Research Programme of the Research Fund for Coal and Steel

FIre and Seismic performances of Hybrid fire WALLs in case of single-storey industrial and commercial steel buildings (FISHWALL)

Fire test report on fire wall connected to an unprotected steel structure by means of fusible links

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WP3: Fire behaviour of a hybrid fire wall solution associated with unprotected steel structure

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ABSTRACT

It is well known that the intrinsic fire resistance of single-storey unprotected steel-framed buildings is largely sufficient to guarantee the evacuation of occupants in the event of fire. In consequence, for this type of building, the main concern of national fire regulations in Europe is how to prevent the spread of fire to the whole building. To achieve this objective, two performances shall be usually satisfied, namely, the appropriateness of constructive systems to ensure that there is no progressive collapse between fire compartments, and the efficiency of fire walls to stop the fire inside the initial compartment regardless of the state of structures exposed to fire. In practice, many constructional solutions can be implemented in order to preserve the integrity of the fire walls, while accepting that the fire exposed part of the structure may collapse. One of the most common solutions is to place a non-load bearing wall between two independent steel structures and to connect it to them by means of "fusible" links. In fire situation, these fusible links have to allow the wall to be disconnected from the structure affected by fire without endangering the separating function of the wall, which shall remain fixed to the steel structure on the other side of the wall and therefore not exposed to fire. However, due to the lack of corresponding scientific evidence, questions are being very often raised about the real efficiency of such systems in fire situation, which, in certain cases, have also to provide an adequate seismic resistance, if they are used in seismic areas.

Today, concrete or masonry wall solutions are frequently used for the compartmentation of buildings, predominately for low-rise commercial and industrial steel buildings. However, as an alternative, lightweight sandwich panels (comprising two thin flat metal faces and an insulated core) could become an appropriate steel fire wall solution, offering numerous benefits in comparison to other solutions, including fire resistance, durability, flexibility, easy dismounting and fast construction times. But, there is an evident lack of technical information about the adequate fire performance of such type of wall solutions when they are implemented in single-storey buildings with unprotected steel structure, which constitutes a major obstacle for their large use.

In this context, the overall goal of the FISHWALL project is to develop a design guidance and recommendations for an innovative hybrid fire wall solution based on lightweight steel-faced sandwich panels associated with unprotected steel structure under both fire and seismic actions, but considered individually. This will be achieved through the following specific tasks: i) Establishing of a full range of experimental evidence about the fire and seismic behaviour of the investigated hybrid fire wall solution by carrying out a number of tests; ii) Investigating intensively the fire and seismic performances of the above hybrid fire wall solution in combination with unprotected single-storey steel structures through a variety of parametric numerical studies by means of validated FE numerical models; iii) Developing both cost-effective and innovative “fusible” connection systems for fire walls to be used in combination with unprotected steel structures of single-storey buildings; and iv) Developing a design guidance and practical recommendations for the studied hybrid fire wall and fusible links solutions, on the basis of above studies, from which engineers can carry out very efficient design.

The present report aims at summing up the results of a fire test carried out at the Testing Laboratory of PAVUS according to EN 1363-1 [1] on a partition fire wall connected to an unprotected steel structure by means of fusible links. The detailed fire test report is provided in Annexe of the report.

1 INTRODUCTION

In order to prevent the spread of fire inside buildings, fire safety regulations commonly require buildings to be divided into several zones of limited size and separated by means of partition fire walls. Among the possible wall solutions, the compartmentation of single-storey steel-framed buildings can be achieved by placing a non-load bearing wall between two independent steel structures and to connect it to them by means of "fusible" links. In fire situation, the fusible links have to allow the wall to be disconnected from the structure affected by fire without endangering the separating function of the wall, which shall remain fixed to the steel structure on the other side of the wall and therefore not exposed to fire. Unprotected steel-framed structures exposed to fire conditions usually exhibit two successive steps of structural behaviour. The first step is due to the thermal expansion of the heated members, which results in pushing forces on the neighbouring structures. Then, as steel increases in temperature, it loses its resistance and stiffness and the heated steel structure starts to fall inwards, leading to tensile forces on the neighbouring structures. In case of a fire wall between adjacent steel structures, a requirement is to ensure that this fire wall does not fail with the steel structure submitted to fire. Thus, fusible links must be designed to resist the pushing phase and to fail for the tensile phase. Although partition fire walls made of sandwich panels may be designed to resist wind-loadings, such type of wall is susceptible to damages during the pushing phase because of the limited capacity of sandwich panels to resist out-of-plane horizontal forces. Thus, this may lead to a partial or a full loss of the fire performance of the wall (integrity and insulation performance) if no action is taken. Consequently, any link failure that would allow the fire-exposed steel structure to meet the sandwich panels must be avoided. Furthermore, the fusible system should also allow the transfer of pushing forces through the wall on the steel structures located on the fire-unexposed side. At normal temperature, the fusible links behave like conventional steel connection systems. So, they are designed to withstand all combinations of loads commonly checked for conditions of normal use of the wall and, where applicable, of the structure.

In this context, a fire test was carried out at the Testing Laboratory of PAVUS on a partition fire wall made of sandwich panels connected to an unprotected steel structure by means of two fusible link solutions based on common steel joints with aluminium bolts acting as the fusible component.

The present report aims at summing up the results of this fire test. The detailed fire test report is reported in Annexe. A detailed analysis and interpretation of the test results will be provided later during the validation work of three-dimensional FE numerical models developed in WP3 for the thermal-mechanical analysis of “fusible” links under fire situation.

2 TESTS SPECIMENS AND TESTS ARRANGEMENT

Only a short description of the test specimen and test arrangement is given hereafter. More detailed information are given in Appendix A, which contains the fire test report provided by PAVUS.

At the progress meeting held in PARIS in October 2022, it should be noted that it was decided to change the test arrangement initially planned [4], by including fusible systems on both sides of the partition fire wall, and not on the fire-exposed side only.

Figure 1 shows the schematic of the final designed test arrangement. The test specimen consisted of a fire wall made of lightweight sandwich panels with 175 mm thick spanning horizontally between two fire-unexposed steel columns connected to steel structures, either steel portal frames on the fire-exposed side or either single steel columns on the other side, using two different "fusible" systems. Each portal frame was constituted of a single steel column connected by a moment-resisting bolted connection to a steel beam supported at its free end by means of a fork support fixed to a fire-protected steel beam as part of a horizontal supporting frame placed around the furnace (see Figure 2). The fork support was designed to allow a free axially thermal expansion of beams along 50 mm. Steel base plates were welded to the bottom of columns and bolted to steel plates placed on the ground floor of the furnace. The bottom end of columns located on the fire exposed side were fire protected.

The wall had overall dimensions of 3.2m high by 3m wide. Eurobond Rockspan Extra panels produced by Euroclad were used.

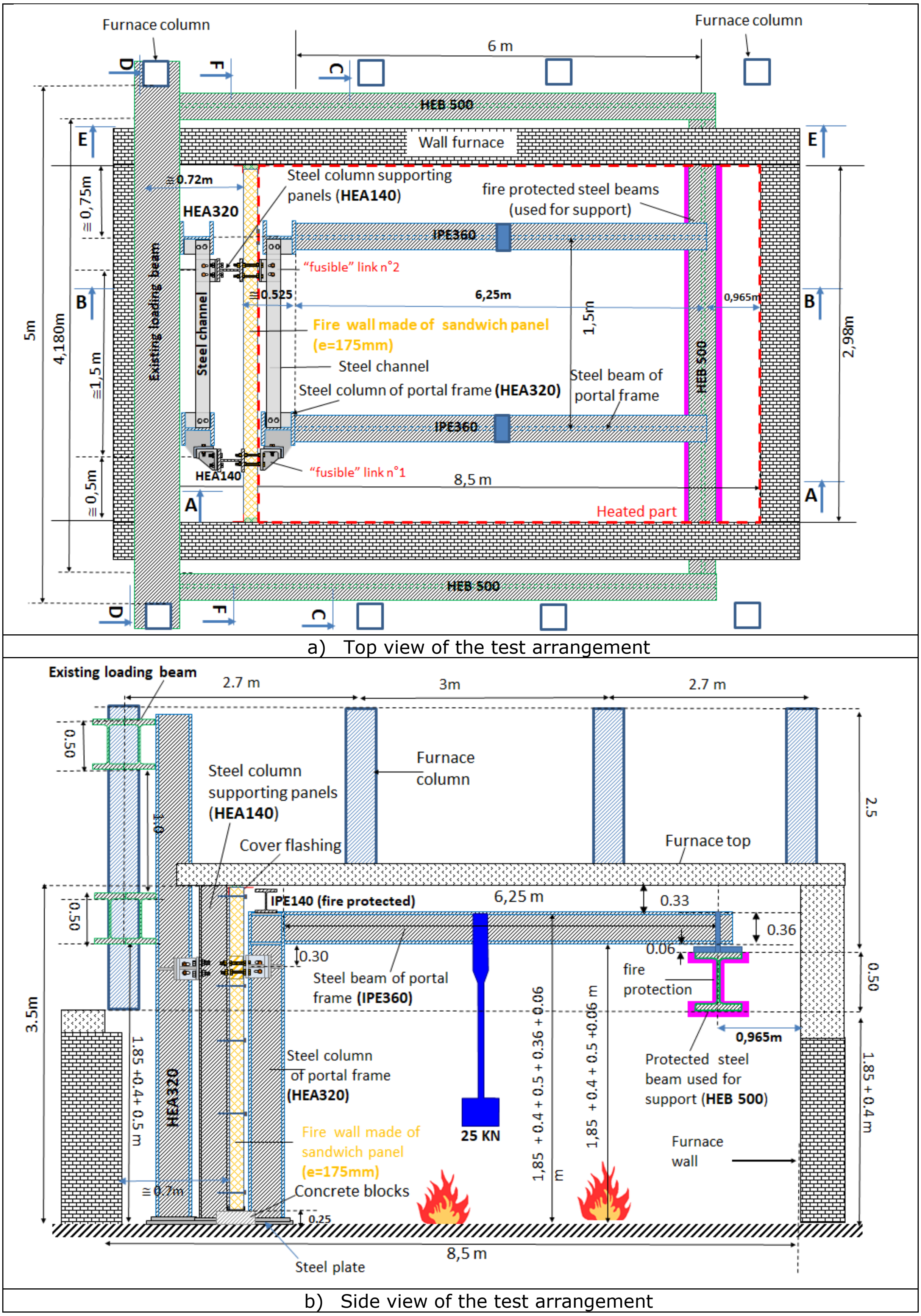
Regarding the "fusible" systems, the following solutions were tested:

- The first link solution is composed of an L-shaped folded plate welded to a gusset plate and a U-shaped steel profile arranged back to back and assembled together with two aluminium bolts (see Figure 3). The gusset steel plate is welded between the column flanges of portal frames while the U-profiles are bolted to the column supporting the sandwich panels, using four threaded steel rods passing through the fire wall on the wall side and four steel bolts on the other side. The steel rods were designed to allow the transfer of pushing forces due to the thermal expansion of the steel portal frames exposed to fire to the structure located on the unexposed side.
- The second link solution consists of an L-shaped steel profile assembled with aluminium bolts to a steel channel spanning horizontally between the portal frame columns, each end of the UPN profile being bolted with slotted holes to a steel stiffener welded between the flanges of the portal frames columns (see Figure 4). These slotted holes allow the free longitudinal thermal expansion of the UPN. The L-shaped profiles are attached to the wall steel column by means of four threaded steel rods passing through the fire wall on the wall side and four steel bolts on the other side.

Photos of the fusible links inside the furnace are given in Figure 5.

The dimensions of steel portal frames were chosen according to the common practice, taking into account the limited dimensions and limited loading capacities of the testing equipment and the availability of steel profiles at the time of design. Regarding the mechanical loading apply to each portal frame exposed to fire, it was decided to use the highest possible load. Thus, a vertical loading of 25 kN was applied at the beam's mid-span using dead weights, as illustrated in Figure 6. Adequate fixations providing hinges were used between the dead weights and the beams to prevent as far as possible unwanted additional moments in the portal frames. Regarding the heating conditions, the temperature rise in the furnace was controlled to follow as close as possible the ISO-834 standard fire curve.

During the test, the furnace temperatures, temperatures at different locations along the steel members, temperatures in fusible links, temperatures of the unexposed side of the wall and the displacements of the test specimen were recorded. The overall behaviour of the test specimen was also monitored visually. Since displacement sensors cannot be installed inside the furnace due to the high temperatures, draw-wire displacement sensors were installed outside the furnace, then attached to the test specimen using stainless steel rods to measure both vertical and horizontal displacements at different locations along the heated steel portal frames: at the beam-to-column connections and at beam's mid-span. Also, the failure and collapse of both steel portal frames and fusible links exposed to fire was monitored and documented.



a) Top view of the test arrangement

b) Side view of the test arrangement

Figure 1: Schematic of the test arrangement

Figure 2: Manufacture and preparation of the test specimen

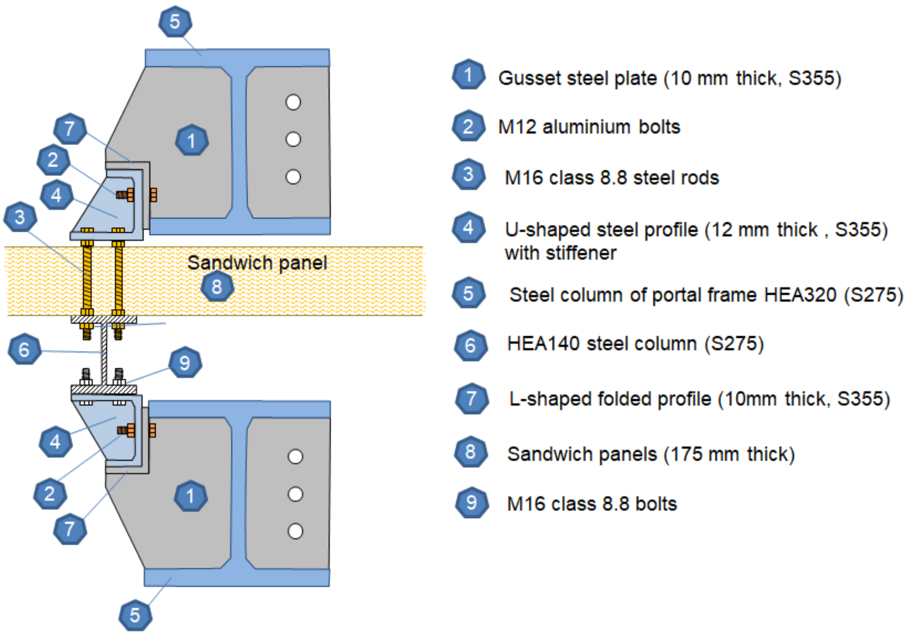


Figure 3: Schematic of the first link solution

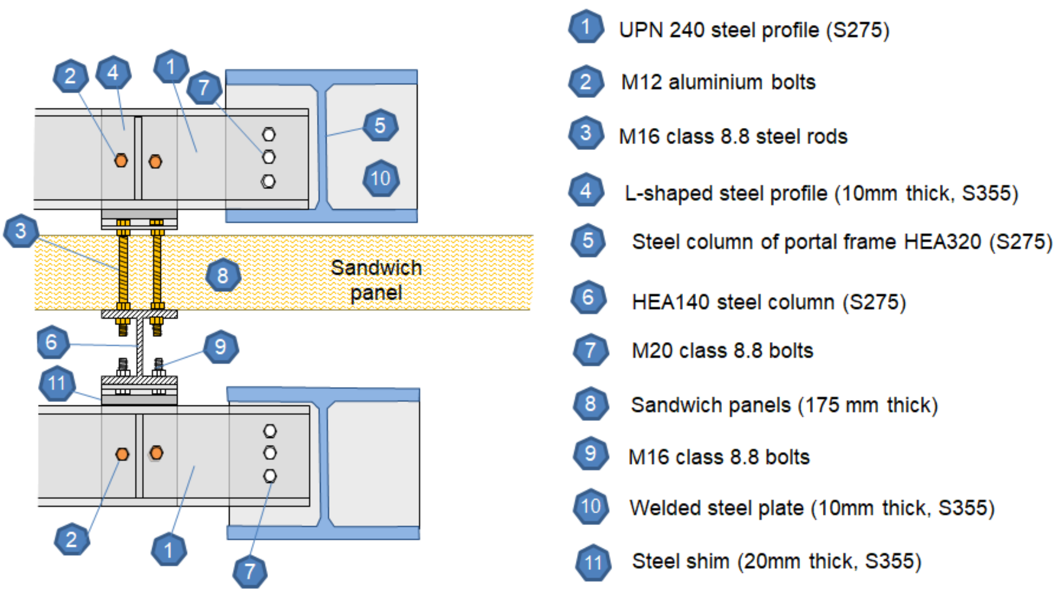


Figure 4: Schematic of the second link solution

Figure 5: View of fusible systems inside the furnace

Figure 6: Loading system

3 TEST RESULTS AND MAIN OBSERVATIONS

Only brief results and observations are given hereafter. Detailed test results are reported in Appendix A.

Some examples of data recorded during the test are illustrated from Figure 7 to Figure 11.

As expected, the steel frames failed due to the lateral torsional buckling of beams under the combined effect of the applied mechanical load and the temperature rise (see Figure 12). The collapse of steel frames was not simultaneous, with one frame failing before the other: after 27 and 29 minutes of standard fire exposure, respectively.

The results confirmed the appropriate fire behaviour of tested fusible system solutions, which allowed the wall to be disconnected from the steel portal frames exposed to fire without endangering the separating function of the wall, which remained fixed to the steel structure on the other side of the wall and therefore not exposed to fire (see Figure 14).

However, it should be noted that the temperature criteria related to the insulation performance of the wall was reached after 18 minutes only, on a thermocouple placed in the upper corner of the wall. At 69th minute of the test, there was also integrity loss of the wall due to sustained flaming in the half of the wall's height, on one vertical edge (see Figure 13). This is mainly because the steel flashings placed on the edges of the wall could not be fixed to the furnace walls, therefore the sandwich panels were on vertical sides without fixing.

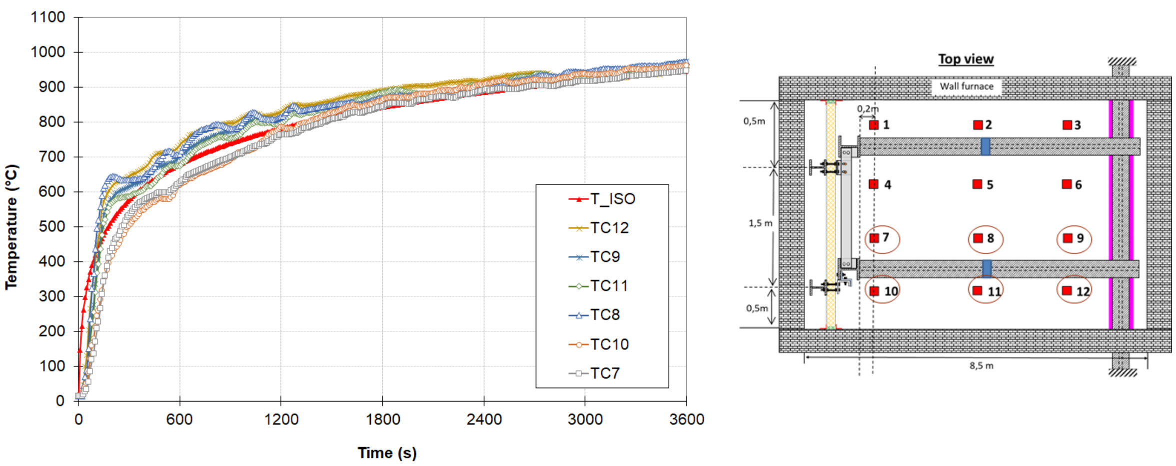


Figure 7: Example of hot gas temperature-time curves recorded during the test

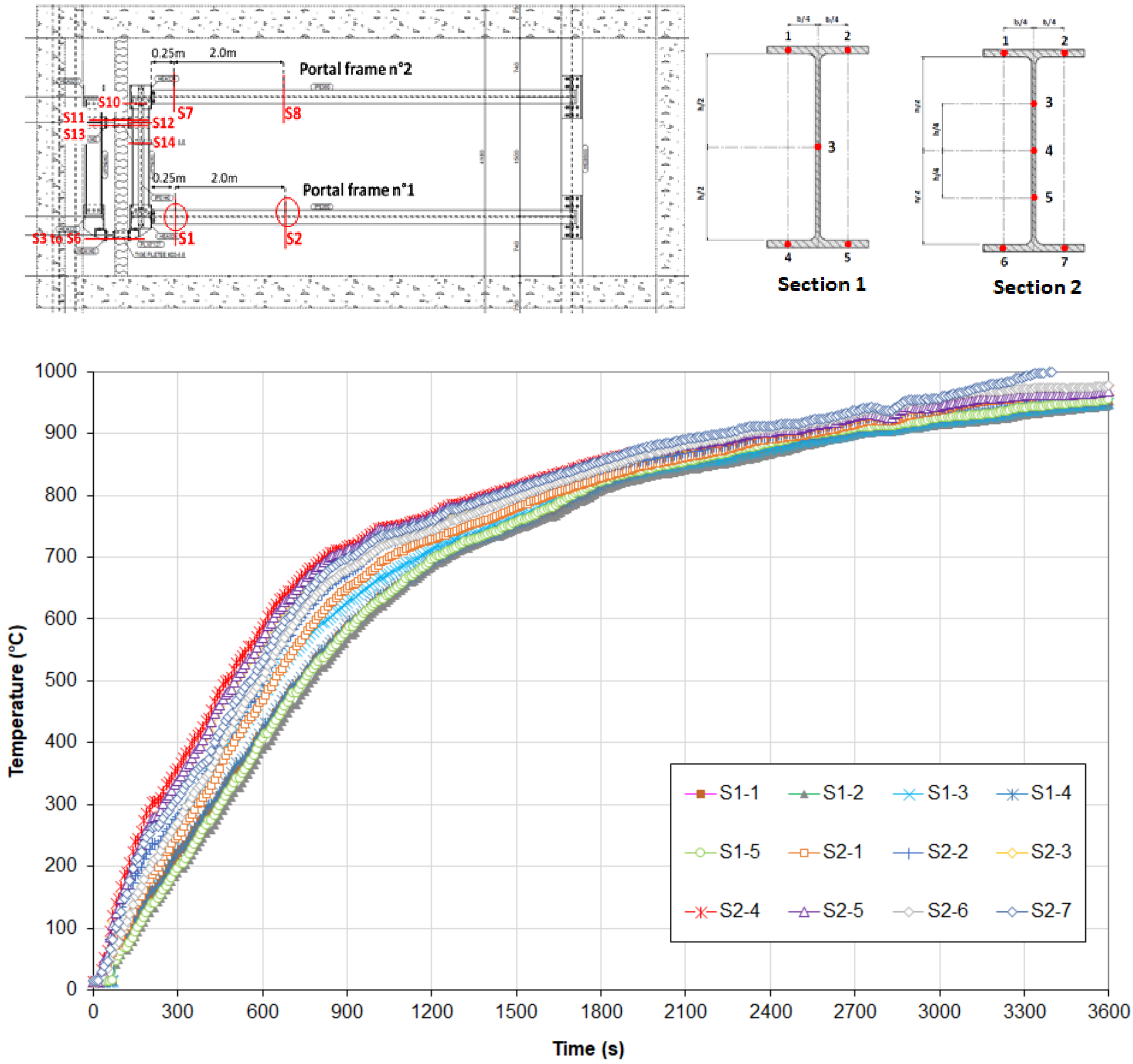


Figure 8: Example of temperature-time curves recorded along beams during the test

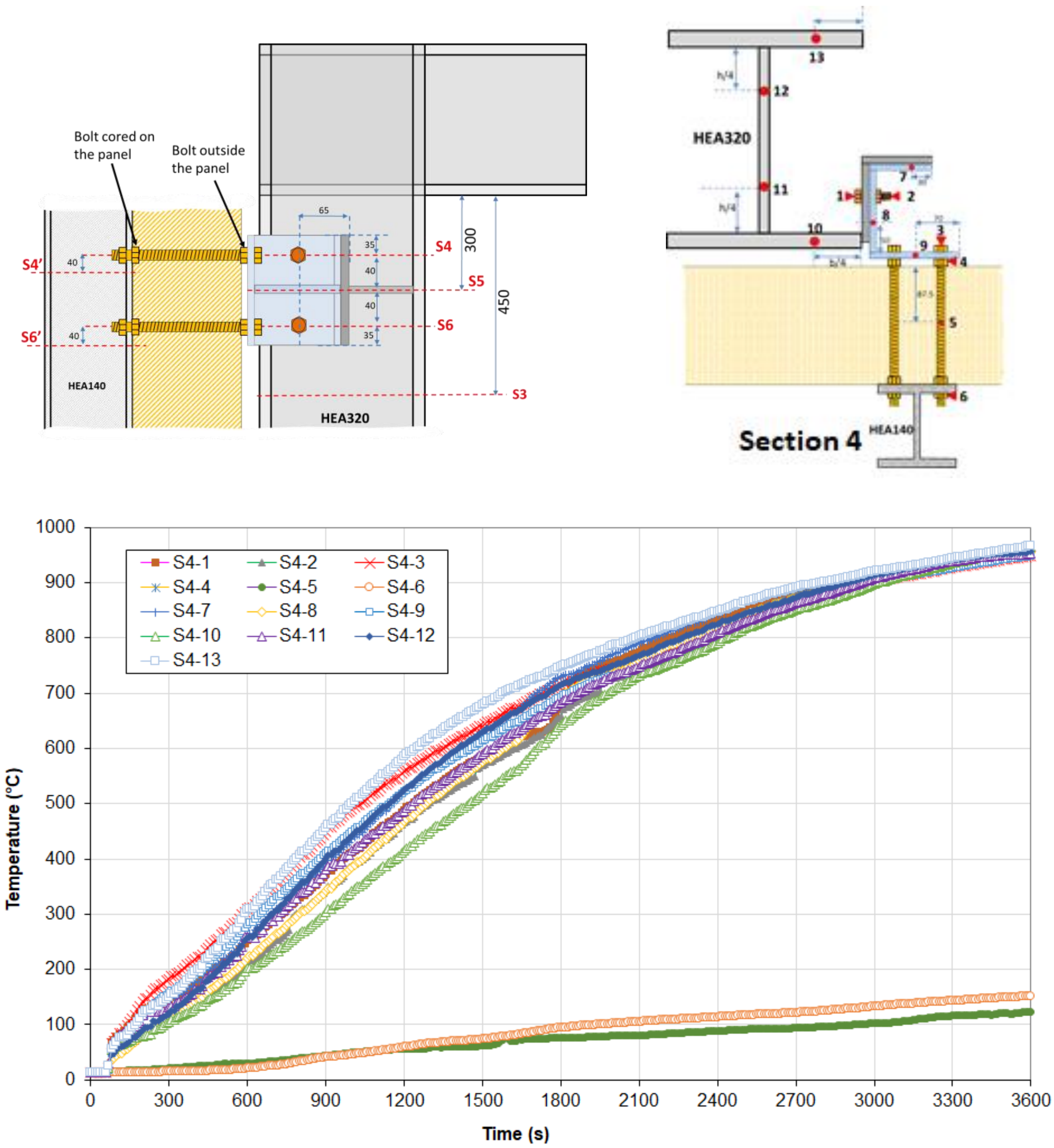
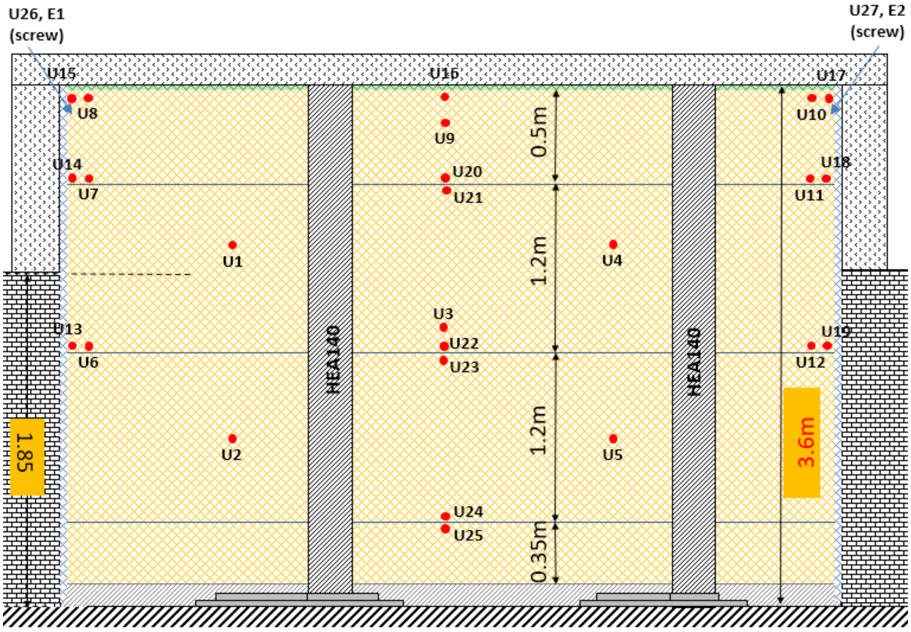


Figure 9: Example of temperature-time curves recorded on fusible links during the test



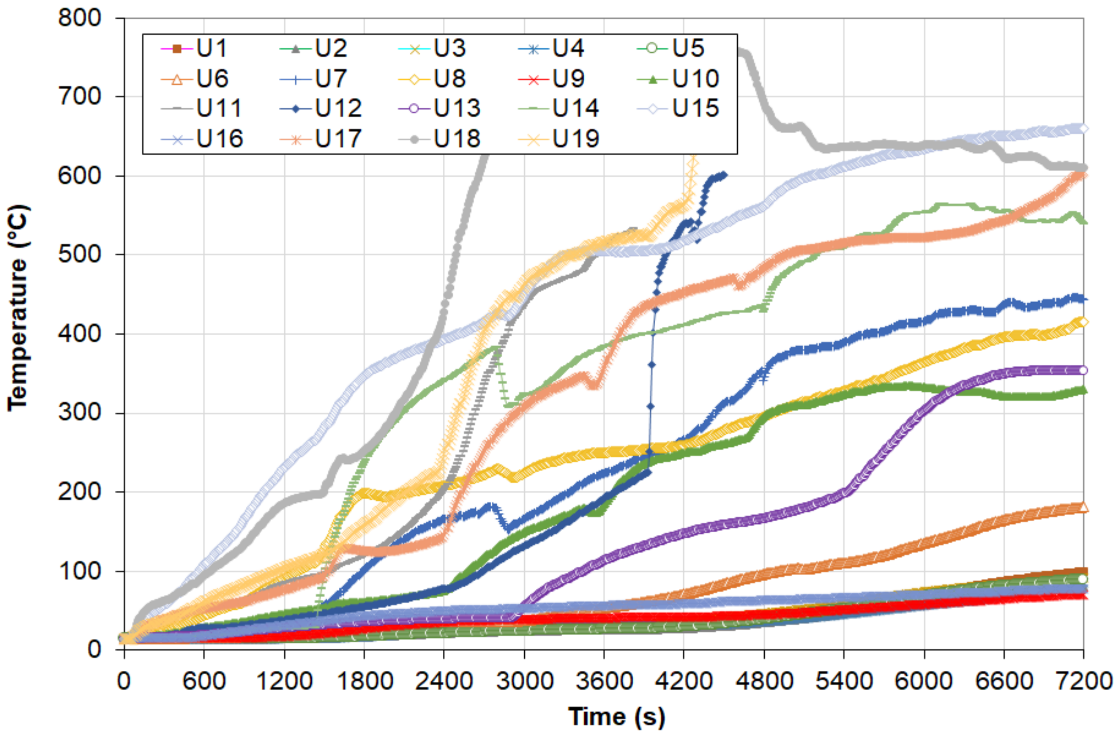
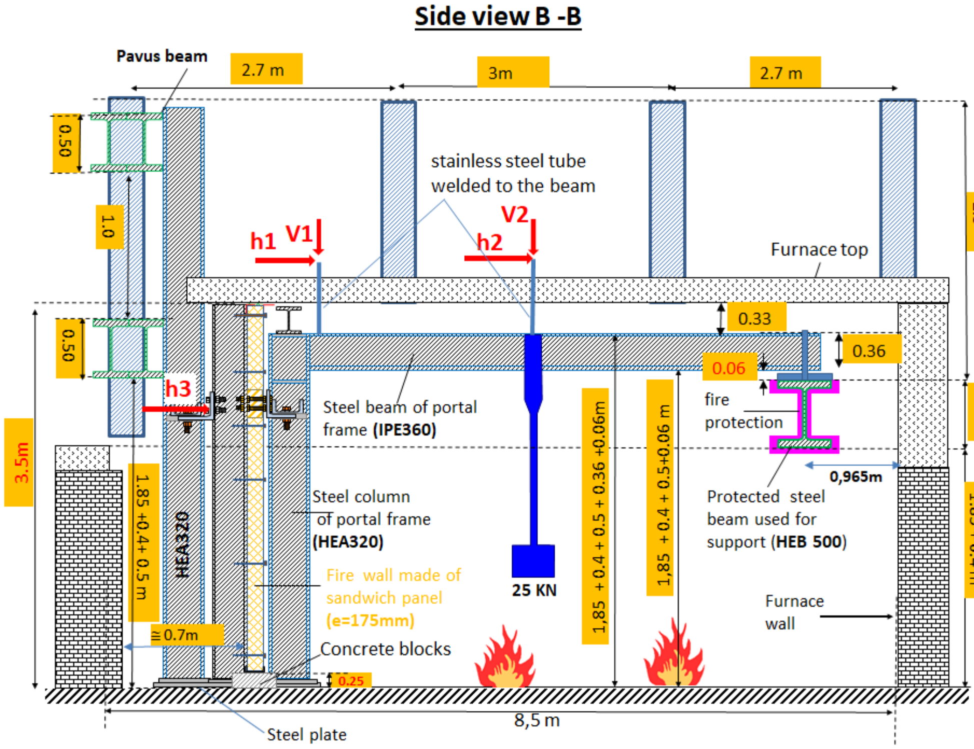


