BB7

STRUCTURES IN FIRE FORUM – 27TH SEPTEMBER 2024

Coat-backs when considering steel hollows

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CEng MIFireE PMSFPE

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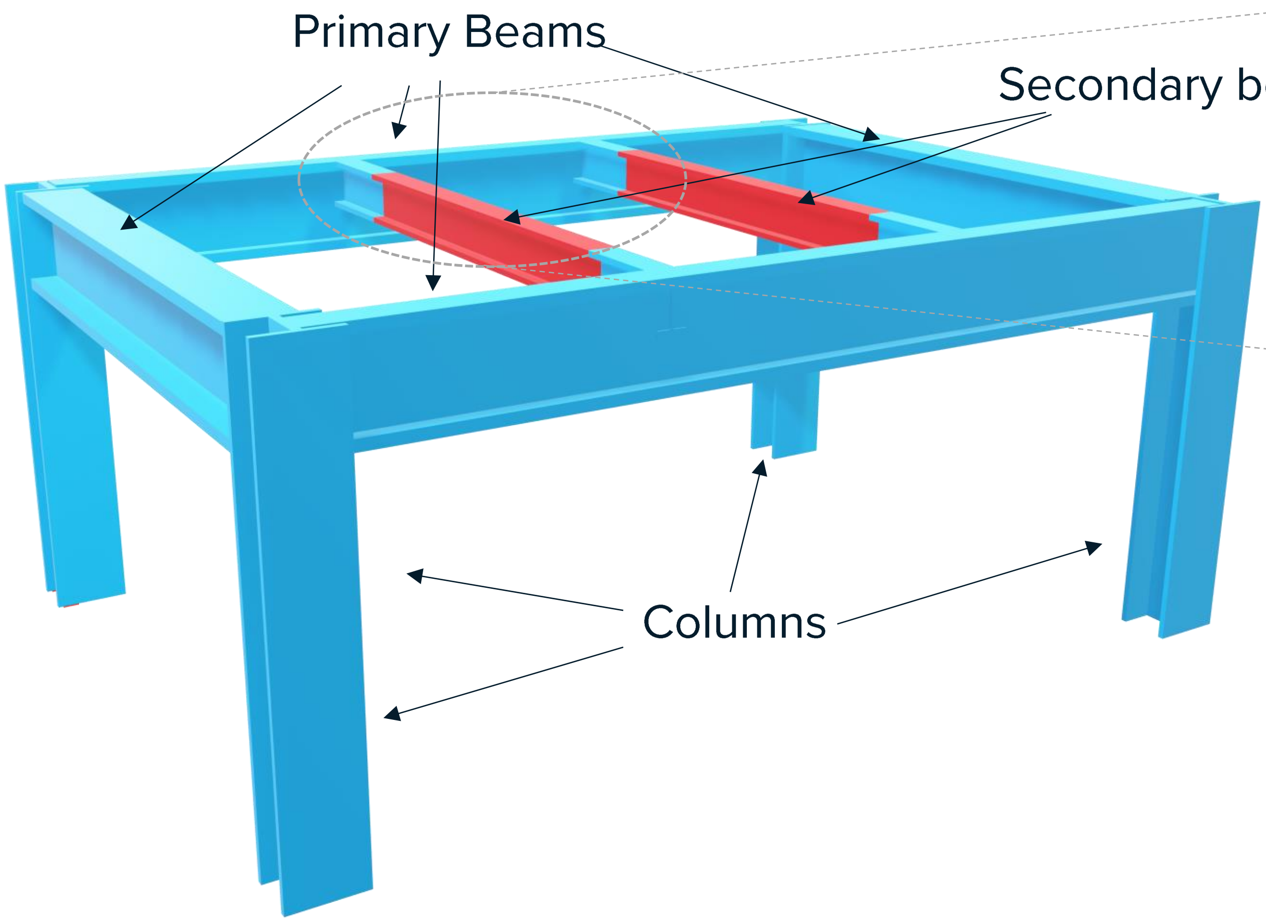
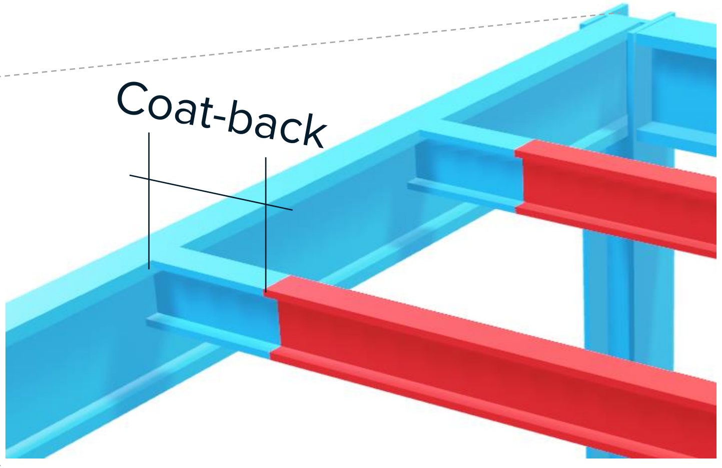
1. What is a Coat-Back?
2. Project - 3D Thermal FEM
3. Research - 2D Thermal FEM Parametric Study
4. Insights and Next Steps
5. Q&A and Discussion

What is a Coat—Back?





Protected Steel

Unprotected Steel

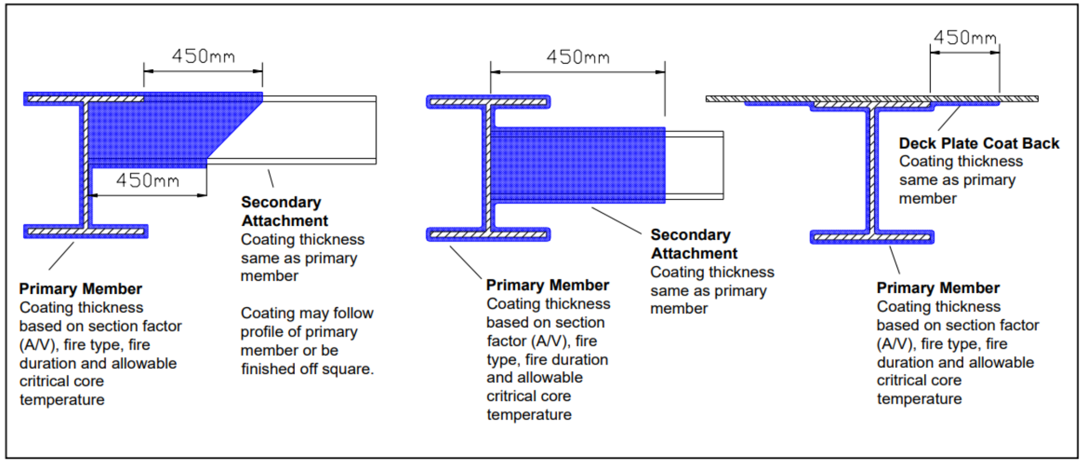
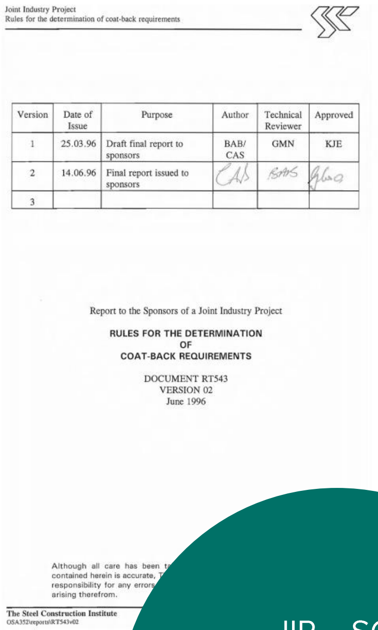


Figure 6.1 Typical coatback details



Joint Industry Project
Rules for the determination of coat-back requirements

Version	Date of Issue	Purpose	Author	Technical Reviewer	Approved
1	25.03.96	Draft final report to sponsors	BAB/ CAS	GMN	KJE
2	14.06.96	Final report issued to sponsors			
3					

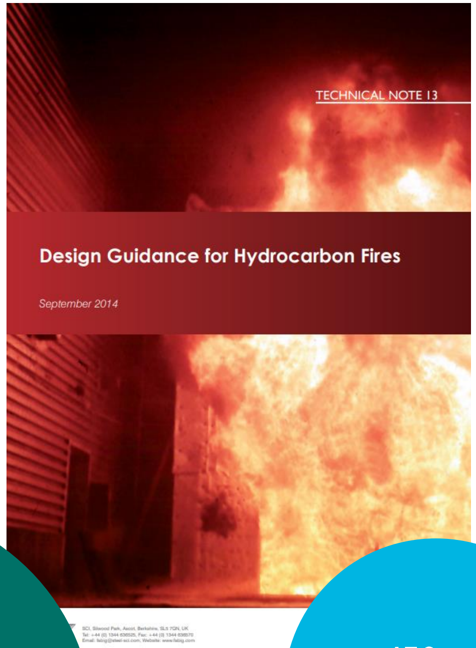
Report to the Sponsors of a Joint Industry Project

RULES FOR THE DETERMINATION OF COAT-BACK REQUIREMENTS

DOCUMENT RT543
VERSION 02
June 1996

Although all care has been t
contained herein is accurate,
responsibility for any errors
arising therefrom.

