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Analysis of Shortfalls and Risks in the Fire Resistance Level Insulation Criteria Since the Adoption of AS1668.1-2015 in the National Construction Code, Paper

Purpose

The purpose of this paper is to highlight the shortfalls and risks of the ‘Fire Resistance Level’, insulation criteria since AS1668.1:2015 was adopted in the National Construction Code 2016 to the current day.

This paper aims to critically examine the limitations and potential risks associated with the fire resistance level (FRL) insulation criteria as outlined in the Australian Standard AS1668.1:2015 since its incorporation into the National Construction Code (NCC) in 2016. By assessing the current state of FRL insulation regulations, this study identifies areas where improvements are necessary to ensure adequate fire safety measures in construction practices. The paper also discusses potential consequences and highlights the importance of revisiting and updating the FRL insulation criteria to mitigate potential risks.

1. Introduction

The current AS1668.1:2015 *“The use of ventilation and air conditioning in buildings. Part 1: Fire and smoke control in buildings”*, Section 3.2.3 (FRL, insulation criteria) has caused confusion and risk in the construction sector. There are two opposing parties with two completely different views in relation to the FRL, insulation criteria.

Party A (including Mechanical Engineers) will argue, when a mechanical fire-rated damper is installed in a fire-rated wall (vertical) and when the damper cannot achieve the insulation criteria as per AS1668.1:2015, Clause 3.2.3, the 2-meter minimum rule is a total minimum measurement of the ducts on both sides and one can aggregate the measurements i.e. 1-meter on both sides or 0.1-meter on side-A and 1.9-meters on side-B and so on.

Furthermore, no one including those in Party A, has not argued with the requirement of having 2-meters of duct on the top side of a damper installed in a floor, or when a damper is installed in a fire-resistance shaft wall or there is a minimum of 2-meters of metal duct in the shaft because the insulation performance is considered to have been provided by the riser shaft or ductwork.

On the other hand, Party B will argue the 2-meter minimum rule applies to both sides separately thus a total measurement of 4-meters.

AS1668.1:2015 was adopted in the NCC 2016 and is still current today. However, the 3.2.3 Insulation provision in this standard has caused a rift within the construction sector. This paper aims to shed light on the disparities and potential hazards associated with Party's A perspectives.

2. Fire Resistance Level (FRL) Insulation Criteria

FRL stands for Fire Resistance Level. It is a measurement used to evaluate the fire resistance performance of various elements and components in a building, such as walls, floors, ceilings, doors, windows, penetrations, etc. The FRL rating provides information about the ability of a particular construction assembly to resist the spread of fire, heat, and smoke for a specified duration.

The FRL rating typically consists of three components:

1. Structural Adequacy (the first digit): This component indicates the time in minutes that the construction assembly can maintain its structural integrity during a fire. It refers to the ability of the element to remain stable and support the load-bearing requirements.

2. Integrity (the second digit): This component denotes the time in minutes that the construction assembly can prevent the passage of flames and hot gases. It measures the ability of the element to contain the fire within a compartment and prevent it from spreading.

3. Insulation (the third digit): This component signifies the time in minutes that the construction assembly can limit the temperature rise on the unexposed side. It measures the ability of the element to reduce heat transfer and protect adjacent compartments from fire-induced heat.

For example, an FRL rating of 60/60/60 means that the construction assembly can maintain structural integrity, prevent the passage of flames and hot gases, and limit temperature rise for 60 minutes.

The FRL ratings are determined through rigorous testing and evaluation methods, as specified in relevant fire resistance testing standard AS1530.4. These ratings play a crucial role in ensuring the safety of occupants and limiting the spread of fire within a building, allowing sufficient time for evacuation and firefighting operations.

It is important to regularly review and update FRL insulation criteria to address any shortfalls or emerging risks, as the effectiveness of fire protection measures can evolve over time due to advancements in construction materials, techniques, and fire safety technologies.

Because penetrations, such as service cables, pipelines, and dampers, are not structural elements, the structural criteria do not apply to them. The insulation criteria was relaxed for a mechanical damper prior to AS1668.1:2015 i.e. FRL---/xxx/---. A metal fire damper would consistently fail AS1530.4 fire tests. The fire doors are yet another illustration of this. Their insulation criteria have a maximum time limit of 30 minutes, therefore a fire door rated for a 2-hour fire would be indicated as FRL---/120/30.

