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Proposed Standard Test Method For Surface Flammability Of Combustible Cladding And Exterior Wall Assemblies Using Vertical Channel Test Apparatus

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Preface

The Vertical Channel test method described in this document has been developed to be a cost-effective full-scale fire test for the evaluation of flame propagation characteristics on combustible exterior cladding systems. Studies have demonstrated that the channel arrangement encourages enhanced combustion, providing comparable exposure conditions to those achieved in the larger full-scale tests (e.g. CAN/ULC S134, NFPA 285, ISO13785–2).

The Vertical Channel Test offers considerable advantages over small-scale tests as the specimen is tested as it would be constructed, complete with construction joints and detailing, and in the correct vertical orientation.

Acknowledgments

This procedure has been adapted from the Draft ASTM Task Group E5.22.07 Vertical Channel Test Method; Standard Test Method for surface Flammability of Combustible Cladding and Exterior Wall Assemblies, ASTM draft, December 1992.

The adaptation of the original draft test procedure for application in New Zealand was funded by the Building Research Levy.

Information from previous BRANZ research has also been used.

Note

This report is intended for building performance regulatory control, fire testing organisations and manufacturers of exterior cladding systems.

PROPOSED STANDARD TEST METHOD FOR SURFACE FLAMMABILITY OF COMBUSTIBLE CLADDING AND EXTERIOR WALL ASSEMBLIES USING VERTICAL CHANNEL TEST APPARATUS

BRANZ Technical Recommendation TR 16 **P. N. Whiting**

REFERENCE

Whiting, P.N. 2005. *BRANZ Technical Recommendation 16: Proposed Standard Test Method For Surface Flammability Of Combustible Cladding And Exterior Wall Assemblies Using Vertical Channel Test Apparatus.* Judgeford, New Zealand

KEYWORDS
Vertical Channel Test, Fire Test Method. Combustible, Exterior Cladding, Façade, Fire, Fire Spread

ABSTRACT

This Technical Recommendation has been prepared following the recommendations contained in the report of Fire Code Reform Centre (FCRC) Project 2B–2 that the vertical channel test apparatus be accepted for regulatory control of the flammability of combustible cladding systems and exterior wall assemblies. This Technical Recommendation has been developed from the Draft ASTM Test Standard E5.22.07 and the findings of *BRANZ Study Report 137*..

The specifications for the vertical channel test apparatus are detailed, together with requirements for the preparation and installation of the test specimen. This document contains the requirements for calibration of the test apparatus, the operation of the test procedure and reporting of test results. Performance criteria are given for the determination of acceptable performance.

Contents

Page

Figures

Appendices

SECTION 1. SCOPE AND GENERAL

1.1 SCOPE

1.1.1 This Technical Recommendation has been prepared following the recommendations contained in the report of Fire Code Reform Centre (FCRC) Project 2B–2 that the vertical channel test apparatus be accepted for regulatory control of the flammability of combustible cladding systems and exterior wall assemblies. The Technical Recommendation has been developed from the Draft ASTM Test Standard E5.22.07.

1.1.2 This test method enables an assessment of the fire spread characteristics of combustible cladding and non-loadbearing exterior wall assemblies.

1.1.3 The test determines the comparative burning characteristics of combustible cladding and exterior wall assemblies by evaluating the following:

a. flame spread over the exterior surface
b. heat flux to the exterior surface as a result of burning of the exterior wall assembly
c. fire spread within the test specimen.

1.1.4 The method tests full-scale specimens including the construction and joint details.

1.2 SIGNIFICANCE

1.2.1 This test method evaluates the performance of an exterior wall assembly under controlled test conditions representing a typical fire exposure resulting from a post-flashover fire in a compartment venting through an opening in the wall. The results may not reflect the actual performance of exterior wall assemblies under all exposure conditions.

SECTION 2. TEST APPARATUS

2.1 APPARATUS

2.1.1 The test apparatus, as shown in Figures 1, 2 and 3, shall consist of a combustion chamber, supports for the test specimen and two vertical panels installed on both sides of the apparatus.

2.1.2 Inside dimensions of the combustion chamber shall be 1900 mm (± 50 mm) high by 1500 mm (± 50 mm) deep and 800 mm (± 20 mm) wide.

