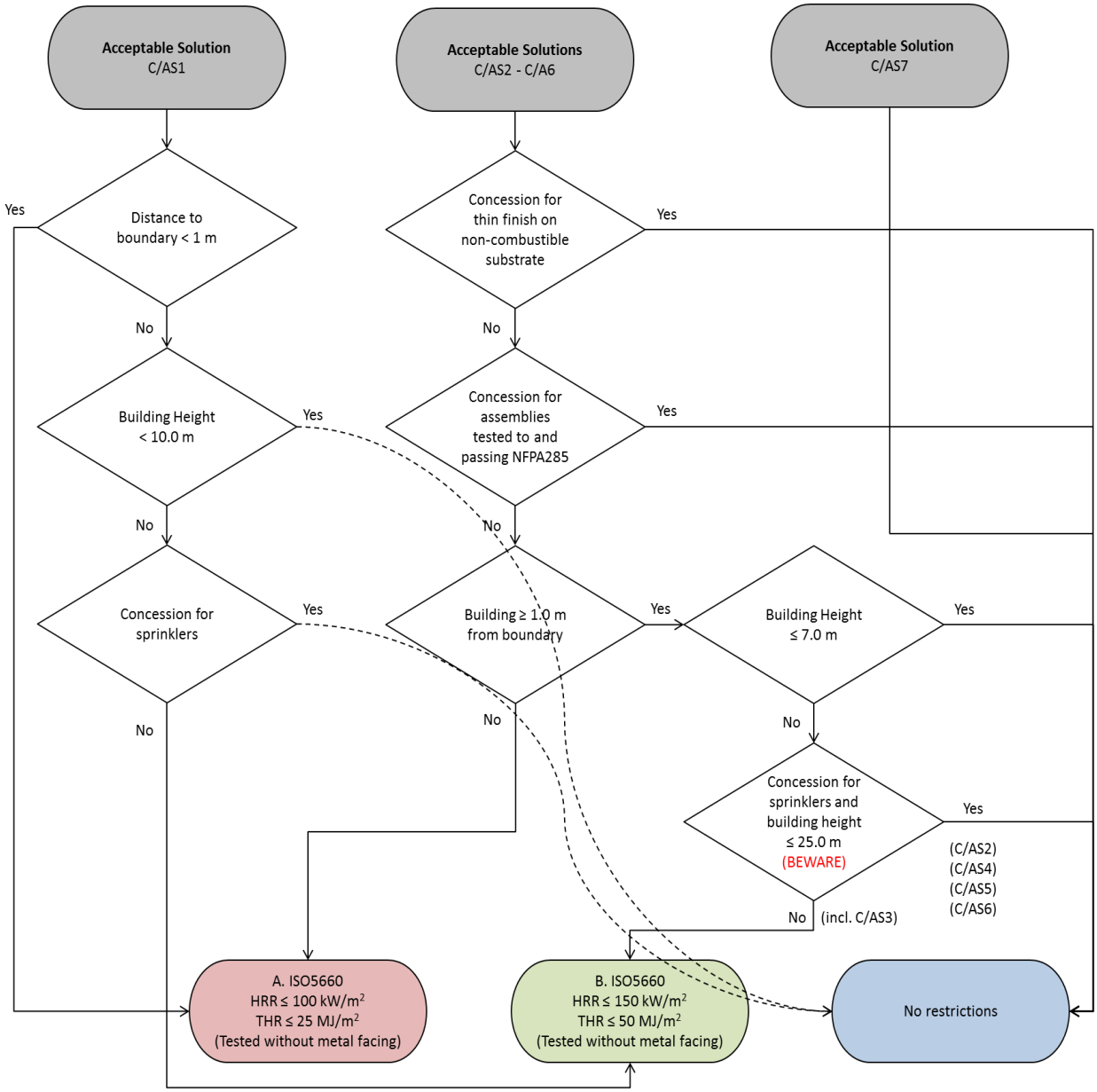

Figure 1: Compliance pathway using the relevant Acceptable Solution (C/AS1 to C/AS7)

Following the Verification Method

C/VM2 is a Verification Method for the specific design of buildings to demonstrate compliance with Building Code clauses C1 to C6 Protection from Fire. It is suitable for use by professional fire engineers who are proficient in the use of fire engineering modelling methods and can be applied to almost all building types (there are a few exceptions such as tunnels and open air stadiums).

C/VM2 includes ten design fire scenarios that must each be considered and designed for. Two of these scenarios are relevant for demonstrating compliance with Building Code clauses C3.5 and C3.7 as shown in Table 3 below (refer to C/VM2 Table 1.1 for full details).

