Commission of the European Communities

industrial processes
building and civil engineering

Testing and classification of the resistance to fire of structural building components

Report

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Testing and classification of the resistance to fire of structural building components

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PREFACE

In recent years, the harmonization measures undertaken in the building and civil engineering sector have included work on the fire resistance of structural elements.

These activities led to the preparation in September 1977 of a preliminary draft Directive relating to the "classification on the basis of test results of the fire resistance of structural elements" which is well known among the circles concerned as "document 1202".

"Document 1202" is an internal Commission working document based on document ISO D.I.S. 834 and was prepared by joint working parties made up of experts from the relevant national ministries and representatives of the approved testing laboratories and the industry.

Implementation of the provisions of such a document in the form of a directive implies a reciprocal recognition of test results and classifications and raises the problem of the comparability of results obtained when using facilities (test furnaces) which exhibit different structural and operational features. In an effort to find a solution to the problems posed by attempts to establish this comparability, a study of the facilities available in approved Community testing laboratories was initiated.

This investigation was carried out in two stages.

During the first, covering the period from January 1979 to December 1980, an agreement was concluded with the three following experts:

D. VANDEVELDE	(RUG)
M. KINGELHÖFFER	(MPA)
J. DEKKER	(TNO)

for the preparation of a questionnaire to be sent to the approved laboratories.

On the basis of this questionnaire, an enquiry involving laboratory visits was conducted in order to :

- draw up a catalogue of the characteristics of existing installations and of the resources available to them, particularly as regards the measurements performed;
- gain knowledge of the procedure employed in fire-resistance tests, with particular reference to the conditions under which test elements are assembled and to the contents of test reports;
- compare the procedures employed with the provisions laid down in document 1202.

During the second phase of the investigation, covering the period from January 1981 to March 1983, the three specialists were responsible for :

- analyzing the results of the enquiry conducted during the first phase and suggesting changes and areas requiring more detailed study with a view to achieving an optimum degree of harmonization;
- amending and supplementing document 1202 on the basis of the above-mentioned activities with a view to rendering it more relevant from the operational standpoint and to reducing differences of interpretation within its field of application.

The results of these activities are the subject of this report, which is in two parts :

<u>Part I</u> Examination of the equipment used in testing fire resistance in approved Community laboratories.

<u>Part II</u> Method of testing and classifying the fire resistance of structural elements.

At each stage of its progress, the study conducted by the three experts was subjected to critical examination by a Working Party consisting of representatives of the Community laboratories which have been approved for the testing and classification of structural elements. This group, the composition of which is shown in the Annex to this preface met for the last time on 19 - 21 April 1982 prior to the finalization of this report.

This meeting produced a large measure of agreement among the participants as regards the contents of the report. Some of them even undertook to ensure that full recognition was given to the test reports and, consequently, to the classifications of structural elements based, like the corresponding tests, on the provisions contained in Part II of this report.

At the present juncture, the Commission believes that even though this undertaking to promote voluntary harmonization is not unanimous, it is extremely important and regards it as an encouragement to continuing efforts to bring current harmonization activities to a successful conclusion.

In the field in question, these efforts will relate, in particular, to installations and methods of calculation and extrapolation, but will also involve an expansion of activities to cover other elements and, lastly, the promotion of sustained and continuing cooperation between the approved laboratories.

Annex to the preface

Attendance list for the meeting of representatives of approved laboratories, held in Brussels on 19 - 21 April 1982

Germany (Federal Republic of)

C. MEYER - OTTENS	T.V. BRAUNSCHWEIG
KLINGELHÖFFER	M.P.A. DORTMUND
WESTHOFF	M.P.A. DORTMUND
STANKE	B.A.M. BERLIN
H. HAFNER	F.M.P.A. STUTTGART

Belgium

P. VANDEVELDE	R.U.G. GAND
BERTRAND	Université d'Etat de Liège
S. MAEKELBERG	Ministère de l'Intérieur

Denmark

E. DANØ	Dantest Copenhague
N. ANDERSEN	Dantest Copenhague

France

LE DUFF	C.S.T.B. - Paris
CAVELIUS	C.T.I.C.M. - Maisière-lez-Metz

Italy

S. BRUSCHETTA	Centro Studi Antiscendi - Roma

Netherlands

J. DEKKER	I.B.B.C. - T.N.O. - Delft

United Kingdom

H.L. MALHOTRA	F.R.S. - Borehamwood
A.G. DEAKIN	Warrington Research Centre
T.V. DAY	F.I.R.T.O. - Borehamwood
P.E. JACKMAN	Trada
C.J. WIGHTENAN	British Gypsum
J.A. MEAD	Yarsley Technical Centre

CONTENTS

P A R T I

ANALYSIS OF FIRE TEST EQUIPMENT

IN E.E.C. LABORATORIES

1. INTRODUCTION

On request of the "Directorate General III, Internal Market and Industrial Affairs" the three authors undertook the task to visit the officialy recognized laboratories of the E.E.C., named by the national delegations in the expert group concerning resistance to fire of building elements. These were the following :

Belgium	:	R.U.G. Laboratorium voor Aanwending der Brandstoffen en Warmte-overdracht Ottergemse steenweg, 711 B - 9000 GENT
Denmark	:	DANTEST Amager Boulevard, 108 DK - 2300 COPENHAGEN
U.K.	:	FIRTO Melrose Avenue Borehamwood, Herts Hertfordshire WD 6 2 BL
		TRADA Stocking Lane Hughenden Valley High Wicombe Buckinghamshire HP 14 4ND
		WARRINGTON RESEARCH CENTRE Holmerfield Road Warrington Cheshire WA1 2DS
		YARSLEY TECHNICAL CENTRE Trowers Way Redhill Surrey RH1 2JN

France	:	C.S.T.B. 84, Avenue Jean Jaurès Champs-sur-Marne F - 77428 Marne La Vallée Cedex 2
		C.T.I.C.M. Domaine de l'I.R.S.I.D. F - 57210 Maizières-lez-Metz
Germany	:	B.A.M. Unter den Eichen 87 D - 1000 Berlin 45
		T.U. Braunschweig Beethovenstrasse, 52 D - 3300 Braunschweig
		M.P.A. Marsbruchstrasse, 186 D - 4600 Dortmund
		F.M.P.A. Pfaffenwaldring, 4 D - 7000 Stuttgart
		H.F. Munchen Winzerestrasse, 45 D - 8000 Munchen
Italy	:	Centro Studi ed Esperienzi del Ministro dell'Interno I - 00100 Roma - Capannelle
The Netherlands	:	I.B.B.C. - T.N.O. Postbus, 49 NL - 2600 AA Delft

During the visits the equipment of the laboratories was looked at, and at least one test in each laboratory was observed. Additionally particular questions concerning the test techniques were discussed with the staff of the labs. In order to provide as much information as possible, in preparation of the visits a questionnaire has been prepared by the undersigned. This questionnaire included a request for test reports. The questions were answered by the labs before the visit and the answers discussed and completed during the visits. During the exercice a second questionnaire concerning the calculation of test load was sent around.

As first result of these visits a full report, containg both the answers to the questionnaire and single reports of the visits, with all detailed information, was delivered to the sponsor. The answers to the second questionnaire here included in this report as far as available on the day of delivery of the full report. It was found that this report included a lot of information which seemed to be important for the further harmonization of the resistance to fire test method. Also analysis of the test reports delivered in the laboratories seemed useful.
The authors therefore accepted the task to analyse these voluminous documents in order to prepare conclusions and guidelines for a revision of the existing document 1202.

This report therefore contains :

a) an analysis of the former report including suggestions for modifications and more detailed specifications of the test procedures;

b) a method for testing and classification of the resistance to fire of structural building components.

Because of the increase of detailed specifications a rearrangement of the logical order was felt to be necessary. Chapter 1 contains the general requirements of test procedure and classification, valid for all types of elements ; Chapter 2 gives for each type of building component, detailed instruction for the test arrangement ; Chapter 3 gives the mandatory contents of the test reports for each type of building component.

2. GENERAL EXPERIENCE WITH DOC. 1202

During the visits the authors made the experience that doc. 1202 was not well known by the laboratories and partially not understood, especially the differences to the national standards were not sufficiently realised and observed. So by most laboratories, even carrying out test following doc. 1202, the tests were done on the basis of the normal way of working, i.e. following the national standard. Only those modifications were made where differences were realised. The results of this were large numbers of differences in test procedure and classification in the different labs.

The reason for this situation was found to be based on :

1°/ A lack of detailed specification in doc. 1202;

2°/ A lack of accessability to the content of the existing doc. because some information on the same subject is dispersed over the document;

3°/ A lack of knowledge concerning the content of 1202 combined with an underestimation of the influence of smaller details in test procedure on the test results.

For this reason :

- the content of doc. 1202 is rearranged;
- especially in Part II detailed drawings concerning the test arrangements are given;
- tolerances for dimensions, minimum accuracy requirements and maximum intervals for measurements are specified;
- end conditions and other test details are specified closely. This means on the one hand that better harmonization will be obtained, but on the other hand it implicates that some situations are not covered by the test, and are not tested "as in practice";
- it was also felt that there was no reason to exclude protected steel members from the test procedure, as long as the use of test results remains limited to the element tested, and no extrapolation is made;

- from these discussions it appeared that extrapolation of test results is not only a problem for protected steel members but also for other building components.

A detailed analysis of the information obtained by the questionnaire and during the visits, is given in the following chapters. Starting from the analysis, amendments and changements to doc. 1202 are proposed. Although much attention was paid during the visits to complete the questionnaires, by making the final analysis it appeared that even in the completed questionnaires some information was not very clear or even missing. Here, either a question mark appears in the tables, or they have been completed by the authors from memory.
As the aim of this work was not to judge the quality of the work in the laboratories but to establish a detailed test procedure, single errors which may appear in the tables, but they have no influence on the final outcome of the work.

3. COMMENTS ON THE FACILITIES IN THE LABORATORIES (see table 1)

- The answers to the general questions in the questionnaire give an overall idea about the situation in each laboratory.

- Table 1 shows the size of the furnace halls. Their volume vary between about 300 and 15 000 m3.
  It is not expected that this will influence test results unless the specimen is directly in front of a large ventilation air entrance.
  Most of the labs are heated but the temperatures which are likely to be encountered are between 0°C and 30°C.
  In order to avoid influence of ambient conditions on the test results, ambient temperature in the furnace hall has to be kept approximately constant during a test. In this respect harmonization is restricted by the existing furnace halls and their ventilation possibilities.

- In the majority of labs, no special conditioning room for the specimen is available.
  The impression during the visits was that in most laboratories there is not enough space for storing the specimens during the conditioning time (e.g. concrete). In this light the product of the number of tests per year multiplied by the given figures for conditioning time does not fit together with the space available, at least for some laboratories.

- Some labs dispose on a large number of furnaces, others only on one ot two which are used for different elements.
  For the multipurpose furnaces in general it will be more complicate to fulfill the requirements for the test, especially where closer specifications are introduced in the revised document.

- Those laboratories who have more than one furnace for a single purpose, probably can provide more information on the influence of furnace construction and other parameters on the test results.

- It is clear that the design of the furnaces influences the test results. In order to get better reproductibility which is necessary for harmonization, it appears desirable to have detailed guidelines for the design of furnaces (preferably working drawings). Such guidelines should be published as recommendation for new furnaces (see also chapt. 7.4).

Laboratories	Furnace hall						Nr. of furnaces	Conditioning of the specimen		
	Heated	Temperature (°C) min	max	Humidity (%) min	max	Volume m^3		Special room	Climate	Artificial drying
RUG	yes	16	28	40	65	11.900	3	yes	20/55	no
Dantest	yes	10	25	35	60	1.350	2	-	-	-
FIRTO	yes	5	25	45	95	7.320	3	-	-	yes
TRADA	yes	8	25	40	60	1.296	1	yes	-	no
Warrington	no	5	28	?	?	2.475	2	yes	-	yes
YARSLEY	yes	5	25	35	70	600	1	no	-	-
CSTB	yes	5	25	40	90	13.673	3	no	-	no
CTICM	yes	6	26	50	70	10.500	3	no	-	no
BAM	yes	18	28	45	65	5.142	3	no	-	no
TU Braunschweig	yes	15	25	35	70	15.904	6	no	-	no
MPA NW	yes	15	28	35	70	5.775	4	no	20 ± 5 55 ± 10	no
FMPA	yes	16	27	30	70	7.700	3	no	-	no
HFM	yes	18	28	30	70	326	1	no	-	no
CSEA Rom	no	10	30	?	?	5.746	1	no	-	no
TNO	yes	5	25	40	80	2.100	3	no	-	sometimes

Table I - The facilities in the laboratories.

4. FURNACES

The furnaces seen in the different labs showed large differences in respect to their dimensions, their design, their heating devices and the furnaces control.

Design of furnaces

- Nine of the labs have a wall-furnace of at least 3 m x 3 m, six have only smaller furnaces.