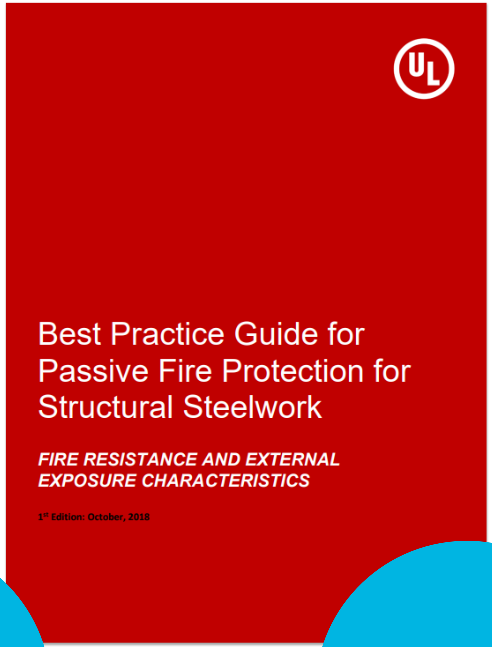
The Steel Construction Institute



TECHNICAL NOTE 13

Design Guidance for Hydrocarbon Fires

September 2014



Best Practice Guide for Passive Fire Protection for Structural Steelwork

FIRE RESISTANCE AND EXTERNAL EXPOSURE CHARACTERISTICS

1st Edition: October, 2018

ASFP

ADVISORY NOTE 21:

ASFP Position on Unprotected Attachments and Unprotected Secondary Members Connected to Protected Primary Members

If secondary steelwork is left unprotected, then in a fire situation, it may heat rapidly and could be a source of heat that conducts into the protected primary member to which it is attached. This may cause early failure with respect to loss of load bearing capacity of the primary section.

In the case of minor attachments, the Fire and Blast Information Group (FABIG) in their Technical Guidance Note 13, recommend that they may be left unprotected when their contact area is no greater than 3,000mm² per linear m or m² on the primary section. This guidance is for hydrocarbon fire exposures typically associated with oil and gas facilities. The ASFP has consulted with the Steel Construction Institute (SCI) who have advised that this guidance may be considered conservative to apply to a cellulosic fire condition as might occur in civil construction. As such, the ASFP recommended the same guidance.

In the case where the unprotected contact area is greater than 3,000mm², then some form of protection to the connecting member or attachment is likely to be required.

The British Constructional Steelwork Association (BCSA) document "Steel construction – Fire Protection" published in 2013 contains several references to obviate the need to protect secondary beams when the primary beam is fire protected. While this approach is sometimes adopted as part of a structural fire engineering assessment, the ASFP and others consider this simplified position to be unconservative in the absence of appropriate justification, with specific reference to the int
of protected primary and unprotected secondary beams.

If there is no evidence to support the omission of, or reduced provision of pass
ondary steelwork then the ASFP position is to recommend that the second
distance of 500mm from the primary section. The protection applie
of protection for the primary section. This protection to the