Table 3: Relevant design scenarios (from C/VM2)

Building Code clause	Relevant design scenario	Expected method
C3.5	Scenario VS: external vertical fire spread	Calculate radiation from unprotected areas as specified
C3.7	Scenario HS: horizontal fire spread	Suitable materials used (proven by testing) and construction features specified (e.g. aprons/spandrels/sprinklers) as required to limit vertical fire spread

C/VM2 refers to the following test methods:

- ISO 5660.1:2002, and
- AS/NZS 3837:1998.

These are both small scale tests and are effectively interchangeable (go to Fire test methods page 12 for more details).

The Verification Method also provides the option to use a large or medium scale façade test but does not explicitly cite one. A test such as NFPA 285:2012 would be suitable.

Note:

Engineers proposing test methods other than those explicitly mentioned in C/VM2 should be suitably qualified, familiar with international literature on fire testing of ACPs, and experienced in reaction to fire test methods.

The following diagrams (one for each of the two relevant design scenarios) illustrate the pathway to compliance using the Verification Method.

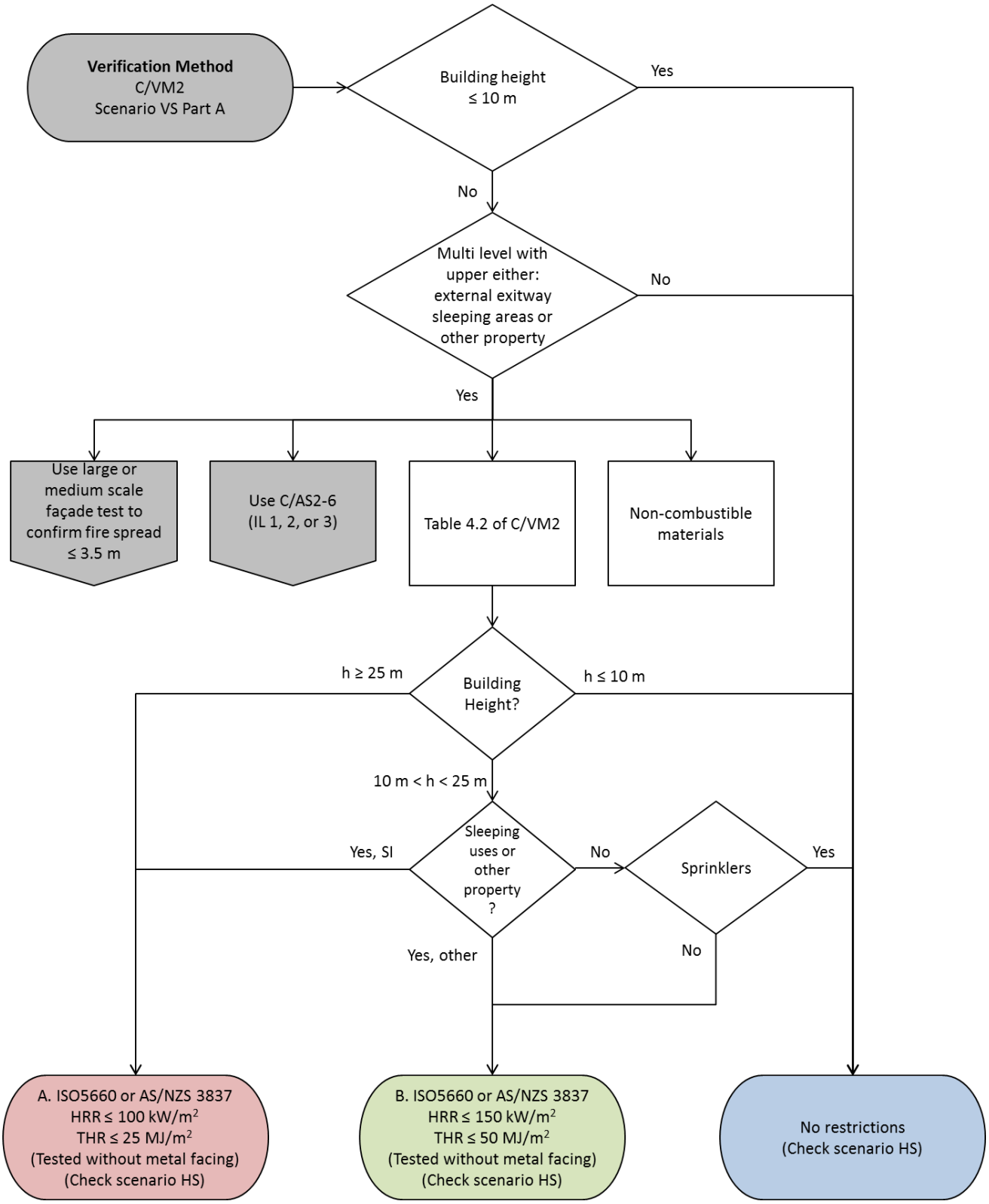

Figure 2: Compliance pathway using the Verification Method C/VM2: scenario VS

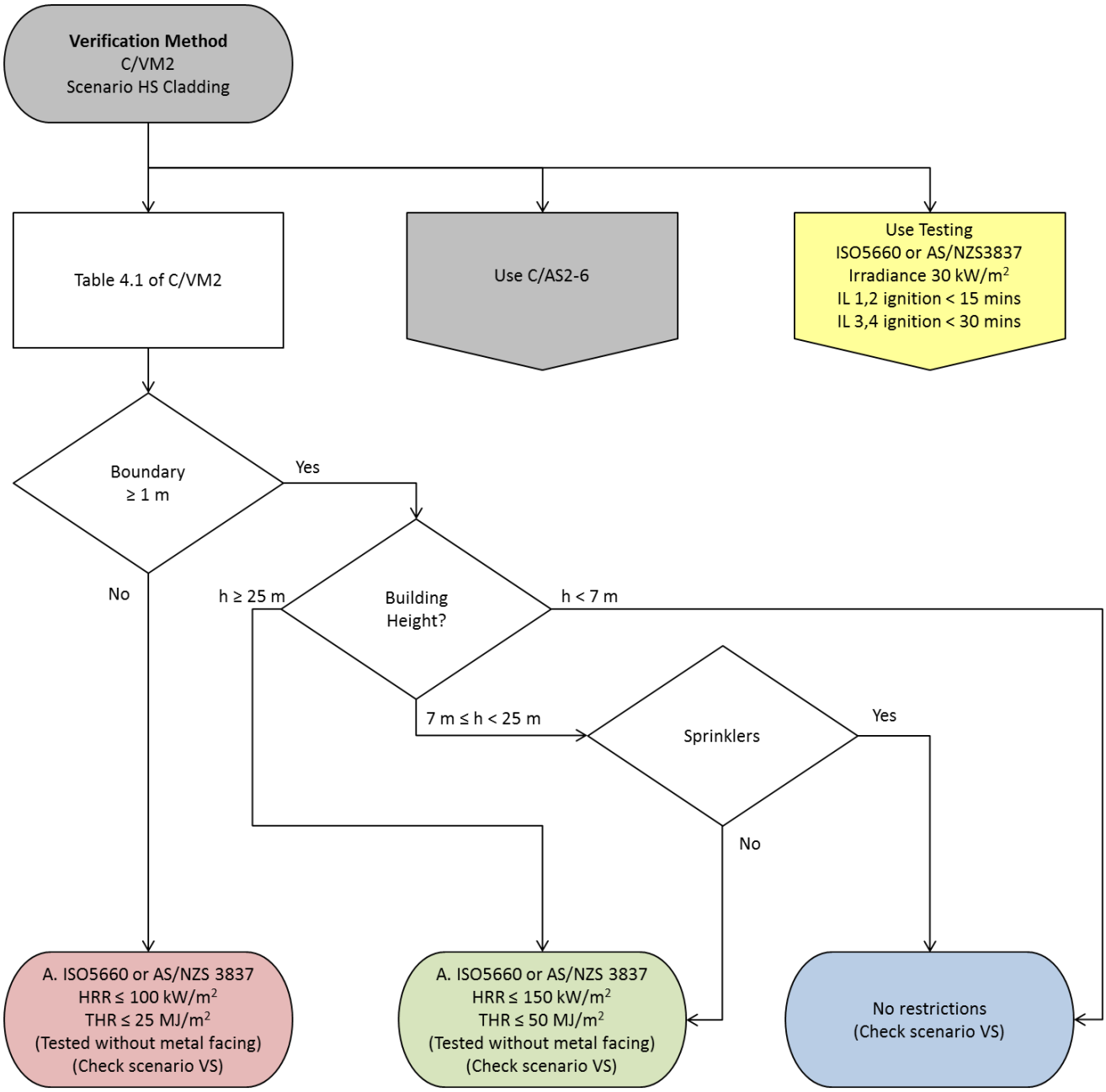

Figure 3: Compliance pathway using the Verification Method C/VM2: scenario HS

Presenting an alternative solution

The performance requirements of Building Code clauses C3.5 and C3.7 are quantitative: i.e. vertical flame spread of not more than 3.5 m, and no ignition when subject to a 30 kW/m^2 heat flux for a specified period.

An alternative solution (i.e. one which does not follow the Verification Method or relevant Acceptable Solution completely) could take an absolute or a comparative approach:

- An absolute approach demonstrates that the alternative solution directly achieves the minimum quantitative performance requirements.
- A comparative approach demonstrates that the alternative solution indirectly satisfies the performance requirements by being equivalent to (or better than) a solution proposed in the Acceptable Solutions C/AS1 to C/AS7 or Verification Method C/VM2.