  The depth of the furnace differs between 0,36 m and 4,0 m.

- The cross-section of the column furnace differs between 1,4 m diameter and 7,75 m x 5,75 m. The height is between 3,0 and 4,6 m.

  The floor furnaces have a cross-section between 2 m x 4 m and 9,5 m x 4 m : their height between 0,7 and 3,1 m.

  The beam furnaces have a horizontal cross section between 3,0 x 3,7 m and 4 x 11,5 m.

  The height of these furnace dimension on the heat transfer to the specimen is unknown.

- A second factor concerning the heat transfer is given by the klc value of the lining. The information on those values where insufficient, most labs do not know the values for k and c.

  The values for p are situated between 780 and 2 760 kg/m3.

- (The question of heat transfer in furnaces is treated e.g. in the "Van Keulen" report N° TNO N° BVI 74-17, "Comparison of heat transfer in several wall furnaces", although the special influence of furnace dimensions on heat transfer is not described separately).

- There seems to be no relation between density and durability of the lining.

- Large furnaces have been built in order to test larger components. The existing version of doc. 1202 allows this. Especially in respect of the statical system of the components it is expected that the dimensions of the specimen can have great influences on the measured R/E/I values.

For harmonization purpose it seems to be necessary to introduce fixed specimen dimensions in the revised doc. 1202.

Table 2a - Wall furnace.

Laboratory	size a x b (m x m)	depth (m)	density of lining kg/m^3	nr. of tests until relining	type of fuel	nr. of burners	Nom.cap. of all b. mJ/h	lenght of flames (m) x)	Is the fuel/air-ratio		O_2-content	
									constant	regulated	mea-sured	av. v. % xx)
RUG	2 x 3	0,36	780	400	prop.	8	3.200	0,1/0,15	yes	yes	no	1-2
Dantest	2,4 x3,2	1,4	850	750	gas	10	5.220	0,7/1,0	yes	yes	no	4-10
FIRTO	3 x 3	0,38	2110/850 2090/80 %	150	nat.gas	100	6.360	0,15 / 0,18	yes	yes	no	?
TRADA	3 x 3	1,3	900 (20%) 1200 (80%)	35 part.	prop.	10	5.200	0,5/1,2	yes	yes	no	6-8
Warrington	3,0 x3,0	0,92	850	400	nat.gas	14		0,4/0,55	yes	yes	no	?
YARSLEY	3 x 3	0,6	850	?	prop.	10	7.020	0,2/0,3	yes	yes	no	?
CSTB xxx)	3 x 3	0,42	2.260	240	oil	12	7.000	no flame in the furnace	yes	yes	no	?
CTICM (u)	3,1 x3,1	4,09	2.760	300	nat.gas	12	10.000	0, 5/0,55	yes	yes	no	10-12
BAM	4,5 x3,5	1,5	1.000	200	oil	6	?	0,5/0,8	yes	yes	no	?
TU Braunschweig	4 x 3,5 / 3 x 3	1,5 / 1,5	640 / 1400	150 / 600	oil	3	9.030	0,5/0,8	yes	yes	no / yes	? / 65
MPA NW	2,9 x2,7	1,84	2.000	200	oil	3	12.400	0, /1,35	yes	yes	no	5-7
FMPA	3 x 2	1,5	?	?	oil	6	10.080	1,2/1,8	yes	yes	no	?
HFM	2 x 2,5	1,5	740	?	oil	8	5.160	0,75/0,75	yes	yes	no	?
CSEA Rom	see table 2c									.		
TNO	2 x 3	0,7	850	?	nat.gas	4	2.400	0,3/0,7	no	no	no	2-6

x) First value at 50%, second value at 100% of nom. capacity.
xx) At non-combustible materials.
xxx) This furnace is also used for columns, floors and beams.
xxxx) Seems to be an error.

Table 2b - Column furnace.

Laboratory	size a x b (m x m)	height (m)	density of lining kg/m^3	nr. of tests until relining	type of fuel	nr. of burners	nom.cap. of all b. mJ/h	length of flames (m) x)	Is the fuel/air-ratio		O_2-content	
									constant	regulated	measured	av.v. % xx)
RUG	2,5x2,4	3,5	780	400	prop.	16	14.000	0,2/0,5	no	yes	no	3-11
Dantest	-	-	-	-	-	-	-	-	-	-	-	-
FIRTO	1,4 Ø	3	850	50	nat.gas	80	5.088	0,2/0,22	yes	yes	no	?
TRADA	-	-	-	-	-	-	-	-	-	-	-	-
Warrington	-	-	-	-	-	-	-	-	-	-	-	-
YARSLEY	-	-	-	-	-	-	-	-	-	-	-	-
CSTB	1,54 Ø	3	2.260	?	oil	10	4.000	0,4/1,0	yes	yes	no	?
CTICM xxx)	7,75x5,75	3,1	1.000	90	oil	16	6.000	1,3/1,7	yes	yes	no	10-12
BAM	2 x 2	3	1.000	200	oil	4	?	0,75/20	yes	yes	no	?
TU Braunschweig	3,6x3,6 4,0x 1,5	(x) 3,5	1.500 1.400	550 400 600	oil	6 2-3	18.060 9.030	1,0/1,5 1,0/1,5	yes yes	yes yes	no no	? < 5
MPA NW	-	-	-	-	-	-	-	-	-	-	-	-
FMPA	2,3 Ø	3,36	?	?	oil	6	10.080	1,2/1,8	yes	yes	no	?
HFM	-	-	-	-	-	-	-	-	-	-	-	-
CSEA Rom	see table 2c											
TNO	-	-	-	-	-	-	-	-	-	-	-	-

x) First value at 50%, second value at 100% of nom. capacity

xx) At non-combustible materials.

xxx)This furnace is also used for walls, beams and floors

(x) 3,0/6,0.

Table 2c - Floor furnace.

Laboratory	size a x b (m x m)	height (m)	density of lining kg/m^3	nr. of tests until relining	type of fuel	nr. of burners	nom.cap. of all b. mJ/h	length of flames (m) x)	Is the fuel/air-ratio		O_2-content	
									constant	regulated	mea-sured	av.v. % xx)
RUG	2 x 6	2	780	400	prop.	8	14.000	0,2/0,2	no	yes	no	2-8
Dantest	5,1 x2,5	1,3	850	750	gas	18	9.450	0,7/1,0	yes	yes	no	4-10
FIRTO	7 x 4	1,5	2.100 (65%)	60	nat.gas	40	21.200	0,35/0,40	yes	.yes	no	?
TRADA	4 x 3	1,5 - 3	900 (50%) 1200(50%)	35 part	prop.	20	10.300	0,5/1,2	yes	yes	no	6-8
Warrington	4,0 x3,0	0,98	850(50%) 2050(50%)	100	nat.gas	14	6.35 0	0,4/0,55	yes	yes	no	?
YARSLEY	-	-	-	-	-	-	-	-	-	-	-	-
CSTB	3,o x3,7	1,65	2.260	100	oil	2	12.000	1 /2,5	yes	yes	no	?
CTICM	3,6 x5,6	3,13	1.000	?	?	8	6.400	0,9/1,1	yes	yes	no	10-12
BAM	4,0 x4,1	1,5	1.750	200	oil	4	?	0,5/0,8	yes	yes	no	?
TU Braunschweig	9,5 x4 10 x 14	1,8 1,5	2.000 1400 2000	400 600	oil	14 16	42.087 40.100	1,0/1,5	yes	yes	no yes	? 5
MPA NW	4,5x4	1,8	2.000	200	oil	3	12.900	0,8/1,35	yes	yes	no	5-7
FMPA	7,9 x2,3	2,25	?	?	oil	12	20.160	1,2/1,8	yes	yes	no	?
HFM	-	-	-	-	-	-	-	-	-	-	-	-
CSEA Rom xxx)	3,0x6,0	?	2.000	500	oil	12	41.000	0,75/1,3	yes	yes	no	?
TNO	2 x 4	0,7	?	?	nat.gas	48	2.880	0,25/0,4	no	no	no	2-6

x) First value at 50%, second value at 100% of nom. capacity

xx) At non-combustible materials.

xxx) This furnace is also used for beams, walls (2,4 x 3) and columns.

Table 2d - Beam furnace.

Laboratory	size a x b (m x m)	height (m)	density of lining kg/m^3	nr. of tests until relining	type of fuel	nr. of burners	nom.cap. of all b. mJ/h	length of flames (m) x)	Is the fuel/air-ratio		O_2-content	
									constant	regulated	measured	av.v. % xx)
RUG	2 x 6	2	780	400	prop.	8	14.000	0,2	no	yes	no	2-8
Dantest	5,15x2,5		850	750	gas	18	9.450	0,7/1,0	yes	yes	no	4-10
FIRTO	7 x 4	1,5	2.110 65% 850 35%	60	nat.gas	40	21.200	0,7/1,0	yes	yes	no	?
TRADA	4 x ?	?	900(50%) 1200(50%)	35 part.	prop.	20	10.300	0,5/1,2	yes	yes	no	6-8
Warrington	4,0 x3,0	0,98	850(50%) 2050(50%)	100	nat.gas	14	6.350	0,4/0,55	yes	yes	no	?
YARSLEY	-	-	-	-	-	-	-	-	-	-	-	-
CSTB	3 x 3,7	1,65	2.260	100	oil	2	12.000	1 /2,5	yes	yes	-	-
CTICM xxx)	3,6 x3,6	3,13	1.000	?	?	8	6.400	0,9/1,1	yes	yes	no	10-12
BAM	2 x 4	1,5	1.750	200	oil	4	?	0,5/0,8	yes	yes	no	?
TU Braunschweig	9,5 x 4 10 x 4	1,8 1,5	1.400 2.000	400 6 00	oil	14	2.087	1,0/1,5	yes	yes	no yes	72 8
MPA NW xxxx)	4,2 x4,0	2,6	2.000	200	oil	8	31.200	0,4/0,6	yes	yes	no	5-7
FMPA	7,9 x2,3	2,25	?	?	oil	12	20.160	1,2/1,8	yes	yes	no	?
HFM	-	-	-	-	-	-	-	-	-	-	-	-
CSEA Rome	see table 2c											
TNO	1,4x8,0	?	850	?	nat.gas	9	4.050	0,3/0,7	no	no	no	2-6

x) First value at 50%, second value at 100% of nom. capacity

xx) At non-combustible materials

xxx) This furnace is also used to partitions, columns and floors.

xxxx) Mainly used for floors

5. OPERATING CONDITIONS (see also tables 2a, 2b, 2c, 2d)

5.1 Heating

- As fuel natural gas, propane and oil are used. As in no lab butane is used, it seems to be reasonable to delete it from doc. 1202.

- Concerning the heat transfer with the different fuels, see the "Van Keulen" report.

- The number of burners in the same type of furnace differs very strongly (for wall furnaces between 3 and 100).

  The reason using a large number of burners is to obtain a good uniformity in furnace temperature. This however was also reached in the furnaces with a small number of burners.

- The figures given for the nominal capacity of the furnaces give no indication about the real combustible consumption, which is not measured at most laboratories.

- The expected relation between inner surface of a furnace, O_2 content and fuel consumption is not reflected in the figures given for maximum nominal capacity. For some figures it is evident that there are mistakes. For others one can expect that the heating capacity is too low to fulfill at the same time the requirements of O_2 excess, and temperature curve for specimens with high heat loss or large thermal capacity.

- In relation with the heat transfer the given values for the length of the flames and the information on the location of the burners, should be looked at. In some furnaces the specimens are heated only by hot gasses, in other furnaces they are subjected to direct radiation from long flames (max. length 2 m). For the moment being one is not in a position to estimate the possible influence of this factor on heat transfer to specimen.

- Although there is the "Van Keulen" report on heat transfer in wall-furnaces which is based on the results of a round-robin exercice, it seems to be useful to study the influence of the detailed factors which are mentioned above.

The aim of these study should be :

a) to show the possible influence of the single factors on test results;

b) to examine the necessity of closer specification of the heating conditions in a future version of doc. 1202.

- Although most furnaces are equipped with automatic temperature control, this equipment is not used and furnaces are manually controlled.

- The question concerning the constancy of fuel air ratio was answered nearly in all cases yes. As it was seen during the visit in most cases the control of fuel and air were linked but as in most laboratories, neither air and fuel consumption nor O_2-content are measured, doubts remain within what limits constancy is obtained.

5.2 O_2-content

- In most laboratories no equipment for O_2-measurement is available. The given figures for O_2-content during a test on a non-combustible material in some cases are only rough estimations (Dräger tubes, which do not measure continuously).

- In order to meet the requirement of doc. 1202 it is necessary to provide O_2-apparatuses. Experience then will show to what extent the existing furnaces do operate at the prescribed values.

- On the basis of the existing experience it can be stated that the minimum value of 2 % (see doc. 1202) can not be satisfied by specimen of combustible materials, therefore the limits of 2 - 5 % where restricted to elements of non-combustible specimen. Experience will show later if these limits can be brought closer together.