Analysis of the current FRL insulation requirements outlined in AS1668.1:2015, Section 3.2.3.1 for a vertically mounted mechanical fire damper is as follows.

a) For a shaft-mounted fire damper, insulation is not required.
b) For a fire damper that is connected to ductwork complying with Clause 2.3.2 and with a minimum total duct length of 2 m, insulation is not required.

c) In all other instances, the insulation criteria shall be not less than the insulation required of the FRL of the building element in which the fire damper is mounted.

3. AS1530 testing and Breakaway Joints.

A requirement of AS1668.1:2015 is that fire dampers are tested to AS1530.4 *Methods for fire tests on building materials, components and structures. Part 4: Fire-resistance tests for elements of construction.*

Figure A below is a photo of a mechanical fire damper in a masonry wall at the EXOVA test laboratory in readiness for the AS1530.4 test.

Figure B is the same damper 15 minutes into the test and the furnace temperature is 750 degrees Celsius. Take notice of the masonry blocks starting to glow and the head from the damper scorching the masonry blocks. And this is on the non-fire side.

Figure C is the same damper moved away after the completion of the test. During the test, the furnace temperature was between 1,100 degrees Celsius and 1,200 degrees Celsius. The non-fire side of the damper rose above 500 degrees Celsius.

It is worth noting that 25mm away from the mounting angle on the vertical surface on the left side, at 30 minutes the temperature was 310 degrees Celsius and at 90 minutes into the test the same location was 527 degrees Celsius. And this is on the non-fire side.

Fig A

Fig B

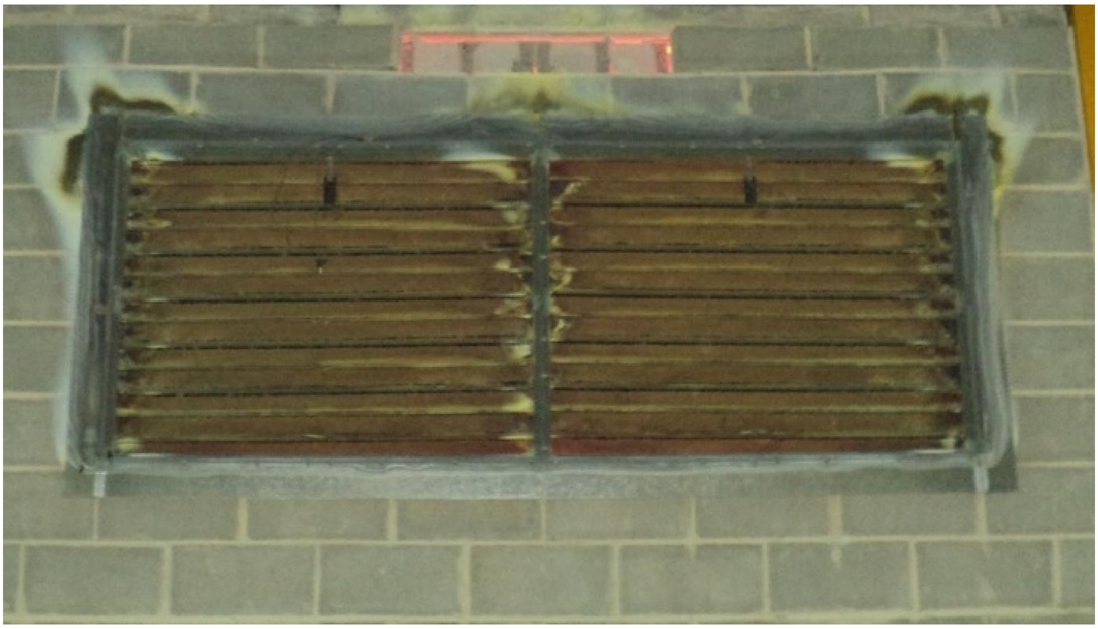

Fig C

A breakaway joint is located where the duct connects to the fire damper. As you will read below, breakaway joints are a requirement of AS1682.2 to protect the damper and in turn, protect the barrier if the duct was to fall away due to fire or not i.e. earthquake, etc.