JIP – SCI
1996 - RT543

450mm –
Hydrocarbon fires

450mm
Hydrocarbon
fires

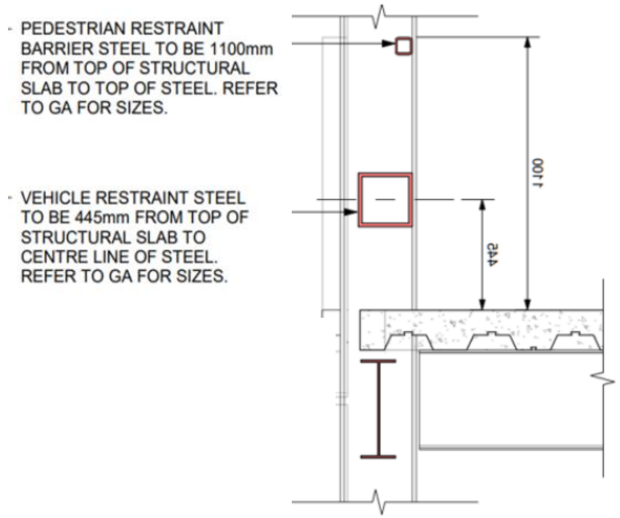
450mm
Cellulosic
fires

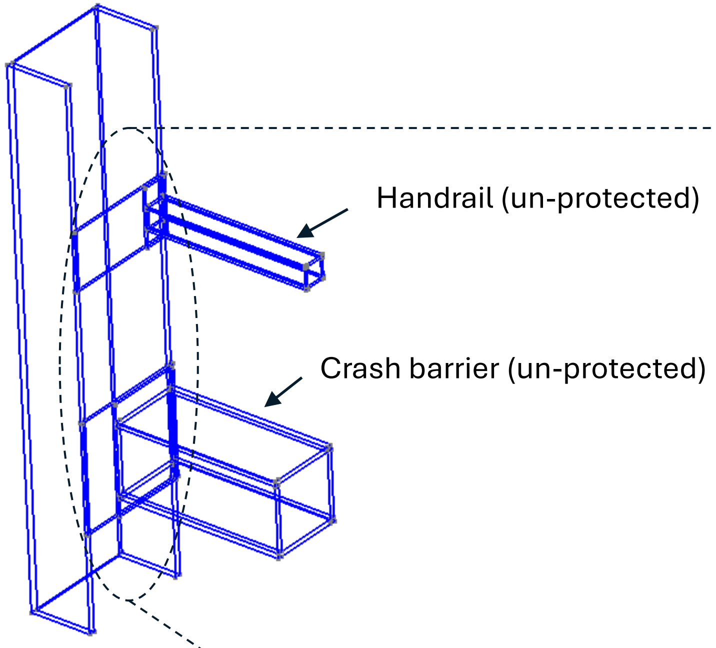
500mm
Cellulosic
fires

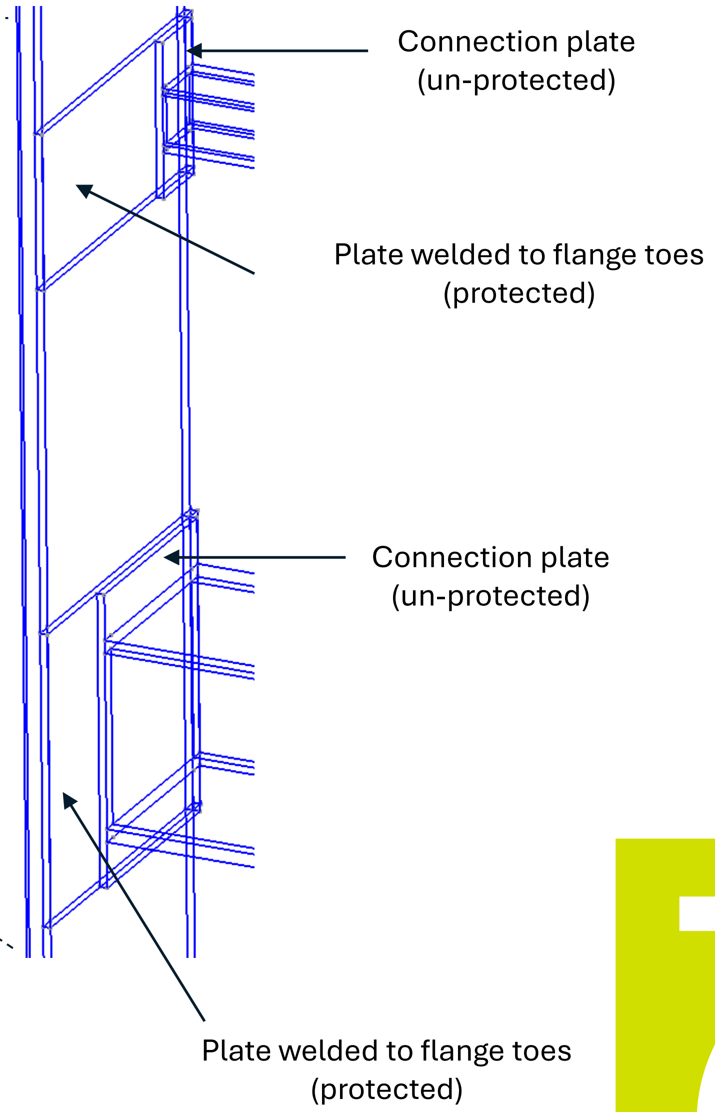
Project – 3D Thermal FEM

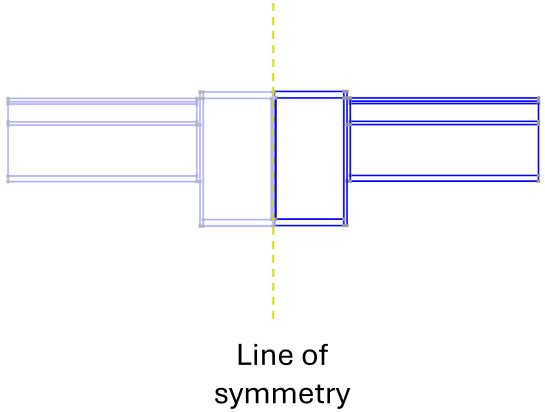
R60

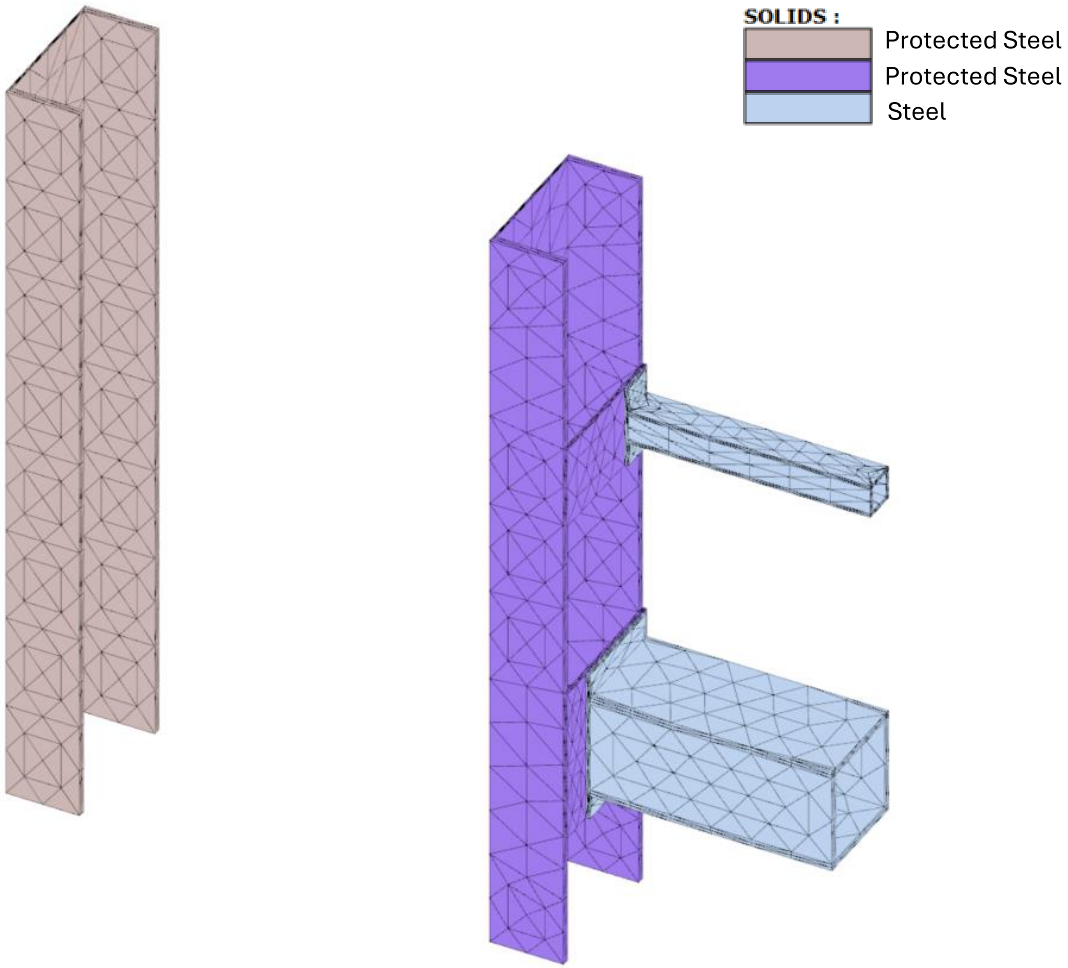

PEDESTRIAN RESTRAINT BARRIER STEEL TO BE 1100mm FROM TOP OF STRUCTURAL SLAB TO TOP OF STEEL. REFER TO GA FOR SIZES.
VEHICLE RESTRAINT STEEL TO BE 445mm FROM TOP OF STRUCTURAL SLAB TO CENTRE LINE OF STEEL. REFER TO GA FOR SIZES.
1100
445


PEDESTRIAN RESTRAINT BARRIER STEEL TO BE 1100mm FROM TOP OF STRUCTURAL SLAB TO TOP OF STEEL. REFER TO GA FOR SIZES.
VEHICLE RESTRAINT STEEL TO BE 445mm FROM TOP OF STRUCTURAL SLAB TO CENTRE LINE OF STEEL. REFER TO GA FOR SIZES.
1100
445


Handrail (un-protected)
Crash barrier (un-protected)


Connection plate
(un-protected)
Plate welded to flange toes
(protected)
Connection plate
(un-protected)
Plate welded to flange toes
(protected)


Line of
symmetry



SAFIR

Technical documentation

Some structures may comprise internal cavities in which no solid but gas is present. This is the case, for example, in internal cavities of hollow core slabs, for the gaps between H steel sections and plates of insulating material, for the interior of hollow steel sections or for the space between the two layers of gypsum plaster boards in steel studs or timber studs gypsum plaster walls. A model that describes the heat transfer by convection and radiation in these cavities is included in SAFIR. It is based on the following hypotheses:

1) There is no heat transfer by conduction within the gas that is in the cavity.
2) The specific heat of the gas in the cavity is neglected.
3) The gas in the cavity is transparent to radiation (non participating media).

Two heat transfer mechanism are involved in the cavity:

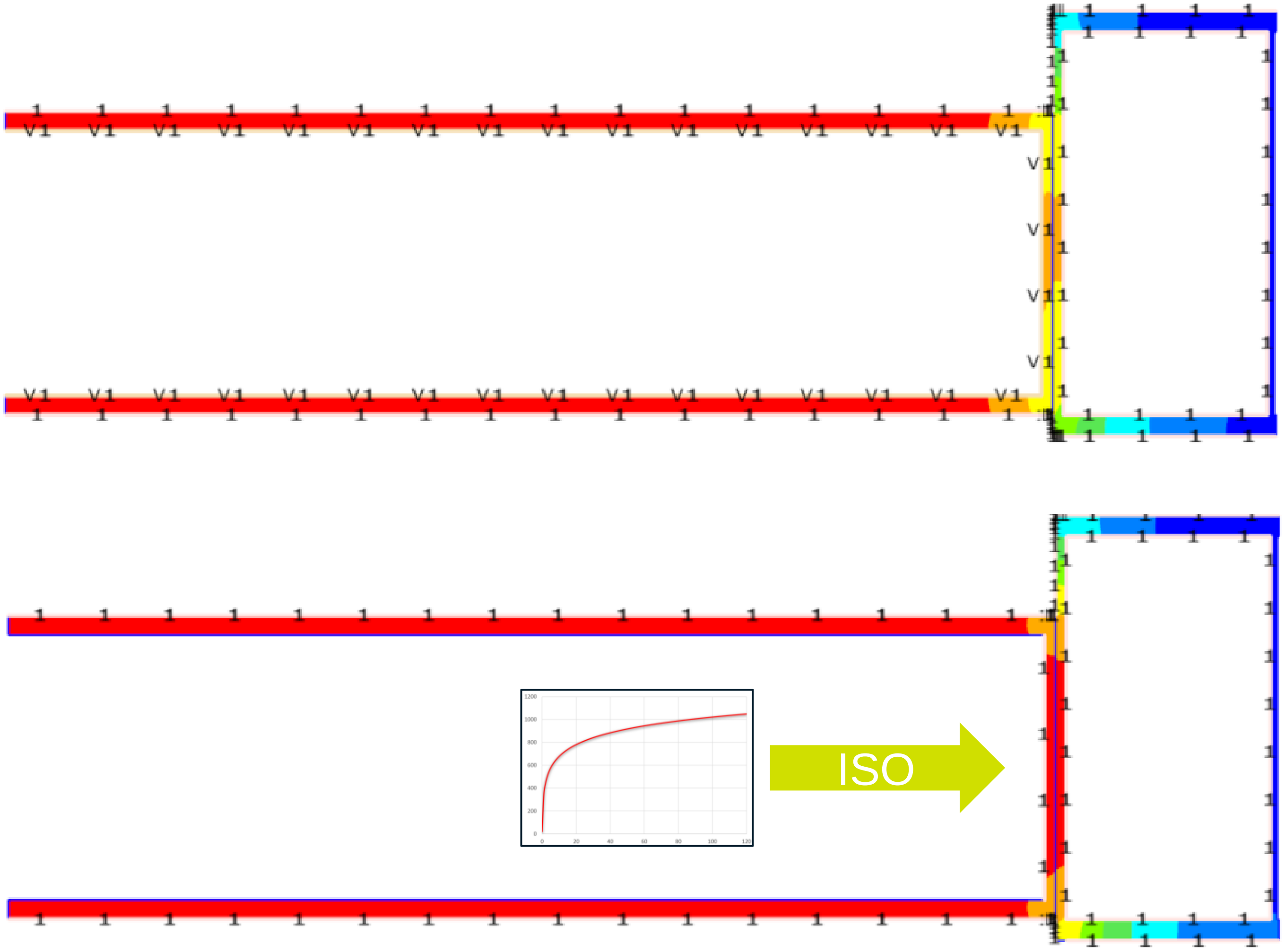
- linear convection between the internal surfaces of the cavity and the air in the cavity;
- radiation between the internal surfaces of the cavity.