5.3 Pressure conditions

- It is proposed to extend the pressure conditions for separating elements to all building components, taking into account the possible influence of convective heat transfer inside the cladding of protected load bearing elements.

- In some labs there are anomalies in pressure distribution near combustion gas outlets and burners. Therefore calibration tests are proposed in order to check the uniformity.

6. MEASURING DEVICES (see table 3)

6.1 Temperature inside the furnace

- Only in a few cases equipment was seen which allows to keep constant the distance between furnace thermocouples and specimen.

  In order to meet this requirement special arrangements have to be made and for the moment being it is not clear whether there is a significant influence as long as there is no contact between thermocouple and specimen. A change of doc. 1202 therefore was proposed, further measurements have to verify this solution.

6.2 Pressure

- The deflector in front of the T-shaped tube is not used in most labs because of practical problems (deformation) and because it had no significant influence.

  For the open tube it was felt that it can give different results from the T-shaped tube, therefore it is proposed that it should not be used without comparing its results with the T-shaped tube.

  Besides this it seemes to be necessary to specify more clearly the location of the pressure measuring points.

- The questions concerning the time delay of pressure measurement were answered unsufficiently. The registration records with pressure pick-ups sometimes show very quick pressure changes which are not observed by slower measuring systems.

  With very quick measuring devices the differences between minimum and maximum peaks can be more than 5 Pa.

  In order to guarantee a harmonised way of working it is proposed to base furnace control on a measurement averaged over a 1 minute period.

6.3 The temperature on non-exposed sides

- As shown in table 3 some laboratories use only the minimum required number of thermocouples and check the hot spots with a movable thermocouple.

  Others use for this purpose a lot of additional fixed thermocouples. In order to harmonize this a more detailed specification for the different elements is given in Part 2.

The movable thermocouples used were different in design. A standardized movable thermocouple is defined as the design has great influence on the response.

- It is felt that there is a general lack of calibration of thermocouples.

6.4 Integrity measurement

- Experience during the visits showed that as well the technique of application of the cotton pad, as the evaluation and interpretation of the results were strongly different in the labs.

In some labs the cotton pas was only applied in front of gaps in others it is also applied in front of hot surfaces (glass) or in front of flames with a duration shorter than 10 seconds. In some laboratories only flaming of the cotton pas is considered as ignition, in others glowing is also considered as ignition (see ISO definition of ignition and combustion)

- A clearly defined specification concerning the cotton wool pad technique is therefore suggested.

- The cotton wool pad technique is not able to judge integrity in the under pressure zone od the partition.Therefore in U.K. and France an additional criterion is used, defined by maximum dimensions of the openings In Germany overpressure in the furnace is increased during short times. In Belgium the overpressure level is higher (20 Pa) and present over the whole height of a vertical specimen.

- The criterion of substained flaming is interpreted differently in different countries. In some labs any flaming means end of integrity, in others 10 s is the minimum duration limit, in one lab 20 s.

- As this criterion strongly influences the classification of separating elements a new discussion is necessary in order **to** find a criterion, acceptable for all countries.

If no agreement is possible on this point, provision has been made in the revised proposal that any flaming on the unexposed faces and its duration is reported so that reclassification in different countries is possible.

Table 3 - Insulation and integrity measurements on walls and floors.

Laboratories	Surface temperature			Furnace pressure		End of integrity by				
	Nr.of fixed thermoc. x)	Movable thermoc.	Other equipm.	Nr. of measur.p. x)	Form of measur.p. x)	Glowing of cotton pad	Ignition of c.p. by radiation	Cracks size (mm)	Flames of (s) duration	Combustion gases determined
RUG	10/10	yes	-	1/1	B/B	no	yes	no	> 0	no
Dantest	5/5	no	-	1/2	A/B	no	yes	no	10	no
FIRTO	7/7	no	-	3/	A/spec form	No	no	no	?	?
TRADA	5/5	yes	-	√1	B/B	no	yes	150x6	10	no
Warrington	?/5	yes	-	5/3	A/A	No	no	150x6	10	no
YARSLEY	⩾6	yes	-	4/-	B/-	no	no	150x6	10	no
CSTB	6/5	no xx)	yes	6/1	B/B	no	no	20-30cm²	20	yes
CTICM	18/9	yes	-	1/1	A/A	no	no	60x1,5	10	yes
BAM	12/6	no	yes	1/1	B/B	yes	yes	xxx)	> 0	yes
TU Braunschweig	⩾ 12/12	no	yes	3/1	B/B	yes	yes	xxx)	> 0	yes
MPA NW	14/10	no	yes	1/1	A/A	yes	yes	xxx)	> 0	yes
FMPA	13/10	no	yes	3/1	B/B	yes	yes	xxx)	> 0	yes
HFM	?/-	no	yes	3/-	A/-	yes	yes	xxx)	> 0	yes
CSEA Rom	5/5	yes	no	no	no	?	?	?	?	?
TNO	10/5	yes	no	1/1	B/B	no	no	no	10	no

x) First value for walls, second value for floors.

xx) Under development.

xxx) For judging cracks in the underpressure zone, the pressure is increased for a short time to a level that in front of the crack an overpressure of about 10 Pa is realised.

6.5 Stability

From the answers on the questionnaire it appeared that the removal of the stability criterion would not cause problems in the cases of non-loadbearing elements.

In order to avoid the creation of a new classification (EI) it is suggested to combine the criterion R with the criterion E for these elements.

7. LOADING AND END CONDITIONS

7.1 Loadbearing walls

7.1.1 Loading system (table 4)

- In all laboratories a hydraulic system is used for the load application on walls and partitions.

- Mostly a single load distribution beam is applied so that the total load (for partitions) is equally divided over the different load bearing studs. Only some laboratories apply several short distribution beams, each of them transmitting the force of one ram.

This raises the question of the test load : is the total load determined by the number of studs multiplied by the load per stud or, is it defined by the load per meter multiplied by the width of the partition. Both approaches can conduct to very different load levels besides the differences in national design codes.

For purposes of harmonization a single load distribution beam over the whole width of the specimen is suggested. This does not cover particular cases where the studs of a partition are unequally loaded.

- The stiffness of the frame has to be considered in direct relation with the load level and therefore a maximum deflection criterion by maximum load, at least for the horizontal members of the frame, has to be established (see C.T.I.C.M.). In the new draft a value of 1/600 for deformation under design load therefore is proposed.

- A similar requirement has to be established concerning a possible partial rotation of the load distribution beam on the vertical members.

- It is observed that very different load capacities (from 8 T to 400 T) are available, linked to very different speeds of the ram : from 0,7 mm/s to 25 mm/s. This can have a minor influence on the stability with a quickly deflecting specimen at the end of the test.

- There is a general and very important uncertainty about the overall accuracy of the load applied to the specimen in most laboratories !

This is due to one or more of the following facts :

1°/ The measurement, and mostly also the monitoring of the load level during the test is based on a measuring device, the accuracy of which in general is only estimated.
A variety of different types of apparatuses are used.

2°/ With exception for load cells, positioned between load distribution beam and specimen, "sensors" are more or less remote from the specimen and subject to faulty measurements caused by friction and/or pressure drop between measuring point and specimen.

3°/ It is astonishing how few information is available in most laboratories about the extent of friction losses in their loading systems.

4°/ A low stiffness of some frame members, together with excentrical loading or specimen deformation can cause jamming of the load distribution beam and hence an uncontrolled increase or decrease of the load.

5°/ Calibration of the loading system in general is insufficient. The use of loads cells between specimen and load distribution beam, or at least as close as possible to the specimen, seems necessary. Besides that it is necessary to use frames and loading equipment with minimum friction. This friction should be established with load cells by loading and unloading of the specimen in cold state. It was not possible to propose a generally applicable solution on the basis of the visits, because the loading system is closely linked to the design of the furnace.

- The question of monitoring the load was not understood properly : it is not clear whether all laboratories do keep constant either the load or the position of the load distribution beam. The latter choice provides an increasing load with thermal dilatation of the specimen.

From the answers it appears that some laboratories have automatic control over the load level (by keeping the oil pressure constant), others have manual control. Usually monitoring is done on the basis of the same measuring instrument as used for the initial application of the load.

(x) VH very high
H high
M medium
L low

TABLE 4 - LOAD-BEARING WALLS : LOADING SYSTEM

Lab.	Rams		Load distribution beam			Stiffness of frame members (x)			Load capacity (max) (Ton)	Speed of rams mm/s	Monitoring the load level			
	Number	Position	Kind of beam	Stiffness of beam (x)	Position of floating beam	Top	Bottom	Vertic			Sensor (type)	Location	Accuracy	Calibration device
R.U.G.	2 to 4	Top	one beam per ram or one beam	L H	top	L H	VH	VH	200	8	Manometer	Pump	5 to 10%	Load cell
DANTEST	2	Bottom	one beam	VH	top				8 or 20	5	Manometer	Pump	5 to 10%	Load cell
FIRTO	2	Bottom	one beam	VH	bottom	VH	VH	H	500	?	Manom.+ load cell	(?)	5%	Load cell
TRADA	≤ 4	Top	4 short beams	VL	top	V	VH	VH	20	1	Pressure gauge	at ram	5%	Load cell
WARR.	2 (?)	Bottom	one beam	M	bottom	H	M	VH	22	25	Hydr. pressure	at ram	2,5%	Load cell
C.S.T.B.	4	Bottom	one beam	VH	bottom	VH	VH	VH	400	0,7	Load cell	?	0,1 F.S	Load cell
C.T.I.C.M (u)	1 or 2 (?)	Top	one beam	defl. < 1/1000	top	def. < 1/1500			220 50 20	1,2 5 12	Manom. or load cell	(?)	3% 0,5%	Load cell
(G)	4 to 8	Top	?	1/1000	top	def. < 1/1500			8 x 30 8 x 150	1 0,25	Manom.+ load cell	(?)	2,5%	Load cell
T.U.B. (1) (2)	1-3 2	- Bottom	- one beam	- VH	- bottom	VH (x)	VH	Ø 120 Ø 20	400 200	6 6	Dynamom. Oil pres.	? ?	1%	Dynamometer
(6)	2	top	"	VH	top	H	H	H	20	6	(?)	?		
M.P.A.	2	Bottom	one beam	M	top	M	M	L Ø 80	5	3	Hydraul. Dynamom.	?	2%	?
F.M.P.A.	Accord. to pract.	Top	according to practice	(?)	top of one	H	H	L Ø 75	200	?	Electronically		1%	Reference load
C.S.E.A.	3 (?)	Top	(?)	(?)	top	H	H	H	?	?	Dynamometer	at pump	?	yes
T.N.O.	2	Top	one beam	H		H	H	M	30	15	Load cell		1%	nO

7.1.2 Mechanical end conditions (table 5)

- It appears that similar as for non-load-bearing walls and partitions also for load-bearing ones the end conditions with both vertical edges free do not necessarily give the worst results.

Changement of doc. 1202 in this respect should be discussed.

- Concerning the mechanical end conditions at top and bottom of walls and load-bearing partitions, a distinction must be made between the possibility of rotation and translation for the load distribution beam and for the other horizontal members on the one hand, and for the horizontal edges of the specimen on the other hand.

- The possibility of (partial) rotation and/or (partial) translation of the horizontal members is dependant on the stiffness of the complete frame, on the stiffness of the individual frame members and on the concept of the system.

- The lack of precise answers in the questionnaire show the lack of consciousness in several laboratories concerning this aspect of the mechanical end conditions.

The influence of this point has already been discussed under § 2.

- The positioning of the walls or partitions against load-distribution beam and against the horizontal members are mostly realised "like in practice" i.e. simply in contact with the frame member for walls and sometimes with top and bottom profile screwed for a partition.

As the fixing of top and bottom can influence the static system (buckling length), in the new doc. a strict requirement is introduced that this has to be done like in practice.

- It has to be noted that in several laboratories the way of mounting (mechanical and thermal end conditions) for walls (concrete and masonry) is different from the way of mounting for load-bearing partition.

This is partially due to the different practical problems related with a low level of loading for partitions (up to 20 T) from the high load level for walls (i.e. up to 400 T).

- The figures given in the table have to be considered rather as the interpretation of the authors than as precise answers from the laboratories

7.1.3 Thermal end conditions (table 5)

- As it can be seen from the table the thermal end conditions in most laboratories are already satisfied. Exposure of all four edges of a loadbearing wall is important. For bottom and top, reduced heat attack can influence E and I. For the vertical edges reduced thermal attack can increase R. Therefore clear specifications are given in Part II.

- The heat loss to the frame at top and bottom of the specimen is influenced by the thermal characteristics of the frame. Therefore a rough specification is introduced in Part II.(ϱ = 2,0 +/- 0,5 kg/m3).