Figure 10: Example of temperature-time curves recorded on the fire-unexposed side of the wall



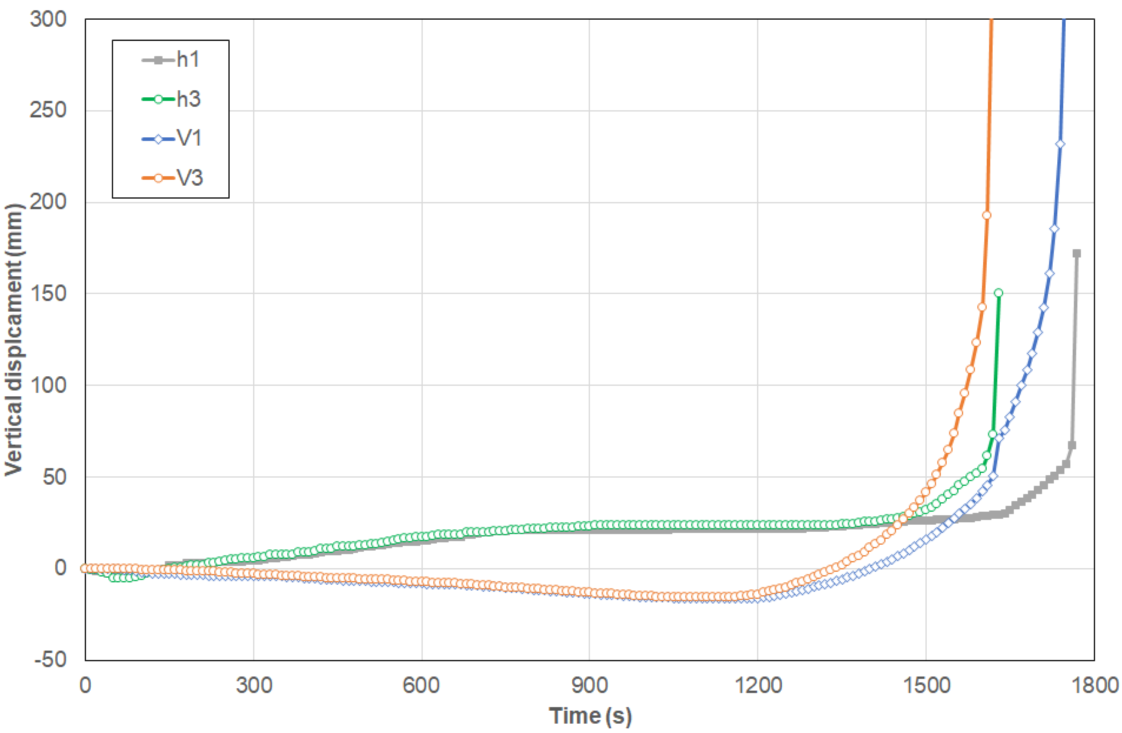
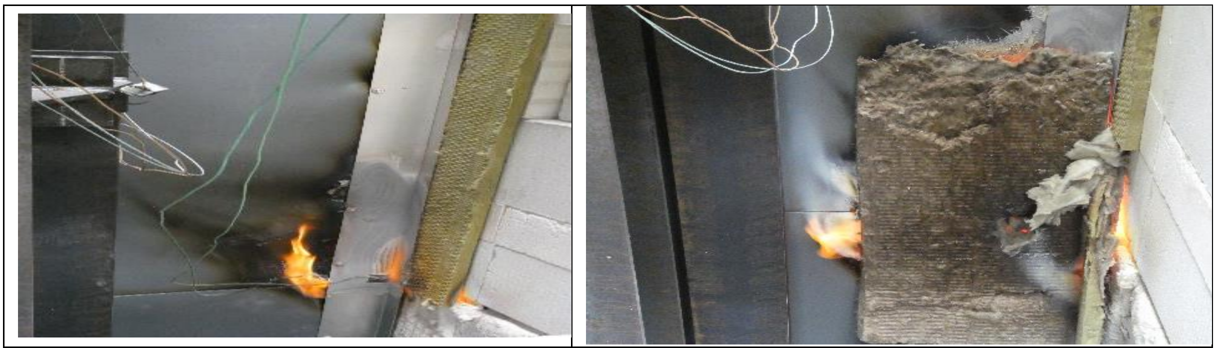


Figure 11: Example of displacement-time curves recorded during the test

Figure 12: View of the test specimen during the test



a) After 69 minutes b) After 110 minutes

Figure 13: Sustained flaming of the vertical edge of the wall

Figure 14: View of the test specimen after the test

4 CONCLUSIONS

This report aimed at summing up results of the fire test carried out at the Testing Laboratory of PAVUS on a partition fire wall made of sandwich panels connected to an unprotected steel structure by means of fusible links. For testing, two fusible link solutions based on common steel joints with aluminium bolts acting as the fusible component were investigated and Eurobond Rockspan Extra panels with 175mm thick produced by Euroclad were used. Two sets of data were recorded during tests, including the temperatures of both fire and steel profiles and the deflection of steel portal frames. All measured values were recorded in Excel sheets to provide data easily to use. The overall behaviour of the test specimen was also monitored visually.

The test result confirmed the appropriate fire behaviour of tested fusible system solutions which allowed the wall to be disconnected from the steel portal frames exposed to fire without endangering the separating function of the wall, which remained fixed to the steel structure on the other side of the wall and therefore not exposed to fire. There was also integrity loss of the wall due to sustained flaming in the half of the wall's height, on one vertical edge. However, this would not have happened if steel flashings placed on the edges of the wall could have been fixed to the furnace walls, as usually happens in standard fire test on walls.

A detailed analysis and interpretation of the test results will be provided later during the validation work of three-dimensional FE numerical models developed in WP3 for the thermal-mechanical analysis of "fusible" links under fire situation.

5 REFERENCES

[1] EN 1363-1: Fire resistance tests - Part 1: General requirement, CEN, 2021.

[2] EN 1364-1, Fire resistance tests for non-loadbearing elements - Part 1: Walls, CEN, 2017.

[3] EN 1363-2: Fire resistance tests - Part 2: Alternative and supplementary procedures, CEN, 2000.

[4] Deliverable D1.4: Design of tests, RFSC project FISHWALL, 2020.

[5] Fire resistance test report n° Pr 23-2.085-En on a fire wall connected to an unprotected steel structure by means of fusible links, 04-10-2023, PAVUS.

APPPENDIX A. FIRE TEST REPORT N°PR-23-2.085-EN

PAVUS, a.s.
AUTHORIZED BODY 216
NOTIFIED BODY 1391
ACCREDITED TESTING LABORATORY
EGOLF MEMBER

Order No.: Z210220040

FIRE TESTING LABORATORY VESELÍ NAD LUŽNICÍ
Testing Laboratory No. 1026 accredited by ČIA
Notified Testing Laboratory
workplace Veselí nad Lužnicí

FIRE RESISTANCE TEST REPORT

No. Pr-23-2.085-En

issued on 2023-10-04

For product

Fire wall connected to an unprotected steel structure by means of fusible links (Task 3.5)

Sponsor: **Consortium of the RFCS project FISHWALL**

Test method:

ČSN EN 1363-1
» Fire resistance tests - Part 1: General requirements «

Test Report includes 57 pages
(6 pages of text + 4 Annexes)

Number of copies: 2
Copy number: 1

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1 INTRODUCTION

The fire resistance test of a fire wall made of steel-faced sandwich panels connected to an unprotected steel structure by means of fusible links was performed based on the order of Consortium of the RFCS project FISHWALL in Fire Testing Laboratory PAVUS, a.s. in Veselí nad Lužnicí.

The test was prepared, performed and assessed on the base of following documents:

[1] ČSN EN 1364-1:2017 Fire resistance tests for non-loadbearing elements - Part 1: Walls

[2] ČSN EN 1363-1:2021 Fire resistance tests - Part 1: General requirements

[3] ČSN EN 1363-2:2000 Fire resistance tests - Part 2: Alternative and supplementary procedures

[4] ČSN EN 13381-4:2018 Test method for determining the contribution to the fire resistance of structural members - Part 4: Applied passive protection to steel members

[5] ČSN EN 13501-2:2017 Fire classification of construction products and building elements - Part 2: Classification using test data from resistance fire tests, excluding ventilation services

[6] ILAC-G17:01/2021 Guidelines for Measurement Uncertainty in Testing

[7] JCGM 100:2008 GUM 1995 with minor corrections, Evaluation of measurement data - Guide to the expression of uncertainty in measurement (Available from www.BIPM.org)

[8] Specimen-related technical documentation delivered by the test sponsor

For the purposes of this document, definitions given in [1] ÷ [7] together with following abbreviations apply:

ČIA	Český institut pro akreditaci, o.p.s. (Czech Institute for Accreditation)
ATL	accredited testing laboratory
TC	thermocouple
TM	thermometer (sheathed TC)
PTM	plate thermometer fit with a TM ∅ 2 mm
EF	exposed specimen face
UF	unexposed specimen face
RTC	roving thermocouple

2 TEST SUBJECT

The fire test aimed at checking the structural behaviour of two fusible link solutions connecting a non-loadbearing fire wall made of sandwich panels spanning horizontally between two fire-unexposed steel columns to unprotected steel structures consisting of either steel portal frames on the fire-exposed side or either single steel columns on the other side.

3 TEST SPECIMEN

The test specimen consisted of a non-loadbearing fire wall made of sandwich panels spanning horizontally between two fire-unexposed HEA 140 steel columns, connected to unprotected steel structures (consisting of either steel portal frames on the fire-exposed side or either single HEA 320 steel columns on the other side) by means of two different fusible systems.

<u>Description of steel structures:</u>

Each portal frame consisted of a single steel column (HEA 320) connected by a moment-resisting bolted connection (using 8 pcs of M20x60 bolts) to a steel beam (IPE 360) supported at its free end by means of fork support fixed to an HEB 500 beam as part of an horizontal supporting frame placed around the furnace. The part of the HEB 500 located inside the furnace was adequately fire protected with mineral wool th. 50 mm, density 100 kg/m^3, wrapped with ceramic blanket insulation Cerablanket 1430, th. 13 mm, density 128 kg/m^3.

The two steel portal frames were linked together with an IPE 140 steel beam, fixed at the top end of columns.

The IPE 140 beam was all around fire protected with mineral wool th. 50 mm and Cerablanket 1430, th. 13 mm. The columns of the portal frames were around 3.2 m high, while the beams span was 6.25 m approximately.

On UF, the HEA 320 steel columns were also fixed to the horizontal supporting frame placed around the furnace. The columns height was approximately 4.8 m.

Steel base plates with 15mm thickness were welded to the bottom of columns and bolted to large steel plates 700x30 mm placed on the ground floor of the furnace. The bottom end of columns located on the fire exposed side were fire protected.

The grade of steel was S275 for steel members and steel plates and 8.8 for bolts.

Description of fusible links:

On both side of the wall, steel structures (steel portal frames or single HEA 320 steel columns) were connected to the wall construction through two types of fusible links.

The first link solution (No. 1) was composed of a L-shaped folded plate welded to a gusset plate and a U-shaped steel profile (with 10 mm thickness) arranged back to back and assembled together with two M12×50 aluminium bolts. The gusset steel plate was welded between the flanges of the column of portal frames while the U-profiles were bolted to the column supporting the sandwich panels, using four M16 threaded steel rods passing through the fire wall on the wall side and four M16×40 steel bolts on the other side. The U-shaped steel profile was reinforced with a 10 mm thick steel stiffener.

The second link solution (No. 2) consisted of an L-shaped steel profile (with 10 mm thickness) assembled with M12×50 aluminium bolts to a UPN 240 steel channel spanning horizontally between the portal frame columns, each end of the UPN profile being bolted with three M20×50 bolts to a 10mm thick steel stiffener welded between the flanges of the portal frame columns. Slotted holes were made to allow the free longitudinal thermal expansion of the UPN 240. The L-shaped profiles were attached to the wall steel column by means of four M16 threaded steel rods passing through the fire wall on the wall side and four M16×40 steel bolts on the other side.

The grade of steel was S275 for steel profiles and S275 or S355 for steel plates and 8.8 for bolts and rods. The grade of aluminium bolts was P60 (made from the aluminium alloy 7075).

Description of the wall construction:

The wall was a non-loadbearing wall measuring 3 000 mm wide × 3 200 mm high × 175 mm thick. It was made of sandwich panels horizontally oriented and consisting of 2 pcs of Eurobond Rainspan Extra panels with mineral wool as an insulation core. The nominal density of mineral wool was 120 kg/m^3. Each panel had dimensions of 1 200 mm (stock width) × 2 995 mm (length) x 175 mm (thickness). One panel was reduced to 500 mm in width and it was mounted to the upper edge of the wall, so that the horizontal contact of panels was 500 ± 150 mm far from the upper edge. Another panel of width 350 mm was mounted to the lower edge of the wall. On EF, the panels had metal sheet, th. 0.5 mm (interior side) and on UF, they had metal sheet, th. 0.5 mm (exterior side). Both sheets were galvanized and coated.

On both vertical sides and on the bottom part of the wall, L-profiles 100x50x2 were mounted on both sides of the wall (on EF and also on UF in the end of the assembly). The profiles were anchored to the bottom aerated concrete lintel of height 250 mm using carbon steel screws TutFast HTF-6.3 x 57 (producer Fixfast Ltd) in spacing of 350 mm. On the sides and the top of the wall these profiles were anchored only to the sandwich panels using screws DrillFast DF2-SS-LS-A15-6.3 x 25 (producer Fixfast Ltd) in spacing of 300 mm, without fixing to the wall of the furnace.

Panels were anchored to HEA140 columns using stainless screws DrillFast DF12-SS-HT-5.5 x 200 (producer Fixfast Ltd) in the direction from EF, in spacing of 500 mm.

The gaps between the test specimen and the rigid construction (concrete lintel or panel, furnace walls) were filled up with mineral wool POWER-TEK BD 660 (manufacturer Knauf Insulation, spol. s r.o.). The nominal density of mineral wool was 100 kg/m^3. The width of the gap was between 20 and 30 mm.

The upper horizontal edge of the wall was left unrestrained in order to enable free specimen moving. The gap between the specimen and the rigid construction of width 50 mm was filled up with mineral wool.

Test specimen related technical documentation delivered by the test sponsor is documented in Annex C.

The specimen was mounted as per [1] cl. 7 and Annex C of this Test Report.

The steel elements were delivered by company Briand CM on 3th April 2023, they were mounted by PAVUS Fire testing laboratory from 14th to 21st April 2023. The specimen of the wall was manufactured and assembled by company Euroclad Group Ltd from 10th to 11th May 2023.

The Testing Laboratory did not participate in extracting elements used for test specimen assembly.

4 TEST PERFORMANCE

4.1 General

The fire resistance test was performed as per [2] on 17th May 2023 in Testing hall PO 1 in horizontal furnace with inner dimensions of 3 000 mm (width) × 8 460 mm (length) × 3 250 mm (height).

Used testing and gauging equipment is stated in Annex A.

4.2 Furnace control

The test furnace was heated with a set of oil burners. In-furnace temperatures were measured by the help of PTMs and recorded at minute intervals. The measuring wires of PTM were distributed uniformly in the region of the loaded beams according to request of the sponsor and [4] cl. 9.2.2, i. e. 500 mm below the soffit of the furnace and 100 mm from the side of the steel beams.

In-furnace temperatures for standard heating curve according to [2] were controlled so that they conformed to the relation according to [2] cl. 5.1.1, within the specified limits (see [2] cl. 5.1.2):

$$T = 345 \log (8t + 1) + 20$$

where T (°C) = required in-furnace temperature in time °C
t (min) = time since the test beginning

The test furnace positive pressure was measured and controlled so that the values correspond to the conditions of [1] cl. 9.2 and [2] cl. 5.2.1 and 9.2.1.

4.3 Specimen measuring

The specimen unexposed face temperatures were taken using K-type disc TCs and recorded at minute intervals. The TCs were fixed on the specimen surface according to [1] cl. 9.1.2.2, 9.1.2.3 and B.3.

K-type thermocouples, the diameter of each wire of 0.5 mm, were used for a measurement of the steel temperature following the consultation between the laboratory and the test sponsor regarding their suitability, see [4]: C.2. Hot junctions of the thermocouples were located according to request of the sponsor and [2]: 9.3, the thermocouples were fixed to the surface by welding and routed according to [4]: Annex C.

The rate of the horizontal and vertical deflections was measured by deflectometers spaced according to request of the sponsor. Since displacement sensors cannot be installed inside the furnace due to the high temperatures, draw-wire displacement sensors were installed outside the furnace, then attached to the test specimen by means stainless steel rods welded to the upper flange of beams to measure both vertical and horizontal displacements at different locations along the heated steel portal frames: at the beam-to-column connections and at beam's mid-span. Total length of stainless steel rods was 800 mm, of which 250 mm was directly in the heated space in the furnace.

One RTC (see [2] cl. 4.5.1.3) was available to measure points where higher temperatures were expected.

The measured points of deflections and the TC positions are described and figured in Annex B.

The initial test conditions met the standard values as per [2] cl. 10.3.

4.4 Loading

A vertical loading of 25 kN was applied at the beam’s mid-span using dead weights made from steel elements, according to request of the sponsor. The loads were applied on the upper flange of beams.

4.5 Ambient temperature

During the test, the ambient temperature was measured using one K-type TM (see [2] cl. 4.5.1.5) according to the conditions of [2] cl. 5.6.

4.6 Conditioning

From the specimen delivery to the Fire Testing Laboratory until the test performance, the specimen was stored in the enclosed ambient of test hall at the air temperature of (15 ± 5) °C and at relative air humidity of (50 ± 5) %.

5 TEST COURSE

Time (min)	Test observation
25.	start of melting of aluminium bolts
26. to 30.	increase of the deflection of both beam’s portal frame and consequential collapse (portal frame No. 1 collapsed earlier)
31.	EF - excessive bending of the end plate of the beam-to-column connection (portal frame No. 2), at the beam upper flange
69.	UF - sustained flaming in the half of the wall’s height on one vertical edge (with repeated further sealing until the end of the test) - **integrity failure**
121.	end of the test at request of the Sponsor

The in-furnace temperatures and pressures met the requirements of [2]. Time relations to the measured temperatures and pressures are specified in Annex B.

6 TEST RESULTS

6.1 Limit state attainment criteria

- **Integrity** (according to [2] cl. 11.2). This criterion means the time in completed minutes for which the test specimen continues to maintain its separating function during the test without either:
  a) causing the ignition of a cotton pad applied in accordance with [2] cl. 10.4.5.2; or
  b) permitting the penetration of a gap gauge as specified in [2] cl. 10.4.5.3; or
  c) resulting in sustained flaming.

- **Insulation** (according to [2] cl. 11.3). This criterion means the time in completed minutes for which the test specimen continues to maintain its separating function during the test without developing temperatures on its unexposed surface which either:
  a) increase the average temperature above the initial average temperature by more than 140 K; or
  b) increase the temperature at any location (incl. RTC) above the initial average temperature by more than 180 K.

6.2 Expression of test results - wall made of sandwich panels

Criterion	Partial criterion	Measured value	Evaluation
Integrity	Cotton pad ignition	68 min	68 min
	Gap gauge passage	120 min, no failure	120 min
	Sustained flaming	68 min	68 min
Insulation	Average temperature	120 min, no failure	68 min [1)]
	Maximum temperature	17 min	17 min

Note:

1) The performance criteria "insulation" shall automatically be assumed not to be satisfied when the "integrity" criterion ceases to be satisfied (see [2] cl. 11.4.2).

6.3 Field of direct application

The results of this fire test have no field of direct application.

6.4 Application of test results

The test results refer only to the tested specimen including the way of its mounting into the construction (see part 2 of this Report).

This report details the method of construction, the test conditions and the results obtained when the specific element of construction described herein was tested following the procedure outlined in ČSN EN 1363-1, ČSN EN 1363-2 and ČSN EN 1364-1. Any significant deviation with respect to size, constructional details, loads, stresses, edge or end conditions other than those allowed under the field of direct application in the relevant test method is not covered by this report.

POŽÁRNÍ ZKUŠEBNA VESELÍ NAD LUŽNICÍ AKREDITOVANÁ ZKUŠEBNÍ LABORATOŘ č. 1026 PAVUS FIRE TESTING INSTITUTE PAVUS, a.s.

The Report and Annex sheets are valid with the embossed stamp only.

NOTIFIED BODY 1391 PAVUS FIRE TESTING INSTITUTE PAVUS, a.s.

Elaborated by: .... Jiří VANĚK, Technical Officer

Approved by: .... Jiří KÁPL, ATL Manager

ANNEX A: TESTING AND GAUGING DEVICES, MEASUREMENT UNCERTAINTY

Test equipment:	**Device registration number:**
Horizontal furnace (+ equipment pressure and temperature control inside the furnace)	0007
Furnace pressure probe	0011
Gap gauge ∅ 6 mm	0112
Gap gauge ∅ 25 mm	0113
Cotton pad frame	0014
Gauging equipment:	**Metrological registration number:**
Differential pressure gauge AMR DPS	3 09 29
Dataloggers Almemo 5990-2	3 10 66, 85
PTM – in-furnace temperature (TM K ∅ 2 mm)	3 10 10
TC (K) – specimen temperature	3 10 14, 3 10 15
TM K ∅ 3 mm – ambient temperature	3 10 09
THERM 2260 + RTC (K)	3 10 13
Winding tape measure	3 01 29
Deflectometer Huggenberger	3 01 39÷42, 55÷58, 60÷62
Stop-watch	3 05 12
Thermo-hygro-barograph	3 13 06
Calliper	3 01 52

Measurement traceability of all measurement equipment is reported in the metrological registration card of the equipment; identified by the same metrological registration number as the equipment.

Quantity measured			**Extended measurement uncertainty**
Name	Symbol	Unit	
Time since the test beginning	t	(min)	3,4 10^{-2}min, for t ≤ 240 min
Integrity disruption time		(min)	< 0,5 min
Temperature: TC or K-type PTM + compensation cable (both of the 2nd tolerance class) + Almemo 5990-2	T	(°C)	$\sqrt{(6{,}40.10^{-6}.T^2 + 1{,}57.10^{1}°C^2)}$, for 40°C ≤ T < 375°C $\sqrt{(8{,}04.10^{-5}.T^2 + 7{,}84°C^2)}$, for 375°C ≤ T ≤ 1000°C
Ambient-to-in-furnace pressure difference	p	(Pa)	$\sqrt{(5.3.10^{-4}.p^2+1{,}1.10^{-5}Pa^2)}$
Weight		(g)	1 g
Deflection (horizontal distortion)		(mm)	1,8 mm

The reported expanded measurement uncertainty is stated as the combined standard measurement uncertainty multiplied by the coverage factor *k* = 2 such that the coverage probability corresponds to approximately 95 %.", see [6] and [7].

The measurement uncertainty arising from sampling is not included in the expanded measurement uncertainty. "Because of the nature of fire resistance testing and the consequent difficulty in quantifying the uncertainty of measurement of fire resistance, it is not possible stated a degree of accuracy of the result", see EN 1363-1: 12.1 w).

ANNEX B: MEASUREMENT

TEMPERATURE AND PRESSURE IN FURNACE, AMBIENT TEMPERATURE

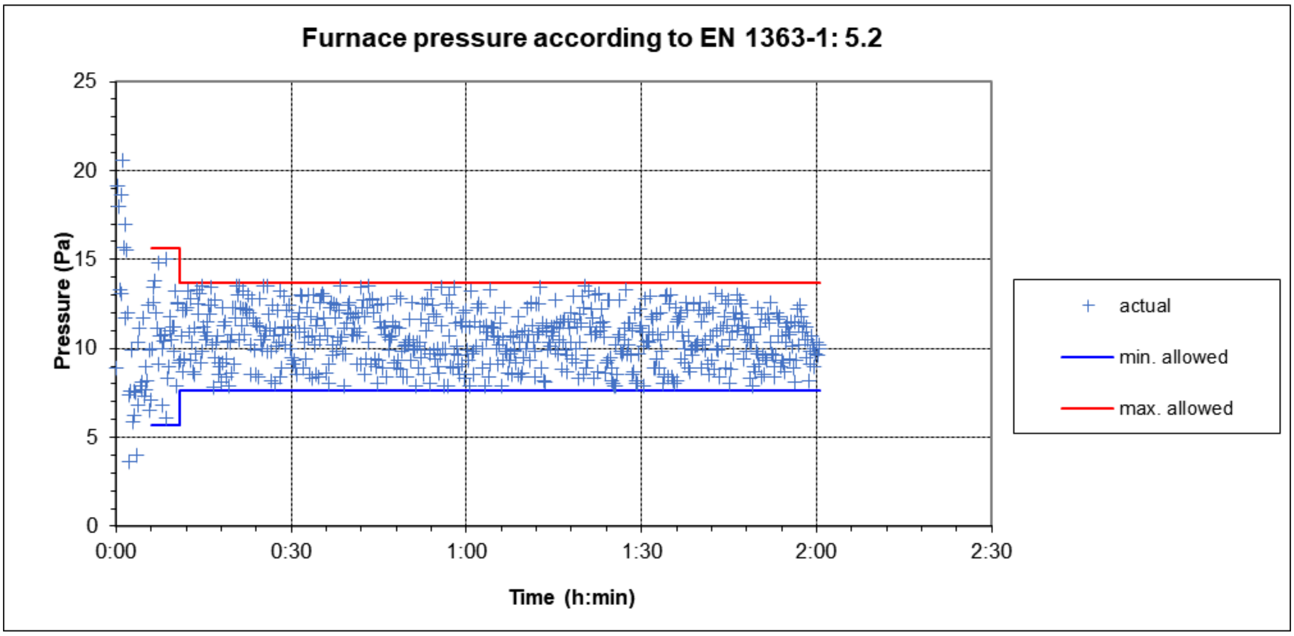
Test conditions according to EN 1363-1: 5

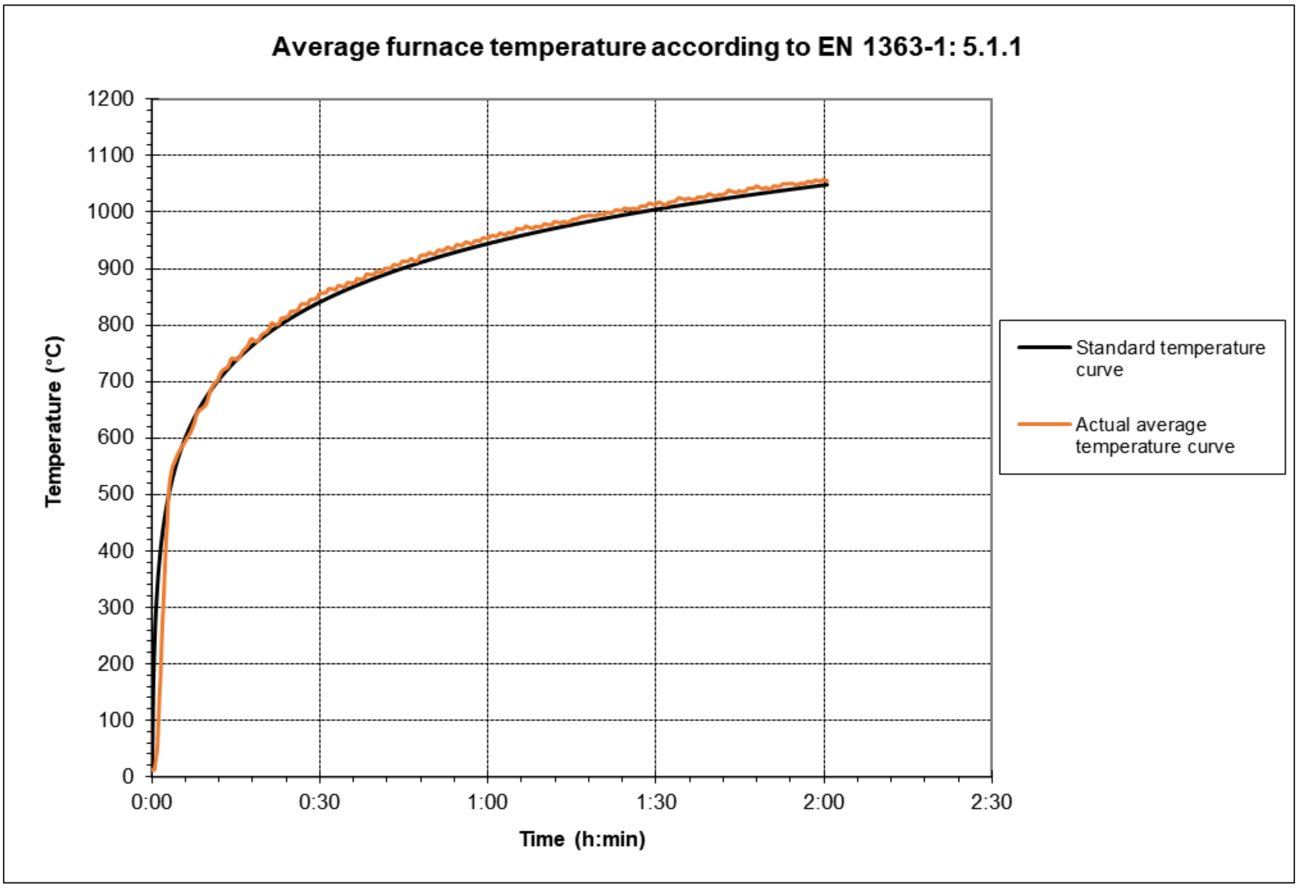
Time	Furnace temperatures														Deviation d_e			Deviation from T		Probe pressure			Ambient
	T	50	51	52	53	54	55	60	61	62	63	64	65	avg	shall be within		actual	min	max	shall be within		actual	temperature
(h:min:s)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(%)	(%)	(%)	(°C)	(°C)	(Pa)	(Pa)	(Pa)	(°C)
0:00:00	20	14	14	14	14	14	14	14	14	14	14	14	14	13								8.9	15
0:05:00	576	643	614	587	633	501	532	544	598	603	581	482	530	580			-20.5					7.7	15
0:10:00	678	733	699	674	708	619	624	636	689	709	695	592	630	671	-15	15	-9.1	-87	55	5.7	15.7	9.8	15
0:15:00	739	797	773	753	780	690	697	720	764	780	782	675	707	739	-12.5	12.5	-5.2	-63	58	7.7	13.7	11.2	15
0:30:00	842	890	862	884	868	861	842	845	863	881	881	815	857	856	-5.0	5.0	-1.7	-27	48	7.7	13.7	11.8	16
0:45:00	902	940	919	936	928	921	904	912	919	939	933	879	911	913	-3.8	3.8	-0.6	-24	38	7.7	13.7	9.3	15
1:00:00	945	955	974	955	972	962	947	980	976	987	966	934	954	954	-2.5	2.5	-0.2	-12	42	7.7	13.7	12.1	15
1:15:00	979	983	1000	982	997	990	981	1006	1003	1014	993	973	988	987	-2.5	2.5	0.1	-7	35	7.7	13.7	11.2	15
1:30:00	1006	1014	1029	1012	1026	1024	1013	1032	1030	1033	1019	1003	1019	1014	-2.5	2.5	0.2	-11	27	7.7	13.7	11.3	15
1:45:00	1029	1036	1047	1029	1044	1039	1032	1052	1052	1050	1038	1025	1036	1037	-2.5	2.5	0.3	-4	23	7.7	13.7	10.5	15
2:00:00	1049	1051	1066	1051	1065	1060	1055	1073	1068	1077	1061	1050	1059	1057	-2.5	2.5	0.4	-5	28	7.7	13.7	10.3	15
2:00:30	1050	1051	1065	1051	1065	1059	1054	1071	1067	1076	1061	1051	1059	1056	-2.5	2.5	0.4	-7	27	7.7	13.7	10.2	15