Section 6.1 (a) of AS1682.2:2015 notes:

6 INSTALLATION REQUIREMENTS

6.1 Fire dampers and combined fire and smoke dampers

The installation shall be in accordance with the manufacturer's installation instructions, an assessment, test report or allowable installation variations in AS 1682.1. In addition, the installation shall comply with the following site specific requirements:

(a) The method of attachment of ductwork to the fire damper shall include breakaway joints in accordance with Appendix C so that any deformation or collapse of the ductwork in a fire does not dislodge the fire damper or adversely affect its operation or performance. Attachment between damper and riser ducts do not require breakaway joints providing that the riser shaft only contains building services, excluding gas and fuel lines, and is not used in any way for storage of materials.

NOTES:

1 See Figure C1 for typical breakaway joints.

2 Compliance with the requirements of Appendix C is intended to meet the objectives of Clause 6.1(a) of these installation requirements.

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APPENDIX C

FIRE DAMPER SLEEVE CONNECTIONS AND INSTALLATIONS WITH BREAKAWAY JOINTS

(Normative)

This Appendix applies in conjunction with Clause 6.1 and the specific damper installation instructions

Breakaway joints are required to ensure that in the event of a fire, the collapse of ductwork will not dislodge the fire damper to which it is connected. The requirements for breakaway joints are as follows:

(a) Breakaway joints shall not rely solely on high temperatures for fastenings to fail. In order that a breakaway joint functions at ambient temperatures, a minimum number of fastenings shall be used.

(b) The breakaway joint shall work by the action of the fastenings shearing or pulling through the damper casing or mounting sleeve that is attached to the ductwork.

(c) Where a clamped raw edge connection is used for breakaway purposes, flange bolts shall not be over-tightened.

(d) Plastic or aluminium flange bolts shall not exceed 8 mm diameter.

(e) Transverse reinforcement of the ductwork to damper breakaway joint shall be applied to the ductwork side of the joint only and be in accordance with AS 4254.2.

(f) Some damper to ductwork breakaway joint systems do not require any fastenings at all.

(g) Where an insulated duct is mounted above the fire damper, it shall be installed so that it will not breakaway or collapse in a fire.

Appendix C *The purpose of the insulated duct not breaking away in a fire is:*

(a) The insulated duct above the damper is responsible for the insulation part of the FRL.

(b) The collapse of the duct on top of the damper could have a damaging effect on it.