TABLE 5 - LOAD-BEARING WALLS : END CONDITIONS

Laboratory	Mechanical-Frame				Mechanical-Specimen		Thermal end conditions		
	Upper member		Lower member		Side/Edges Free de-flection	Top/Bottom	Edges directly exposed to heat		
	Rot.	Transl.	Rot.	Transl.			Top	Sides	Bottom
RUG wall	yes	part.	no	no	yes	S.P.	no	yes	no
RUG part.	no	no	no	no	yes	practice	yes	yes	yes
DANTEST	no	no	no	no	yes	?	yes	yes	yes
FIRTO	no	no	part.	no	yes	practice	?	yes	?
TRADA	yes	part.	no	no	yes	S.P /SP	yes	yes(?)	yes
WARR.	no	no	part.	part.	yes	Fixed/ Fixed	yes	yes	yes
CSTB	no	no	no	no	no		no	yes	yes
CTICM	yes	yes	no	no	?	fixed/(x)	yes	yes	yes
T.U.B.	part.	no	no	no	yes	?	yes	yes	yes
M.P.A.	part.	part.	no	no	yes	SP/fixed	no	yes	yes
FMPA	part.	part.	part.	part.	only 1 side	fixed/ fixed	yes	yes	yes
CSEA	yes	part.	part.	no	high degree of ? friction Masonry (x)	yes/S.P.	no	yes	yes
TNO	no	no	no	no	yes	fixed/ fixed	yes	yes	yes

(x) Not clear from questionnair (no or incomplete answer)

S.P. : Simply put.

7.2 Floors (table 6)

7.2.1 Loading system

- In several labs the loading system used for floors depends on the type of floor and the magnitude of the load.

- As can be seen from the table the loading system in the different laboratories is quite different. This concerns as well the number of loading points as the contact surface. Especially for dead loads the contact surface, which should characterise the thermal influence seems insufficient to characterise it. In C.S.T.B. nearly the total specimen surface is covered although the contact surface is only 0,3 %. A solution is presented by limiting the surface of the horizontal projection of the loading points.

- For hydraulic load system A a multipivoted pyramidal load distribution system is necessary in order to guarantee a well defined equal load distribution. In this respect line loads have to be excluded.

  This was introduced in the new doc.

- The relation between the size of loading spots and the thickness of the floor seems unreasonable because especially thin floors are weak in relation with high local load concentrations, therefore the corresponding requirement of doc. 1202 was replaced by fixed values of surface area.

- During the visits it appeared that the load distribution did not provide statically equivalent loading (maximum loading moment and maximum shear forces).

  The text of the revised doc. has been closer specified.

7.2.2 End conditions

- In the discussion it appeared that the end conditions with floors supported at two sides do not give necessarily the worst results.
A changement of doc. 1202 in this respect (3 sides fixed edges in practice) should be discussed.

- In most laboratories free deflection is guaranteed but the thermal elongation in several laboratories is partially prevented by friction. In part II of the revised doc. a rolling support on one side is introduced mandatory.

Table 6 : FLOORS - LOADING SYSTEM AND END CONDITIONS.

Laboratory	Loading: Load system h=hydraul. d = dead	Nr.of load. points per m^2	Contact surface of floor (%)	Max. load capacity (t)	Speed of rams (mm/s)	End conditions: Distance (cm) between furnace wall and support	end of specimen	Free elongation of specimen	Free deflection of specimen
RUG	h d	2 line loads/12 1	10 6	30 3	2,5 -	0	30	friction	yes
Dantest	h	2 line loads/13	4	20	5	30	40	yes	yes
FIRTO	d	?	?	10	-	0	25	friction	yes
TRADA	d	variable	-	10	-	0	10	friction	?
Warrington	h d	16 variable	1,3 -	45 2,1	10	10	20	friction	yes
YARSLEY	-	-	-	-	-	-	-	-	-
CSTB	d	24 line loads/12	0,3 see § 7.2.1	?	-	15	30	friction	yes
CTICM	h	2 line loads/12	?	220	?	?	?	yes	yes
BAM	h	8 lines/16	6	120	5	35	?	friction	yes
TU Braunschweig	h d	4 line loads/ 16 1	2,3	120	6	37,5	50	yes	yes
MPA NW	d	1,5	20	6	-	40	50	yes	yes
FMPA	?	?	?	?	?	12,5	21,5	yes	yes
HFM	-	-	-	-	-	-	-	-	-
CSEA Rom	h	3 line loads/18	?	?	?	40	50	friction	yes
TNO	h	1	8	20	15	$\leq$ 10	$\leq$ 20	yes	yes

- Great differences have been observed concerning the unheated ends of the floors. As this can have great influence maximum values have been introduced.

7.3 Beams (table 7)

Most of the remarks made for floors are also applicable for beams, especially the problem of the cold edges.

7.3.1 Loading system

- Except in TRADA all laboratories used hydraulic loading systems.

- In some laboratories it was noted that in the load distribution system no provision is made to avoid changes in the loading system when the specimen deforms (elongation and deflection). Thus additional horizontal components are created.

The load distribution system must be isostatic by design. A requirement in this direction is introduced in Part II.

- In two labs the topping of the beam was cast in one block and was more or less fixed to the beam with anchors. By this arrangement the topping will overtake at least an undeterminate part of the load bearing function.

In part II a detailed description and mandatory requirement for the topping are introduced.

This concerns also the nature of the topping in relation with the heat loss.

Composite floor-beam elements are tested in the same way as floors without additional topping.

- During the visits, no problems with torsional deformation or lateral buckling were observed.

If torsional deformation or a lateral buckling in a test on a single beam are expected provision like in practice can be made in order to avoid this. The load applied during the test shall be adopted accordingly (composite structure).

7.3.2 Heating conditions

- Care must be taken that for beams exposed at three sides, the vertical sides are fully exposed over the total height.

TABLE 7 : BEAMS - LOADING SYSTEM AND END CONDITIONS.

Laboratory	Loading			Topping			End conditions			
	Nr.of loading points	Max.load capacity (t)	Speed of rams (mm/s)	thickness (cm)	nature	can it follcw deformation	distance between furnace wall and (cm) support	end of specimen	free elongation of specimen	free deflection of specimen
RUG	2-4	80	2,5	10-80	gas-concrete	yes	15	30	yes	yes
Dantest	-	20	5	no detailed information						
FIRTO	4	4,5	?	12,8	concrete	yes (x)	12,5	20	yes	yes
TRADA	no detailed informations									
Warrington	4	45	25	13	concrete	yes (x)	30	40	yes	yes
YARSLEY	-	-	-	-	-	-	-	-	-	-
CSTB	2	36	?	?	concrete	no	15	30	friction	yes
CTICM	2	220	?	no	-	-	?	?	yes	yes
BAM	4	120	5	no detailed informations						
TU Braunschweig	4	120	6	12,5	gas-concrete	yes	37,5	50	yes	yes
MPA NW	-	-	-	-	-	-	-	-	-	-
FMPA	2	100	?	12,5	gas concrete	yes	12,5	21,5	yes	yes
HFM	-	-	-	-	-	-	-	-	-	-
CSEA Rom	2-3	?	?	no	-	-	40	50	friction	yes
TNO	4	20	13				$\leqslant$ 10	$\leqslant$ 20	yes	yes

(x) See comment

7.4 Columns (table 8)

- In most laboratories the stiffness of the frame seemed sufficient at least in one direction but there were great differences in the end conditions and the way of mounting the specimen. Especially the possibility of rotation or restrained are not fully defined in most cases.

- Where the possibility of rotation is intended, this was not fully achieved and the same is valid for end restrained.

Concerning clearly defined end conditions a statement is made in doc. 1202. However it is considered that this aim cannot be achieved without important and expensive changements of the equipment. The consequence of the existing differences are judged of great influence on the measured R values, because it influences strongly the buckling length of the specimen, and by this the load bearing capacity.

- An other point of similar importance is the axiality, resp. excentricity of the load. By excentric loads, bending moments and torsions are introduced which will cause an earlier failure.

Only in two labs there were special means to guarantee exact centricity, in one other lab a well defined excentricity was applied in order to meet excentricities which occur in practice and in order to improve the reproductibility during the tests. For harmonization purpose it is absolutely necessary to give clear instructions on this. In the revised doc. therefore it is suggested to check the situation before each test by using straingauges. An alternative solution could be to impose the maximum excentricity allowed for centrically loaded columns and to describe the way how to achieve this.

- It was questionned whether in all cases testing of the two static systems will provide results relevant to practice.

In the revised document it is suggested to check which of the two static systems will give the worst results and not to carry out the other test. An other suggestion was to make a general choice for the static system for the test. T.N.O. offered to prepare a document providing the theoretical background for this choice.

Differences of 0 to 0,6 m were observed between heated length and calculation length, the calculation length being defined as the length between hinges and restrained ends.

It is expected that this causes great differences in R-values. Also this problem can not be solved without important changes to the equipment.

In addition also the heat loss of the column ends to the surrounding (e.g.) concrete blocks, steel plates, unheated column ends) was different.

The above-mentioned points show that for columns harmonization is restricted by the differences in the existing equipments.

Comparable results can only be expected by identical furnaces and loading equipments. It is therefore suggested to prepare a design of a furnace which should be followed when new furnaces are built.

TABLE 8 : COLUMNS - LOADING SYSTEM AND END CONDITIONS

Laboratory	Max. load capacity (t)	Speed of rams (mm/S)	Stiffness of frame	Heated length minus calculation length (m)	heated length (m)	length of the cold end (m) at		Ends restraint/rotation possible at	
						top	bottom	top	bottom
RUG	400	1,2	H/L **	0	3,86	0,25	0,25	restraint	restraint
Dantest	-	-	-	-	-	-	-	-	-
FIRTO	500	?	H	- 0	3	0,2	0,44	restraint	rotation
TRADA	-	-	-	-	-	-	-	-	-
Warrington	-	-	-	-	-	-	-	-	-
YARSLEY	-	-	-	-	-	-	-	-	-
CSTB	250	0,4	4	- 0,6	3	?	?	not defined	not defined
CTICM	220	1,2	VH	- 0,5	3,1	0,20	0,21	partially	partially
BAM	200	2	M	- 0,64	3	0,49	0,15	partially	partially
TU Braunschweig	400	6	VH	- 0,2	2,0-6,0	0,1	0,1	rotation	rotation
MPA NW	-	-	-	-	-	-	-	-	-
FMPA	400	?	VH	- 0,485	3,36	0,255	0,22	rotation *	restraint
HFM	-	-	-	-	-	-	-	-	-
CSEA Rom	?	?	H	0	3,34	0	0	not defined	not defined
TNO	-	-	-	-	-	-	-	-	-

VH very high
H high
M medium
L low

* only in one direction
** high in one direction, low in the other

8. TEST LOAD (see table 9)

It is evident that the test load has an important influence on the fire resistance time of a load bearing element.

In most laboratories the test loads are calculated following national design codes. Therefore differences between these codes influence the test load and hence the test result. It is out of the scope of this study to compare the national design codes.

Nevertheless it seemed to be usefull to have some comparative data on the loading calculations.

Therefore the laboratories have been asked to give the calculations of the test load for four load bearing elements.

The elements were :

a) a steel beam - simply supported;

b) steel column - one end hinged, the other end fully restrained;

c) steel column - both ends fully restrained;

d) timber stud wall.

With the exception of Italy answers were received from all the participating countries. The data are summarized in table 9.

For the steel beam the table shows neglectable differences between the test load calculated.

For the steel columns the test loads calculated show differences up to about 200 kN on a test load of app. 1 000 kN.

Extreme great differences are found for the timber stud wall.

It is noted that in some countries the contribution of the lining materials are not taken into account by the calculation of the test load of a timber stud wall. Besides, the situation in Denmark - a great difference between calculated load and test load in practice - is of interest. From this simple investigation on test loads can be learned that full harmonization of fire resistance test requires prior harmonization of design codes within the EEC.

However, according to the statement in § 5.2 of the revised document 1202 the test results are applicable with the limitation to the load applied during the test.

This has to be mentioned expressively in the test report.

Table 9. Summary answers received on questionnaire concerning test load on a beam, column and partition.

Country		Test load in kN				Calculation method	Remarks
		Steel columns 3m HEB 180	3m HEB 180	Steel beam HEB 180	Wooden partition 3mx 3 m		Construction partition Studs 60x100mm distance between centrelines 600mm. Particle board 16 mm on both sides.
Belgium		991 kN	1063 kN	33,4 kN/m^2	-		No design code available for timber structures. Load on request of sponsor
Denmark		960 kN	1030 kN	37 kN/m^2	66,6 kN/m^2 (pract.)	Columns and beams DS 412 and DS 410	test load on partition in practice 10-40% of design load normally (7-26 kN/m^2)
England		970 kN	1019 kN	37,7 kN/m^2	Hem-fir GS 23,2 kN/m^2 Redwood SS 28,8 kN/m^2	Columns and beams BS 449 part 2 - 1969.	
France		1140 kN	1198 kN	34 kN/m^2	25,83 kN/m^2	Calc. acc. règles de calcul des constructions en acier.	Partition: Particle board is not taken into account by calculation of test load.
Germany		969 kN	1136 kN	34,1 kN/m^2	300 kN/m^2	Columns and beam DIN 1050. Partition DIN 1052 ($\sigma_{\perp}$= 2,5 N/mm^2	Partition : 15.8 kN/m^2 (nail distance 40 mm)
Italy							
The Nether-lands		1042 kN	1147 kN	34,1 kN/m^2	42 kN/m	Columns and beam TGB-1972-steel-partition TGB 1972 timber.	Diameter nails Ø 4 mm
Minimum value test load		960 kN	1019 kN 994 kN	33,4 kN/m^2	23,2 kN/m^2		
Maximum value test load		1140 kN	1198 kN	34,1 kN/m^2	66,6 kN/m^2		

9. CRITERIA AND APPLICATION OF TEST RESULTS

9.1 Criteria

For load bearing elements which are subjected to bending two different deformation criteria are given for stability.