2.1.3 The walls and ceiling of the combustion chamber shall be lined with a lightweight refractory material.[i]

2.1.4 The floor of the combustion chamber shall be paved with fired clay or concrete paving stones.

2.1.5 Two openings shall be provided in the front wall of the combustion chamber (see Figure 3): one 440 mm (± 5 mm) high by 800 mm (±10 mm) wide opening at the bottom of the wall and one 420 mm (± 5 mm) high by 800 mm (± 10 mm) wide opening at the top of the wall.

2.1.6 BURNERS

2.1.6.1 The combustion chamber shall be equipped with two 750 mm (± 10 mm) long linear propane burners[ii] spaced 400 mm (± 10 mm) on centre, with their longitudinal axes being perpendicular to the front wall, and centred on the combustion chamber floor in the other direction.

2.1.6.2 The burners shall be supplied with a non-premixed gas.iii

2.1.6.3 The burners shall be designed so that gas is released with a low velocity and uniformly along each burner.

2.1.6.4 Each burner shall be equipped with a remotely operated ignitor.

2.1.7 GAS SUPPLY CONTROLS

2.1.7.1 The controls for gas flow shall include a control valve and a gas flow meter calibrated to read in increments equivalent to 0.5 g/s or less.

2.1.7.2 The flow meter shall provide electric output proportional to the mass flow of propane gas.

2.1.8 SPECIMEN SUPPORT

2.1.8.1 The test specimen support system shall consist of a beam resting on two columns, and a set of adjustable lateral supports fastened to a steel structure extending the full height of the combustion chamber plus the height of the specimen (see Figures 1 and 2).

2.1.8.2 The beam shall be located immediately above the combustion chamber, flush with the front wall of the combustion chamber.

2.1.8.3 The beam shall be protected from fire on the exposed side.iv

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[i] 25 mm thick ceramic fibre blanket has been found suitable for this purpose.

[ii] 150 mm wide and 200 mm deep trays filled with a porous bed of concrete aggregate (4.75 mm to 13 mm), and with a perforated pipe distributing propane gas beneath the bed, were found suitable.

[iii] Propane gas of 95% purity has been found suitable.

[iv] 25 mm thick ceramic fibre blanket has been found suitable.

2.2 INSTRUMENTATION FOR TEST OPERATION

2.2.1 Two water-cooled heat flow transducers,[v] range 0–100 kW/m² shall be installed in the test specimen, 3500 mm (± 20 mm) above the top of the window and 200 mm (± 10 mm) horizontally off the centre line of the wall.

2.2.2 The transducers shall be installed so that their sensing faces are flush with the outer face of the test specimen.

2.2.3 Type K bare-beaded, 1.5 mm diameter sheathed thermocouples shall be used to monitor temperature of the specimen at five levels above the top of the window at 1000 mm intervals, starting 1500 mm above the window opening.

2.2.4 At each level, one thermocouple shall be installed on the outer face of the specimen and one on the outer face of each distinct layer within the specimen.

2.2.5 A data acquisition system shall be used to record readings of the gas flow meter, heat flow transducers and thermocouples. Readings shall be recorded at intervals of 10 seconds or less.

[v] A Medtherm Corp Series 64, range 0–100 kW/m², has been found suitable.

SECTION 3. TEST PROCEDURES

3.1 TEST SPECIMEN

3.1.1 The test specimen shall be 800 mm (± 5 mm) wide and 5000 mm (± 50 mm) high.

3.1.2 The test specimen shall consist of sections stacked one above the other. The height of each of the sections shall be representative of the vertical distances between expansion joints or other divisions applied in practice.

3.1.3 The joints between stacked sections shall be made using techniques and materials typically applied in practice (e.g. using sealant and backer rods).

3.1.4 The test specimen shall be representative of the complete cladding system or exterior wall assembly (incorporating sheathing, cladding, insulation and all other components).

3.1.5 The test specimen shall be able to support its weight when resting on its short side and kept in position by lateral supports fastened to the back of the specimen.

3.2 CONDITIONING

3.2.1 Samples which are factory-manufactured but require joint sealing while installed shall be left to stand at ambient temperature > 0°C for the manufacturer's specified curing period following installation of the test apparatus.

3.2.2 Samples which consist of components that need curing shall be left to stand at ambient temperature > 0°C for the manufacturer's specified curing period before the test.

3.2.3 Samples at the time of test shall have strength and moisture content approximate to the conditions expected in normal service. If the test sample contains or is liable to absorb moisture, it shall not be tested until it has reached an air-dry condition.

3.3 WEATHERING

3.3.1 Weathering conditioning may be applicable to exposed materials where the fire-retardant characteristics of exterior components of the assembly may be adversely affected by the natural elements (e.g. exposed fire-retardant treated wood). The method of conditioning is outside the scope of this test method.