The consequence of hypotheses 1) and 2) is that the temperature of the air in the cavity is uniform and equal to the average of the temperatures of the surfaces of the cavity.

The consequence that a simple linear convective is considered is that more complex phenomena such as the direction of gravity, the characteristic dimension of the cavity or the velocity of the convective movements are not taken into account.

The consequence of the hypothesis 3) is that radiation and the temperature of the air in the cavity don't influence each other.

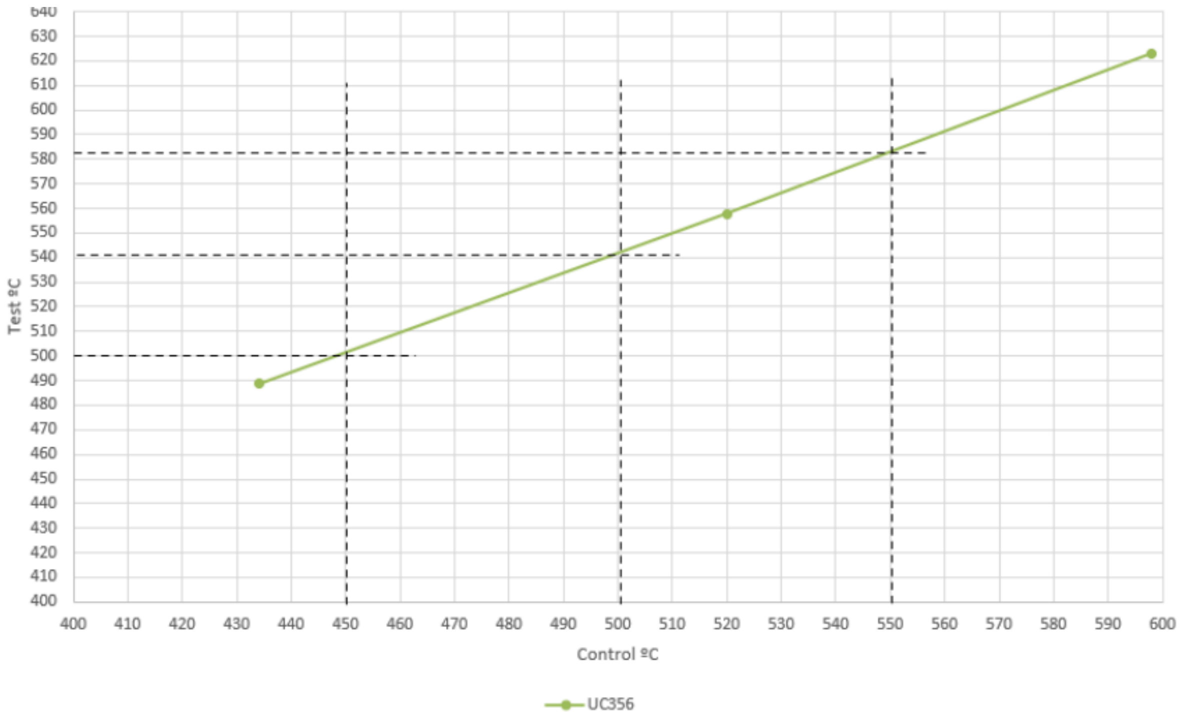
Because the computation of view factor between the surfaces of the cavity have been programmed only for 2D situations, internal cavities cannot be considered in 3D thermal calculations.



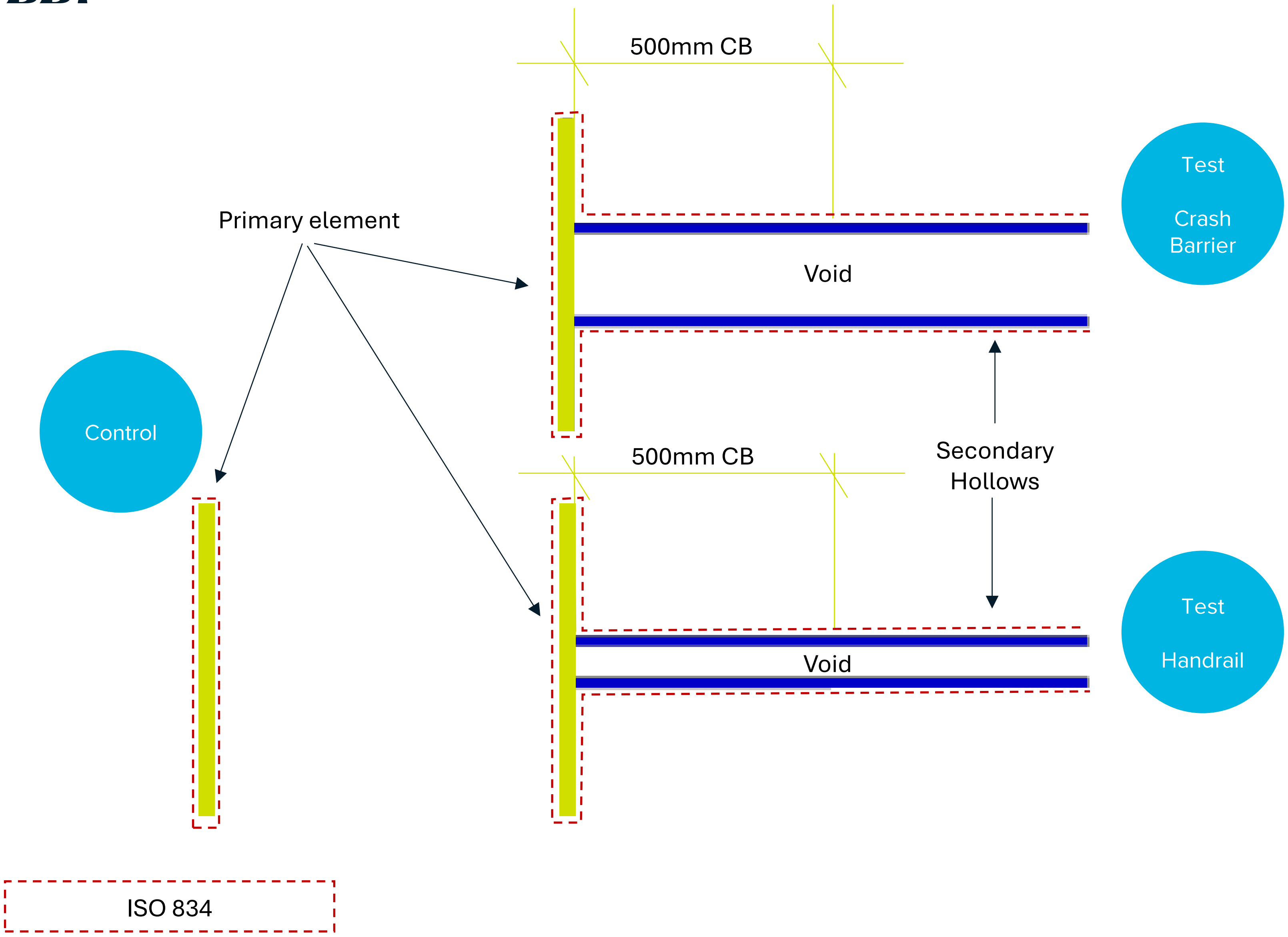
We observed a slight increase of 20°C in the average temperature of the protected primary element

Control

Test



Research – 2D Thermal FEM Parametric Study



Voids included

PFP is modeled as an insulation material (constant thermal conductivity)

