Bauforschung

Entwicklung eines Prüfverfahrens zum Brandverhalten von Baustoffen – Verbesserung am SBI-Test

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Entwicklung eines Prüfverfahrens zum Brandverhalten von Baustoffen – Verbesserungen am SBI-Test –

Dipl.-Ing. Klingelhöfer

Juli 1999

Materialprüfungsamt Nordrhein-Westfalen
- Außenstelle Erwitte -

1. Aufgabenstellung

Im Rahmen eines ersten Entwicklungsprogramms wurde von einer Gruppe von 9 Laboratorien in verschiedenen europäischen Ländern ein Prüfverfahren zum Brandverhalten von Baustoffen entwickelt. Das als Ergebnis der Arbeit vorgestellte Verfahren wurde vom Grundsatz her akzeptiert.

In diesem Anschlußprojekt sollten Detailverbesserungen an dem Prüfverfahren vorgenommen und erprobt werden, so daß das Verfahren als Grundlage für die europäische Klassifizierung des Brandverhaltens von Baustoffen genormt werden kann. Bestandteil der Arbeit war auch die Erarbeitung eines ersten Normentwurfs.

2. Umfang und Durchführung des Vorhabens

Die Arbeiten zur Verbesserung des SBI-Tests wurden folgenden 12 Brandversuchslaboratorien aus verschiedenen europäischen Ländern gemeinsam übertragen:

RIJKSUNIVERSITEIT GENT (RUG)
Laboratorium voor aanwending der brandstoffen
Ottergemsesteenweg 711
B-9000 Gent / Belgium

DANISH INSTITUTE OF FIRE TECHNOLOGY (DIFT)
Amager Boulevard 108
DK-2300 Kobenhavn S / Denmark

MATERIALPRÜFUNGSAMT NORDRHEIN-WESTFALEN (MPA NRW)
Auf den Thränen 2
D-59597 Erwitte / Germany

CENTRE SCIENTIFIQUE ET TECHNIQUE DU BATIMENT (CSTB)
84, Avenue Jean Jaurès
Champs-sur-Marne
F-77421 Marne-La-Vallée Cédex 2 / France

LABORATORIO DI STUDI + RICERCHE SUL FUOCO s.r.l. (LSF)
Via Vetrenia, 1
I-22070 Grandate (Como) / Italy

IBBC-TNO (TNO)
Fire Research
Lange Kleiweg 5, Rijswijk
NL-2600 AA Delft / Netherlands

FIRE RESEARCH STATION (FRS)
Building Research Establishment
Garston, Watford, WD2 7JR / UK

SWEDISH NATIONAL TESTING & RESEARCH INSTITUTE (SP)
Dept. of Fire Technology
P.O. Box 857
S-50115 Boras / Sweden

VTT BUILDING TECHNOLOGY (VTT)
Fire Technology
P.O. Box 1803
FIN-02044 VTT / Finland

MAGISTRAT DER STADT WIEN (MA 39)
Magistratsabteilung 39
Versuchs- und Forschungsanstalt der Stadt Wien
Rinnböckstr. 15
A-1110 Wien / Austria

CENTRO DE ENRAYOS & INVESTIGACION DEL FUEGO (LICOF)
AFITI LICOF
Ctra. Valencia km 23,400
E-28500 Arganda del Rey
Madrid / Spain

LABORATORIO NACIONAL DE ENGENHARIA CIVIL (LNEC)
LN EC, Avenida do Brasil, 101
P-1799 Lisboa Codex / Portugal

Zur Erledigung der Arbeiten wurden Teilabschnitte mit Einzelaufgaben definiert, die jeweils einem oder mehreren Teilnehmern zur Bearbeitung zugewiesen wurden. Die Abschnitte und Einzelaufgaben sind in der folgenden Zusammenstellung jeweils mit den für ihre Bearbeitung zuständigen Brandschutzlaboratorien aufgeführt.

Die Teilaufgaben wurden zunächst von den Laboratorien bearbeitet, denen sie zugewiesen waren. Nach Abschluß der Arbeiten an den Einzelprojekten wurden die Ergebnisse in gemeinsamen Sitzungen aller Teilnehmer abgestimmt.

In regelmäßigen Zusammenkünften wurden auch die Ergebnisse der Arbeiten der EU-Kommission und der Gruppe der Regulators vorgestellt, so daß von dort kommende Einwendungen und Anregungen berücksichtigt werden konnten.

Aufgaben	**Brandschutzlabor**
1. Technische Verbesserungen der Prüfeinrichtung und des Prüfverfahrens	
a) Abgassystem	RUG, TNO
b) Brennersystem	MPA, LSF
c) Rauchdichtemessung	RUG, FRS
d) Einbau und Befestigung der Proben	MPA, DIFT
e) Kalibrierung	DIFT, FRS
f) Verarbeitung der Meßdaten	TNO
g) Präzisierung der visuellen Beobachtungen	SP, LSF
h) Konstruktive Details der Apparaturen	CSTB, RUG
2. Weitere Analyse der Rundversuchsergebnisse	
a) Ausreißer/mögliche Ausreißer/Abweichungen	VTT, TNO
b) Optimierung der Parameter	VTT, SP
c) Korrelation der Parameter zueinander	VTT, CSTB
3. Empfehlungen an die Gruppe der Regulators	
a) Verwendung der SBI/Room Corner-Parameter	SP, CSTB
b) Klassengrenzen	RUG, TNO
c) Vereinfachter Versuch	LSF, CSTB
4. Erarbeitung eines Normentwurfs	
a) Prüfverfahren und Apparatur	TNO
b) Auswertealgorithmus	TNO
5. Überprüfung der Kalibrierung der Versuchsapparturen	alle Teilnehmer
6. Koordinierung und Berichterstattung	RUG, TNO

3. Ergebnisse der Arbeit

3.1 Vom MPA NRW wurde das Teilprojekt 1b Brennersystem gemeinsam mit der italienischen Prüfstelle LSF bearbeitet. Im Auftrag der Industrielaboratorien nahm außerdem die französische Prüfstelle LNE (Laboratoire National d'Essais) an den Arbeiten teil.

Wesentliche Zielvorgabe war einerseits die Verbesserung der Reproduzierbarkeit der Brandbeanspruchung, andererseits eine Reduzierung der stark schwankenden Flammenhöhen. Ferner sollte nach Möglichkeit die Verbrennung soweit verbessert werden, daß die Rauchdichte der Abgase 0 % betrug.

Zur Erreichung des angestrebten Ziels wurden Versuche mit Brennern gemacht, bei denen dem zugeführten Verbrennungsgas eine geringe Menge Luft beigemischt wurde. Das Mischungsverhältnis wurde variiert. Ferner wurde unterhalb der Sandschicht, durch die die Verbrennungsgase strömen, ein Luftverteilungshohlraum angeordnet. Durch diese Maßnahmen wurden geringfügige Verbesserungen der Gleichmäßigkeit der Beanspruchung sowie der Stabilität der Flammenform erzielt. Der Abschlußbericht über die Arbeiten zu diesem Teilprojekt ist als Anlage 1 beigefügt. Die erreichten Verbesserungen wurden in der Diskussion mit den übrigen Laboratorien nicht so hoch bewertet, daß die technischen Änderungen (Ergänzung der Zuluftversorgung um Luftmengen- und Gasmengen-Messungen) gerechtfertigt erschienen.

3.2 Das Teilprojekt 1d (Einbau und Befestigung der Proben) wurde vom MPA NRW gemeinsam mit DIFT bearbeitet. Als Vertreter der Industrielaboratorien nahm die Brandversuchsstelle der Bayer AG an der Arbeit teil. Die Vorarbeit zu diesem Thema war von einer hiermit beauftragten ad hoc-Gruppe des NABau-Arbeitsausschusses 00.34.01 geleistet worden. In dieser ad hoc-Gruppe waren die Festlegungen zur Prüfung im Brandschachtversuch nach DIN 4102 Teil 15 bzw. Teil 16 zusammengetragen worden, die ggf. bei der Probenanordnung und ihrem Einbau im SBI-Test als praxisgerechte Anordnung Verwendung finden konnten. In gemeinsamen Besprechungen wurden die verschiedenen Versuchsanordnungen auf ihre Anwendbarkeit im SBI-Test überprüft. Dabei beschränkte sich die Diskussion nicht nur auf allgemeine Befestigungstechniken und die Festlegung von Abständen der Proben zur Hinterlegung. Es wurden auch Regeln zum Einbau spezieller Produkte entworfen (analog zu DIN 4102 Teil 16). Der Abschlußbericht mit den Ergebnissen der Arbeit ist als Anlage 2 beigefügt.

In der abschließenden Erörterung der Egebnisse der Arbeit an dem Teilprojekt konnte nicht zu allen vorgeschlagenen Lösungen Einvernehmen erzielt werden. Diese wurden zunächst aus dem Normentwurf ausgeklammert (z.B. Rohrdämmstoffe, Kabel und Abwasserrohre). Rein produktspezifische Festlegungen werden teilweise in den Produktnormen zu berücksichtigen sein.

3.3 Nach Abschluß der Arbeiten an den technischen Details der Versuchsanordnung und Versuchsdurchführung wurden von 10 der beteiligten Brandschutzlaboratorien Kalibrierversuche an ihren Versuchseinrichtungen ausgeführt.

Die Ergebnisse sind in Anlage 3 zusammengestellt.

Es zeigte sich, daß durch die getroffenen Maßnahmen eine deutliche Verbesserung der Reproduzierbarkeit erreicht wird.

3.4 Die Ergebnisse der Arbeiten an den Teilschritten 1 bis 3 wurden in einem von der TNO zunächst zusammengestellten, danach jedoch von allen Prüfstellen gemeinsam erörterten Entwurf der Norm über die Versuchsapparatur und Versuchsdurchführung sowie über das Auswerteverfahren zusammengestellt. Der Normentwurf ist als Anlage 4 beigefügt.

3.5 Nach Abschluß der Arbeiten wurde der als Anlage 5 beigefügte zusammenfassende Abschlußbericht in englischer Sprache zusammengestellt.

4. Zusammenfassung

Nachdem im Rahmen eines ersten Entwicklungsprojektes von einer Gruppe von neun Laboratorien ein Prüfverfahren zum Brandverhalten von Baustoffen entwickelt worden war, fand dieses Verfahren grundsätzliche Akzeptanz. In einer zweiten Stufe wurde eine auf 12 Laboratorien vergrößerte Gruppe damit beauftragt, Detailverbesserungen zu verschiedenen versuchstechnischen Details (Apparatur, Kalibrierung, Einbau der Proben, Messdatenverarbeitung usw.) zu erarbeiten. Die Arbeit wurde in einzelne voneinander abgegrenzte Teilprojekte aufgeteilt, die einzelnen Teilnehmern an dem Projekt zur getrennten Bearbeitung übertragen wurden. Die Ergebnisse der Arbeiten wurden dann im Kreis aller beteiligter Laboratorien vorgestellt und zur Beschlußfassung diskutiert.

Vom MPA NRW wurden zwei dieser Teilprojekte federführend bearbeitet:
- Verbesserungen am Brennersystem
- Einbau und Befestigung der Proben.

Als Ergebnis der Arbeiten an dem Brennersystem konnte zwar eine leichte Verbesserung der Stabilität der Flammen erzielt werden. Der technische Aufwand, der zur Erzielung dieses Effektes erforderlich war, war jedoch vergleichsweise hoch, so daß die Gruppe der Laboratorien beschloß, von einer Änderung des Brennersystems abzusehen.

Die im Hinblick auf den Einbau und die Befestigung der Proben erarbeiteten grundsätzlichen Regelungsvorschläge wurden sachlich akzeptiert. Soweit sie allgemeiner Natur waren, d.h. auf alle Produkte anwendbar, wurden sie in den Normentwurf übernommen, der als Ergebnis des Gesamtprojekts erstellt wurde. Auf die Übernahme von Regelungen für spezielle Produkte wurde zunächst verzichtet. Es ist vorgesehen, die hierzu gemachten Vorschläge als Grundlage für die Diskussion über Einbau- und Befestigungsregeln mit den jeweiligen Produktkomitees zu verwenden.

Als Ergebnis der Arbeiten wurde ein Normentwurf über den SBI-Test erarbeitet, der neben der Versuchsapparatur und ihrer Kalibrierung das Prüfverfahren und die Auswertung der Versuchsergebnisse beschreibt.

(Dipl.-Ing. Klingelhöfer)

Anlage 1 zum Abschlußbericht

"Verbesserungen am SBI-Test"

SBI 2

Action 1b

Improvements of the burner (-system)

Final report

1. Participating laboratories

As members of the OLG MPA NRW and LSF are responsible for this task.

As representative of the supporting laboratories LNE was the contact laboratory.

2. Task

The task was given to the group to improve the burner of the SBI-test which provides the fire exposure to the specimen. The deficiencies of the burner stated in the report of the first programme relate mainly to

- reproducibility on the exposure conditions

- the fluctuation of the top of the flames

- the smoke development in the absence of combustible specimen

3. Steps of work

In the first phase possible approaches to the solution of the above task were made and tried out in a number of tests (see report OLG N 15).

In order to improve the stability of the flames tests were carried out using a burner which allowed the addition of a variable amount of combustion air to the propane gas. The result of the tests was reported in the above mentioned document as follows:

The admission of air leads to

- more complete combustion
- less smoke production
- reduction of fluctuation of the top of the flames
- reduction of radiant level
- increase of convection level which compensates the reduction of irradiance
- in order to achieve these results an amount of air of about 100l/min was enough. An optimisation of the air inlet seems to be necessary.

After presentation of this approach it was rejected because it did not seen to be an improvement of the burner only. The proposal was considered to be a change of the exposure conditions and to carry a strong risk of invalidating the previous work.

A second approach which mainly was pursued in the second phase consisted in a modification of the burner in such a way that the gas flow was more equal distributed over the surface of the surface.

In order to achieve this a void below the sand layer was realised.

A second solution was achieved by replacing the two layers of gravel and sand by two layers of steel balls (first layer diameter of 7 mm, second layer diameter of 4 mm). In order to protect the steel balls against falling debris of the specimen they were covered by a third layer of sand (approx. 3 cm thick) and a metal grid which both easily could be replaced after spoiling (see Figure 1).

For all arrangements a number of tests was carried out in order to examine the influence of the modifications on

- shape and colour of the flames
- height of flames
- their tendency to fluctuate
- level of thermal attack

- smoke development

4. Results of tests

4.1 Pretests at LNE

In order to detect the location of the maximum thermal exposure of the specimen a number of pretests were carried out using thermographic measuring equipment. By these tests the „hottest spot" was identified to be 8 cm away from the corner. For the normal sandbox-burner the height of this spot was localised at 16 cm height above the burner. For the burner filled with steel balls and with its upper edge 5 cm above the U-profile this spot was found at 22 cm above the upper burner edge.

An additional burner was investigated using pieces of porous ceramic tiles for the gas distribution(with regularly arranged holes of about 1 mm diameter).

4.2 Tests with the modified burner design

For each test the gas supply was adjusted to the agreed capacity of 30 kW. The specimen were represented by CaSi-boards with a thickness of 20 mm (LNE used 12 mm CaSi-boards). At the location of the maximum thermal exposure (according to the results of the pretests) flux measurements were carried out using different types of heat flux meters. In the tests at MPA a Schmidt-Boelter-type heat flux meter was used, in the tests at LNE a Gardon-type heat flux meter was used. For some tests a radiation measurement was made excluding the convection part of the heat flux by a glazing. The results of the flux measurements are presented in annex 1.

During the test the fluctuation of the flames was observed and for some test video-recorded. In addition to that smoke development measurements were carried out.

The results of the tests can be summarized as follows:

- Height of the flames / fluctuation

  A significant improvement in respect to flame height and fluctuation of flames could not be achieved by using the burner with the steel balls.

  The visual impression with the steel ball burner was that the gas flow distribution over the surface of the burner was slightly better than with the sandbox-burner. According to the observations during the pretests at LNE slight differences occurred depending on the compression of the sand . This resulted also in slight differences of the heat flux curves.

- Smoke measurement

  A significant difference in respect to the smoke development was not observed. For both burners a small obscuration (3 - 4 %) occurred which could be avoided only by adding a small amount of combustion air to the propane gas. (see chapter 2).

- Heat flux

  The results obtained in various tests differed between 45 kW/m² and 70 kW/m² depending on the laboratory, the type of burner, type of measuring equipment and the location of the measuring point. The general tendency was that the burner with steel balls gives slightly lower flux values than the sandbox-burner (approx. 10 %).

  For all tests the results of the heat flux measurement were fluctuating significantly. The amplitude of the fluctuation was in the range ± 7.5 kW/m².

  At the beginning of the test some time was needed to reach equilibrium. This time was not a constant delay but depending on test details and other influences for which no

explanation was found. In some cases even within ten minutes constant values were not reached. After reaching constant flux values in most tests no further change occurred. For some tests however after reaching a constant flux level the values later decreased during the test. Also sudden steps without any change of the test conditions occurred.

The above differences not only occurred in one laboratory but also in different laboratories.

- Radiation measurement
  The radiation measured in the test (using a flux meter with window) showed less fluctuating values than the measurements without window. The results of this measurement were between 25 kW/m² and 35 kW/m².

5. Conclusions / recommendations

As result of the above mentioned tests it can be stated that the burner with the design according to Figure 1 is working slightly better than the sandbox-burner. The distribution of gas flow is more equal and better reproducible as the density of the packaging of the steel balls and the dimensions kept constant. The handling of the burner is similar to the handling of the sandbox-burner. Problems of removal of debris and particles of the specimen are not relevant as the covering sand layer prevents that the steel balls are spoiled.

The measured flux values were slightly lower than the flux values measured using the sandbox-burner.

The proposal to use premixed gas / air was not longer investigated as it was rejected by the OLG. According to the results of the tests in the first phase this would however lead to a further slight improvement of the burner without significant changes in exposure conditions.

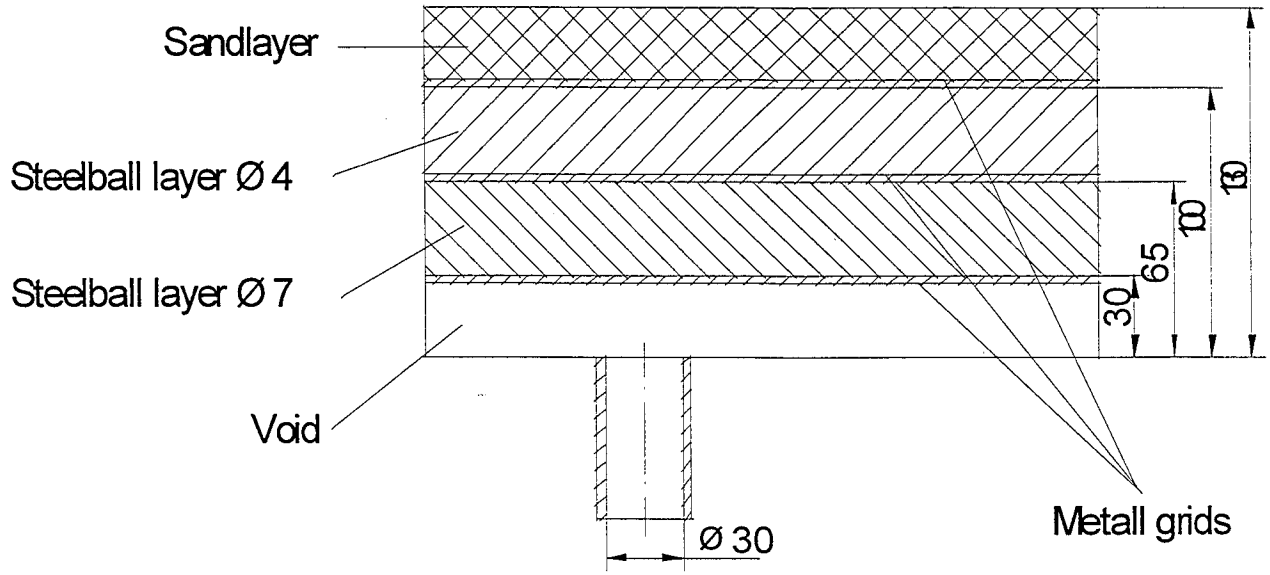
An additional proposal presented by LNE on behalf of an additional laboratory intended to investigate a burner which contains ceramic tiles (similar to the ceramic tiles of the Radiant Panel). A recommendation to use this kind of burner at present can not be made as no information about manufacturing tolerances and their influence on repeatability and reproducibility of exposure conditions are available.

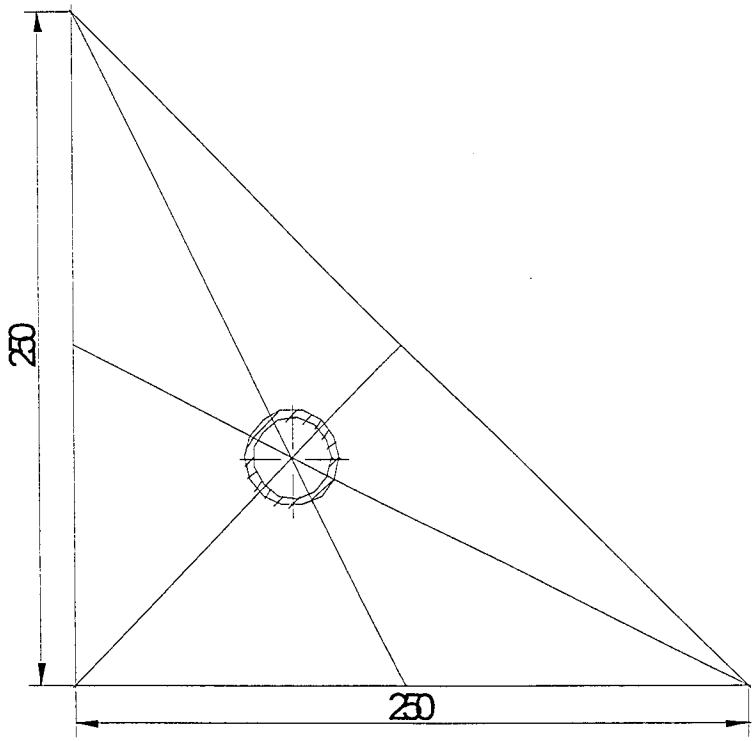
According to the decision taken in the first programme the control of exposure conditions is made by using a precisely controlled gas flow using calibrated flow meters and by calibration procedure which included the total system. This decision was taken in view of a number of measuring results presented to the OLG which showed that the heat flux by radiation measured by a flux meter with window was between 25 kW/m² and 35 kW/m² and the heat flux measured by a flux meter without window was between 45 kW/m² and 60 kW/m², similar results were reported at that time also by LSF.

The results of heat flux measurements carried out in this exercise show that the heat flux measurements are not appropriate for the calibration of the exposure conditions. It is recommended to retain the decision on the burner control.

LSF reported about a new development using a corner shaped insulated steel plate with a thickness of 5 mm and an exposed surface of about 600 cm² which promises a more appropriate measurement of the expose conditions. At present this development is not enough advanced to be recommended for introduction in the calibration procedure.

Fig. 1: Steel ball burner





Anlage 2 zum Abschlußbericht

"Verbesserungen am SBI-Test"

SBI 2

Action 1d

Mounting + fixing of specimen

Final Report

1. General

1.1 Definitions

Substrate: A material which is used immediately beneath the product about which information is required. The product is fixed to the substrate either mechanically or glued.

Backing board: A material used to back the test specimen. The backing board can be placed directly against a freestanding test specimen or at a distance from the test specimen.

1.2 Substrates

For tests where a substrate is required for a product, the rules for the selection of substrates given in pr/EN 0000 shall be followed, unless otherwise stated in this document.

The boards for the substrates shall have the following dimensions: 1000 ± 5 mm x 1500 ± 5 mm for the large wing and 495 ± 5 mm x 1500 ± 5 mm for the short wing.

The definition of the calcium silicate board given in PR/EN 000 should be changed. Instead of the given specification the following product should be chosen: calcium silicate board, density 870 ± 50 kg/m³, thickness 10 ± 1 mm. A corresponding proposal will be made to be included in the above standard.

1.3 Backing boards

Backing boards are required for all tests in the SBI. The backing board shall consist of one calcium silicate board of 15 mm thickness, density 870 ± 50 kg/m³.

An alternative was presented.

Two panels of calcium silicate board of 10 mm thickness, density 870 ± 50 kg/m³ (this would allow to replace only one 10 mm calcium silicate board in case of damage. For products which are fixed to a substrate identical to the backing board only one backing board behind each test specimen is required.

Backing boards shall have the following dimensions: (1000 ± 5 mm + air gap) x 1500 ± 5 mm for the large wing and at least 570 mm + specimen thickness + air gap x 1500 ± 5 mm for the small wing.

A solid metal angle (aluminium or steel) 50 ± 5 mm wide and e.g. 3 ± 1 mm thick shall be used to fix the backing boards in the corner. Additionally a metal frame work can be arranged at the backside of the backing boards (see Fig. 1).

Backing boards without unburned residues causing significant contribution to RHR and SPR and without cracks or other mechanical damages can be reused.

1.4 Arrangement of the backing board and the test specimen

Test specimen shall be arranged in such a way that the two specimen (including substrate) overlap in the corner as shown in Fig. 1.

The distance of the backing board to the products which in practice are mounted freestanding shall be 25 cm (minus thickness of the material). The sides of the cavity between the product and the backing board shall be open.

For some products an air gap between the test specimen and the backing board is required. If the product is self supporting the air gap is made using distance holders at the top and bottom of the specimen. If the product is not self supporting it should be mounted on a frame according to Fig. 2 or according to end-use conditions on request by the sponsor.

1.5 Free standing boards / sheets with an airgap

Free standing boards shall be tested fixed to a frame according to Fig. 2 using appropriate fixings according to table 1. If the product maintains its stability during the test and in its end use condition is not fixed it may be tested without the frame and the fixings.

Multilayered products with air channels (e.g. polycarbonate) shall be tested with vertical channels. Openings at the edges must be closed according to the instructions of the manufacturer.

The corner between the two wings of the specimen shall be closed according to the specification of the manufacturer. If no specification is given for this, an aluminium L-profile can be used to close the joint at the corner.

1.6 Fixing of specimen to substrates

Unless otherwise stated in the following chapters products shall be fixed to a substrate according to specifications of the sponsor. If no fixing of the product is required the product is tested without substrate using only backing boards.

Boards which are fixed mechanically to a substrate shall be fixed using screws unless otherwise specified by the sponsor. The number of fixings is 15 at the large wing and 10 at the small wing. The fixings shall be evenly distributed on the boards, none of them closer than 25 mm to the edge of the board (see Fig. 3).

For mechanical fixing of insulation products pins and 50 mm washers. The number of fixings is the same as for boards.

Planks shall have at least 3 fixings on each, one close to the top, one in the middle and one close to the bottom.

Proposals were presented to reduce the standard number of fixings to 2 and to increase the number to 4. A general statement which of these solutions gives the worst results is not possible. A discussion is necessary whether or not tests have to be carried out to identify the worst case for each material.

Products which are glued to a substrate shall be glued using the glue and the procedure specified by the sponsor. If the sponsor has not specified a glue a sodium silicate solution with the following specifications shall be used:

Silica (as SiO_2)	30 ± 2 %
Total Alkali (as Na_2O)	10 ± 1 %
Water	Balance
Weight ratio SiO_2: Na_2O	3.1 - 3.4 : 1
Viscosity at 20 °C CPS	650 - 1200

1.7 Coatings and paintings

If in practice the products are equipped with surface coatings in the manufacturing procedure they are to be tested together with the surface coating. Plastic foils for transport protection however have to be removed before testing.

If the surfaces of the products are coated/painted only after leaving the factory, this coatings/paintings have to be included in this assessment too, applying usual amount/thickness of coating. Where possible representative types of coatings shall be (e.g. for tests on building boards a dispersion based painting can be used to simulate other wall paintings).

For paintings/coatings are applied to reduce the flame spread properties of wood or wood-based products (e.g. intumescent coatings) as standard substrate a particle board according to the specification of the above standard shall be used.

Fire retardant impregnations for wood and wood based materials have to be tested together with the substrate used in practice.

1.8 Special treatment for thermoplastic materials

For all thermoplastic materials an aluminium foil is arranged at the lower edge of the specimen in order to protect the apparatus and to collect molten material. The aluminium foil shall be wrapped around the test specimen in such a way that the front, and the back of the bottomedges of the specimen are covered up to a height of at least 20 mm. Fig. 4 shows the position of the aluminium foil.

A proposal was made to introduce the following note: „Normally thermoplastic materials in practice are not applied with an aluminium foil at the bottom. If the test arrangement with an aluminium foil is effecting the test results, the test should be done without using a foil".

2. Rules for specific types of Products

2.1 Facade claddings

As substrate a calcium-silicate-board according to the above standard (modified) shall be used. To cover all noncombustible insulation products the mineral wool according to the specification of the above standard shall be used (the field of application has to follow the instructions of the above standard).

For combustible insulation products the specific products have to be included in the test system. For ventilated facades the air gap between the facade cladding and the insulation shall be 25 mm. This air gap shall not be closed at the top of the specimen. Construction details at the top of windows and at the bottom of the facade have to be included in the test specimen at a height of 300 mm above the lower end of the specimen (see Fig. 5). If the design of these two points is not identical the evaluation of the fire performance shall be based on that design which gives the worst results. If the worst case can not be identified by experience, one test has to be carried out

with the design of the bottom of the facade and one test with the design at the top of the window. The design which provides the least favourable results has to be used for 2 further tests.

Not ventilated facades shall be tested in the same way. The only deviation from the above rules is that the test specimen shall be closed at the sides and the lower and upper end.

2.2 Joints and sealing materials for joints at facades and other arrangements

In order to evaluate the fire performance of joints alone, 1 joint in the corner of the specimen has to be included and another one on the long wing at a distance of 200 mm from the corner.

In order to simulate joints between massive mineral elements (e.g. concrete, masonry) angles of calcium-silicate-boards (according to the specification of the above modified standard) have to be used as supporting construction.

For joints between metallic elements including a noncombustible insulation steel angles shall be used as supporting construction (see Fig. 6).

For joints in all other types of elements the test specimen have to be build up according to the practical system.

2.3 Insulation products

For foams which in practice have a maximum thickness up to 40 mm, the maximum thickness shall be tested. For foams which are applied in different thicknesses, up to more than 40 mm, one set of samples of 40 mm and one set with maximum thickness have to be tested, if the 40 mm specimen burns through.

For mineral wool the specimen must have the maximum thickness in which the product is produced. In respect to density maximum and minimum values have to be tested.

As substrate calcium-silicate-boards according to the above standard (modified) shall be chosen to represent all other substrates of Euroclasses A and B.

The glue used to attach foams to the substrate shall be chosen in accordance with practice. No extrapolation in respect to the glue can be proposed for the moment being.

Mineral wool shall be fixed to the backingboard according to section 1.5.

2.4 Insulation products for cavities and joints between building elements (e.g. granulated, poured or blown in insulation material and in situ prepared foams)

To test these materials 2 boxes made of 20 mm calcium silicate boards shall be produced. The height of the boxes shall be 150 cm. 1 box shall have a width of 100 cm, 1 box shall have a width of 50 cm. At the lower end of these boxes for a height of 30 cm the calcium silicate boards at the fire side shall be replaced by a steel wire mesh (size of the mesh 2,5 cm or according to the material to be tested).The top of the two boxes shall be left open.

The material to be tested shall be put into these boxes, in such a way that the boxes are completely filled (unless instructions for the use of the insulation material give a different specification for the specific product).

The specimen shall be arranged according to Fig. 7

2.5 Sandwich panels (steel/insulation/steel)

The sandwich panels have to be tested with maximum thickness of the insulation. If the panels are produced with different densities , maximum and minimum density have to be tested. The specimen shall include joints. These joints shall be realised as in practice. 1 vertical joint shall be in the corner, 1 vertical joint shall be at the longer wing, 200 mm away from the corner. If in

practice also horizontal joints are used, 1 horizontal joint 500 mm above the bottom shall be included.

2.6 Raised floors (fire attack from below)

The underside of the panels shall be exposed to the fire. The panels shall be fixed to a metal frame. The distance from the back side of the panels to the backing board shall be 25 cm (minus thickness of the panels). The joints between the panels shall be closed like in practice.

2.7 Vapour barriers for roofs

The foils shall be attached to a frame of light metal profiles according to Fig. 2 using the fixing means according to table 1.

Vapour barriers, which in practice are used in connection with mineral wool insulation shall be tested in loose contact with the standard mineral wool product according to the above standard.

Vapour barriers, which in practice are used without insulation shall be tested with a distance of 25 cm to the backing board.

2.8 Waste water and other tubes

These products are regarded as exotic products - proposals for these products are postponed. By the concerned industry the following proposal was made: „ One tube shall be placed in the corner. If end use requires more than one tube with a distance of less than 30 cm this should be tested adequately".

Further discussion is needed, in which cases end use conditions require more than one tube and how the adequate test arrangement shall look like.

Table 1: Fixing of specimen

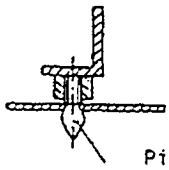
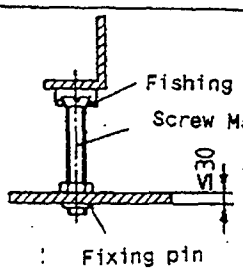
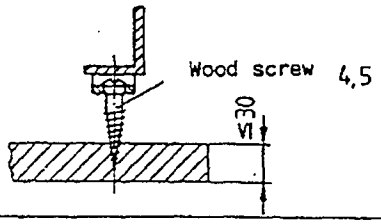
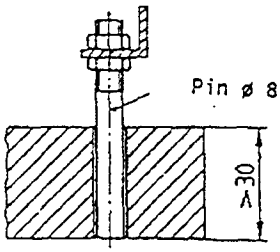
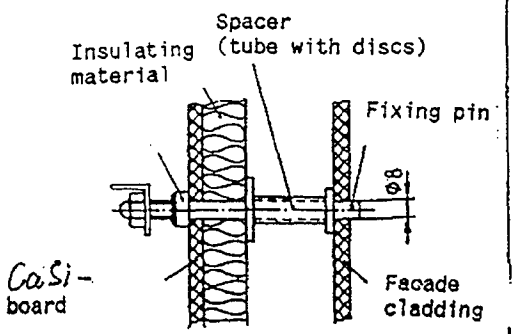
Nr.	Probenart	Probenbefestigung
1	Foils and textiles	
2	Thermoplastic boards (thickness max. 30 mm) and other boards which cannot be screwed	
3	Boards which can be screwed	
4	Boards which cannot be screwed (thickness ≥ 30 mm)	
5	Ventilated facade products	