The one is for simply supported elements, the other for hyperstatic elements. A criterion imposed to avoid a special danger in practice cannot be dependend on the statical system. Therefore it should be considered to apply the same delfection criterion (either deflection rate or a maximum deflection) for both cases.

9.2 Extrapolation

The existing document 1202 does not contain explicitly information on extrapolation and interpolation of test results.

Implicitly extrapolation is allowed by the regulation concerning size of specimen : the requirement to choose a height and width of 3 m for a wall specimen it it is in practice greater, implies an unlimited possibility to extrapolate the dimensions to a greater height.

This requirements excludes as well the possibility of extrapolation to lower dimensions as the possibility of any extrapolation from speciem which have lower dimensions than 3 m x 3 m.

From a technical point of view it seems not acceptable to use this extrapolation rule without limitation.

So one cannot accord the same classification to elements with essential higher dimensions than the tested element.

It is clear that for practical reasons extrapolation of test results is necessary.

These extrapolation rules should cover the field of higher and lower dimensions.

In some countries extrapolation rules exist for some elements and these rules are different from country to country.

For trade, harmonization in this field, is of the same importance as harmonization of the test method.

This work is not covered by this document. It will require an extensive study. In the opinion of the authors it should be started with a detailed questionnaire on the existing extrapolation rules and habits in the different countries covering all possibilities of extrapolation e.g. dimensions, load, massivity factor, etc.

In the light of the above mentioned problems the following points should be discussed :

- non-load bearing walls and partitions : limitation of the extrapolation to a greater height;
- for load bearing elements : the extrapolation limitations should take into account the static system and the load level;
- extrapolation of steel columns and beams to other profiles the massivity factor must be taken into account.

10. REMARKS ON TEST REPORT

A basic requirement for international acknowledgement of test results is that the test reports contain all necessary information in an understandable and harmonized way. Therefore the actual way of drafting test reports by the different laboratories was compared.

A survey of these reports has been given in table 10.

Special attention was given to the following points :

a) description of the test specimen (including drawings and details);

b) information on material properties;

c) description of thermal and mechanical end conditions;

d) test load and its calculation;

e) test procedure;

f) observations during and after the test.

The results of the study have been summarized in the tables 11-15.

Table 10. Survey of test reports

Country	Name of Laboratory	Type of construction					
		Beam	Column	Floor or Roof	Non load bearing wall/partition	Load bearing wall/partition	Other Items
Belgium	RUG	x	x	x	x	x	
Denmark	DANTEST			x		x	
England	FIRTO		x	x	x		
	TRADA			x		x	
	WARRINGTON	x		x	x		
	Yarsley				x		
France	CSTB	x	x	x	x	x	
	CTICM		x	x	x		
Germany	BAM		x				
	TU-Braunschweig	x		x	x		
	MPA -NW			x	x		
	H.F.M.						Glazed door
	F.M.P.A.		x		x		
Italy	CSEA	x	x	x	x		
The Nether-lands	TNO			x		x	
	Total	4	7	11	10	4	1

Table 11A. Summary of reports on beams

Name of laboratory	Specimen	Test specimen							End conditions			
		Construction of specimen			Material properties Measured values on day of test				Thermal		Mechanical	
					Protecting materials			beam	length of			
		Description	drawings	details	density	relative humidity	thickness	mechanical properties	heated part	unheated part	supports	restrained
RUG	Protected steel beam	Missing : way of fixing of the protection cladding (sprayed, by hand etc.) scatter in thickness of the protection.			not given	not given	given	missing steel properties at normal temperature	6000 mm	2x350 mm	not given	not given
TU Braunschweig	Protected steel beam	sufficient	sufficient	sufficient	given	given	given	missing steel properties at normal temperature	4750 mm	2x125 mm	two rolling supports	Beams tested complete unrestrained.
Warrington	unprotected steel beam	sufficient	sufficient	sufficient	not applicable			missing steel properties at normal temperature	4000 mm	2x392 mm	2 rolling supports	rotation unrestrained. Elongation unknown
CSTB	Protected steel beam	sufficient	sufficient	sufficient	not given in the report				3740 mm	2x250 mm	supported by I- beams	Elongation partly restrained (by friction)
CSEA	Special roof beam	poor	dimensions insuff. given.	details of ceiling etc not given.	not given in the report				3800 mm	?	not given	?

See also next page for table 11 B.

Table 11B.

Summary of reports on beams

Name of laboratory	Specimen	Testload		Test method					Observations and Measurements		Other remarks
		Calculation of testload	Loadsystem	Time temp. curve: Diagram or table	Time temp. curve: Tolerance temp.distr. within furnace	Time temp. curve: Integral curve	Furnace pressure	O_2 content	Observ. in furnace	Measurements	
RUG	Protected steel beam	Principles of calculation are given (permissable stresses 14 kN/m^2)	No detailed description or drawing	No data concerning time temp. curve in the report			acc. to NBN 713 020 20 ± 5 Pa No registration	missing	Short	Steel temp. given in report (diagram) missing deflection diagram	Topping of steel beam given in
TU Braunschweig	Protected steel beam	acc. to German standard DIN 1050 last fall H = 160 N/mm^2. Calculation is missing	No detailed description or drawing	No data concerning time temperature curve in report.			acc. to DIN 4102 10 Pa, no registration.	missing	Short	Steel temp. and deflection given in diagram.	Topping of steel beam given in report.
Warrington	Unprotected steel beam	Complete calc. given in the report.	No detailed description or drawing	Mean furn. temp.given in diagr.	not given in the report	not given in the report	not given in report	missing	Sufficient	steeltemp. and deflection giv. in a diagram	Topping of steel beam given in report
CSTB	Protected steel beam	Calc. of test load not given in report	No detailed description or drawing	All thermocouple readings given in a diagram		not given in the report.	not given in report	missing	Sufficient	steeltemp. and deflect. in diagram	Topping given in report
CSEA	Special roof beam	tested unloaded	not applicable	Mean furn. temp.given in report	not given in the report	not given in the report	not given in report	missing	not given in report	temps. of beams in a diagram	

Table 12A

Summary of test reports on columns

Name of lab.		Test specimen							End conditions			
		Construction of specimen			Material properties. Measured values on day of test				Thermal	Mechanical		
		Description	Drawings	Details	Protecting density	materials. relative humidity	thickness	column mechanical properties	length of heated part	length of unheated part	Top	Bottom
RUG	protected steel column	sufficient	suff.	missing joints between rock-wool plates	given	not given	given	steel prop-erties at normal temp.	3780 mm	0 mm	fully restr-ained	fully restrained
FIRTO	protected steel column	sufficient	suff.	suff.	given	given	given	not given	not given	not given	incom-plete descr-iption	incomplete description
BAM	Rectangular steel column filled with concrete	sufficient	suff.	suff.	not applicable			Yield strength steel and compressive strength concrete given	3000 mm	3600 - 3000 = = 600 mm	incom-plete descri-ption	incomplete description
FMPA	protected steel column	sufficient	suff.	suff.	given	given	given	steel properties at normal temp. not given	3360 mm	3845 - 3360 = = 485 mm	rotation in one direct-ion possible	fully restrained
CSEA	steel column protected with an intumes-cent paint	sufficient	suff.	missing: way in which paint is applied.	not applicable		given	not given	N O T	G I V E N	I N T H	E R E P ORT
CSTB	steel column protected with intumes-cent paint	extensive	suff.	suff.	not applicable	not applicable	given	not given	3300 mm	3600 - 3000 = = 600 mm	incom-plete descr-iption and drawing	incomplete description and drawing
CTICM	protected steel column	suff.	suff.	suff.	given	not given	given	not given	3600 mm	3600- 3100 = = 500 mm	incom-plete descr-iption and drawing	incomplete description and drawing

See also next page for table 12 B.

Table 12 B.

Summary of test reports on columns.

Name of lab.	Specimen	Calculation test load	Test method			Observations and measurements			Other remarks
			Control of furnace temp.	Furnace pressure	O_2 content	Observ. in furn.	Measurements		
							Steel	Elongation	
RUG	protected steel column	given in rep. acc. to NBN B51.001 euler 1. Both ends fully restr.	not given	20 ± 5 Pa	not given	suffic.	measured with 8 thermo-coup. results in diagram	given in a diagram	Steel temp. only measured in the middle part of column and not in upper and lower part.
FIRTO	protected steel column	given in rep. acc. to BS 449: part 2: 1969 effective length 0,7 1 euler.	only a diagram mean furnace temp. in the report	not given	not given	suffic.	measured with 12 thermo-coup. mean and max. temp. given in the report	given in a diagram	Reloading after 24 hours. Persons who witnessed the test are mentioned in the report.
CSTB	steel column protected with intu-mescent paint	only calc. meth.given in the report.	furn. temp. given in a diagram (all readings)	not given	not given	suffic.	steel temps. not measured	given in a diagram	
CTICM	protected steel column	only main points of the calc. are given	furnace temp. given in a diagram (all readings)	10 ± 5 Pa diagram given in the report	not given	suffic.	measured with 9 thermo-coup. diagram with all readings in the report	given in a diagram	
BAM	rectangular steel column filled with concrete	not given in the report	Furnace temp. given in (mean value and individual readings)	not given	not given	suffic.	steel + concr. temp. in a diagram	given in a diagram	
FMPA	protected steel column	the main points of the calc. are given	Furn.temp. given in a diagram (mean val-ue and individual	10Pa at 0,75 m from top column	not given	suffic.	measured with 6 thermo-coup. diagram with all readings in the report	recorded during whole heating	
CSEA	steel column protected with intum-escent paint	not given the report Testload indicated by sponsor	Furnace temp. given in a diagram (only mean value).	not given	not given	not given	measured with 6 thermo-coup. results in a diagram.	not given	

Table 13 A.

Summary of test reports on load bearing walls or partitions.

Name of lab.	Specimen	Test specimen						End conditions				
		Construction of the specimen			Material properties on day of test			Thermal		Mechanical		
		Description	Drawings	Details	Density	Humidity	Others	Heated part (widthXlength)	Dim. specimen (widthXlength)	Top	Bottom	Vertical edges
RUG	wall of aerated concrete blocks	suff.	suff.	suff.	not given	not given	report contains composition of the mortar. And dry weight of the concrete blocks	not given	1950 X 3250 mm	Not given in the report		
Dantest	timber stud wall	suff.	insuff. Horiz-ontal section is not very clear.	Constr. of the verti-cal joint between the two panels is unclear	given	not given	-	not given	2398 X 2495 mm	Not given in the report		free movement
Trada	timber stud wall	suff.	suff.	suff.	not given	only a drying time of 4 weeks is mentioned	-	given	3000 X 2440 mm	Fully restr-ained	not given	not given
CSTB	Wall of concrete blocks	suff.	suff.	suff.	not given	Drying time of 344 days is mention-ed.	-	not given	2820 X 2800 mm	Not given		
TNO	timber stud wall	suff.	suff.	suff.	given	not given	-	not given	1960 X 2440 mm	Not given		

See also next page for table 13B.

Table 13 B Summary of the reports on load bearing walls or partitions

Name of lab.	Testload		Test method					Observations and measurements		
	Calc. of test load.	Load system	Time temperature curve: Diagram or table	Time temperature curve: Tolerance temp. distr. within furnace	Time temperature curve: Integral curve	Furnace pressure	O_2 content	Observ. exposed and unexposed side	Measurements	Other remarks
Belgium RUG	Centrical loading $T = 4 kg/cm^2$ calc.not given in report	not given	no data concerning furnace temperature given in the report.			20+5Pa no re-ristra-tion	not given	sufficient	given in a diagram: average temp. of the unexposed side and deflection measured in the centre of the wall	Roving thermocouple for measuring the max. temp. rise not mentioned in the report
Denmark Dantest	calc. not given in the report. Change of testload after 30 and 60 minutes.	not given	diagram	given in a diagram	not given	not given	not given	sufficient	thermocouple readings of the unexposed side are given in a diagram. Deflection in a table.	Idem. the partition was loaded 2 hours before the start of the heating.
England Trada	The whole calculation is given in an appendix	not given	average temp. is given in the report	not given	not given	2.5 Pa no re-gistra-tion.	not given	extensive		Re-load test 24 hours after test. Roving thermocouple not mentioned in the report.
France CSTB	only total amount of loading is mentioned.	not given	all furn. thermoc-ouple readings given in a diag-ram.	diagram	not given	not given	not given	sufficient	thermocouple readings of the unexposed face and in the interior of the wall given in diagr. Deflec-tion and elongation in a diagram	Roving thermocouple not mentioned in the report.
The Netherlands TNO	only total amount of load is mentioned	not given	average furnace temp.is given in a table.	not given	not given	not given	not given	sufficient	max. + average temp. rise of the unexposed side as well as the deflec-tion given in a diagram	Roving thermocouple not mentioned in the report.