Accounted for the reduction in performance for Hollows

R60

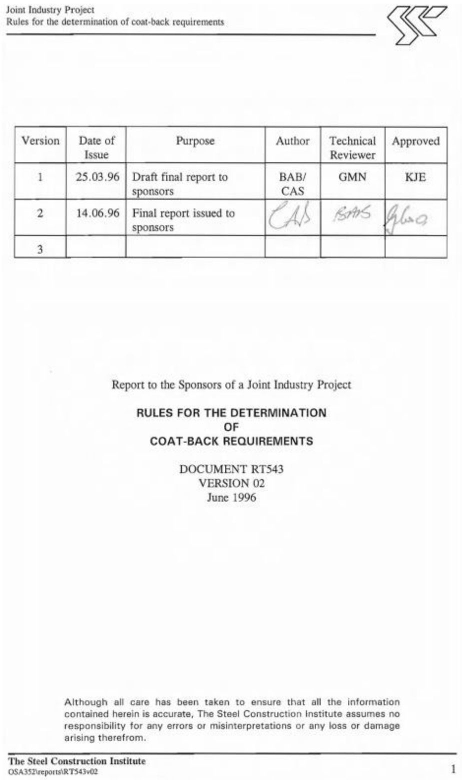
R120

509°C

501°C

626°C

563°C



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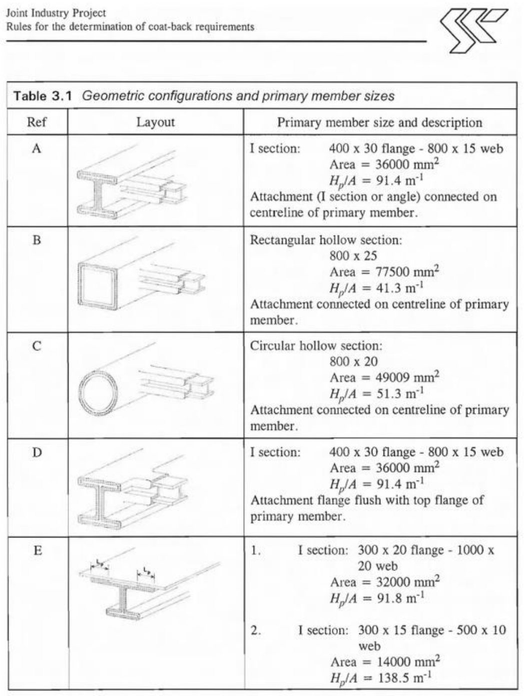
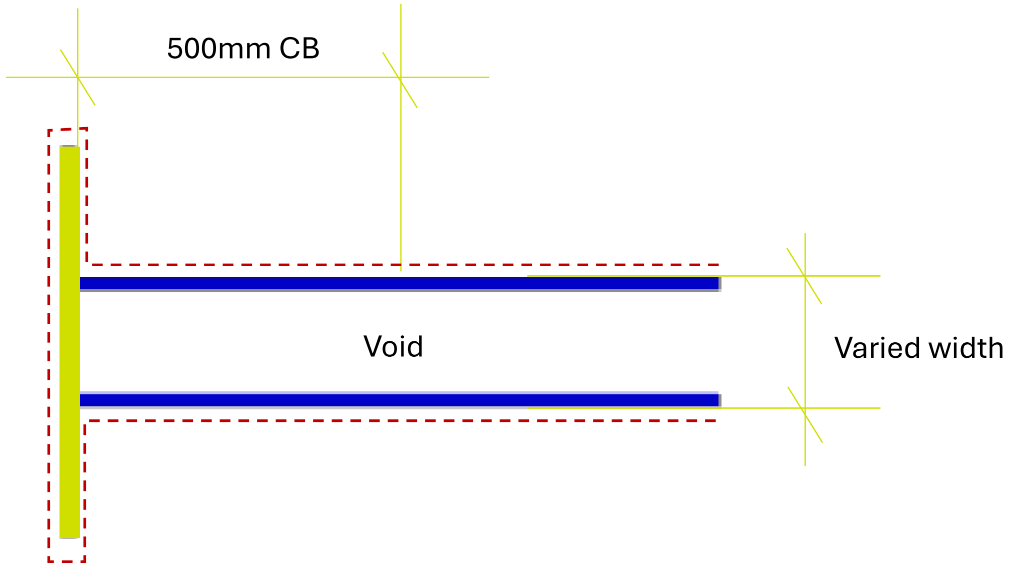
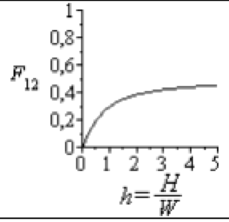


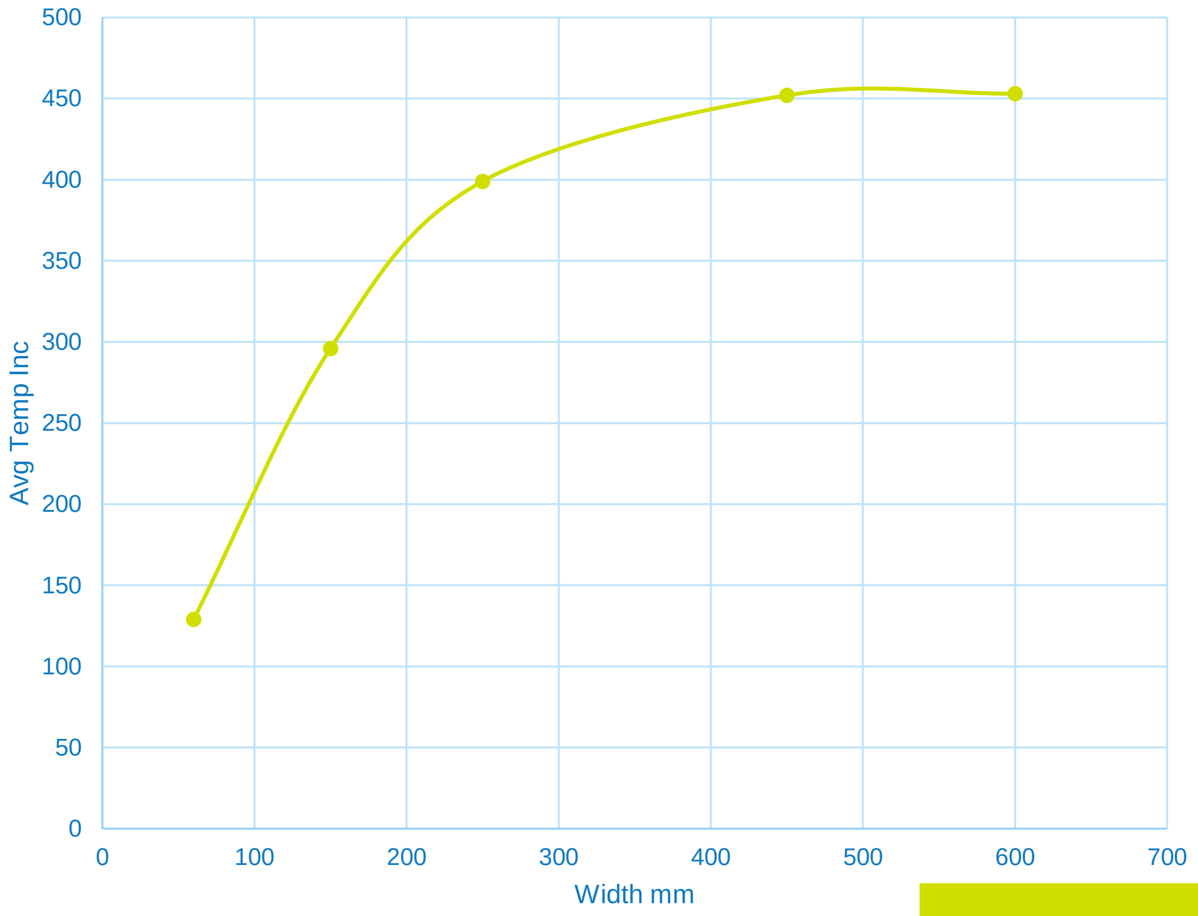
Table 3.1 *Geometric configurations and primary member sizes*

Ref	Layout	Primary member size and description
A		I section: 400 x 30 flange - 800 x 15 web Area = 36000 mm^2 H_p/A = 91.4 m^{-1} Attachment (I section or angle) connected on centreline of primary member.
B		Rectangular hollow section: 800 x 25 Area = 77500 mm^2 H_p/A = 41.3 m^{-1} Attachment connected on centreline of primary member.
C		Circular hollow section: 800 x 20 Area = 49009 mm^2 H_p/A = 51.3 m^{-1} Attachment connected on centreline of primary member.
D		I section: 400 x 30 flange - 800 x 15 web Area = 36000 mm^2 H_p/A = 91.4 m^{-1} Attachment flange flush with top flange of primary member.
E		1. I section: 300 x 20 flange - 1000 x 20 web Area = 32000 mm^2 H_p/A = 91.8 m^{-1} 2. I section: 300 x 15 flange - 500 x 10 web Area = 14000 mm^2 H_p/A = 138.5 m^{-1}



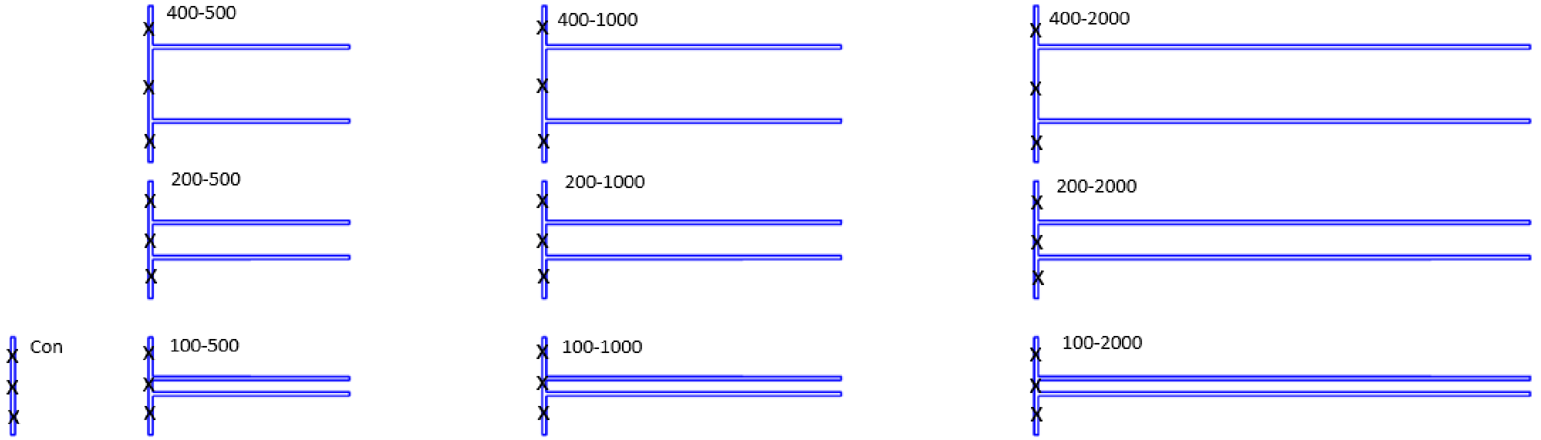
Unequal normal adjacent strips

Case	View factor	Plot
Adjacent long strips at 90º, the first (1) of width W and the second (2) of width H, with $h=H/W$. H W	$F_{12} = \frac{1+h-\sqrt{1+h^2}}{2}$ (e.g. $F_{12}\|_{H=W} = 1-\frac{\sqrt{2}}{2} = 0.293$)	