Fig. 1: Arrangement of specimen and backing boards

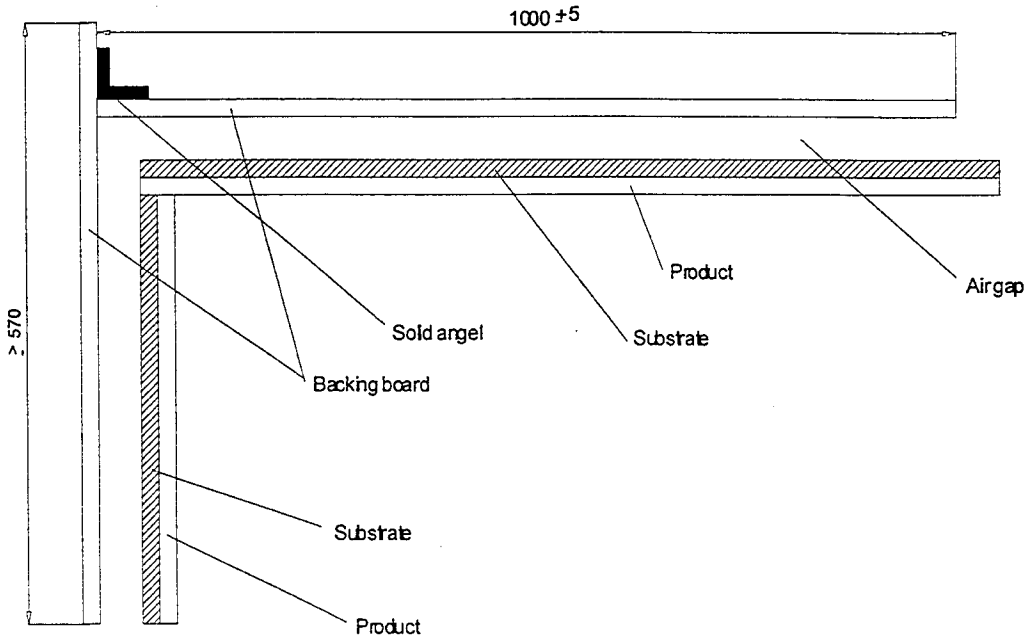


Fig. 2: Frame for free standing boards

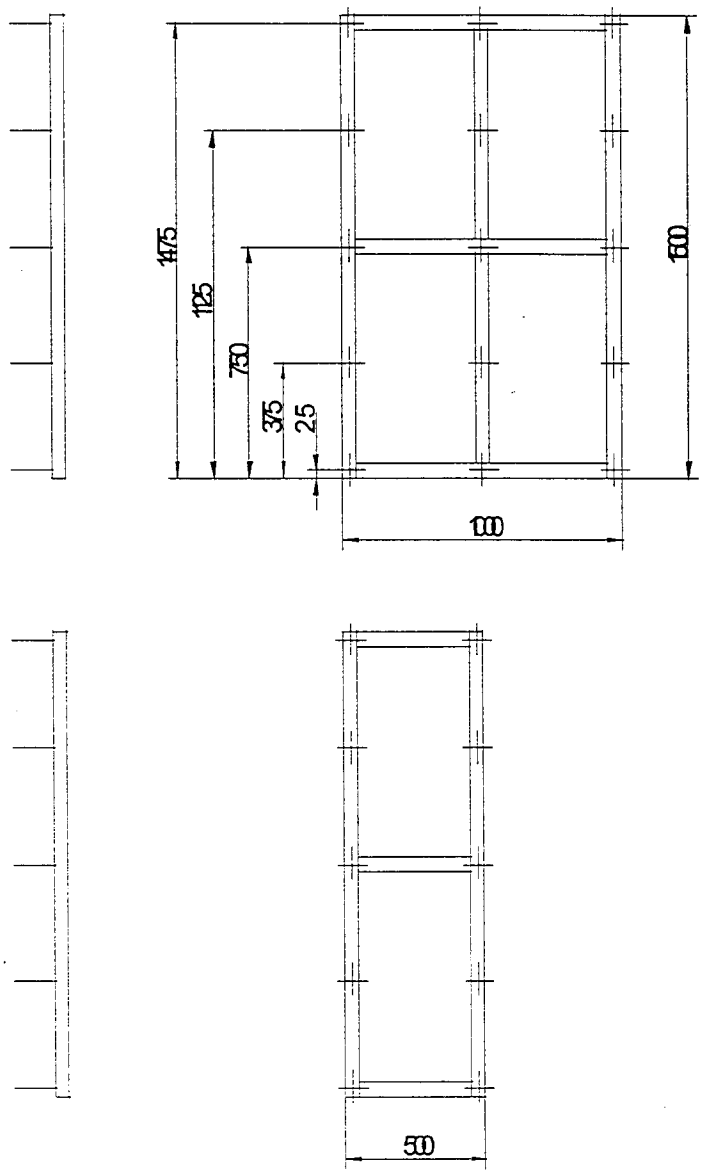


Fig. 3: Mechanical fixing of specimen to substrates

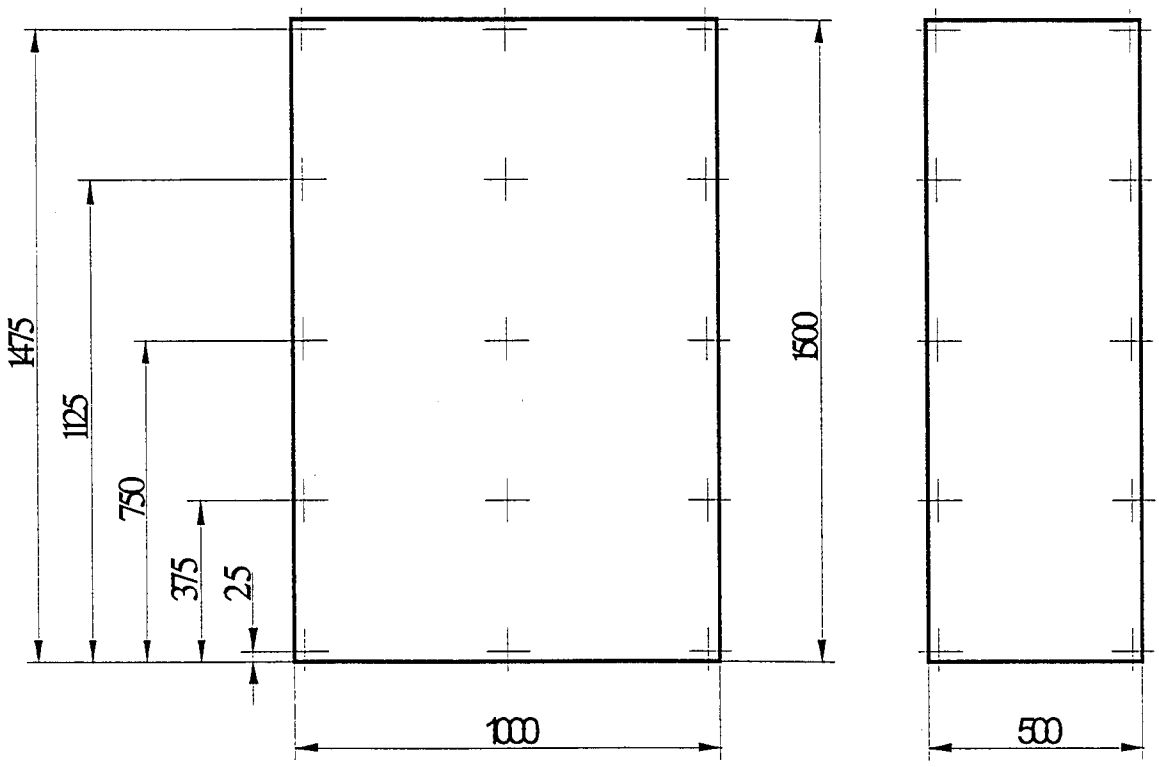


Fig. 4 Thermoplastics

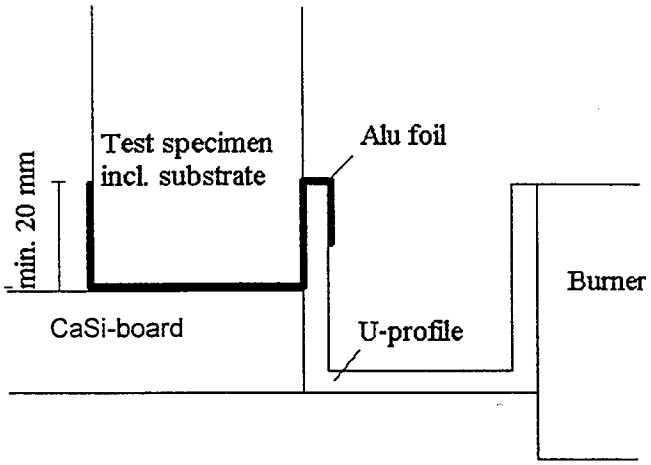


Fig. 5: Facades

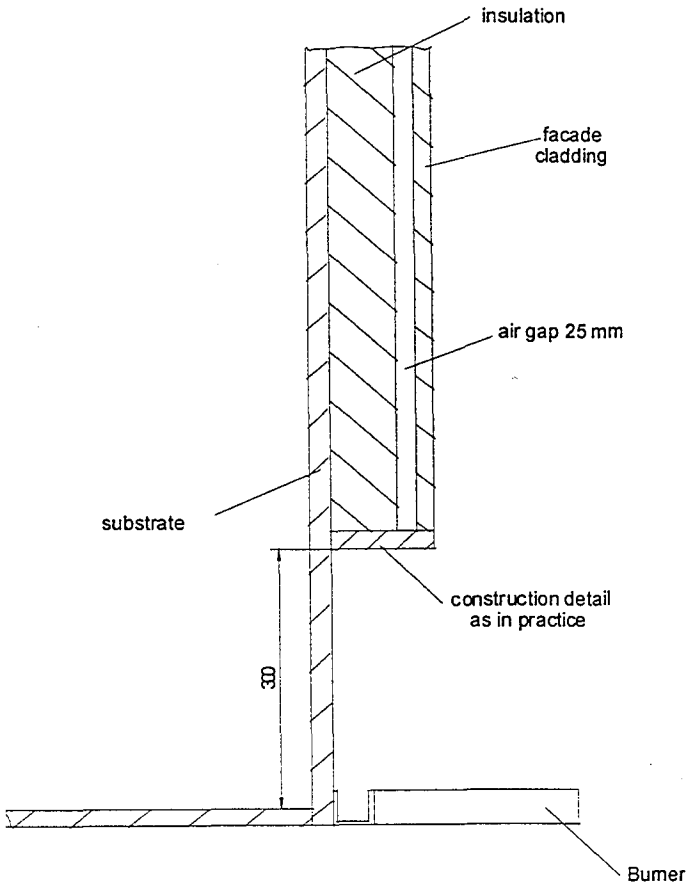
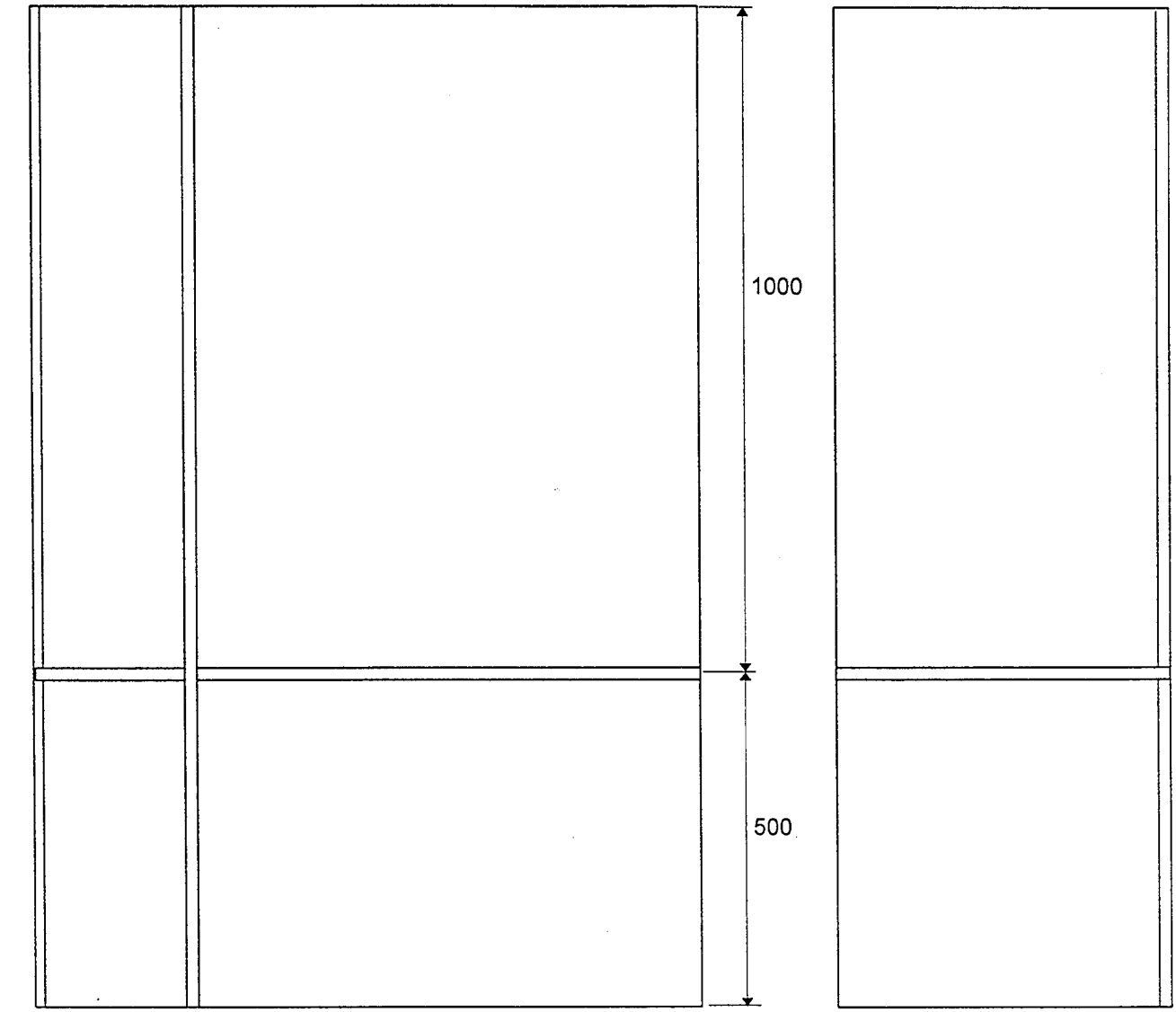


Fig. 6: Joints


1000
500

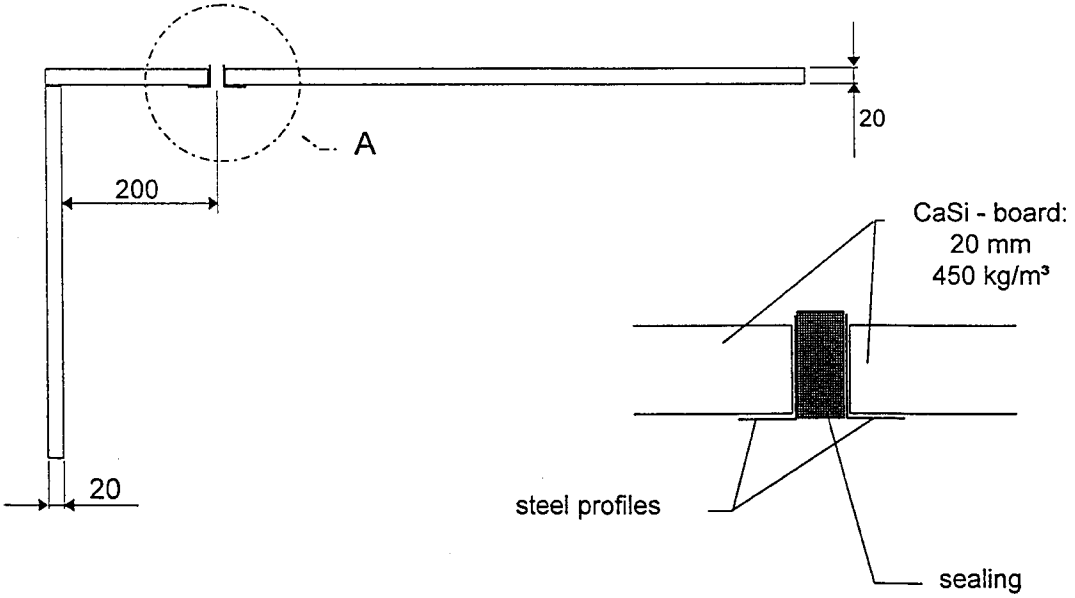
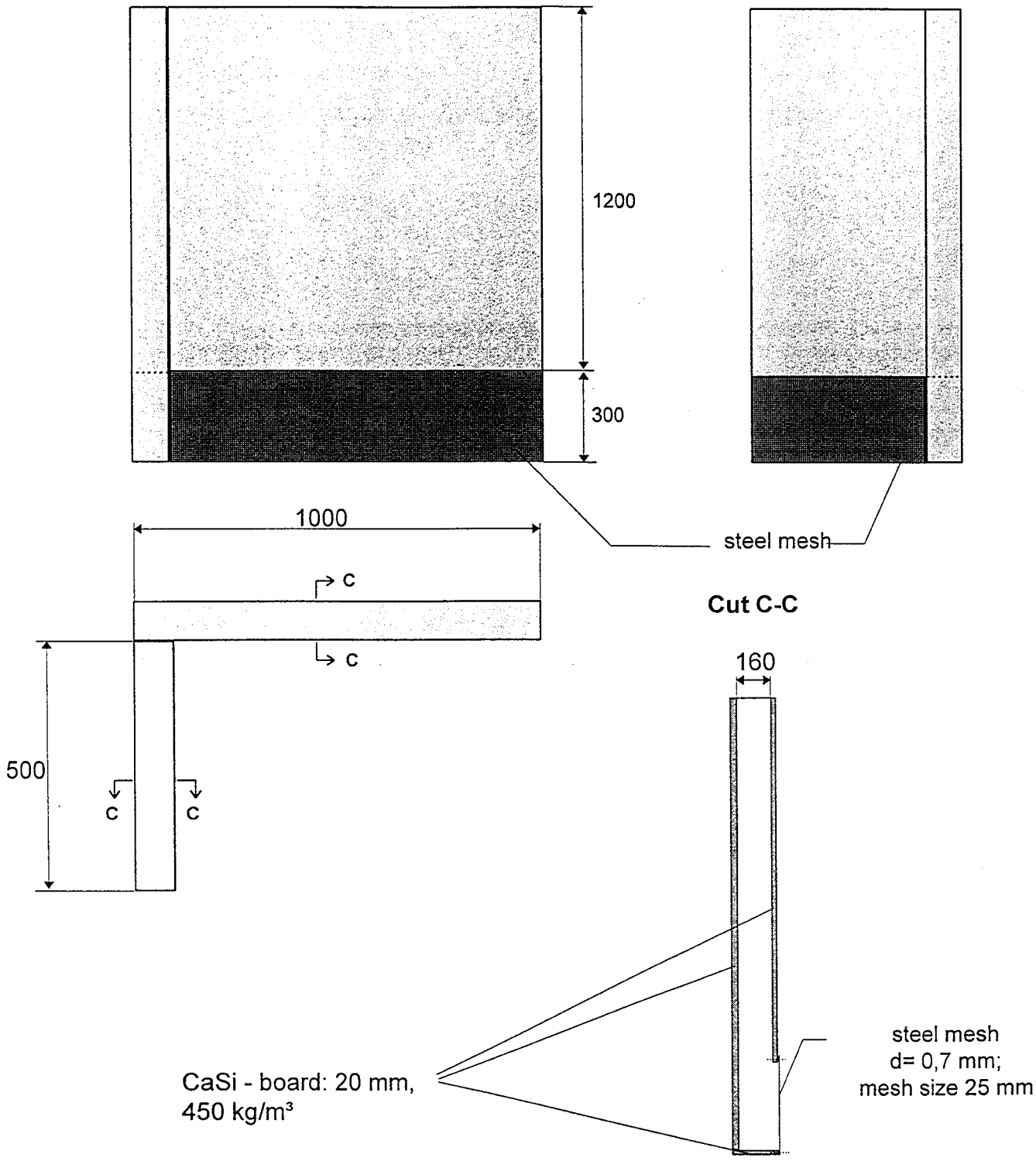

A
200
20
20
CaSi - board:
20 mm
450 kg/m³
steel profiles
sealing

Fig. 7: Insulation Products for cavities



Anlage 3 zum Abschlußbericht

"Verbesserungen am SBI-Test"

Calibration	Criterion	Laboratories									
		Lab A	Lab B	Lab C	Lab D	Lab E	Lab F	Lab G	Lab H	Lab I	Lab J
B.1.2- O2 analyser noise & drift											
drift	<= 0.01 %	0.0020 %	0,0046	0,0003%	0.0034 %	0,0010%	0.0014 %	0,0066%	0.0022 %	< 0.0001 %	0,00010%
noise	<= 0.01 %	0.0079 %	0,0069	0,0012%	0.0027 %	0,0020%	0.0026 %	0,0046%	0.0037 %	0.0001 % ??	0.0059 %
B.1.4- Propane MFC check											
accuracy	<= 6 mg/s		0,05	1,3			6,1	5	15		16
B.1.5.2- Light system stability											
drift	<= 0.5 %	0.002 %	0,11%	0,05%	0.14 %	0,27%		0,6%	0.44 %		
noise	<= 0.5 %		0,03%	0,01%	0.19 %	0,26%		0,2%	0.27 %		
B.1.5.3- Light system optical filter											
rel. difference in d for d=0.05	<= 20										9,4%
rel. difference in d for d=0.1	<= 10 %	18,0%	7,5%			< 5%		1,1%	5,6%		
rel. difference in d for d=0.15	<= 6.7 %			-5,9%							
rel. difference in d for d=0.3	<= 5 %	10,0%	3,3%	-7,3%		< 5%	-3.8% (d=0.31)	2,6%	0,8%		16,3%
rel. difference in d for d=0.5	<= 5 %	5,3%	-0,7%			< 5%	5.1% (d=0.57)		4,5%		4,7%
rel. difference in d for d=0.6	<= 5 %			-2,0%							
rel. difference in d for d=0.7	<= 5 %					< 5%					-2,4%
rel. difference in d for d=0.8	<= 5 %	3,2%	-2,1%			< 5%	2.3% (d=0.91)		4,5%		
rel. difference in d for d=1.0	<= 5 %	0,4%	-3,3%	-1,2%		< 5%	2.5% (d=1.21)	4%	2,9%		2,9%
rel. difference in d for d=2.0	<= 5 %	4,0%					4.7% (d=1.82)		13,1%		2,1%
B.2.1- Burner RHRstep											
delay time O2 steps 2,4,5,6	<= 30 s	21	3,13,16,17	12,9,12,12	12,12,9,12	15,12,12,15	,12,9,15	12	15,15,12,18	12,12,12,15	9,12,6,9
delay time CO2 steps 2,4,5,6	<= 30 s	15	3,10,12,16	12,9,12,12	12,12,12,12	9,9,9,9	,9,6,9	6	21,21,18,24	12,12,12,12	12,12,12,12
response time O2 steps 2,4,5,6	<= 12 s	12	,15,12,15	6,6,3,6	6,9,9,11	9,12,9,9	,12,12,6	12	9,15,12,6	9,12,9,12	9,9,9,15
response time CO2 steps 2,4,5,6	<= 12 s	9	,14,10,12	9,6,6,6	9,12,12,15	6,9,9,6	,12,6,6	9	9,15,12,12	3,15,9,12	9,18,9,9
burner switch response time	<= 12 s	15	11	9	9	9	24	12	9	12	9
kt used		0.9	0,86	0,92	0.744 ?		0,836	0,89	0.823	0.87	0.84
temperature response times	<= 6 s	3	4,1,5,4	3,0,3,3	6,9,6,6	6,6,6,6		6	6,9,9,12	3,3,3,6	12,18,9,12
abs(Tms-temps)	<= 0.5%		< 0.5%		< 0.5%				< 0.2 %		
abs(dXO2)	<= 0.02 %		0,01		0.002 %						0.002
abs(dXCO2)	<= 0.02 %		0,01		0.002 %						0.003
q30s(t)/RHR30s(t) step 2	100+/- 5%	95-103 %	94-96	99-102	101-101 %	101-102	102-105	100-103	97-99	95-97	97-102
q30s(t)/RHR30s(t) step 3	100+/- 5%	103-105 %	94-96	100-102	101-102 %	100-102	101-105	98-102	98-103	93-101	98-100
q30s(t)/RHR30s(t) step 4	100+/- 5%	101-102 %	98-102	98-100	95-98 %	102-105	98-105	97-101	98-100	102-106	98-102
q30s(t)/RHR30s(t) step 5	100+/- 5%	102-104 %	88-93	100-101	100-101 %	95-99	98-100	95-97	91-101	91-96	95-97
RHRstep3-RHRstep2	<= 0.5 kW	-0.5 kW	0,12	0,22	=> <0.5kW	0,1	0.61	0,4	0.63		0.0
B.2.2- Smoke calibration											
RSP (av) (indication)			0.25-0.35		0.22-0.28		0.3-0.4	0.2-0.25	ca. 0.25-0.35	0.3-0.35	0.30-0.35
TSP/m	100-150 m2/kg		134	ca. 127 (lin.corr.)	106			93	ca. 112 (lin.corr.)	132	133
abs(lend-l0)	<= 1 %			>> 1% if no corr.	1%		2%		>> 1% if no corr.		<1%
RHR (av)		95-110	85-120		85-100		90-105	95-115	100-125	105-115	90-110
THR/m	42.3-46.8 MJ/kg	44,54	44,37	45,25	41.79		45,21	42,47	46.0	47.4	42,8
B.2.3- Velocity profile factor kt,v											
Vc [m/s]		8,3	8,1	8,8	8.4 m/s	7,6	8.7	7,9	9.9 m/s ?	8.0	6.8 m/s ?
kt,v		0.87	0,86	0,936	0.821	0,867	0.825	0,9	0.866	0.87	0.88
B.2.4- Flow factor kt,gas											
kt,qgas		0.926	0,8	0,92	0.7571	0,87	0,836	0,86	0.823	0.83	0.84
kt,qheptane		0.90	0,86	0,905	0.814	0,84	0,813	0,94	0.797	0.82	0.86
kt		0.90	0,84	0,91				0,9			

Anlage 4 zum Abschlußbericht

"Verbesserungen am SBI-Test"

NABau 00.34.01 Nr 99-99

CEN/TC127 N1496

Reaction to fire tests for building products - Building products excluding floorings - exposed to the thermal attack by a single burning item

("SBI test")

Draft, June, 1999

Note annex E in separate file

TO BE CONSIDERED BY TC 127 ON 6 SEPTEMBER FOR AGREEMENT FOR PROGRESSING TO THE UAP

Contents

Foreword

This European Standard has been prepared by Technical Committee CEN/TC 127 "Fire safety in buildings", the secretariat of which is held by BSI.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of the Construction Products Directive.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by [month] 2000, and conflicting national standards shall be withdrawn at the latest by [month] 2000.

In accordance with the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard; Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

Introduction

The Euroclassification of reaction to fire performance of construction products (OJ No.L241 P27, 28) defines the different performance classes for building products excluding floorings and, separately, floorings. The relevant test methods for determining the performance are being prepared by CEN/TC127.

Safety warning

The attention of all persons concerned with managing and carrying out this reaction to fire test, is drawn to the fact that fire testing may be hazardous and that there is a possibility that toxic and/or harmful smoke and gases may be evolved during the test.

An assessment of all potential hazards and risks to health should be made and safety precautions should be identified and provided. Smoke and gases should be removed from the workplace. Written safety instructions should be issued. Appropriate training should be given to relevant personnel. Laboratory personnel should ensure that they follow written safety instructions at all times.

Special attention is asked for the propane gas supply system.

- The equipment such as tubes, couplings, flow meters, etc. should be approved for propane.
- The burner should be equipped with a remote-controlled ignition device, for example a pilot flame or a glow wire. There should be a warning system for leaking gas and a valve for immediate and automatic cut-off of the gas supply in case of extinction of the ignition flame. The pilot flames may be ignited directly by an operator in the test room, however, no one should be present in the test room during ignition of a burner.
- It should be possible to operate the switch between auxiliary and main burner and the preceding main valve (to open or stop the propane supply) from outside the test room.

Special attention is asked for the extinction of burning specimens.
Especially when the extinction is carried out because of a too intensive combustion of the specimens, it is recommended that a second operator is ready to intervene. Means for extinguishing should be available (e.g. since the heat output during intensive combustion may damage the apparatus).

1 Scope

This European Standard specifies a method of test for determining the reaction to fire behaviour of building products excluding floorings when exposed to the thermal attack by a single burning item (SBI). Details of all the calculation procedures are given in annex A. Information on the precision of the test method is given in annex B.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European standard only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies.

EN 60584-1 Thermocouples – Part1: Reference tables (IEC 584-1:1995)

prEN ISO 13943 Fire safety - Vocabulary (DIS 13943)

prEN 13501-1 Fire classification of construction products and building elements - Part 1 Classification using test data from reaction to fire tests

prEN 13238 Reaction to fire tests for building products - Conditioning procedures and general rules for selection of substrates

3 Definitions

For the purposes of this European Standard, the definitions given in prEN ISO 13943 and prEN 13501-1, together with the following, apply:

3.1 backing board: Calcium silicate panel used to back the specimen. The backing board can be placed directly against a freestanding test specimen or at a distance from it.

3.2 specimen: Piece of a product which is to be tested. This may include the mounting technique used in its end-use application. This also may include an air gap and/or a substrate where appropriate.

3.3 substrate: A product which is used immediately beneath the product about which information is required.

3.4 RHR: Rate of heat release.

3.5 FIGRA: Fire growth rate index.

3.6 THR600s: Total heat release from the specimen in the first 600 s of exposure to the burner flames.

3.7 LFS edge: The occurrence of lateral flame spread on the long specimen wing until the far edge of the specimen.

3.8 RSP: Rate of smoke production.

3.9 SMOGRA: Smoke growth rate index.

3.10 TSP600s: Total smoke production from the specimen in the first 600 s of exposure to the burner flames.

3.11 FDP: The occurrence of flaming droplets/particles fallen on the floor outside the burner zone.

4 Test facility

4.1 General

The SBI test facility consists of a test room, the test-apparatus (trolley, frame, burners, hood, collector and tubing), the smoke exhaust system and general measuring equipment. These components are specified in more detail in 4.2 to 4.7. Details of normative calibration procedures are given in annex C and annex D details informative calibration procedures.

4.2 Test room

4.2.1 The room shall have inner dimensions: height (2,4 ± 0,1) m and a floor area of (3,0 ± 0,2) m in both directions. The wall material shall be made of stone type building blocks (e.g. cellular concrete), gypsum boards, calcium silicate boards or other boards classified as Euroclass A1 or A2.

4.2.2 One wall of the test room shall have an opening to insert the trolley from the surrounding laboratory into the test room. The opening shall be more than 1470 mm wide and 2450 mm high (dimensions of the frame). Windows shall be placed in the two walls facing the front side of the two perpendicular specimen planes. To be able to handle the SBI apparatus and the specimen when the trolley is in place, an additional door is needed; the position of this door is not prescribed.

4.2.3 With the trolley in place in the test room, the distance between the long wing specimen surface touching the U-profile and the wall of the test room shall be (2,1 ± 0,1) m. This distance shall be measured perpendicular from the wall facing the long wing. The openings of the room, except the air inlet at the bottom of the trolley and the smoke exhaust opening in the hood, shall not exceed a total of 0,05 m^2.

4.2.4 Both left oriented specimens, as shown in figure 1, and right oriented specimens (the trolley shown in figure 1 mirrored around a vertical line) are allowed.

Note 1: To be able to remove side plates of the hood without removing the collector, attention should be paid to the connection between the frame of the SBI apparatus and the ceiling of the room. It should be possible to move the side plate outwards at the bottom.

Note 2: The relative position of the frame in the SBI room is not exactly prescribed. The exact relative position depends on the details of the connection between room and frame.

4.3 Test apparatus

4.3.1 Drawings of the apparatus are given in annex E. The apparatus consists of:

a) a trolley on which two perpendicular specimen parts are placed, with a sandbox burner at the bottom of the vertical corner; the trolley is put in place with its back side closing the opening in the wall of the SBI test room; the air inlet under the floor of the trolley is provided with perforated plates to produce an evenly distributed flow along the floor of the test room;
b) a fixed frame in which the trolley is pushed and which supports the hood; a second burner is fixed to the frame;
c) a hood on top of the frame which collects the combustion gases;
d) a collector on top of the hood with baffles and a horizontal outlet for the exhaust tube;
e) a (J-shaped) measuring tube (circular tube of inner diameter 315 mm, and insulated with 50 mm high temperature resistant mineral wool), with the following parts (in flow direction):
   * (connection to the collector);
   * tube length 500 mm with 4 thermocouple mountings (for optional temperature measurements) after 400 mm;
   * tube length 1000 mm;
   * two 90° tube bends (radius of curvature of axis 400 mm);
   * tube length 1625 mm with guide vanes and an orifice; guide vane length 630 mm starting 50 mm after the bends; directly behind the guide vanes a (2,0 ± 0,5) mm thick circular orifice with inner opening diameter 265 mm and an outer diameter of 314 mm;
   * tube length 2155 mm with mountings for pressure-probe, 4 thermocouples, gas-sampling probe and white light extinction system; this section is called the "general measurement section";
   * tube length 500 mm;
   * (connection to exhaust).

Note1: Attention should be paid to the fixing of the measuring tube; the total weight excluding probes etc is about 250 kg.

4.3.2 The SBI apparatus shall contain two identical sandbox burners, one in the bottom plate of the trolley (the "main burner"), one fixed to a post of the frame (the "auxiliary burner"), with the following specifications:

a) Shape: right angled triangle (top view) with equal sides of 250 mm, height 80 mm, bottom closed except a 12,5mm pipe socket at the gravitational centre, top open. A right angled triangular perforated plate shall be positioned in the burner at 10 mm above the

bottom. Metal gauzes with a mesh size less than 2 mm shall be positioned at 12 mm and 60 mm height above the bottom. All dimensions ± 2 mm.

b) Material: box made of 1,5 mm stainless steel, filled from bottom to top with a 10 mm void, a layer of pebbles within a size distribution of 4mm to 8 mm up to a height of 60 mm, and a top layer of "sand" within a size distribution of 2mm to 4 mm up to a height of 80 mm. The metal gauzes shall stabilize the two layers and prevent the pebbles from entering the gas pipe socket. The pebbles and sand used shall be rounded (river) stones, not broken ones

c) Position of main burner: mounted in the tray (see design drawing of trolley bottom plate) and connected to the U-profile at the bottom of the specimen position. The top edge of the main burner shall be at the level of the top edge of the U-profile within 2 mm.

d) Position of auxiliary burner: fixed to the post of the frame opposite to the specimen corner, with the top of the burner at a height of (1450 ± 5) mm from the floor of the test room (1000 mm vertical distance to the hood), its diagonal parallel and nearest to the hypotenuse of the main burner.

Note: Protection of the burner with a grid is allowed when previous tests on the same type of product have led to an early stop of test caused by material fallen on the sand bed in accordance with 7.5.c). The grid shall have an openings ratio of at least 90%.

4.3.3 The specimens shall be protected from the heat flux of the flames of the auxiliary burner by a shield of rectangular shape, width (370 ± 5) mm, height (550 ± 5) mm, made of calcium silicate board (specifications equal to the backing boards). It shall be fixed to the hypotenuse side of the auxiliary burner, centered in the horizontal plane (shielding the total width of the diagonal plus (8 ± 5) mm at both sides) with the top edge (470 ± 5) mm above the top level of the auxiliary burner.

4.3.4 The propane used shall be commercial propane 95% minimum purity. The propane shall be supplied through a mass flow controller with a range of at least 0g/s to 2.3 g/s and an accuracy of 1% of the reading for the range 0,6g/s to 2,3 g/s. In addition, the mass flow controller shall fulfil the criteria in accordance with C.1.4.

Note: The propane flow of 2,3 g/s corresponds to a heat release of 107 kW using the effective lower heat of combustion of propane (46360 kJ/kg).

4.3.5 The main and auxiliary burner shall not be burning at the same time during the tests, except during burner switch. The switch used to supply propane to one of both burners shall prevent propane to be supplied to both burners at the same time, except during burner switch time (the short period of time the auxiliary burner is decreasing and the main burner is increasing in output). This burner switch response time, calculated in accordance with A.3.1. shall be not more than 12 s, or not more than 24 s under the condition that the time period the 12 seconds are exceeded is compensated for in accordance with A.3.1.
It shall be possible to operate the switch and the preceding main valve from outside the test room.

4.3.6 Backing boards shall be used to back the specimen wings in the trolley.

The backing boards shall be calcium silicate boards with a density of (800 ± 150) kg/m^3 and a thickness of (12 ± 3) mm. The dimensions of the backing boards shall be:

a) for the short wing: (at least 570mm + width of specimen) mm x (1500 ± 5) mm,

b) for the long wing: (1000 ± 5) mm x (1500 ± 5) mm.

On the short wing, the backing board is wider than the specimen. The additional width shall extend at one side only.

4.4 Smoke exhaust system

Under test conditions, the smoke exhaust shall be capable of continuously extracting a volume flow, normalized at 298 K, of 0,50 m^3/s to 0,65 m^3/s.

Note: Due to changes in heat output, some exhaust systems (especially those provided with local fans) may need manual or automatic readjustment during tests, to meet the requirement given.

4.5 General measurement section equipment

4.5.1 The general measurement section of the exhaust tube shall include three thermocouples, a bi-directional probe, a gas sampling probe, and a light attenuation measurement system. The position of the relevant parts in this section is given in the drawings in annex E and, where appropriate, in the following clauses.

4.5.2 Three thermocouples shall be installed, all of the K-type in accordance with EN 60584-1, diameter 0,5 mm, sheathed and insulated. The position of the tips shall be at a radius of (87 ± 5) mm from the axis and with 120° mutual angular distance.

4.5.3 The bi-directional probe shall be connected to a pressure transducer with a range of at least 0Pa to100 Pa, and an accuracy of 2 Pa. The pressure transducer output shall have a 90% response time of 1 s or better.

4.5.3 The gas sampling probe shall be connected to a gas conditioning unit and gas analysers for O_2 and CO_2.

a) The O_2 analyser shall be of the paramagnetic type and capable of measuring a range of at least 0% to 21% oxygen (V_{O2}/V_{air}). The response time of the analyser shall be not more than 12 s (as measured in accordance with C.2.1). The noise and drift of the analyser shall be not more than 100 ppm over a period of 30 min (both as measured in accordance with C.1.2). The output from the analyser to the data aquisition system shall have a resolution of maximum 100 ppm.

b) The CO_2 analyser shall be of the IR type and capable of measuring a range of at least 0% to 10% carbon dioxide. The linearity of the analyser shall be 1% of full scale or better. The response time of the analyser shall be not more than 12 s (as measured in accordance with C.2.1). The output from the analyser to the data aquisition system shall have a resolution of maximum 100 ppm.

4.5.5 The exhaust duct shall have side ducts (circular tube of inner diameter 45 mm) horizontally perpendicular to and at the height of the longitudinal axis of the exhaust duct. A light system shall be mounted with a flexible connection to the side ducts. Air shall be introduced in the side ducts such that the optics stay clean within the given light attenuation drift requirements (A.3.4).
The light attenuation system shall be of the white light type, with the following specifications:

a) The lamp shall be of the incandescent filament type and shall operate at a colour temperature of (2900 ± 100) K. The lamp shall be supplied with stabilised direct current, stable within ± 0,5 % (including temperature, short-term and long-term stability).

b) The lens system shall align the light to a parallel beam with a diameter of at least 20 mm. The photocell aperture shall be placed at the focus of the lens in front of it and it shall have a diameter, d, chosen with regard to the focal length of the lens, f, so that d/f is less than 0,04.

c) The detector shall have a spectrally distributed responsivity agreeing with the CIE, V(□)-function (the CIE photopic curves) to an accuracy of at least ± 5 %.
The detector output shall over an output range of at least 2 decades be linear within 3% of measured transmission value or 1 % absolute transmission.

d) The light attenuation system shall meet the requirements in accordance with C.1.5.

4.6 Other general equipment

4.6.1 The (ambient) temperature of the air flow into the test room shall be measured with a thermocouple of the K-type in accordance with EN 60584-1, diameter (2 ± 1) mm, installed on the outer wall of the test room, within 0,20 m of the trolley opening and less than 0,20 m above the floor.

4.6.2 The ambient pressure shall be measured with equipment having an accuracy of 200 Pa (2 mBar).

4.6.3 The relative ambient air humidity shall be measured with equipment having an accuracy of 1 % within the range 20 % to 80 %.

4.6.4 The data acquisition system (used to record the data automatically) shall have an accuracy equal to or better than 100 ppm (0,01 %) for O_2 and CO_2, 0,5 °C for the temperature measurements, 0,01 % of full scale instrument output for all other instruments and 0,1 s for time. The data acquisition system shall record and store the following quantities every 3 s. Information on a data file format is given in annex F.

a) time, in s;
b) mass flow of propane gas through the burner, in mg/s;

c) pressure difference in general measuring section, in Pa;
d) relative light intensity, dimensionless;
e) O_2 concentration, in (V_{O2}/V_{air}) %;
f) CO_2 concentration, in (V_{CO2}/V_{air}) %;
g) ambient temperature at air inlet at bottom of trolley, in K;
h) 3 temperatures in general measurement section, in K.

5 Test specimen

5.1 Dimensions of specimen

The corner specimen consists of two wings, designated the short and long wings respectively. The maximum thickness of a specimen is 200 mm.

5.1.1 Sheet products shall have the following dimensions:

a) short wing: (495 ± 5) mm x (1500 ± 5) mm,
b) long wing: (1000 ± 5) mm x (1500 ± 5) mm.

Note: If additional products are used to compose the specimen (e.g. according to 5.3.2) the given dimensions refer to the total specimen.

5.1.2 Specimens with a thickness of more than 200 mm, shall be reduced to a thickness of (200 +0/-10) mm by cutting away the unexposed surface.

5.1.3 Non flat products shall be tested in such a way that not more than 30% of a representative area of 250 mm x 250 mm of the exposed surface area is more than 10 mm away from the surface plane in case it had a flat surface.

Note: The position of the surface has influence on the heat received from the burner flames. If too large parts of the product are too far behind the plane through the highest points on the specimen surface, these highest points should extend over the U-profile. This is done by cutting away stripes from the exposed surface near the edges, where the product touches the trolley (e.g. the U-profile).

5.1.4 Two horizontal marks shall be drawn on the front side of the long wing near the edge of the specimen farthest from the corner, to allow for observation of lateral flame spread reaching the edge between 500 mm and 1000 mm height. The line width shall be less than 3 mm; the accuracy of position 3 mm.

5.2 Mounting of specimen

5.2.1 Products can be mounted in accordance with an end use application. The test results then are valid for that application.

5.2.2 Standard mounting

Products can be mounted in accordance with a standard mounting procedure. The test results can have more general validity in that case. Specifications of standard mounting procedures and their validity for end use applications are given in the relevant product standards.
Some general rules apply for standard mounting procedures:

a) Boards that are free standing in end-use application shall be tested free standing with a distance of at least 80 mm from the backing board. The sides of the cavity farthest away from the corner shall be open.

b) Boards that are fixed mechanically to a substrate in end-use application, shall be tested fixed to a substrate using appropriate fixings. Fixings that stick out of the specimen surface shall be placed such that the specimen wing can be placed against the u-profile at the bottom and against the other specimen wing at its side, over its full length.

c) Boards that are, in end-use application, fixed mechanically to a substrate with a cavity behind it, shall be tested with a cavity between substrate and backing board. The distance between the substrate and the backing board shall be at least 40 mm. The cavities behind both specimen wings shall be in open connection. The sides of the cavity farthest away from the corner shall be open.

d) Products that are, in end-use application, glued to a substrate shall be tested glued on a substrate.

e) Products tested with a horizontal joint, shall be tested with a horizontal joint in the long wing at a height of 500 mm from the bottom edge of the specimen. Products tested with a vertical joint, shall be tested with a vertical joint in the long wing at a distance of 200 mm from the corner line, measured when the wings are mounted ready for testing.

f) Multi-layered products with air channels shall be tested with vertical channels.

g) Standard substrates shall meet the requirements according to prEN13238. The dimensions of the substrates shall be in accordance with the dimensions of the specimens (see 5.1.1).