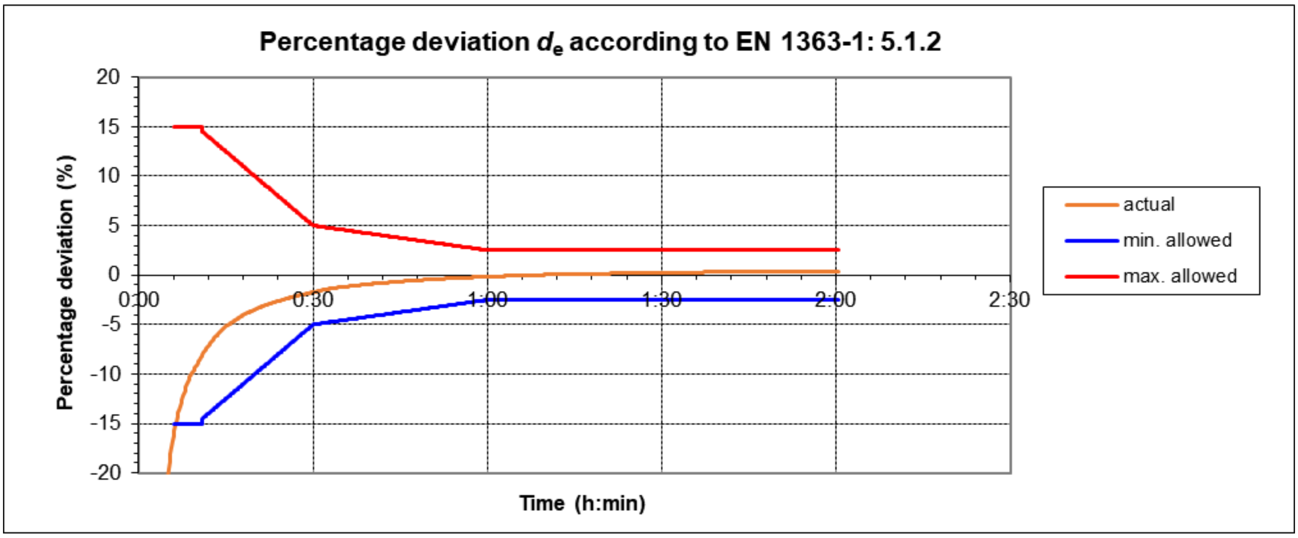
Key

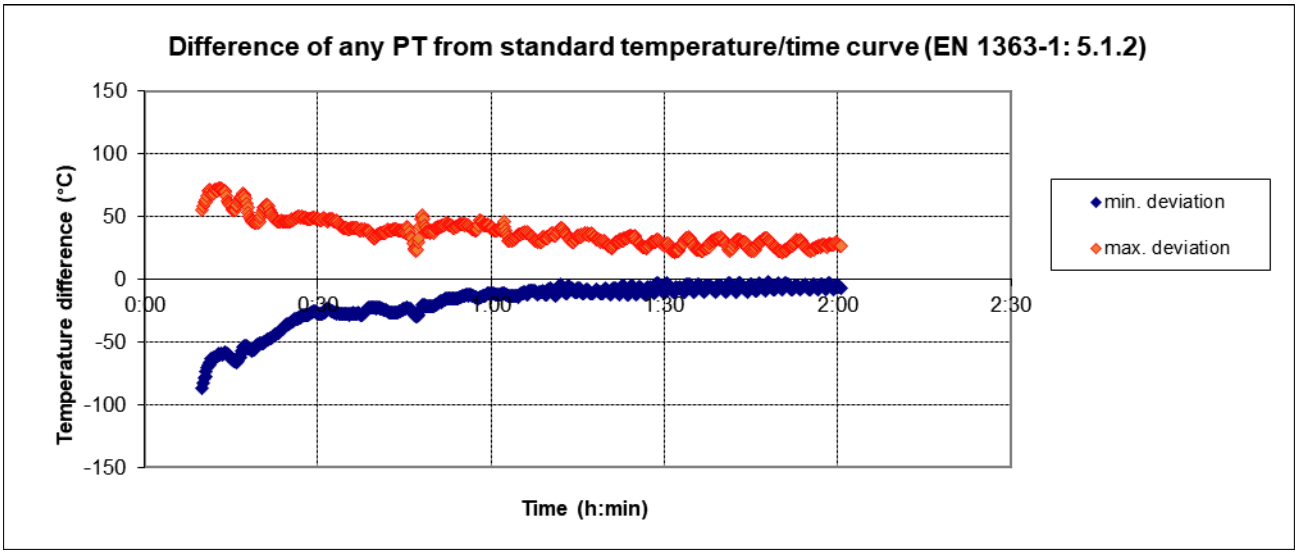
t is the time, in min;
T is the standard average furnace temperature, in °C, $\{T\} = 345.\log_{10}(8\{t\}+1) + 20$;
avg is the actual average furnace temperature, in °C;
d_e is the percentage deviation in the area of he actual average temperature/time curve from the area of the standard temperature/time curve;

"Pressure" is the difference of the pressure in the furnace and the ambient pressure at the same hight level:
The pressure of 20.0 Pa is required 100 mm below underside of the separating element
Then the pressure of 10.7 Pa is expected in pressure sensor 1200 mm below underside of the separating element


Furnace pressure according to EN 1363-1: 5.2
Pressure (Pa)
25
20
15
10
5
0
0:00
0:30
1:00
1:30
2:00
2:30
Time (h:min)
actual
min. allowed
max. allowed


Average furnace temperature according to EN 1363-1: 5.1.1
Temperature (°C)
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
0:00
0:30
1:00
1:30
2:00
2:30
Time (h:min)
Standard temperature curve
Actual average temperature curve


Percentage deviation d_e according to EN 1363-1: 5.1.2
Percentage deviation (%)
20
15
10
5
0
-5
-10
-15
-20
0:00
0:30
1:00
1:30
2:00
2:30
Time (h:min)
actual
min. allowed
max. allowed


Difference of any PT from standard temperature/time curve (EN 1363-1: 5.1.2)
Temperature difference (°C)
150
100
50
0
-50
-100
-150
0:00
0:30
1:00
1:30
2:00
2:30
Time (h:min)
min. deviation
max. deviation

Measuring points

Purlin 1		
Drawing		Datalogger
S1-	1	00
	2	01
	3	02
	4	03
	5	04
S2-	1	30
	2	31
	3	32
	4	33
	5	34
	6	35
	7	36
S3-	1	05
	2	06
	3	07
	4	08
	5	09
S4-	1	10
	2	11
	3	12
	4	13
	5	14
	6	15
	7	16
	8	17
	9	18
	10	19
	11	20
	12	21
	13	22
S4´-	1	23
	2	24
S5-	1	25
	2	26
	3	27
S6-	1	28
	2	29
	3	30
	4	31
	5	32
	6	33
S6´-	1	34
	2	35

Purlin 2		
Drawing		Datalogger
S7-	1	36
	2	37
	3	38
	4	39
	5	40
S8-	1	40
	2	41
	3	42
	4	43
	5	44
	6	45
	7	46
S9-	1	41
	2	42
	3	43
	4	44
	5	45
S10-	1	46
	2	47
	3	48
	4	49
	5	50
	6	51
S11-	1	52
	2	53
	3	54
	4	55
	5	56
	6	57
	7	58
	8	59
S12-	1	60
	2	61
	3	62
	4	63
	5	64
S13-	1	65
	2	66
	3	67
	4	68
	5	69
	6	70
	7	71
	8	72
	9	73
S14-	1	74
	2	75
	3	76
S15-	1	77
	2	78

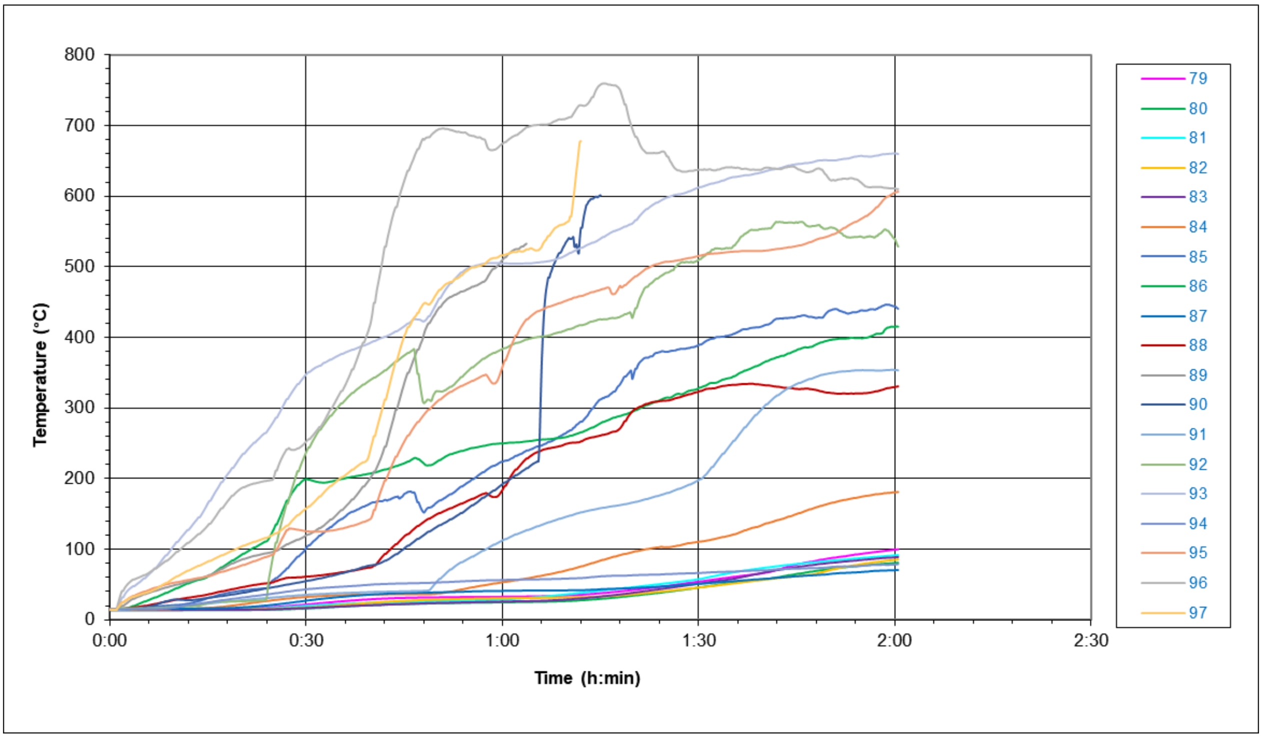
Wall	
Drawing	Datalogger
U1	79
U2	80
U3	81
U4	82
U5	83
U6	84
U7	85
U8	86
U9	87
U10	88
U11	89
U12	90
U13	91
U14	92
U15	93
U16	94
U17	95
U18	96
U19	97
U20	98
U21	99
U22	20
U23	21
U24	22
U25	23
U26 (screw on US)	24
U27 (screw on US)	25
E1 (screw on ES)	26
E2 (screw on ES)	27

Note: drawings with all measuring points are in Annex C

Time (h:min:s)	Temperature on the unexposed face of the wall (°C)																				
		T_{aver}					T_{max}														
	T_{aver}	U1 79	U2 80	U3 81	U4 82	U5 83	U6 84	U7 85	U8 86	U9 87	U10 88	U11 89	U12 90	U13 91	U14 92	U15 93	U16 94	U17 95	U18 96	U19 97	T_{max}
0:00:00	**14**	15	14	14	14	14	14	15	15	15	15	15	14	14	15	14	15	15	15	14	**15**
0:05:00	**14**	15	14	14	14	14	14	17	25	15	20	36	18	16	16	57	15	39	63	37	**63**
0:10:00	**14**	15	14	14	14	14	15	21	44	16	29	50	29	19	18	108	18	53	95	61	**108**
0:15:00	**15**	15	14	15	15	14	17	31	62	16	36	63	31	23	24	166	25	62	134	83	**166**
0:17:10	**15**	16	14	15	15	14	19	36	74	16	40	72	34	25	26	195	28	68	158	91	**195**
0:30:00	**18**	22	16	20	17	17	33	102	199	27	61	120	55	36	238	348	43	126	253	158	**348**
0:45:00	**26**	31	22	26	27	23	36	179	222	38	119	336	101	41	375	416	52	253	622	403	**622**
1:00:00	**29**	33	25	29	31	26	53	224	250	41	184	510	192	113	384	505	56	359	674	516	**674**
1:15:00	**35**	38	30	41	33	33	84	312	279	43	261		601	158	426	540	62	468	758		**758**
1:30:00	**51**	54	46	58	46	51	111	389	328	51	323			198	510	612	66	516	637		**637**
1:45:00	**72**	79	65	79	62	75	150	429	382	62	327			334	563	646	73	530	640		**646**
2:00:00	**89**	99	81	92	85	89	181	444	415	70	330			354	539	660	78	605	611		**660**
2:00:30	**89**	100	81	92	86	89	181	441	415	71	331			353	529	660	79	607	610		**660**

Temperature recorded at 10 s intervals. In the table, they figure in 15 minute intervals

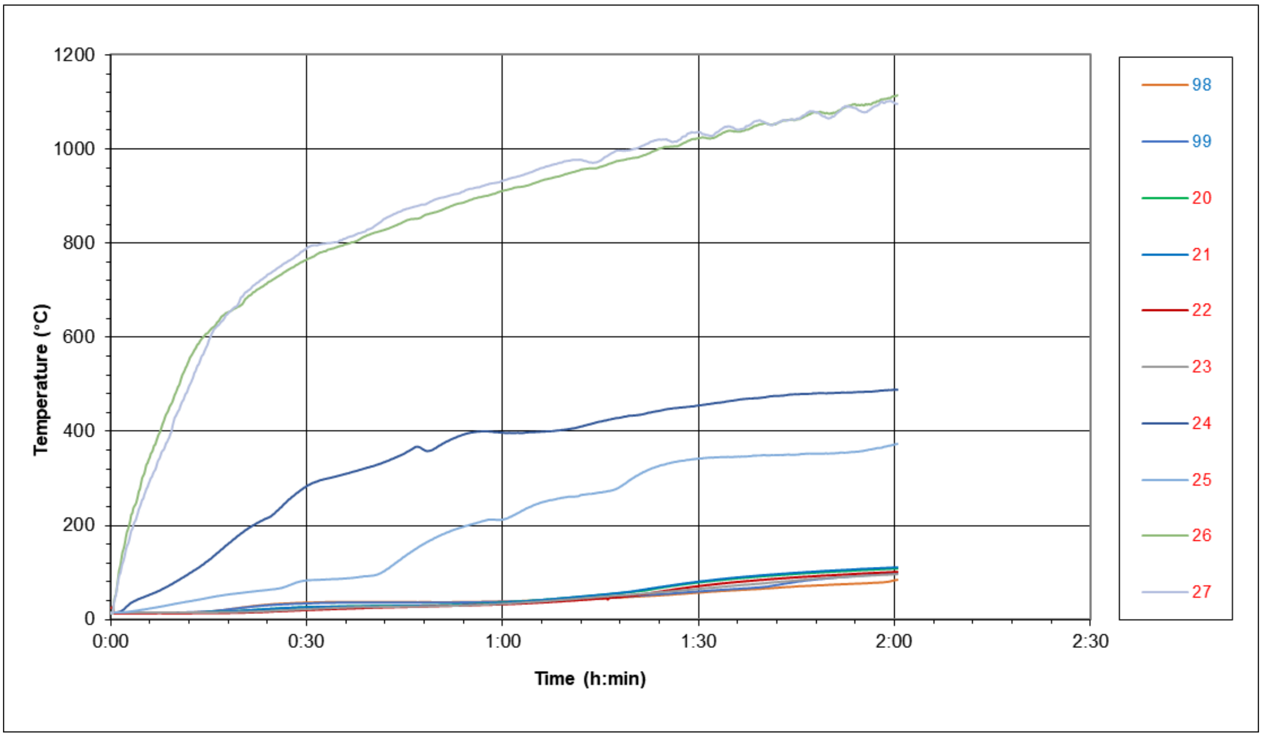
XX	Designation of measuring joint of TC as figured in Annex C
XX	Time and temperature when the insulation criterion has been exceeded
	TC fell down



Time (h:min:s)	Temperature on the unexposed face / fixing of the wall (°C)										
		T_{max}						T_{fixing}			
		U20	U21	U22	U23	U24	U25	U26	U27	E1	E2
	T_{max}	98	99	20	21	22	23	24	25	26	27
0:00:00	**25**	15	15	15	14	25	14	15	15	14	14
0:05:00	**15**	15	15	15	14	14	14	47	21	306	257
0:10:00	**16**	16	16	15	15	14	14	80	34	482	433
0:15:00	**18**	17	18	15	15	15	15	126	46	611	592
0:30:00	**36**	36	34	26	26	21	22	284	83	764	790
0:45:00	**38**	38	36	29	29	27	27	354	133	845	872
1:00:00	**39**	39	38	36	35	33	33	398	212	911	934
1:15:00	**53**	45	46	52	53	45	47	422	270	962	977
1:30:00	**81**	58	60	78	81	72	64	456	341	1022	1037
1:45:00	**100**	71	80	96	100	90	82	480	350	1062	1065
2:00:00	**112**	84	98	107	112	102	95	490	371	1111	1100
2:00:30	**112**	85	98	108	112	102	96	490	373	1114	1097

Temperature recorded at 10 s intervals. In the table, they figure in 15 minute intervals

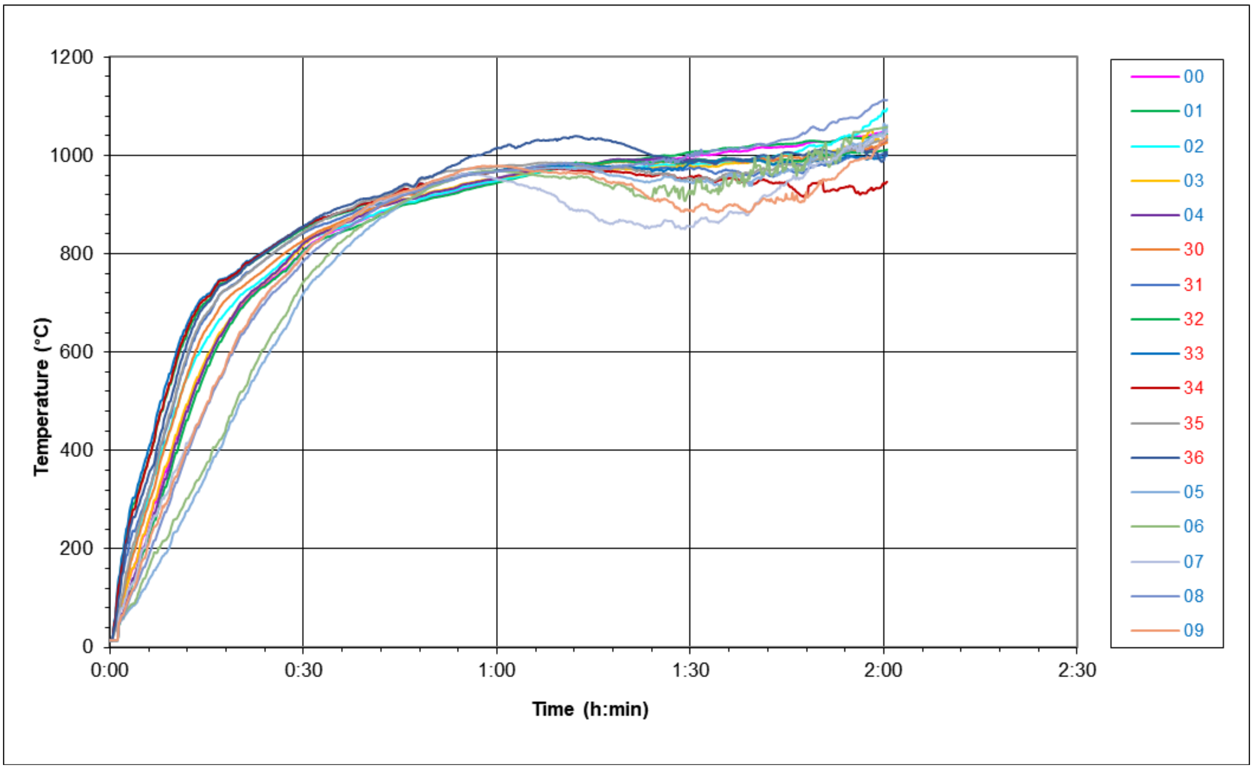
XX	Designation of measuring joint of TC as figured in Annex C
XX	Time and temperature when the insulation criterion has been exceeded



Time	Section	S1-					S2-							S3-				
		1	2	3	4	5	1	2	3	4	5	6	7	1	2	3	4	5
(h:min:s)	*TC No.*	*00*	*01*	*02*	*03*	*04*	*30*	*31*	*32*	*33*	*34*	*35*	*36*	*05*	*06*	*07*	*08*	*09*
0:00:00		14	14	14	14	14	14	14	14	14	14	14	16	14	14	14	14	14
0:05:00		221	189	267	225	197	249	279	340	358	338	271	310	113	133	197	158	176
0:10:00		417	388	478	424	407	469	501	564	588	571	504	531	234	259	356	328	343
0:15:00		586	567	627	591	581	649	673	704	717	712	679	699	355	374	493	491	496
0:30:00		807	806	822	818	821	828	842	851	856	854	845	855	720	744	801	785	798
0:45:00		899	897	902	909	909	915	922	925	928	928	933	937	900	902	920	917	924
1:00:00		948	945	949	954	954	969	969	970	971	969	978	1016	969	969	952	967	979
1:15:00		981	979	974	976	983	983	976	983	978	967	973	1034	971	951	879	977	957
1:30:00		998	1007	983	980	992	987	975	988	984	957	952	989	946	921	856	998	890
1:45:00		1019	1024	1004	990	991	1000	973	992	986	946	983	1007	968	988	948	1033	912
2:00:00		1048	1043	1092	1029	1026	1023	1004	1010	997	944	1031	990	1065	1057	1040	1114	1030
2:00:30		1049	1043	1095	1036	1032	1026	1008	1012	1000	947	1033	1002	1061	1058	1051	1113	1040

Temperature recorded at 10 s intervals. In the table, they figure in 15 minute intervals

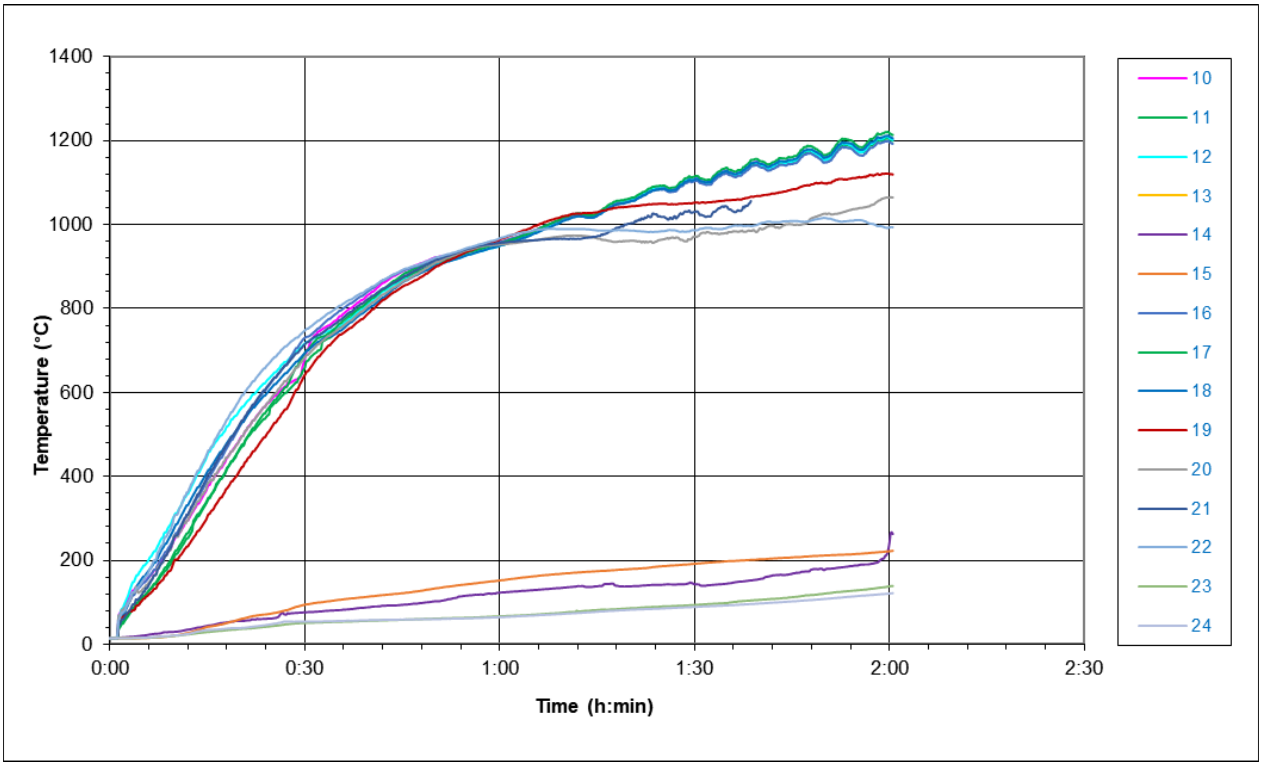
XX Designation of measuring joint of TC as figured in Annex C



Time	Section	S4-													S4´-	
		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*1*	*2*
(h:min:s)	*TC No.*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*
0:00:00		14	14	14		14	14	14	14	14	14	14	14	14	14	14
0:05:00		146	112	182		21	15	144	113	158	105	131	120	149	15	16
0:10:00		253	211	310		30	21	260	220	281	201	260	258	307	20	21
0:30:00		680	659	717		76	95	730	694	694	642	683	715	748	51	54
0:45:00		889	880	868		94	122	890	873	862	852	863	874	892	59	59
1:00:00		958	956	950		123	152	958	955	950	965	953	957	968	67	65
1:15:00		1024	1022	1022		138	174	1021	1027	1021	1029	967	972	986	82	78
1:30:00		1109	1106	1107		143	192	1103	1114	1107	1052	972	1030	986	94	89
1:45:00		1152	1150	1151		168	207	1144	1161	1154	1084	1001		1009	112	102
2:00:00		1206	1203	1206		243	222	1196	1217	1210	1121	1064		993	138	121
2:00:30		1202	1200	1202		263	223	1193	1214	1206	1119	1065		994	139	122

Temperature recorded at 10 s intervals. In the table, they figure in 15 minute intervals

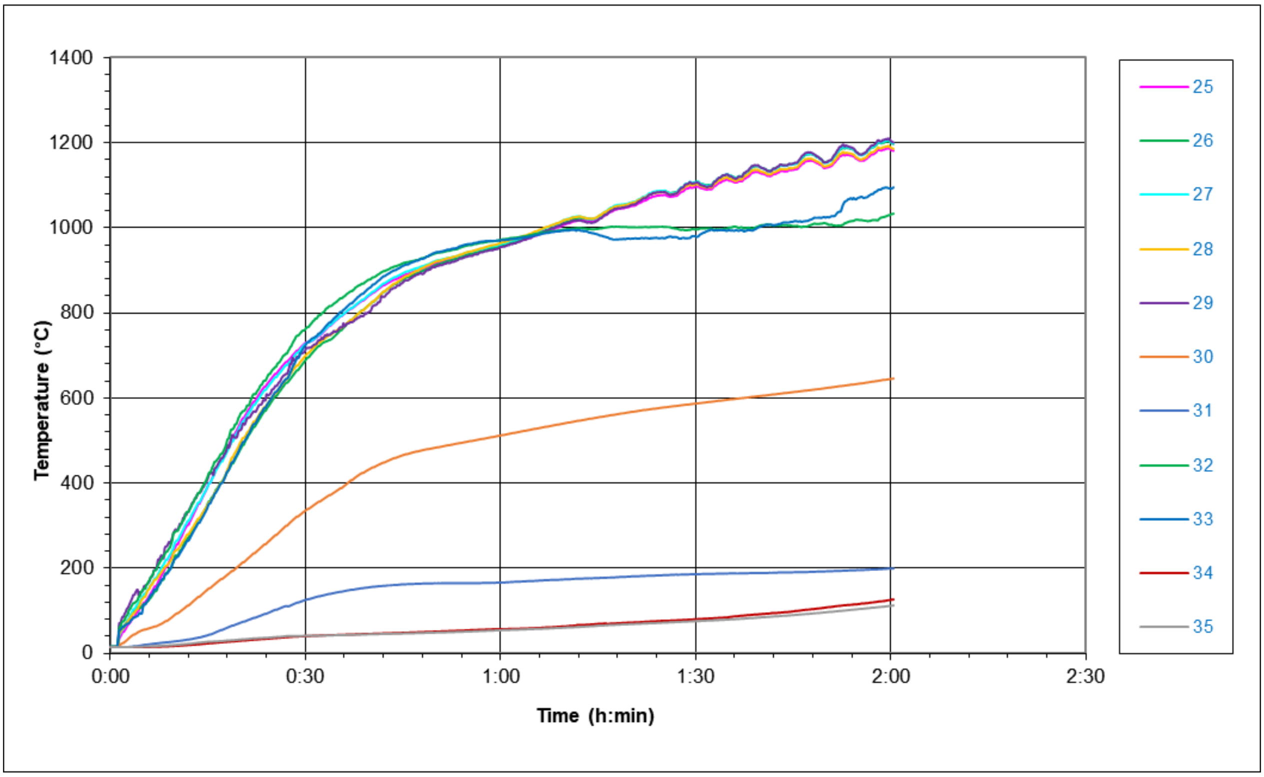
XX	Designation of measuring joint of TC as figured in Annex C
	Failure of TC



Time	Section	S5-			S6-						S6´-	
		1	2	3	1	2	3	4	5	6	1	2
(h:min:s)	TC No.	25	26	27	28	29	30	31	32	33	34	35
0:00:00		14	14	14	14	14	14	14	14	14	14	14
0:05:00		115	112	134	128	148	54	19	149	107	15	16
0:10:00		251	229	261	240	291	91	28	285	222	17	20
0:15:00		394	352	394	350	412	150	42	417	346	23	27
0:30:00		730	688	727	699	714	335	125	762	725	41	41
0:45:00		888	878	894	881	872	465	162	916	911	48	46
1:00:00		957	957	962	964	955	511	166	971	972	57	54
1:15:00		1020	1024	1026	1026	1018	554	177	997	985	69	64
1:30:00		1097	1107	1108	1101	1106	586	186	996	981	80	75
1:45:00		1136	1149	1149	1139	1152	613	190	1004	1015	99	89
2:00:00		1185	1201	1203	1189	1207	644	199	1030	1094	126	110
2:00:30		1181	1197	1199	1185	1202	645	199	1033	1096	127	111