3.4 CALIBRATION OF TEST APPARATUS

3.4.1 EXPOSURE

3.4.1.1 Flames emerging from the combustion chamber shall expose the test specimen of the wall to a heat flux density of 50 (± 5) kW/m² at 500 mm above the opening and 27 (± 3) kW/m² at 1500 mm above the opening, calculated as an average over the 20 minute period of gas supply.[vi]

Note: The objective of the calibration procedure is to find a gas flow rate that results in heat flow to the wall as described above. This can be achieved through running a series of calibration tests with consecutive approximations of gas flow rate. The starting value of the

[vi] Equivalent to fire exposure conditions achieved in the full-scale test – refer Oleskiewicz, I. Fire Exposure to Exterior Walls and Flame Spread on Combustible Cladding, *Fire Technology*, 26:4 (November 1990).

steady gas flow rate can be established from past experience, or if no such data exists for the facility to be calibrated, 15 g/s can be taken as the starting value.

3.4.2 PREPARATION OF TEST FACILITY FOR CALIBRATION

3.4.2.1 Install a 13 mm (nominal) thick mineral composition board[vii] of nominal density 700 kg/m^3 to the specimen mounting face of the test apparatus.

3.4.2.2 For measurement of the exposure conditions, the heat flow transducers are relocated to one at 500 mm and one at 1500 mm above the opening in the combustion chamber, on the centre line of the wall.

3.4.2.3 The transducers shall be installed so that their sensing faces are flush with the outer face of mineral composition board in 3.4.2.1.

3.4.3 CALIBRATION PROCEDURE

3.4.3.1 Ignite the burners.

3.4.3.2 Adjust gas flow rate to the required level.

3.4.3.3 Start collecting data (gas flow and heat flow).

3.4.3.4 Continue the steady supply rate of gas for 20 minutes.

3.4.3.5 Gradually close the control valve until gas supply is completely shut off.

3.4.3.6 Calculate the time average (over the 20 minute period of steady gas supply) values of heat flux density.

3.4.3.7 If the average heat flux densities at the 500 mm location and at the 1500 mm location are not as specified in 6.1.1, undertake another run with a modified gas flow rate.

3.4.3.8 The gas flow rate established in a successful calibration run shall be used in testing until a reason arises to repeat the calibration or at longest annually. Some of the foreseeable reasons to recalibrate the facility are: modification of the equipment, changes in heating value of the commercially available propane gas and ambient laboratory temperature conditions outside of the range from 10°C to 30°C.

[vii] Calcium silicate based has been found suitable.

SECTION 4. REPORTING OF RESULTS

4.1 TEST PROCEDURE

4.1.1 Ignite the burners and adjust gas flow immediately.

4.1.2 Start the data acquisition system and video recording of the test.

4.1.3 Still colour pictures shall also be taken before, during and after the exposure period of the test.

4.1.4 The test may be terminated at any time if the flames extend to the top of the specimen.

4.1.5 Following fire exposure, continue recording data and video until self-extinguishment of the specimen occurs or the test is terminated because the flame has extended to the top of the specimen.

4.1.6 Following cooling of the test facility and the specimen, document damage to the specimen by removing distinct layers of the specimen and taking still colour pictures.

4.2 TEST RESULTS

4.2.1 GENERAL

4.2.1.1 The performance of the specimen shall be judged on the basis of visual observations, analysis of video recordings and heat flow and temperature data. Because of strong turbulence present in flames, the recorded heat flow and temperature data show random oscillations that have to be smoothed in order to reflect significant trends and values. Averaging over one minute periods is recommended to smooth out insignificant peaks yet preserve important changes in time.

4.2.1.2 The performance of the specimen shall be acceptable [viii] [ix] if during the exposure period and the time to self-extinguishment.

4.2.1.3 Flame does not spread more than 5 metres above the bottom of the specimen, assessed by the temperature measured at 4.5 m above the window opening exceeding 500°C for at least 30 seconds.

4.2.1.4 Heat flux density 3500 mm above the window opening does not exceed 35 kW/m² at any of the two heat transducers.

4.2.1.5 The temperatures recorded by thermocouples installed in the specimen provide additional information about fire penetration into the specimen and possible flame spread inside the specimen (e.g. in cavities).