Note:

Designers proposing alternative solutions should be suitably qualified, familiar with international literature on the fire testing of ACPs, and experienced in reaction to fire test methods.

Fire test methods

The standard tests

The standard tests referenced in the Acceptable Solutions and Verification Method for demonstrating compliance with Building Code clauses C3.5 and C3.7 are contained in:

- ISO 5660.1:2002 (referenced in C/AS1-C/AS6 and VM2)
- AS/NZS 3837:1998 (referenced in C/VM2)
- NFPA 285:2012 (referenced in C/AS2-C/AS6 and which may be a suitable medium or large scale façade test to meet the vertical fire spread requirements of C/VM2).

These are described below.

ISO 5660-1:2002 and AS/NZS 3837:1998 (small scale test methods)

ISO 5660-1:2002 'Reaction to fire tests – Heat release, smoke production and mass loss rate. Part 1: Heat release rate (cone calorimeter method)' is a small scale test referred to in C/AS1 to C/AS6 and C/VM2 (noting that testing shall be to the additional requirements specified in Appendix C clause C7.1.2 of those documents).

This test involves testing a specimen 100 x 100 x 50 mm subjected to 50 kW/m^2 irradiance from a cone element (hence the test's name). Exhaust gases are collected and the amount of oxygen 'consumed' is calculated from the measurement of oxygen concentration. From this, the heat release rate can then be determined.

ISO 5660-1:2002 is effectively the same as AS/NZS 3837:1998 'Method of test for heat and smoke release rates for materials and products using an oxygen consumption calorimeter', a test method which is also referred to in C/VM2.

Testing without the metal facing

If the metal facing of the material being tested melts below 750°C and the inner core is combustible, paragraph C7.1.5 of Appendix C (normative): Test methods of the Acceptable Solutions CAS/1 to C/AS6 requires testing to ISO 5660 Part 1 to be carried out without the metal facing.

This requirement applies to ACPs, as aluminium has a melting point below 750°C.

NFPA 285:2012 (full scale test method)

NFPA 285: 2012 'Standard Test Method for Evaluation of Fire Propagation Characteristics of Exterior Non-Load-Bearing Wall Assemblies Containing Combustible Components' is a full scale test referred to in C/AS2 to C/AS6 and which may be used to satisfy the relevant requirements of C/VM2.

The test assembly consists of a two-storey structure 4.8 m high with a test room on each storey. This assembly is also known as the Intermediate Scale Multistorey Apparatus (ISMA).

NFPA 285 is a pass/fail test. The fire propagation characteristics are determined for post-flashover fires of interior origin. The test evaluates the ability of the wall assembly to resist:

- flame propagation over the exterior face of the wall assembly
- vertical flame propagation within the combustible components from one storey to the next
- vertical flame propagation over the interior surface of the wall assembly from one storey to the next, and
- lateral flame propagation from the compartment of fire origin to adjacent compartments or spaces.

Other medium and large scale test methods

Examples of other medium and large scale tests that may contribute to demonstrating compliance are listed below.

- BS 8414:2015
  - (Part 1) 'Fire performance of external cladding systems. Test method for non-load bearing external cladding systems applied to the masonry face of a building'
  - (Part 2) 'Fire performance of external cladding systems. Test method for non-load bearing external cladding systems fixed to and supported by a structural steel frame'
- ISO 13785:2002
  - (Part 1) 'Reaction-to-fire tests for façades - Part 1: Intermediate-scale test'
  - (Part 2) 'Reaction-to-fire tests for façades -- Part 2: Large-scale test'
- BS EN 13823:2010 (+A1:2014) 'Reaction to fire tests for building products - Building products excluding floorings exposed to the thermal attack by a single burning item'
- BS EN 13501-1:2007 (+A1:2009) 'Fire classification of construction products and building elements. Classification using test data from reaction to fire tests'.

Note:

Test methods, including recognised international standard fire tests, are highly empirical and are not likely to be directly comparable. Anyone proposing to use these tests to demonstrate compliance must be suitably qualified and familiar with the test methods.

In particular, many fire tests do not provide comparable information for compliance with the Building Code requirements relating to external fire spread. One example is ISO 9705-1 Room corner test for wall and ceiling lining products – Part 1: Test method for a small room configuration. This is a method for generating material group numbers (categories for wall and ceiling linings). This tests a different hazard to external fire spread as it focuses on the contribution of surface linings to flashover in a confined space.

Further information

Resources

Ministry of Business, Innovation and Employment www.building.govt.nz

The Ministry's website provides a wealth of detailed information and guidance about the various topics covered in this document. This includes information about building product assurance at www.building.govt.nz/product-assurance and product substitution www.building.govt.nz/product-substitution-guide

New Zealand Legislation www.legislation.govt.nz

The New Zealand Legislation website gives free access to all current New Zealand legislation, including regulations made under an Act.

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