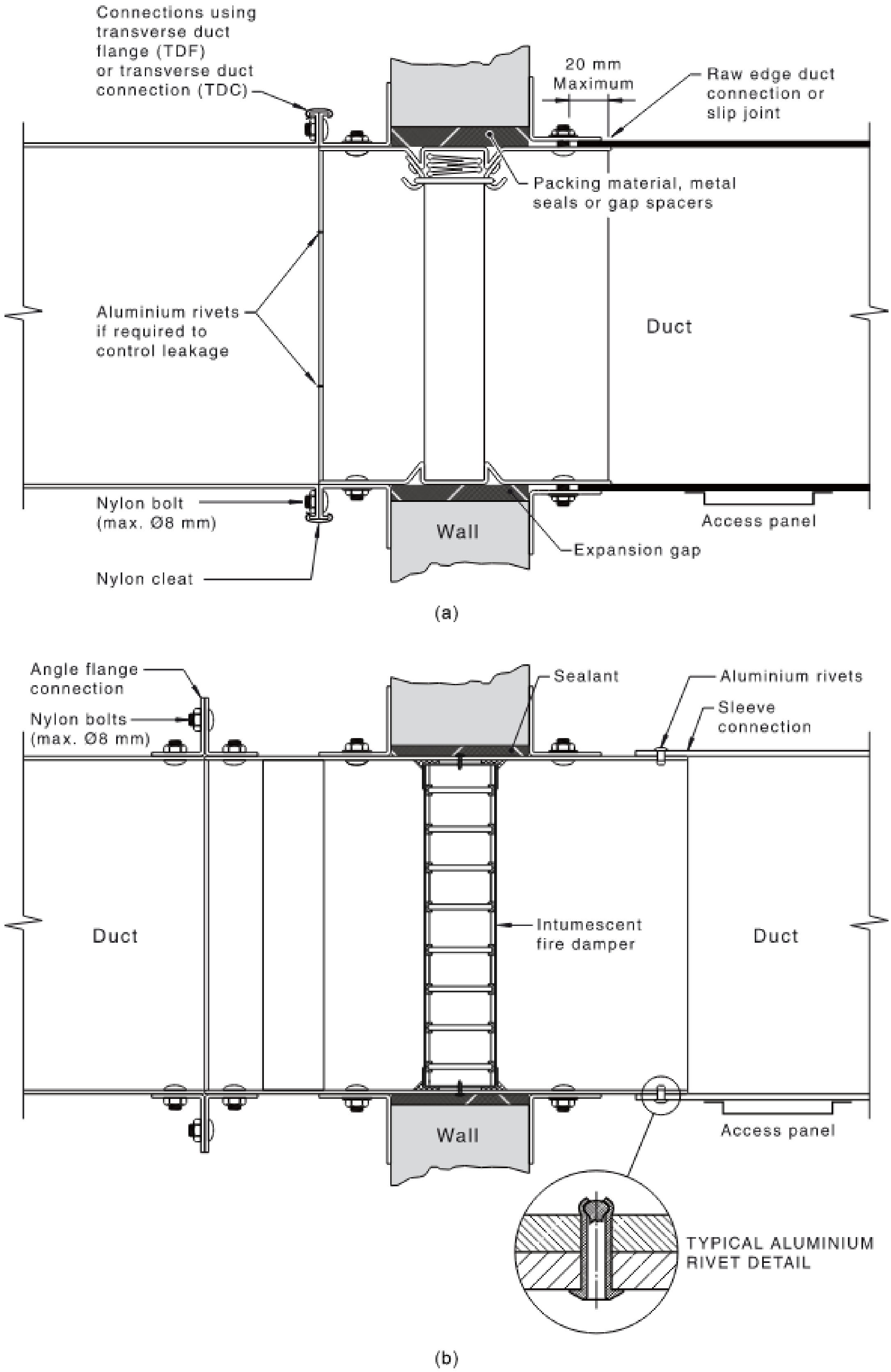

FIGURE C1 TYPICAL FIRE DAMPER BREAKAWAY CONNECTIONS

3. Shortfalls and argument that the FRL Insulation Criteria 3.2.3.1 (b) cannot be aggregated.

The method of aggregating the duct in AS1668.1:2015 is not documented that the duct can aggregate wherever one chooses. There is no test data or any data in the standard to support his opinion.

In the case of a metal mechanical damper, the duct does not continue through the penetration, past the damper and onto the other side. The duct stops at the damper on side A, and a seconded duct is usually connected to the duct on side B. Thus, two completely separate ducts i.e. duct-damper-duct. FIG 1 below is a 2-way rated wall. Meaning protection is from the opposite side, regardless of what side the fire is on. Refer to Figure 1 below.

It's worth noting that cardboard burns at 232 degrees Celsius and ignites at 427 degrees Celsius. The ignition point for uPVC is 391 degrees Celsius. This means uPVC pipes if within close proximity of the radiant heat from the damper would most probably combust within 60 minutes and cardboard within 30 minutes of the fire starting.