Temperature recorded at 10 s intervals. In the table, they figure in 15 minute intervals

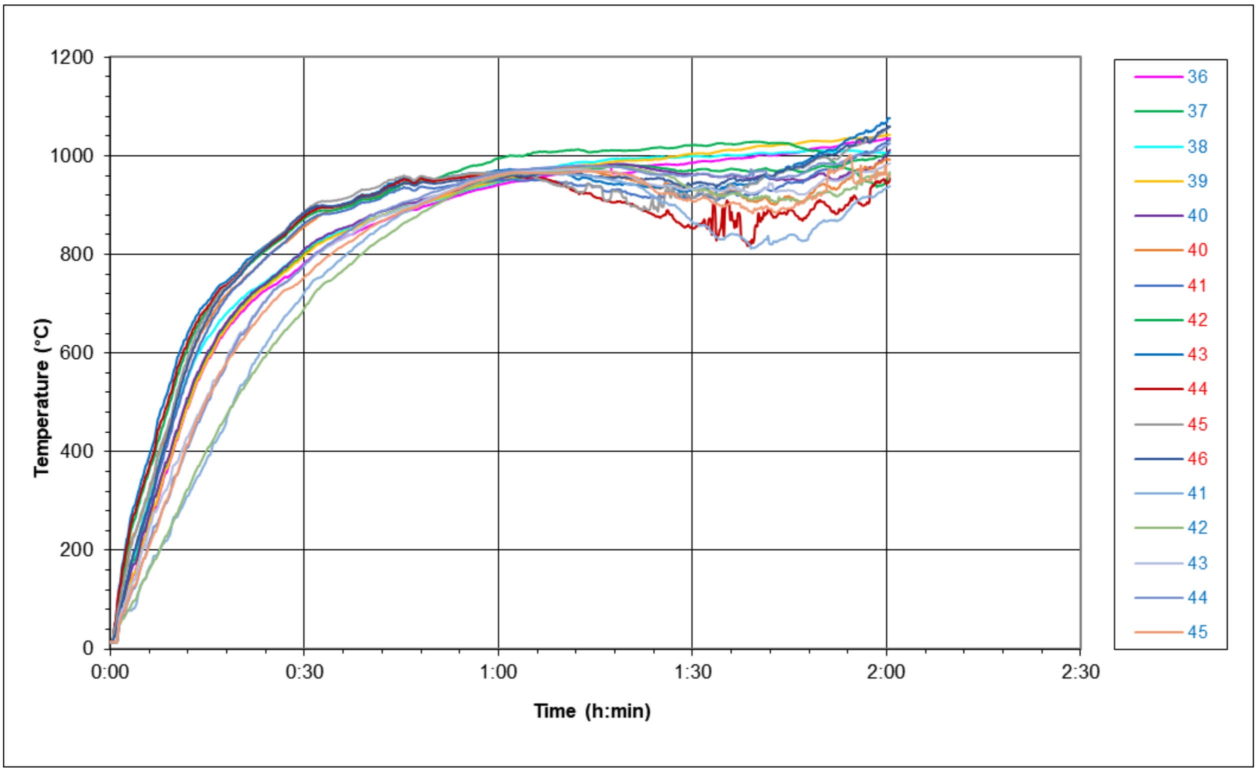
XX Designation of measuring joint of TC as figured in Annex C



Time	*Section*	*S7-1*	*S7-2*	*S7-3*	*S7-4*	*S7-5*	*S8-1*	*S8-2*	*S8-3*	*S8-4*	*S8-5*	*S8-6*	*S8-7*	*S9-1*	*S9-2*	*S9-3*	*S9-4*	*S9-5*
(h:min:s)	*TC No.*	*36*	*37*	*38*	*39*	*40*	*40*	*41*	*42*	*43*	*44*	*45*	*46*	*41*	*42*	*43*	*44*	*45*
0:00:00		14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
0:05:00		215	238	263	216	232	279	246	320	349	329	283	253	137	137	202	178	178
0:10:00		415	431	481	418	435	492	471	536	571	550	502	489	266	267	374	349	347
0:15:00		586	596	631	589	601	661	647	686	705	694	682	671	388	406	514	501	509
0:30:00		783	801	809	799	810	857	863	873	883	878	887	886	724	692	778	780	755
0:45:00		885	895	893	893	902	941	933	942	952	949	957	943	883	861	894	904	887
1:00:00		941	947	948	950	954	966	951	995	971	960	968	959	962	957	963	966	961
1:15:00		975	974	988	983	979	968	939	1008	949	917	939	958	957	976	970	979	968
1:30:00		986	970	999	1004	962	931	916	1022	932	854	917	943	866	932	933	961	908
1:45:00		1005	972	1007	1024	952	917	946	1025	978	889	974	975	840	914	930	959	893
2:00:00		1035	1003	1006	1042	1003	993	1028	946	1068	944	1053	1056	935	967	981	1020	961
2:00:30		1036	1006	1006	1043	1012	993	1032	953	1076	954	1059	1059	939	967	984	1025	960

Temperature recorded at 10 s intervals. In the table, they figure in 15 minute intervals

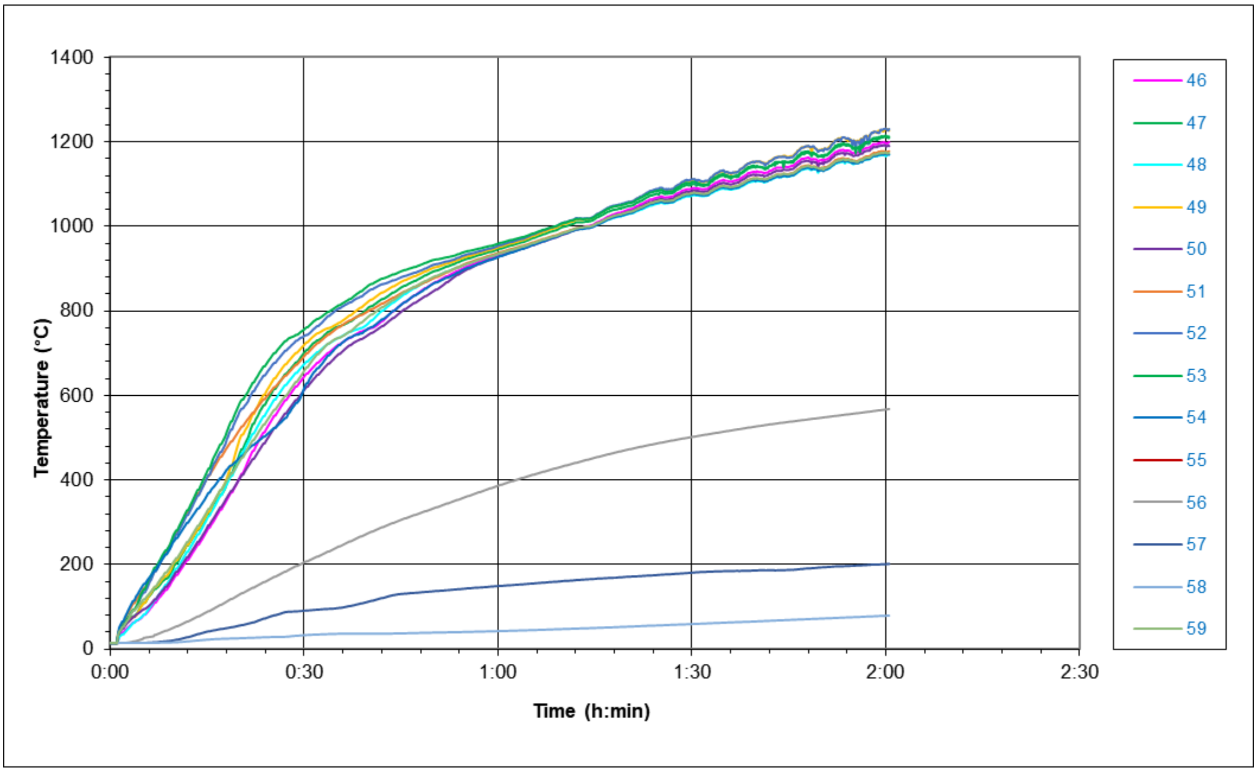
XX Designation of measuring joint of TC as figured in Annex C



Time	Section	S10-						S11-							
		1	2	3	4	5	6	1	2	3	4	5	6	7	8
(h:min:s)	TC No.	46	47	48	49	50	51	52	53	54	55	56	57	58	59
0:00:00		14	14	14	14	14	14	14	14	14		14	14	14	14
0:05:00		78	106	79	106	93	140	131	137	150		24	15	14	115
0:10:00		172	200	187	207	179	272	266	276	258		52	21	16	211
0:15:00		282	316	310	320	288	406	407	421	365		88	41	22	327
0:30:00		645	701	674	720	613	693	741	756	618		205	91	33	659
0:45:00		815	856	834	869	798	842	880	894	815		306	130	37	839
1:00:00		932	946	936	950	928	937	954	959	928		387	149	42	935
1:15:00		1007	1018	1003	1024	1004	1004	1026	1024	1001		453	166	50	1005
1:30:00		1090	1099	1073	1109	1084	1078	1111	1104	1076		502	181	59	1078
1:45:00		1141	1151	1118	1165	1134	1124	1162	1152	1119		538	187	69	1123
2:00:00		1195	1212	1166	1231	1190	1177	1231	1215	1172		567	201	79	1175
2:00:30		1199	1209	1170	1227	1190	1178	1230	1212	1170		568	201	79	1173

Temperature recorded at 10 s intervals. In the table, they figure in 15 minute intervals

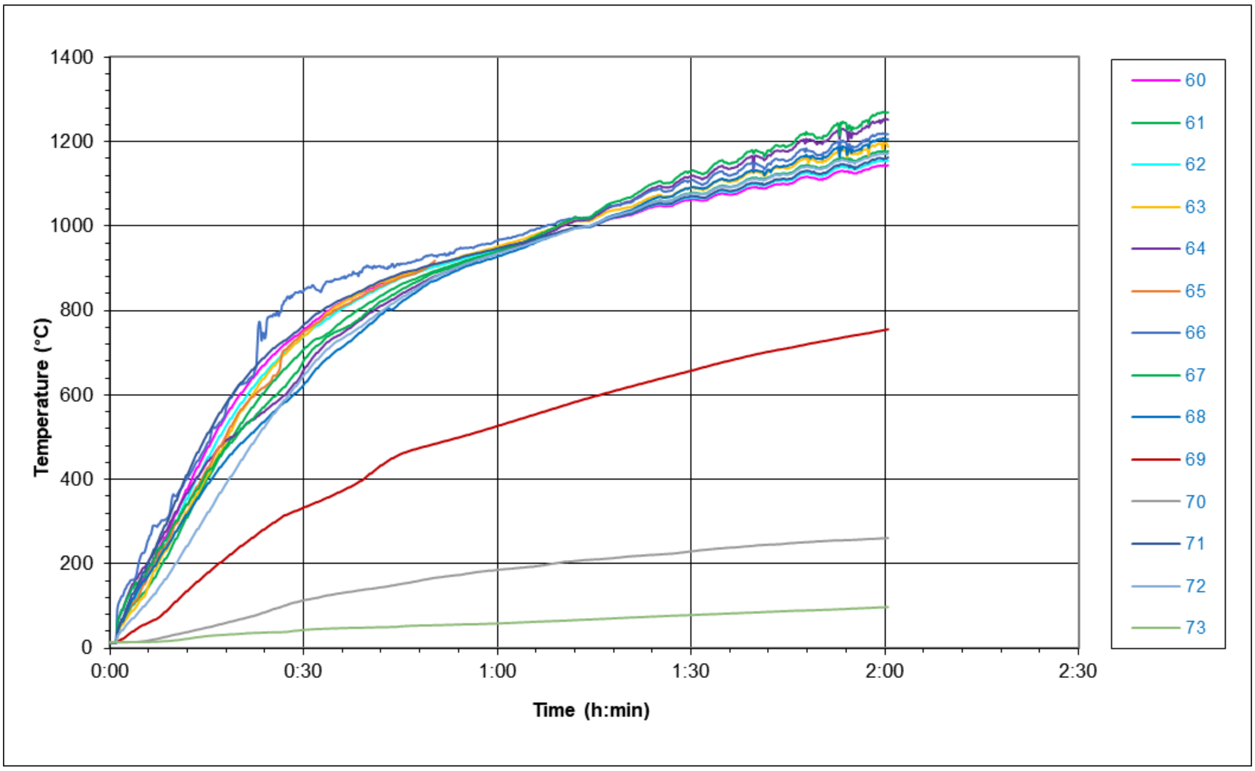
XX	Designation of measuring joint of TC as figured in Annex C
(orange)	Failure of TC



Time	Section	S12-					S13-									S14-			S15-	
		1	2	3	4	5	1	2	3	4	5	6	7	8	9	1	2	3	1	2
(h:min:s)	TC No.	*60*	*61*	*62*	*63*	*64*	*65*	*66*	*67*	*68*	*69*	*70*	*71*	*72*	*73*	*74*	*75*	*76*	*77*	*78*
0:00:00		14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
0:05:00		161	127	150	117	187	144	225	170	154	54	16	174	96	14	204	204	179	174	107
0:10:00		312	253	292	271	318	290	360	295	271	108	32	342	197	18	403	404	345	273	227
0:15:00		471	400	447	408	440	423	482	416	386	177	49	505	318	29	566	558	502	389	359
0:30:00		754	708	739	740	658	749	847	680	624	333	113	765	646	43	796	807	762	722	717
0:45:00		885	861	877	882	838	878	911	848	819	460	152	888	829	52	894	895	882	864	866
1:00:00		947	940	944	952	936		965	940	928	526	185	947	935	59	948	951	945	950	950
1:15:00		1002	1003	1002	1017	1022		1027	1029	1005	596	210	1002	1005	69	1005	1005	1004	1019	1027
1:30:00		1062	1078	1068	1091	1118		1108	1130	1091	658	229	1071	1077	79	1074	1069	1072	1094	1112
1:45:00		1099	1124	1107	1137	1176		1154	1189	1143	711	248	1111	1122	88	1115	1105	1114	1142	1165
2:00:00		1145	1178	1156	1195	1252		1218	1268	1206	754	260	1160	1172	97	1165	1149	1163	1202	1234
2:00:30		1144	1178	1155	1188	1252		1217	1269	1206	755	261	1163	1172	97	1166	1150	1164	1194	1233

Temperature recorded at 10 s intervals. In the table, they figure in 15 minute intervals

XX	Designation of measuring joint of TC as figured in Annex C
	Failure of TC

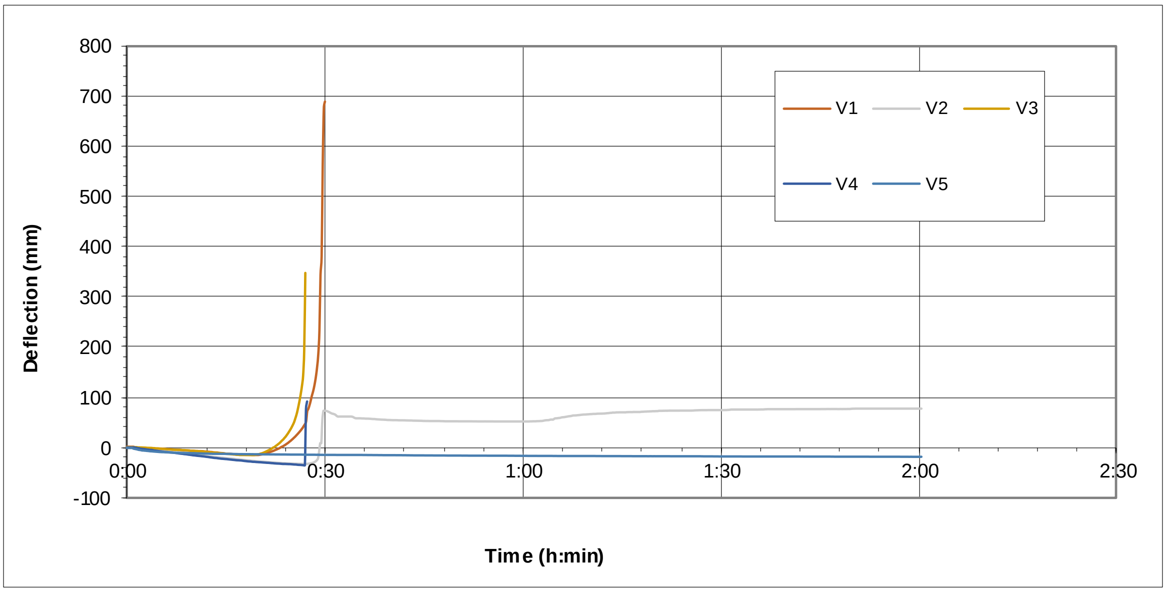


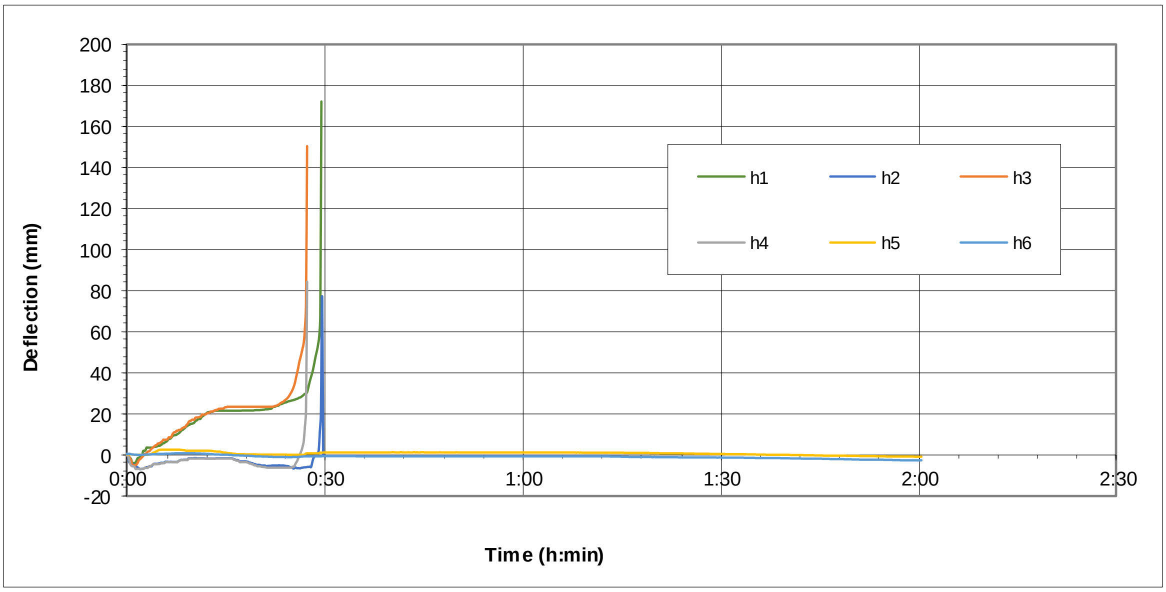
Time	Deflection (mm)										
(h:min:s)	V1	V2	V3	V4	V5	h1	h2	h3	h4	h5	h6
0:00:00	0	0	0	0	0	0	0	0	0	0	0
0:05:00	-4	-7	-3	-8	-9	4	-4	6	-4	2	0
0:10:00	-8	-14	-7	-15	-12	15	-2	17	-2	2	0
0:15:00	-14	-22	-13	-23	-13	21	-2	23	-2	1	0
0:20:00	-16	-29	-14	-29	-14	22	-5	24	-5	0	-1
0:25:00	16	-34	42	-33	-15	26	-6	32	-6	0	-2
0:26:00	30	-34	84	-34	-15	27	-6	45	0	0	-2
0:27:00	51	-34	348	-35	-15	30	-6	73	21	0	-1
0:27:10	71	-34		76	-15	30	-6	151	84	0	-1
0:27:20	76	-34		90	-15	30	-6			0	-1
0:28:00	108	-33			-15	39	-4			0	-1
0:29:00	232	-23			-15	54	2			0	-1
0:29:30	564	8			-15	172	77			1	-1
0:29:50	690	75			-16					1	-1
0:30:00		75			-16					1	-1
0:45:00		54			-17					1	-1
1:00:00		53			-18					1	-1
1:15:00		71			-18					1	-1
1:30:00		76			-19					0	-2
1:45:00		78			-19					-1	-2
2:00:00		79			-20					-1	-3
2:00:30		79			-20					-1	-3

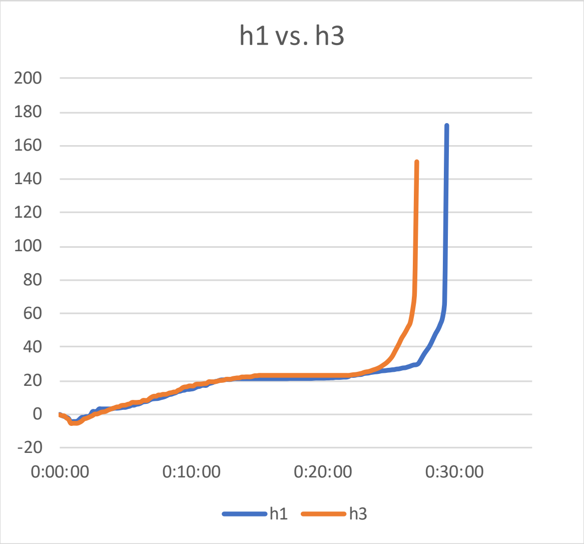
Failure of deflectometer

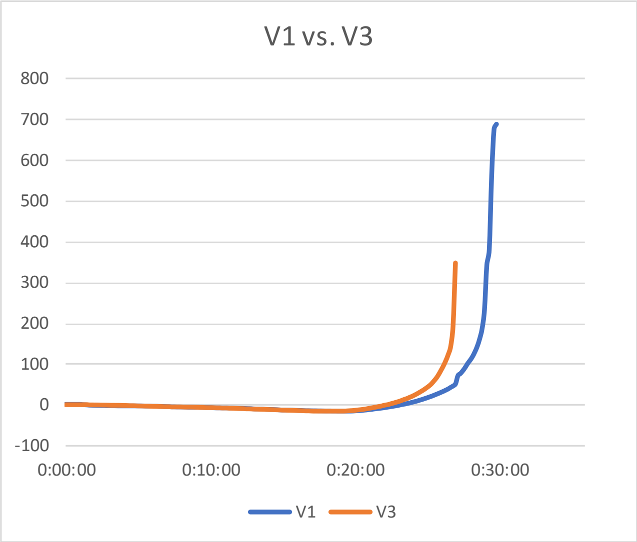
Values **"+"** - deflection in furnace

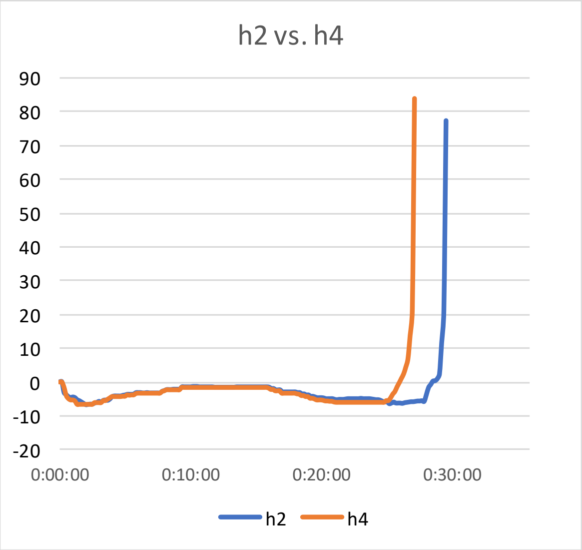
Values **"-"** - deflection away from furnace

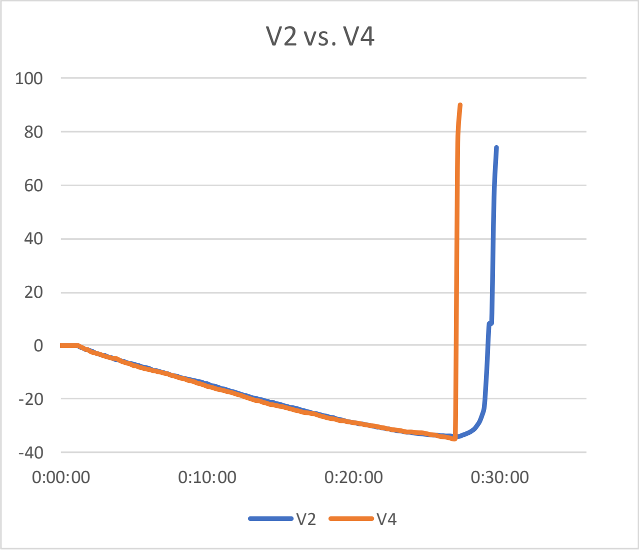

Deflection (mm)
800
700
600
500
400
300
200
100
0
-100
0:00
0:30
1:00
1:30
2:00
2:30
Time (h:min)
V1
V2
V3
V4
V5

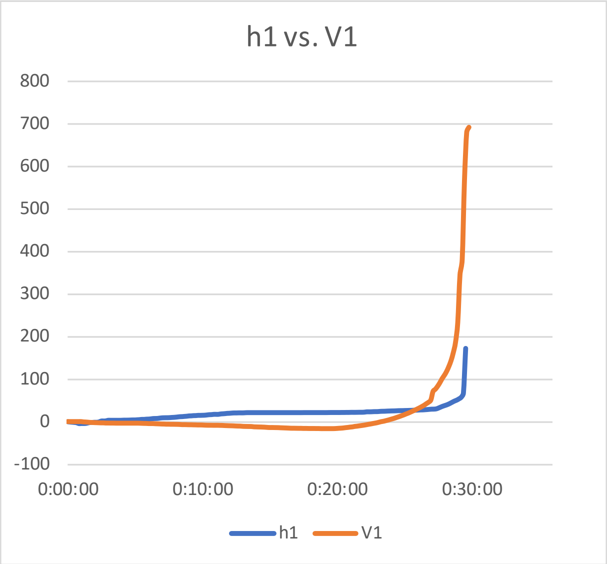

Deflection (mm)
200
180
160
140
120
100
80
60
40
20
0
-20
0:00
0:30
1:00
1:30
2:00
2:30
Time (h:min)
h1
h2
h3
h4
h5
h6

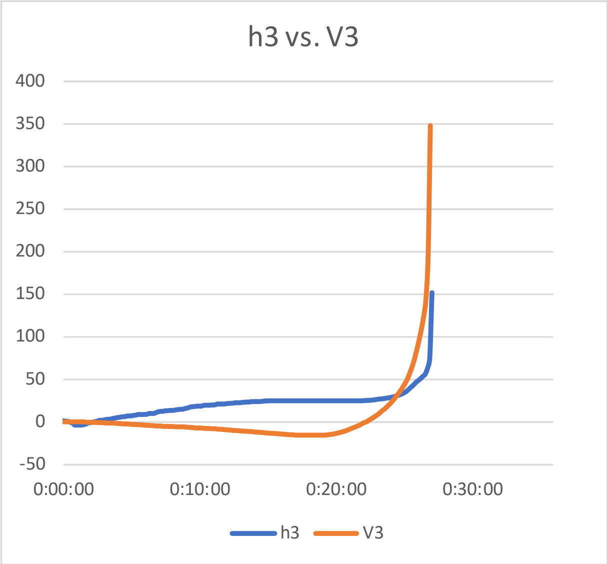

h1 vs. h3
200
180
160
140
120
100
80
60
40
20
0
-20
0:00:00
0:10:00
0:20:00
0:30:00
h1
h3

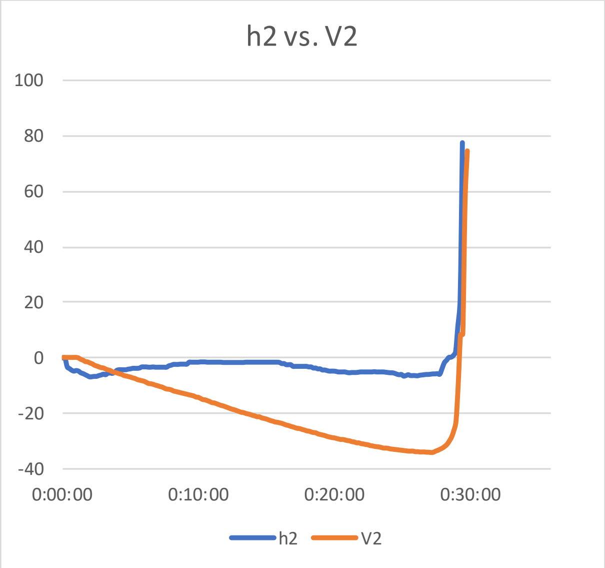

V1 vs. V3
800
700
600
500
400
300
200
100
0
-100
0:00:00
0:10:00
0:20:00
0:30:00
V1
V3

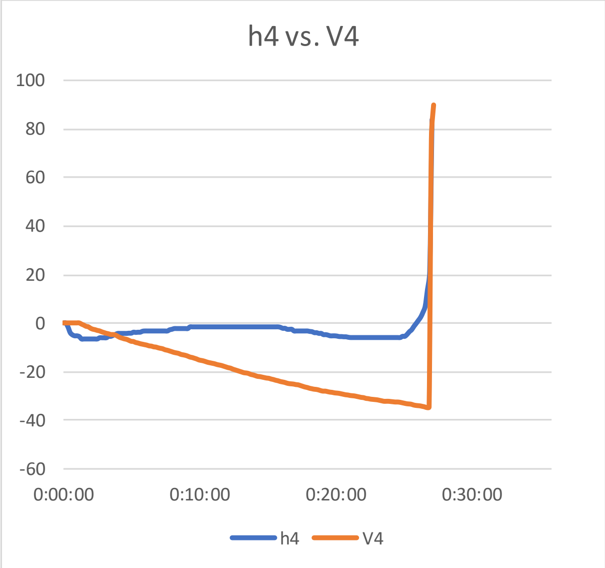

h2 vs. h4
90
80
70
60
50
40
30
20
10
0
-10
-20
0:00:00
0:10:00
0:20:00
0:30:00
h2
h4


V2 vs. V4
100
80
60
40
20
0
-20
-40
0:00:00
0:10:00
0:20:00
0:30:00
V2
V4


h1 vs. V1
800
700
600
500
400
300
200
100
0
-100
0:00:00
0:10:00
0:20:00
0:30:00
h1
V1


h3 vs. V3
400
350
300
250
200
150
100
50
0
-50
0:00:00
0:10:00
0:20:00
0:30:00
h3
V3