Note1: The bottom edge of the specimen is not visible when the specimen is installed in the trolley. The height is measured from the bottom edge of the specimen, not from the top of the U-profile of the trolley.

Note 2: Figure 2 presents an example arrangement of specimen and backing board.

5.3 Installation of the specimen wings in the trolley

5.3.1 The specimen wings shall be placed in the trolley as follows:

a) First, the short wing specimen and backing board are placed on the trolley, with the extending part of the backing board at the main burner side and the bottom edge of the specimen against the short U-profile on the trolley floor.

b) Next, the long wing specimen and backing board are placed on the trolley, with the side edge of the backing board against the extending backing board of the short wing and the bottom edge of the specimen against the long U-profile on the trolley floor.

c) Both wings shall be wedged at the top and the bottom.

d) The corner line of the backing boards should not widen during a test. Therefore, one of both following provisions shall be used:

(i) A metallic L-profile, length 1500 mm, shall be placed at the backside side edge of the long wing backing board, in the corner with the small wing backing board. Connect the L-profile to the backing boards using fixings with a mutual distance of 250 mm maximum.

(ii) Steel frames shall be placed behind the backing boards.

5.3.2 The exposed edges of the products and the joint in the corner may be protected using additional products, as specified by the sponsor of the test, if this is in accordance with its end use application. When additional products are used, the width of the wings shall be according to 5.1.1 including the additional product.

5.3.2 After installation of the specimen on the trolley, the configuration shall be photographed as follows:

a) A total view of the exposed surface of the long wing. The center point of the long wing shall be in the centre of the view. The camera shall be directed perpendicular to the surface of the long wing.

b) A close-up of the vertical outer edge of the long wing at a height of 500 mm. The camera angle shall be about horizontal and at about 45° to the vertical plane of the wing.

c) If additional products according to 5.3.2 are used: a close-up of the edges and/or joints where the products are applied.

5.4 Number of specimens

Three specimens (three sets of long plus short wing) shall be tested following the procedure given in clause 7.

6 Conditioning

6.1 The conditioning shall be performed according to prEN13238, however with the addition of the requirements in 6.2 and 6.3.

6.2 The parts that compose a specimen may be conditioned separately or fixed together. However, specimens that are tested glued to a substrate shall be glued before conditioning.

Note: Reaching constant mass may take longer for specimens that are fixed together.

6.3 The total test procedure according to clause 7 shall be carried out within 2 h after removal of the specimen from the conditioned environment.

7 Test procedure

7.1 Principle of test procedure

7.1.1 A test specimen, consisting of two vertical wings forming a right-angled corner, is exposed to the flames from a burner placed at the bottom of the corner (the "main burner"). The flames are obtained by combustion of propane gas, injected through a sandbox. The heat output of the burner is (30 ± 2) kW.

7.1.2 The test specimen and the main burner are mounted on a trolley which, for the tests, is placed under a hood. A frame into which the trolley fits supports this hood. The frame is mounted in a small chamber with windows allowing observation of the test from the outside. Above the hood, there is a collector with an exhaust duct linked to a ventilator inlet.

7.1.3 The test specimen is exposed to the flames of the main burner during 21 min. During that interval the following parameters of the burning process are recorded: heat production, smoke production, flame spread and falling flaming droplets and parts.
A period of 5 min before ignition of the burner is used to adjust settings and measure the heat output of the burner alone, using an identical burner away from the specimen (the "auxiliary burner").

Note: The 21 min of exposure to the flames is used to evaluate the performance of the specimen during 20 min. The additional one-minute is needed due to the use of time averaged quantities, accepted inaccuracies and delay times.

7.1.4 The duct is equipped with sensors to measure the temperature, light attenuation, O_2 and CO_2 mole fraction and a flow induced pressure difference in the duct. These quantities are recorded automatically and used to calculate the volume flow, the rate of heat release (RHR; using among others O_2 and CO_2 mole fraction and volume flow), and the rate of smoke production (RSP; using among others light attenuation and volume flow).

Note: The oxygen and carbon dioxide concentrations are measured only in the exhaust duct, both are supposed to be constant (± 0.01 % V_{O2}/V_{air}) in the ambient air. Note that this may not be true when the ambient air is supplied from a space where oxygen is consumed (fire tests !).

7.1.5 Visual observations are made of the horizontal flame spread and falling of flaming droplets and particles.

7.2 Testing operations

7.2.1 Perform the following steps (7.2.2 to 7.2.11) in sequence with the measuring equipment operating and the trolley with the specimen wings and the main burner placed in the frame, under the hood.

7.2.2 Set the volume flow of the exhaust to: $V_{298} = (0{,}60 \pm 0{,}05)$ m³/s (as calculated according to A.5.1.1.a). This volume flow shall be within the range 0,50 m³/s to 0,65 m³/s during the total test period.

Note: Due to changes in heat output, some exhaust systems (especially those provided with local fans) may need manual or automatic readjustment during the test, to meet the requirement given.

7.2.3 Record the temperatures T1, T2 and T3 in the exhaust duct and the ambient temperature during at least 300 s. The ambient temperature shall be within (20 ± 10) °C, and the temperatures in the duct shall not differ more than 4°C from the ambient temperature.

7.2.4 Ignite the pilot flames of both burners (if pilot flames are used). Changes in the gas supply to the pilot flames during the tests shall not exceed 5 mg/s.

7.2.5 Record the pre-test conditions on the record sheet. The data to be recorded are given in 7.3.2.

7.2.6 Start the time measurement with the chronometer and the automatic recording of data. The time of start is t = 0 s, by definition. The data to be recorded are given in 7.4.

7.2.7 At t = (120 ± 5) s:
Ignite the auxiliary burner and adjust the propane mass flow to $m_{gas} = (647 \pm 10)$ mg/s. The adjustments shall be made before t = 150 s.

Note: The time period 210 s < t < 270 s is used to measure the base line for the rate of heat release.

7.2.8 At t = (300 ± 5) s:
Switch the propane supply from the auxiliary burner to the main burner. Observe and record the time when the main burner ignites.

Note: The nominal exposure period of the specimen to the flames of the main burner is 1260 s to evaluate the performance during 1200 s.

7.2.9 Observe the burning behaviour of the specimen and record the data on the record sheet. The data to be recorded are given in 7.3.3 and 7.3.4.

7.2.10 At t ≥ 1560 s:

a) Terminate the gas supply to the burner.
b) Stop the automatic recording of data.

7.2.11 Record the end of test conditions on the record sheet at least one minute after any remaining combustion. The data to be recorded are given in 7.3.5.

Note: The end of test conditions should be recorded without the influence of remaining combustion. If the specimen is difficult to extinguish totally, removing the trolley may be an option.

7.3 Visual observation and manual recording of data

7.3.1 General

The quantities mentioned in this clause shall be observed visually and recorded in the format given. The observer shall be provided with a chronometer equipped with an event logger. The observations shall be recorded on a record sheet, of which an example is given in annex G.

7.3.2 Pre test conditions

The following quantities shall be recorded:

a) ambient pressure (Pa);
b) ambient relative humidity (%H_2O).

7.3.3 Lateral (=horizontal) flame spread on the long wing

The lateral flame spread shall be recorded as the occurrence of flames reaching the far edge of the long wing specimen at any height between 500 mm and 1000 mm. The determining phenomenon shall be the boundary of sustained flaming combustion at the surface of the specimen.

Note1: The lower edge of the specimen is not visible when the specimen is installed in the trolley. When installed, the specimen height at the top of the U-profile of the trolley is about 20 mm.
Note 2: Sustained flaming is defined in prEN ISO 13943 as: "Persistence of flame on or over a surface for a minimum period of time". The minimum period of time used here is 5 s.

7.3.4 Flaming particles or droplets

The falling of flaming droplets or particles shall be recorded only within the first 600s of the exposure period and when the droplets/particles reach the floor level of the trolley outside the burner zone. This zone is defined as the trolley floor area at the front side of the specimen wings, more than 0,3 m from the cornerline between the specimen wings. Two occurrences shall be recorded:

a) the falling of a flaming droplet/particle, in the given time interval and area;
b) the falling of a flaming droplet/particle, in the given time interval and area, that remains flaming for more than 10 s after falling.

Note1: The moment of falling is defined here as the moment of reaching the floor of the trolley (the level of the lower edge of the specimen).
Note 2: A quarter circle drawn on the floor of the trolley is needed to allow for discriminating the right floor area. The line width shall be less than 3 mm; the accuracy of positions 3 mm.

Note3: Flaming parts of specimen touching the floor of the trolley outside the burner zone is to be regarded as fallen particles although the part concerned may still be an integral part of the specimen (e.g. bending of a weakened product).

7.3.5 End of test conditions

The following quantities shall be recorded:

a) light transmission at the "general measuring section" in the duct (mV);
b) O_2 mole fraction at the "general measuring section" in the duct (%);
c) CO_2 mole fraction at the "general measuring section" in the duct (%).

7.3.6 Recorded events

The following events shall be recorded on the record sheet:

a) occurrence of a surface flash;
b) smoke from the specimen not entering the hood during the test, but flowing out of the trolley into the surrounding SBI room;
c) falling of parts of the specimen;
d) development of a gap in the corner (mutual fixing of backing boards fails);
e) occurrence of one or more of the conditions which justify an early stop of test according to 7.5.
f) tendency towards distortion or collapse of the specimen;
g) all additional events that may be of importance to the right interpretation of the test results or to the field of application of the product.

7.4 Automated recording of data

7.4.1 The quantities mentioned in this clause shall be measured and recorded automatically every 3 s during the period specified in 7.2. and shall be stored for further processing.

7.4.2 Time (t), in s; at the start of recording of data, t = 0 by definition.

7.4.3 Mass flow of propane gas to the burner (m_{gas}) in mg/s.

7.4.4 Pressure difference between the two chambers of the bi-directional probe (Δp), at the general measuring section in the exhaust duct, in Pa.

7.4.5 Signal from the light receiver (I), of the white light system at the general measuring section in the exhaust duct, in mV.

7.4.6 O_2 mole fraction in exhaust flow (XO_2), sampled at the gas sampling probe at the general measuring section in the exhaust duct, in %.

7.4.7 CO_2 mole fraction in exhaust flow (XCO_2), sampled at the gas sampling probe at the general measuring section in the exhaust duct, in %.

7.4.8 Ambient temperature (T0) at air inlet at bottom of trolley, in K.

7.4.9 Three temperatures (T1, T2 and T3) at the general measuring section in the exhaust duct, in K.

7.5 Early stop of test

The main burner may be stopped earlier than the nominal exposure period, if the following conditions occur (depending of the behaviour of the specimen):

a) a too intensive combustion of the specimen, with a rate of heat release of the specimen instantaneously exceeding 350 kW or exceeding a mean value of 280 kW during 30 s;

b) a too intensive combustion of the specimen, with a duct temperature instantaneously exceeding 400 °C or exceeding a mean value of 300 °C during 30 s;

b) burning or non-burning material fallen on the sand bed of the burner heavily disturbing the flame of the burner or extinguishing the burner by choking.

Record the time of termination of the gas supply to the burner and the reason why, on the record sheet.

Note1: The results of a test are not valid when an early stop of test has been performed.
Note 2: Measured values for temperature and rate of heat release will contain a certain amount of noise. Therefore it is advised not to stop the test based only on one or two successive measurement values from the instruments exceeding the given maxima.

8 Expression of results

8.1 The results of a test are valid, only when the calibrations according to annex C and the criteria according to annex A are both met.

Note: In accordance with 5.4, the number of tests needed is at least three.

8.2 For each test, the burning behaviour of the product shall be given as the graphs of $RHR_{av}(t)$, THR(t) and $RHR_{av}(t)/t$, all graphs for the time interval $0 \leq t \leq 1500$ s, the values of FIGRA and THR600s, calculated according to A.5, and the occurrence or not of lateral flame spread until the edge of the specimen (LFS edge) according to 7.3.2.

8.3 For each test, the smoke production behaviour of the product shall be given as the graphs of $RSP_{av}(t)$, TSP(t) and $RSP_{av}(t)/t$, all graphs for the time interval $0 \leq t \leq 1500$ s and the values of SMOGRA and TSP600s, calculated according to A.6.

8.4 For each test, the flaming droplets and parts behaviour of the product shall be given as the occurrence or not of one or both categories of fallen flaming droplets and parts ($FDP_{f\leq 10s}$ and $FDP_{f>10s}$) according to 7.3.4.a) or b).

9 Test report

The test report shall include the following information as a minimum. A clear distinction shall be made between the data provided by the sponsor and data determined by the test.

a) reference that the test was carried out in accordance with EN SBI

b) any deviations from the test method

c) name and address of the testing laboratory

d) date and identification number of the report

e) name and address of the applicant

f) name and address of the manufacturer/supplier, if known

g) date of sample arrival

h) identification of the product

i) description of the sampling procedure, where relevant

j) a general description of the product tested including density, weight per unit area and thickness, together with the form of construction of the test specimen

k) description of substrate and fixing to the substrate (if used).

l) details of conditioning

m) date of test

n) test results expressed in accordance with clause 8.

o) photographs according to 5.3.3.

p) observations made during the test

q) on request of the contractor: data file with data recorded automatically according to 7.4. and/or latest calibration reports.

r) the statement 'The test results relate to the behaviour of the test specimens of a material under the particular conditions of the test; they are not intended to be the sole criterion for assessing the potential fire hazard of the material in use'.

ANNEX A (NORMATIVE) CALCULATION PROCEDURES

A.1 General

A.1.1 General remarks

A.1.1.1 The test procedure is described in clause 7. Some information is repeated here for convenience.

a) Major moments in time during this procedure are:
   t = 0 s : start data acquisition;
   t = (120 ± 5) s : start auxiliary burner;
   t = (300 ± 5) s : switch from auxiliary to main burner;
   t ≥ 1560 s : stop main burner and stop data acquisition.

b) The performance of the specimen is evaluated during the first 1200 s (300 s ≤ t ≤ 1500 s) in which the specimen is exposed to the flames of the main burner. This period is called the exposure period.

c) Due to the use of time averaged quantities, accepted inaccuracies and delay times, a maximum of 60 seconds additional data under burner flame exposed conditions (after t = 1500 s) is needed.

d) The time interval 210 s ≤ t ≤ 270 s is used to do measurements on the burner output only. This interval is called the base line period. The average burner output during the base line period is subtracted from the total output of burner and specimen, to get the output of the specimen only.

e) During 1560 seconds the following "raw" data are recorded every 3 seconds: gasflow, pressure difference, light attenuation, oxygen and carbon dioxide concentration, temperatures (ambient and smoke temperatures). All in accordance with 7.4.

A.1.1.2 Notation

In this annex a simplified notation is used for averages over a time period:
f(t1....t2) is defined as the average value of f(t), in the time period $t1 \leq t \leq t2$

A.1.2 Calculations to be performed on the data of a test

After a test, a series of parameters shall be calculated to evaluate the performance of the product. All calculations in this annex, excluding the calculations in A.2, shall be performed on data shifted in time in accordance with A.2. The following calculations shall be carried out:

- synchronization of data
- calculation of equipment response
- calculation of exposure period
- calculation of RHR(t) (Rate of Heat Release)
- calculation of time averaged RHR(t): RHR30s(t)
- calculation of THR(t) (Total Heat Release) and THR600s
- calculation of FIGRA (Fire Index Growth Rate)
- calculation of RSP(t) (Rate of Smoke Production)
- calculation of time averaged RSP(t): RSP60s(t)
- calculation of TSP(t) (Total Smoke Production) and TSP600s
- calculation of SMOGRA.

The results of a test are valid, only when the criteria for equipment response according to A.2 have been met. The calculations are specified in detail in clauses A.2 to A.6

A.1.3 Calculations to be performed on the data of calibrations

The calibration procedures are specified in annex C. The quantities to be calculated are specified in A.7 if not already specified in A.2 to A.6 as part of the analysis of standard test data.

A.1.4 Standard data set

As the calculation methods are complex a standard data set is given in annex H which can be used to exercise the calculation steps and benchmark software.

A.2 Synchronization of data

A.2.1 O_2 and CO_2 synchronization with T_{ms}

Due to the switch from auxiliary to main burner, the major quantities measured show a short peak or dip on the same moment in time. These peaks and dips are used to synchronize the data. It is assumed that this automatic synchronization procedure and/or the measured delay times are erroneous if the shift calculated by this automatic synchronization procedure differs more than 6 s from the delay times of the analyzers determined in the calibration procedure according to C.2.1.

a) The time t_{0_T} is calculated as the time of the last data point before the temperature $T_{ms}(t)$ drops more than 2.5 K, after t = 270 s, relative to the average of T_{ms} during the base line period (210 s ≤ t ≤ 270 s). The value t_{0_T} shall be between 273 and 315 s.

$$\overline{T_{ms}(210s...270s)} - T_{ms}(t_{0\_T}) \le 2.5K \wedge \overline{T_{ms}(210s...270s)} - T_{ms}(t_{0\_T}+3) > 2.5K$$

Equation 1

in which:
$T_{ms}(t)$ = temperature in the general measurement section [K]

b) The time t_{0_O2} is calculated as the time of the last data point before the oxygen concentration rises more than 0.05 % (= 500 ppm), after t = 270 s, relative to the average during the base line period (210 s ≤ t ≤ 270 s):

$$XO_2(t_{0\_O2}) - \overline{XO_2(210s...270s)} \le 0.05\% \wedge XO_2(t_{0\_O2}+3) - \overline{XO_2(210s...270s)} > 0.05\%$$

Equation 2

in which:
XO_2 = oxygen concentration in mole fraction [%].

c) The time t_{0_CO2} is calculated as the time of the last data point before the carbon dioxide concentration drops more than 0.02 % (= 200 ppm), after t = 270 s, relative to the average during the base line period (210 s ≤ t ≤ 270 s):

$$\overline{XCO_2(210s...270s)} - XCO_2(t_{0\_CO2}) \le 0.02\% \wedge \overline{XCO_2(210s...270s)} - XCO_2(t_{0\_CO2}+3) > 0.02\%$$

Equation 3

in which:
XCO_2 = carbon dioxide concentration in mole fraction [%].

d) The oxygen and carbon dioxide data are shifted so that the O_2 peak and the CO_2 dip coincides with the dip in T_{ms} (such that $t_{0\_T} = t_{0\_O2} = t_{0\_CO2}$). Both shifts shall not differ more than 6 s from the delay times of the analyzers determined in the calibration procedure according to C.2.1.

$$XO_2(t) = XO_2(t - t_{0\_T} + t_{0\_O2})$$ Equation 4

in which:
XO_2 = oxygen concentration in mole fraction [%];
t_{0_O2} = time as specified under b);
t_{0_T} = time as specified under a).
The same equation is valid for CO_2 after replacement of O_2 by CO_2 in the equation.

A.2.2 Shift all data to t = 300 s

After the O_2 and CO_2 synchronization with T_{ms}, the time is shifted for all data such that $t_0 = t_{0\_T} = t_{0\_O2} = t_{0\_CO2} = 300$ s for convenience. This shift shall be less than 15 s.

Note: Here all data (m_{gas} , Δp, I, XO_2, XCO_2, T0, T1, T2 and T3) are shifted in time together. In A.2.1.d, the O_2 and CO_2 data were shifted in time relative to the other data.

A.2.3 All calculations in A.3 to A.6 shall be performed on data shifted in time in accordance with this section (A.2).

A.3 Checking equipment response

A.3.1 General

The results of a test are valid, only when the calibrations and the test meet the requirements of this standard. Besides requirements that specify how to carry out the test, given elsewhere in this standard, the following requirements apply for the response of the measurement equipment.

A.3.2 Burner switch response time

The burner switch response time is the difference between t_{up} and t_{down}, which are defined as:
t_{up} = the time of the first data point at which the oxygen concentration has passed the "90% burner output level" in upwards direction after t = 270 s, and
t_{down} = the time of the first data point thereafter at which the oxygen concentration has passed the same level in downwards direction.

$$XO_2(t_{up}) > 0.1 \bullet \overline{XO_2(30s...90s)} + 0.9 \bullet \overline{XO_2(210s...270s)}$$ Equation 5

$$t_{down} > t_{up} \quad \wedge \quad X_{O2}(t_{down}) < 0.1 \bullet \overline{XO_2(30s...90s)} + 0.9 \bullet \overline{XO_2(210s...270s)}$$ Equation 6

Criterion: $t_{down} - t_{up} \leq 12$ s Equation 7

in which:
$XO_2(t)$ = oxygen concentration in mole fraction [%].

Note1: As a consequence t_{down} is never later than t = 315 s. Meeting the criterion is of major importance for the correct assessment of FIGRA and SMOGRA values.

Note 2: During the switch from auxiliary burner to main burner (at $t \approx 300$ s), for a short time, the total heat output from the burners is lower than the standard heat output of one burner. As a consequence the rate of heat release has a dip and the oxygen level has a peak. See figure A.1. The peak in XO2 is about 25%-50% of the contribution of one burner. The width of the peak should be small since this "missing" heat output is subtracted from the heat output of the specimen as described

below. The peak width is measured at a level of 90 % of the normal burner contribution, and is called the burner switch response time. In the example presented in figure A.1, the response time is 9 s.

Note 3: The 90% burner output level is calculated as 90% of the step from test start level to the base line level, added to the test start level. The oxygen test start level used here is the average oxygen concentration before ignition of the burners (30 s $\leq$ t $\leq$ 90 s). The oxygen base line level is the average oxygen concentration during burning of the auxiliary burner (210 s $\leq$ t $\leq$ 270 s).

A.3.3 Temperature readings

The temperature readings of thermocouples 1, 2 and 3, all mounted in the general measurement section, shall differ not more than 0,5 % of the average value T_{ms} (=(T1+T2+T3)/3) [K] at any moment.
If one thermocouple differs more than 0.5% from the average and the two remaining thermocouples do not differ more than 0,5 % from their average, the average of the remaining two thermocouples may be used to calculate T_{ms}. The use of only two thermocouples shall be mentioned in the test report.

Note the criteria for temperatures at the start of the test or the calibrations.

A.3.4 Drift in gas concentration measurement

The drift in the XO2 and XCO2 gas concentration measurements is calculated as the difference between start and end value reported on the record sheet.

Criteria:

$$| XO_{2\_begin} - XO_{2\_end} | \leq 0.02\ \% \qquad \text{Equation 8}$$

$$| XCO_{2\_begin} - XCO_{2\_end} | \leq 0.02\ \% \qquad \text{Equation 9}$$

in which:
XO_2 = oxygen concentration in mole fraction [%];
XCO_2 = carbon dioxide concentration in mole fraction [%].

Note: The visual reading of the end values are carried out after a period of at least 60 seconds in which no combustion products enter the exhaust duct.

A.3.5 Drift in light attenuation measurement

The drift in the light attenuation measurement is calculated as the difference between start and end value reported on the record sheet.

Criterion:

$$| I_{begin} - I_{end} | \leq 2\ \% \qquad \text{Equation 10}$$

in which:
I = signal from the light receiver [mV].

Note: The visual reading of the end values are carried out after a period of at least 60 seconds in which no combustion products enter the exhaust duct. Note that a major part of the difference in begin and end value can be caused by soot deposits on the lenses of the optical measurement system.

A.4 Exposure period

The specimens are exposed to the flames of the main burner from $t = t_0 = 300$ s, until the propane supply to the burner is stopped (t'). The exposure period is equal to: $t' - t_0$.
This burner stop may be checked by calculating the first moment t' after t_0, at which the propane mass flow is lower than 300 mg/s at t' as well as at the next data point (t'+3 s):

$$[mgas(t'-3) \geq 300\ mg/s] \wedge [m_{gas}(t') < 300\ mg/s] \wedge [m_{gas}(t'+3s) < 300\ mg/s]$$

Equation 11

in which:
$m_{gas}(t')$ = propane mass flow rate [kg/s].

A.5 Heat output

In this clause the calculation of RHR and THR are described, as well as FIGRA.

A.5.1 Calculation of rate of heat release (RHR)

A.5.1.1 Total RHR of specimen and burner: RHR_{total}

a) Calculation of $V_{298}(t)$

$$V_{298}(t) = c \bullet A \bullet \frac{k_t}{k_\rho} \bullet \sqrt{\frac{\Delta p(t)}{T_{ms}(t)}}$$

Equation 12

in which:
$V_{298}(t)$= volume flow of exhaust system, normalized at 298 K [m^3/s];
c = $\sqrt{(2 \bullet T_0 / \rho_0)} = 22.4$ [$\sqrt{(K \bullet m^3/kg)}$]
A = area of the exhaust duct at the general measurement section [m^2];
k_t = flow profile factor, determined according to C.2.4 [-];
k_ρ = Reynolds number correction for the bidirectional probe, taken as 1.08 [-];
$\Delta p(t)$ = pressure difference [Pa];
$T_{ms}(t)$ = temperature in general measurement section [K].

b) Calculation of $\phi(t)$

$$\phi(t) = \frac{\overline{XO_2(30s...90s)} \bullet (1 - XCO_2(t)) - XO_2(t) \bullet (1 - \overline{XCO_2(30s...90s)})}{\overline{XO_2(30s...90s)} \bullet (1 - XCO_2(t) - XO_2(t))}$$

Equation 13

in which:
$\phi(t)$ = oxygen depletion factor [-];
$XO_2(t)$ = concentration of oxygen [%];
$XCO_2(t)$ = concentration of carbon dioxide [%].

c) Calculation of X_{a_O2}

$$X_{a\_O2} = \overline{XO_2(30s...90s)} \bullet \left(1 - \frac{H}{100 \bullet p} \bullet \exp(23.2 - \frac{3816}{\overline{T_{ms}(30s...90s)} - 46})\right)$$ Equation 14

in which:

X_{a_O2} = ambient mole fraction of oxygen including water vapour [%];
$XO_2(t)$ = concentration of oxygen [%];
H = humidity [%];
p = ambient pressure [Pa];
$T_{ms}(t)$ = temperature in general measurement section [K].

d) Calculation of $RHR_{total}(t)$

$$RHR_{total}(t) = E \bullet V_{298}(t) \bullet X_{a\_O2} \bullet \left(\frac{\phi(t)}{1 + 0.105 \bullet \phi(t)}\right)$$ Equation 15

in which:

$RHR_{total}(t)$ = total rate of heat release of specimen and burner [kW];
E = heat release per volume of oxygen consumed at 298 K, = 17.200 [kJ/m^3];
$V_{298}(t)$ = volume flow of exhaust system, normalized at 298 K [m^3/s];
X_{a_O2} = ambient mole fraction of oxygen including water vapour [%]
$\phi(t)$ = oxygen depletion factor [-].

A.5.1.2 RHR of the burner

The $RHR_{burner}(t)$ of the burner is equal to $RHR_{total}(t)$ during the base line period. The average RHR of the burner is calculated as the average $RHR_{total}(t)$ during the base line period (210 s ≤ t ≤ 270 s):

$$RHR_{av\_burner} = \overline{RHR_{total}(210s...270s)}$$ Equation 16

in which:

RHR_{av_burner} = average rate of heat release of the burner [kW];
$RHR_{total}(t)$ = total rate of heat release of specimen and burner [kW].

The level and stability of the burner during this base line period shall meet requirements on absolute level and stability. The standard deviation is calculated using the "nonbiased" or "n-1" method.

Criteria:

$RHR_{av\_burner} = 30.7 \pm 2.0$ kW Equation 17

$$stdev[RHR_{burner}(210s),..,RHR_{burner}(270s)] = \sqrt{\frac{n\sum_{t=210s}^{270s} RHR_{burner}(t)^2 - (\sum_{t=210s}^{270s} RHR_{burner}(t))^2}{n(n-1)}} < 1\,kW$$ Equation 18

in which:

RHR_{av_burner} = average rate of heat release of the burner [kW];
$RHR_{burner}(t)$ = rate of heat release of the burner [kW];
n = number of data points (n = 21).

Note: The ratio between carbon dioxide production and oxygen depletion during the base line period (210 s ≤ t ≤ 270 s; combustion of propane only) can be used as a check of the gas analysers before the burner switch. The ratio should be 0.60 ± 0.05.

A.5.1.3 RHR of the specimen

In general the rate of heat release of the specimen is taken as the total rate of heat release $RHR_{total}(t)$, subtracted with the average rate of heat release of the burner RHR_{av_burner}.

For t > 312 s:

$$RHR(t) = RHR_{total}(t) - RHR_{av\_burner} \qquad \text{Equation 19}$$

in which
RHR(t) = rate of heat release of the specimen [kW];
$RHR_{total}(t)$ = total rate of heat release of specimen and burner [kW];
RHR_{av_burner} = average rate of heat release of the burner [kW].

During the switch from auxiliary to main burner at the start of the exposure period, the total heat output of the two burners is less than RHR_{av_burner}. Equation 19 then leads to negative values for the RHR(t) for at most 12 seconds (burner switch response time). Such negative values and the value for t=0 are set to zero:

For t = 300 s:

RHR(300) = 0 kW

For 300 s < t ≤ 312 s:

$$RHR(t) = \max[0kW, RHR_{total}(t) - RHR_{av\_burner}] \qquad \text{Equation 20}$$

in which:
RHR(t) = rate of heat release of the specimen [kW];
$RHR_{total}(t)$ = total rate of heat release of specimen and burner [kW];
RHR_{av_burner} = average rate of heat release of the burner [kW];
max[a,b] = maximum of two values *a* and *b*.

A.5.1.4 Calculation of RHR30s

RHR30s(t) is the 30 seconds average of RHR(t):

$$RHR30s(t) = \frac{\left(0.5 \bullet RHR(t-15s) + RHR(t-12s) + \ldots + RHR(t+12s) + 0.5 \bullet RHR(t+15s)\right)}{10} \qquad \text{Equation 21}$$

in which:
RHR30s(t) = 30 seconds average of RHR(t) [kW];
RHR(t) = rate of heat release at time t [kW].

A.5.2 Calculation of THR(t) and THR600s

The total heat release of the specimen THR(t) and the total heat release of the specimen in the first 600 seconds of the exposure period (300 s ≤ t ≤ 900 s), THR600s, are calculated as:

$$THR(t_a) = \frac{1}{1000} \bullet \sum_{300s}^{t_a} RHR(t) \bullet 3s \qquad \text{Equation 22}$$

$$THR600s = \frac{1}{1000} \bullet \sum_{300s}^{900s} RHR(t) \bullet 3s \qquad \text{Equation 23}$$

in which

$THR(t_a)$ = total heat release of the specimen during 300 s ≤ t ≤ t_a [MJ];
RHR(t) = rate of heat release of the specimen [kW];
THR600s = total heat release of the specimen during 300 s ≤ t ≤ 900 s [MJ]; (equal to THR(900s)).

A.5.3 Calculation of FIGRA (FIre Growth RAte index)

The FIGRA is defined as the maximum of the quotient $RHR_{av}(t)/(t\text{-}300s)$, multiplied by 1000. The quotient is calculated only for that part of the exposure period in which the threshold levels for RHR_{av} and THR have been exceeded. If one or both threshold values are not exceeded during the exposure period, FIGRA is equal to zero.

a) The average of RHR, RHR_{av}, used to calculate the FIGRA is equal to RHR30s according to A.5.1.4 with the exception of the first 12 ss of the exposure period. For data points in the first 12 seconds, the average is taken only over the widest possible symmetrical range of data points within the exposure period:

For t = 300 s: $RHR_{av}(300s) = 0$
For t = 303 s: $RHR_{av}(303s) = \overline{RHR(300s...306s)}$
For t = 306 s: $RHR_{av}(306s) = \overline{RHR(300s...312s)}$
For t = 309 s: $RHR_{av}(309s) = \overline{RHR(300s...318s)}$
For t = 312 s: $RHR_{av}(312s) = \overline{RHR(300s...324s)}$

For t ≥ 315 s: $RHR_{av}(t) = RHR30s(t)$ Equation 24

b) The moments in time the threshold values are exceeded are defined as:
t_{t_RHR} = first moment after t = 300 s at which $RHR_{av}(t) > 3$ kW;
t_{t_THR} = first moment after t = 300 s at which THR(t) > 0.1 MJ.

c)

$$FIGRA = 1000 \bullet \max[(\frac{RHR_{av}(t)}{t\_300s}), for: (t \geq t_{t\_RHR}) \wedge (t \geq t_{t\_THR}) \wedge (t \leq 1500s)] \qquad \text{Equation 25}$$

In which:
FIGRA = fire growth rate index [W/s];
$RHR_{av}(t)$ = average of RHR(t) as specified in a) [kW];
$\max[a(t),b_t]$ = maximum of the function a(t) for the given t values b_t.

Note:
As a consequence, specimens with a RHR_{av} not more than 3 kW during the total test period or a THR not more than 0.1 MJ over the total test period, have a FIGRA value of zero.

A.6 Smoke production

A.6.1 Calculation of rate of smoke production (RSP)

A.6.1.1 Total RSP of specimen and burner: RSP_{total}

a) Calculation of V(t)

$$V(t) = V_{298}(t) \bullet \frac{T_{ms}(t)}{298K}$$ Equation 26

in which:
V(t) = volume flow of exhaust system [m^3/s];
$V_{298}(t)$ = volume flow of exhaust system, normalized at 298 K [m^3/s];
$T_{ms}(t)$ = temperature in general measurement section [K].

b) Calculation of $RSP_{total}(t)$

$$RSP_{total}(t) = \frac{V(t)}{L} \bullet \ln\left[\frac{\overline{I(30s...90s)}}{I(t)}\right]$$ Equation 27

in which:
$RSP_{total}(t)$ = total rate of smoke production of specimen and burner [m^2/s];
V(t) = (non-normalized) volume flow of exhaust system [m^3/s];
L = length of light path through duct [m];
I(t) = signal from the light receiver [mV].

A.6.1.2 RSP of the burner

The $RSP_{burner}(t)$ of the burner is equal to $RSP_{total}(t)$ during the base line period. The average RSP of the burner is calculated as the average $RSP_{total}(t)$ during the base line period (210 s ≤ t ≤ 270 s):

$$RSP_{av\_burner} = \overline{RSP_{total}(210s...270s)}$$ Equation 28

in which
$RSP_{total}(t)$ = total rate of smoke production of specimen and burner [m^2/s];
RSP_{av_burner} = average rate of smoke production of the burner [m^2/s].

The level and stability of the burner during this base line period shall meet requirements on absolute level and stability. The standard deviation is calculated using the "nonbiased" or "n-1" method.

Criteria:

$RSP_{av\_burner} = 0 \pm 0.05\ m^2/s$ Equation 29

$$stdev[RSP_{burner}(t), for: 210s \le t \le 270s)] = \sqrt{\frac{n\sum_{t=210s}^{270s} RSP_{burner}(t)^2 - (\sum_{t=210s}^{270s} RSP_{burner}(t))^2}{n(n-1)}} < 0.01\,m^2/s$$

Equation 30

in which:
RSP_{av_burner} = average rate of smoke production of the burner [m^2/s];
$RSP_{burner}(t)$ = rate of smoke production of the burner [m^2/s];
n = number of data points (n = 21).

A.6.1.3 RSP of the specimen

In general the RSP of the specimen is taken as the total rate of smoke production $RSP_{total}(t)$, subtracted with the average RSP of the burner RSP_{av_burner}.

For t > 312 s

$$RSP(t) = RSP_{total}(t) - RSP_{av\_burner} \qquad \text{Equation 31}$$

in which:
$RSP_{total}(t)$ = total rate of smoke production of specimen and burner [m^2/s];
RSP_{av_burner} = average rate of smoke production of the burner [m^2/s];
RSP(t) = rate of smoke production of the specimen [m^2/s].

During the switch from auxiliary to main burner at the start of the exposure period, the total smoke production of the two burners might be less than RSP_{av_burner}. Equation 31 then may lead to negative values for the RSP(t) for some seconds. Such negative values and the value for t=0 are set to zero:

For t = 300 s:

$$RSP(300) = 0 \ m^2/s$$

For 300 s < t ≤ 312 s:

$$RSP(t) = \max[0 \ m^2/s, RSP_{total}(t) - RSP_{av\_burner}] \qquad \text{Equation 32}$$

in which:
$RSP_{total}(t)$ = total rate of smoke production of specimen and burner [m^2/s];
RSP_{av_burner} = average rate of smoke production of the burner [m^2/s];
RSP(t) = rate of smoke production of the specimen [m^2/s];
max[a,b] = maximum of two values *a* and *b*.

Note:
The smoke production of the burner flames most probably changes when the specimen starts to produce combustible volatiles. However, the base line smoke production is taken as a first approximation with acceptable accuracy, especially at the start of the exposure period where the base line level is important for the SMOGRA calculation.

A.6.1.4 Calculation of RSP60s

RSP60s(t) is the 60 seconds average of RSP(t).

$$RSP60s(t) = \frac{\left(0.5 \bullet RSP(t-30s) + RSP(t-27s) + \ldots + RSP(t+27s) + 0.5 \bullet RSP(t+30s)\right)}{20} \qquad \text{Equation 33}$$

in which:
RSP60s(t) = 60 s average of RSP(t) [m^2/s];
RSP(t) = rate of smoke production of the specimen [m^2/s].

A.6.2 Calculation of TSP(t) and TSP600s

The total smoke production of the specimen TSP(t) and the total smoke production of the specimen in the first 600 seconds of the exposure period (300 s ≤ t ≤ 900 s), TSP600s, are calculated as:

$$TSP(t_a) = \sum_{300s}^{t_a} RSP(t) \bullet 3s \qquad \text{Equation 34}$$

$$TSP600s = \sum_{300s}^{900s} RSP(t) \bullet 3s \qquad \text{Equation 35}$$

in which

$TSP(t_a)$ = total smoke production of the specimen during 300 s ≤ t ≤ t_a [m^2];
$RSP(t)$ = rate of smoke production of the specimen [m^2/s].
TSP600s = total smoke production of the specimen during 300 s ≤ t ≤ 900 s [m^2]; (equal to TSP(900s)).

A.6.3 Calculation of SMOGRA (SMOke Growth RAte index)

The SMOGRA is defined as the maximum of the quotient $RSP_{av}(t)/(t\text{-}300s)$, multiplied by 10,000. The quotient is calculated only for that part of the exposure period in which the threshold levels for RSP_{av} and TSP have been exceeded. If one or both threshold values are not exceeded during the exposure period, SMOGRA is equal to zero.

a) The average of RSP, RSP_{av}, used to calculate the SMOGRA is equal to RSP60s according to A.6.1.4 with the exception of the first 27 s of the exposure period. For data points in the first 27 s, the average is taken only over the widest possible symmetrical range of data points within the exposure period:

For t = 300 s: $RSP_{av}(300s) = 0\ m^2/s$
For t = 303 s: $RSP_{av}(303s) = \overline{RSP(300s...306s)}$
For t = 306 s: $RSP_{av}(306s) = \overline{RSP(300s...312s)}$ etcetera, until
For t = 327 s: $RSP_{av}(327s) = \overline{RSP(300s...354s)}$

For t ≥ 330 s: $RSP_{av}(t) = RSP60s(t)$ Equation 36

b) The moments in time the threshold values are exceeded are defined as:
t_{t_RSP} = first moment after t = 300 s at which $RSP_{av}(t) > 0.1\ m^2/s$.
t_{t_TSP} = first moment after t = 300 s at which $TSP(t) > 6\ m^2$.

c)

$$SMOGRA = 10{,}000 \bullet \max\left[\left(\frac{RSP_{av}(t)}{t - 300s}\right), for : (t \geq t_{t-RSP}) \wedge (t \geq t_{t-TSP}) \wedge (t \leq 1500s)\right]$$

Equation 37

In which:
SMOGRA = smoke growth rate index [m^2/s^2];
$RSP_{av}(t)$ = average of RSP(t) as specified in a) [m^2/s];
$\max[a(t),b_t]$ = maximum of the function a(t) for the given t values b_t.