Table 14 A. Summary of test reports on non-load bearing wall/partition

Name of laboratory	Specimen	Test specimen: Construction of the specimen: Description	Drawings	Details	Material properties on day of test: Density	Humidity	Others	End conditions: Thermal: Heated part (widthXheight)	Dim. specimen (widthXheight)	Mechanical: Top	Bottom	Vertical edges
RUG	A symmetrical partition	Sufficient	Suff.	Suff.	Not given	Not given	-	Not given	2000x2500 mm	The 4-sides Fixed as in practice to the innerside of a concrete frame		
FIRTO	Non load-bearing wall made of blocks	Sufficient	Suff.	Suff.	Given	Not given mentioned a drying time of 12 days	-	Not given	3050x2500 mm	No detailed description or drawing		
WARRINGTON	Symmetrical	Extensive	Extensive	Extensive	Not given	Not given	-	Not given	3000x2450 mm	The 4-sides fixed as in practice to the innerside of a concrete form		
YARSLEY	Sandwich panel (concrete and polystyrene core	Short	Suff.	Suff.	Composition and material properties of concrete and polysterene not given			Not given	3000x2500 mm	The 4-sides fixed with mortar to the innerside of a concrete frame.		
CSTB	Symmetrical partition	Extensive	Extensive	Suff.	Not given	Not given	-	2600x2670 mm	2600x2670 mm	The 4-sides fixed as in practice to the innerside of a concrete frame		
CTICM	Symmetrical partition	Extensive	Suff.	Suff.	Not given	Not given	-	Not given	2600x2700 mm	The 4-sides fixed as in practice to the innerside of a concrete test frame		
TU-BRAUN-SCHWEIG	Symmetrical partition	Extensive	Extensive	Suff.	Given	Given	-	3000x3000 mm	3000x3000 mm	Test 1 : 4-sides fixed as in practice to the innerside of a test frame. Test 2 : Top and bottom fixed, vertical sides non-fixed.		
MPA-NW	Symmetrical partition	Short	Suff.	Suff.	Partly given in the report. Reference is given to other reports			Not given	3000x3000 mm	Test 1 : 4-sides fixed as in practice to the innerside of a test frame. Test 2 : Top and bottom fixed vertical sides non-fixed.		
FMPA	Symmetrical partition	Sufficient	Suff.	Suff.	Not given in report. Reference is given to other reports			Not given	3000x3000 mm	Test 1 : 4-sides fixed as in practice to the innerside of a test frame. Test 2 : Top and bottom fixed vertical sides not fixed, joints filled with mineral wool		
CSEA	Prefabricated panel	Sufficient	Suff.	Suff.	Given	Not given	-	1200x1800 mm	1200x1800 mm	Not given		

See also next page for table 14 B.

Table 14 B. Summary of test reports on non-load bearing wall/partitions

Name of laboratory	Test method					Observations and measurements		Other remarks
	Time temperature curve			Furnace pressure	O_2- content in furnace	Observations exposed and unexposed side	Measurements	
	Diagram or table	Tolerance temp. distr. within furnace	Integral curve					
RUG	No data concerning furnace temperature given in report			20 ± 5 Pa	Not given	Unexposed side: extensive exposed side: short	Only average temp. rise unexposed face given in a diagram	Missing : reason why only one test is carried out on an a-symmetrical partition
FIRTO	Average furnace temp. given in diagram	Not given	Not given	Not given	Not given	Extensive	Maximum and mean temp.rise unexposed side given in a diagram	
WARRINGTON	Diagram and table	Given	Main points given in table	Not given	Not given	Extensive	Maximum and mean. temp. rise unexposed side given in a diagram	
YARSLEY	Diagram with readings	Not given	Not given	From 20 ' to the end of the test 10 Pa	Not given	Sufficient	All readings of thermo-couple fixed to the unexposed face given in a diagram	
CSTB	Diagram with all readings	Not given	Not given	Diagram pressure between 25 Pa and + 10 Pa	Not given	Sufficient	All readings of thermo-couple fixed to the unexposed face given in a diagram	
CTICM	Diagram	Not given	Not given	Given in a diagram (± 10 Pa)	Not given	Sufficient	All readings of thermo-couple fixed to the unexposed face given in a diagram	
TU-BRAUNSCHWEIG	Diagram	Not given	Not given	10 Pa	Not given	Extensive	All readings of thermo-couples fixed to the unexposed face given in a diagram	
MPA-NW	Table	Not given	Not given	Given in a table (10 Pa)	Not given	Extensive	Thermo-couple readings and deformation measure-ments given in a table	
FMPA	Diagram with all readings	Not given	Not given	10 ± 2 Pa	10 ± 2 Pa	Short	All readings of thermo-couples fixed to the unexposed face given in a diagram	
CSEA	Average furnace temp. given in a diagram	Not given	Not given	Not given	Not given	Short	All readings of the 5 thermo-couples fixed to the unexposed face given in a diagram	Tested was only a panel and not a partition (missing vertical joint)

Table 15A Summary of test reports on floors

Name of Laboratory	Specimen	Test specimen: Construction of specimen: Description	Drawings	Details	Material properties measured values on day of test: Density	Relative humidity	mechanical properties	End conditions: Thermal: Length of heated part	unheated part	Mechanical: Supports	Restrained
RUG	Floor consisting of prefabricated floorslabs	Extensive	Suffic.	Suffic.	Only composition of concrete is given			Not given	Not given	Not given Test is carried out on a simply supported floor	
DANTEST	Roof consisting of prefabricated elements	Sufficent	Suffic.	Suffic.	Not given	Not given	Not given	6050 mm	Each shorter side a strip with a width of 50 - 100 mm	Simply supported one rolling and one fixed support	No restrained
FIRTO	Concrete floor	Sufficient	Suffic.	Suffic.	given	Measured: moist content conrete in equilibrium with atmosf. furnace hall	Given:concrete 28 days compressive strength. Not given: steel properties	4000x3000 mm	Each shorter side a strip with a width of 140 mm	Given in a drawing	Elongation partly restrained by friction
TRADA	Timber floor ceiling construction	Sufficient	Suffic.	Suffic.	Grade of timber given. Composition of ceiling material known by the laboratory			Not given	Not given	Not given	Not given
CSTB	Floor (steel beams concrete slab) with ceiling	Sufficient	Suffic.	Suffic.	Not given	Not given	Not given	3740x3020	Total area of Ceiling directly heated	Unclear	Unclear
WARRINGTON	Concrete floor (with corrugated steel plates)	Extensive	Suffic.	Suffic.	given	way of drying given (natural and forced) mass of drying sample given	Cube strength concrete given steel properties Not given.	2710 x 4200 mm	Each shorter side a strip with a width of 150 mm	Only given in report Simply supported clear span 4200 mm	
CTICM	Floor with prefabricated prestressed concrete beams	Extensive	Suffic.	Suffic.	Given of some materials	Only given results of preliminary tests plaster concerning	Cub strength concrete given steel properties Not given.	4600 x 3140 mm	Each shorter side edgebeam with a width of 150 mm	Both shorter edges directly supported on furnace wall	Elongation partly restrained by friction
TU-BRAUN - SCHWEIG	Timber floor	Extensive	Suffic.	Suffic.	Given	Given	Grade of timber given	4000 x 3060 mm	Not given	Two rolling supports	Unclear
MPA-NW	Floor (steel beams + concrete slabs) with ceiling	Sufficient	Extens.	Suffic.	Given (not on day of test)	Not given	Not given	4000 x 2000 mm	Total area of ceiling directly heated	Steel beams supported on a wall	No restrained
CSEA	Prefabricated concrete floor	Short	Suffic.	Suffic.	Not given	Not given	Not given	Not given	Not given	Not given	Not given
TNO	Timber floor ceiling construction	Sufficient	Suffic.	Suffic.	Not given	Only mentioned a drying time of 8 weeks	Not given	Not given	Not given	Mentioned in report: shorter side placed on furnace walls	Not given

See also next page for table 15 B

Table 15B Summary of test reports on floors

Name of Laboratory	Test load		Test method					Observations and mesurements		
	Calculation of test load	Load system	Time temperature curve		Integral curve	Furnace pressure	O_2-content in furnace	Observations exposed and unexposed side	Measurements	Other remark
			Diagram or table	Tolerance temp. distr. within furn.						
RUG	Not given (test load according to an equally load of 6,5kN/m^2	Not given	Not given	Not given	Not given	20±5 Pa	N. given	Sufficent	Diagram: Temp. unexposed face elongation deflection	
DANTEST	Given according to DS 1051)	System given in principle (two line loads)	Diagram	Not given	Not given	N. given	N. given	Sufficient	Diagram: Temp. unexposed face deflection	
FIRTO	Not given (load as requested by sponsor)	Dead load (distribution given on a photograph)	Average furnace temp. given in a diagram	Not given	Not given	N. given	N. given	Sufficient	Diagram with unexposed steel and concrete temp.deflection	
TRADA	Given (Maximum stresses acc. CP 112	Not given	Average furnace temp. given in a diagram	Not given	Not given	10±2 PA	N. given	Short	Max. temp. unexposed face in a diagram deflection in table	
WARRINGTON	Given in an appendix	Given (photographs)	Diagram and table	Given	Given	10±2 Pa	N. given	Extensive	Diagram: temp.unexposed face temp.steel reinforcement temp.concrete deflection	Test carried out according to CEC document ref. III/1202/77/-EN
CSTB	Not given, only mentioned amount and distribution of testload	Diagram with all readings	Not given	Not given	Not given	Not given	N.given	Sufficent given observations during and after heating period	Diagrams with unexposed face temp. steel temp. cavity temp. ceiling temp.deflection	
CTICM	Not given	Given (two line loads)	Diagram with all readings	Not given	Not given	Given in a diagram (5-15Pa)	N. given	Sufficient (given observations during and after heating period)	Diagrams with: unexposed face temp.distribution inside specimen	
TU-BRAUNSCHWEIG	Principles given	Dead load	Diagram	Not given	Not given	Not given	N.given	Extensive	Diagrams with: unexposed face temp. deflection	Two tests are carried out
MPA-NW	Calculation not given Amount of load and bending stresses in steel beams given	Not given	Table	Not given	Not given	Given in a table	N. given	Sufficient	Table with temp. of unexposed face steel beams	Two tests are carried out both with a topping of aereted concrete
CSEA	Not given Only mentioned: a maximum bending moment	Not given only mentioned: two line loads	Average furnace temp.given in a diagram	Not given	Not given	N. given	N. given	Short	Diagram with unexposed face temp.	
TNO	Given	Dead load (concrete tiles)	Diagram and table	Not given	Not given	N. given	N. given	Extensive	Table and diagram unexposed face temp. cavity temp. deflection	

The following points can be listed :

a) In most reports the specimen is described sufficiently, however there is an important lack of information on material properties.

b) Thermal and mechanical end conditions are described insufficiently, especially the supports of loadbearing elements.

c) Test load

In most of the reports the load is given.
Four ways of reporting the load appear :

1. the full calculation;
2. only the national design code with which the test load is calculated;
3. the test load as determined by the sponsor;
4. just the amount of load.

d) Test procedure

Most reports contain a diagram with the actual furnace temperature (in most cases a copy of the original record paper).
Only a few reports mention if the prescribed furnace temperature tolerances are satisfied.
Most reports do not give the measured values but only mention the required overpressure in the furnace.
No report contains data concerning O_2-content in the furnace.

e) Observations and measurements

Nearly all reports contain sufficient observations concerning the behaviour of the exposed and unexposed face of the test specimen during heating.

In most reports the results of the measurement are given in diagrams in some reports in tables. Nearly all reports contain the unexposed surface temperatures, measured by fixed thermocouples. Results of a movable thermocouple are in no reports.
Most test reports contain diagrams or tables with the following deformation data :

Column	:	elongation
Floors	:	deflection in the centre
Load bearing walls	:	deflection in the centre

The study lead to the conclusion that there is a lack of information in the existing test reports mainly concerning :

- material properties (density, humidity and mechanical properties on day of test);
- thermal and mechanical end conditions;
- calculation of test load;
- results of measurements of furnace conditions : temperatures, overpressure, O_2- content;
- results obtained by a movable thermocouple.

By including a chapter 3 with standard test reports in the revised version of document 1202 the above mentioned points were covered.