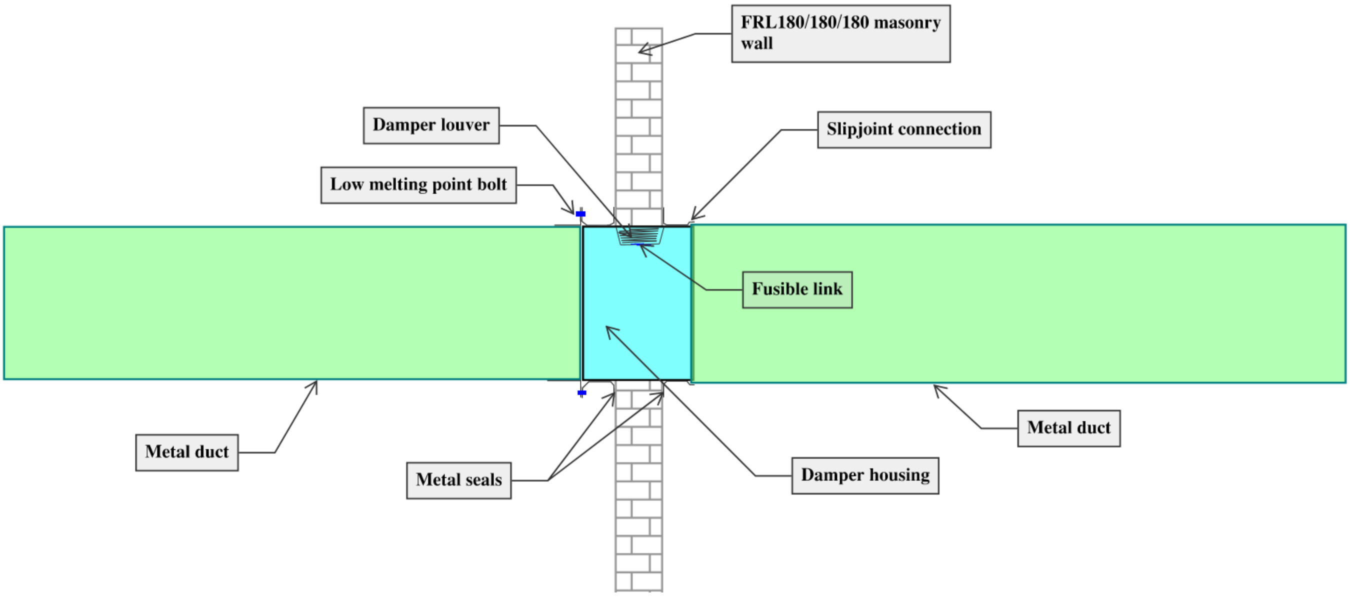

Fig 1

The argument for Party B is that the 2-meter rule applies to both sides of the damper since:

- The ducts on the left and right sides are separate.
- Nowhere in AS1668.1:2015 or in the National Construction Code (NCC) does it document that one can aggregate the duct distances wherever one like's if the combined measurement is a total of 2 meters minimum.
- AIRAH's educational documents and manuals are not evidence of suitability as per the NCC.

For example, a damper was installed into a 2-way FRL180/180/180 masonry wall, and the duct on the left was 1.9 meters and the duct on the right was 0.1 meters. A fire started on the left and the low melting point bolts gave way with 50 minutes since the start of the fire. For the next 130 minutes, the 0.1-meter duct will not be long enough to shield the radiant heat and fire can start on the right side, thus making the passive fire system non-compliant. Refer to Figure 2 below.

Furthermore, in regard to a one-way FRL120/120/120 plasterboard firewall, 1.95 meters of the duct was installed on the fireside and 0.05 meters of the duct was installed on the non-fire side. A fire started on the left and the low melting point bolts gave way with 50 minutes since the start of the fire.

For the next 70 minutes, the 0.05-meter duct will not be long enough to shield the radiant heat and fire can start on the right side, thus making the passive fire system non-compliant. Refer to Figure 3 below.