4.2.2 TEST REPORT

4.2.2.1 The test report shall contain the following:

[viii] Performance criteria – refer Whiting, P.N. (2005), Development of the Vertical Channel Test Method for Regulatory Control of Combustible Exterior Cladding Systems, *Study Report 137*, Building Research Association of New Zealand (BRANZ), Judgeford, New Zealand.

[ix] Equivalent to fire exposure conditions achieved in the full-scale test – refer Oleskiewicz, I. Fire Exposure to Exterior Walls and Flame Spread on Combustible Cladding, *Fire Technology*, 26:4 (November 1990).

A A detailed description of the specimen.

B Details of instrumentation (location of heat flow transducers and thermocouples within the specimen).

C Smoothed plots of heat flux density and temperature readings recorded during the test for all sensor locations. The smoothing procedure shall produce data averaged over a one-minute period (60 second running average calculated on the basis of 30 seconds behind and 30 seconds ahead).

D Plots of calibration data.

E Visual observations and descriptions of the following:
a) test facility with the specimen installed prior to test
b) test in progress
c) the specimen after the test is terminated
d) the specimen during dismantling.

F Documentation of performance of the specimen with respect to amount and time of:
a) flame spread over exterior face
b) heat flux density recorded 3500 mm above the window opening
c) damage to the specimen.