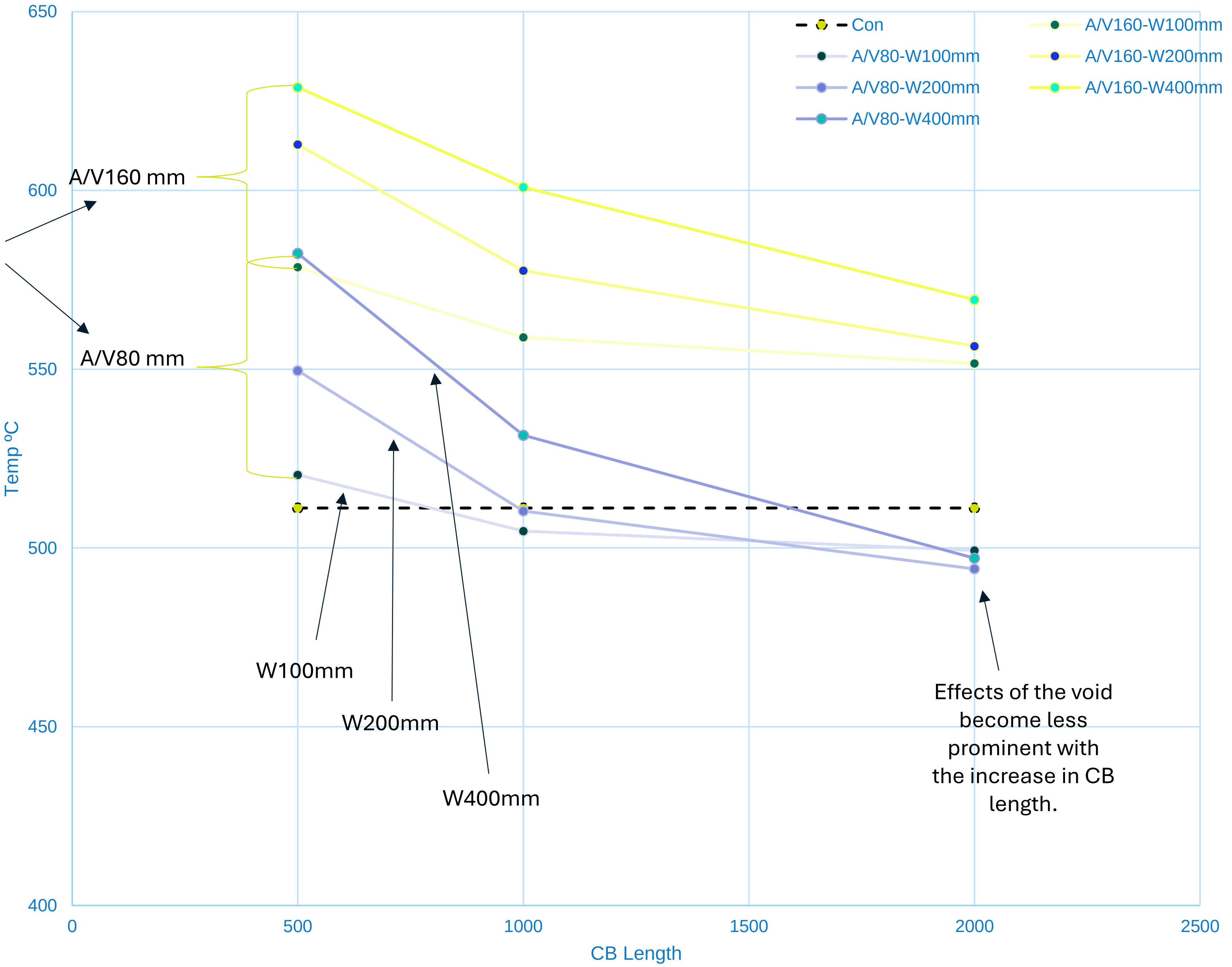
	Secondary mm		
Primary mm	6.3	12.5	20
6.3	x		
12.5	x	x	
20	x	x	x

Width Primary mm	250mm
	500mm
	1000mm
CB length	500mm
	1000mm
	2000mm
Width Secondary hollow	100mm
	200mm
	400mm
Temp	500
	600
R	60
	90
	120



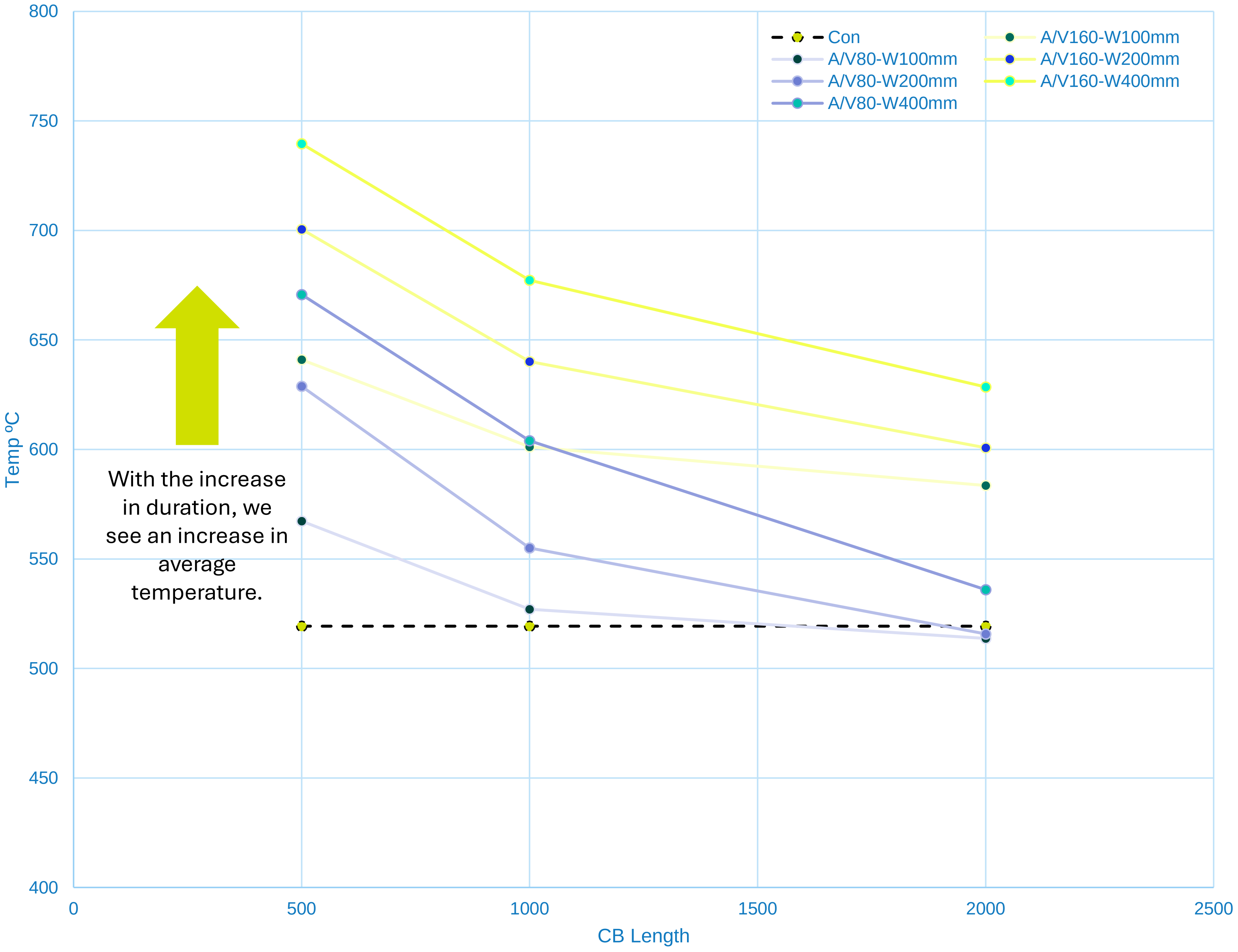
108 .in files
972 samples

The level of protection based on the primary element has a large effect on the average heating.