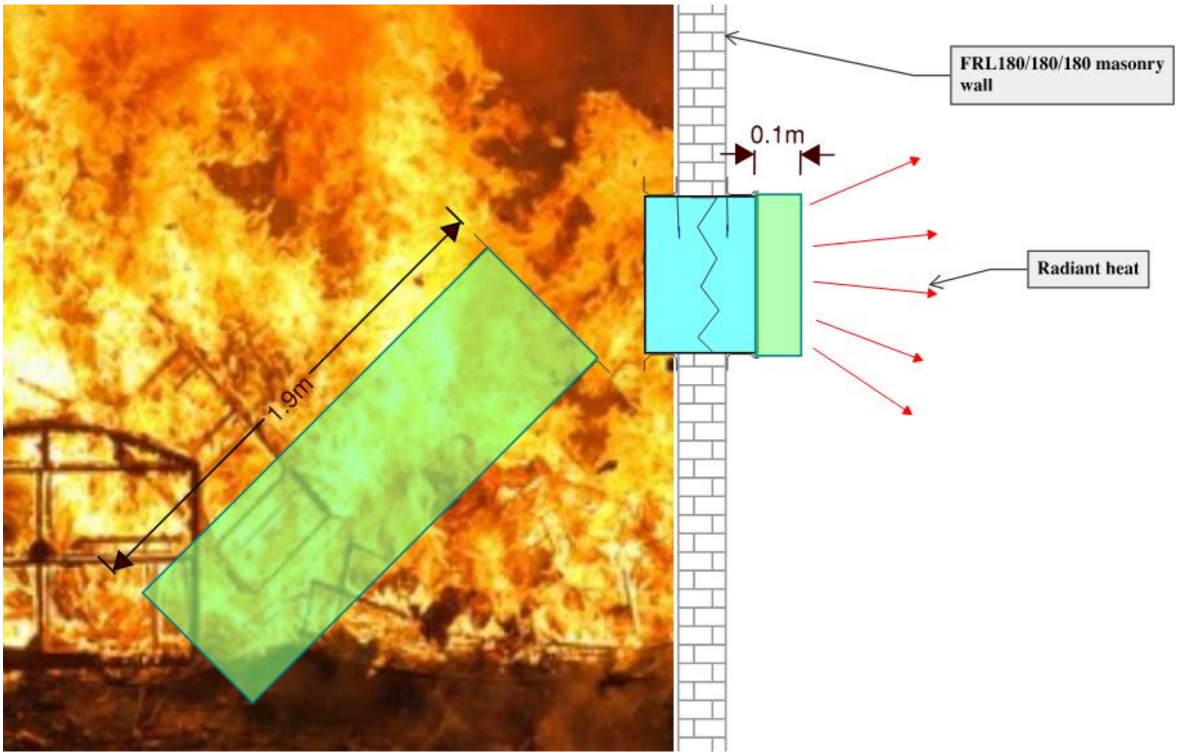

Fig 2

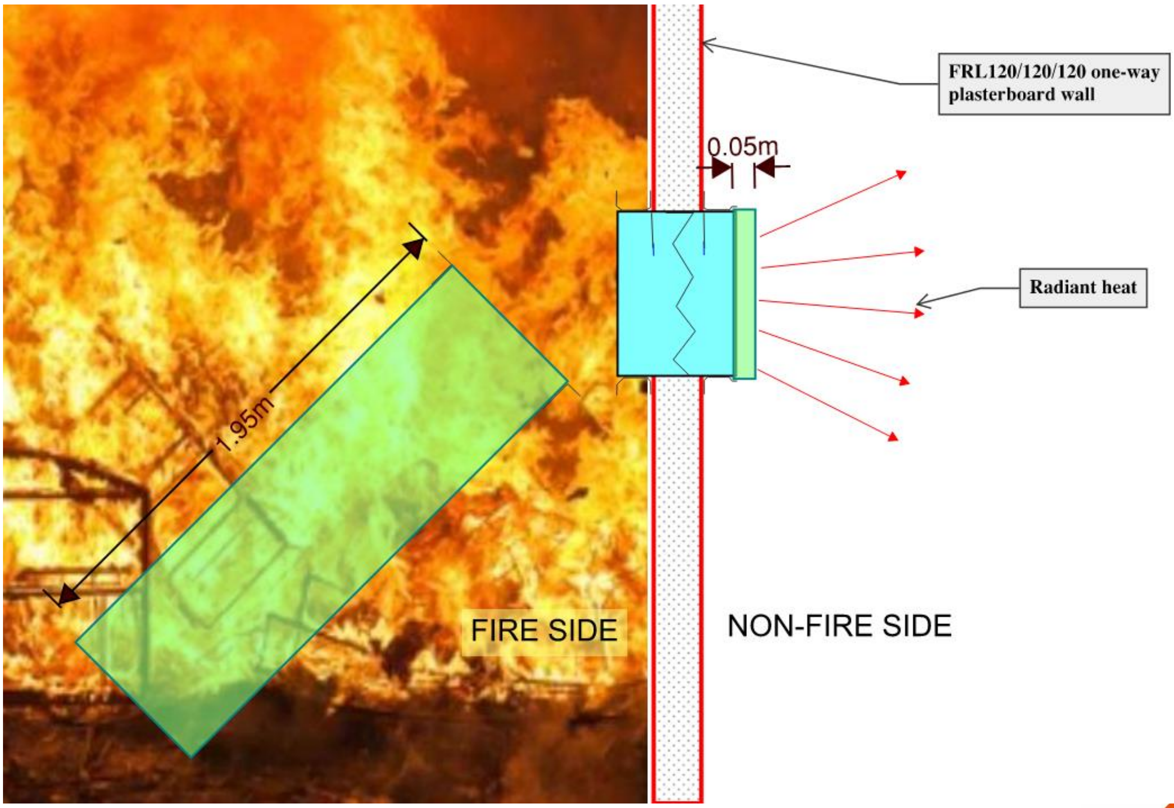

Fig 3

4. Impact on Fire Safety

The FRL's insulation criteria were introduced in AS1530.4 "Methods of fire tests on building materials, components and structures" and the standard was adopted by the Building Code of Australia. Prior to AS1530.4 was AS30 "Fire-resistance, incombustibility and non-inflammability of building materials and structures (including method of test)". There was no insulation criteria in AS30 and a 2-hour wall would have been noted as FRR 2hr. FRR stands for Fire Resistance Rating.

According to AS1530.4:2014, the failure point of the test is as follows:

a) The average temperature of the unexposed face of the test specimen, as measured by thermocouples specified in Clause 2.2.3.1, exceeds the initial temperature by more than 140K; or
b) The temperature at any location on the unexposed face of the test specimen exceeds the initial temperature by more the 180k.

The insulation, regardless of its construction, is there to protect the non-fire side from heat tracking through the penetration and igniting combustible materials on the non-fire side.

If the passive system is not installed correctly, there is a high risk to life safety, property damage, and overall building performance.

Since there is no quantitative data, and evidence that can be used as evidence of suitability according to the NCC to back Party A's argument, one puts themselves at risk of being sued for negligence against the Queensland Building and Construction Legislation (Non-conforming Building Products-Chain of Responsibility and Other Matters) Amendment Bill 2017.

5. Industry Perspectives and Stakeholder Feedback

Bart Taylor, General Manager of A.G. Coombs Advisory Pty Ltd and Harald Weber of All Construction Approvals agrees the 2-meter rule applies to both sides, the way the additional commentary reads in AS1668.1:2015, C3.2.3 below.

The insulation requirement in Item (d) does not apply to vertical fire dampers and wall grilles that are connected to a fire-resistant riser shaft or ductwork with an insulation performance level and of minimum 2 m in length because the insulation performance is considered to have been provided by the riser shaft or ductwork.

6. Mechanical Engineer vs the QLD Passive Fire Certifier (PFC).