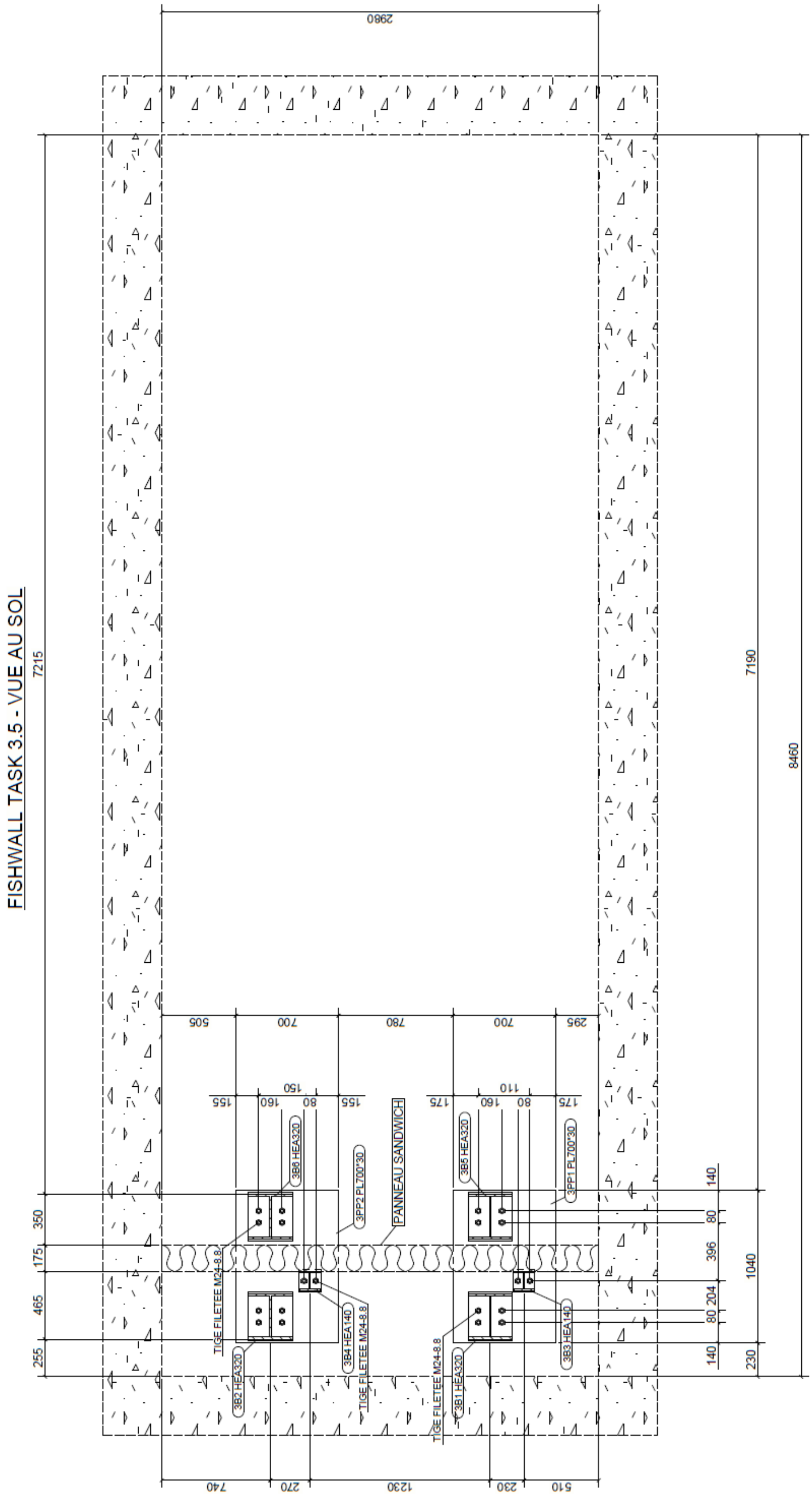

h2 vs. V2
100
80
60
40
20
0
-20
-40
0:00:00
0:10:00
0:20:00
0:30:00
h2
V2

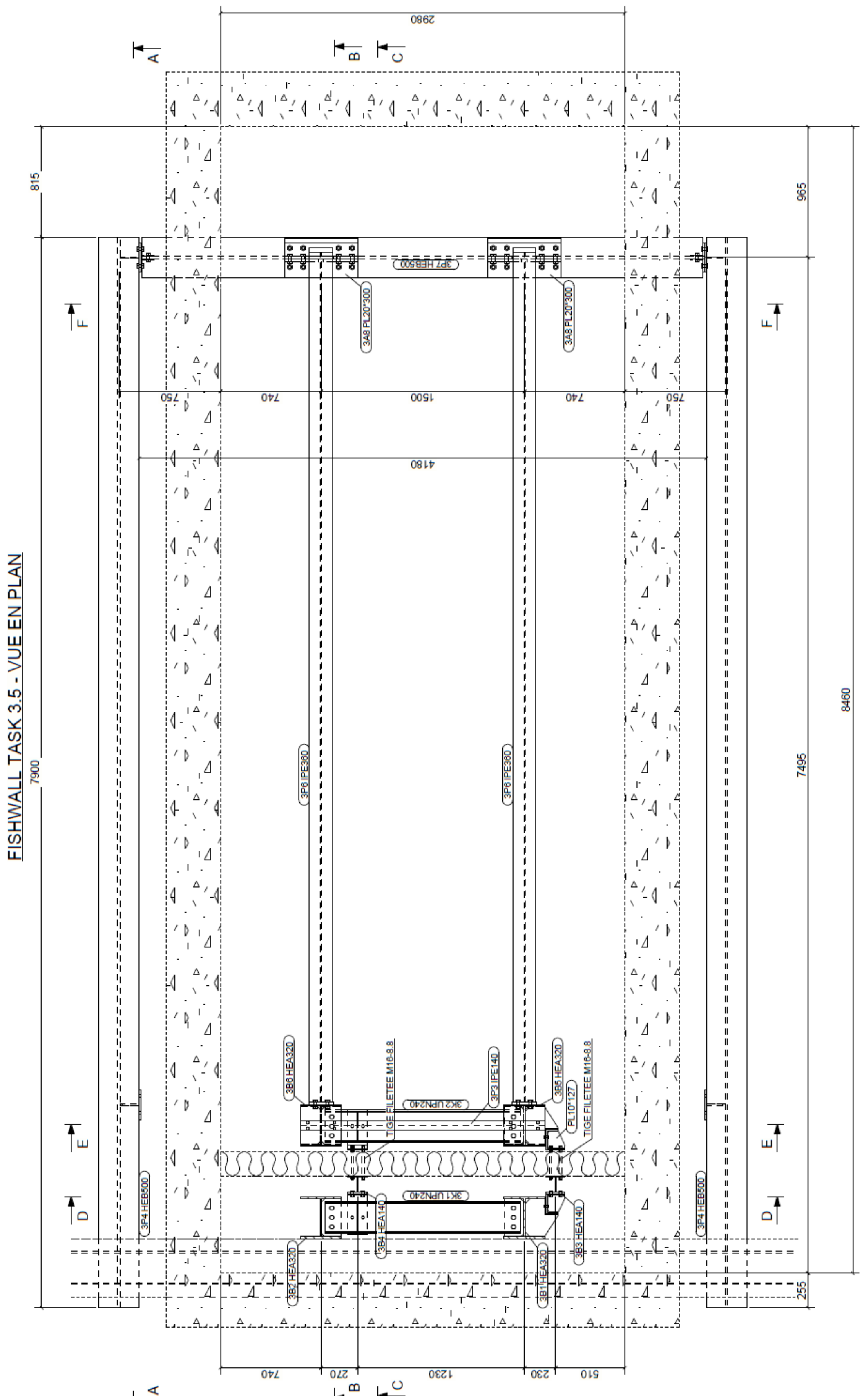

h4 vs. V4
100
80
60
40
20
0
-20
-40
-60
0:00:00
0:10:00
0:20:00
0:30:00
h4
V4

ANNEX C: DOCUMENTATION

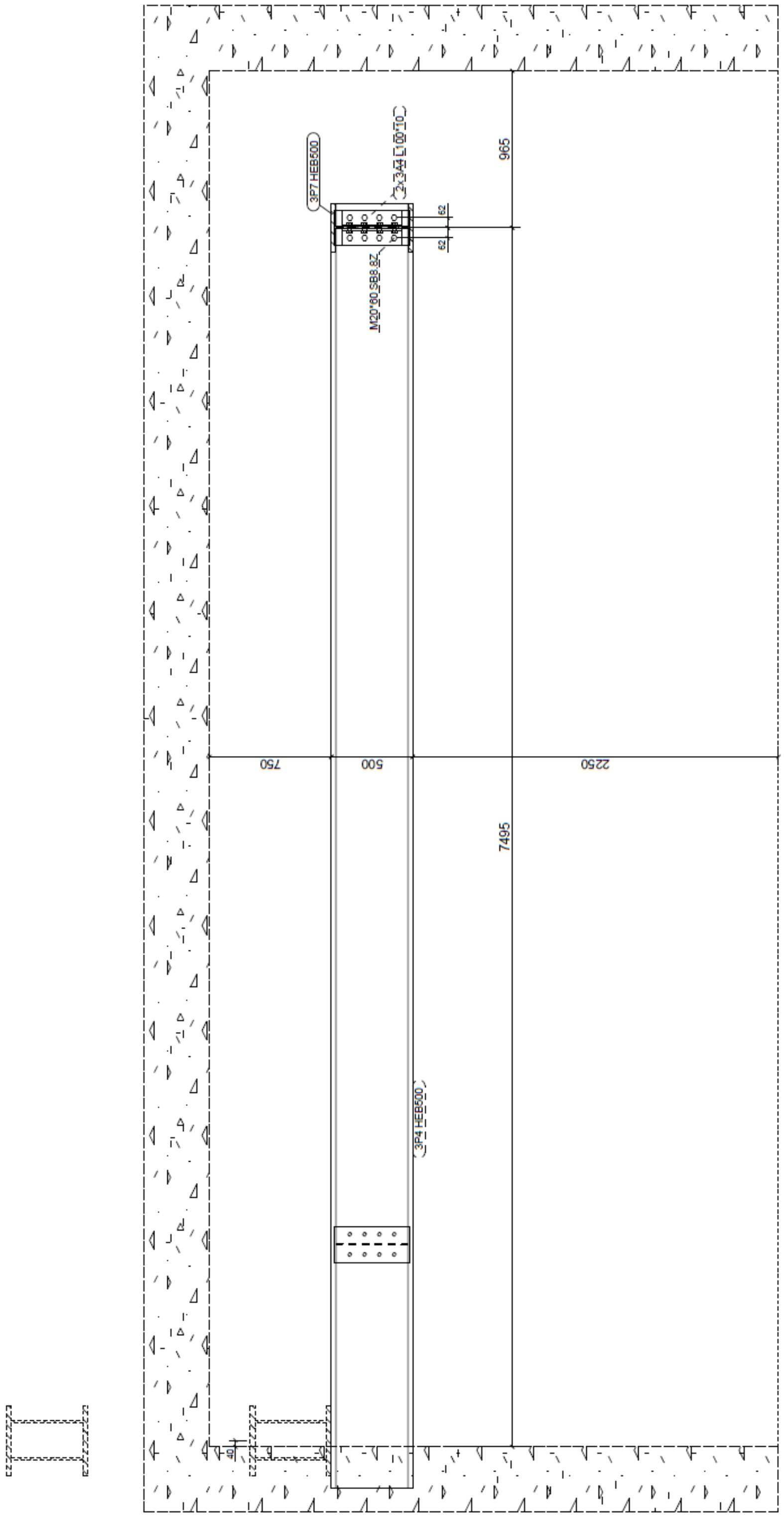
Specimen-related documentation delivered by the test sponsor.

Drawings ot test specimen

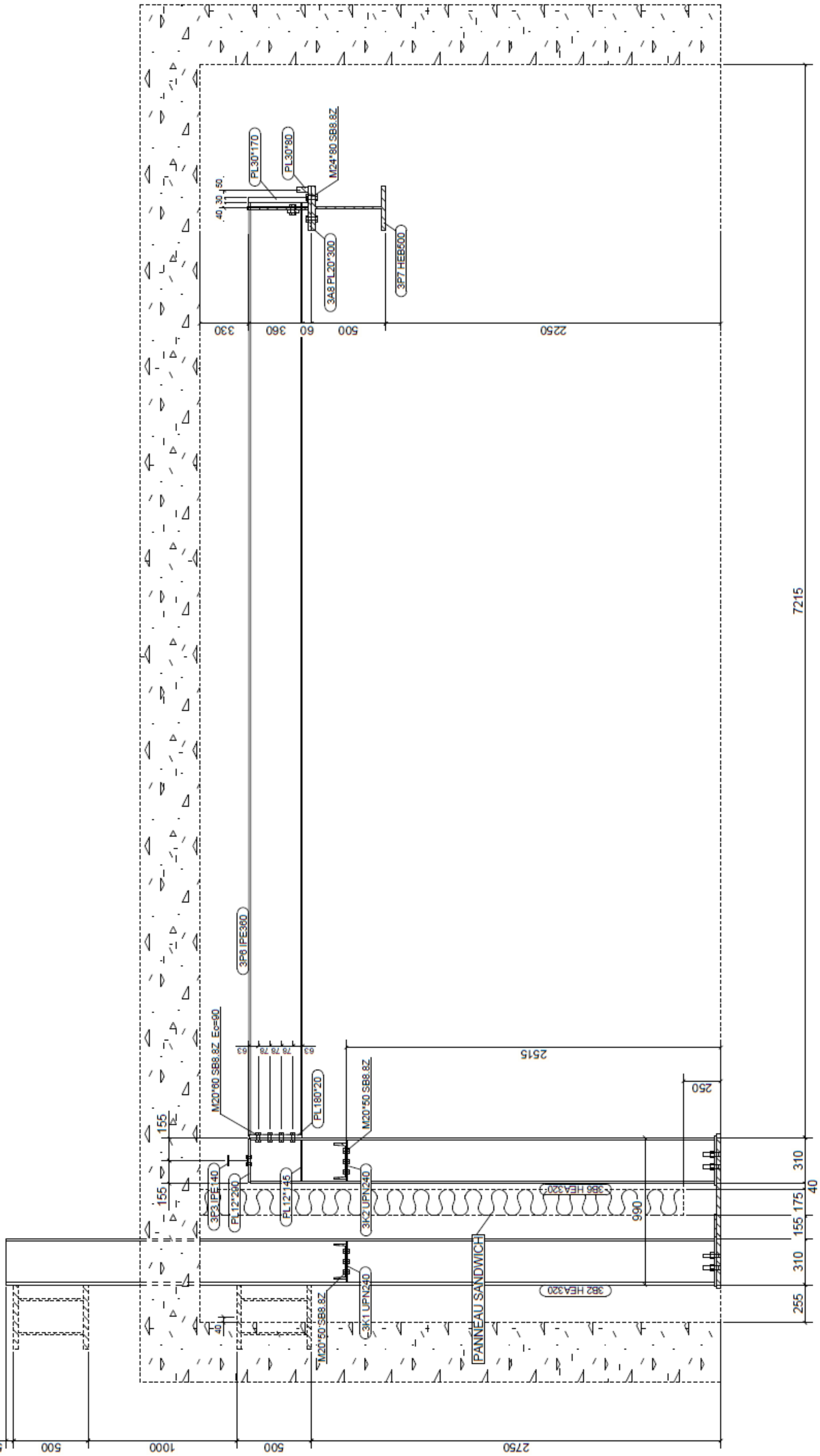


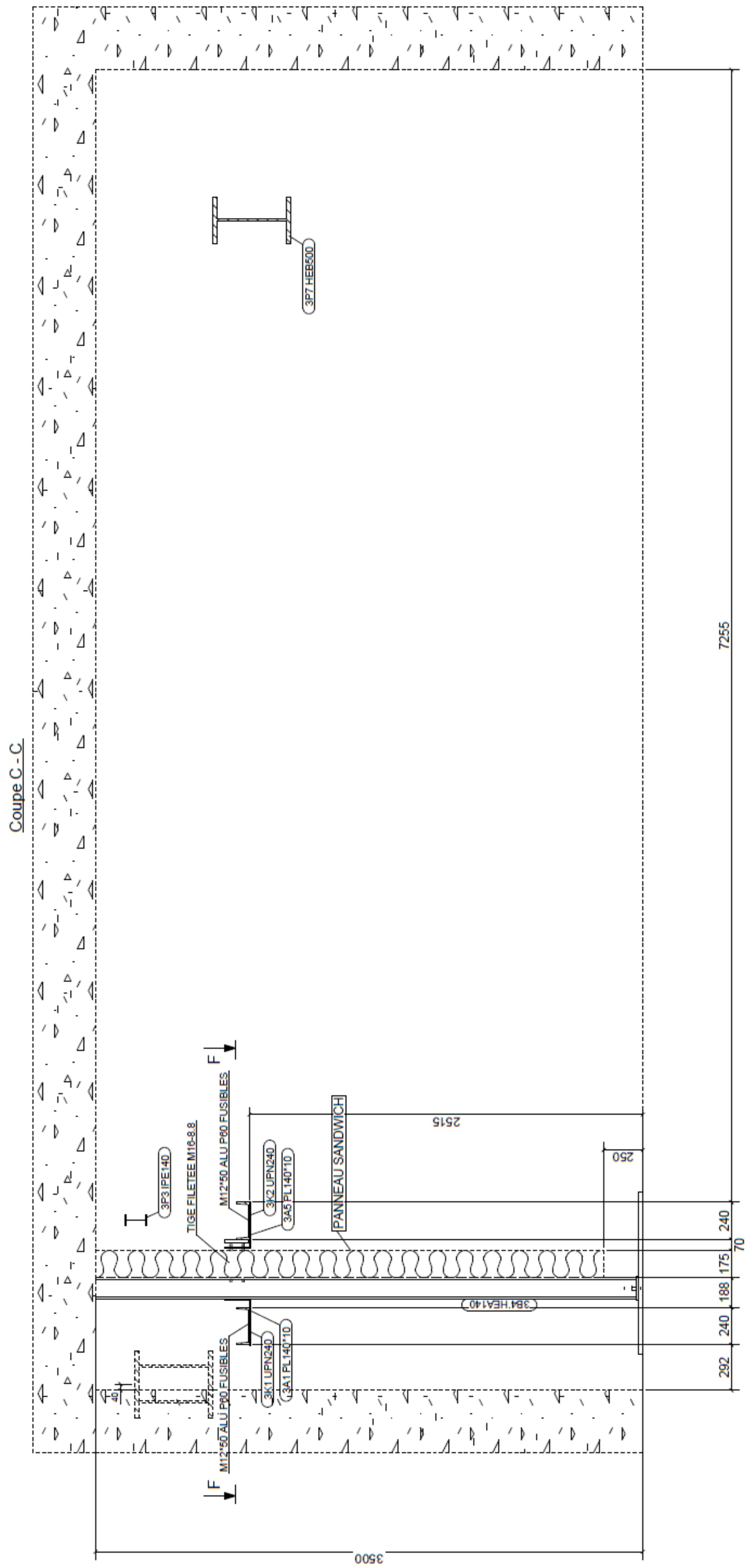

FISHWALL TASK 3.5 - VUE EN PLAN
2980
815
965
7900
7495
8460
255
750
740
1500
740
750
4180
740
270
1230
230
510
3P7 HEB500
3A8 PL20*300
3P6 IPE360
3B6 HEA320
TIGE FILETEE M16-8.8
3K2 UPN240
3P3 IPE140
3B5 HEA320
PL10*127
3K1 UPN240
3B4 HEA140
3B3 HEA140
3B2 HEA320
3B1 HEA320
3P4 HEB500
A
B
C
D
E
F

Coupe A - A

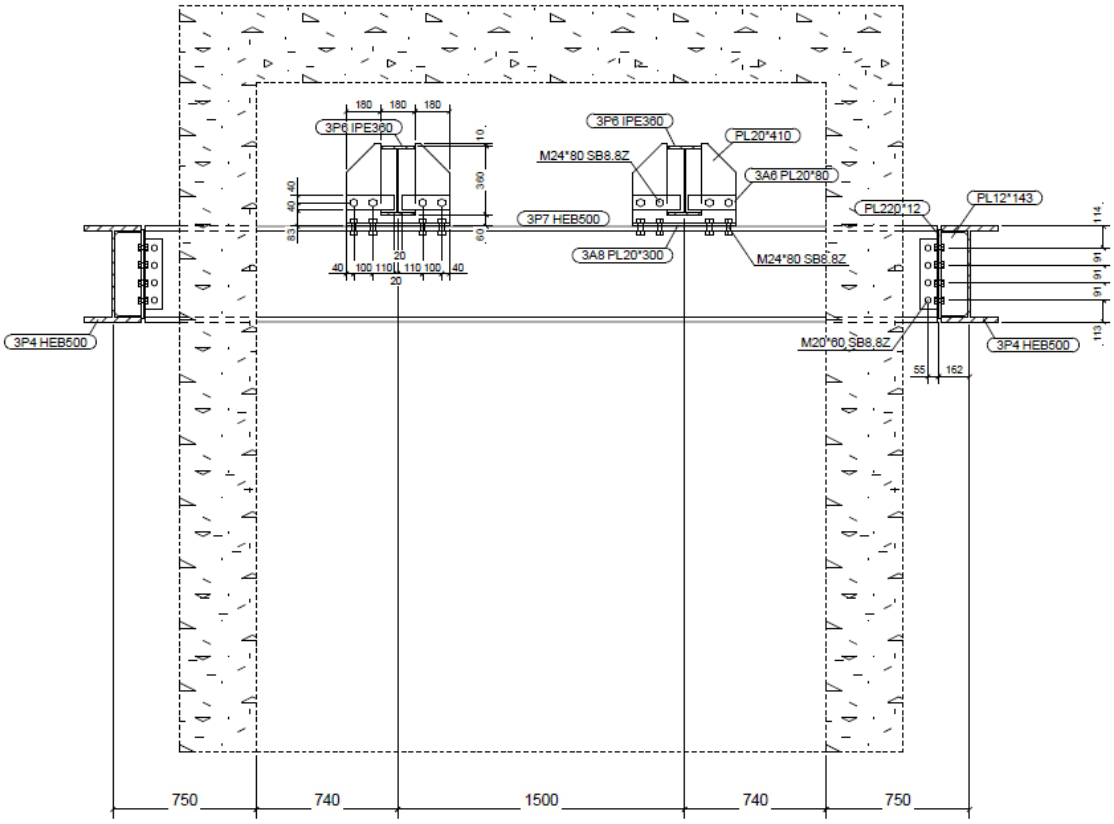


Coupe B - B

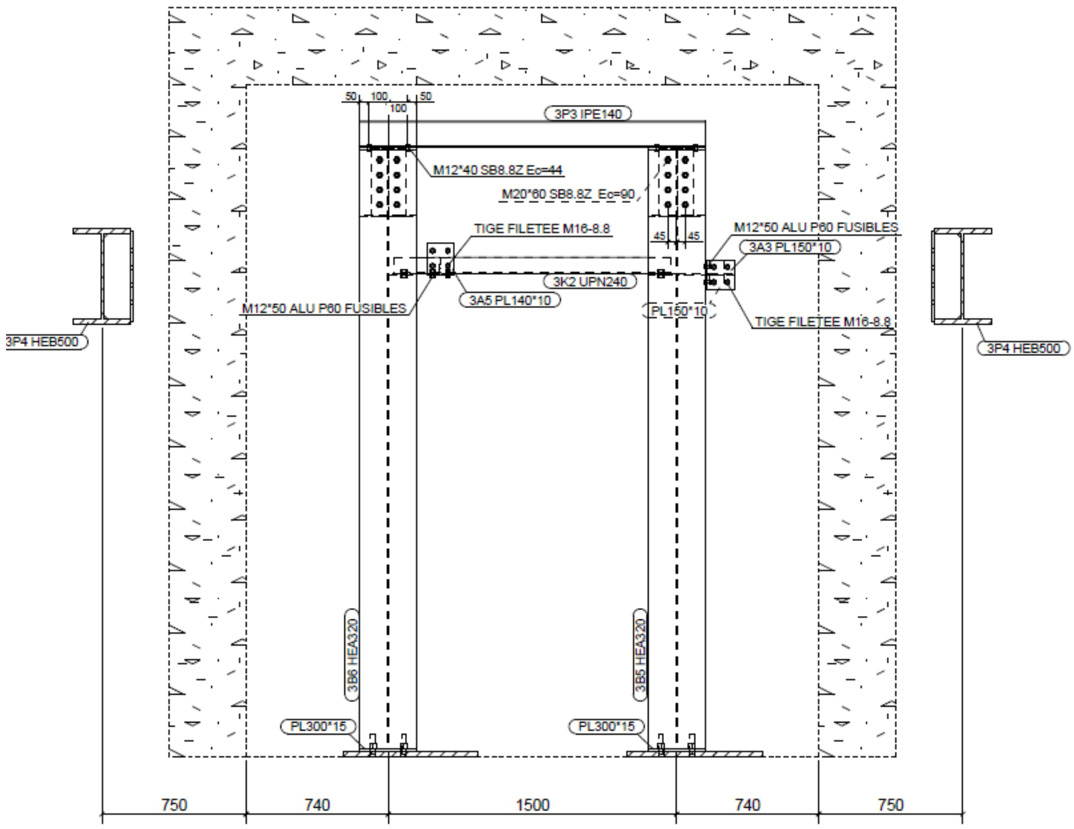

PL30*170
PL30*80
M24*80 SB8.8Z
3A8 PL20*300
3P7 HEB500
330
360
60
500
2250
7215
3P6 IPE360
M20*60 SB8.8Z Ec=90
PL180*20
M20*50 SB8.8Z
2515
250
3P3 IPE140
PL12*290
PL12*145
3K2 UPN240
3B6 HEA320
PANNEAU SANDWICH
3B2 HEA320
3K1 UPN240
M20*50 SB8.8Z
990
310
40
175
155
310
255
50
500
1000
500
2750


Coupe C - C
3P7 HEB500
7255
2515
250
PANNEAU SANDWICH
3K2 UPN240
3A5 PL 140*10
M12*50 ALU P80 FUSIBLES
TIGE FILETEE M16-8.8
3P3 IPE140
F
240
70
175
188
240
292
3B4 HEA140
3K1 UPN240
3A1 PL 140*10
M12*50 ALU P80 FUSIBLES
F
3500