R60

Primary A/V – 80
CT – 500°C
Primary L 500mm



R90

Primary A/V – 80
CT – 500ºC
Primary L 500mm

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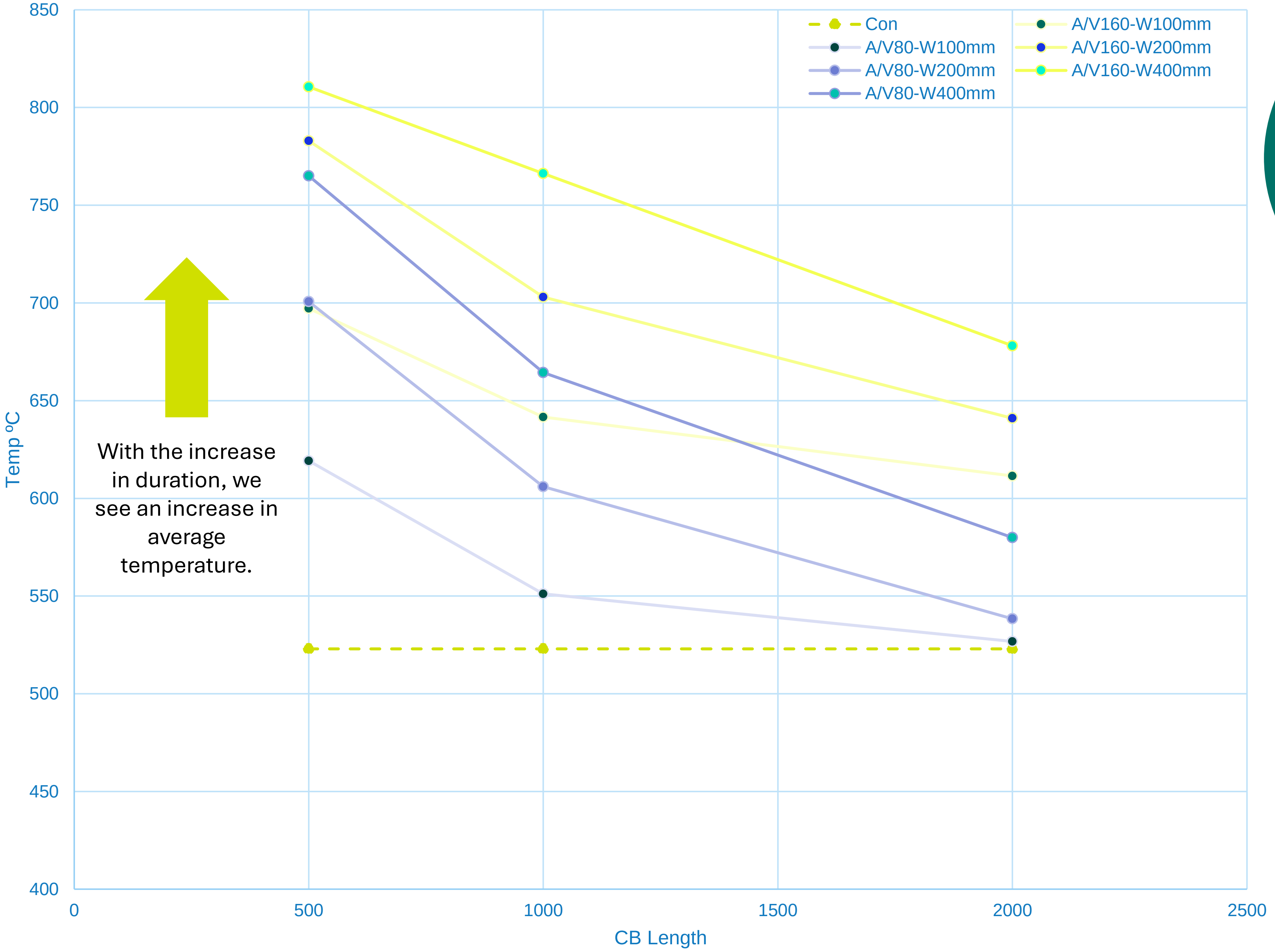
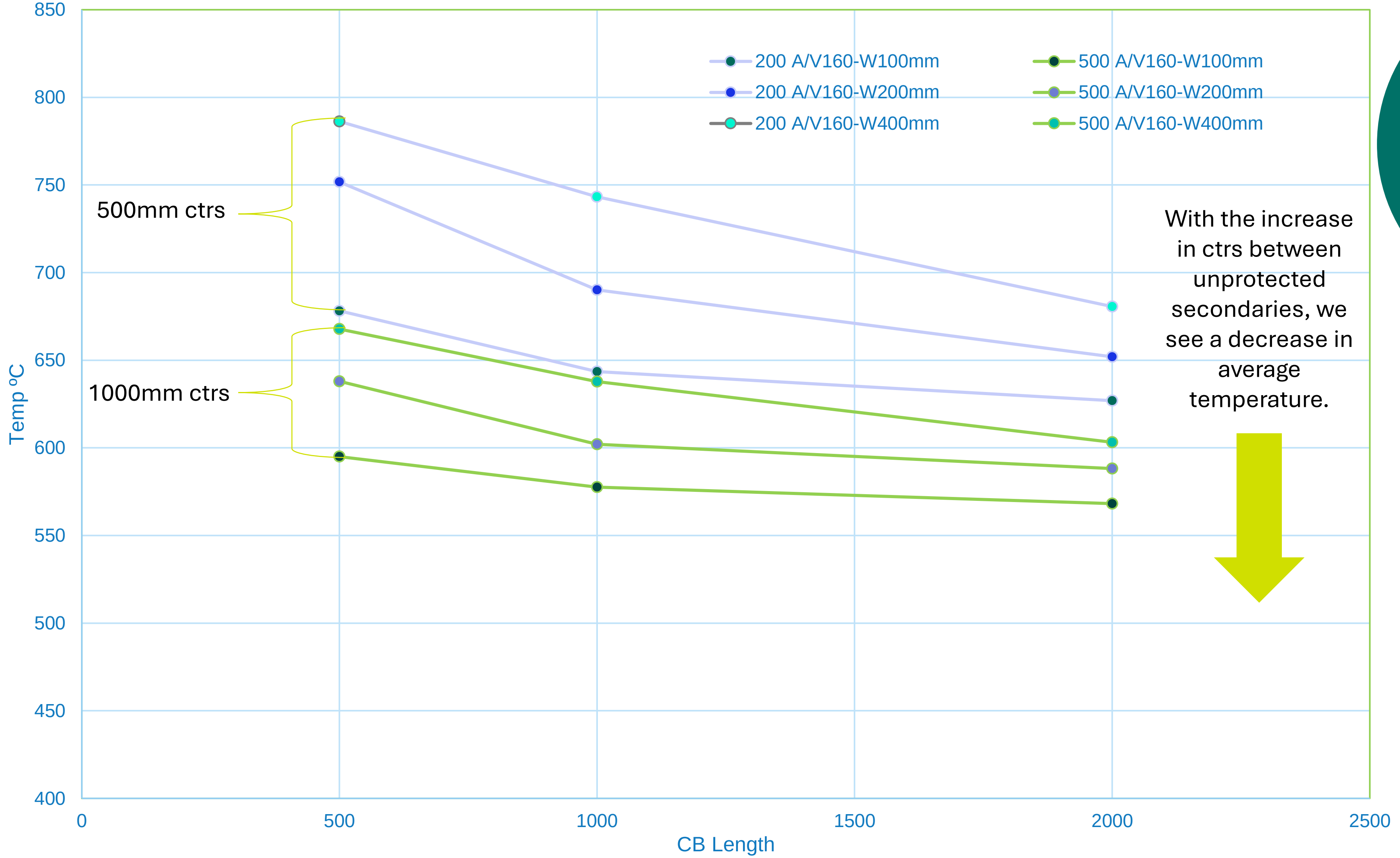