There are some that believe that the Mechanical Engineer (ME) is more qualified thus overriding the PFC. However, in Queensland, the ME cannot certify the installation of the fire damper system, only the PFC can. So in the event of a fire causing harm or death, the PFC is first to be sued or appear in a criminal court.

The Delmer is a monetary one. Party A's methodology cost less to construct. And since Developers, Governments and Clients are cost adverse, Party A's methodology will be adopted most if not all the time. ME's and Building Certifiers don't want to go to their clients and say Party B's method is correct for fear of losing credibility and future work due to cost increases.

7. Recommendations for Revising FRL Insulation Criteria

ABCB send out a nationwide bulletin informing everyone that Party B's methodology to implemented; and,

1. Conduct an AS1530.4:2014 fire test with a NATA-approved testing laboratory for both methodologies; and

2. Change AS1668.1:2015 to reflect the most favourable, cost-effective and safe outcome; or

3. Leave AS1668.1:2015 as is but document segmented measurements that you can aggregate the duct i.e. 1m/1m, 1.2m/0.8m, 0.6m/1.4m and so on and have this method examined and tested by Keith Nicholls of CSIRO for accuracy against the AS1530.4:2015 so that the outcome is no less that of the insulation performance.

8. Conclusion

Since there is a lack of data and evidence to back up the methodology of Party A argument and a Mechanical Engineer cannot certifier the installation of the fire damper system, I highly recommend section 7 of this paper be implemented as so as possible.

By addressing the deficiencies in the current FRL insulation criteria, this paper aims to contribute to the ongoing efforts to enhance fire safety standards in the construction industry. The research presented here serves as a foundation for further discussions, policy development, and regulatory improvements to ensure buildings are adequately protected against fire hazards.

Mark Azzopardi (DipPM, QBCC-PFC),

Reference documents:

- *AS1668.1:2015*
- *AS30*
- *AS1530.4:2014*
- *National Construction Code*
- *Queensland Building and Construction Legislation (Non-conforming Building Products-Chain of Responsibility and Other Matters) Amendment Bill 2017*
- *Exova Warrington fire test report 2718300*