Note:
As a consequence, specimens with a RSP_{av} not more than 0,1 m^2/s during the total test period or a TSP not more than 6 m^2 over the total test period have a SMOGRA value of zero.

A.7 Calculations for calibrations

A.7.1 Propane heat release

A.7.1.1 The theoretical heat release of the propane mass flow is calculated as:

$$q_{gas}(t) = \Delta h_{c,eff} \bullet m_{gas}(t) \qquad \text{Equation 38}$$

in which:
$q_{gas}(t)$ = theoretical heat release of propane mass flow [kW];
$\Delta h_{c,eff}$ = effective lower heat combustion of propane, = 46360 kJ/kg;
$m_{gas}(t)$ = propane mass flow rate [kg/s].

A.7.1.2 The 30 seconds average of $q_{gas}(t)$ is calculated as:

$$q30s_{gas}(t) = \frac{\left(0.5 \bullet q_{gas}(t-15s) + q_{gas}(t-12s) + \ldots + q_{gas}(t+12s) + 0.5 \bullet q_{gas}(t+15s)\right)}{10} \qquad \text{Equation 39}$$

in which:
$q30s_{gas}(t)$ = 30 seconds average of $q_{gas}(t)$ [kW];
$q_{gas}(t)$ = theoretical heat release of propane mass flow [kW].

A.7.2 k_t factors

A.7.2.1 The factor $k_{t,qgas}$, is calculated as:

$$k_{t,qgas} = k_{t,stepcalib} \bullet \frac{q_{gas,step2} + q_{gas,step3} + q_{gas,step5}}{RHR_{step2} + RHR_{step3} + RHR_{step5}} \qquad \text{Equation 40}$$

in which:
$k_{t,qgas}$ = flow profile factor adjusted to the propane energy content [-];
$k_{t,stepcalib}$ = flow profile factor used for calculation of RHR in the "burner heat output step calibration" according to C.2.1. [-];
RHR_{stepx} = the rate of heat release of the burner in step x, calculated according to C.2.1.3 [kW];
$q_{gas,stepx}$ = energy content of propane mass flow in step x, calculated according to C.2.1.3 [kW].

A.7.2.2 The factor $k_{t,qheptane}$, shall be calculated as:

$$k_{t,qheptane} = k_{t,smokecalib} \bullet \frac{Y}{THR} \qquad \text{Equation 41}$$

in which:

$k_{t,qheptane}$ = flow profile factor adjusted to the heptane energy content [-];
$k_{t,smokecalib}$ = flow profile factor used for calculation of RHR in the "heptane smoke and heat output calibration" according to C.2.2. [-];
THR = the total heat release of heptane, calculated according to C.2.2 [MJ/kg];
Y = energy content of heptane, = 44.56 MJ/kg.

A.7.2.3 The k_t factor shall be calculated as:

$$k_t = (k_{t,v} + k_{t,qgas} + k_{t,qheptane}) / 3 \qquad \text{Equation 42}$$

Criteria:
$| (k_t - k_{t,v}) / kt | \leq 5\ \%$
$| (k_t - k_{t,qgas}) / kt | \leq 5\ \%$
$| (k_t - k_{t,qheptane}) / kt | \leq 5\ \%$;

in which
$k_{t,v}$ = flow profile factor measured according to C.2.3;
$k_{t,qgas}$ = flow profile factor calculated in accordance with A.7.2.1., as the factor needed to fit the averages RHR_{stepx} of the burner heat output step calibration to the averages $q_{gas,stepx}$;
$k_{t,qheptane}$ = flow profile factor calculated in accordance with A.7.2.2., as the factor needed to fit the THR, calculated according to C.2.2, to the theoretical energy content of heptane.

ANNEX B (INFORMATIVE) PRECISION OF TEST METHOD

(Relevant text to be included from the round robin exercise)

ANNEX C (NORMATIVE) CALIBRATION PROCEDURES

C.1 Procedures for separate pieces of equipment

Several of the measuring instruments used, need regular calibration. In this standard it is assumed that the instruments are maintained and calibrated according to the producers specifications. The calibrations in this annex shall be performed, when not already performed on basis of the producers' specifications.
Gas concentration percentages are in V_{O2}/V_{air} respectively V_{CO2}/V_{air}.

C.1.1 Oxygen analyser adjustment

The oxygen analyser shall be adjusted for zero and span each day on which tests are performed. The span width shall be within 0,04% V_{O2}/V_{air} of the width defined by the calibration gasses used. The analyser output for dried ambient air shall be (20.95 ± 0.01) %. A possible procedure to perform the adjustment is given in D.1.1.

C.1.2 Oxygen analyser output noise and drift

C.1.2.1 Noise and drift of the oxygen analyser output using the data acquisition system shall be checked after set up, maintenance, repair or replacement of the oxygen analyser or other major components of the gas analysis system and at least every six months.

C.1.2.2 Actions

a) Feed the oxygen analyser with oxygen-free nitrogen gas, until the analyser reaches equilibrium.
b) After at least 60 min in oxygen-free conditions, adjust the volume flow in the exhaust duct to (0,60 ± 0,05) m^3/s and switch to air from the exhaust duct with the same flow rate, pressure and drying procedure as for sample gases. When the analyser reaches equilibrium, adjust the analyser output to (20,95 ± 0,01) %.
c) Within 1 min, start recording the oxygen analyser output at 3 s interval for a period of 30 min.
d) Determine the drift by use of the least squares fitting procedure to fit a straight line through the data points. The absolute value of the difference between reading at 0 min and at 30 min of this linear trend line represents the drift.
e) Determine the noise by computing the root-mean-square (rms) deviation around the linear trend line.

C.1.2.3 Criteria

The sum of drift and noise (both taken as positive values) shall be not more than 0,01 % (V_{O2}/V_{air}).

C.1.2.4 Calibration report

The calibration report shall include the following information:

a) the graphs of O2(t) in % V_{O2}/V_{air};
b) the noise and drift values calculated according to C.1.2.2 d) and e) in % V_{O2}/V_{air}.

C.1.3 Carbon dioxide analyser adjustment

The carbon dioxide analyser shall be adjusted for zero and span each day on which tests are performed. The span width shall be within 0,1 % V_{CO2}/V_{air} of the width defined by the calibration gasses used. The analyser output for carbon dioxide-free nitrogen gas shall be (0.00 ± 0.02) %. A possible procedure to perform the adjustment is given in D.1.2.

C.1.4 Check of propane mass flow controller

C.1.4.1 The accuracy of the mass flow controller shall be better than 6 mg/s at the propane mass flow rate as used during standard tests (647 ± 10) mg/s. This check shall be performed at least every six months. A possible procedure to perform the check is given in D.1.3.

C.1.5 Light system calibration

C.1.5.1 The light system calibration shall be performed before tests, after set up, maintenance, repair or replacement of the smoke measurement system holder or other major components of the exhaust system and at least every six months. The calibration consists of two parts: an output stability check and an optical filter check.

C.1.5.2 Stability check

Perform *the following* steps with the measuring equipment operating and with the trolley (excluding specimen, including backing boards) in the frame, under the hood.

a) Set the volume flow of the exhaust to: $V_{298} = 0{,}60 \pm 0{,}05$ m³/s (as calculated according to A.5.1.1.a)).
b) Start the time measurement and record the signal from the light receiver for a period of 30 min.
c) Determine the drift by use of a least squares fitting procedure to fit a straight line through the data points. The absolute value of the difference between reading at 0 min and at 30 min of this linear trend line represents the drift.
d) Determine the noise by computing the root-mean-square (rms) deviation around the linear trend line.

Criterion: Both noise and drift shall be less than 0,5% of the start value.

C.1.5.3 Optical filter check

The light system shall be calibrated with at least five neutral density filters in the optical density range of 0,05 to 2,0. The optical density calculated with the measured light receiver signal shall be within ± 5% or ± 0,01 of the theoretical value of the filters.
A possible procedure to perform the calibration is given in D.1.4.

C.2 System response calibrations

C.2.1 Burner heat output step calibration

C.2.1. This calibration procedure uses the standard burner at three different levels of heat output. It is used to determine the response and delay time of the gas analysers, the burner switch response time, the thermocouples response time and the calculation of rate of heat release. This calibration procedure shall be performed at least once a month or after 30 tests.

C.2.1.2 Actions

Perform *the following* steps with the measuring equipment operating and with the trolley (excluding specimen, including backing boards) in the frame, under the hood.

a) Set the volume flow of the exhaust to: $V_{298} = 0{,}60 \pm 0{,}05$ m³/s (as calculated according to A.5.1.1.a). This volume flow shall be between 0,65 m³/s and 0,50 m³/s during the total calibration period.
b) Record the temperatures T1, T2 and T3 in the exhaust duct and the ambient temperature during at least 300 s. The ambient temperature shall be within (20 ± 10) °C, and the temperatures in the duct shall not differ more than 4°C from the ambient temperature.
c) Record the pre-test conditions on the record sheet. The data to be recorded are given in 7.3.2.
d) Start the time measurement and the automatic recording of data: t = 0 s, by definition. The data to be recorded every 3 s, are t, m_{gas}, XO_2, XCO_2, □p and T0 till T3, according to 7.4.
e) Ignite the auxiliary burner and adjust the propane mass flow according to table C.1 within the first 5 s of each step.

Table C.1 Burner ignition times and propane mass flow

Step number	Time (min)	Propane mass flow Auxiliary burner [mg/s]
1	0 - 2	0
2	2 - 5	647 ± 50

(f) Switch the propane supply from the auxiliary burner to the main burner, and adjust the propane mass flow according to *the following* table within the first 5 seconds of each step.

Table B.4 Time to switch propane supply to main burner

Step number	Time (min)	Propane mass flow main burner [mg/s]
3	5 – 8	647 ± 50
4	8 – 11	2000 ± 100
5	11 – 14	647 ± 50
6	14 - 17	0

g) Stop the automatic recording of data at the end of step 6.
h) Record the end of test conditions. The data to be recorded are given in 7.3.

Note1: The burner shall produce approximately 0, 30 and 93 kW at the requested propane mass flow levels.
Note 2: The margins used in the mass flow settings are larger than in the test procedure, because adjustments can hardly be made in the available time.

C.2.1.3 Calculate the following quantities:
Based on the unshifted (!) data, calculate:

a) for each step, except step 3:

- t_{gas} the start time of the step as the time of the first data point at which the propane flow has changed 100 mg/s in comparison with the average value in the last two minutes of the previous step;
- t_T the time of the first data point at which the temperature T_{ms} has changed 2.5 K in comparison with the average value in the last two minutes of the previous step;
- t_{O2} the time of the first data point at which the oxygen has changed 0,05 % in comparison with the average value in the last two minutes of the previous step;
- t_{CO2} the time of the first data point at which the carbon dioxide has changed 0,02 % in comparison with the average value in the last two minutes of the previous step;
- $t_{O2,10\%}$ the time of the first data point at which the oxygen concentration has reached 10 % of its deflection using the average values in the last two minutes of the previous and the concerning step;
- $t_{O2,90\%}$ analogue to $t_{O2,10\%}$, however for 90 % instead of 10 % deflection;
- $t_{CO2,10\%}$ the time of the first data point at which the carbon dioxide concentration has reached 10 % of its deflection using the average values in the last two minutes of the previous and the concerning step;
- $t_{CO2,90\%}$ analogue to $t_{CO2,10\%}$, however for 90 % instead of 10 % deflection;
- $t_{T,10\%}$ the time of the first data point at which the temperature T_{ms} has reached 10 % of its deflection using the average value in the last 15 s of the previous step and the average value between 15 s and 30 s after the start of the step concerned;
- $t_{T,75\%}$ analogue to $t_{T,10\%}$, however for 75 % instead of 10 % deflection.

b) the delay time of the oxygen analyser as the average of $t_{O2} - t_T$ found for the steps 4, 5 and 6;

c) the delay time of the carbon dioxide analyser as the average of $t_{CO2} - t_T$ found for the steps 4, 5 and 6;

d) the response time of the oxygen analyser as the average of $t_{O2,90\%} - t_{O2,10\%}$ found for the steps 4, 5 and 6;

e) the response time of the carbon dioxide analyser as the average of $t_{CO2,90\%} - t_{CO2,10\%}$ found for the steps 4, 5 and 6.

f) the burner switch response time as the difference between t_{up} and t_{down}, which are defined as:

- t_{up} the time of the first data point in step 3 at which the oxygen concentration has increased 10 % of the difference between the average values in the last two minutes of step 1 and step 2;
- t_{down} the time of the first data point in step 3 thereafter at which the oxygen concentration has passed the same level in downwards direction.

g) the temperature response time as the average of $t_{T,75\%} - t_{T,10\%}$ found for the steps 2, 4, 5 and 6.

h) $q_{gas}(t)$ and $q30s_{gas}(t)$, according A.7.1;

i) the average value of $q_{gas}(t)$ according to (h) during the last two minutes in steps 2, 3 and 5 ($q_{gas,step2}$, $q_{gas,step3}$ and $q_{gas,step5}$);

Then shift the O_2 and CO_2 data backwards in time in accordance with the analyser delay times found, and calculate:

j) RHR(t), equal to $RHR_{total}(t)$ according to A.5.1.1 using however an E value of 16,800 kJ/m^3 (value for propane);
k) RHR30s(t), according to A.5.1.4, using RHR(t) according to (j);
l) the average values of RHR(t) according to (j) during the last two minutes in steps 2, 3 and 5 (RHR_{step2}, RHR_{step3}, and RHR_{step5});
m) the flow profile factor $k_{t,qgas}$, according to A.7.2.1.

Note1: The $q_{gas,stepx}$ values are used for the calculation of the k_t factor (together with the RHR_{stepx} values).
Note 2: The delay and response time of the analysers in step 2 are used as a check. The difference with the time delays in the steps 4, 5 and 6 may point at additional time delay(s) in the propane supply system.
Note 3: The temperature response time is calculated to check for dysfunction of, and soot deposits on the thermocouples. The criterion for the thermocouple response time takes account of the influence of the thermal response of the duct system as a whole.

C.2.1.4 Criteria

The following criteria shall be met:

a) the delay time of both analysers shall not exceed 30 s;
b) the response time of both analysers shall not exceed 12 s;
c) the burner switch response time shall not exceed 12 s;
d) the temperature response time shall not exceed 6 s;
e) the equipment response shall meet the criteria of A.3.2 and A.3.3.;
f) the ratio q30s(t)/RHR30s(t) shall continuously be within (100 ± 50 % during the intervals between 40 s and 160 s after the start of the steps 2, 3, 4 and 5. For the start of steps 2, 4 and 5, t_T is used, the start of step 3 is taken as t = 300 s;
g) the averages RHR_{step2} and RHR_{step3} according to C.2.1.3.(l). shall not differ more than 0,5 kW.

C.2.1.5 Calibration report

The calibration report shall include the following information:

a) the graphs of $q_{gas}(t)$/RHR(t) and $q30s_{gas}(t)$/RHR30s(t);
b) the maximum and minimum of the ratio $q30s_{gas}(t)$/RHR30s(t) during each of the four intervals according to C.2.1.4.(f);
c) the delay and response times of both analysers;
d) the burner switch response time;
e) the temperature response time;
f) the values of $q_{gas,stepx}$, and RHR_{stepx}, for the steps 2, 3, and 5;
g) the values of k_t used in the RHR(t) calculation and of $k_{t,qgas}$.

C.2.2 Heptane smoke and heat output calibration

C.2.2.1 The smoke calibration shall be performed before tests, after set up, maintenance, repair or replacement of the smoke measurement system holder or other major components of the exhaust system and at least once a year. The measurements are made using:

a) Circular open steel fuel tray of internal diameter (350 ± 5)mm, with an internal wall height of 152 mm and a wall thickness of 3 mm;
b) Heptane (> 99% purity);

C.2.2.2 Actions

Perform the following steps with the measuring equipment operating and with the trolley (excluding specimen, including backing boards) in the frame, under the hood.

a) Set the volume flow of the exhaust to: V_{298} = (0,60 ± 0,05) m^3/s (as calculated according to A.5.1.1.a). This volume flow shall be witin the range 0,65 m^3/s to 0,50 m^3/s during the total calibration period.
b) Record the temperatures T1, T2 and T3 in the exhaust duct and the ambient temperature during at least 300 s. The ambient temperature shall be within (20 ± 10) °C, and the temperatures in the duct and the temperature off the fuel tray and its mounting shall not differ more than 4 °C from the ambient temperature.
c) The fuel tray is placed over the trolley platform, on a standard calcium silicate board with dimensions of 400 mm x 400 mm. Supports of 100 mm high raise the calcium silicate board above the conduit that runs diagonally across the floor of the trolley. The fuel tray should be positioned such that the distance between the internal corner of the specimen holder and the sidewall of the fuel tray is 500 mm. When positioned correctly, the sidewall of the fuel tray should be at least 300 mm from both the back and side panels.
d) Pour (2000 ± 10) g of water into the fuel tray.
e) Record the pre-test conditions on the record sheet. The data to be recorded are given in 7.3.2.
f) Start the time measurement and the automatic recording of data: $t = t_0$, by definition. The data to be recorded every 3 s, are t, m_{gas}, XO_2, XCO_2, □p, T0 till T3 and the signal from the light receiver, according to 7.4.
g) Two minutes after t_0 (t_0+120s) gently pour (2840 ± 10)g of heptane onto the water in the fuel tray.
h) Three minutes after t_0 ($t_1 = t_0$+180s) ignite the heptane.
i) When the burning ceases, the data recording is continued for a further five minutes and then stopped (t_2).
j) Record the end of test conditions. The data to be recorded are given in 7.3.

C.2.2.3 Calculate the following quantities:

a) the total smoke production TSP according to A.6 over the time interval from time to ignition to five minutes after flame out. The TSP is then divided by the mass of fuel used (m).
b) the total heat release THR according to A.5 over the time interval from time to ignition to five minutes after flame out. The heat release calculation (A.5.1.1) shall be carried out using an E value of 16,500 kJ/m^3 (value for heptane). The THR is then divided by the mass of fuel used (m).
c) the flow profile factor $k_{t,qheptane}$, according to A.7.2.2.

C.2.2.4 Criteria

The following criteria shall be met:

a) the ratio THR/m [MJ/kg] shall be 44,56 MJ/kg ± 5 %;

b) at t2, the signal from the light receiver shall be within 1% of its initial value (i.e. ≥ 99%);

c) the equipment response shall meet the criteria of A.3.2 and A.3.3.

Note: The ratio TSP/m [m^2/kg] can be used as an indication for the performance of the smoke measurement system. It's value should be (125 ± 25) m^2/kg.

C.2.2.5 Calibration report

The calibration report shall include the following information:

a) the graphs of RSP(t) and RHR(t);

b) the ratios TSP/m and THR/m.

g) the values of k_t used in the RHR(t) calculation and of $k_{t,qheptane}$.

C.2.3 Velocity profile factor $k_{t,v}$

C.2.3.1 The $k_{t,v}$ factor shall be measured after set up, maintenance, repair or replacement of the bi-directional probe or other major components of the exhaust system and at least every year. The measurements are made using a pitot tube or a hot wire anemometer.

C.2.3.2 Measurement specifications

a) The equipment shall be run on a damping setting sufficiently high to obtain a steady reading.

b) When inserted into the duct the measurement probe shall be positioned mechanically fixed, rather than held by hand. The horizontal or vertical positioning of the probe (whichever is required) and the right angles to the duct shall be checked.

c) The entry ports not used by the anemometer shall be closed.

d) The gas velocity shall be measured 20 times in every measurement position, 10 times when traversing outwards from the centre, 10 times when traversing inwards to the centre.

e) The measurement positions on a single radius are at the following distance from the wall expressed as a fraction of the radius (taken from ISO 3966:1977): 0.0378, 0.1530, 0.3050, 0.4342, 0.7224 and 1.000 (centre). The positions are indicated in figure C.1.

Note: For the duct diameter used (315 mm), these positions are in mm from the centre: 0 mm, 43,7 mm, 89,1 mm, 109,5 mm, 133,4 mm, 151,5 mm.

C.2.3.3 Actions

Perform the following steps:

a) Set the volume flow of the exhaust to: V_{298} = (0,60 ± 0,05) m^3/s (as calculated according to A.5.1.1.a).

b) Record the temperatures T1, T2 and T3 in the exhaust duct and the ambient temperature during at least 300 s. The ambient temperature shall be within (20 ± 10) °C, and the temperatures in the duct shall not differ more than 4°C from the ambient temperature.

c) Measure the gas velocity in all measurement positions, six positions per entry port.

d) Calculate the gas velocity at all measurement positions as the average of the 20 values measured, giving V_c for the centre position and five V_n values for the five other positions for each entry port.

Note: As a result, the velocity profile is measured and calculated both horizontally and vertically over the full diameter.

C.2.3.4 Calculation of $k_{t,v}$

For a given radius the average velocity at a radius n is given by V_N, which is the average of the four V_n values measured. The velocity at the centre position is given by V_C, which is the average of the four V_c values measured. The profile factor $k_{t,v}$ is then $1/5\Sigma\ (V_N/V_C)$.

C.2.3.5 Measurement report

The measurement report shall include the following information:

a) the velocity profile based on the average V_n at five radii and Vc, separately for each entry port (a vertical and a horizontal cross section);

b) the values of four V_n's, four V_c's, V_N, V_C and the resulting $k_{t,v}$.

C.2.4 Flow factor k_t

The k_t factor (used for the calculation of the rate of heat release in A.5.1) shall be calculated as the average of the three values $k_{t,v}$, $k_{t,qgas}$, and $k_{t,qheptane}$ in accordance to A.7.2.3.

ANNEX D (INFORMATIVE) CALIBRATION PROCEDURES

D.1 Procedures for separate pieces of equipment

This clause includes calibration procedures that meet the performance based calibration requirement they refer to.
Gas concentration percentages are in V_{O2}/V_{air} respectively V_{CO2}/V_{air}.

D.1.1 Oxygen analyser adjustment

The oxygen analyser may be adjusted using the following procedure. An analyser adjusted according to this procedure is expected to meet the requirements of C.1.1.

a) For zeroing, feed the analyser with oxygen-free nitrogen gas, with the same flow rate and pressure as for sample gases. When the analyser reaches equilibrium, adjust the analyser output to (0,00 ± 0,01) %.

b) For span calibration either dried ambient air or a specified gas with oxygen content of (21,0 ± 0,1) % may be used. If ambient air is used for span calibration the exhaust system should be running at (0,6 ± 0,05) m^3/s during the entire calibration, if "a specified gas" is used, the exhaust system is not needed. When the analyser reaches equilibrium, adjust the analyser output to (20,95 ± 0,01)% if dried air is used and to within 0,01 % of the actual oxygen content if the specified gas is used.

D.1.2 Carbon dioxide analyser adjustment

The carbon dioxide analyser may be adjusted using the following procedure. An analyser adjusted according to this procedure is expected to meet the requirements of C.1.3.

a) For zeroing, feed the analyser with carbon dioxide-free nitrogen gas, with the same flow rate and pressure as for sample gases. When the analyser reaches equilibrium, adjust the analyser output to (0,00 ± 0,01) %.

c) For span calibration a specified gas with carbon dioxide content between 5 % and 10 % should be used. Feed the analyser with the gas, with the same flow rate and pressure as for sample gases. When the analyser reaches equilibrium, adjust the analyser output to the carbon dioxide content of the specified gas ± 0.01 %.

D.1.3 Check of propane mass flow controller

D.1.3.1 The accuracy of the mass flow controller may be checked by using a single cylinder of propane and the main burner at the propane mass flow rate as used during standard tests (647 ± 10) mg/s. The gas usage rate is determined from the initial and final weight of the gas cylinder. Use a balance or weighing platform with an accuracy of 5 g or better. A mass flow controller meeting the criterion of this procedure is expected to meet the requirements of C.1.4.

D.1.3.2 Actions

a) Place the cylinder on the weighing platform and connect it to the supply system.

b) Set up the test facility as in a standard calibration test with backing boards fitted. Ignite the main burner and adjust the gas supply to (647 ± 10) mg/s, to have the main burner running at the standard rate as used during standard tests.

c) Record the weight of the cylinder and simultaneously start a timing device.

d) After (3600 ± 30) s, again record the weight of the cylinder and simultaneously stop the timing device.
e) Determine the average rate of usage of gas in mg/s.

D.1.3.3 Criterion
The average rate of usage of gas set in b) and determined in e) should be equal within 6 mg/s.

D.1.4 Optical filter check

D.1.4.1 The light system may be calibrated using the following procedure. A light system calibrated according to this procedure is expected to meet the requirements of C.1.5.3.

D.1.4.2 Actions
Perform the following steps with the measuring equipment operating and with the trolley (excluding specimen, including backing boards) in the frame, under the hood.
a) Place a light blocking insert into the filter holder and adjust to zero.
b) Remove the light blocking insert and adjust the signal from the light receiver to 100%.
c) Start the time measurement and record the signal from the light receiver for a period of two minutes.
d) Introduce one of the following filters with optical density (d) 0,1, 0,3, 0,5, 0,8, 1,0 and 2,0 and record the corresponding signal for at least one minute.
e) Repeat step d) for the other filters.
f) Stop the data acquisition and calculate the mean transmission values for all filters.

D.1.4.3 Criterion
Each d-value calculated from the mean transmission value ($d = - \log(I)$) should be within ± 5% or within ± 0,01 of the theoretical d-value of the filter.

Note: The theoretical transmission values for the given d-values 0,1, 0,3, 0,5, 0,8, 1,0, 2,0 using the given formula, are 79,43 %, 50,12 %, 31,62 %, 15,85 %, 10 % and 1%.

ANNEX E (NORMATIVE) DESIGN DRAWINGS

(for the draft of EN SBI and for convenience this is included in a separate document, N1496 annex E)

ANNEX F (INFORMATIVE) RECORD SHEET

SBI Test - Record sheet

General information	
Operator:	Date of test:
Product:	Data filename:

Pre-test conditions		
Conditioning of specimens:	Start date:	End date:
	mass1 (g):	mass2 (g):
Ambient conditions:	Ambient pressure (Pa):	Ambient humidity (%H_2O):

Visual observations				
General observations and checks:			Lateral flame spread	
Observation	*time (s)*		*Observation*	*Y/N*
Start time data recording	= 0		Till end of specimen	
Main burner ignites				
			Flaming drops or particles:	
			Observation	*Y/N*
			fallen drop/particle	
			fallen drop/particle burning > 10 s	

End of test conditions		
Light trans.(mV):	O_2 conc. (%):	CO_2 conc. (%):

Remarks:

ANNEX G (INFORMATIVE) DATA FILE FORMAT

(To be added)

ANNEX H (INFORMATIVE) EXAMPLE DATA FILES FOR CALCULATIONS CHECK

(To be added)

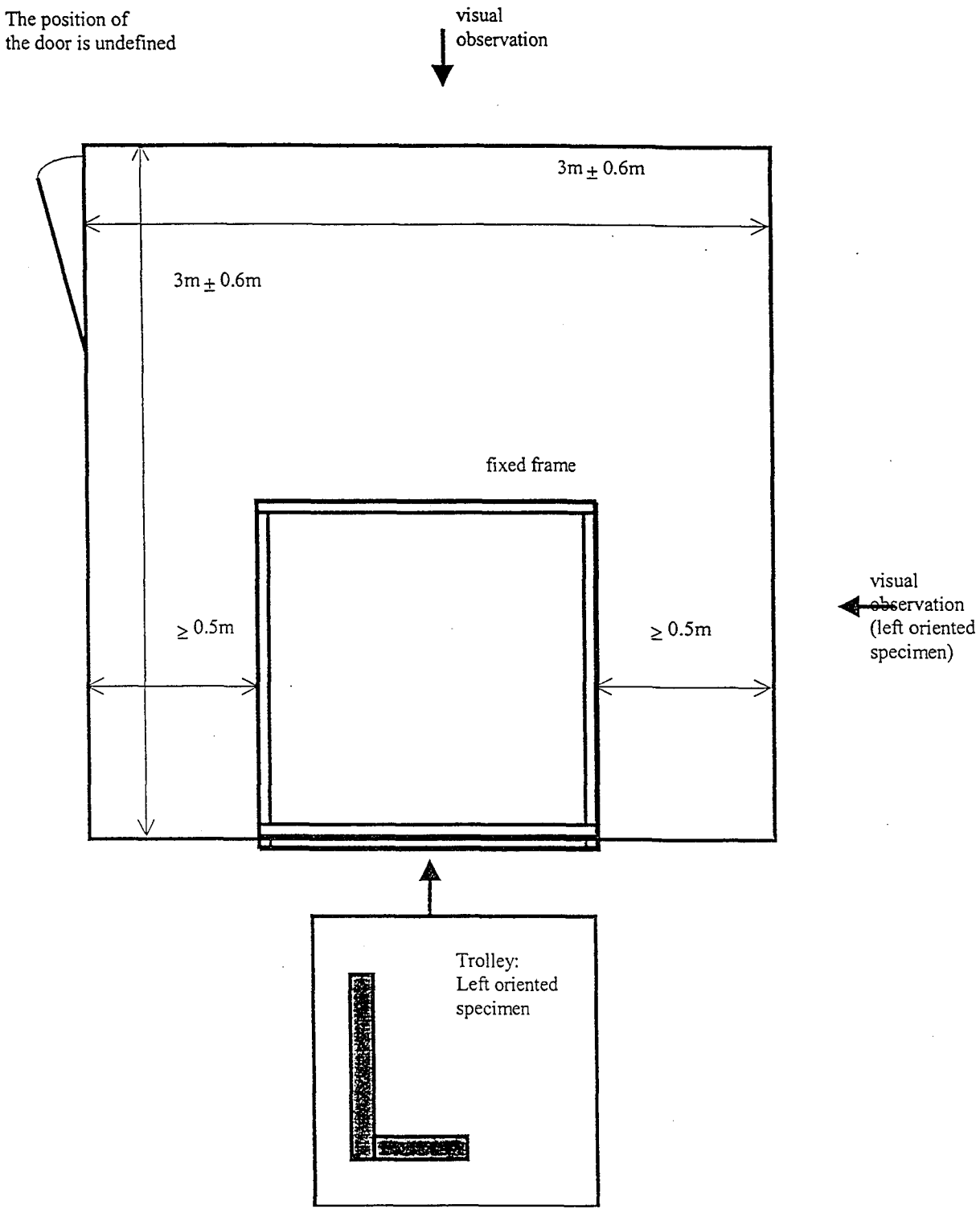


Figure 1 Top view of a possible SBI test room design. Both left oriented and right oriented specimens are acceptable. For right oriented specimens the figure is mirrored around a vertical line

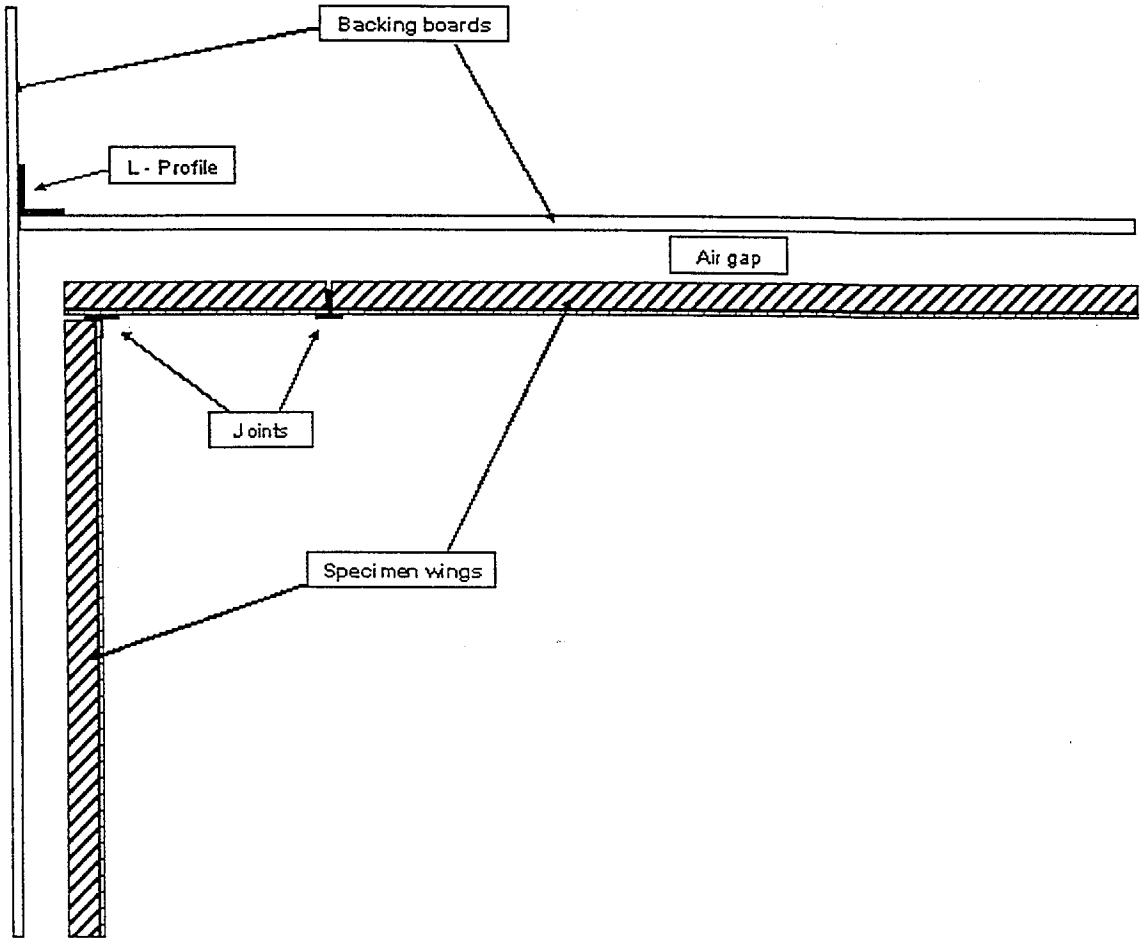


Figure 2 Example arrangement of specimen and backing boards.

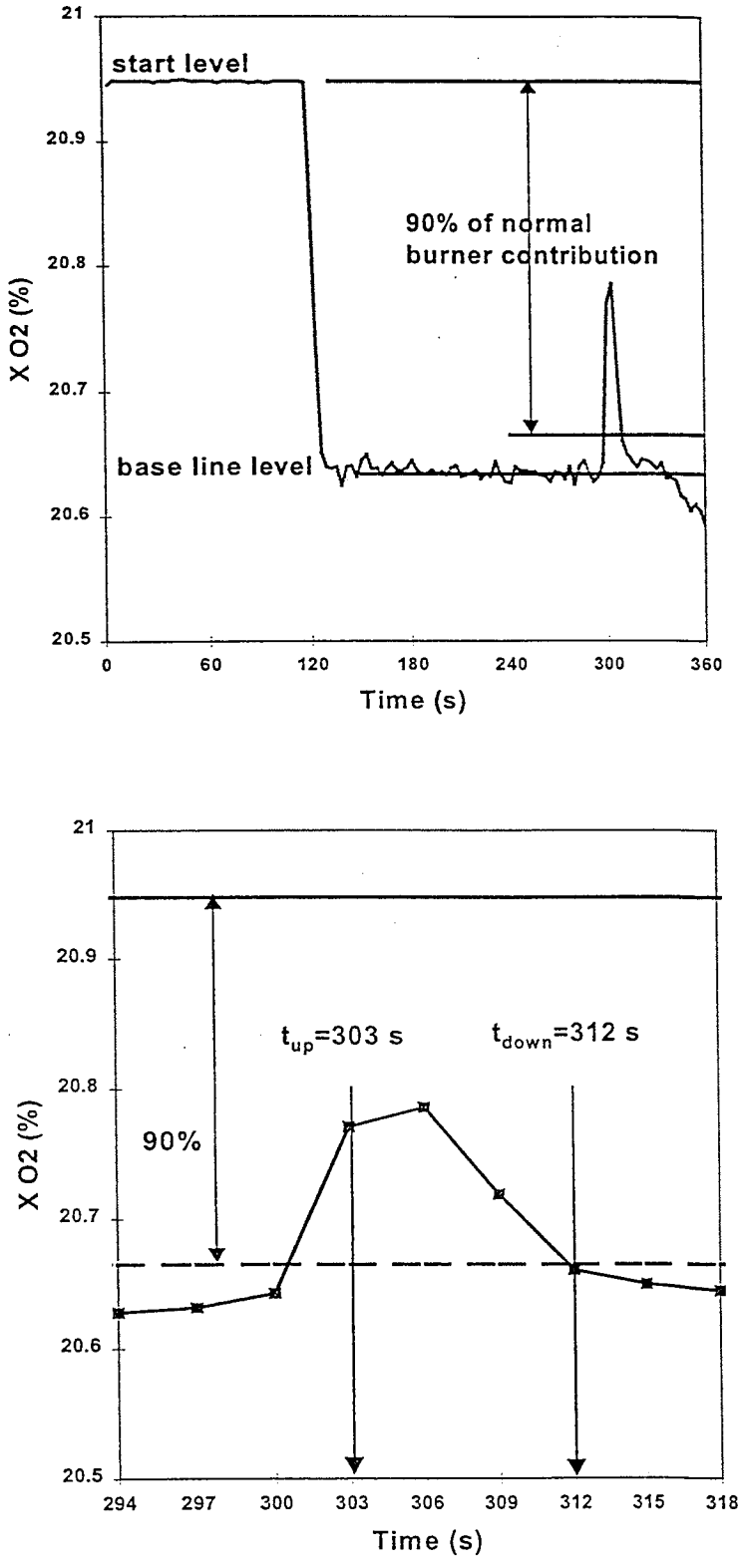
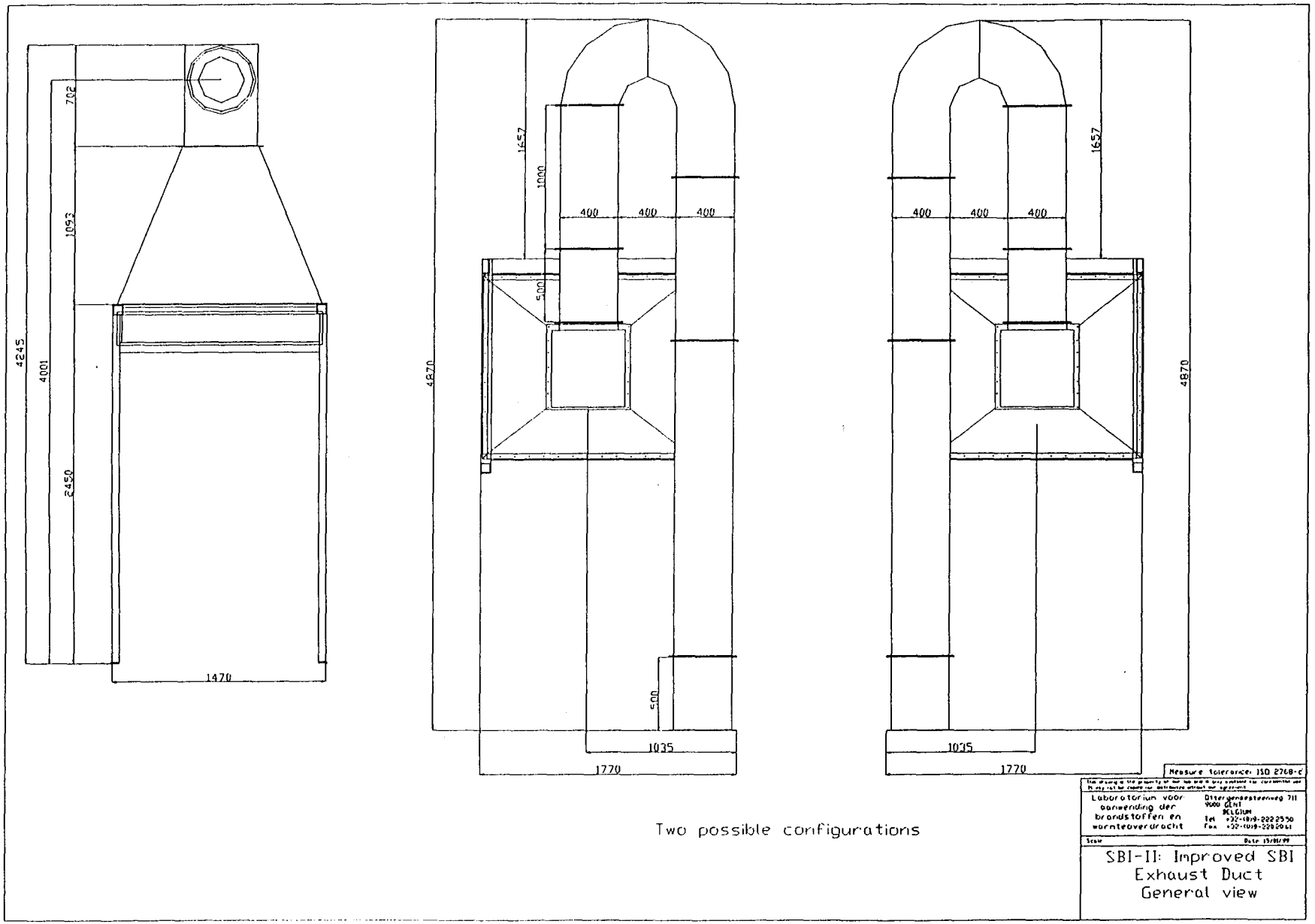


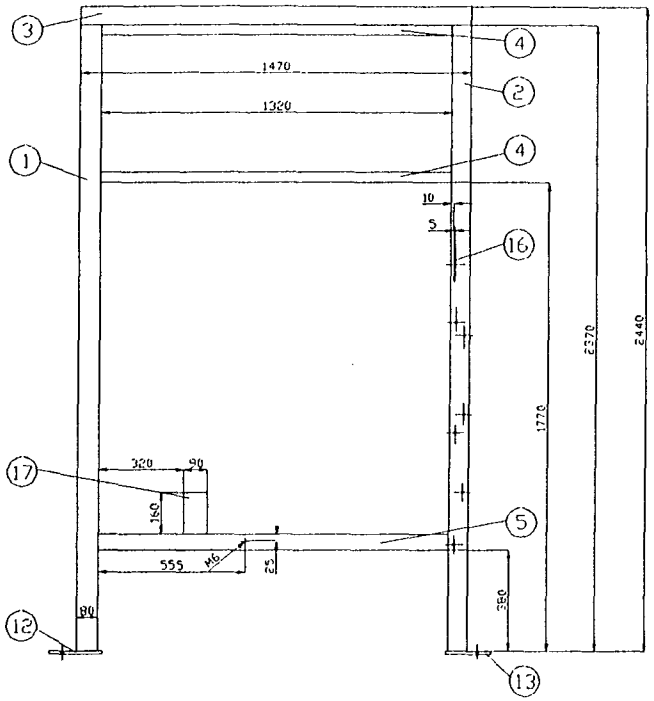
Figure A.1 Oxygen concentration during the first part of the test. Main events: (1) auxiliary burner on at t ≈ 120 s, (2) switch from auxiliary burner to main burner at t ≈ 300 s. The time interval around t = 300 s is magnified in figure b. The calculated burner response time is 9 s in this case.