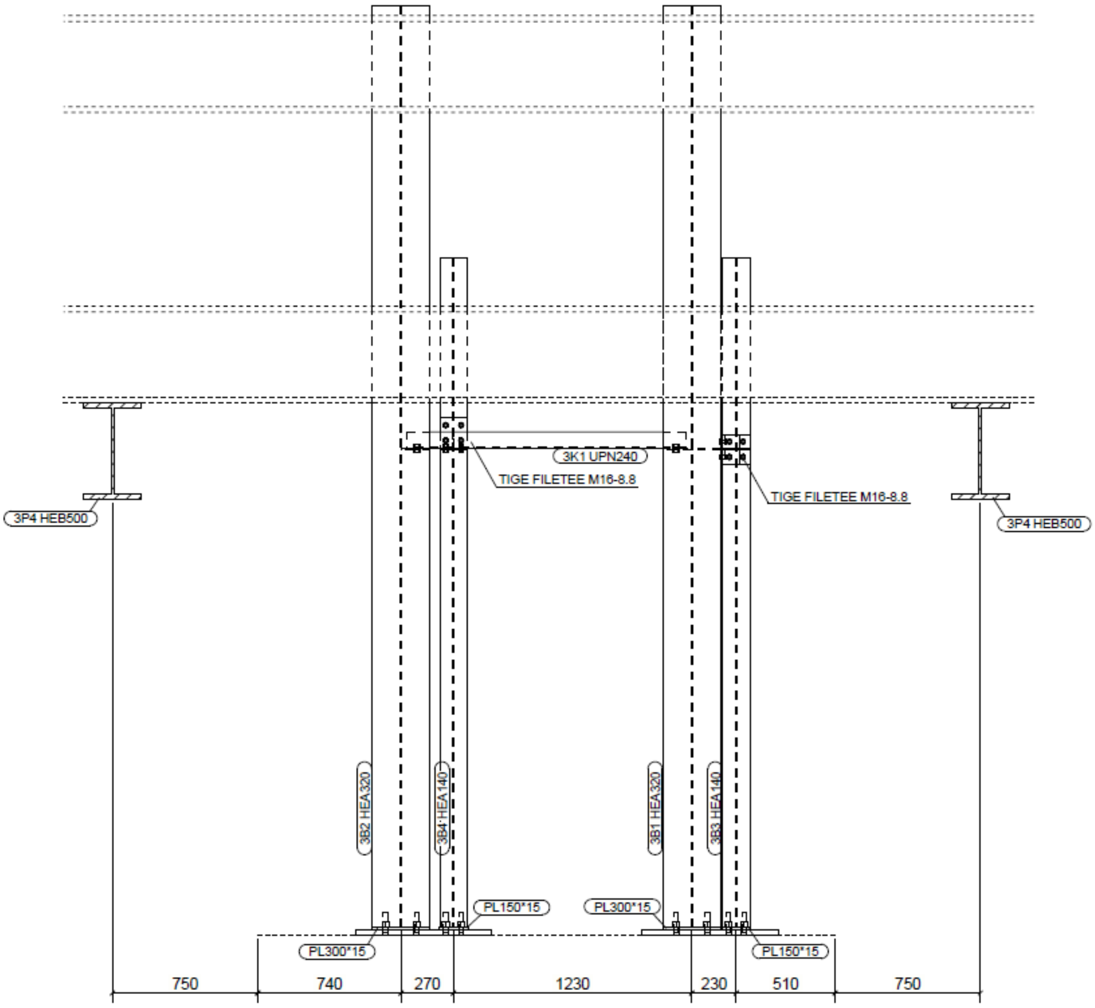
Coupe F - F



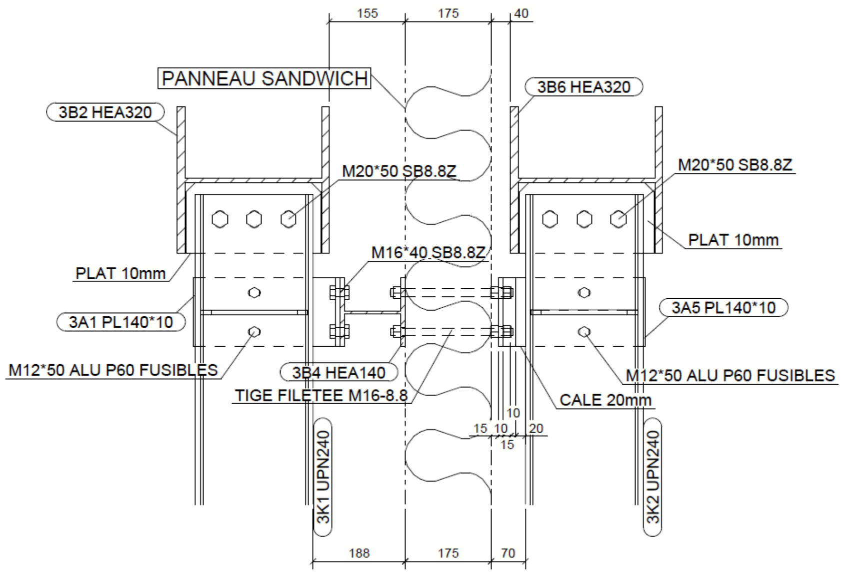
Coupe E - E



Coupe D - D

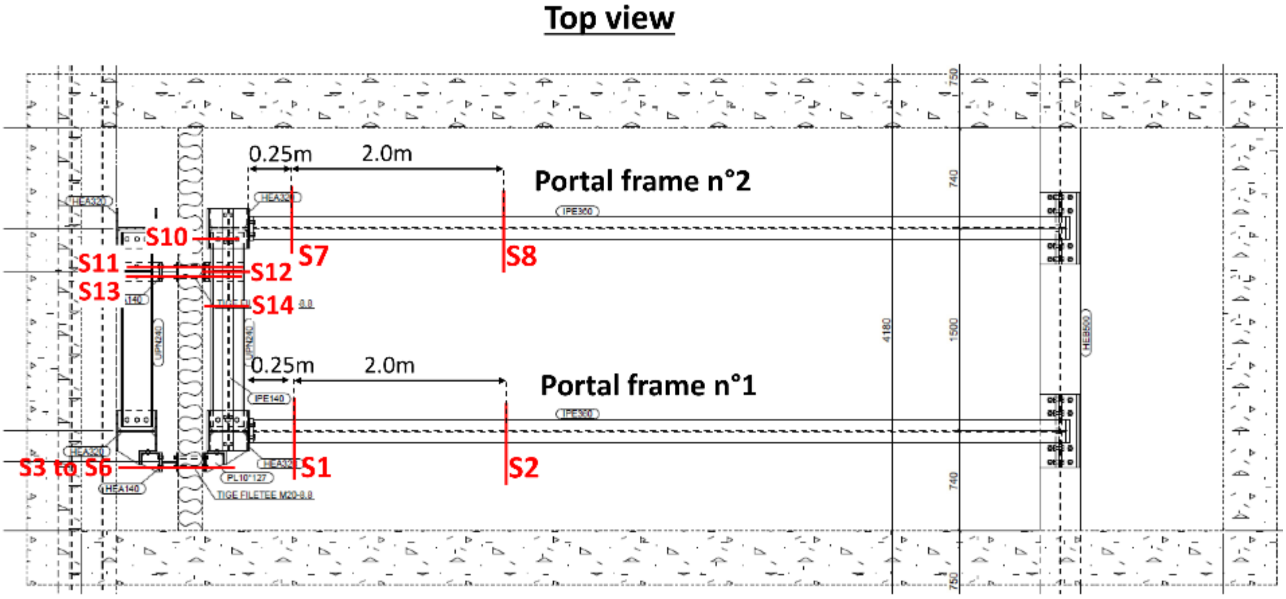


Coupe F - F

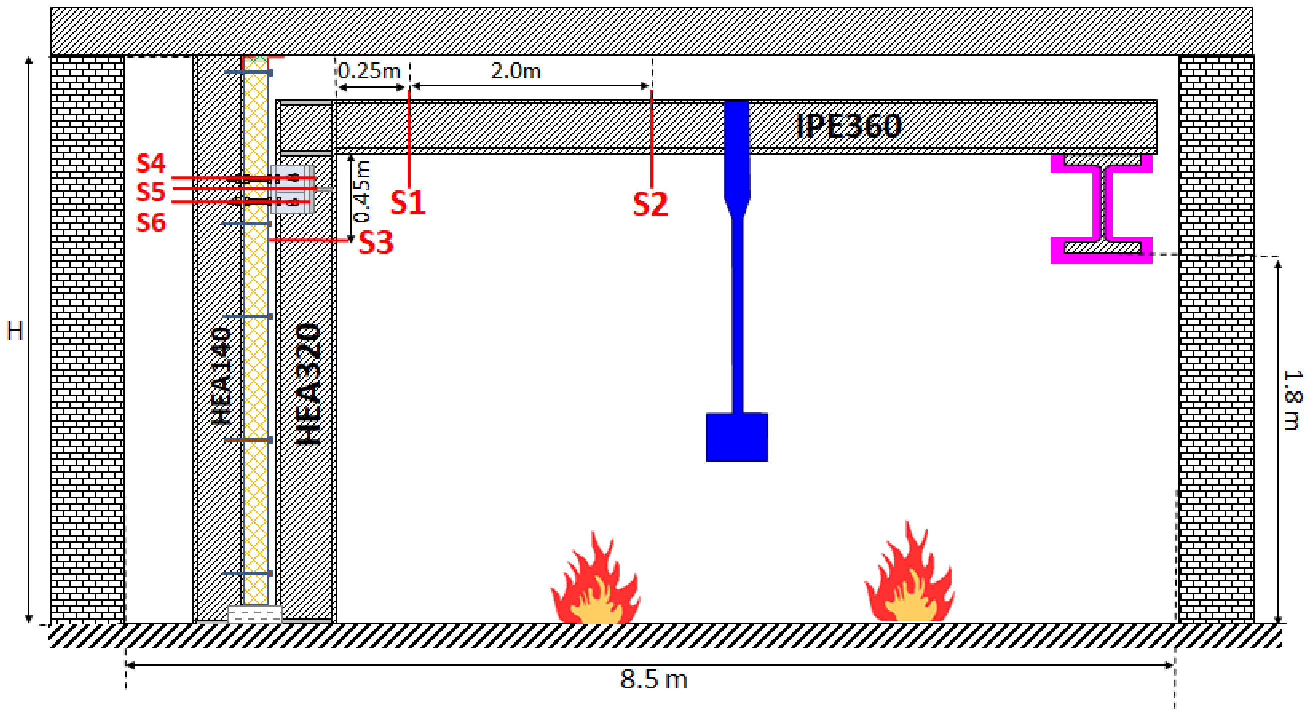


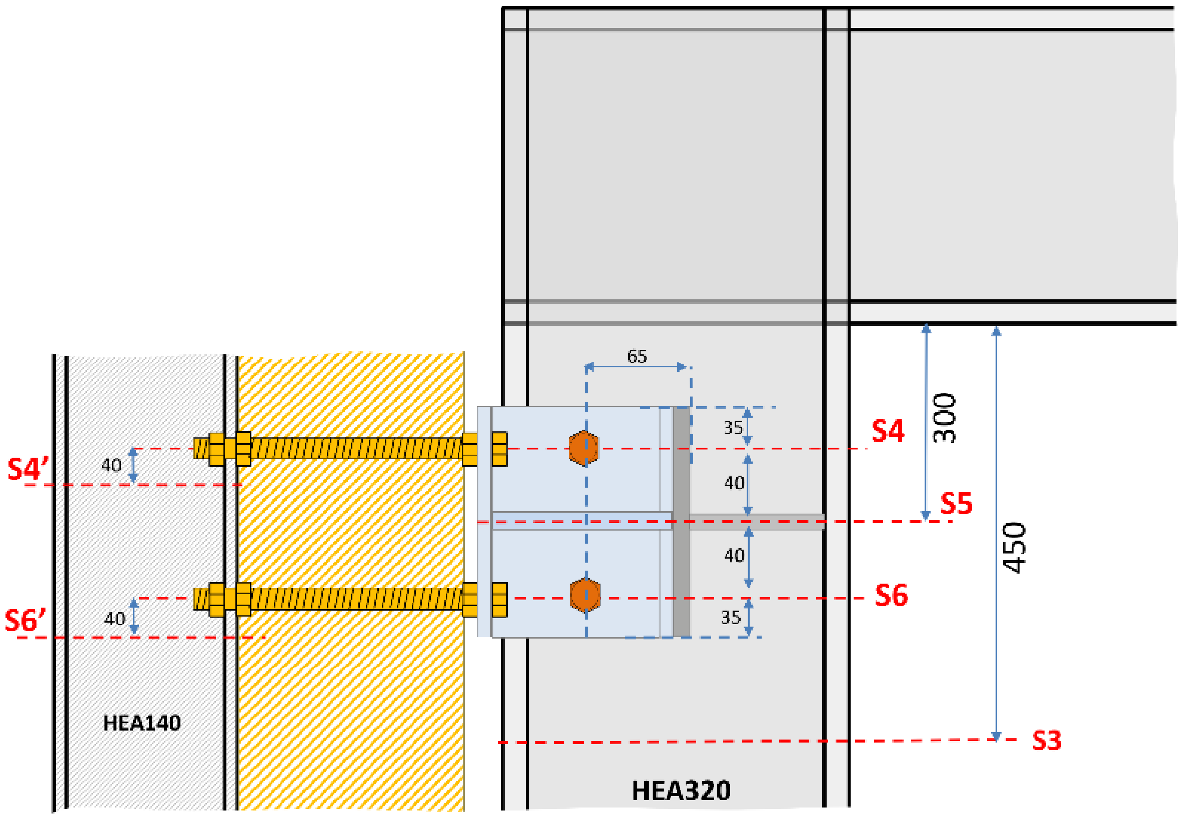
LOCATIONS OF THERMOUCOUPLES

Location of the measuring cross-section along all members

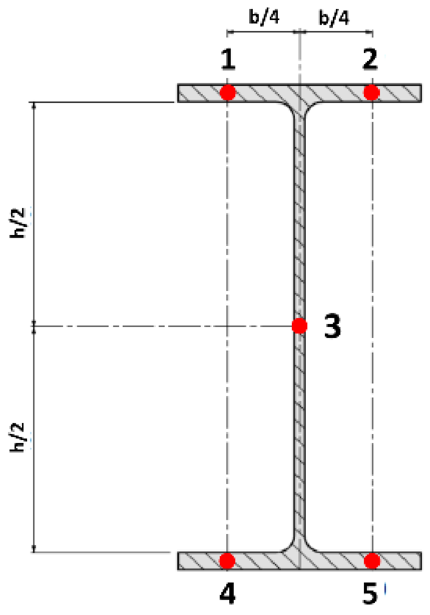


Location of the measuring cross-section along the portal frame n°1

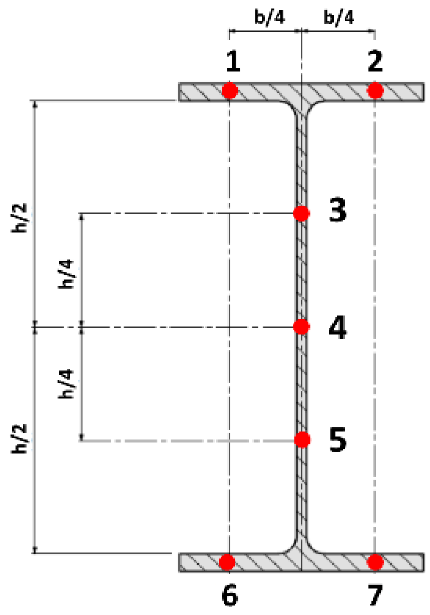


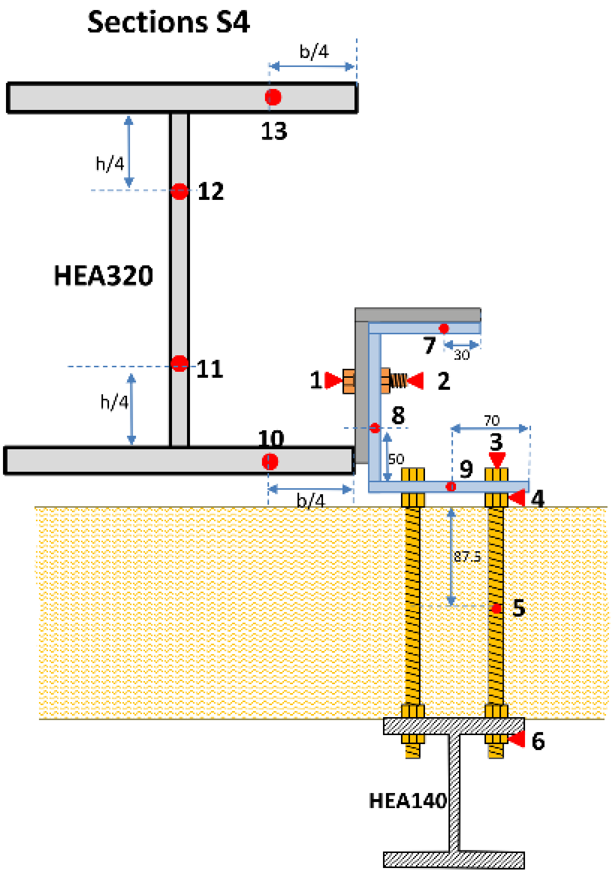


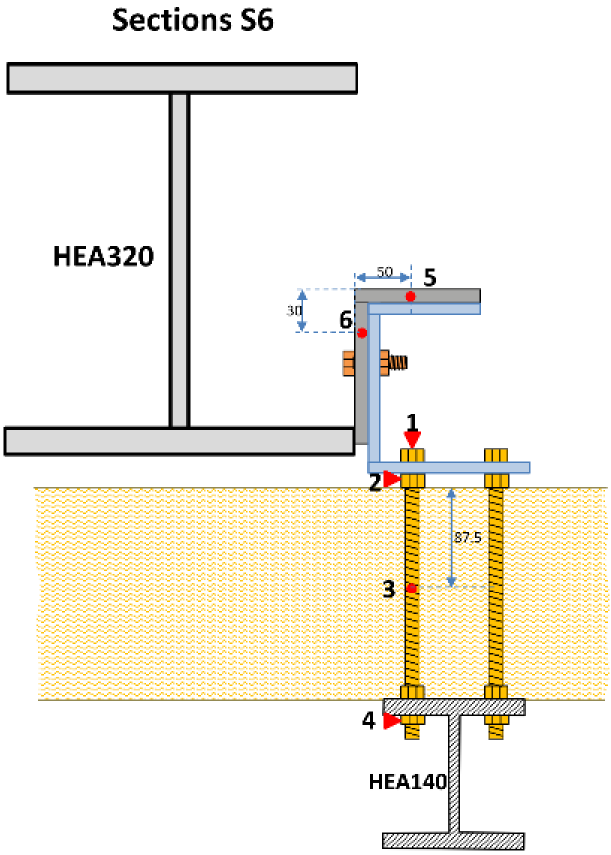
Sections S1 & S3

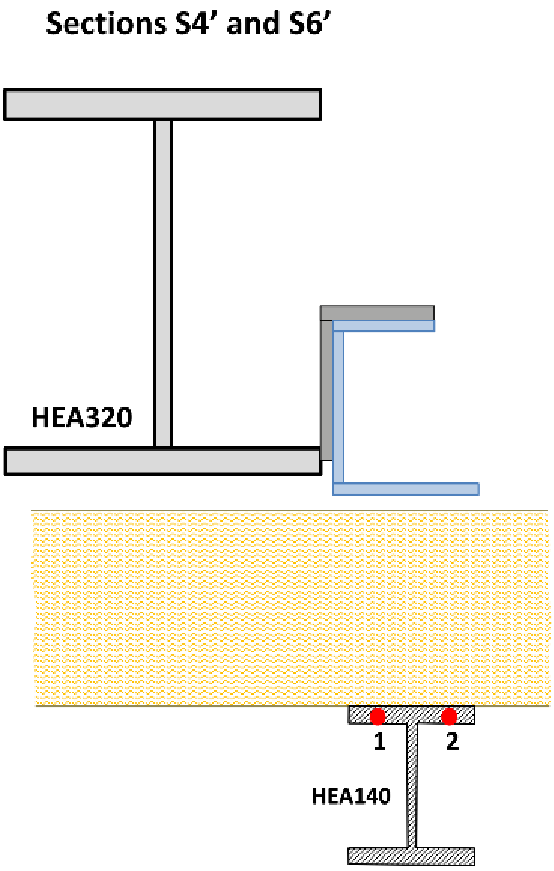


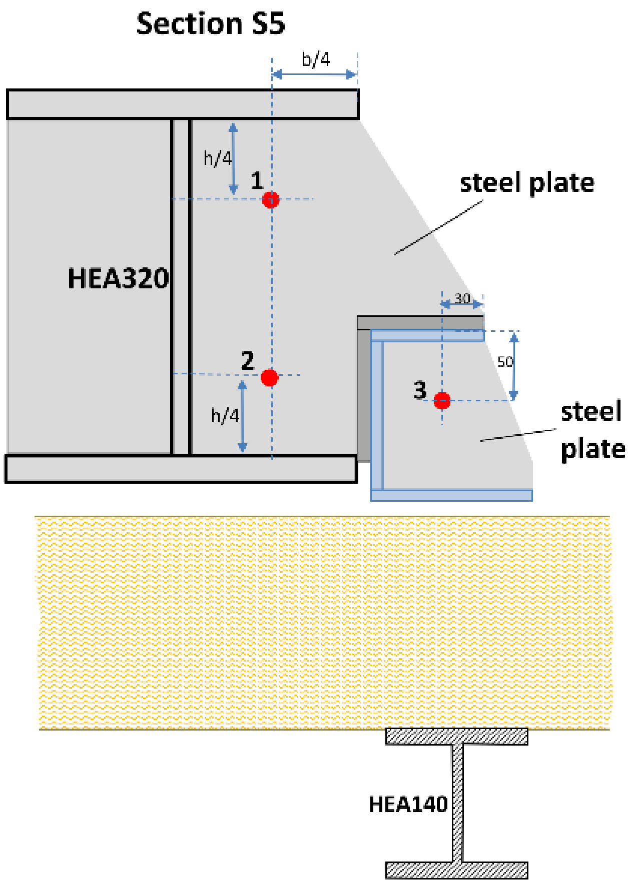
Section S2



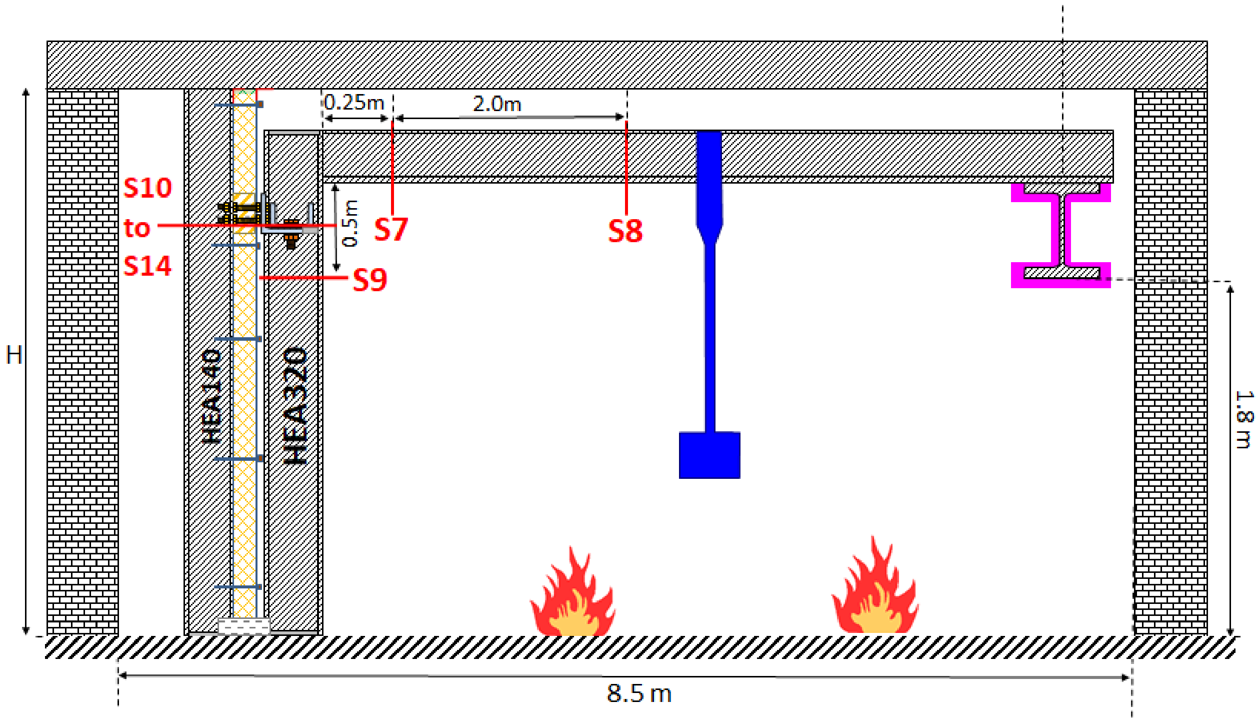

Sections S4
b/4
13
h/4
12
HEA320
11
h/4
10
b/4
7
30
1
2
8
70
3
50
9
4
87.5
5
6
HEA140


Sections S6
HEA320
50
5
30
6
1
2
87.5
3
4
HEA140

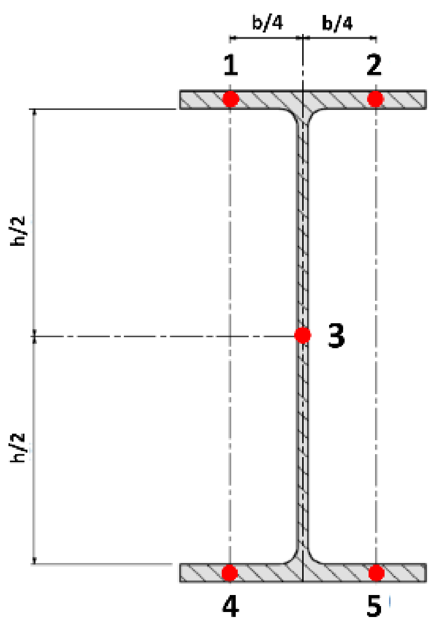

Sections S4' and S6'
HEA320
1
2
HEA140


Section S5
b/4
h/4
1
steel plate
HEA320
30
50
2
3
h/4
steel plate
HEA140

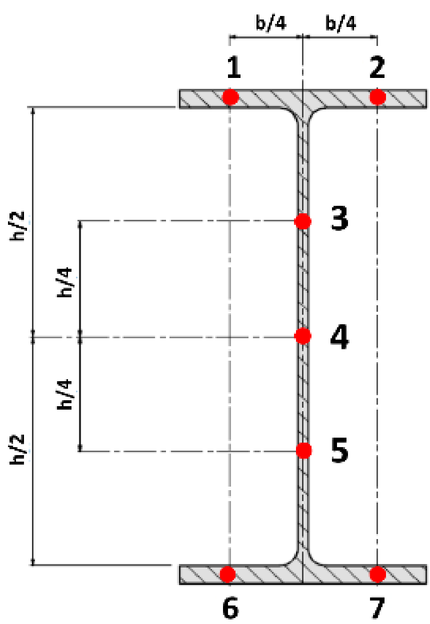
Location of the measuring cross-section along the portal frame n°2