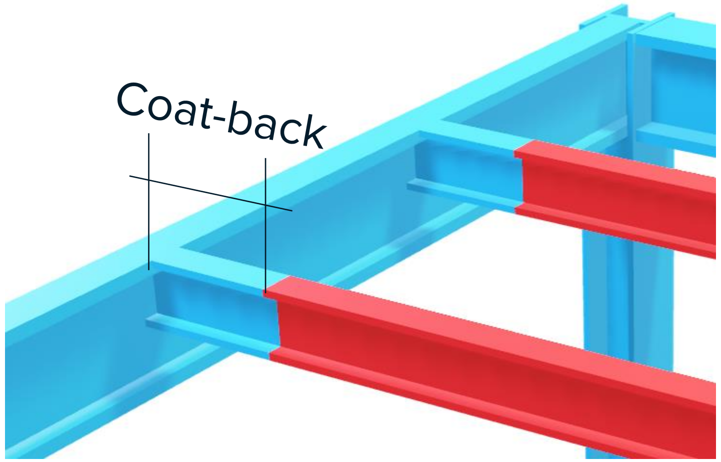
R120

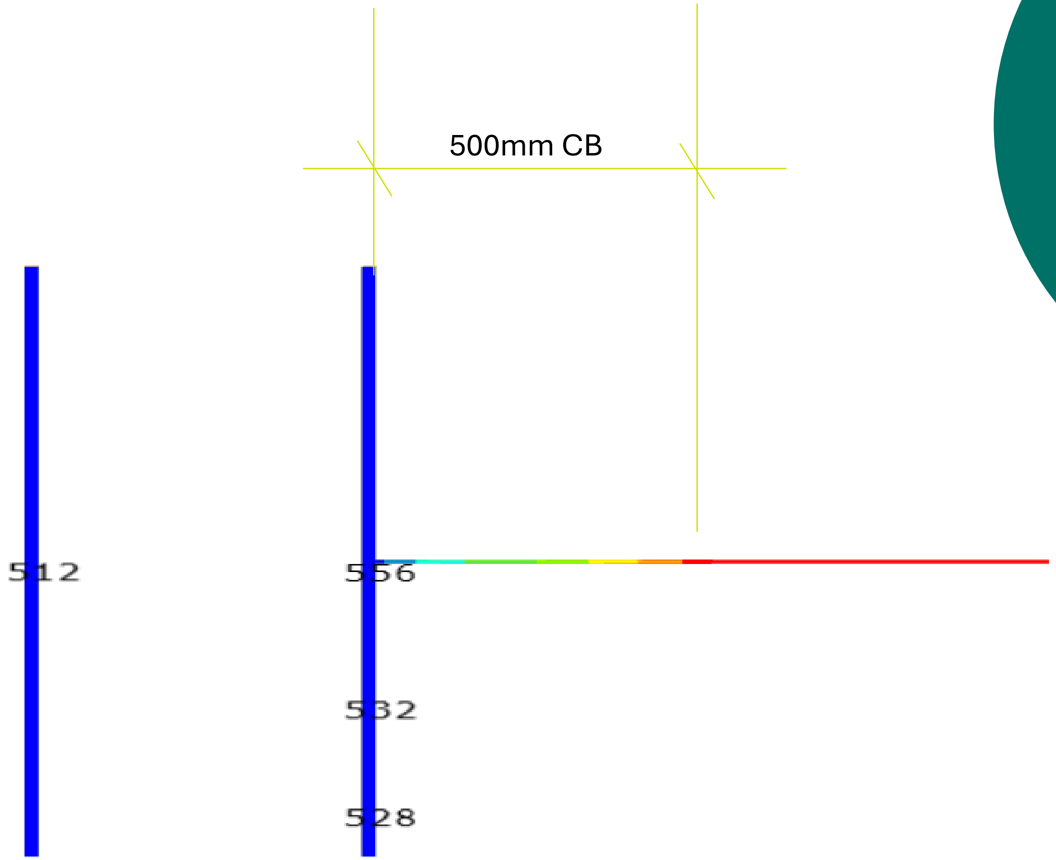
Primary A/V – 80
CT – 500ºC
Primary L 500mm



With the increase in ctrs between unprotected secondaries, we see a decrease in average temperature.

Primary 500mm
Vs
Primary 1000mm





When examining I-sections and a 500mm coat-back, the worst-case scenario only resulted in an average temperature increase of 25°C to the primary.

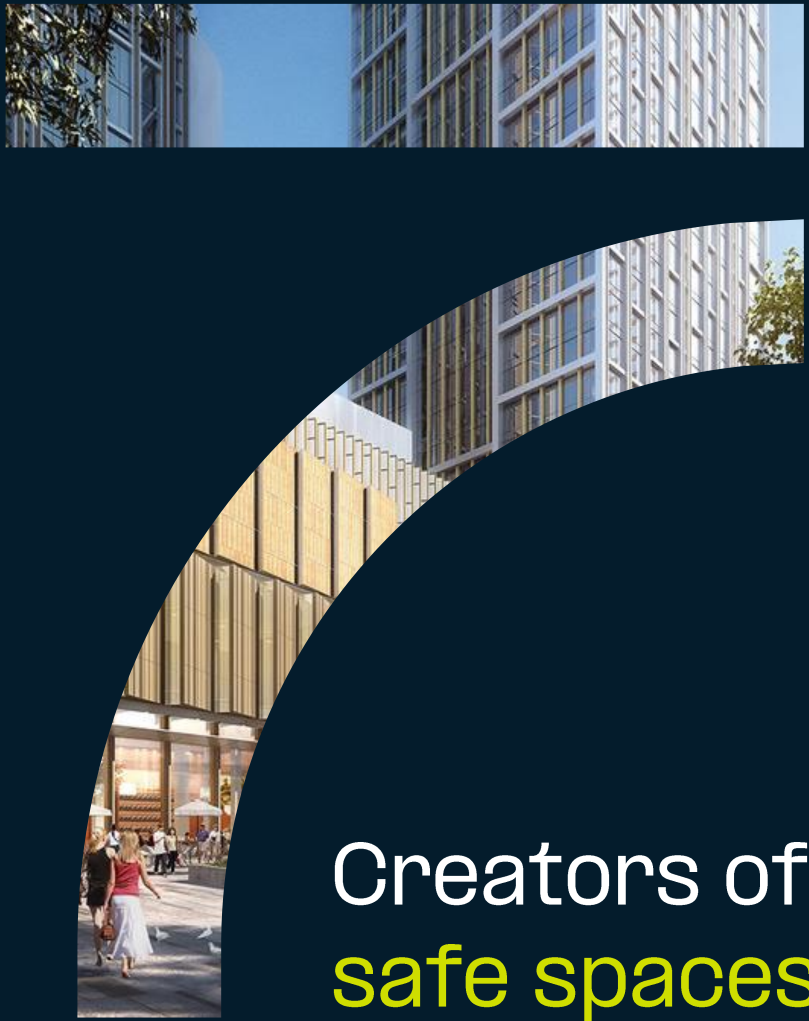
Insights and next steps

Insights:

- Increasing the coat-back length reduces the average temperature increase to the primary.
- Longer fire durations increase the heating of the primary element.
- The height of the primary greatly impacts the average temperature increase seen.
- **The width of the hollow (up to 400mm) has a huge impact on the average temperature increase of the primary.**
- **The section factor of the secondary relative to the primary has a large impact on the average temperature, more so than for coat-backs on open sections.**

500mm only works for limted scenarios (lower durations like 60 mins and only when the primary and secondary section factors are equal).

In most cases, a longer coat-back length or full protection to the secondary hollow would be required.

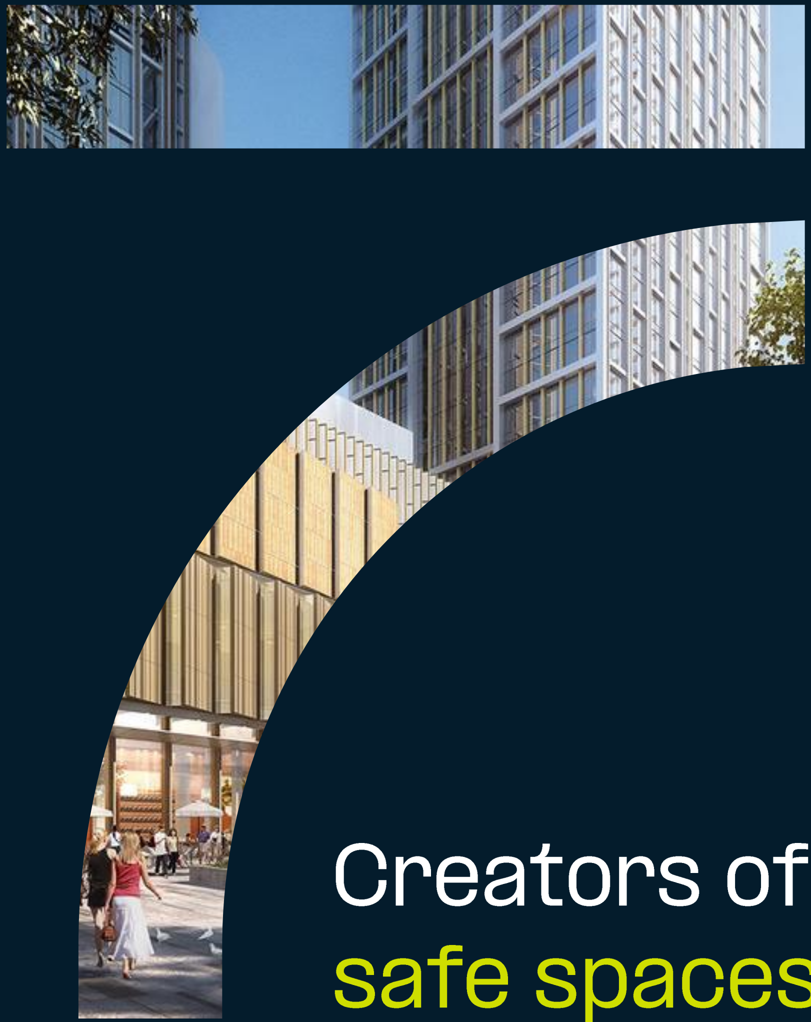


Creators of
safe spaces

Further work next steps:

- Look to publish a paper on our initial findings.
- Investigate the thermal response in 3D.
- A fire test to underpin the research would be of great value.
- Look at other connection details (fin and gusset plates).

We are working with the ASFP to look into the possibility of updating guidance and conducting testing when research is furthered.



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THANK YOU

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