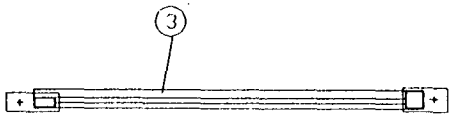
Figure 1



Two possible configurations

Figure 2





Measure tolerance: ISO 2768-c

Ref	Description	Number
17	Steel plate 160x90x5	1
16	Steel plate 240x120x5	1
15	Tube profile 20x20x2 / l = 60	1
14	Tube profile 20x20x2 / l = 1280	1
13	Steel plate 170x90x10	2
12	Steel plate 260x120x10	2
5	Tube profile 60x40x4 / l = 1320	2
4	Tube profile 40x20x3 / l = 1320	2
3	Tube profile 70x70x5 / l = 1470	2
2	Tube profile 70x70x5 / l = 2370	2
1	Tube profile 60x40x4 / l = 2370	2

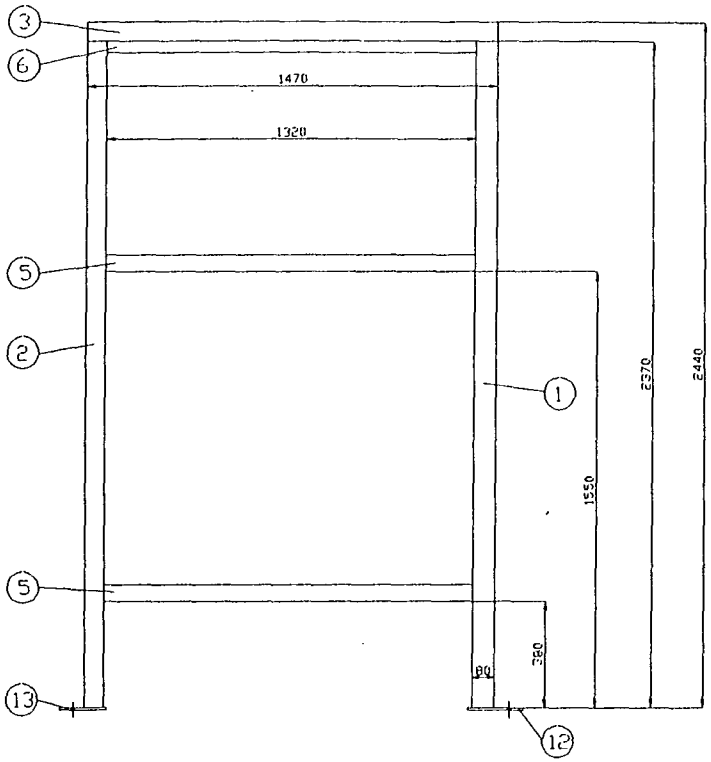
Laboratorium voor aanwending der brandstoffen en warmteoverdracht
Ottergemsesteenweg 711
9000 GENT
BELGIUM

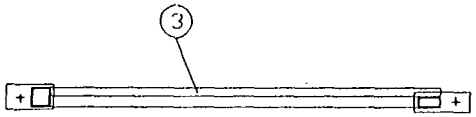
Scale :

Date 08/02/99

SBI-II: Improved SBI
Frame - Welded parts
Right part

Figure 3





Measure tolerance: ISO 2768-c

Ref	Description	Number
13	Steel plate 170x90x10	2
12	Steel plate 200x70x10	2
6	Tube profile 40x40x3 / l = 1320	1
5	Tube profile 60x40x4 / l = 1320	2
3	Tube profile 70x70x5 / l = 1470	2
2	Tube profile 70x70x5 / l = 2370	2
1	Tube profile 80x40x4 / l = 2370	2

Laboratorium voor aanwending der brandstoffen en warmteoverdracht

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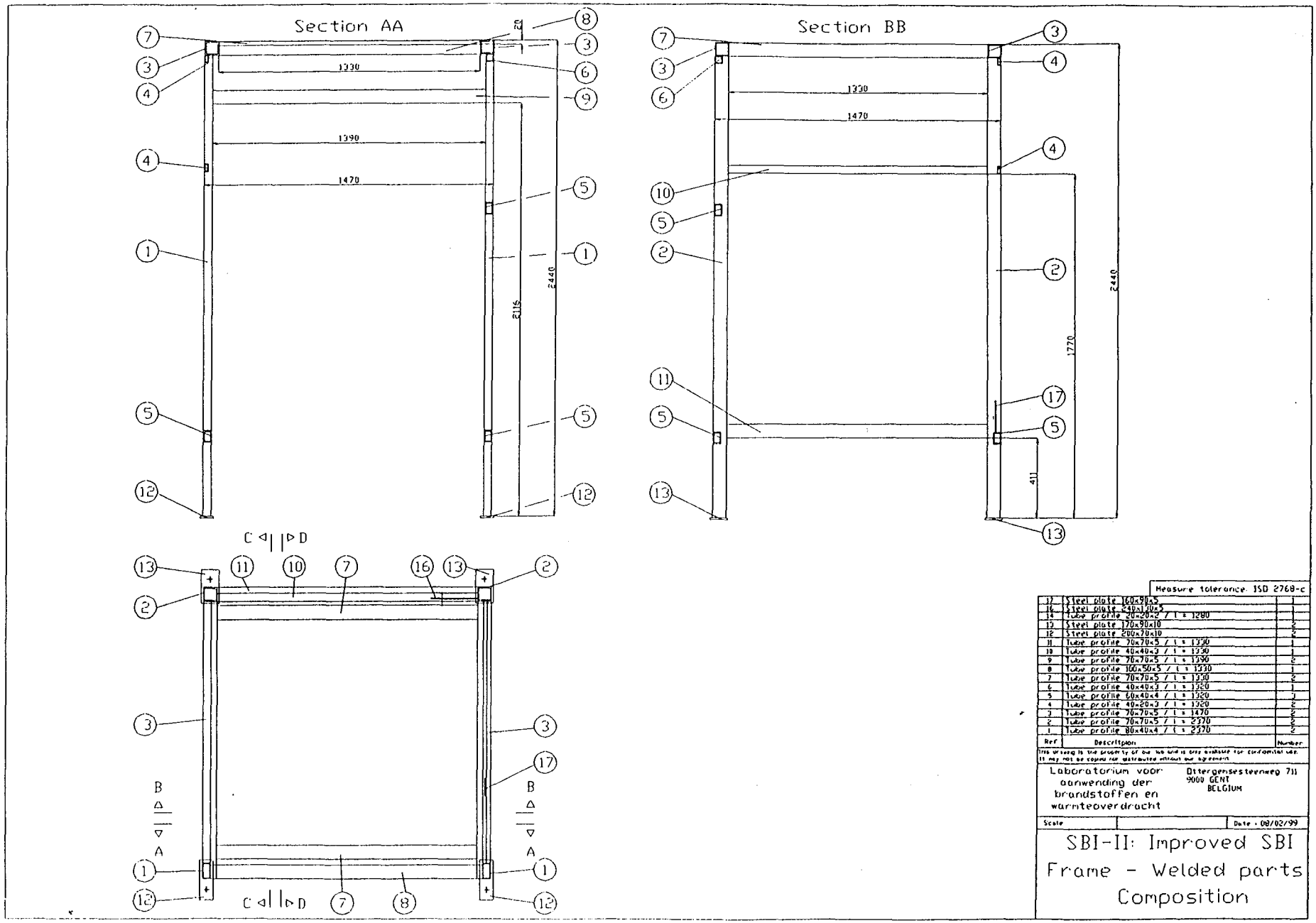
Scale :

Date : 08/02/99

SBI-II: Improved SBI

Frame - Welded parts

Left part


Section AA
Section BB
1330
1390
1470
2115
2440
1770
411
C
D
B
A
Measure tolerance: ISO 2768-c
17 Steel plate 160x90x5 1
16 Steel plate 240x120x5 1
14 Tube profile 20x20x2 / l = 1280 1
13 Steel plate 170x90x10 2
12 Steel plate 200x70x10 2
11 Tube profile 70x70x5 / l = 1330 1
10 Tube profile 40x40x3 / l = 1330 1
9 Tube profile 70x70x5 / l = 1390 2
8 Tube profile 100x50x5 / l = 1230 1
7 Tube profile 70x70x5 / l = 1230 2
6 Tube profile 40x40x3 / l = 1320 1
5 Tube profile 60x40x4 / l = 1320 3
4 Tube profile 40x20x3 / l = 1320 2
3 Tube profile 70x70x5 / l = 1470 2
2 Tube profile 70x70x5 / l = 2370 2
1 Tube profile 80x40x4 / l = 2370 2
Ref Description Number
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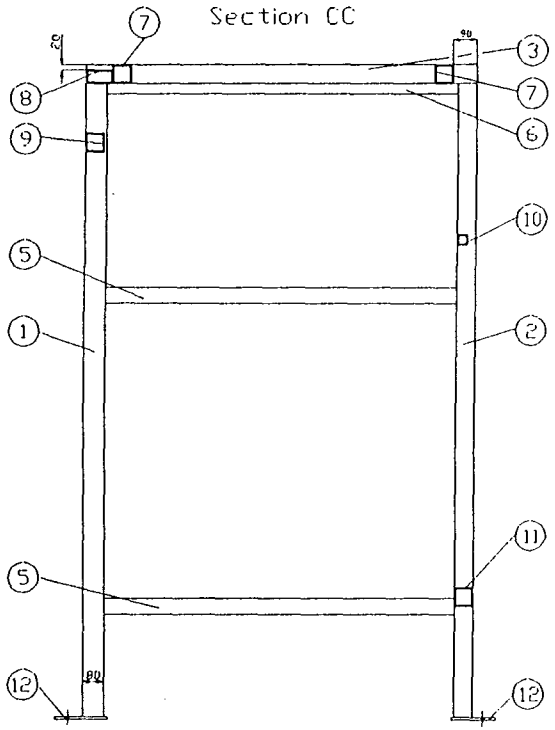
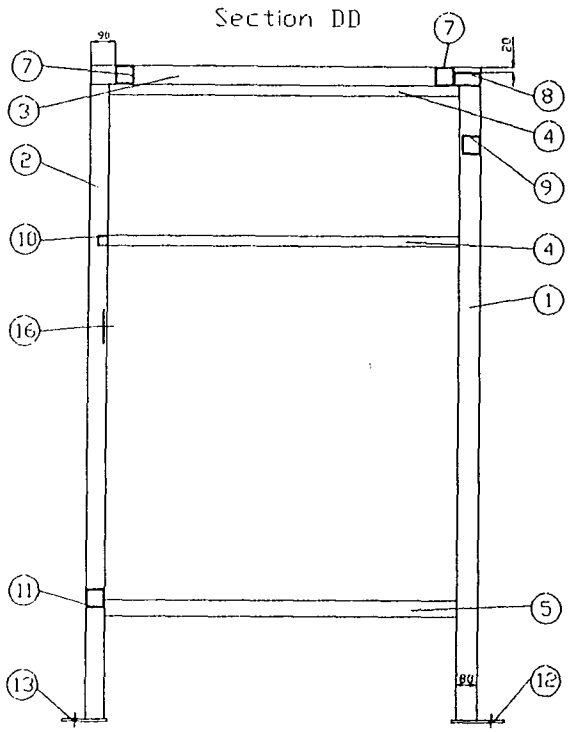
BELGIUM
Scale
Date : 08/02/99
SBI-II: Improved SBI Frame - Welded parts Composition

Figure 4

Figure 5





Measure tolerancel: ISO 2768-c

Ref	Description	Number
17	Steel plate 160x90x5	1
16	Steel plate 240-170x5	1
15	Tube profile 20x20x2 / l = 1280	1
14	Steel plate 170x90x10	2
13	Steel plate 200x70x10	2
11	Tube profile 70x70x5 / l = 1330	1
10	Tube profile 40x40x3 / l = 1330	1
9	Tube profile 70x70x5 / l = 1390	2
8	Tube profile 100x50x5 / l = 1330	1
7	Tube profile 70x70x5 / l = 1330	2
6	Tube profile 40x40x3 / l = 1320	1
5	Tube profile 60x40x4 / l = 1320	1
4	Tube profile 40x20x3 / l = 1320	2
3	Tube profile 70x70x5 / l = 1470	2
2	Tube profile 70x70x5 / l = 2370	2
1	Tube profile 80x40x4 / l = 2370	2

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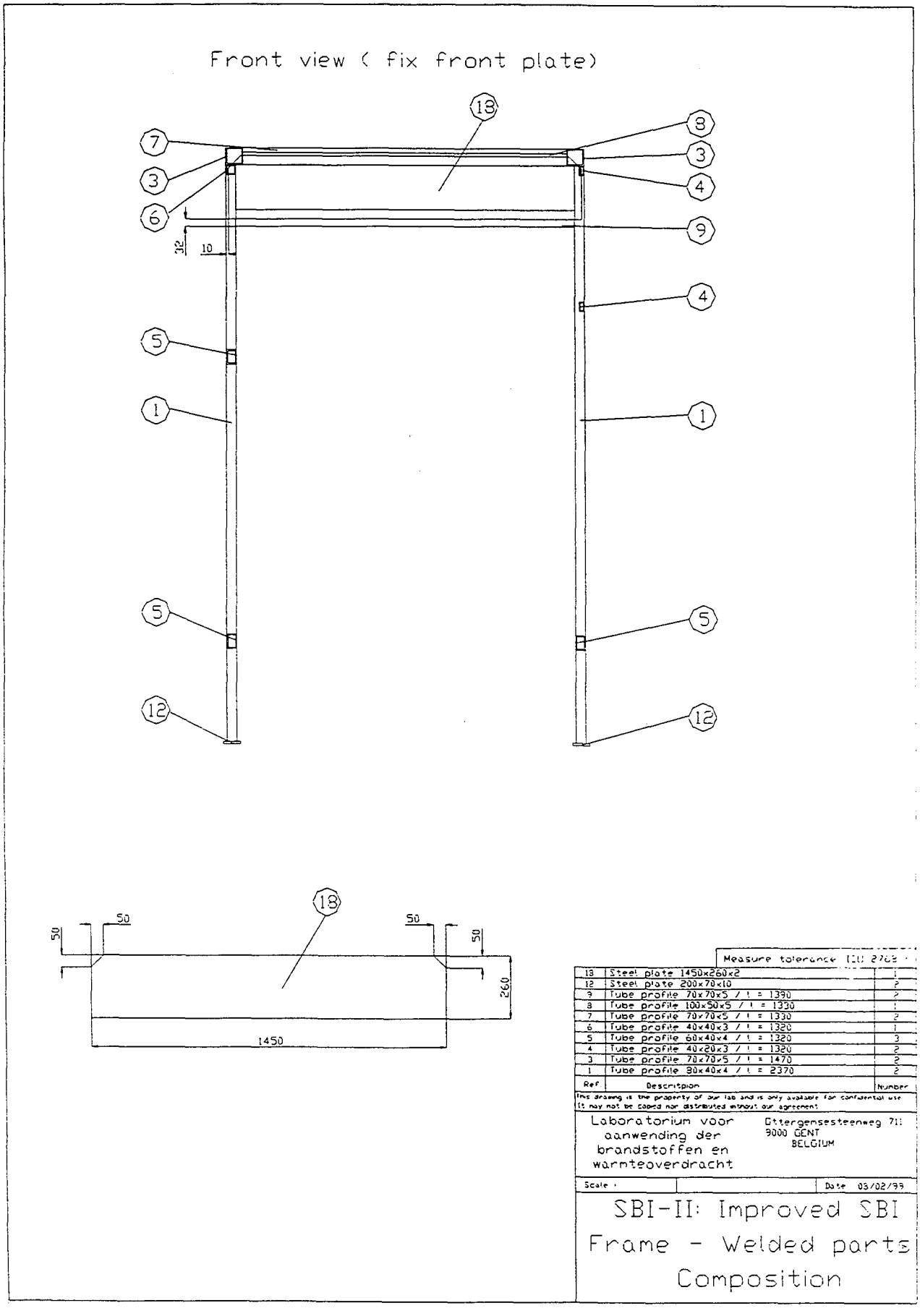
SBI-II: Improved SBI

Frame - Welded parts Composition


Front view (fix front plate)
18
7
3
6
8
3
4
9
4
5
1
1
5
12
5
12
12
10
50
50
50
50
260
1450
Measure tolerance ISO 2768
18 Steel plate 1450x260x2 1
12 Steel plate 200x70x10 2
9 Tube profile 70x70x5 / t = 1390 2
8 Tube profile 100x50x5 / t = 1330 1
7 Tube profile 70x70x5 / t = 1330 2
6 Tube profile 40x40x3 / t = 1320 1
5 Tube profile 60x40x4 / t = 1320 3
4 Tube profile 40x20x3 / t = 1320 2
3 Tube profile 70x70x5 / t = 1470 2
1 Tube profile 80x40x4 / t = 2370 2
Ref Description Number
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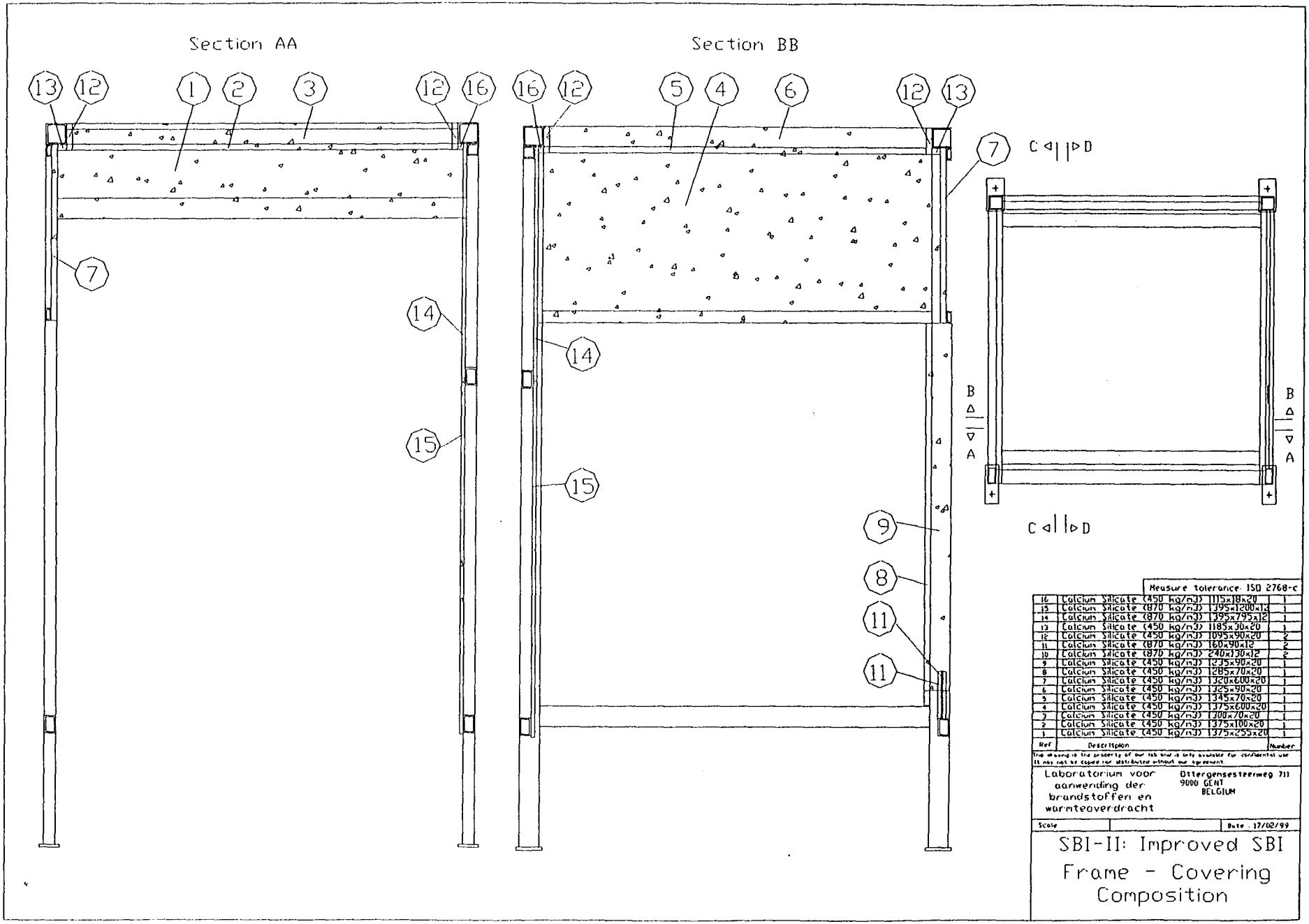
Scale -
Date 03/02/99
SBI-II: Improved SBI
Frame - Welded parts
Composition

Figure 6


Section AA
Section BB
Measure tolerance ISO 2768-c
16 Calcium Silicate (450 kg/m3) 1115x18x20 1
15 Calcium Silicate (870 kg/m3) 1395x1200x12 1
14 Calcium Silicate (870 kg/m3) 1395x795x12 1
13 Calcium Silicate (450 kg/m3) 1185x30x20 1
12 Calcium Silicate (450 kg/m3) 1095x90x20 2
11 Calcium Silicate (870 kg/m3) 160x90x12 2
10 Calcium Silicate (870 kg/m3) 240x30x12 2
9 Calcium Silicate (450 kg/m3) 1235x90x20 1
8 Calcium Silicate (450 kg/m3) 1285x70x20 1
7 Calcium Silicate (450 kg/m3) 1320x600x20 1
6 Calcium Silicate (450 kg/m3) 1325x90x20 1
5 Calcium Silicate (450 kg/m3) 1345x70x20 1
4 Calcium Silicate (450 kg/m3) 1375x600x20 1
3 Calcium Silicate (450 kg/m3) 1300x70x20 1
2 Calcium Silicate (450 kg/m3) 1375x100x20 1
1 Calcium Silicate (450 kg/m3) 1375x255x20 1
Ref Description Number
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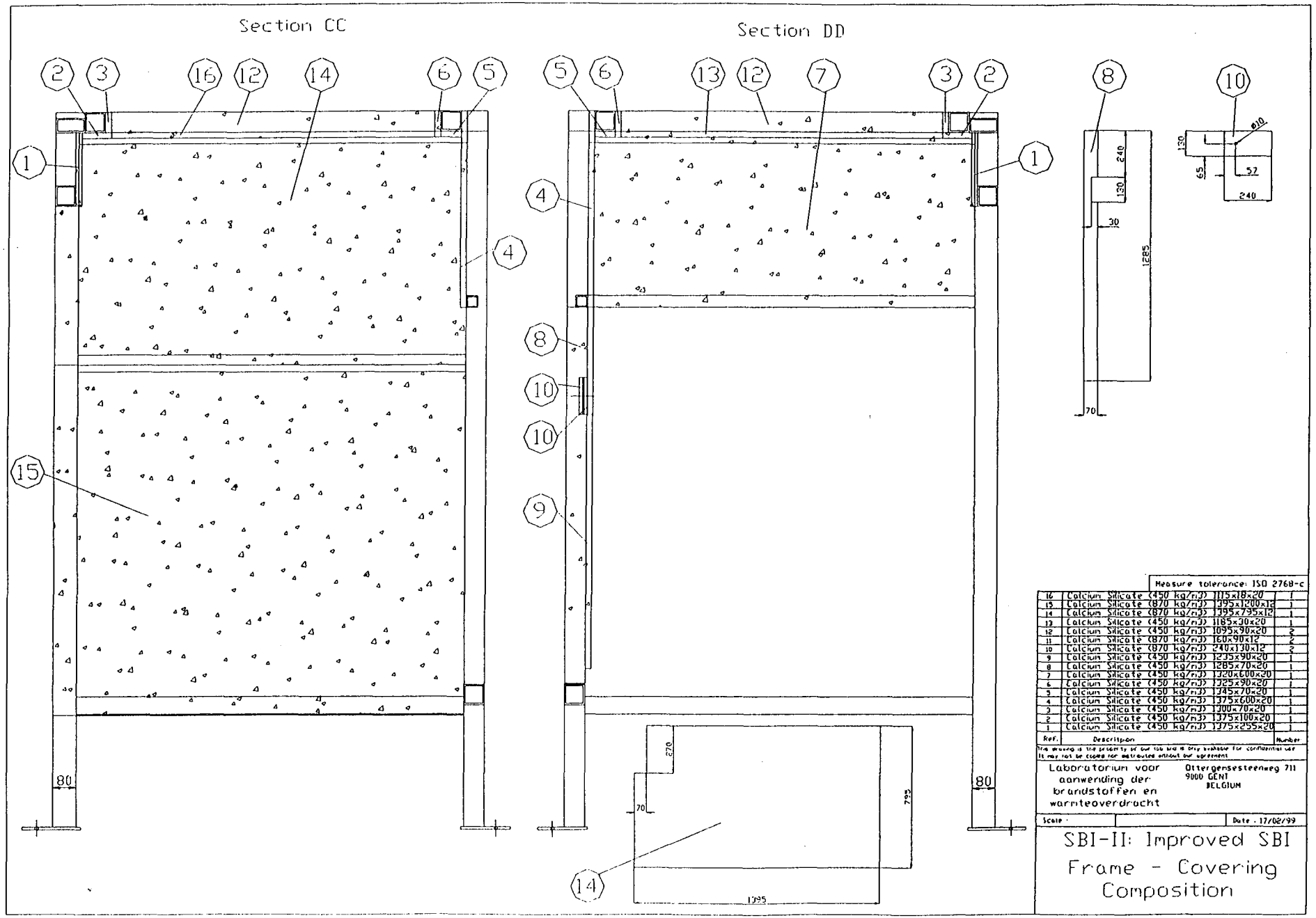
Scale
Date : 17/02/99
SBI-II: Improved SBI
Frame - Covering
Composition

Figure 7

Figure 8


Section CC
Section DD
Measure tolerance: ISO 2768-c
16 Calcium Silicate (450 kg/m3) 1115x18x20 1
15 Calcium Silicate (870 kg/m3) 1395x1200x12 1
14 Calcium Silicate (870 kg/m3) 1395x795x12 1
13 Calcium Silicate (450 kg/m3) 1185x30x20 1
12 Calcium Silicate (450 kg/m3) 1095x90x20 2
11 Calcium Silicate (870 kg/m3) 160x90x12 2
10 Calcium Silicate (870 kg/m3) 240x130x12 2
9 Calcium Silicate (450 kg/m3) 1275x90x20 1
8 Calcium Silicate (450 kg/m3) 1285x70x20 1
7 Calcium Silicate (450 kg/m3) 1320x600x20 1
6 Calcium Silicate (450 kg/m3) 1325x90x20 1
5 Calcium Silicate (450 kg/m3) 1345x70x20 1
4 Calcium Silicate (450 kg/m3) 1375x600x20 1
3 Calcium Silicate (450 kg/m3) 1300x70x20 1
2 Calcium Silicate (450 kg/m3) 1375x100x20 1
1 Calcium Silicate (450 kg/m3) 1375x255x20 1
Ref. Description Number
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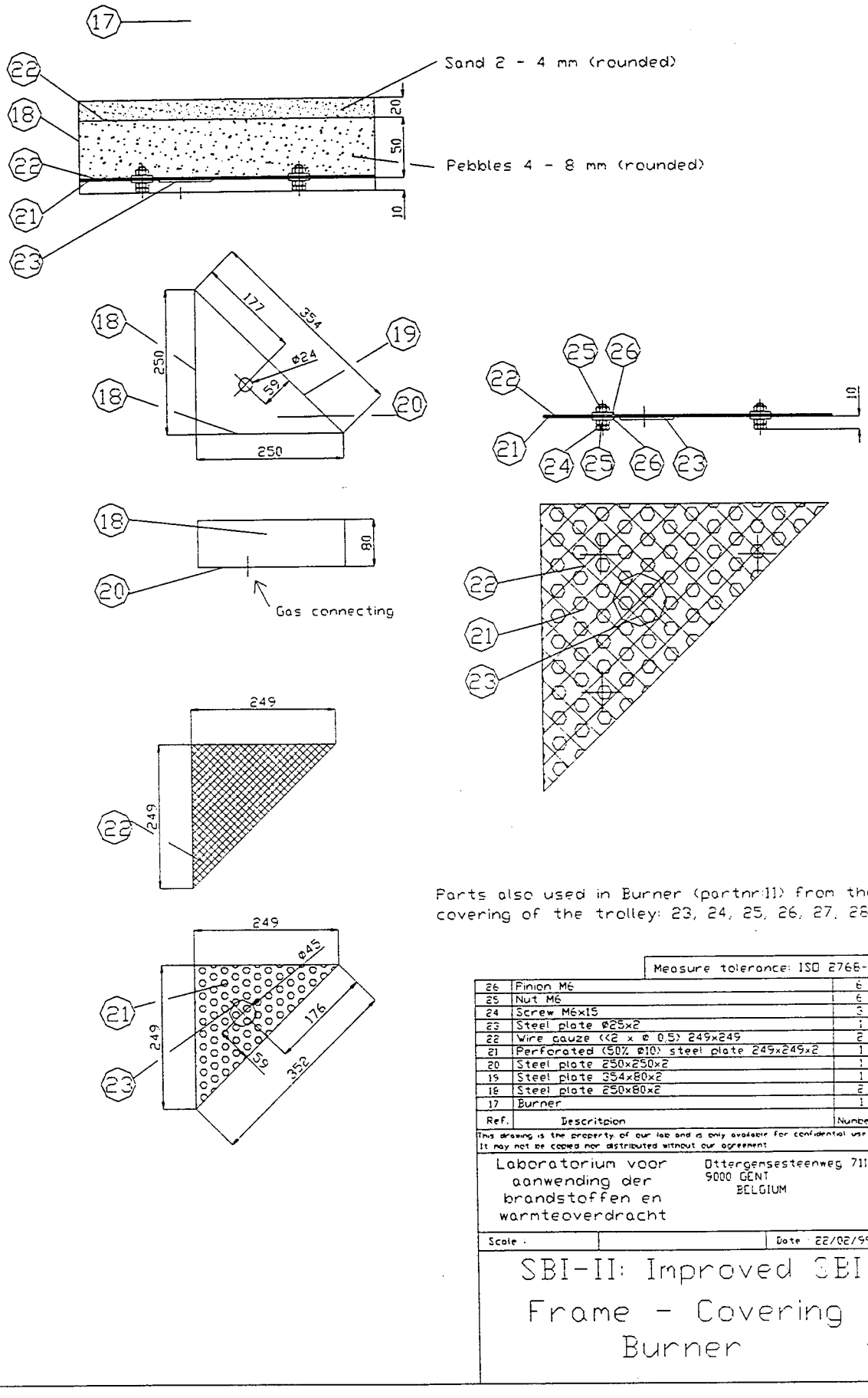
Scale :
Date : 17/02/99
SBI-II: Improved SBI Frame - Covering Composition



Parts also used in Burner (partnr:11) from the covering of the trolley: 23, 24, 25, 26, 27, 28

Measure tolerance: ISO 2768-c

Ref.	Description	Number
26	Pinion M6	6
25	Nut M6	6
24	Screw M6x15	3
23	Steel plate ø25x2	1
22	Wire gauze (<2 x ø 0.5) 249x249	2
21	Perforated (50% ø10) steel plate 249x249x2	1
20	Steel plate 250x250x2	1
19	Steel plate 354x80x2	1
18	Steel plate 250x80x2	2
17	Burner	1

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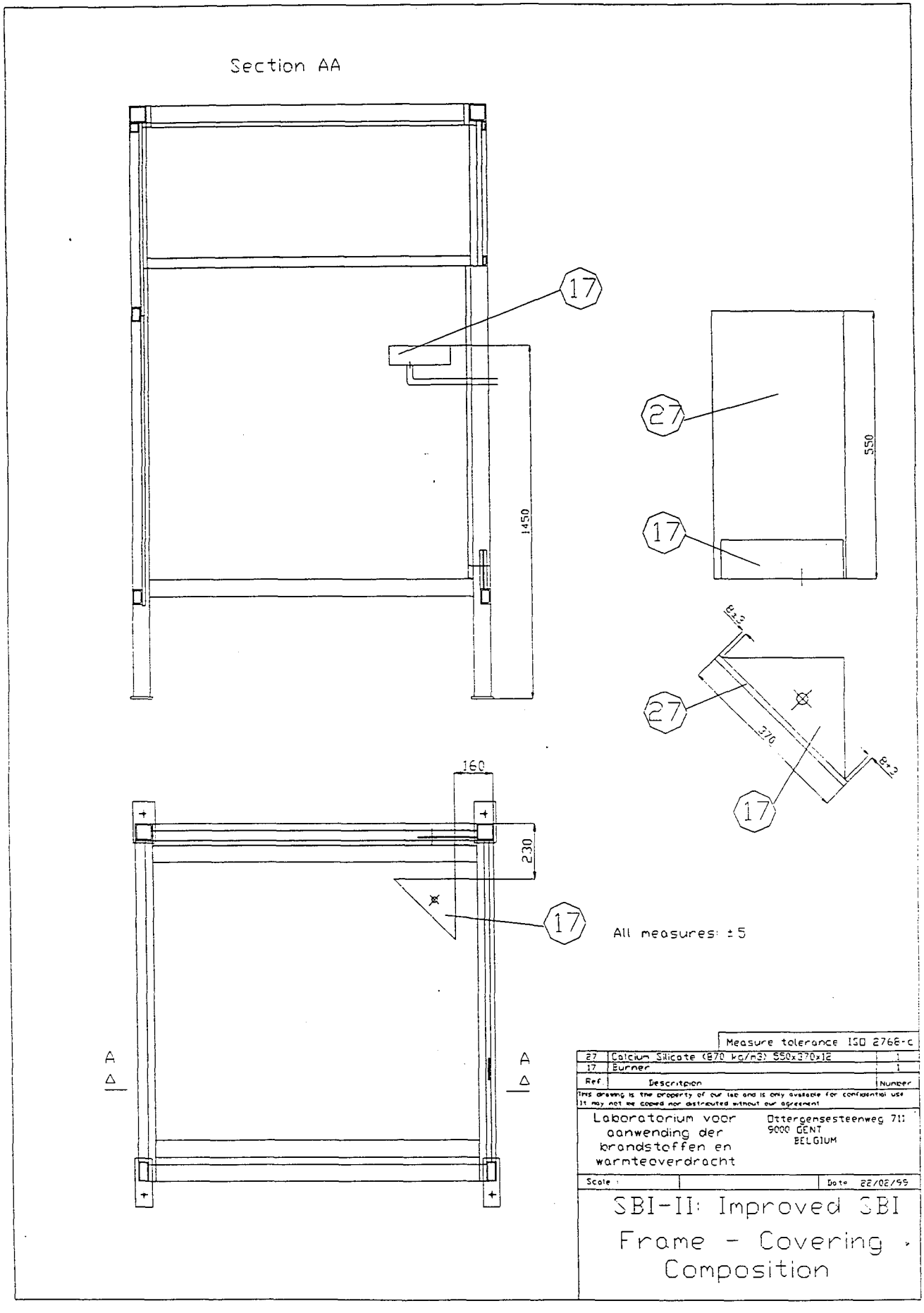
Scale :