At the end of each standard test report a chapter 8 "Remarks" was introduced. On this chapter guidelines in relation with the applicability (extrapolation rules, limitation or restrictions, special warnings, etc.) shall be given.

11. FINAL CONCLUSIONS

The study carried out has shown a serie of points which have to be harmonized in order to achieve international acknowledgement of test results.

A lot of work remains to be done in respect of harmonization of load calculation and in respect of extrapolation of test results.

The outcome of this work is a revised version of doc. 1202 containing 3 parts :

- Part I giving the general outline of the procedure
- Part II giving particular rules for testing different elements :
  - non-load bearing walls/partitions
  - load bearing walls/partitions
  - columns
  - floors
  - beams
- Chapter 3 giving standard test reports for these elements.

The work didn't cover particular types of constructions e.g. : external walls with particular end conditions, floors with special end conditions.

The scope of doc. 1202 is actually restricted to the above mentioned types of elements.

On the basis of chapter 1 of the revised doc. 1202 the field of application can be extended to other elements (e.g. door assembly) which are especially subject to trade.

It appeared that due to the continuous evolution in building concepts in the daily testing work always new problems arise which have to be solved in a harmonized way. It seems therefore necessary to continue harmonizing by installing regular meetings of the concerned laboratories in the course of which new problems can be solved. A similar way of operating is already established in the U.K. and Germany with good success.

Work remains to be done in respect of harmonization especially concerning extrapolation rules.

Full harmonization for load bearing elements requires also harmonization of the load calculation and the measurements of material properties. This is outside the scope of this study.

P A R T I I

TESTING AND CLASSIFICATION OF THE RESISTANCE TO FIRE OF STRUCTURAL BUILDING COMPONENTS

Chapter 1

SECTION I : SCOPE

1. This document concerns the testing and classification of the fire-resistance of structural building components.

SECTION II : FIELD OF APPLICATION

2. This document is applicable to :

- load-bearing walls or load-bearing partitions*
- non-load-bearing walls or non-load-bearing partitions*
- simply supported floors (with or without ceilings **) with fire attack from the underside only ***
- columns
- simply supported beams.

This document provides no extrapolation rules. The use of the test results may therefore be restricted to the elements tested (see comments on extrapolation). Additional tests and/or requirements may be necessary e.g. in order to check the adhesive quality of claddings, or to meet corrosion problems. The document is not applicable to other building elements than those listed above.
The fire-resistance classification by testing of other types of building components requires specific provisions which shall be dealt with in each case by special Documents or annexes to this Document.

Warning :

* This document is intended for walls and partitions with fire from one side only. It does not cover walls and partitions with fire attack from both sides nor the parts containing doors, glazings and installation penetrations (ventilation ducts, pipes, cables). External walls can be included with fire attack from inside as far as the end conditions can be reproduced by the test arrangement following Chapter 2.

** Tests following this document do not determine the contribution of the suspended ceilings to the fire resistance of a floor construction.

*** In some cases fire attack from the upperside can give a lower fire-resistance.

SECTION III : TEST EQUIPMENT

3.1. Furnace.

The furnace is capable of subjecting a specimen to the standard conditions specified in Chapter 1 Section 5 and Chapter 2. A specification of constructional details of the furnaces is not possible for the moment being (see footnote).

(i) The design of the furnace shall be such that the temperature conditions as given in § 5.1.1. are respected.

(ii) The design must also provide :
- for horizontal elements, a uniform static pressure in a plane 100 mm below the element ;
- for vertical elements, a linear pressure gradient over the whole height and a uniform pressure over the width.

(iii) One of the following fuels must be used : light heating oil, natural gas, propane, town gas with calorific value about 14,7 Mj/m3.

Footnote :

- The existing furnaces are different in form, size and lining material used. It is recommended to follow the ISO directive (under development) on this subject.

- For the moment being the only advice given in ISO 834/1975 Amendment 2 (1980) is the following : "It is recommended that primarily new furnaces, and existing furnaces when repaired, should mainly be lined with materials having a minimum thickness of 50 mm and a thermal inertia ($\sqrt{k\rho c}$ at 773 K not greater than 600 W s $^{1/2}$/mK. Such refractory lining materials are readily available in the form of fibrous bats, solid blocks and castable material".

3.2. Loading equipment.

The test component can be loaded either by applying dead loads or by the use of a hydraulic system or other mechanical system.

The loading equipment must not affect essentially the heat transfer through the test component nor the measurement with the cotton pad or the thermocouples.

Devices must be provided for maintaining the constancy and the distribution of the load throughout the test.

Details of loading equipment are given in Chapter 2.

3.3. Equipment for monitoring furnace operating conditions.

3.3.1. Furnace temperature.

3.3.1.1. Furnace thermocouples.

Specifications :

- Bare wire thermocouples of wire diameter not less than 0,75 mm and not more than 1,5 mm shall be used. The hot junction shall be welded.

- The wires of the thermocouples shall enter in open tubes of heat-resistant material, for example porcelain, approximately 25 mm from the hot junction (Fig. 1).
- Sheated or other thermocouples may be used provided that they have the same reading and response time as those of (the above mentioned) bare wire thermocouples.
- The overall accuracy of the temperature measurements shall be better than ± 10 °C.

Location :

- At the beginning of the test, the hot junction is at 100 mm from the test specimen.
  Even at deformation of the specimen during the test the distance

between specimen and thermocouples shall be between 50 and 150 mm.

Number :

- For each type of building component the number of thermocouples required is specified in Chapter 2.

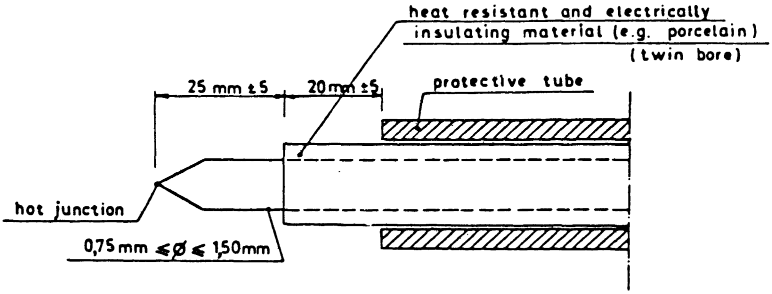


Fig. 1 - Bare wire thermocouple for measuring furnace temperature T

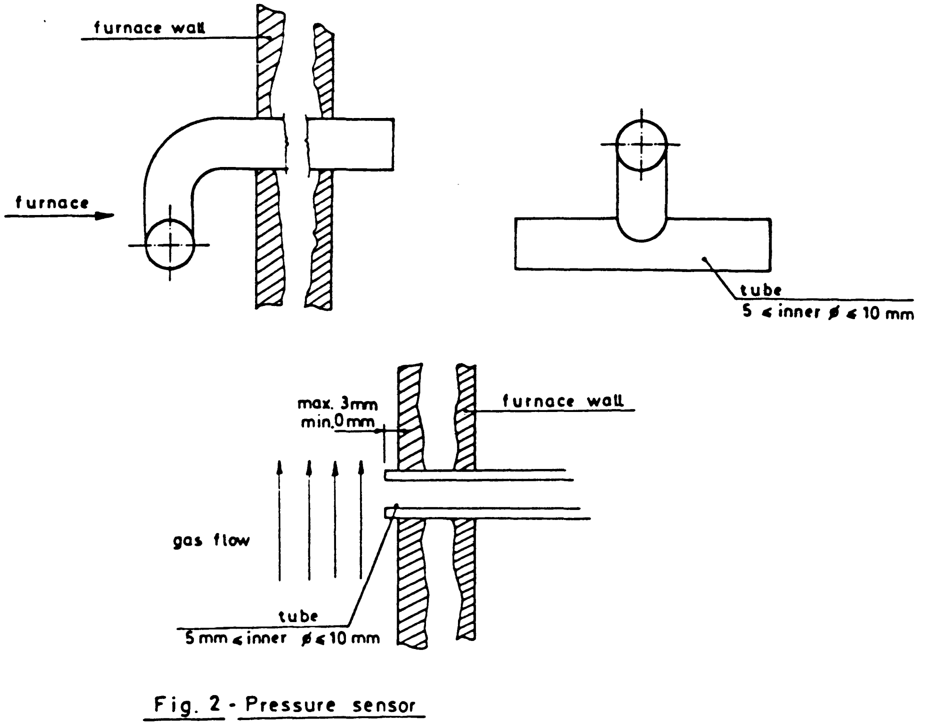


Fig. 2 - Pressure sensor

3.3.2. Furnace overpressure

3.3.2.1. Equipment for measuring overpressure in the furnace

The static pressure in the furnace must be determined by a T-shaped pressure sensor as detailed in Fig. 2. The device shall be constructed of steel tubes. The internal diameter of the tubes must be not less than 5 mm and not more than 10 mm.

A simple stainless steel tube of 5-10 mm diameter or other systems may be used provided that it is checked that the results of this measurement are comparable with those obtained with the T-tube.

The accuracy of the overpressure measurement shall be better than ± 1 Pa. If quick measuring devices are used the furnace control is based on readings averaged over a 1 minute period.

3.3.2.2. Location of sensor

The overpressure must be measured and checked at two points :

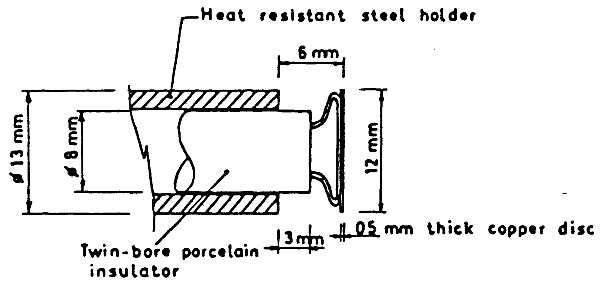
(a) in the case of horizontal components, both in a plane at 100 mm from the lower surface of the test component ;
(b) in the case of vertical components, both located at a height of approximately three-quarters of the height of the test specimen, and for walls and partitions, at a distance of 100 mm from the specimen.

3.3.3. Oxygen content

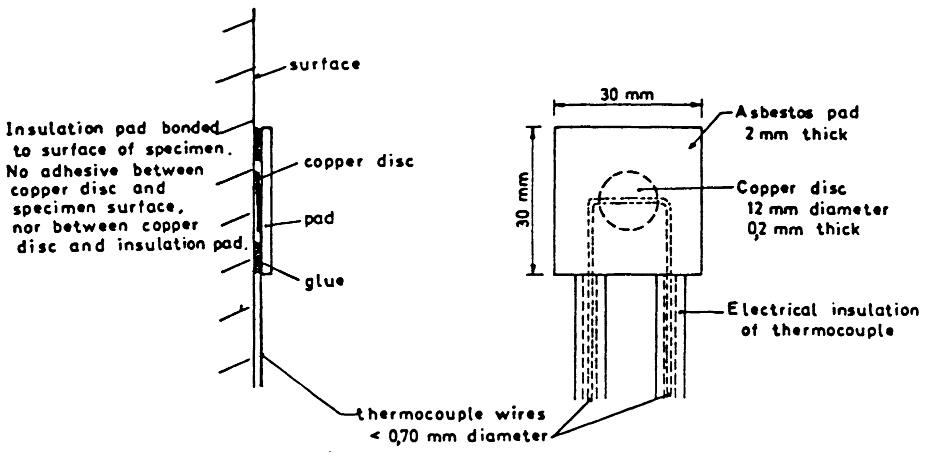
The test equipment must include a device for measuring the oxygen content of the atmosphere in the furnaces.

Measurements may be taken either continously or at intervals of not more than five minutes, the gases being sampled in the overpressure zone of the furnace.
This measurement must be performed with an accuracy of ± 0,5 % oxygen.

Fig. 3



Roving thermocouple measuring junction



Elevation unexposed surface thermocouple

3.4. Equipment for measuring the behaviour of the test element.

3.4.1. Temperature of unexposed side.

(a) Fixed thermocouples :

Surface temperatures of test specimens shall be measured by means of thermocouples with a wire diameter of not more than 0,7 mm. Each thermocouple junction shall be soldered to the centre of the face of a copper disk 12 mm in diameter and 0,2 mm thick, which is fixed to the surface of the specimen at the required position. The accuracy of the thermocouple reading shall be better than $\pm$ 2°C. For the fixed thermocouples the disks shall be covered with overdry square asbestos pads 30 mm x 30 mm and 2 mm thick. The asbestos material shall have a density of 900 kg/m3 $\pm$ 10 % at 100 °C and a thermal conductivity of 0,13 $W.m^{-1}oC^{-1}$ at 100°C (Fig. 3).
Instead of the asbestor pad a non-combustible asbestos free material with similar caracteristics can be used (such as "NEFALITH 16"). The thermocouples are fixed to the specimen before the test and as follows :

- The copper disk shall be held against the specimen surface by the asbestos pad. The pad is glued to the surface with a suitable adhesive, avoiding the presence of any glue between copper disk and specimen and between copper disk and pad.