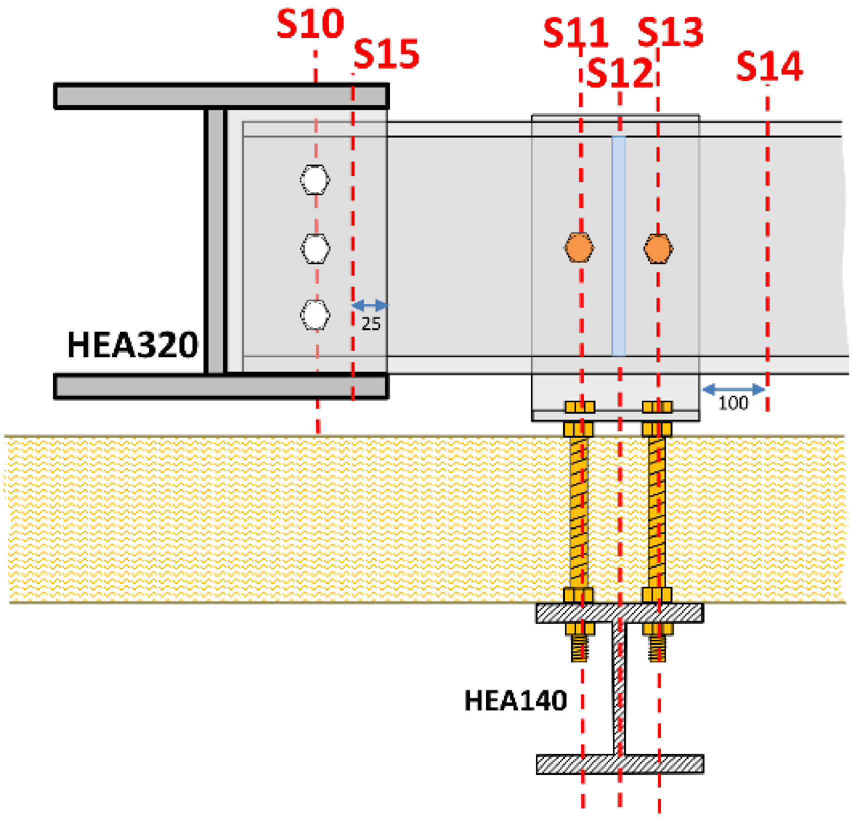


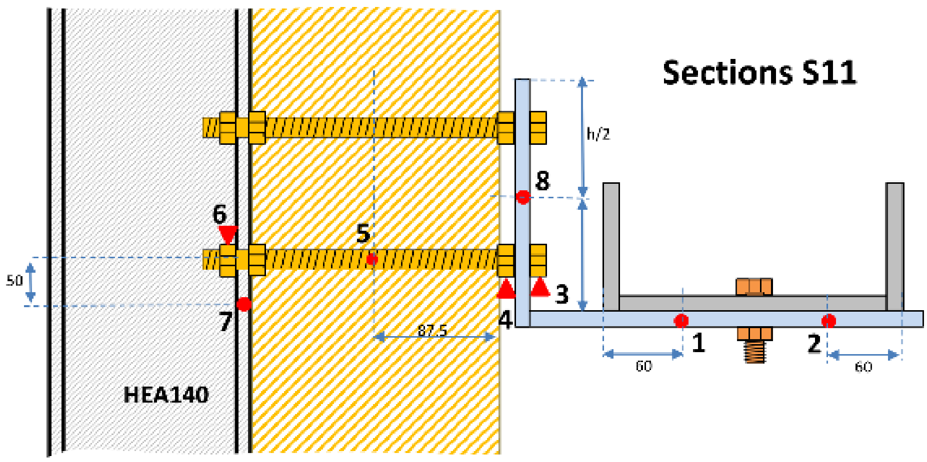
Sections S7 & S9

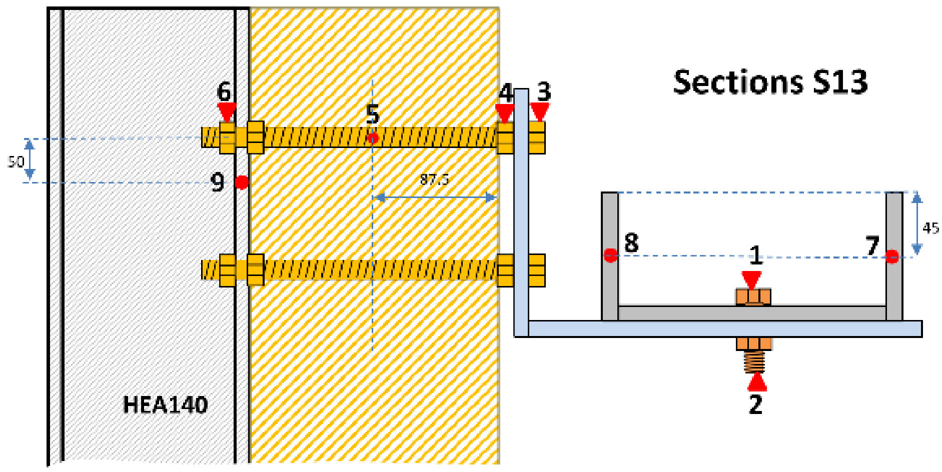


Section S8

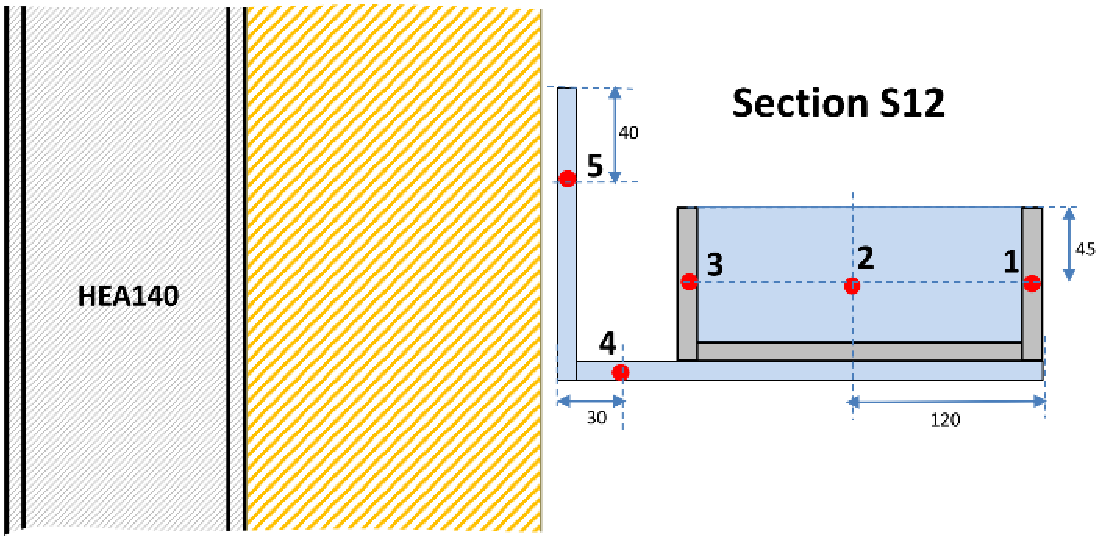



S10
S15
S11
S13
S12
S14
HEA320
25
100
HEA140

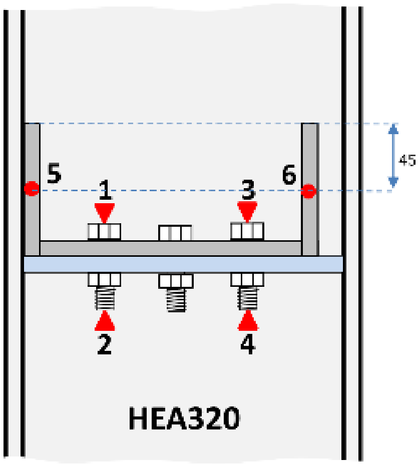

Sections S11
h/2
8
6
5
3
50
7
4
87,5
1
2
60
60
HEA140


Sections S13
6
4
3
5
50
9
87,5
45
8
1
7
2
HEA140

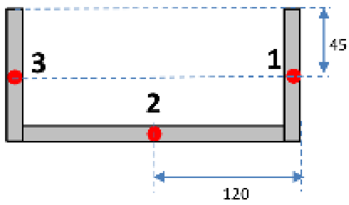
Section S12



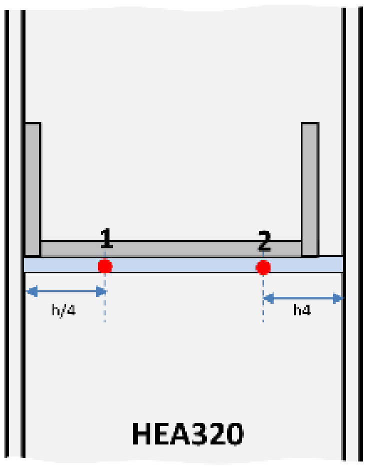
Section S10



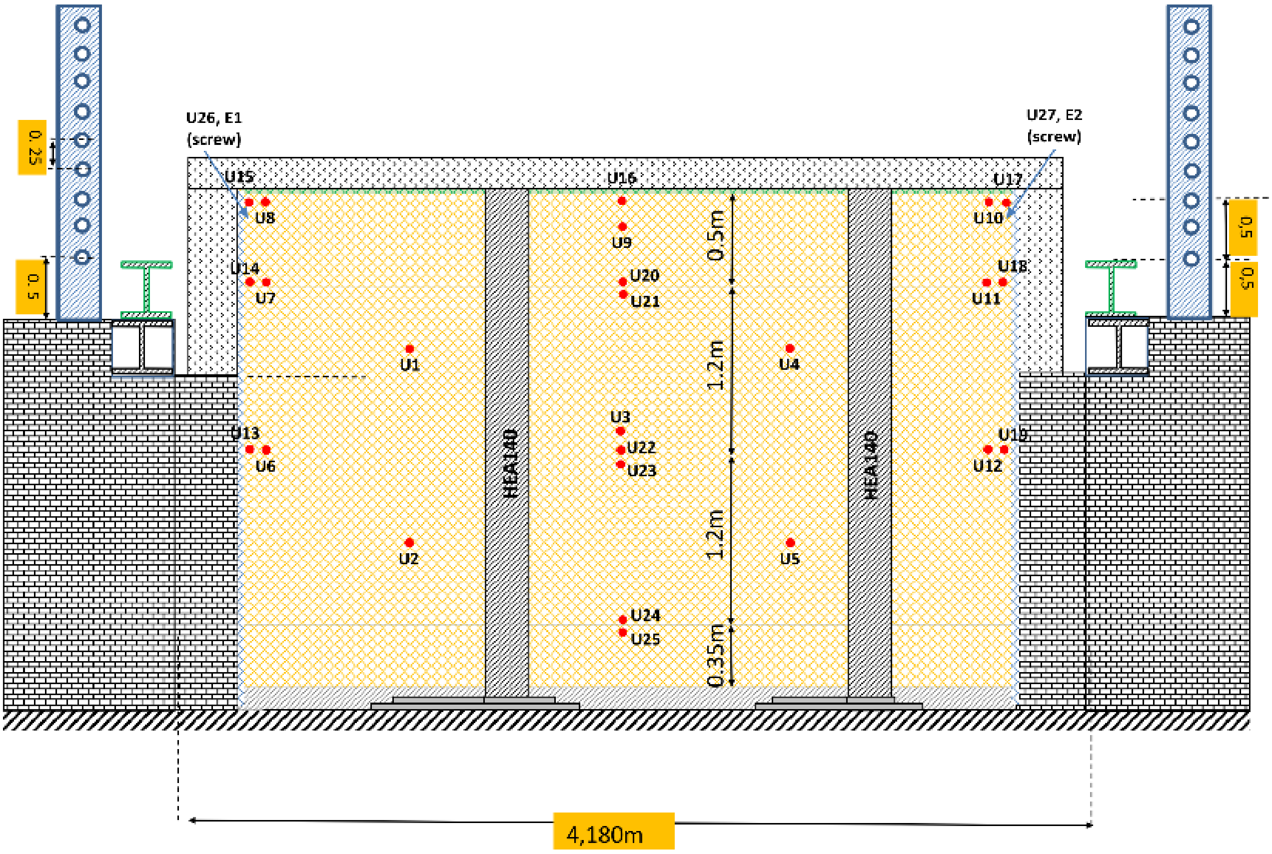
Section S14



Section S15

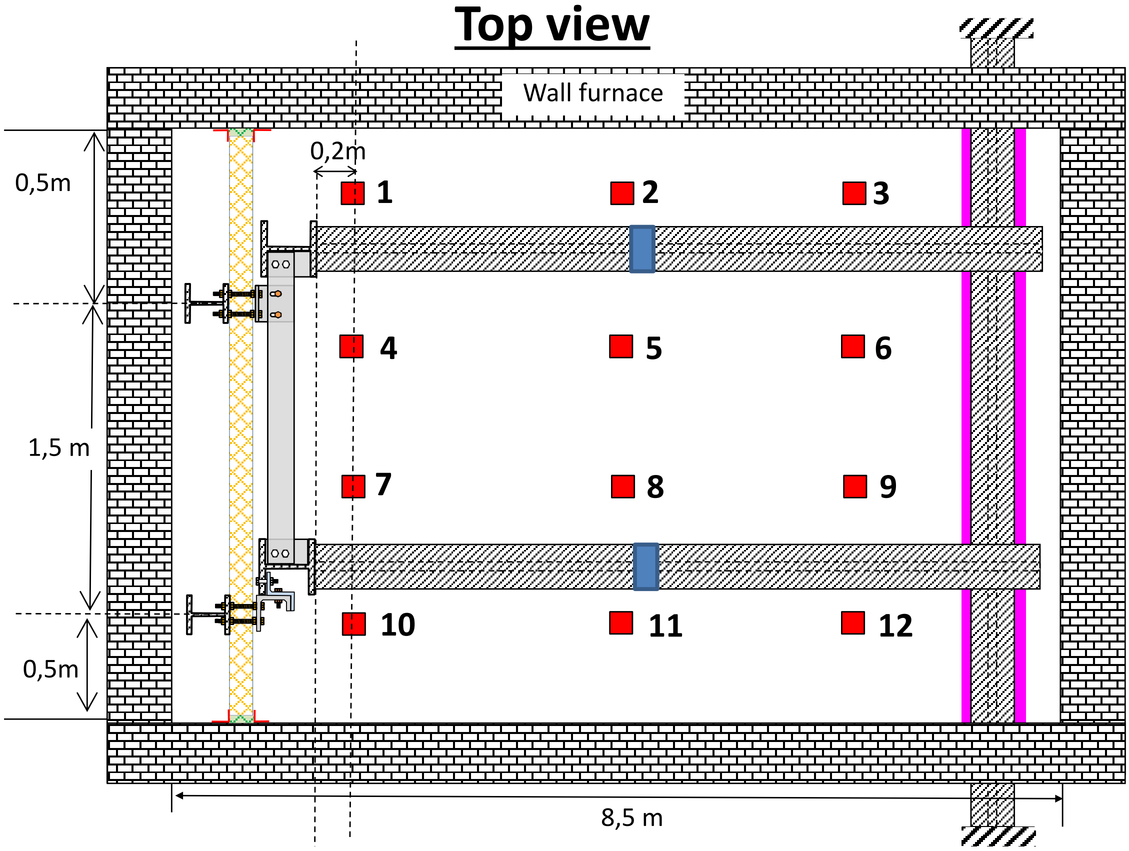


Location of thermocouples on the fire-unexposed side of the wall

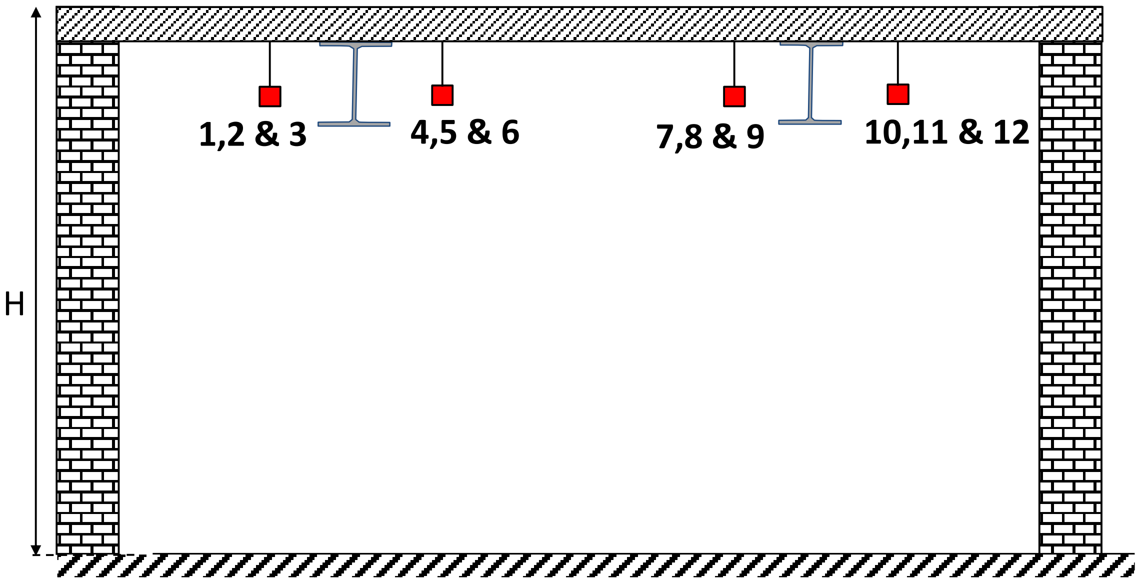


LOCATIONS OF PLATETHERMOTERS INSIDE THE FURNACE

Top view

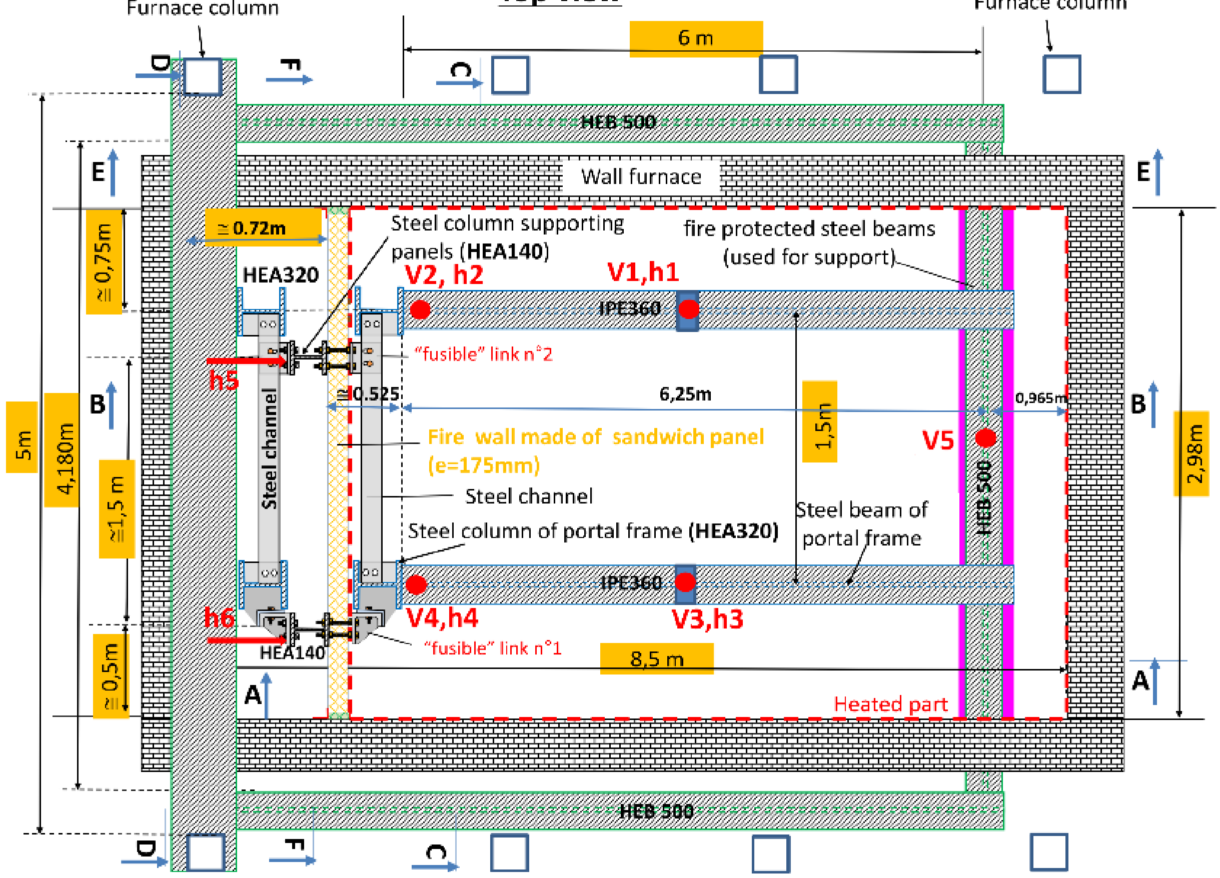


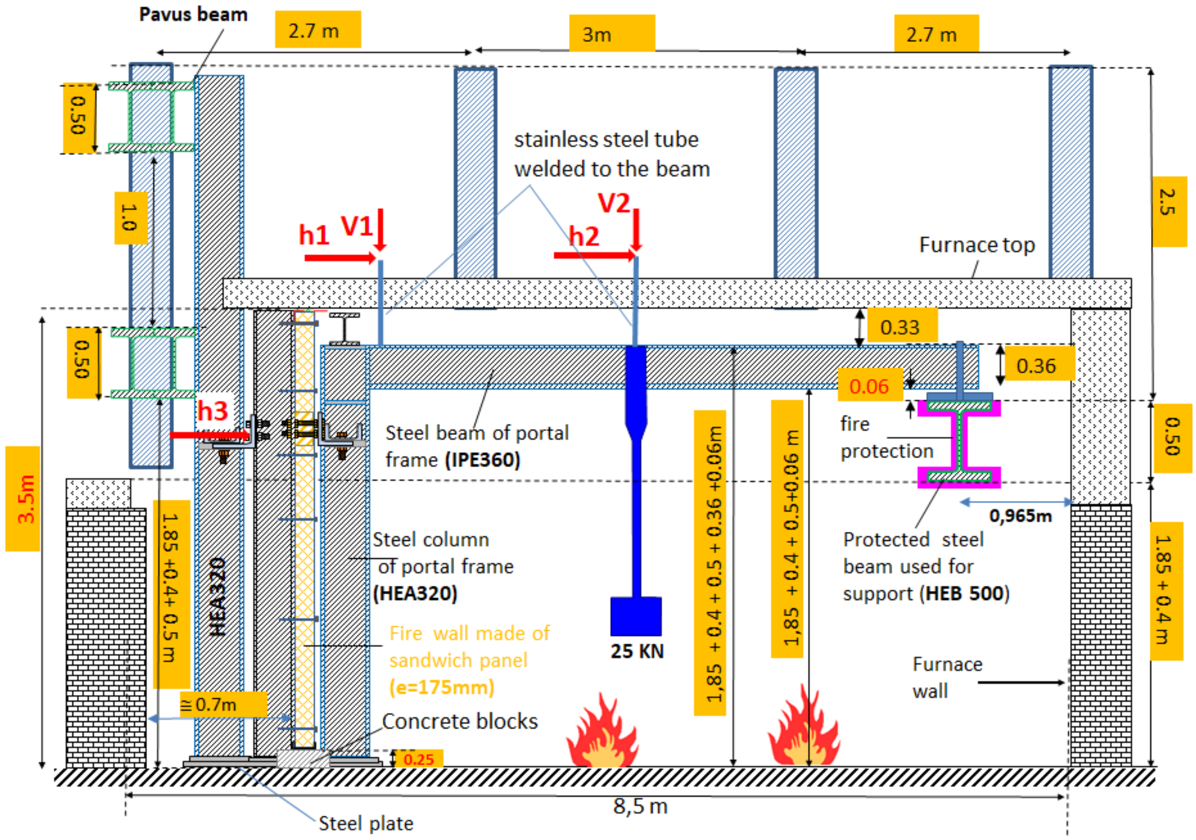
Side view

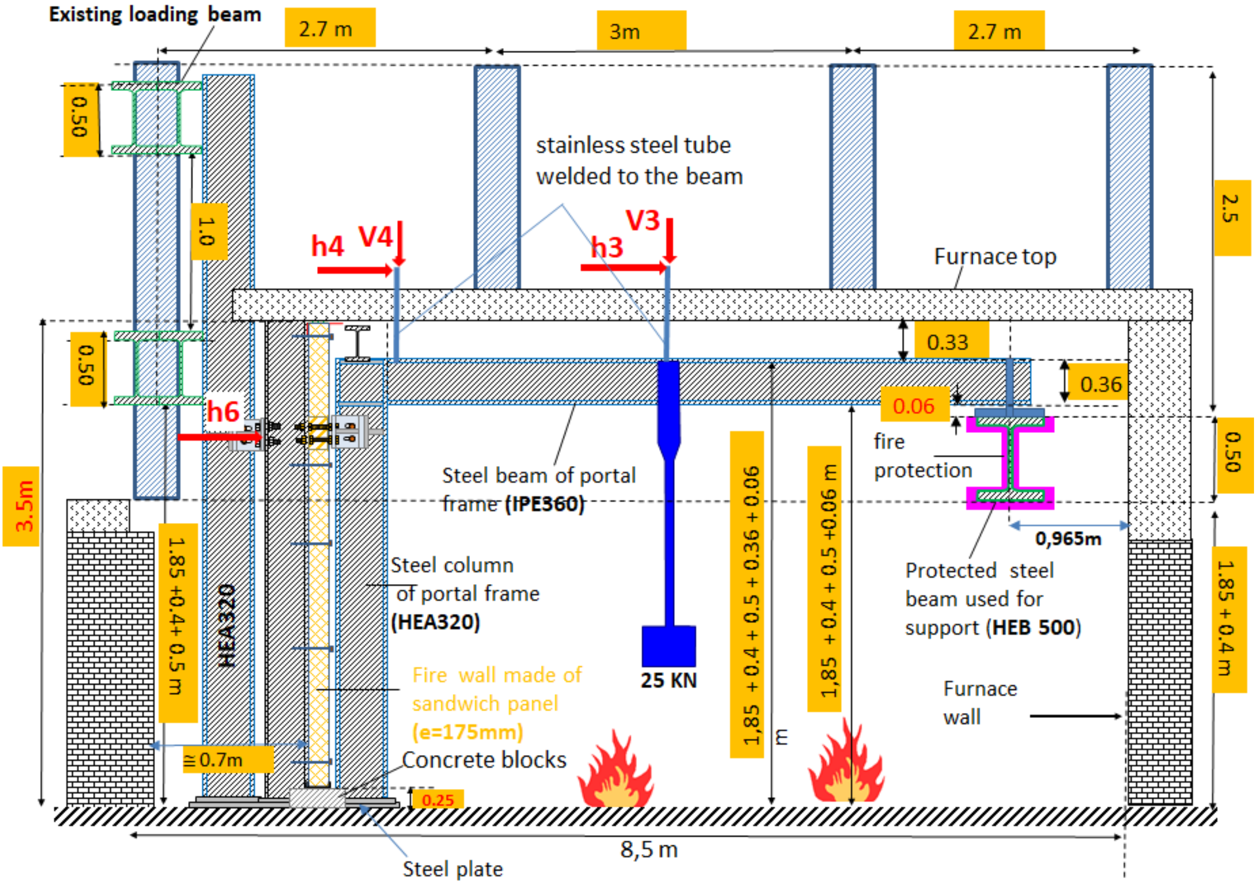


LOCATIONS OF DISPLACEMENT MEASUREMENTS

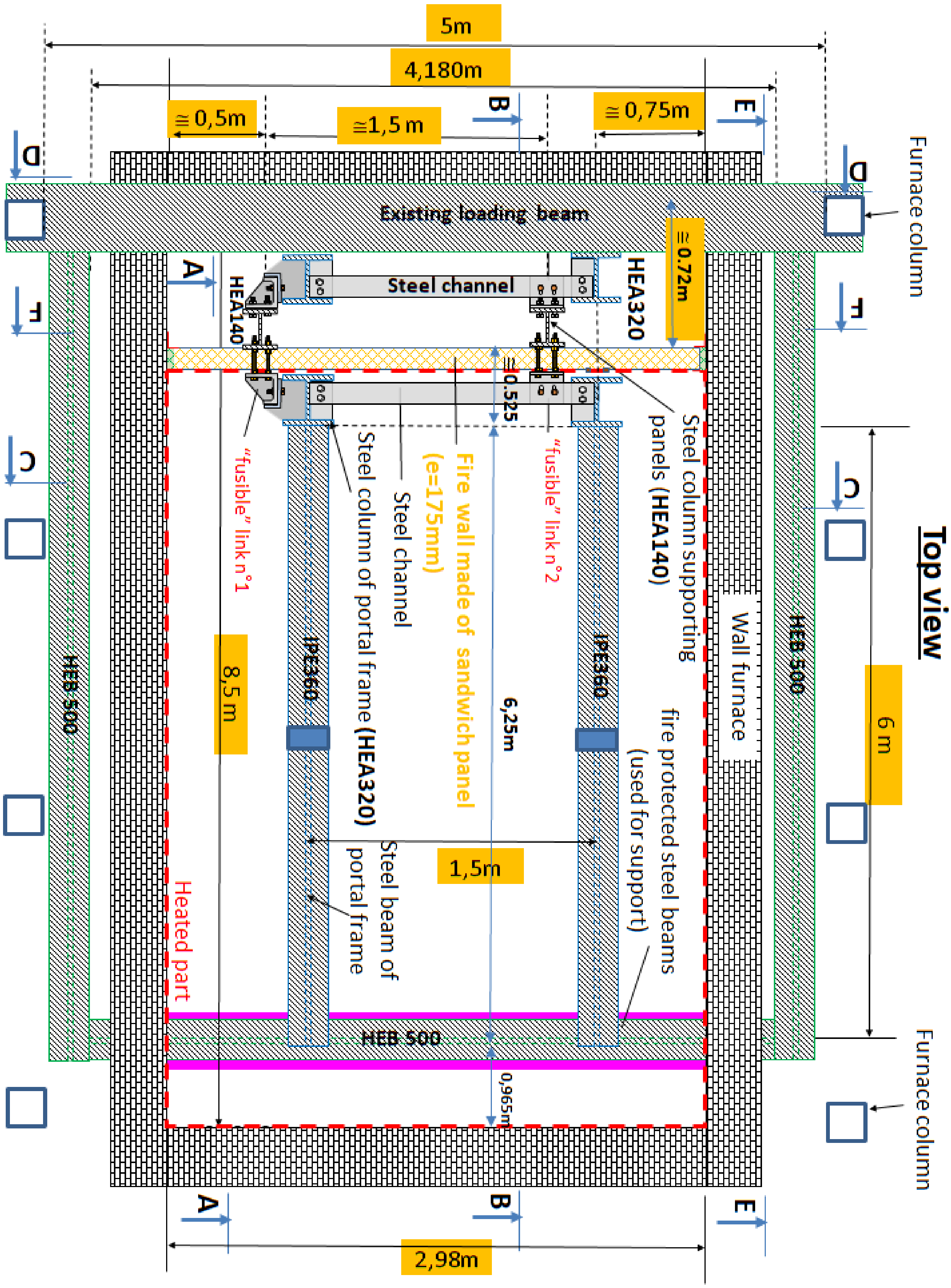
Top view



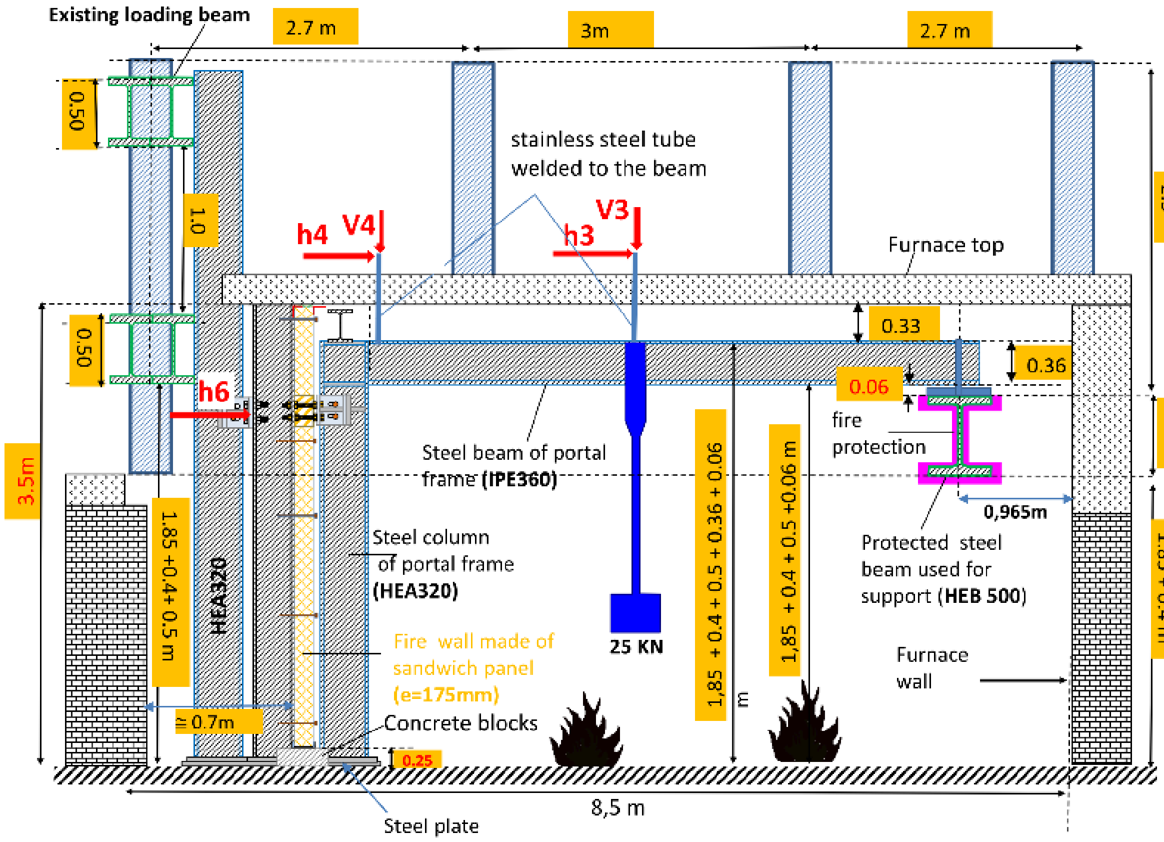



Existing loading beam
2.7 m
3m
2.7 m
0.50
1.0
0.50
3.5m
stainless steel tube
welded to the beam
h4
V4
V3
h3
h6
Furnace top
2.5
0.33
0.36
0.06
0.50
fire
protection
Steel beam of portal
frame (IPE360)
Steel column
of portal frame
(HEA320)
HEA320
1.85 +0.4+ 0.5 m
Fire wall made of
sandwich panel
(e=175mm)
25 KN
1,85 +0.4 + 0.5 + 0.36 + 0.06
m
1,85 +0.4 + 0.5 +0.06 m
0,965m
Protected steel
beam used for
support (HEB 500)
1.85 + 0.4 m
Furnace
wall
≅ 0.7m
Concrete blocks
0.25
8,5 m
Steel plate