Date : 22/02/99

SBI-II: Improved SBI Frame - Covering Burner

Figure 9


Section AA
17
1450
27
550
17
6±2
27
370
6±2
17
160
230
17
All measures: ± 5
A
A
Measure tolerance ISO 2768-c
27 Calcium Silicate (870 kg/m3) 550x370x12 1
17 Burner 1
Ref. Description Number
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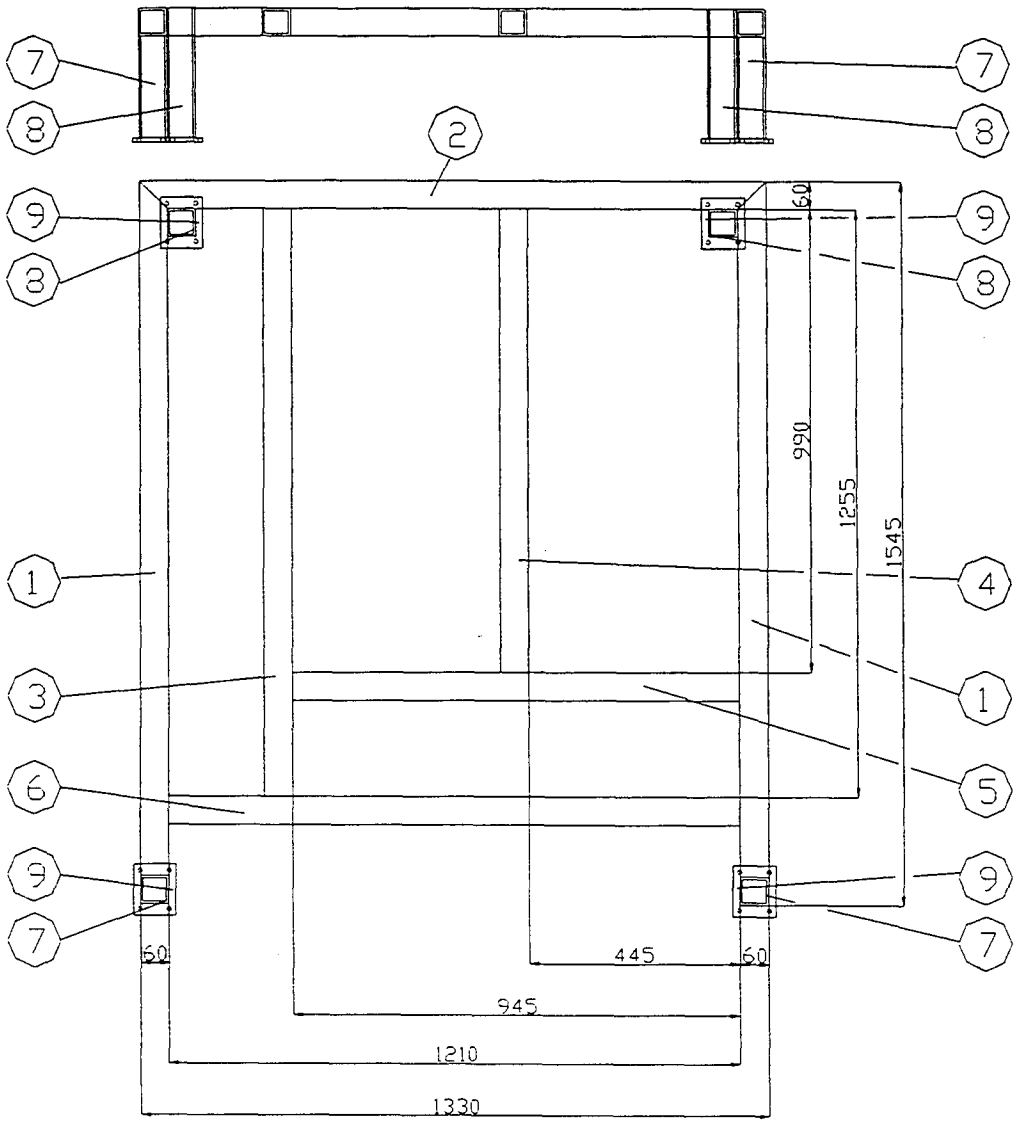
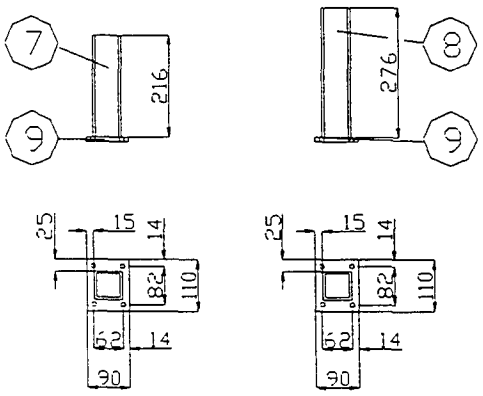
Scale :
Date 22/02/99
SBI-II: Improved SBI
Frame - Covering
Composition

Figure 10





Measure tolerance ISO 2768-c

Ref.	Description	Number
9	Steel plate 110x90x10	4
8	Tube profile 60x60x5 / ! = 276	2
7	Tube profile 60x60x5 / ! = 216	2
6	Tube profile 60x60x5 / ! = 1210	1
5	Tube profile 60x60x5 / ! = 945	1
4	Tube profile 60x60x5 / ! = 990	1
3	Tube profile 60x60x5 / ! = 1255	1
2	Tube profile 60x60x5 / ! = 1330	1
1	Tube profile 60x60x5 / ! = 1545	2

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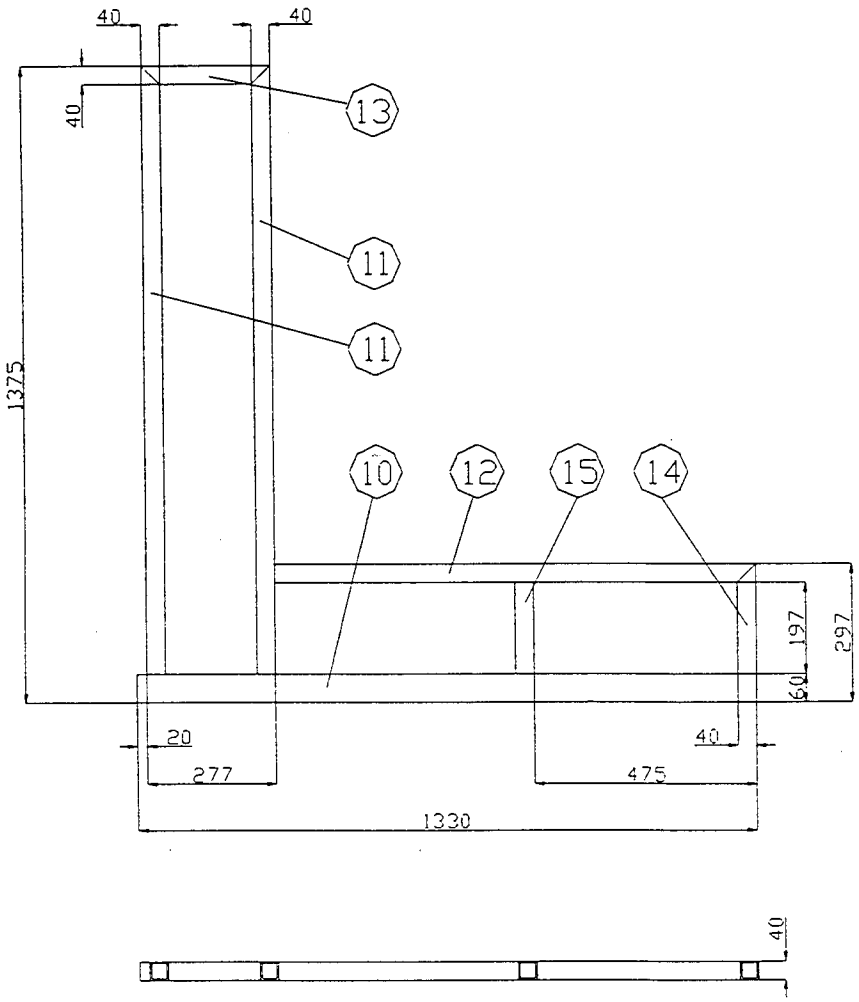
Scale : | Date 11/02/99

SBI-II: Improved SBI Trolley - Welded parts Bottom

Figure 11



Measure tolerance: ISO 2768-c

Ref.	Description	Number
15	Tube profile 40x40x4 / l = 197	1
14	Tube profile 40x40x4 / l = 237	1
13	Tube profile 40x40x4 / l = 277	1
12	Tube profile 40x40x4 / l = 1033	1
11	Tube profile 40x40x4 / l = 1315	2
10	Tube profile 60x40x4 / l = 1330	1

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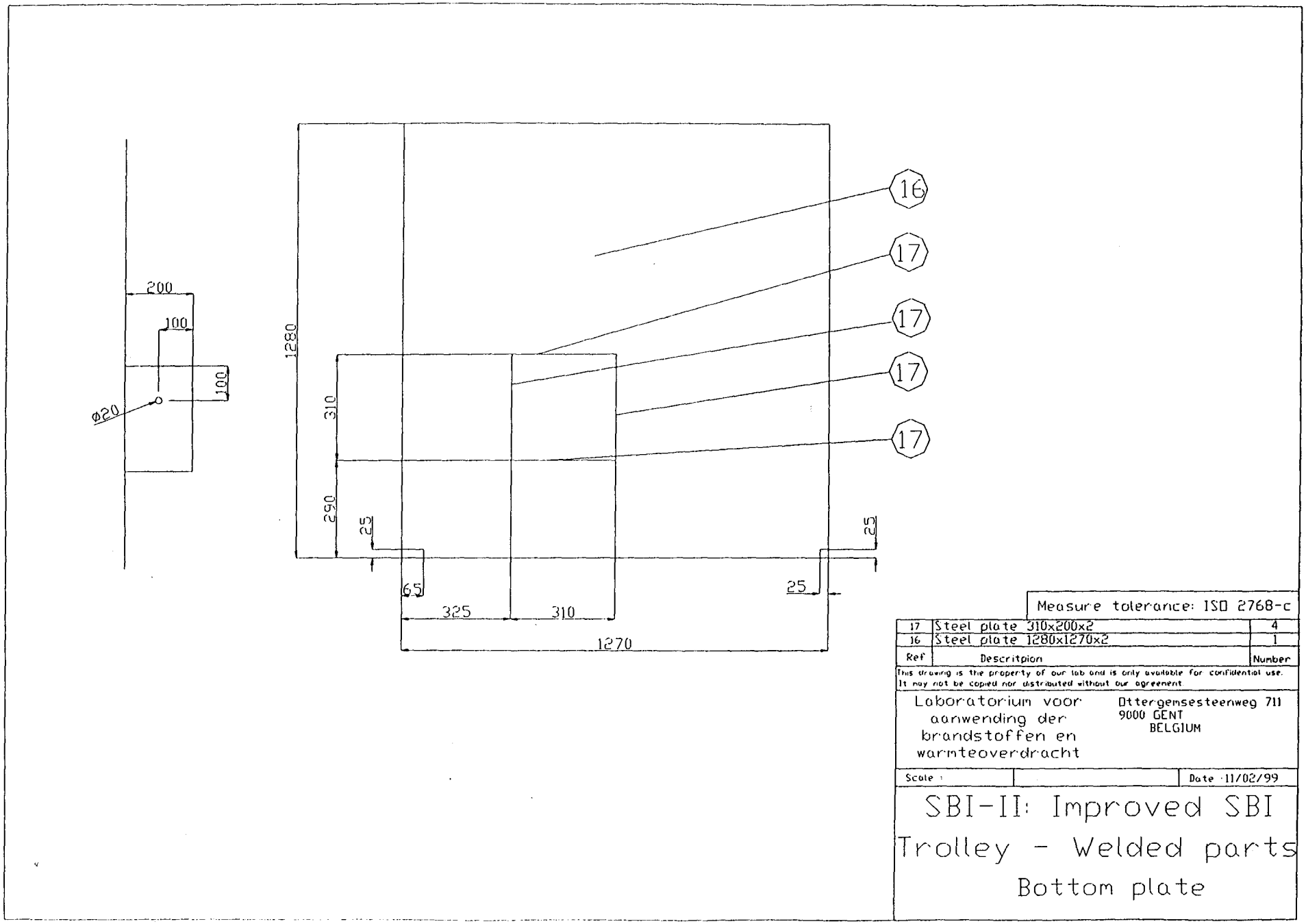
SBI-II: Improved SBI Trolley - Welded parts

Upper frame

Figure 12



Measure tolerance: ISO 2768-c

Ref	Description	Number
17	Steel plate 310x200x2	4
16	Steel plate 1280x1270x2	1

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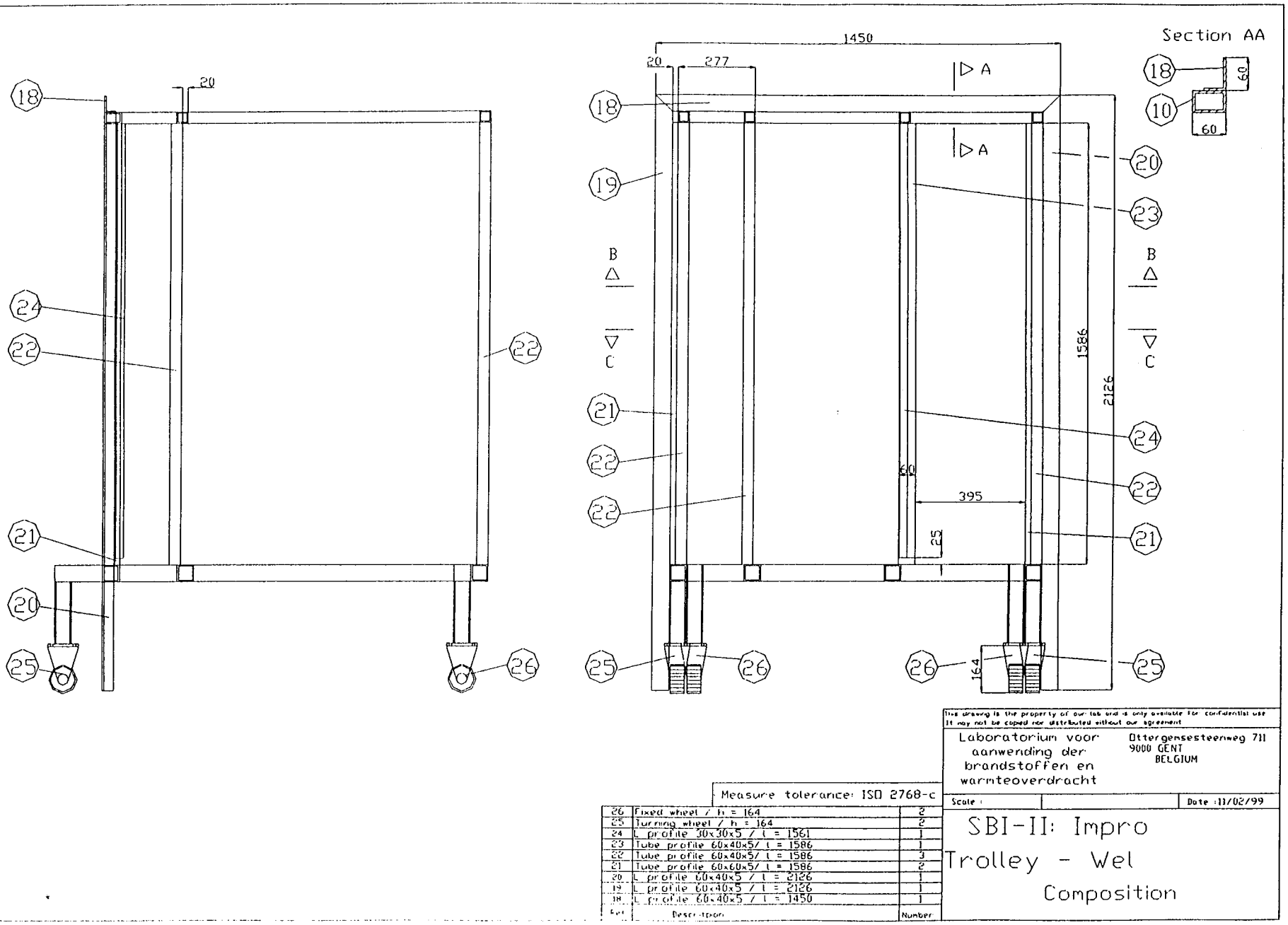
SBI-II: Improved SBI Trolley - Welded parts

Bottom plate

Figure 13


Section AA
1450
277
20
60
1586
2126
395
25
164
Measure tolerance: ISO 2768-c
26 Fixed wheel / h = 164 2
25 Turning wheel / h = 164 2
24 L profile 30x30x5 / L = 1561 1
23 Tube profile 60x40x5/ L = 1586 1
22 Tube profile 60x40x5/ L = 1586 3
21 Tube profile 60x60x5/ L = 1586 2
20 L profile 60x40x5 / L = 2126 1
19 L profile 60x40x5 / L = 2126 1
18 L profile 60x40x5 / L = 1450 1
Part Description Number
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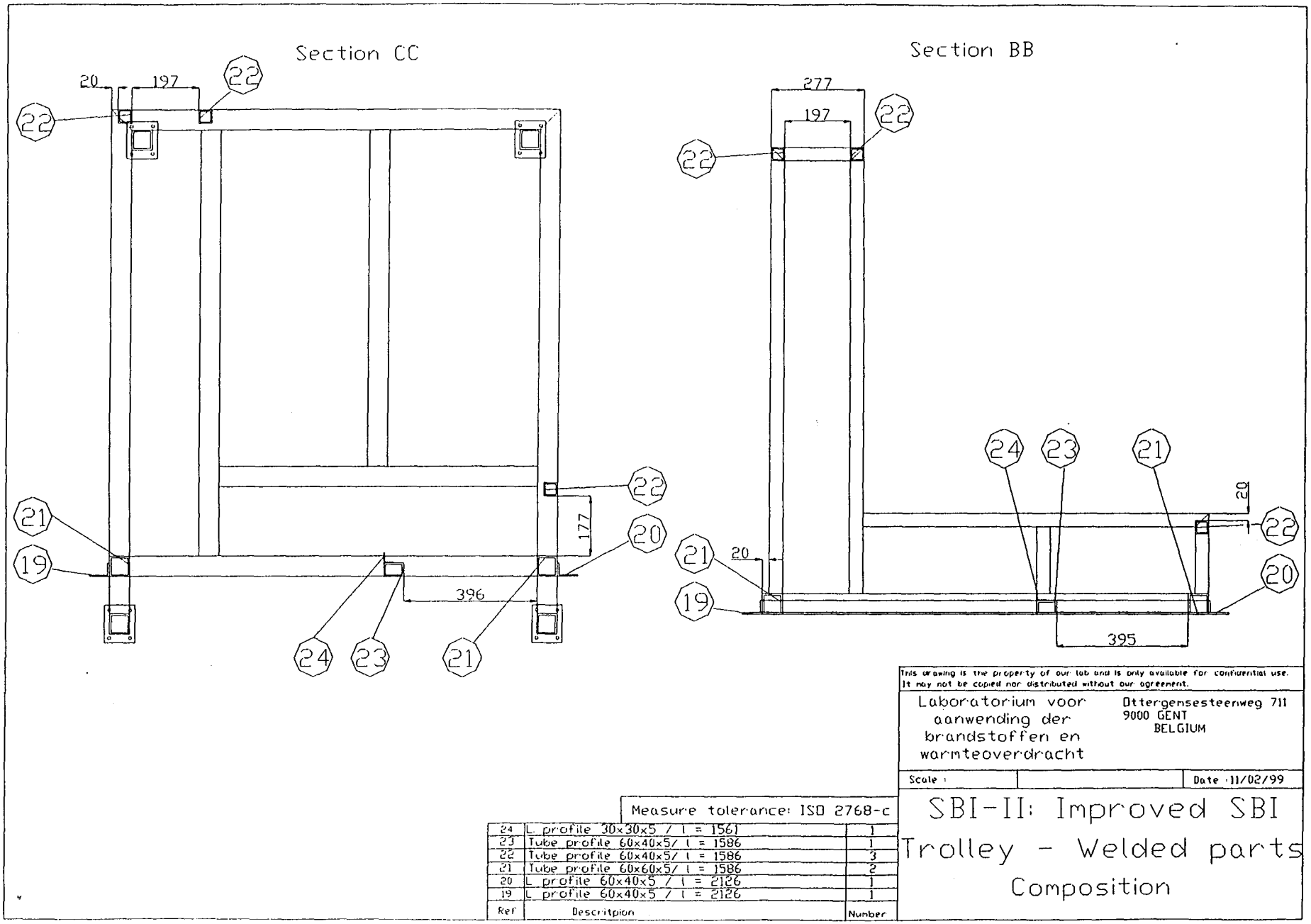
9000 GENT
BELGIUM
Scale :
Date :11/02/99
SBI-II: Impro
Trolley - Wel
Composition

Figure 14


Section CC
Section BB
20
197
22
277
177
396
395
24
23
21
19
Measure tolerance: ISO 2768-c
24 L profile 30x30x5 / l = 1561 1
23 Tube profile 60x40x5/ l = 1586 1
22 Tube profile 60x40x5/ l = 1586 3
21 Tube profile 60x60x5/ l = 1586 2
20 L profile 60x40x5 / l = 2126 1
19 L profile 60x40x5 / l = 2126 1
Ref Descritpion Number
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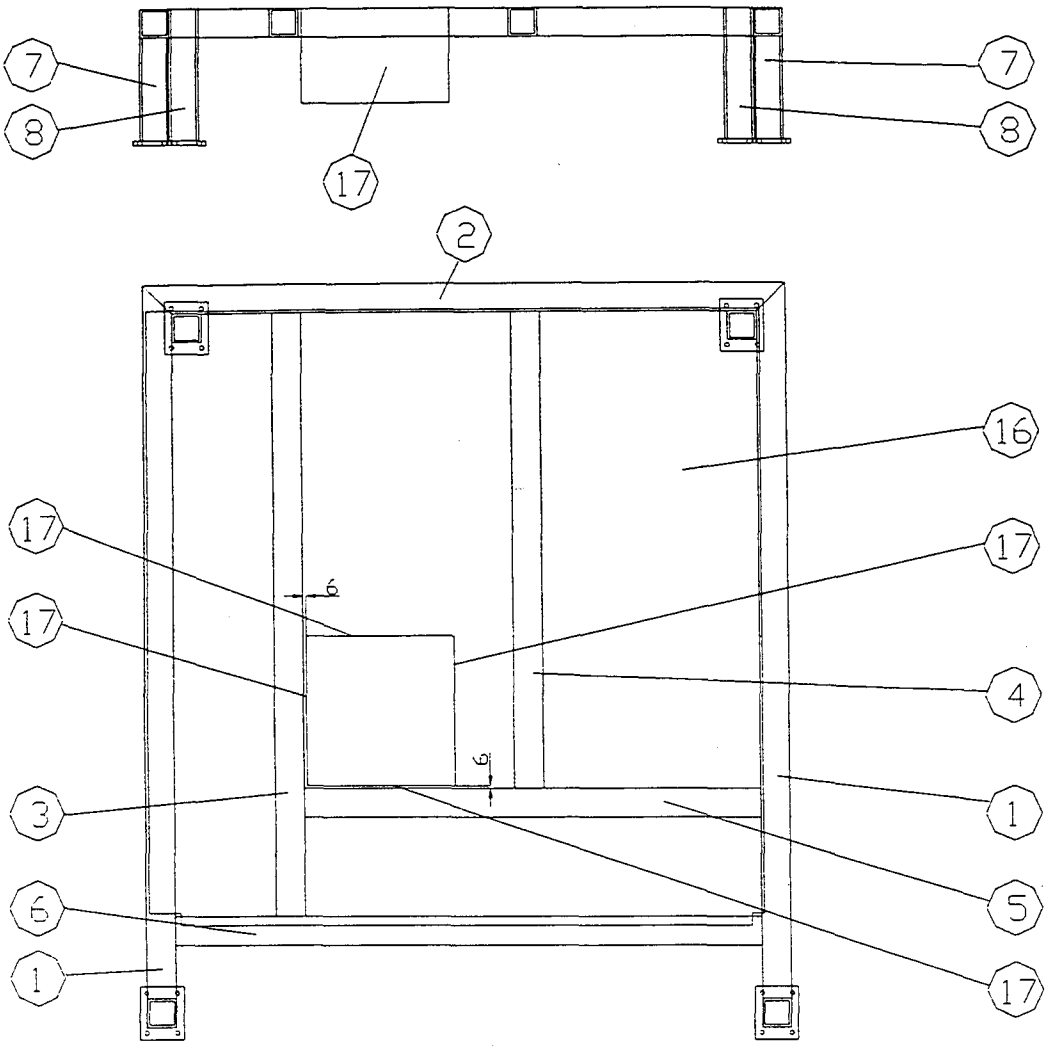
Scale :
Date :11/02/99
SBI-II: Improved SBI
Trolley - Welded parts
Composition

Figure 15



Measure tolerance: ISO 2768-c

Ref.	Descritpion	Number
17	Steel plate 310x200x2	4
16	Steel plate 1280x1270x2	1
8	Tube profile 60x60x5 / ! = 276	2
7	Tube profile 60x60x5 / ! = 216	2
6	Tube profile 60x60x5 / ! = 1210	1
5	Tube profile 60x60x5 / ! = 945	1
4	Tube profile 60x60x5 / ! = 990	1
3	Tube profile 60x60x5 / ! = 1255	1
2	Tube profile 60x60x5 / ! = 1330	1
1	Tube profile 60x60x5 / ! = 1545	2

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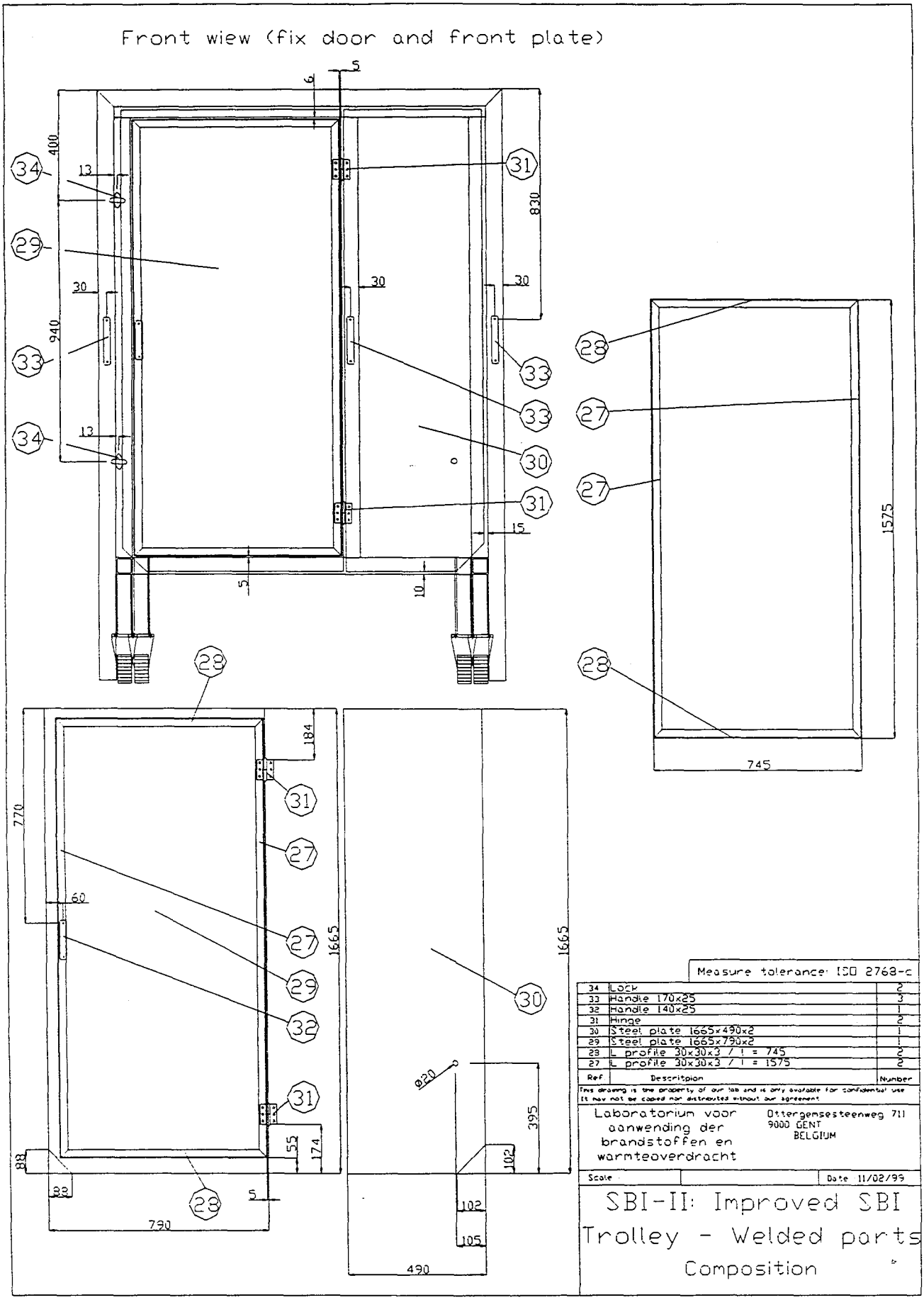
SBI-II: Improved SBI Trolley - Welded parts Composition

Figure 16


Front wiew (fix door and front plate)
Measure tolerance: ISO 2768-c
34 Lock 2
33 Handle 170x25 3
32 Handle 140x25 1
31 Hinge 2
30 Steel plate 1665x490x2 1
29 Steel plate 1665x790x2 1
28 L profile 30x30x3 / 1 = 745 2
27 L profile 30x30x3 / 1 = 1575 2
Ref Description Number
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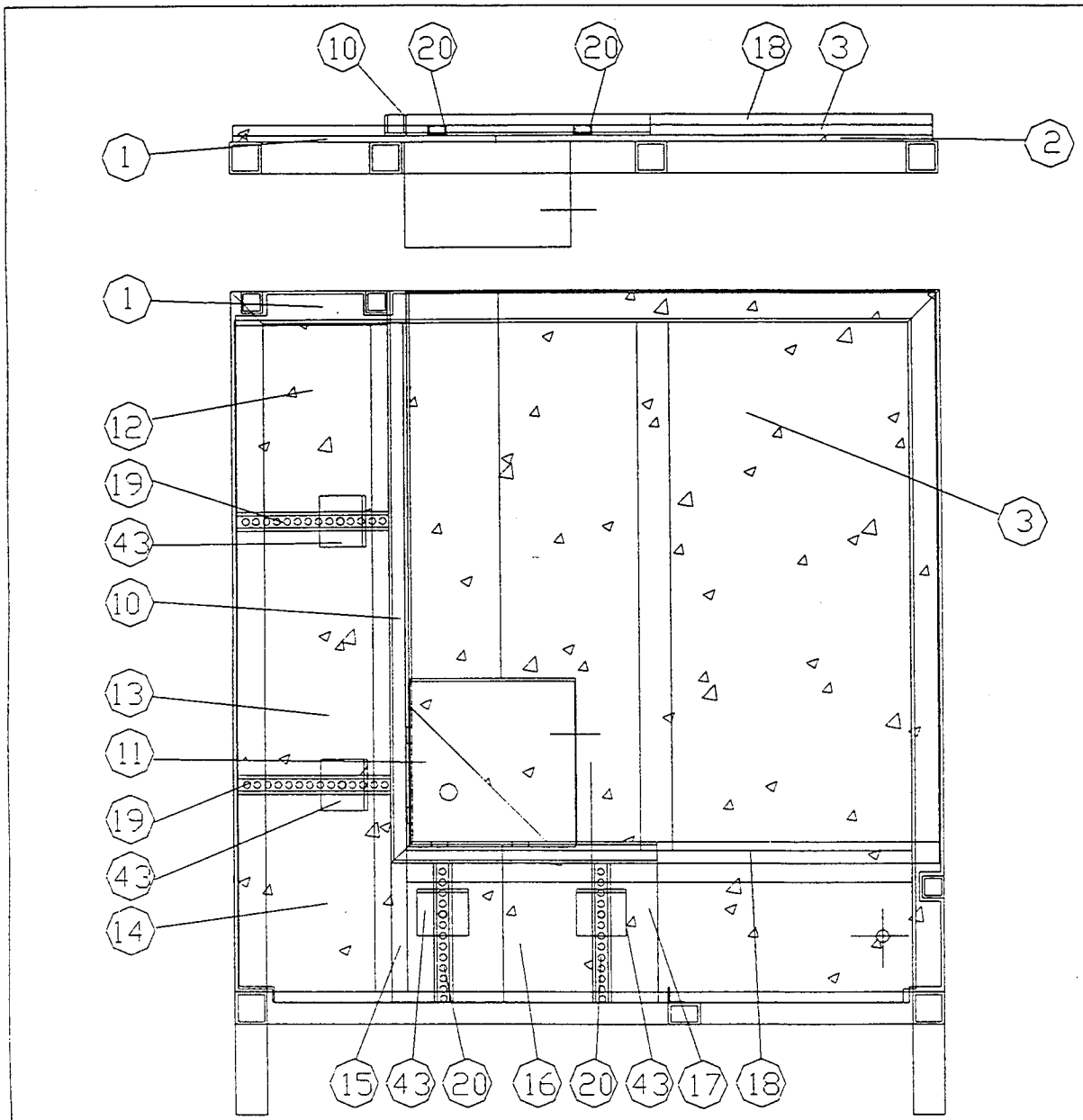
Scale
Date 11/02/99
SBI-II: Improved SBI
Trolley - Welded parts
Composition

Figure 17



Ref.	Descritpion	Number
43	L Profile 55x55x4 / ! = 60	8
18	Calcium Silicate (450 kg/m3) 527x40x20	1
17	Calcium Silicate (450 kg/m3) 86x257x20	1
16	Calcium Silicate (450 kg/m3) 262x257x20	1
15	Calcium Silicate (450 kg/m3) 80x257x20	1
14	Calcium Silicate (450 kg/m3) 390x293x20	1
13	Calcium Silicate (450 kg/m3) 460x293x20	1
12	Calcium Silicate (450 kg/m3) 350x293x20	1
11	Burner	1
10	Welded U profiles	1
3	Calcium Silicate (450 kg/m3) 1033x990x20	1
2	Calcium Silicate (870 kg/m3) 1330x820x12	1
1	Calcium Silicate (870 kg/m3) 1330x495x12	1

Measure tolerance: ISO 2768-c

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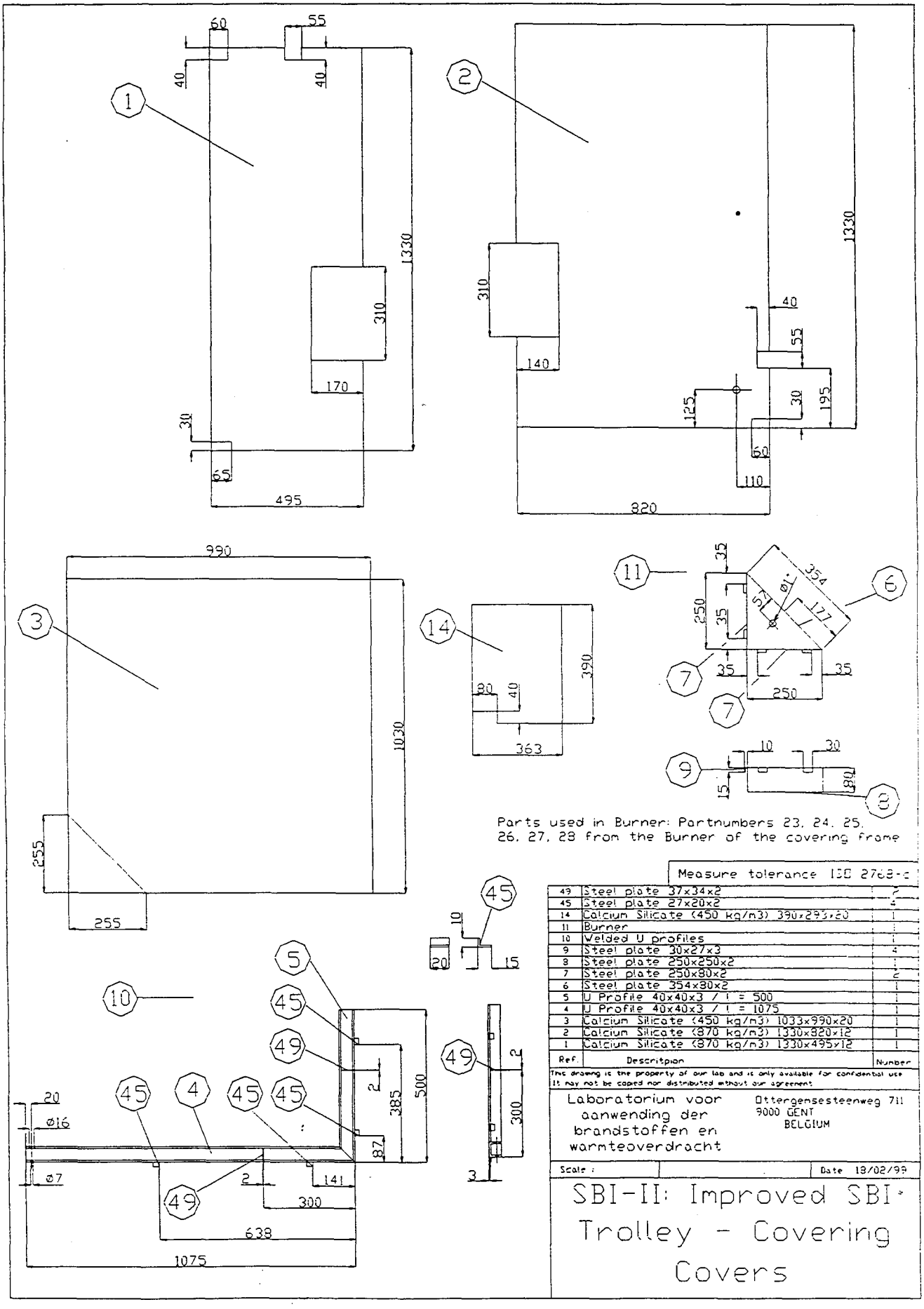
Scale :