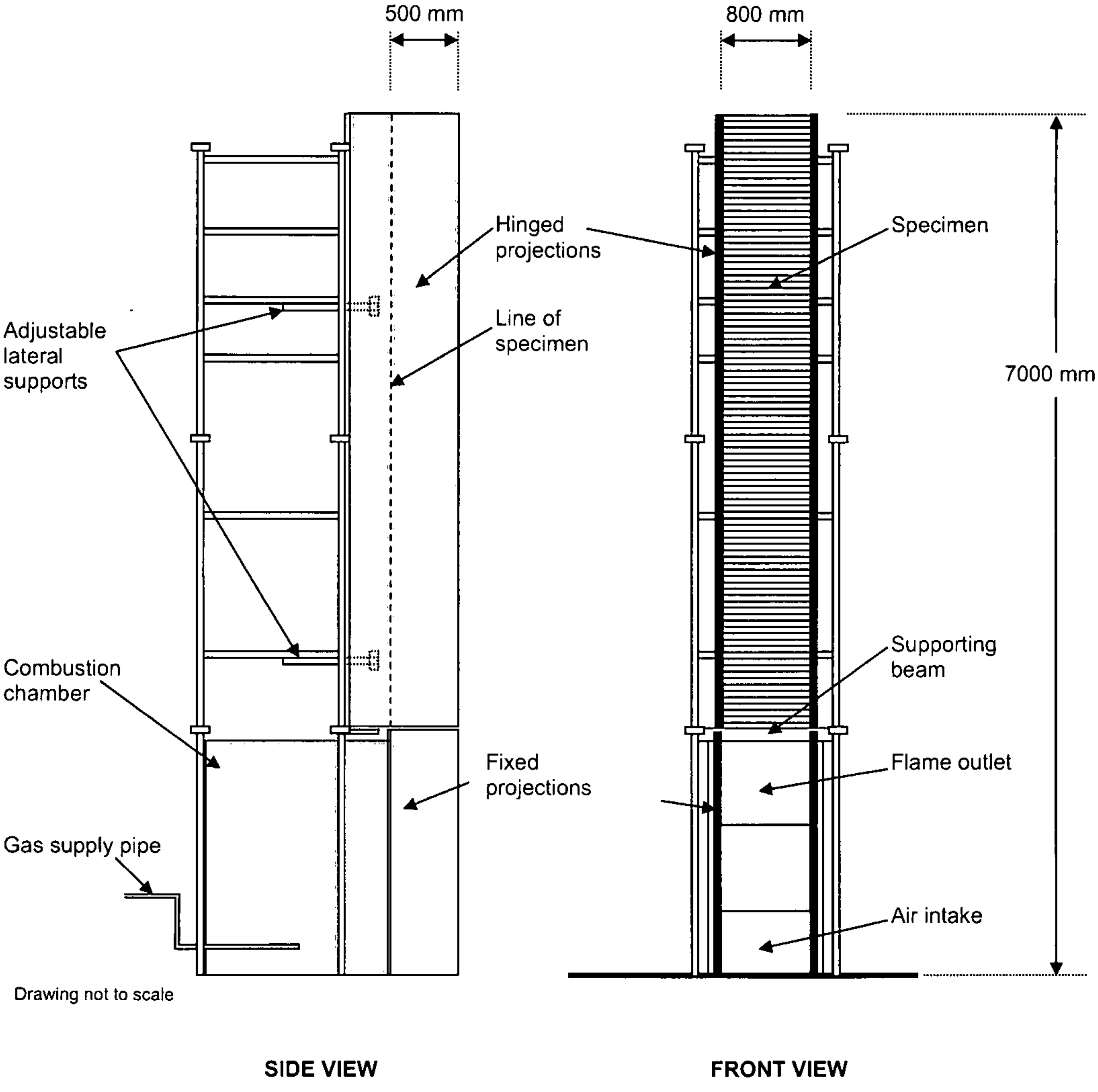
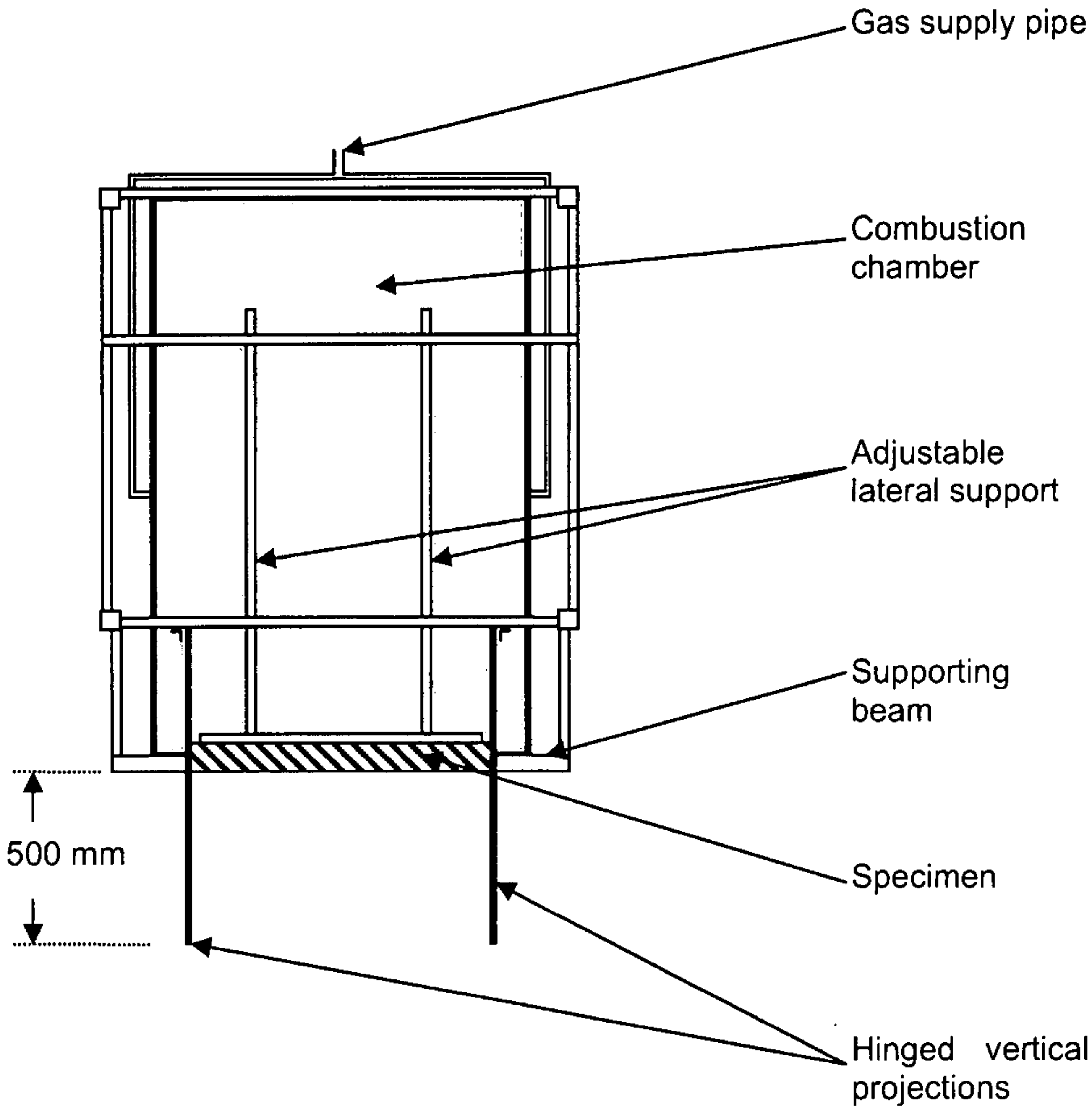