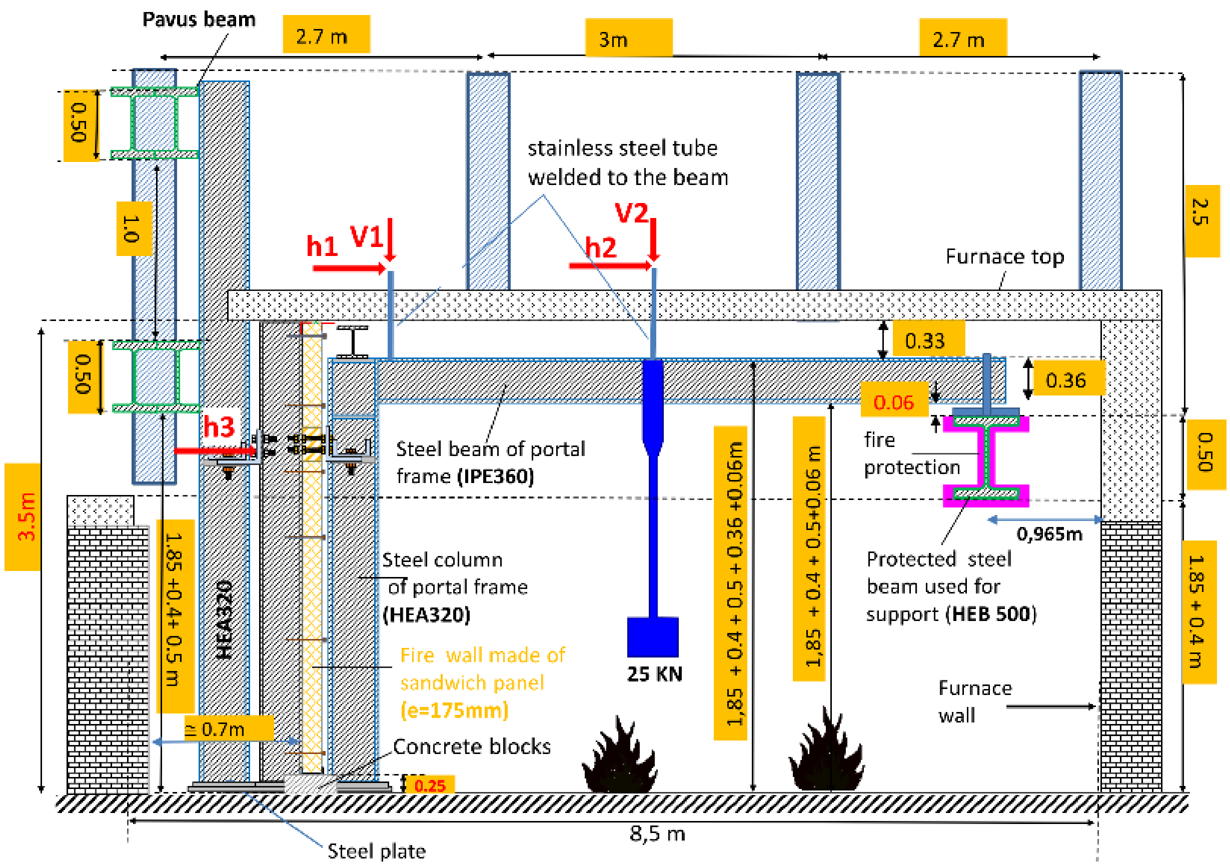
SCHEMATICS OF THE TEST SPECIMEN



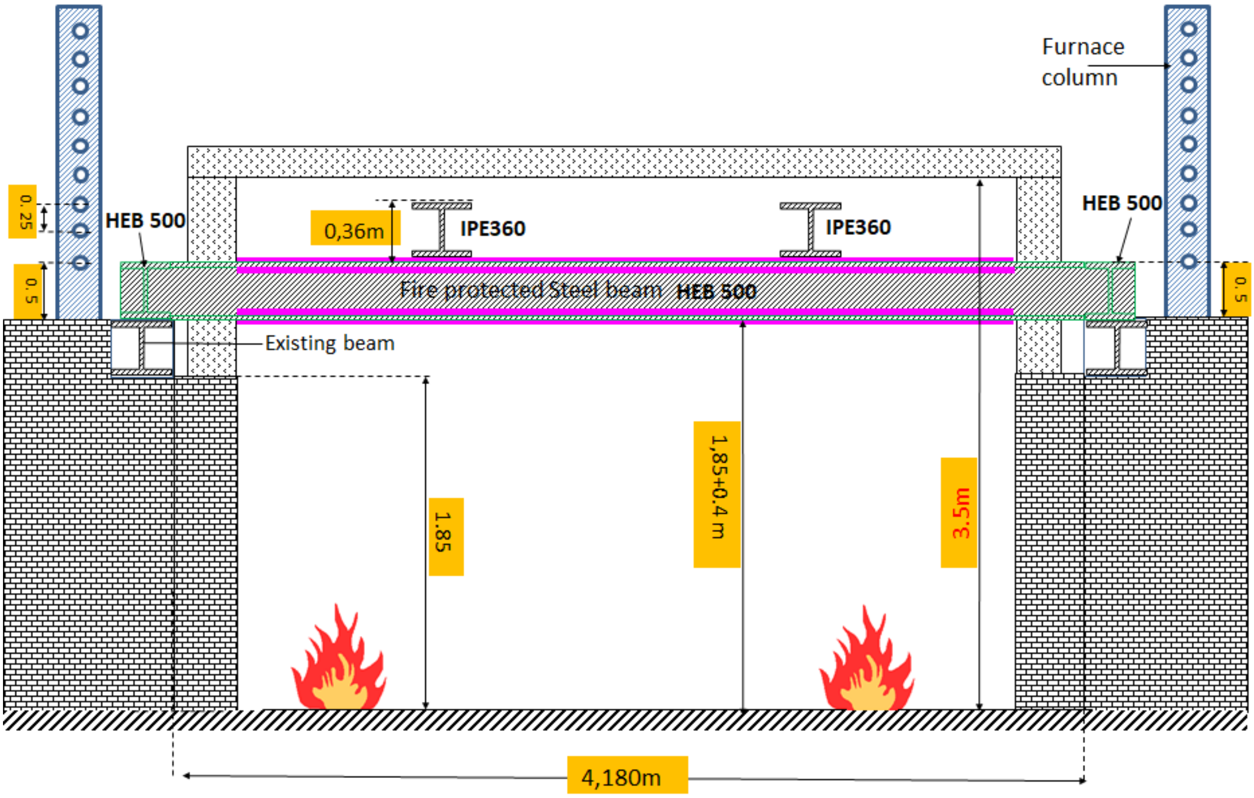
Side view A -A



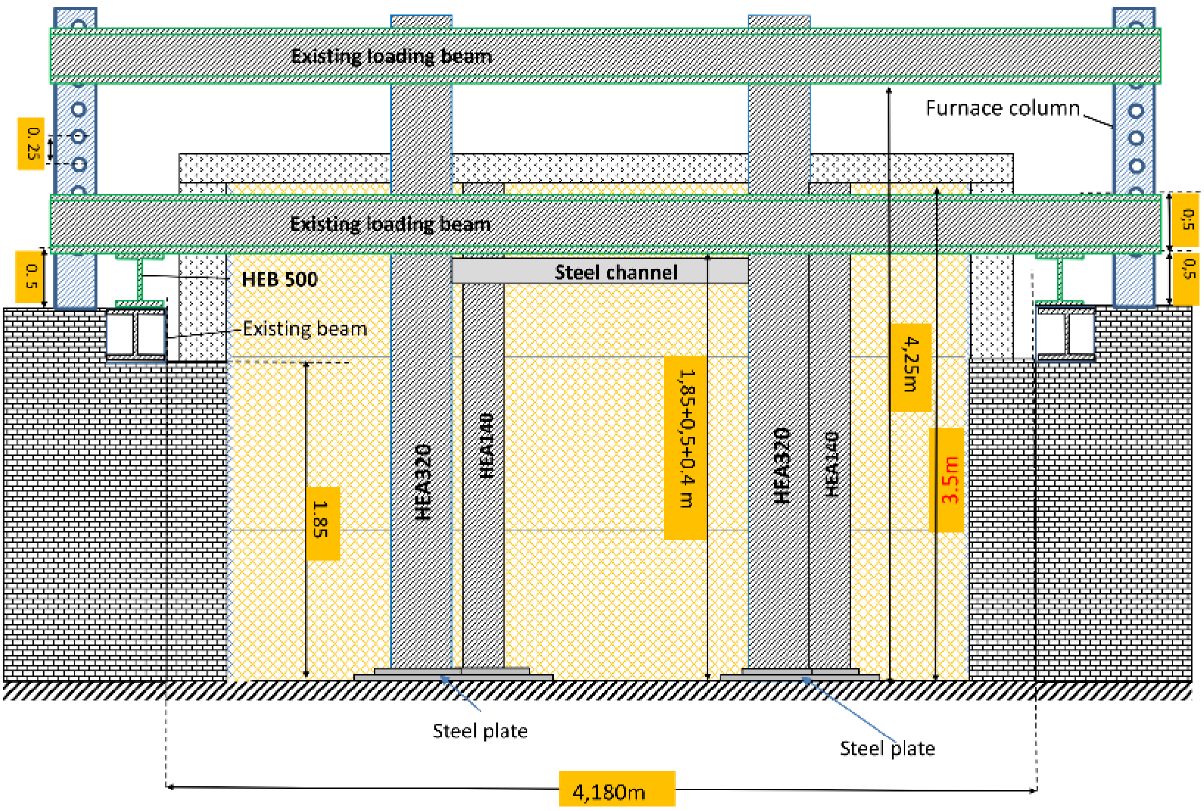
Side view B -B



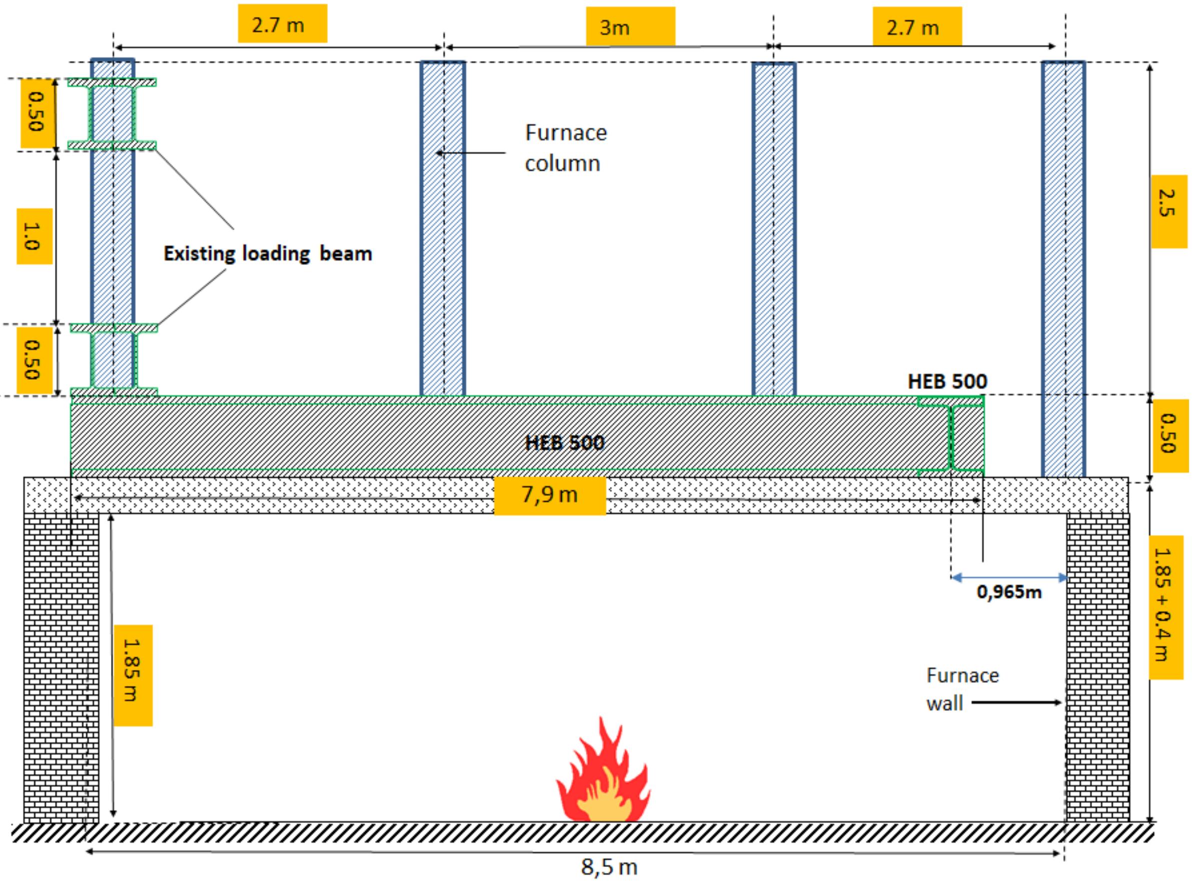
Side view C -C



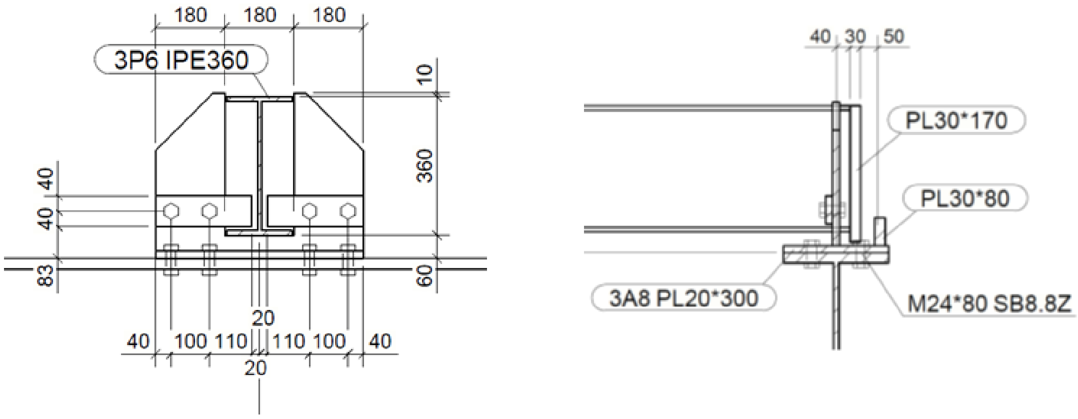
Side view D -D



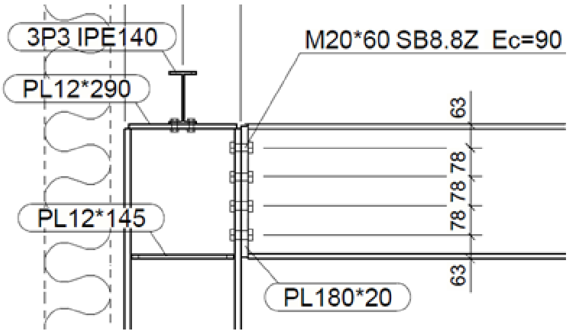
Side view E -E

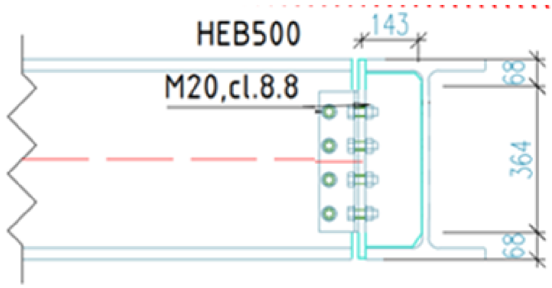

2.7 m
3m
2.7 m
0.50
1.0
0.50
Furnace
column
Existing loading beam
2.5
HEB 500
HEB 500
0.50
7,9 m
0,965m
1.85 m
Furnace
wall
1.85 + 0.4 m
8,5 m

CONSTRUCTIONAL DETAILS



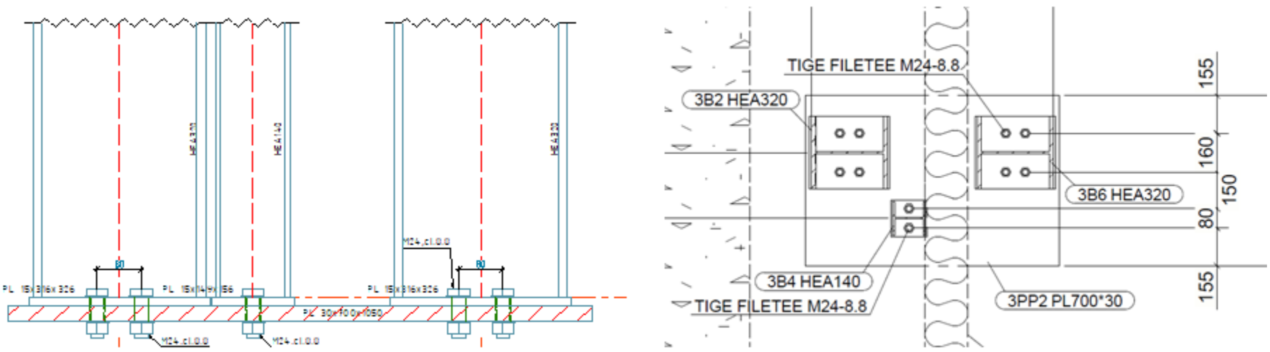
Fork support at beam end of portal frame





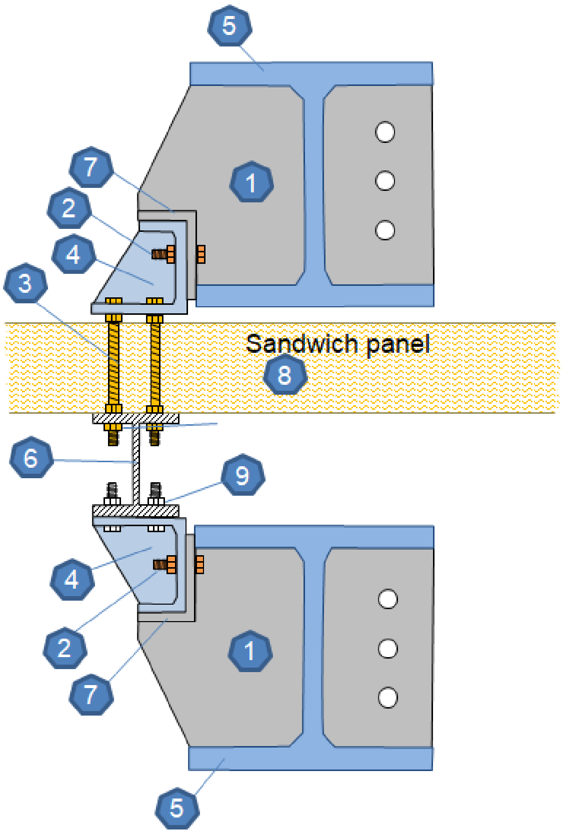
Beam-to-beam connection

Beam-to-column connection

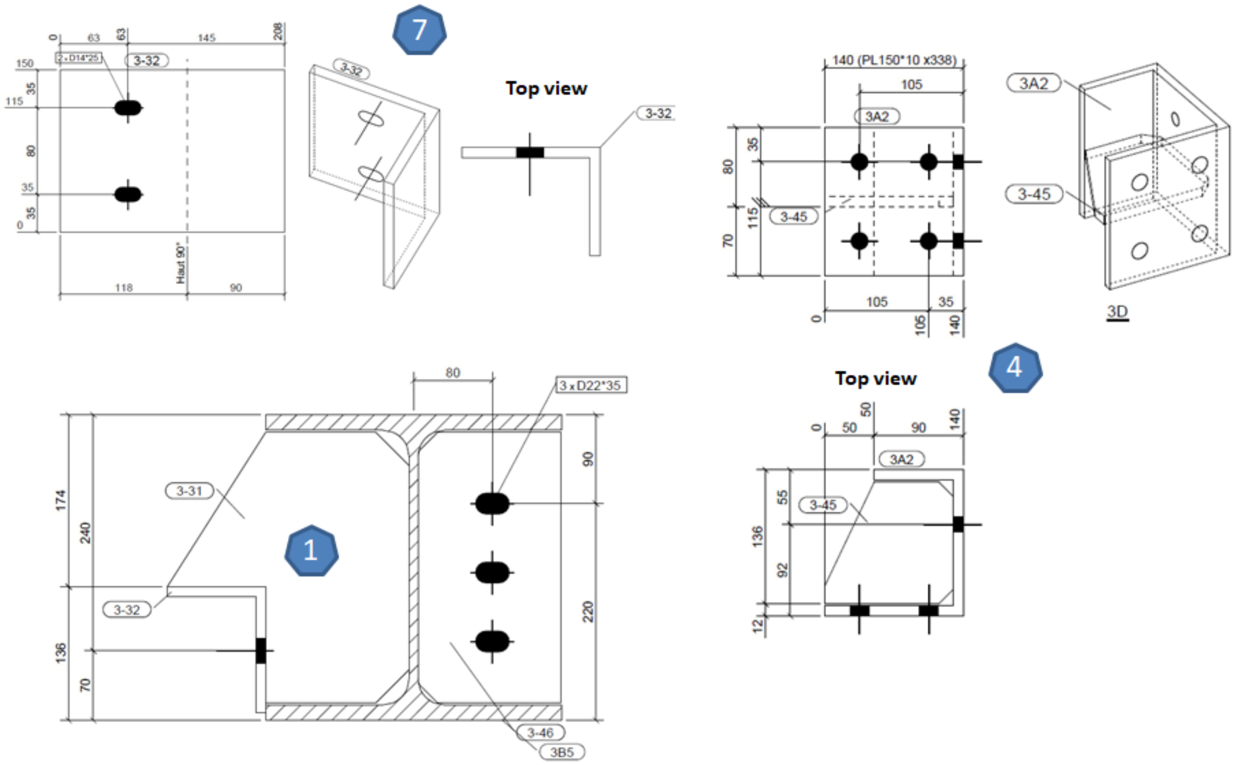


Bottom end of columns

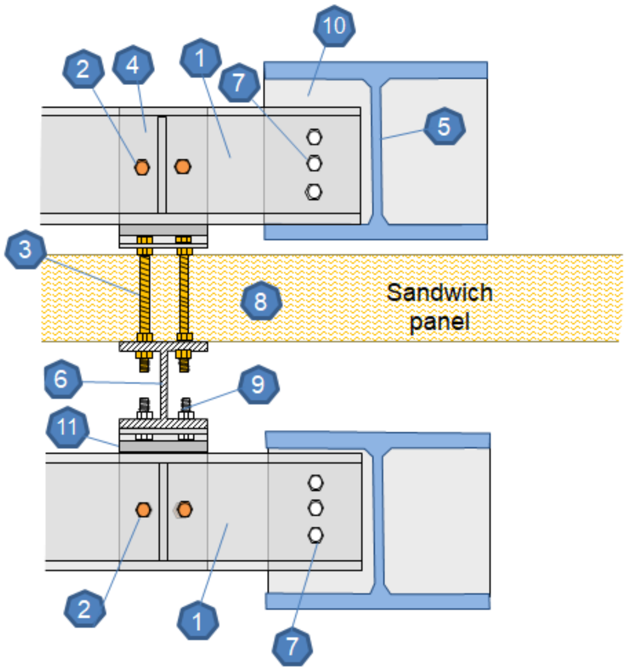
DETAILS OF FUSIBLE LINK n°1



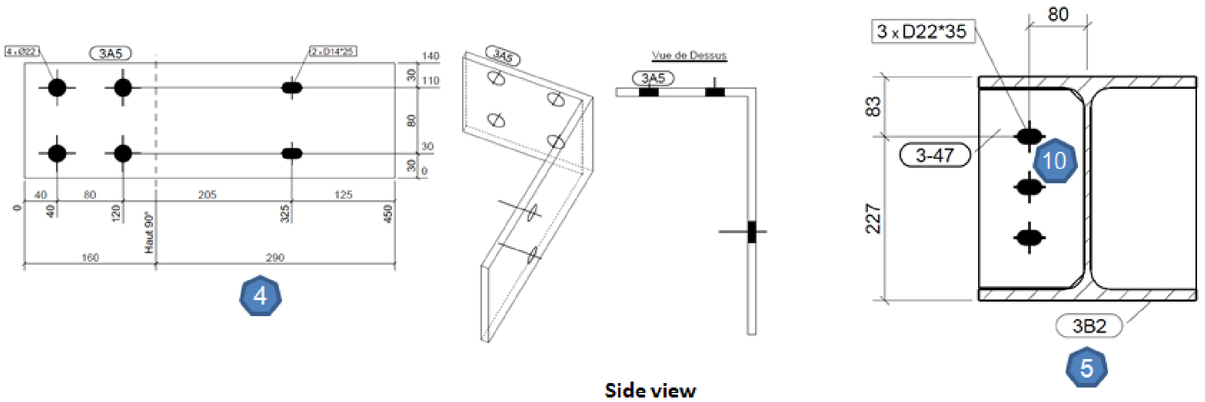
1. Gusset steel plate (10 mm thick, S355)
2. M12 aluminium bolts
3. M16 class 8.8 steel rods
4. U-shaped steel profile (12 mm thick , S355) with stiffener
5. Steel column of portal frame HEA320 (S275)
6. HEA140 steel column (S275)
7. L-shaped folded profile (10mm thick, S355)
8. Sandwich panels (175 mm thick)
9. M16 class 8.8 bolts



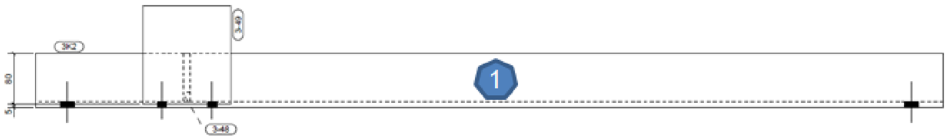
DETAILS OF FUSIBLE LINK n°2



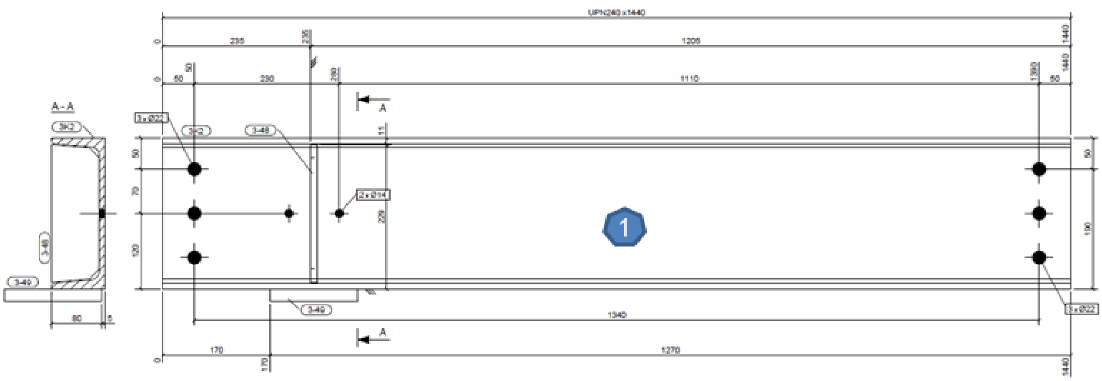
1. UPN 240 steel profile (S275)
2. M12 aluminium bolts
3. M16 class 8.8 steel rods
4. L-shaped steel profile (10mm thick, S355)
5. Steel column of portal frame HEA320 (S275)
6. HEA140 steel column (S275)
7. M20 class 8.8 bolts
8. Sandwich panels (175 mm thick)
9. M16 class 8.8 bolts
10. Welded steel plate (10mm thick, S355)
11. Steel shim welded to the UPN (20mm thick, S355)
12. Steel stiffener (10mm thick, S355)



Side view



Top view

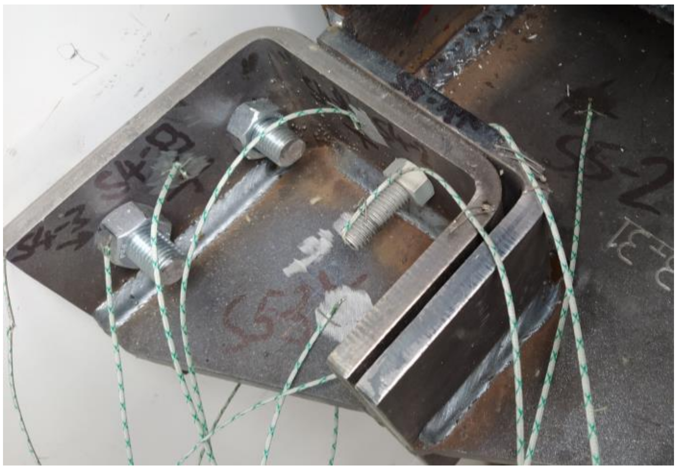


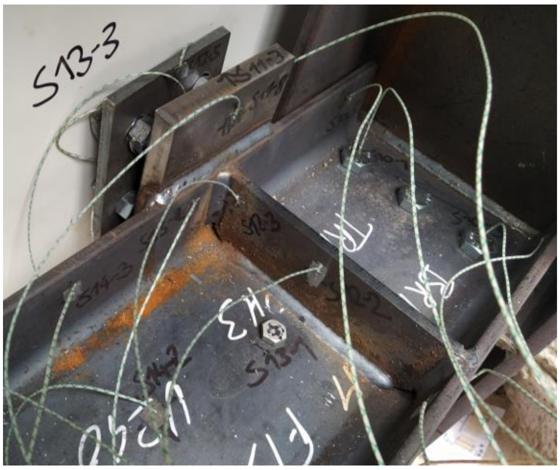
ANNEX D: PHOTOS

Assembly of the steel structure

Assembly of the wall

Application of the load

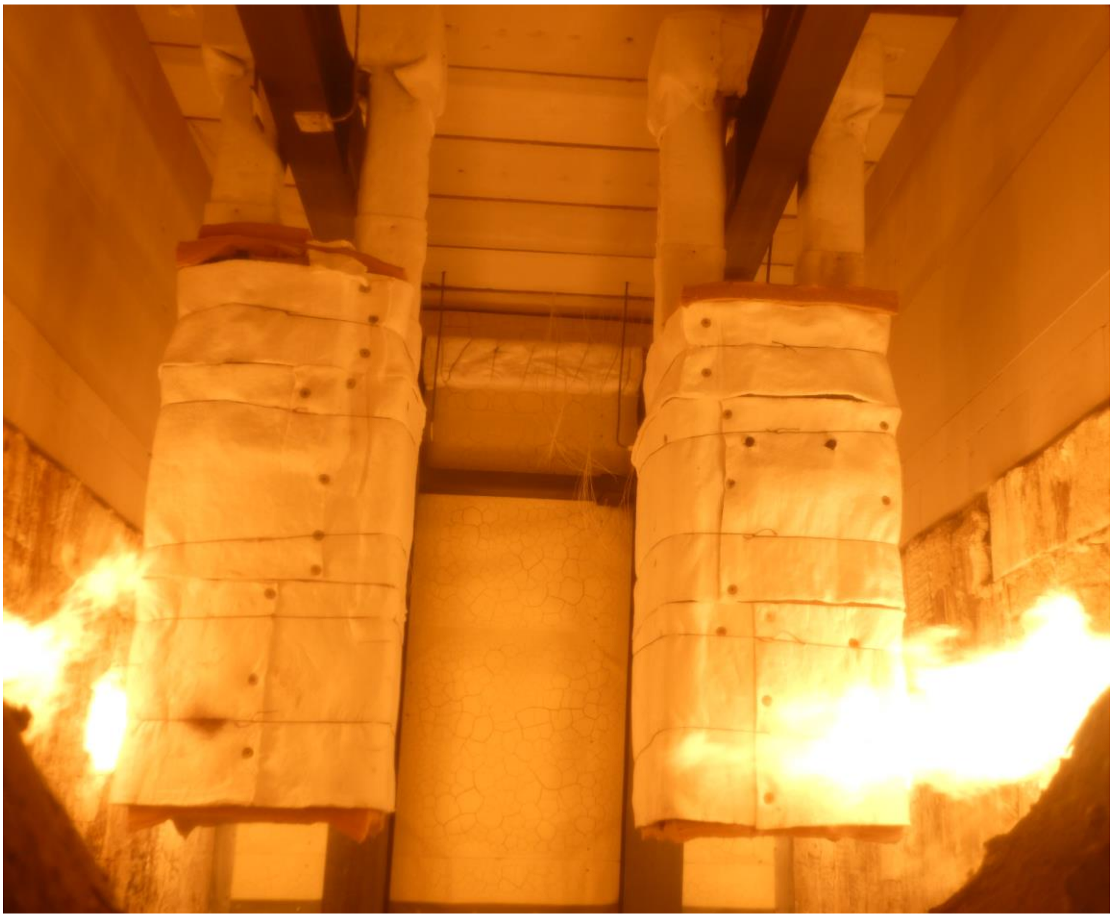




Detail of the thermocouples in the area of the fusible links

EF before the test

UF before the test

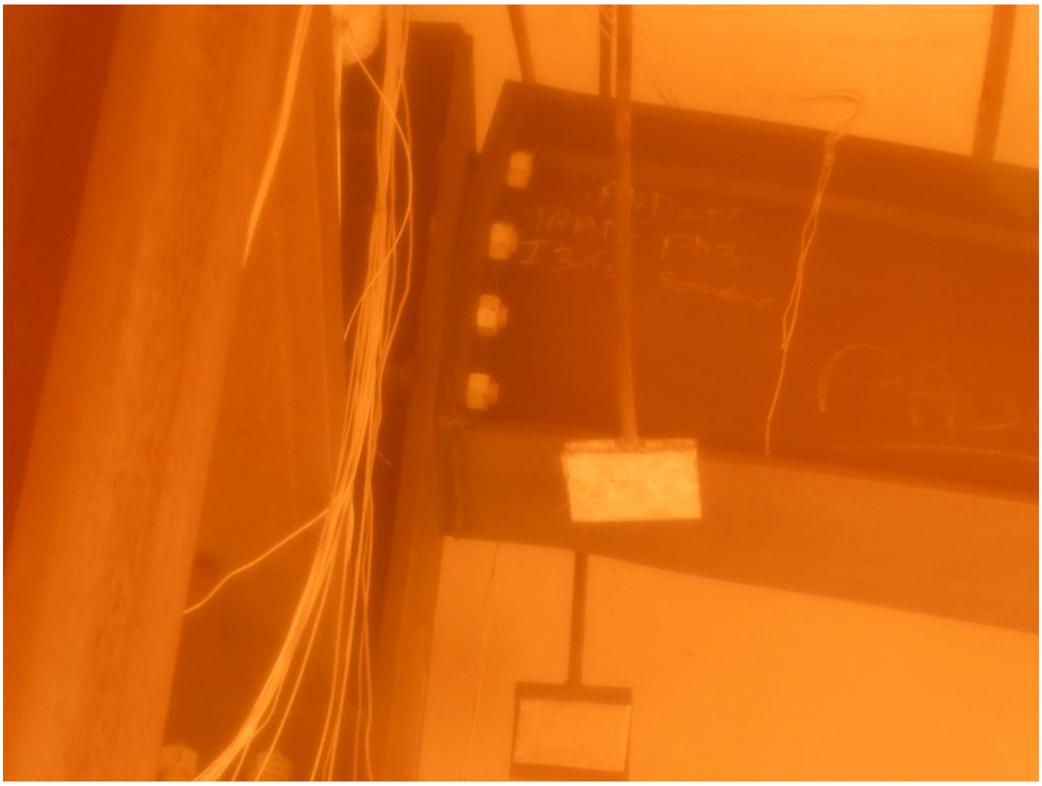


EF after 20 minutes of the test

View of the fusible link No. 2 after 25 minutes of the test

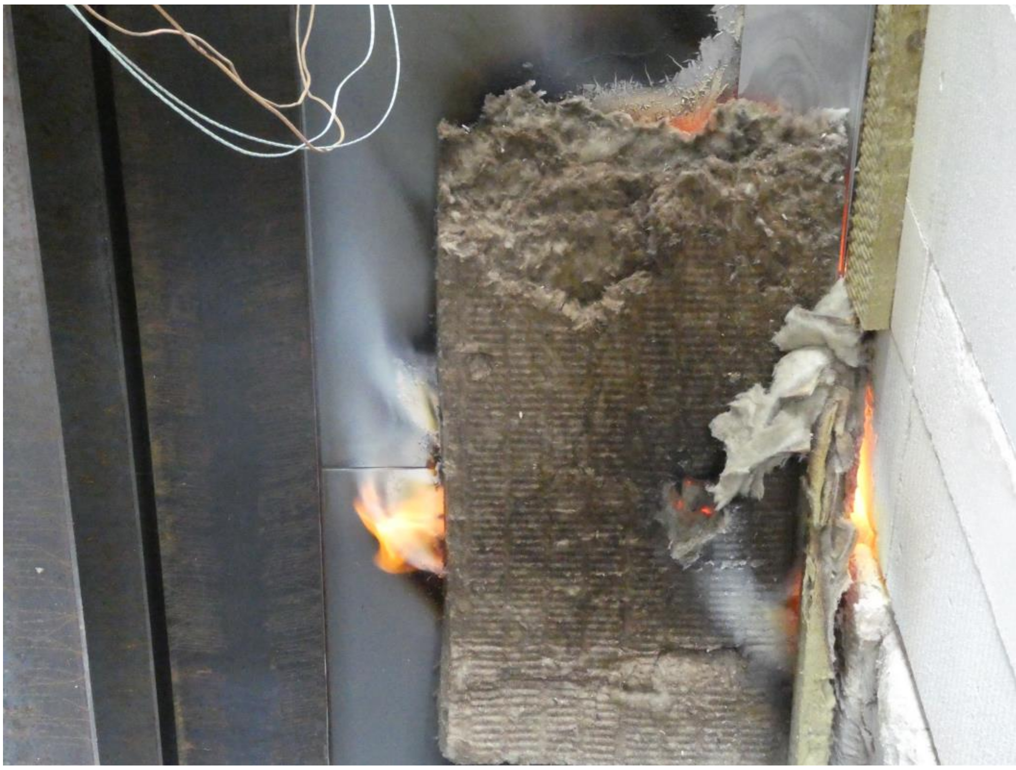
EF after 27 minutes of the test

EF after 30 minutes of the test

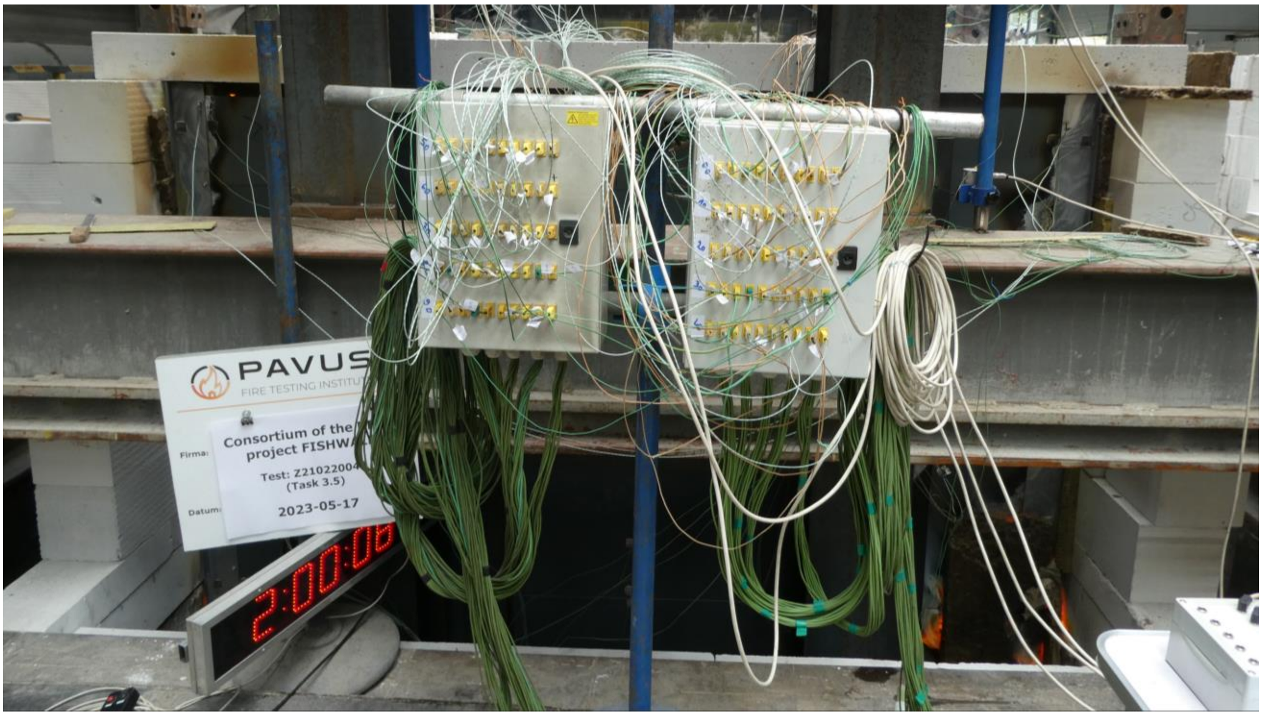


Detail of the beam to column connection of steel portal frame No. 2 after 32 minutes of the test

Sustained flaming of the vertical edge of the wall from 69th minute of the test



UF of the wall after 110 minutes of the test



UF after 120 minutes of the test


EF after 120 minutes of the test and turn off the burners

EF the second day after the test



EF the second day after the test