Date : 18/02/99

SBI-II: Improved SBI Trolley - Covering Composition

Figure 18


Parts used in Burner: Partnumbers 23, 24, 25, 26, 27, 28 from the Burner of the covering frame
Measure tolerance ISO 2768-c
49 Steel plate 37x34x2 2
45 Steel plate 27x20x2 4
14 Calcium Silicate (450 kg/m3) 390x293x20 1
11 Burner 1
10 Welded U profiles 1
9 Steel plate 30x27x3 4
8 Steel plate 250x250x2 1
7 Steel plate 250x80x2 2
6 Steel plate 354x80x2 1
5 U Profile 40x40x3 / 1 = 500 1
4 U Profile 40x40x3 / 1 = 1075 1
3 Calcium Silicate (450 kg/m3) 1033x990x20 1
2 Calcium Silicate (870 kg/m3) 1330x820x12 1
1 Calcium Silicate (870 kg/m3) 1330x495x12 1
Ref. Description Number
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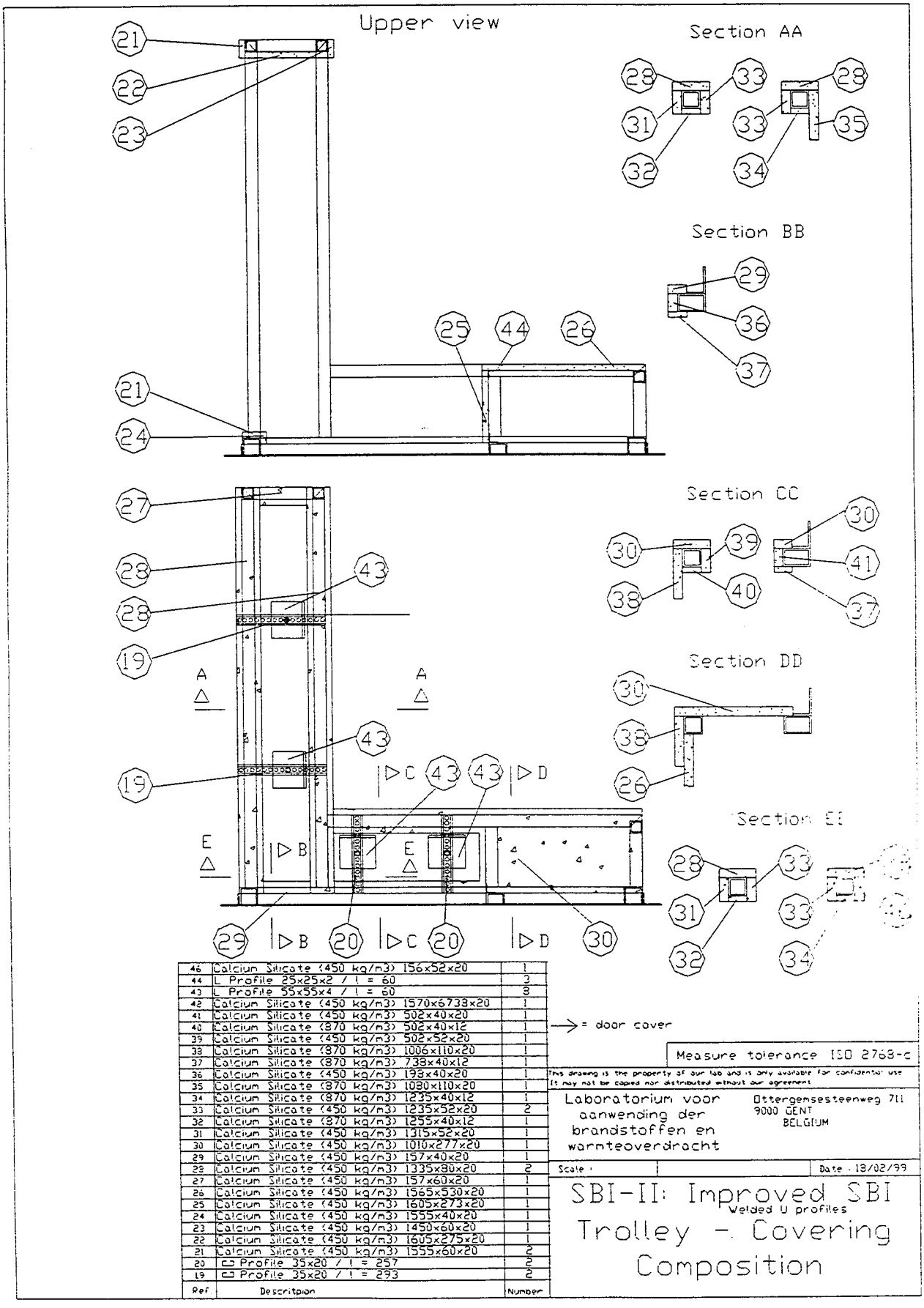
Scale :
Date 18/02/99
SBI-II: Improved SBI* Trolley - Covering Covers

Figure 19



Ref	Description	Number
46	Calcium Silicate (450 kg/m3) 156x52x20	1
44	L Profile 25x25x2 / l = 60	3
43	L Profile 55x55x4 / l = 60	8
42	Calcium Silicate (450 kg/m3) 1570x6738x20	1
41	Calcium Silicate (450 kg/m3) 502x40x20	1
40	Calcium Silicate (870 kg/m3) 502x40x12	1
39	Calcium Silicate (450 kg/m3) 502x52x20	1
38	Calcium Silicate (870 kg/m3) 1006x110x20	1
37	Calcium Silicate (870 kg/m3) 738x40x12	1
36	Calcium Silicate (450 kg/m3) 198x40x20	1
35	Calcium Silicate (870 kg/m3) 1080x110x20	1
34	Calcium Silicate (870 kg/m3) 1235x40x12	1
33	Calcium Silicate (450 kg/m3) 1235x52x20	2
32	Calcium Silicate (870 kg/m3) 1255x40x12	1
31	Calcium Silicate (450 kg/m3) 1315x52x20	1
30	Calcium Silicate (450 kg/m3) 1010x277x20	1
29	Calcium Silicate (450 kg/m3) 157x40x20	1
28	Calcium Silicate (450 kg/m3) 1335x80x20	2
27	Calcium Silicate (450 kg/m3) 157x60x20	1
26	Calcium Silicate (450 kg/m3) 1565x530x20	1
25	Calcium Silicate (450 kg/m3) 1605x273x20	1
24	Calcium Silicate (450 kg/m3) 1555x40x20	1
23	Calcium Silicate (450 kg/m3) 1450x60x20	1
22	Calcium Silicate (450 kg/m3) 1605x275x20	1
21	Calcium Silicate (450 kg/m3) 1555x60x20	2
20	⊏ Profile 35x20 / l = 257	2
19	⊏ Profile 35x20 / l = 293	2

→ = door cover

Measure tolerance ISO 2768-c

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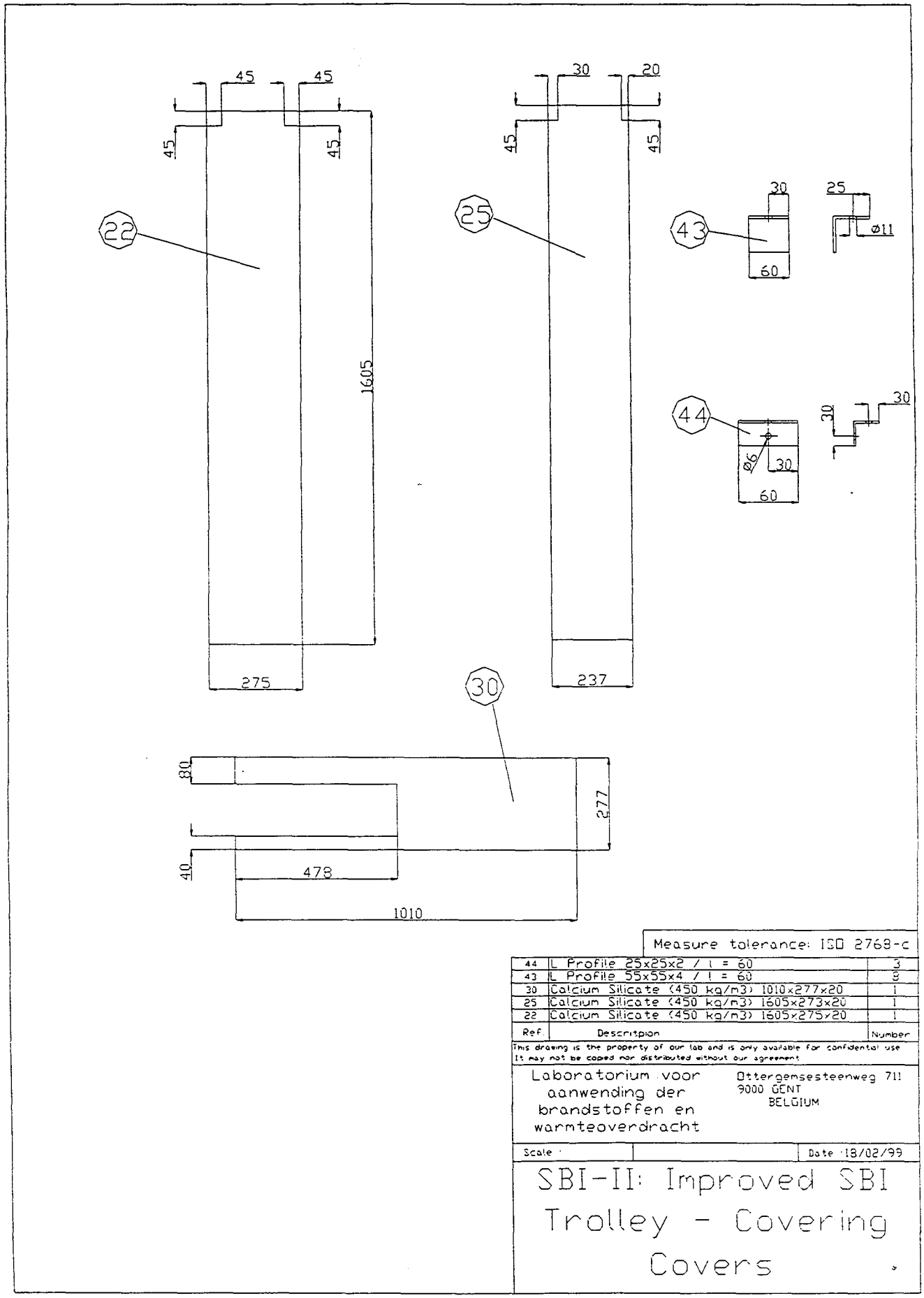
BELGIUM

Scale :

Date : 18/02/99

SBI-II: Improved SBI
Welded U profiles
Trolley - Covering Composition

Figure 20



Measure tolerance: ISO 2768-c

Ref.	Description	Number
44	L Profile 25x25x2 / l = 60	3
43	L Profile 55x55x4 / l = 60	8
30	Calcium Silicate (450 kg/m3) 1010x277x20	1
25	Calcium Silicate (450 kg/m3) 1605x273x20	1
22	Calcium Silicate (450 kg/m3) 1605x275x20	1

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9000 GENT
BELGIUM

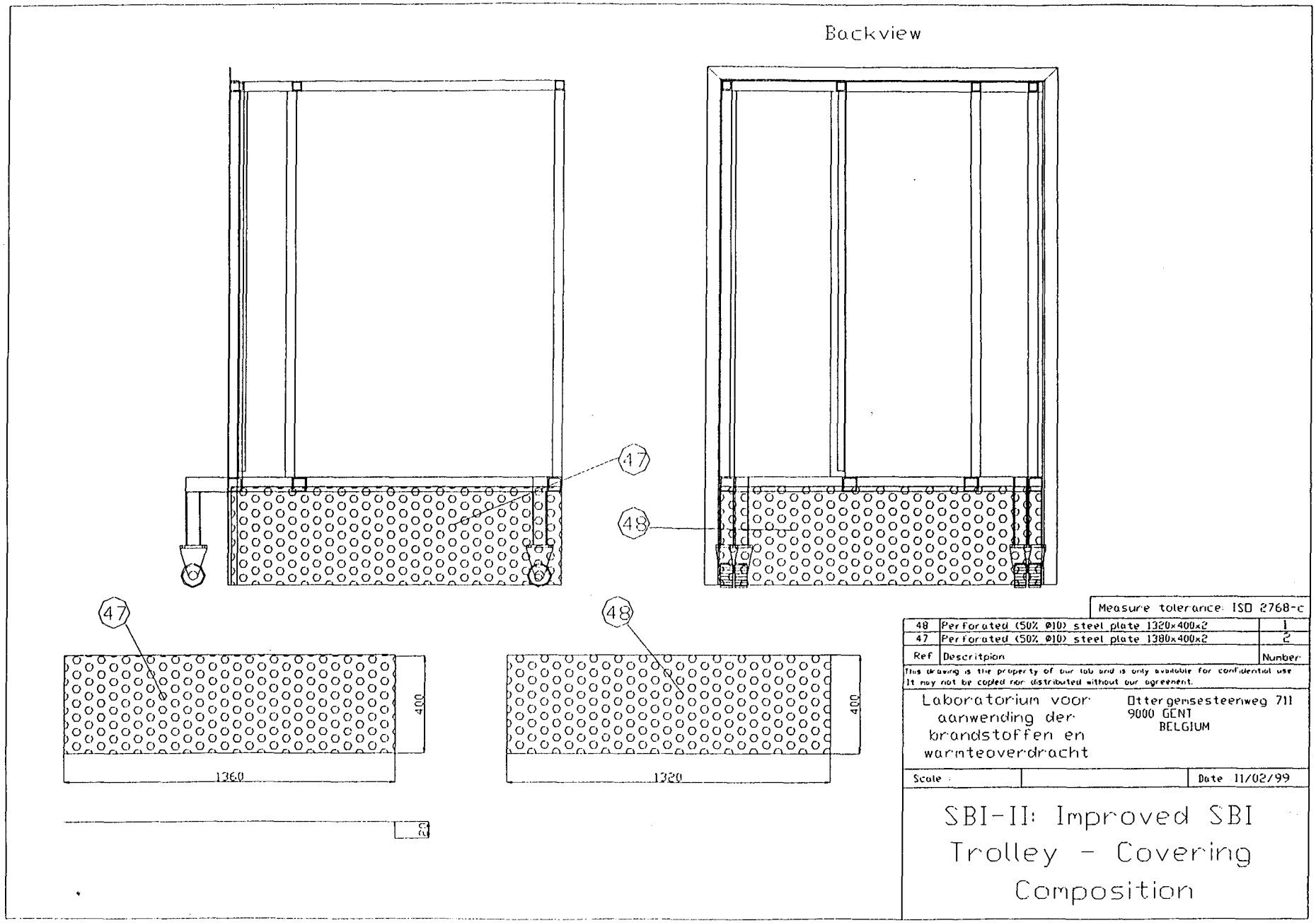
Scale :

Date : 18/02/99

SBI-II: Improved SBI Trolley - Covering Covers

Figure 21

Figure 22



Measure tolerance: ISO 2768-c

Ref	Description	Number
48	Perforated (50% Ø10) steel plate 1320x400x2	1
47	Perforated (50% Ø10) steel plate 1380x400x2	2

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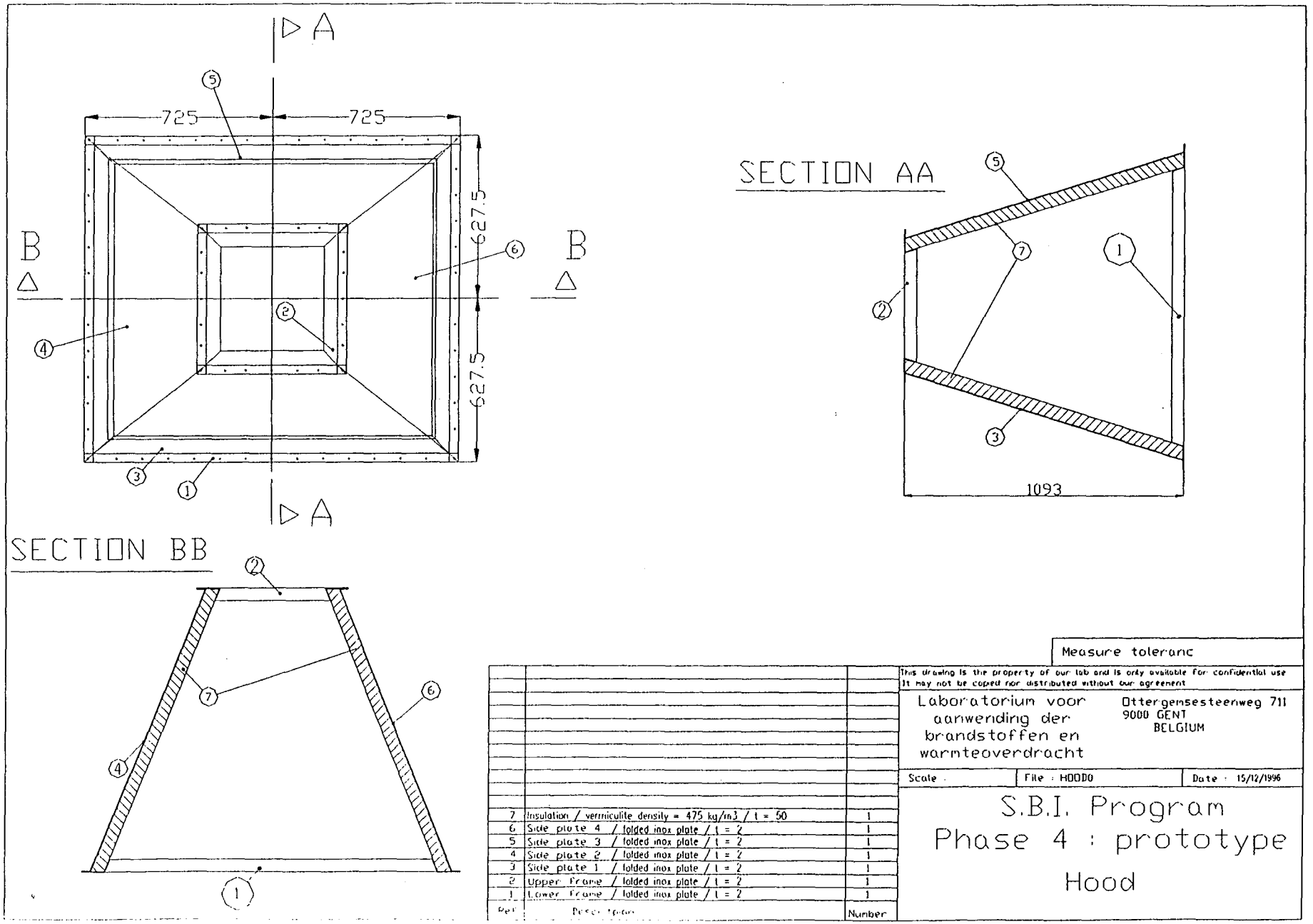
Scale:

Date: 11/02/99

SBI-II: Improved SBI Trolley - Covering Composition


A
B
725
725
627.5
627.5
SECTION AA
1093
SECTION BB
Measure tolerance
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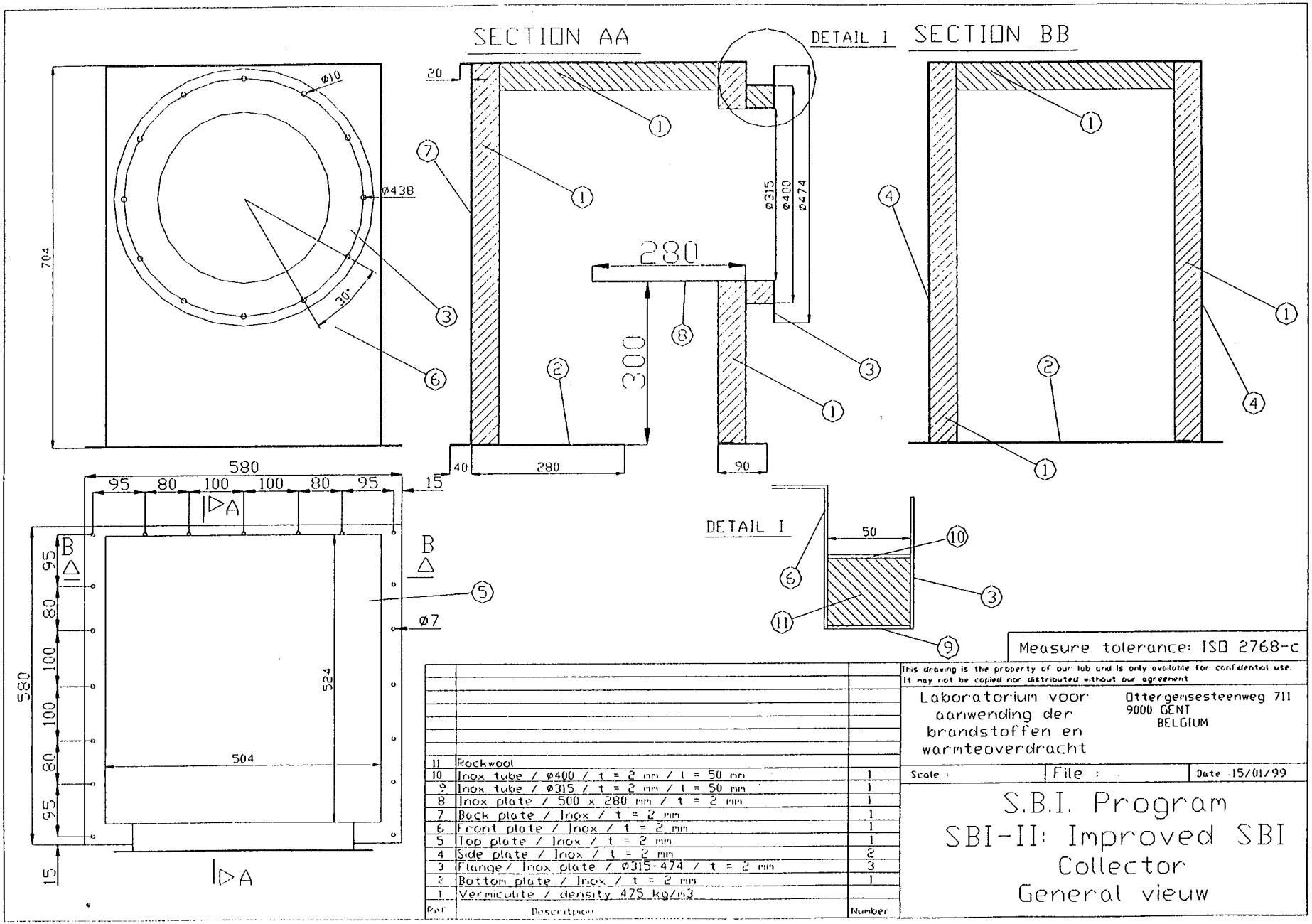
Ottergemsesteenweg 711
9000 GENT
BELGIUM
Scale :
File : HOOD0
Date : 15/12/1996
S.B.I. Program
Phase 4 : prototype
Hood
7 Insulation / vermiculite density = 475 kg/m3 / t = 50 1
6 Side plate 4 / folded inox plate / t = 2 1
5 Side plate 3 / folded inox plate / t = 2 1
4 Side plate 2 / folded inox plate / t = 2 1
3 Side plate 1 / folded inox plate / t = 2 1
2 Upper Frame / folded inox plate / t = 2 1
1 Lower Frame / folded inox plate / t = 2 1
Ref
Number

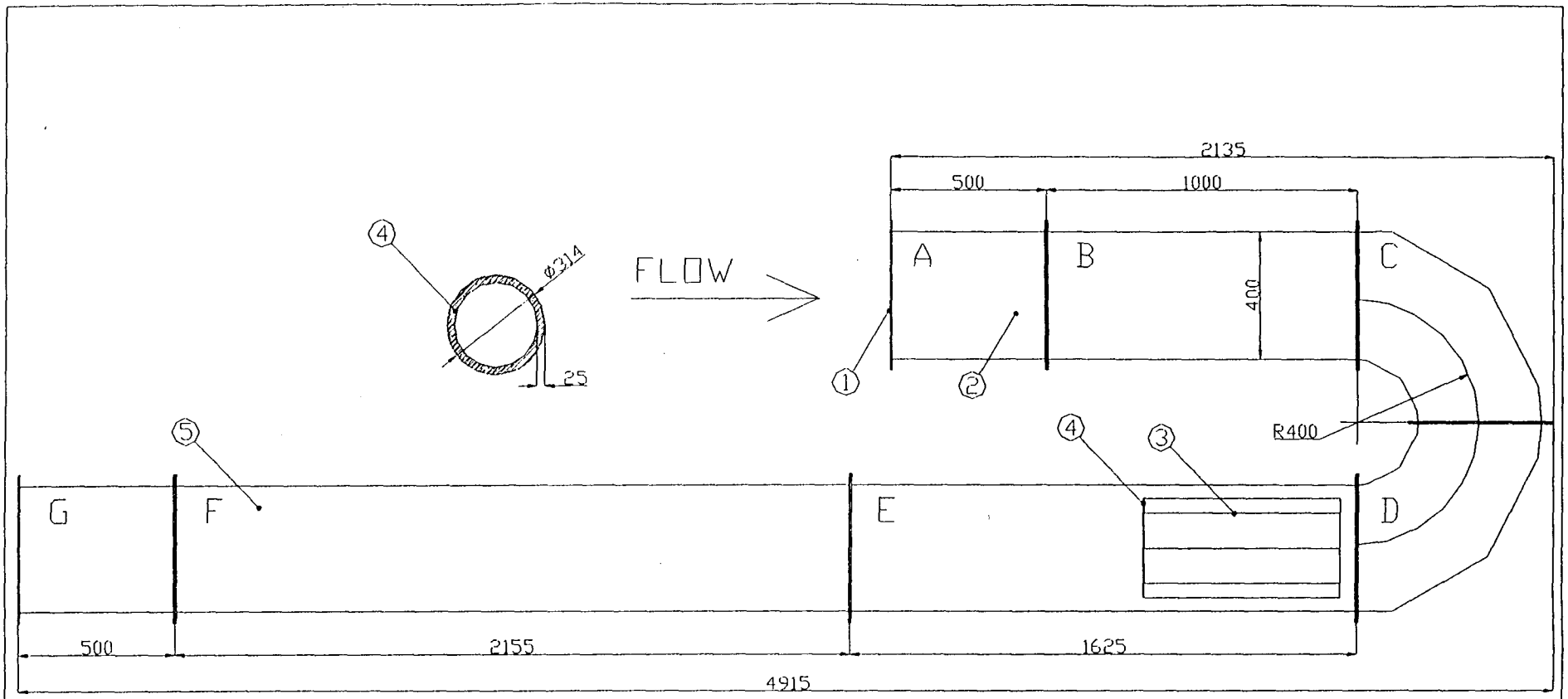
Figure 23



Ref	Description	Number
11	Rockwool	
10	Inox tube / ø400 / t = 2 mm / l = 50 mm	1
9	Inox tube / ø315 / t = 2 mm / l = 50 mm	1
8	Inox plate / 500 x 280 mm / t = 2 mm	1
7	Back plate / Inox / t = 2 mm	1
6	Front plate / Inox / t = 2 mm	1
5	Top plate / Inox / t = 2 mm	1
4	Side plate / Inox / t = 2 mm	2
3	Flange / Inox plate / ø315-474 / t = 2 mm	3
2	Bottom plate / Inox / t = 2 mm	1
1	Vermiculite / density 475 kg/m3	

Figure 24

Figure 25



Ref	Description	Number
5	Measurement section (dp, Temp., Smoke, Sample)	
4	Reduction ring (Stainless steel, Ø314 / thickness 2mm)	
3	Guide vanes	
2	Temperature measurement	
1	Connection to collector and hood	

Measure tolerance: ISO 2768-c

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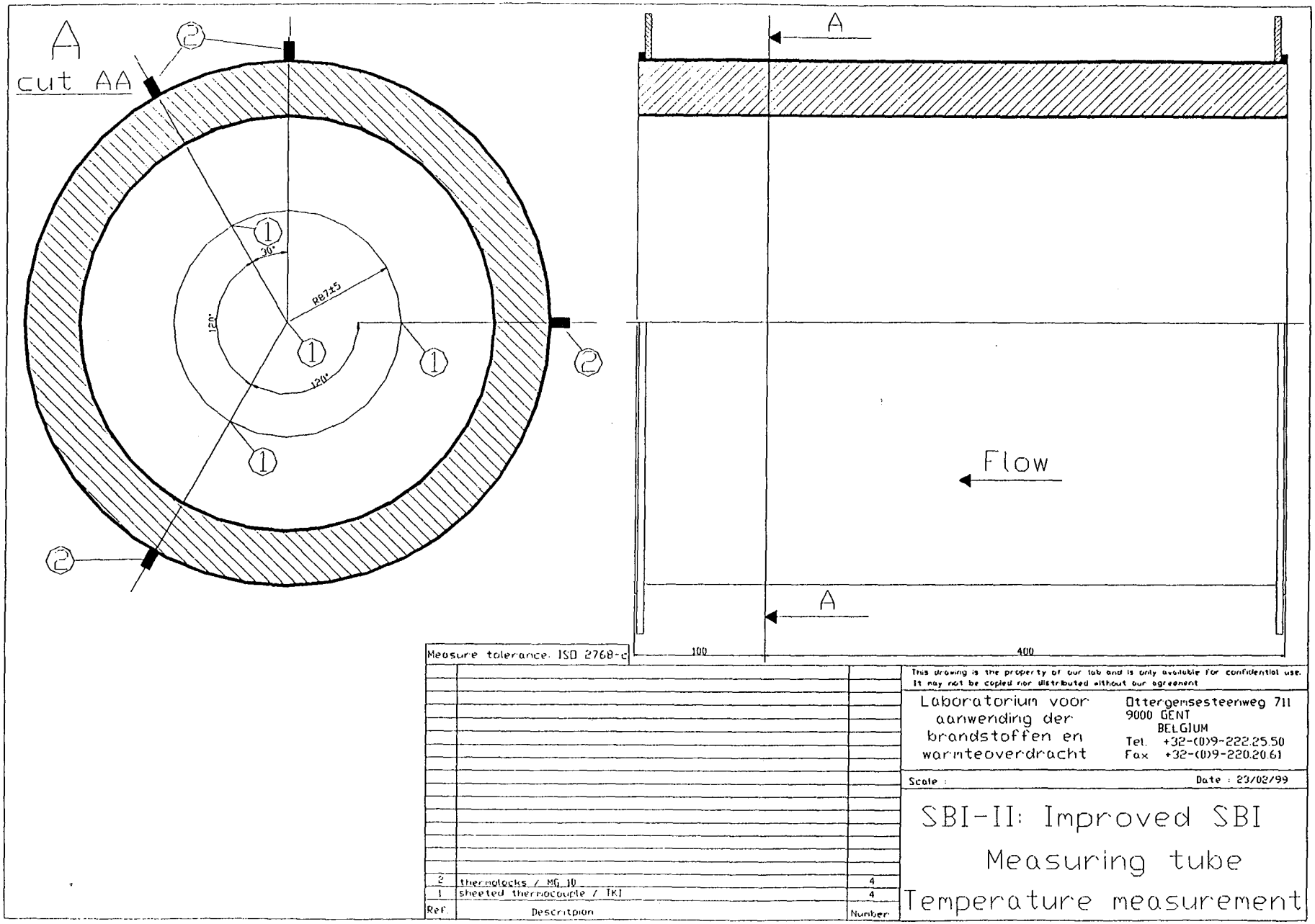
Scale :

Date: 15/01/99

SBI-II: Improved SBI Exhaust Duct General view


A
cut AA
A
A
Flow
30°
120°
120°
R8745
100
400
Measure tolerance: ISO 2768-c
2 thermolocks / MG 10 4
1 sheeted thermocouple / TKI 4
Ref. Description Number
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BELGIUM
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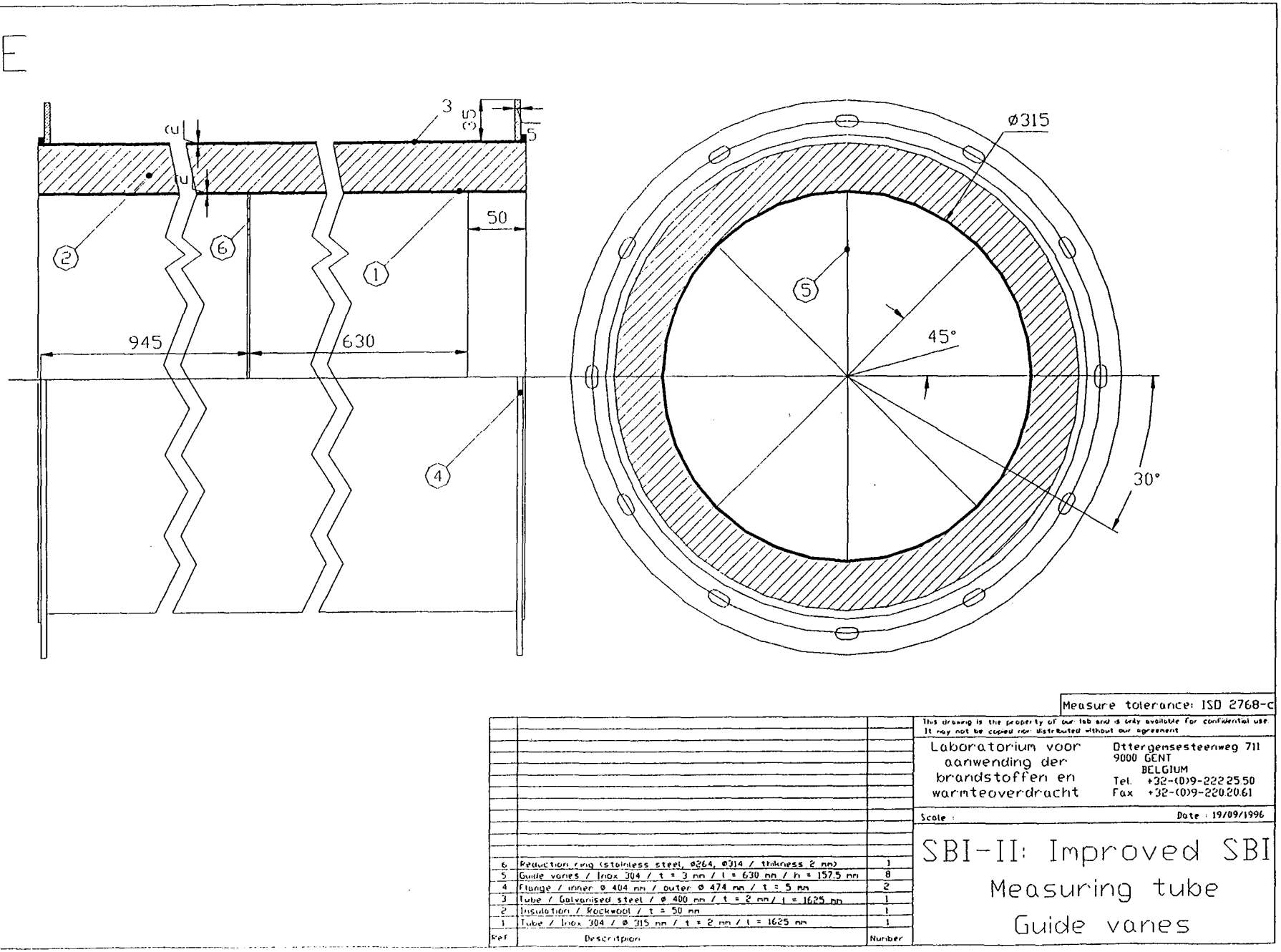
Fax +32-(0)9-220.20.61
Scale :
Date : 23/02/99
SBI-II: Improved SBI
Measuring tube
Temperature measurement

Figure 26



Ref	Description	Number
6	Reduction ring (stainless steel, ø264, ø314 / thikness 2 mm)	1
5	Guide vanes / Inox 304 / t = 3 mm / l = 630 mm / h = 157.5 mm	8
4	Flange / inner ø 404 mm / outer ø 474 mm / t = 5 mm	2
3	Tube / Galvanised steel / ø 400 mm / t = 2 mm / l = 1625 mm	1
2	Insulation / Rockwool / t = 50 mm	1
1	Tube / Inox 304 / ø 315 mm / t = 2 mm / l = 1625 mm	1

Measure tolerance: ISO 2768-c

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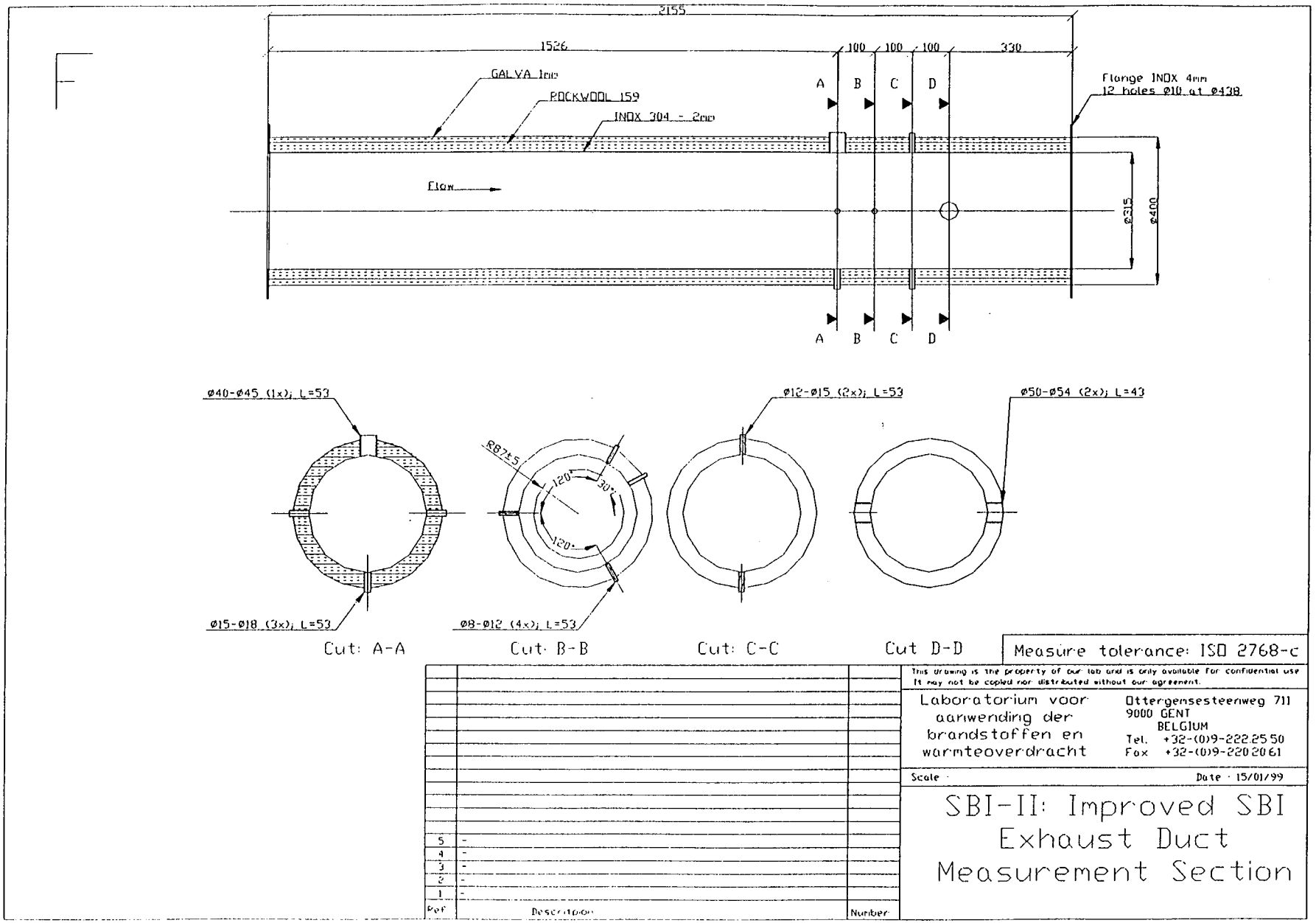
Tel. +32-(0)9-222 25 50
Fax +32-(0)9-220.20.61

Scale :