Figure 1. Test apparatus



Drawings not to scale

Figure 2. Horizontal cross-section above combustion chamber

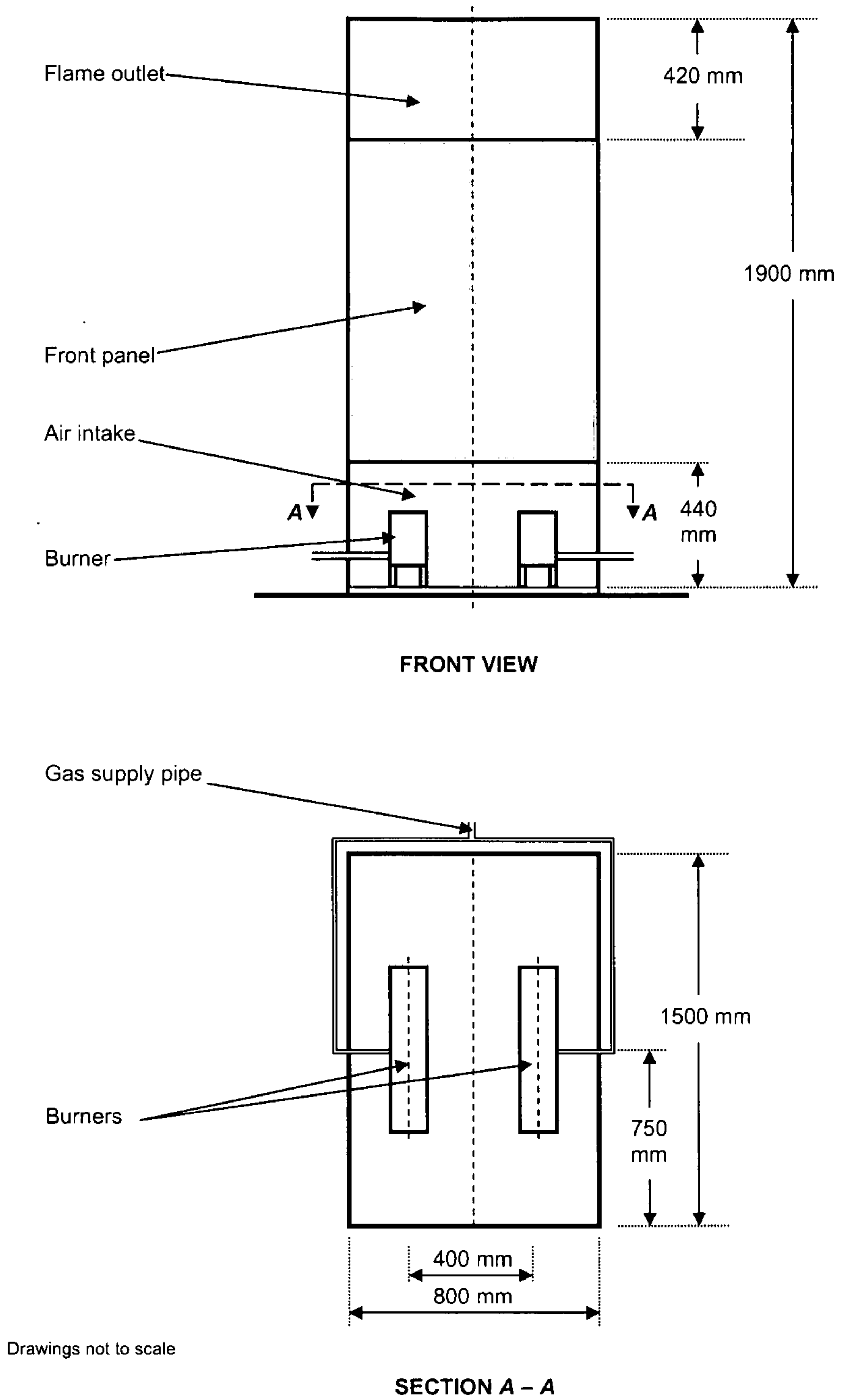


Figure 3. Combustion chamber details

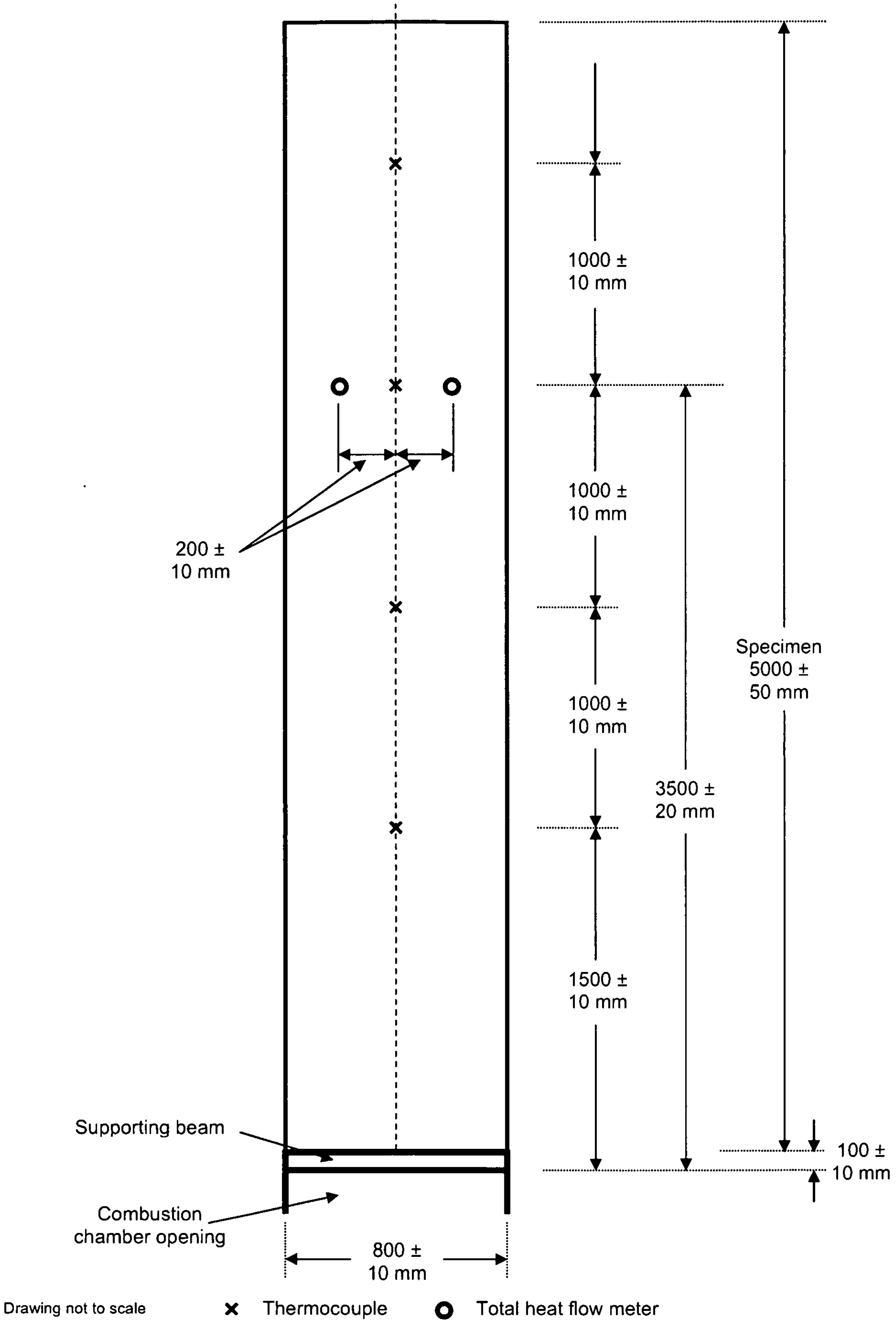


Figure 4. Specimen dimensions and instrumentation layout

SECTION 5. REFERENCES

ASTM Task Group E5.22.07, 1992. *Vertical Channel Test. Proposed standard test method for surface Flammability of Combustible Cladding and Exterior Wall Assemblies.* ASTM draft, December 1992.

Oleskiewicz, I. 1990. Fire Exposure to Exterior Walls and Flame Spread on Combustible Cladding. *Fire Technology*, 26:4.

Wade, C.A. & Clampett, J.C. 2000. *BRANZ Report of FCRC Project 2B–2.* Judgeford, New Zealand.

Whiting, P. N., 2005. *BRANZ Study Report 137: Development of the Vertical Channel Test Method for Regulatory Control of Combustible Exterior Cladding Systems.* Judgeford, New Zealand.