Date : 19/09/1996

SBI-II: Improved SBI
Measuring tube
Guide vanes

Figure 27


2155
1526
100
100
100
330
GALVA 1mm
ROCKWOOL 159
INOX 304 - 2mm
Flange INOX 4mm
12 holes Ø10 at Ø438
A
B
C
D
Flow
Ø315
Ø400
Ø40-Ø45 (1x); L=53
Ø15-Ø18 (3x); L=53
R87±5
120°
30°
120°
Ø8-Ø12 (4x); L=53
Ø12-Ø15 (2x); L=53
Ø50-Ø54 (2x); L=43
Cut: A-A
Cut: B-B
Cut: C-C
Cut D-D
Measure tolerance: ISO 2768-c
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BELGIUM
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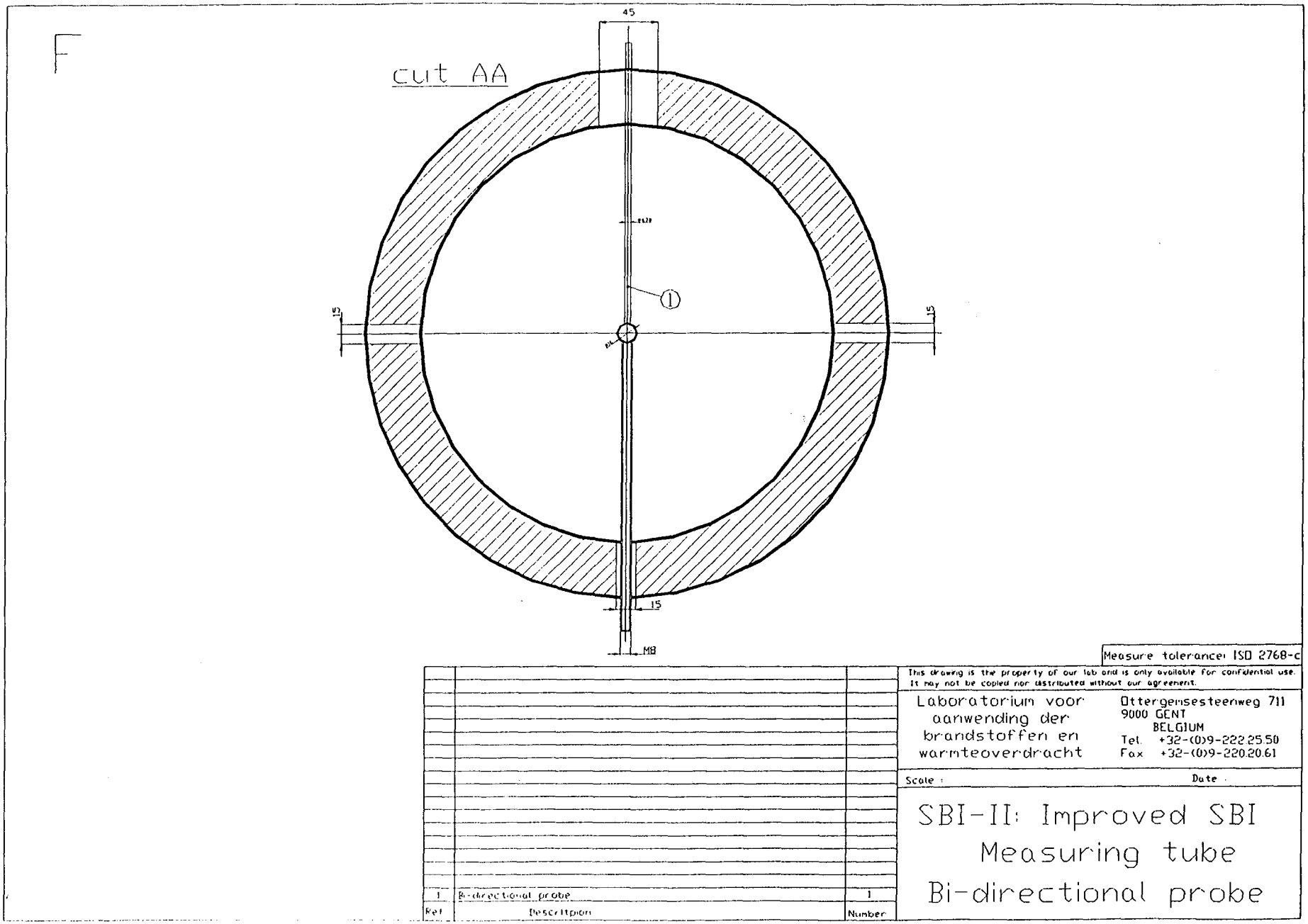
Scale
Date : 15/01/99
SBI-II: Improved SBI Exhaust Duct Measurement Section
Ref
Description
Number

Figure 28


F
cut AA
45
15
15
15
M8
1
Measure tolerance: ISO 2768-c
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BELGIUM
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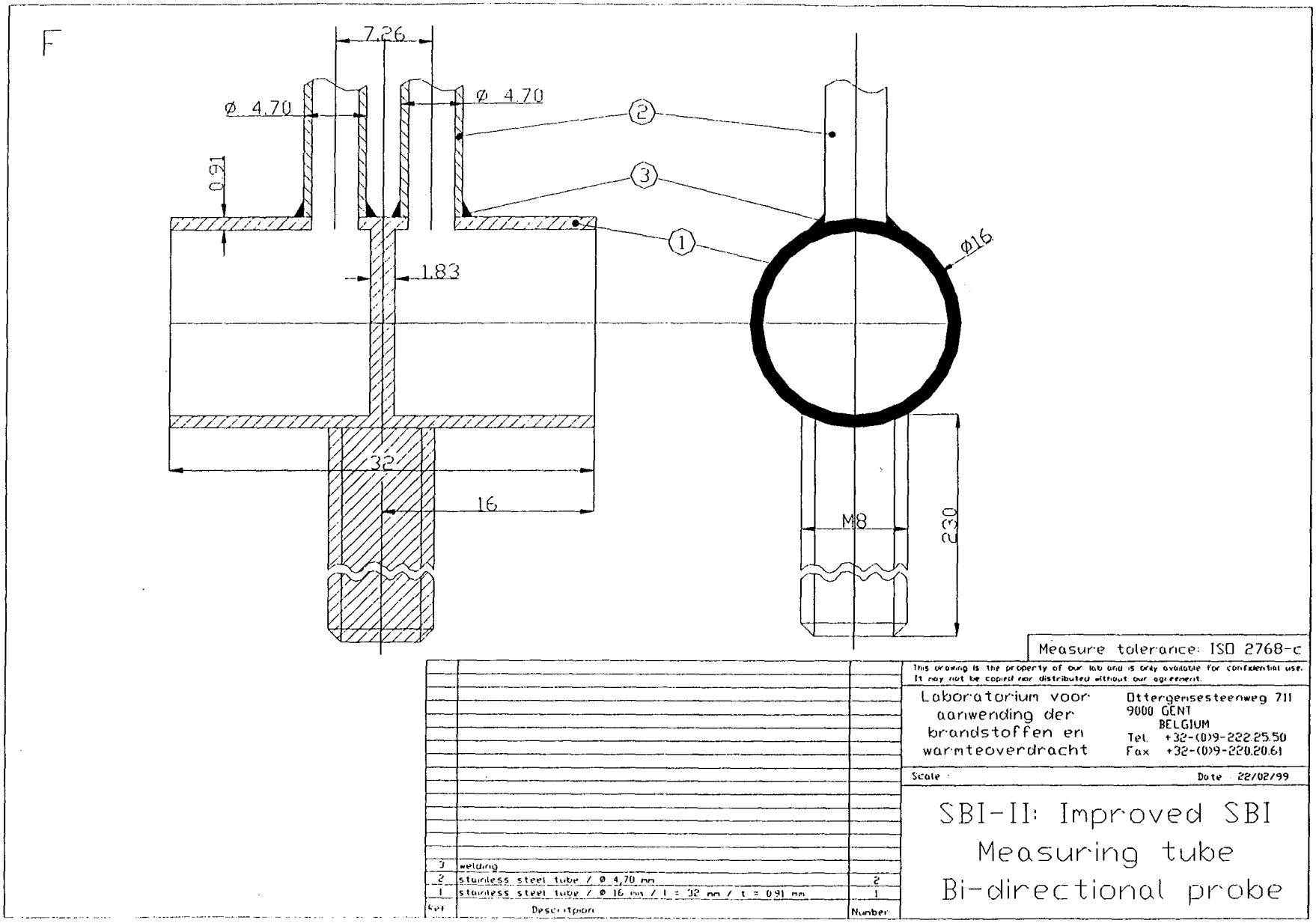
Fax +32-(0)9-220.20.61
Scale :
Date :
SBI-II: Improved SBI
Measuring tube
Bi-directional probe
1
Bi-directional probe
1
Ref
Description
Number

Figure 29


F
7.26
ø 4.70
ø 4.70
0.91
1.83
32
16
M8
230
ø16
2
3
1
Measure tolerance: ISO 2768-c
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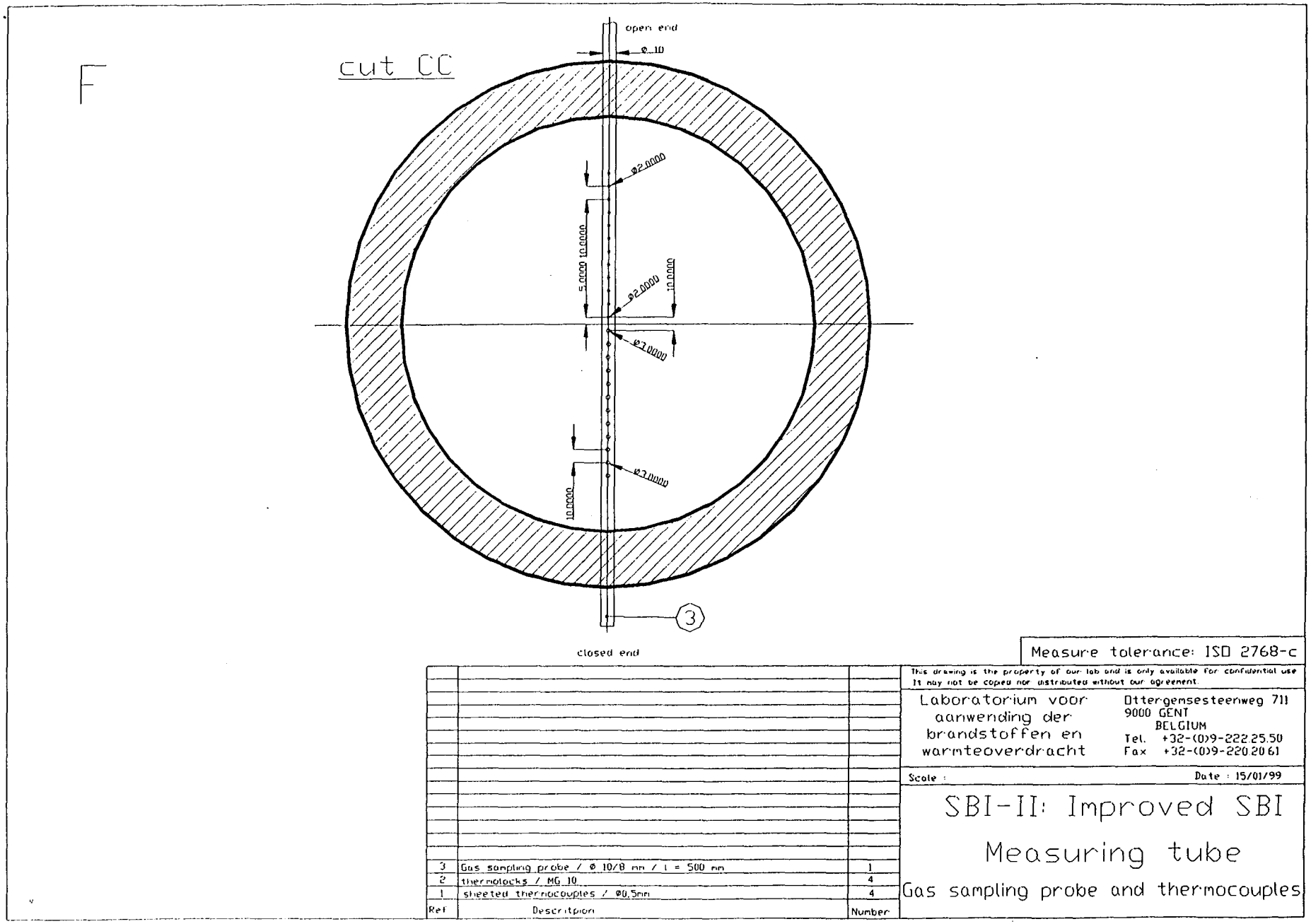
BELGIUM
Tel. +32-(0)9-222.25.50
Fax +32-(0)9-220.20.61
Scale :
Date 22/02/99
SBI-II: Improved SBI
Measuring tube
Bi-directional probe
3 welding
2 stainless steel tube / ø 4,70 mm 2
1 stainless steel tube / ø 16 mm / l = 32 mm / t = 0.91 mm 1
Ref Description Number

Figure 30



Measure tolerance: ISO 2768-c

Ref	Description	Number
3	Gas sampling probe / Ø 10/8 mm / l = 500 mm	1
2	thermolocks / MG 10	4
1	sheeted thermocouples / Ø0,5mm	4

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Scale :

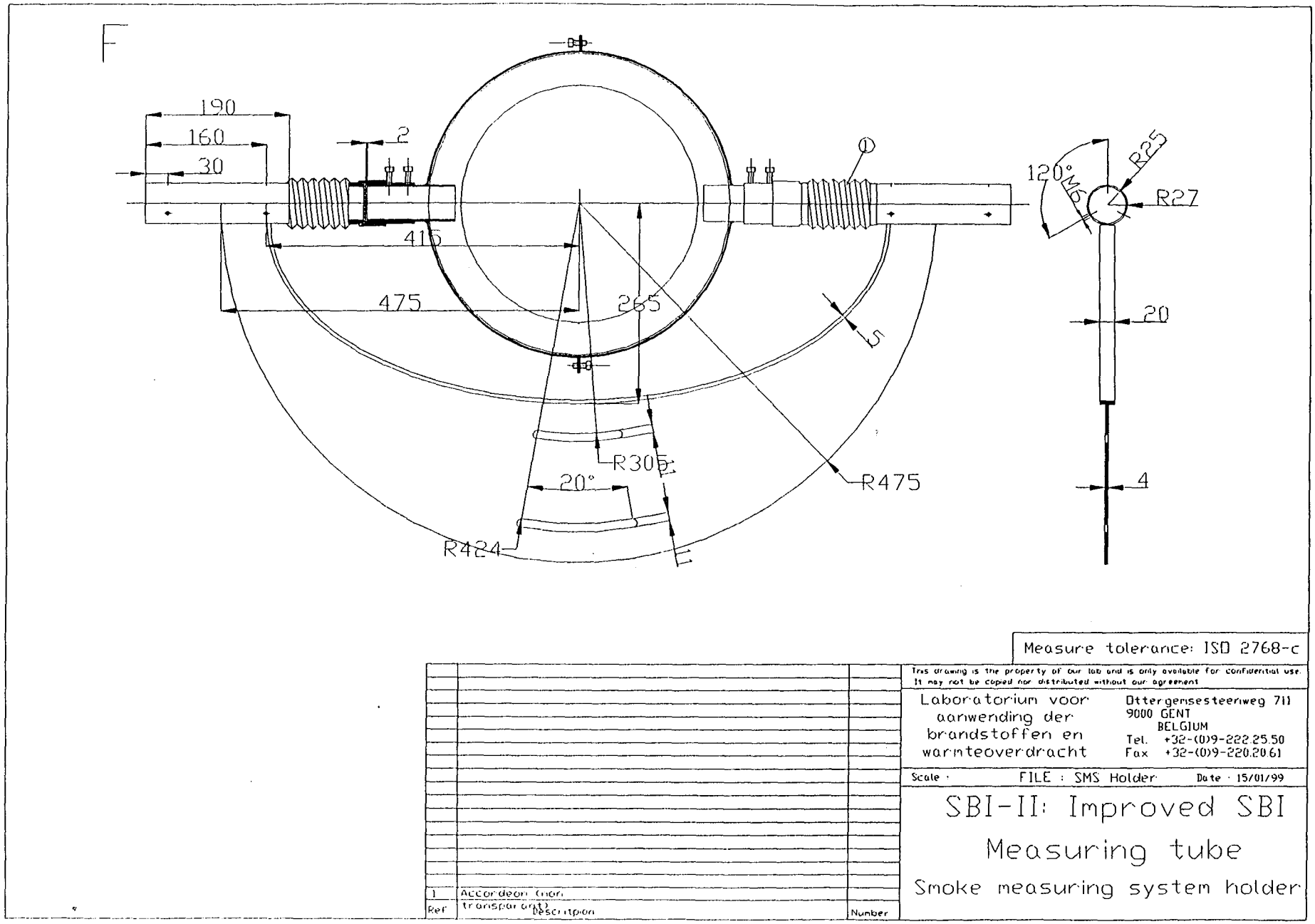
Date : 15/01/99

SBI-II: Improved SBI

Measuring tube

Gas sampling probe and thermocouples

Figure 31


F
190
160
30
2
415
475
265
5
R305
20°
R424
R475
120°
R25
R27
20
4
Measure tolerance: ISO 2768-c
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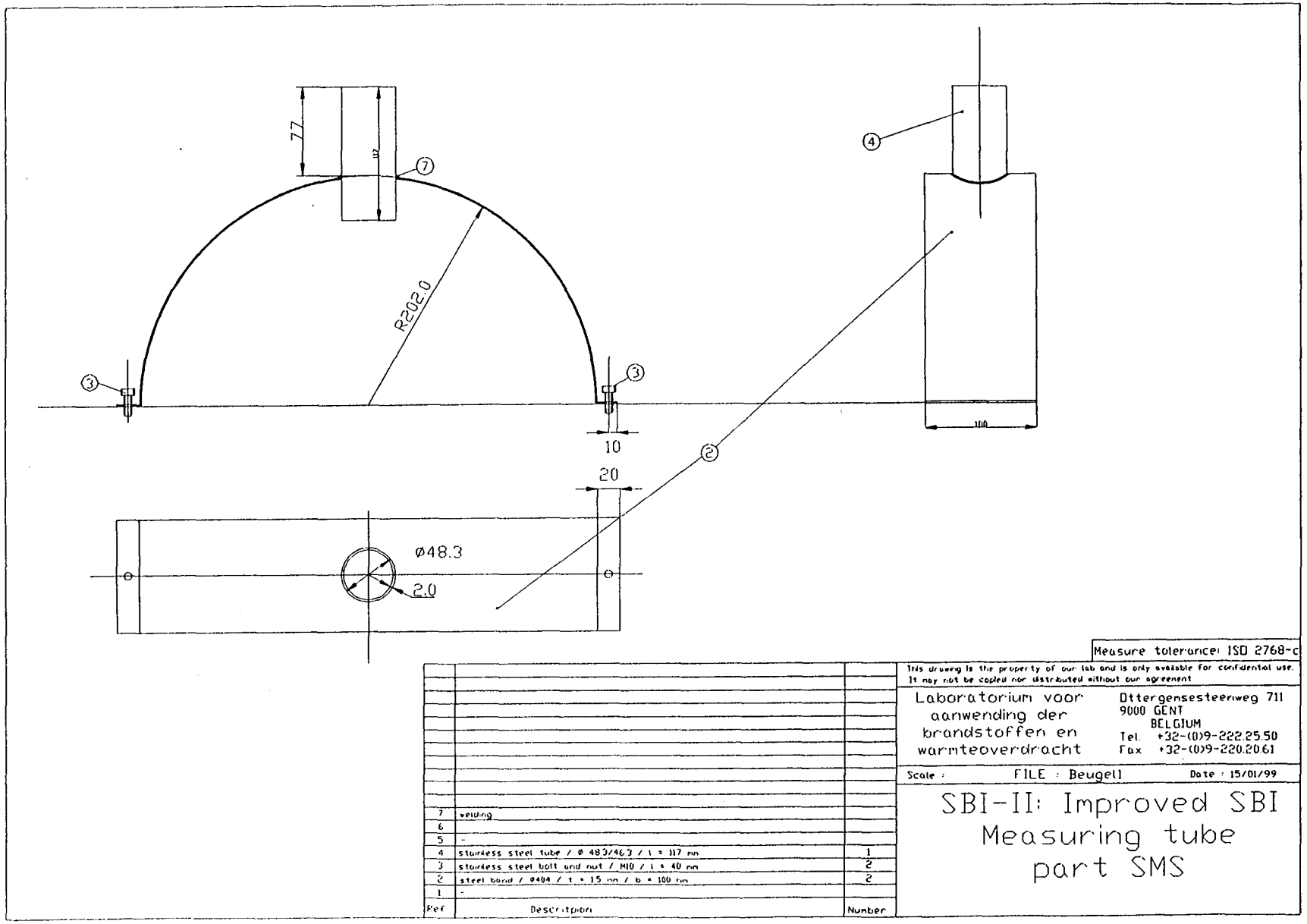
9000 GENT
BELGIUM
Tel. +32-(0)9-222.25.50
Fax +32-(0)9-220.20.61
Scale :
FILE : SMS Holder
Date : 15/01/99
SBI-II: Improved SBI
Measuring tube
Smoke measuring system holder
1
Accordeon (non transparant)
Ref
Description
Number

Figure 32


77
R202.0
10
20
ø48.3
2.0
100
Measure tolerance: ISO 2768-c
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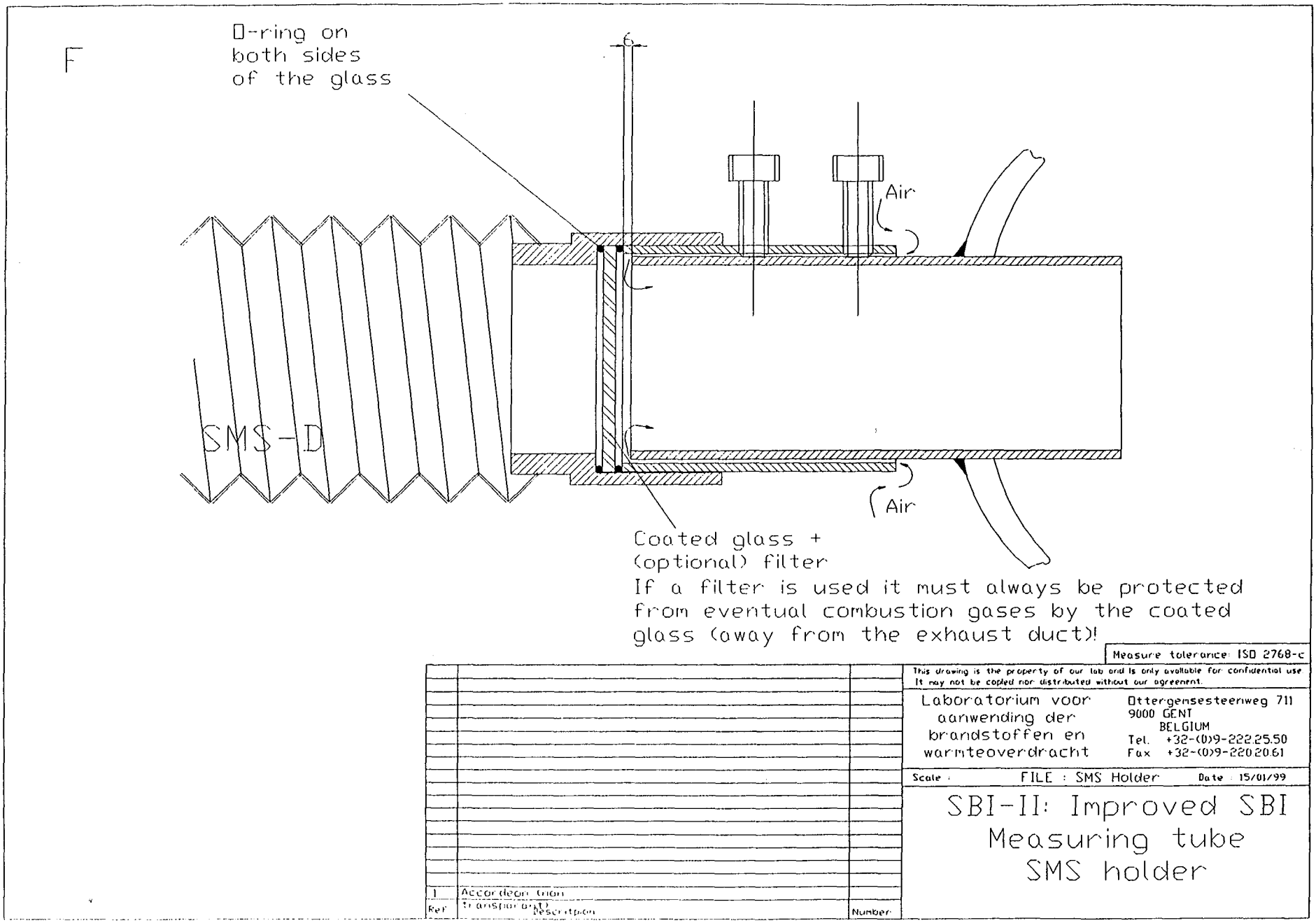
Dttergemsesteenweg 711
9000 GENT
BELGIUM
Tel. +32-(0)9-222.25.50
Fax +32-(0)9-220.20.61
Scale :
FILE : Beugel1
Date : 15/01/99
SBI-II: Improved SBI
Measuring tube
part SMS
Ref
Description
Number
7 welding
6 -
5 -
4 stainless steel tube / ø 48.3/46.3 / l = 117 mm 1
3 stainless steel bolt and nut / M10 / l = 40 mm 2
2 steel band / 9404 / t = 1.5 mm / b = 100 mm 2
1 -

Figure 33


F
O-ring on
both sides
of the glass
6
Air
SMS-D
Air
Coated glass +
(optional) filter
If a filter is used it must always be protected
from eventual combustion gases by the coated
glass (away from the exhaust duct)!
Measure tolerance: ISO 2768-c
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warmteoverdracht
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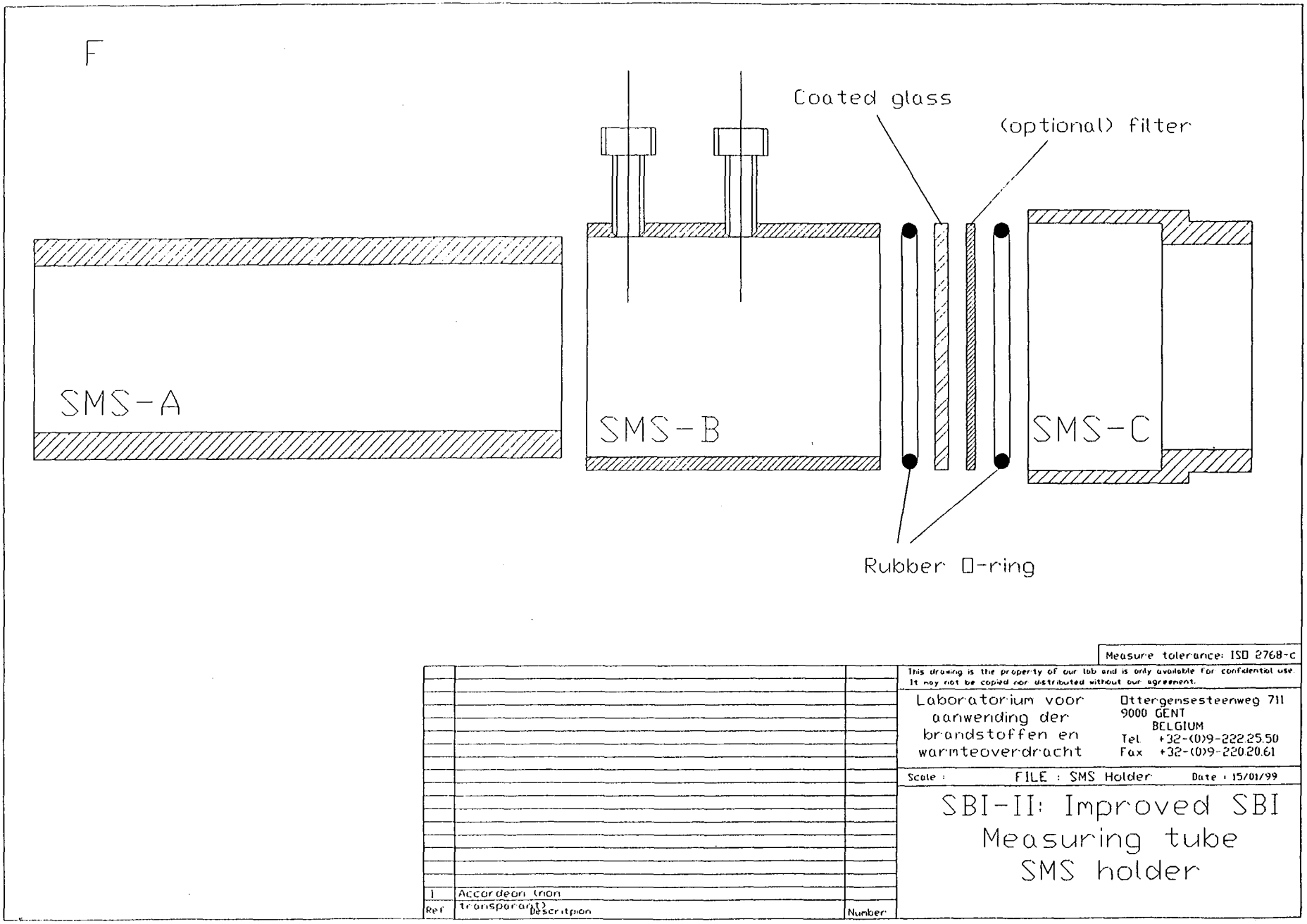
BELGIUM
Tel. +32-(0)9-222.25.50
Fax +32-(0)9-220.20.61
Scale :
FILE : SMS Holder
Date : 15/01/99
SBI-II: Improved SBI
Measuring tube
SMS holder
1
Accordeon trian
Ref
Description
Number

Figure 34


F
Coated glass
(optional) filter
SMS-A
SMS-B
SMS-C
Rubber O-ring
Measure tolerance: ISO 2768-c
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9000 GENT
BELGIUM
Tel +32-(0)9-222.25.50
Fax +32-(0)9-220.20.61
Scale :
FILE : SMS Holder
Date : 15/01/99
SBI-II: Improved SBI
Measuring tube
SMS holder
1
Accordeon (non transparant)
Ref
Description
Number

Figure 35

Anlage 5 zum Abschlußbericht

"Verbesserungen am SBI-Test"

TNO-report
1999-CVB-R1154

REFINEMENT OF THE SBI TEST METHOD

TNO Building and
Construction Research

Contact person
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Date
18 May 1999

Author(s)
Ir. R.J.M. Van Mierlo

Sponsor : European Commission DG III, National authorities of the EU Member States

Project name : SBI 2
Project number : 08.20.5.7865

Number of pages : 10

Summary

In September 1994, Commission Decision 94/611/EC, concerning the classification system for the reaction to fire performance of building products, was published. This system refers to a number of test methods already defined by the standardisation bodies, with the exception of the so called "Single Burning Item" (SBI) test method.

During the years 1994 to 1997 the SBI test method was developed by a group of laboratories nominated by the member states. The test method was accepted by the Standing Committee in December 1997 as one of the test methods to be used in the "Euroclasses" classification system, under the condition that possible refinements were investigated and introduced as far as they would lead to more repeatable and reproducible test results and/or better optimisation of the classification.

This report presents the results of the refinement process and the end product in which the results are implemented: a new draft of the SBI standard.

The refinement of the SBI was investigated by a group of twelve laboratories nominated by their member states. The investigation was performed along the lines set out in the document "Schedule of actions for improvement of the SBI test method" (RG document N133).

The result of this refinement project is a clear improvement of the SBI test facility and a set of parameters which, in the opinion of the Fire Regulators Group, fulfils the classification needs of the member states. Furthermore, the total text of the standard has gone through a comprehensive redrafting process and e.g. now contains much improved sections on calculation and calibration procedures.

Contents

1. Introduction

Based on the Constructive Product Directive 89/106/EEC, the Commission Decision 94/611/EC concerning the classification system for reaction to fire performance of building products, was published in September 1994. Two parts were distinguished: a system for floor coverings and a system for the other building products. This second system refers to three test methods already defined by the standardisation bodies, and the so called "Single Burning Item" test method (abbreviated: SBI).

During the years 1994 to 1997 the SBI test method was developed by a group of nine laboratories nominated by nine member states. The development consisted of the design of a prototype, the installation of test facilities, the determination of the accuracy of the method and the production of data needed to finalise the classification system.
The test method was accepted by the Standing Committee in December 1997 as one of the test methods to be used in the "Euroclasses" classification system, under the condition that possible refinements were investigated and introduced as far as they would lead to a better repeatability and reproducibility of the test results and/or an optimisation of the classification.

The aim of this project was to refine the SBI test method to optimise its use with respect to classification. The investigation was performed along the lines set out in the RG document "Schedule of actions for improvement of the SBI test method" (RG document N133). The actions were clustered in four groups:

1. Technical improvements to the test facility and the test method
2. Further analysis of the round robin test data
3. Recommendations to the EC Fire Regulators Group, and
4. Provision of a pre-standardisation document for submission to CEN

The recommendations (group 3) and the pre-standardisation document (group 4) contain the end result of the more technical investigations in group 1 and 2.

2. Project organisation

The SBI test method was developed by a group of twelve fire laboratories nominated by twelve Member States, called the "Official Laboratories Group". The group contained the original nine laboratories that developed the SBI until its acceptance in December 1997, and three additional laboratories from three member states not represented in the original group. Since the three added laboratories were not yet in possession of an SBI facility or experience in the test method, the technical work (groups 1 and 2) was done by the other nine laboratories.
The original group consisted of (abbreviations between brackets):

- Belgium Universiteit Gent (RUG)
- Denmark Danish Institute of Fire Technology (DIFT / DBI)
- France Centre Scientifique et Technique du Bâtiment (CSTB)
- Germany Staatliches Materialprüfungsamt NRW (MPA)
- Italy Laboratorio di Studi e Ricerche sul Fuoco srl (LSF)
- Netherlands TNO Building and Construction Research (TNO)
- United Kingdom Fire Research Station, BRE (FRS)
- Finland VTT Building Technology (VTT)
- Sweden Sveriges Provnings- och Forskningsinstitut (SP)

the added laboratories were:

- Austria Magistrat der Stadt Wien (MA39)
- Spain Centro de Ensayos e Investigacion del Fuego (LICOF)
- Portugal Laboratoria Nacional de Engenharia Civil (LNEC)

The meetings of the OLG were attended by representatives of the EC-DG III, DIBt (the contract holder), CEN, CEPMC and the twelve laboratories.
The co-ordination of the project was in the hands of RUG and TNO. The meetings were chaired by TNO.

3. Project progress

During the project, the progress has been reported to the Fire Regulators Group in the following RG documents:

- "Summary of principles leading to the SBI classification system" – RG N138
- "Classification of smoke and flaming droplets/particles" – RG N140
- "Background information relating to the Euroclasses proposal and analysis of options" – RG N152
- "Some thoughts about the ongoing role of the reference scenario" – RG N153
- "Technical improvements to the SBI facility and test method – Progress reports – RG N141 and N154
- "Some considerations in relation to the choice of ΔT or O_2-depletion technique for evaluation of rate of heat release" – RG N154a
- "Smoke production limits" - Annex to RG N163,

in parts of several other RG documents, and by verbal comments during the RG meetings.

The part of the work not presented in the RG is the results of the calibrations. This part of the work was carried out during February and March of this year (1999) to investigate whether the calibrations annex of the standard needed further redrafting. The results of the calibrations are summarised in annex 1.

The results of this project have been incorporated as much as possible in the text and the design drawings of the new SBI draft standard (version 26 March 1999), which are presented in full in annex 2.

The changes introduced to the standard[1] can be summarised as follows:

A. Changes to the test facility:
   Major changes were introduced in the design of the exhaust duct to improve the flow pattern and reduce potential measurement errors. The same is valid for the design of the smoke measurement system (new mounting for the optics, improved air purging, holders for calibration filters).
B. Changes to the test method:
   Additional checks for the validity of the measurement have been incorporated. All data needed for calculation of heat and smoke output (including timing of events and synchronisation of measurements) are now calculated from automatically recorded data (no human observations are used). A reduced set of parameters has been selected based on correlation with the reference scenario, removal of highly correlated parameters and avoidance of parameters based on human ob-

[1] The changes presented are the main differences between the draft standard versions of 26 March 1999 (end result of this project) and the version of 28 June 1997 (used during the SBI round robin and starting point for this project).

servations. The stability of the heat output parameters has been improved by introduction of threshold values.

C. Introduction of detailed calculation and calibration procedures
The calculation procedures are now specified step by step. References to calculations in ISO9705 are replaced and detailed further where appropriate. The calibration procedures were redrafted based on the experience in the SBI round robin and on the results of the calibrations presented in annex 2. Calibrations of the smoke measurement system and of separate pieces of equipment were added.

4. Conclusions

The scope of the project was to introduce refinements in the SBI test method to optimise its use with respect to classification. The project has resulted in technical improvements to the SBI facility, less error prone determination of the test results, better detailed and less ambiguous calculation and calibration procedures, and a set of representative parameters for the SBI test. This set of parameters was acknowledged by the Fire Regulators Group and the Standing Committee on Construction, as fulfilling the needs for classification in the Euroclasses system.

The results of this project are incorporated in a new draft of the SBI standard.

Rudolf van Mierlo, M.Sc. E.W. Janse, M.Sc.

Annex 1: Calibration results

The final task in the project was the performance of the proposed calibration procedures by all participating laboratories in possession of an SBI facility, after introduction of the proposed technical improvements.

The end result of the calibrations is summarised in the table below. Each row represents an item of one of the calibrations. The laboratories presented anonymously are those that sent in the results of at least the majority of the calibrations, being the nine OLG laboratories and Rockwool. The results not meeting the requirements are in bold on a shaded background.

It is clear that the majority of the calibration results meets the requirements. For some items a few laboratories may need to further investigate the source of the deviation (e.g. the "RHR_{step3}-RHR_{step2}" in the "Burner heat output step calibration"). For some other items, like the temperature response times in the "Burner heat output step calibration", a less severe requirement may be more appropriate[2].

The drift, noise, delay times and response times of the gas analysers showed not to give real problems in the laboratories. The even more important "burner switch response time", which checks the consistent start of attack of the specimens, is within a small bandwidth in all laboratories except one. One laboratory in the small band is just outside the requirement.
It may be useful to investigate in the future whether the criteria for the deviation in kt values and optical filter density are the optimal ones.

During the calibrations it became obvious that a newly installed component of the smoke measurement system was not in accordance with the design accepted. As a consequence, the original problem of soot deposit on the lenses was still present in some laboratories. Some of those laboratories managed to change again this component and to repeat the calibration in time successfully. The smoke calibration result (TSP/m) of two laboratories not able to do this in time, was corrected by subtracting a linear increasing rate of smoke as a first estimation of the error introduced. The result of these two laboratories are given with the additions "ca." and "(lin. corr.)". The results of the smoke calibration probably is influenced by differences in the type of heptane used.

The result of this series of calibrations gives a good basis to assume that the calibration procedures can be used in their current form. Experience based on performing

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[2] Such further fine tuning however is not part of this project and will remain possible at least as long as a test method is not used in practice for some years.

large numbers of tests and calibrations may be used in a later stage to further optimise the calibration procedures.

Annex 2: Draft SBI standard

(78 pages excluding this one, of which 35 pages of design drawings).