APPENDIX A: COMMENTARY ON FIRE TESTING OF EXTERIOR WALL ASSEMBLIES

A1. Introduction

A1.1. This commentary is provided to give background information on the development of the method and to describe the rationale for the design of various features of the test facility and the test procedure.

A2. Background information

A2.1. Fire spread over or within exterior wall assemblies that include combustible components may contribute to spread of fire throughout a building. There are three primary ignition sources for a building's exterior walls:

A An exterior compartment fire venting through a window

B Burning of combustible accumulated near the wall (burning rubbish, vehicle fire, bush fire, etc)

C Fire in an adjacent building.

A2.2. Of these, the first, a fire within a building venting through a window, is perceived to be a severe and significant exposure to exterior walls. The severity of this exposure results from direct impingement of a fire plume on the outer face of the exterior wall.

A2.3. Flame propagation over the outer face of an exterior wall may itself create a problem for fire-fighters or may cause fire spread to the storeys above the storey of fire origin. The hazard is extremely high for tall buildings because fire may extend beyond the reach of fire services.

A2.4. Piloted ignition of ordinary combustibles can be expected at exposures as low as 12.5 kW/m^2. Since the exposures recorded in full-scale experimental fires surpass this value at levels a number of times more than 12.5 kW/m^2, it has to be assumed that an exterior wall assembly containing combustible components will be ignited in the area above the window opening venting an interior fire. However, the incremental hazard due to the assembly's combustibility may not be significant if the burning assembly does not add much heat to the window plum, and if the fire spread on the assembly is limited to the area receiving substantial amount of heat from the window plume. Factors such as the amount of combustibles per unit area, their heat of combustion, the ignition temperature of the combustible components of the assembly, thermal inertia, the composition of the assembly (e.g. the presence of a protective layer) and preservation of integrity when exposed to fire, are factors determining the propensity to vertical fire spread of the assembly.

A3. Summary of the test method

A3.1. The small-scale cone calorimeter test (AS/NZS 3837) is called up in the New Zealand Building Code Acceptable Solutions for the control of upward flame spread via external cladding systems. This approach is satisfactory for many materials, but there are some types of cladding systems where it may not be adequate. For example, aluminium on some aluminium clad plastic-core panel may not melt at bench-scale test. The vertical channel test provides an alternative to the cone calorimeter where the small-scale test may not reveal important aspects of fire performance. The vertical channel test is capable of testing a specimen including joints, which may be critical for some products. Claddings with geometry or other characteristics varying across the cladding (e.g. corrugations) may not be adequately represented in small-scale tests. Codes in North America call up a large-scale facade test. The performance achieved in the vertical channel test was close to that achieved in the large test. The advantage of the vertical channel test is that it is more economic to run and requires less material, and avoids some of the limitations of using only bench-scale fire test methods. The apparatus is also useful for investigating the performance of the composite panel system.

A3.2. This test replicates exposure conditions of a post-flashover fire in a compartment venting through an opening (e.g. a window). The fire plume exposes the outer face of the test specimen.

A3.3. Depending on the properties of the test specimen, the area involved in burning may increase, remain without substantial change, or decrease as the combustible material of the specimen has been consumed. The performance of the specimen is rated by the extent of the flame front above the opening, as well as by the additional heat flow to the wall at a specific distance above the opening. These performance ratings are deemed to reflect the potential of spread of fire to storeys above the storey of fire origin as a result of the presence of combustible materials in an exterior wall assembly.

A4. References

Building Industry Authority (BIA) 2001. *Approved Document for the New Zealand Building Code Fire Safety*, BIA, New Zealand.

Drysdale, D. 1985. *An Introduction to Fire Dynamics*, John Wiley & Sons.

Oleskiewicz, I. 1990. Fire Exposure to Exterior Walls and Flame Spread on Combustible Cladding. *Fire Technology*, 26:4, (November 1990).

AS/NZS 3837:1998. *Method of test for heat and smoke release rates for materials and products using an oxygen consumption calorimeter.* Standards Australia and Standards New Zealand.

APPENDIX B: INSTALLATION OF THERMOCOUPLES

B1. Thermocouples should be installed with a 12 mm exposed bead. They should be held in place in such a manner as to neither damage the test specimen nor move during the test.

B2. It is recommended that thermocouples be attached to the test specimen as follows:

A Substrate Attach thermocouple flush with the exterior face of the substrate with the bead exposed

B Insulation Attach thermocouple to the exterior face of the insulation with the bead exposed

C Exterior membrane Attach thermocouple flush to the exterior face of the membrane.