  Instead of gluing the pad, other suitable means like pins, springs, screws, etc... can be used, depending on the nature of the specimen surface. Care shall be taken not to cover the back side of the pad in front of the copper disk.

- In order to get representative measurements, thin decorative surface finishings which tend to loose contact with the specimen during the test have to be removed at the location of the fixed thermocouples (e.g. p.v.c. -folies).

(b) Movable thermocouples :

The design of the movable thermocouple is also given in Fig. 3.

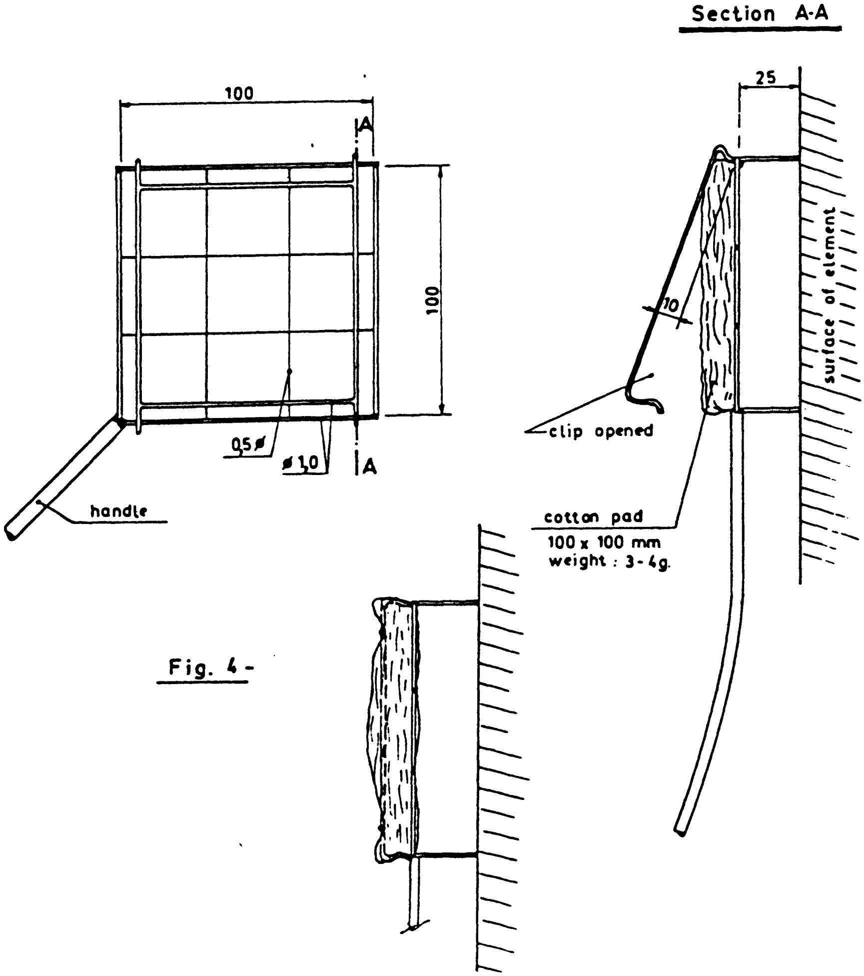

Section A-A
100
A
100
0,5 ∅
∅ 1,0
A
handle
25
10
surface of element
clip opened
cotton pad
100 x 100 mm
weight : 3-4g.

Fig. 4 -

3.4.2. Integrity.

The cotton-wool pad, measuring approx. 100 mm x 100 mm x 20 mm, must consist of new cotton fibres, soft and undyed, without any admixture of artificial fibres.

It shall have a mass between 3 and 4 g. The pad shall be conditioned by drying in an oven at 100 ± 5°C for at least 0,5 h.

It must be attached by metal clips to a 100 mm x 100 mm frame made of steel wire 1 mm in a diameter secured to a suitable handle.

The design of the cotton pad holder is given in Fig. 4.

3.4.3. Deformation measurement.

Information about the location of measuring points and intervals for deformation measurements are given in Chapter 2.

The accuracy of the deformation measurement shall be better than ± 1,0 mm.

The method of measurement must not affect the extent of deformation.

SECTION IV : TEST SPECIMEN

4.1. Construction.

The test shall be made on a test specimen representative of the complete element of construction on which information is required. Each type of element requires a different approach. Detailed specifications are given in Chapter 2 for the different test elements.

The material and standard of workmanship of the test specimen shall be representative of those applying in good practice, as defined by existing national codes and standards.

For load-bearing elements, the constituent materials of the specimen shall have a mechanical strength close to that expected for a similar element in service.

Relevant actual material properties and dimensions must be determined, in accordance with national standards, by the laboratories or on its request, by another laboratory independent of the sponsor. The samples for strength determination must be identical to the test construction and conditioned in the same way to correspond to the material properties of the test construction.

4.2. Number of tests.

The number of tests is depending on the element and the results of the tests. It is specified in Chapter 2.

4.3. Dimensions.

The test specimen should be full-size.
Where this is not possible the specimen shall have the size as specified in Chapter 2.

4.4. Mounting and end conditions.

Mounting and end conditions should be as in practice.

The practical situation however varies from building to building and is usually not known. Some practical situation cannot be realised in the existing furnaces. For these reasons standards conditions are defined in Chapter 2, which cover the different practical situations as far as possible.

Non-load-bearing elements must not be subjected to any static load, except such stresses as produced by the fixing devices, and the thermal elongation of the specimen during the test.

4.5. Conditioning.

The test specimen shall be conditioned in such a way that it corresponds as closely as possible, in temperature, moisture content and mechanical strength, to the expected state of a similar element in service.

The test specimen shall not be tested until its moisture content is in dynamic equilibrium (*) with an ambient atmosphere approximating to that expected in service. This dynamic equilibrium shall be checked either on the test specimen itself or on a representative sample.

The moisture content of the principal materials of the element shall be measured at the time of the test.

The components may be dried either naturally or artificially.

If dried naturally, they must be stored in an atmosphere kept constant at 27°C ± 15°C measured on a dry thermometer, and at a relative humidity of 40 to 65 %.

If drying is performed artificially in the laboratory, care must be taken not to reach a temperature that affects the fire-resistant properties of the components. It is recommended that a temperature of 65°C is not exceeded, for gypsum : 42°C.

If the drying time required in order to arrive at a satisfactory moisture content of the test component is too long, the following times should be adopted for natural drying :

concrete density $<$ 2000 kg/m3	=	200 days (**)
concrete density $>$ 2000 kg/m3	=	100 days
masonry	=	100 days
claddings applied by moistening	=	50 days

Should the product embody synthetic products or resins for which the level of conditioning (e.g., the degree of polymerization) is critical, the applicant or the manufacturer of the component must specify the moment at which stabilization is achieved.

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* As normal moisture content inside buildings can be considered : concrete: 3 percent, masonry : 5 percent, timber : 12 percent. Conditioning for other materials shall follow the recommendations of manufacturers.

**Some types of light weight concrete loose their moisture very slowly.

Section V : TEST PROCEDURE

5.1. Furnace conditions.

5.1.1. Temperature

The temperature of the furnace thermocouples shall be measured at intervals not greater than 2 minutes.

By definition the furnace temperature T is the mean of the temperatures recorded by the furnace thermocouples. This temperature must be controlled so that it varies with time, within the limits defined below, according to the following equation :

$$T - T_0 = 345 \log_{10} (8t + 1)$$

where

t is the time in minutes ;

T is the temperature of the furnace at time t, expressed in degrees Kelvin ;

T_0 is the initial temperature of the furnace expressed in degrees kelving.

The above equation gives the values shown in the table below.

Table 1 : Rise in the furnace temperature as a function of time.

Time t Mins.	Rise in furnace temperature $T - T_0$ K
5	556
10	659
15	718
30	821
60	925
90	986
120	1 029
180	1 090
240	1 133
360	1 193

The curve representing this function - known as the "temperature/time curve" is given in Fig. 5.

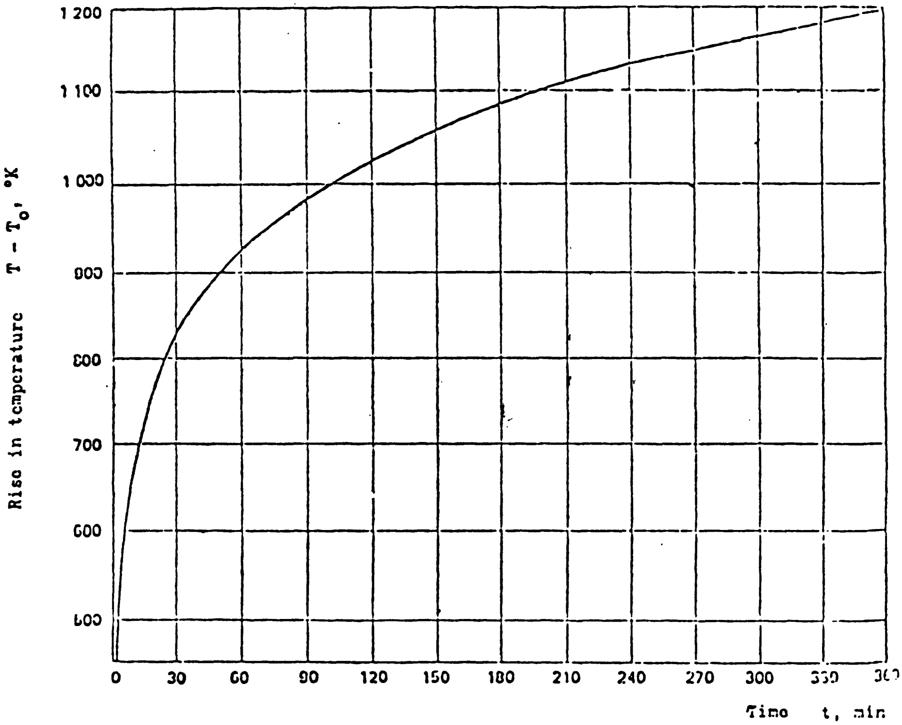


Fig. 5 - Temperature/time curve

Tolerances.

(a) Deviation of $T - T_0$ from the specified curve.

- This deviation is given as a percentage by the following expression :

$$\frac{A - B}{B} \times 100$$

w h e r e :

A is the integral of the average furnace temperature $T - T_0$, expressed as a function of time, and calculated on the basis of measurement taken with intervals not greater than 2 minutes.

B is the integral of $T - T_0$ determined by the equation given under 5.1.1. above.

- The deviation must be within the following tolerance limits :
  $\pm$ 15 % during the first 10 minutes of the test period.
  $\pm$ 10 % between the 10th and the 30th minute.
  $\pm$ 5 % after the 30th minute.

(b) Uniformity of furnace temperature.

- At no time after the first 10 minutes of the test period the temperature recorded by any of the thermocouples may deviate from the specified furnace temperature T by more than 100 K.

- In the case of structural components containing combustible materials which flame on the exposed surface, none of the thermocouples may show a deviation of more than 200 K.

5.1.2. Oxygen-content

The oxygen-content of the atmosphere in the furance during the test, must be measured at intervals not exceeding 5 minutes.
The burners must operate at constant fuel/air ratio so that the O_2 content with a specimen of non-combustible material is between 2 % and 5 % in volume.

Note : During tests with specimens of combustible material the O_2 - can fall below 2 %.

5.1.3. Pressure conditions.

For all building elements, after the first five minutes, an overpressure of 10 Pa $\pm$ 2 Pa, measured as specified in § 3.3.2. at intervals not exceeding 5 minutes, shall exist in the furnace during the whole heating period.

The uniformity of the pressure inside the furnace has to be checked in a calibration test. For horizontal elements in the plane 100 mm below the specimen, for vertical elements along the line as specified in § 3.3.2.2. the pressure variation must be within tolerances of $\pm$ 2 Pa.

Warning : strong local pressure drops can occur near burners, gas outlets, etc.

For vertical elements, overpressure shall exist over at least the upper two thirds of the height of the specimen.

5.2. Loading.

The test load shall be determined on the basis of one of the two ways explained in § 5.2.1. and § 5.2.2.

The testing laboratory shall report clearly the basis on which the choice has been made and give full details as required in Chapter 3. Where the test load under 5.2.2. is less than the calculated load under 5.2.1., this shall be clearly stated as restricting the applicability of the test results.

5.2.1. Calculated test load.

(a) Steel- and concrete elements.

The load is calculated on the basis of the actual (see § 4.1) properties of materials* and the load factors given in rules or standards. If necessary the maximum allowable deflection is also taken into account.

(b) Timber elements

In the case of timber elements the test load is calculated on the basis of the permissible stresses and E-modulus belonging to the grade of wood used in the construction.* If necessary the maximum allowable deflection is also taken into account.

5.2.2. Specified test load

Specified test load is the load specified by the sponsor on the basis of the use of the element in a building for which loading levels are specified in a code.
This specified load shall be adjusted if the actual material properties of the specimen exceed the minimum guaranteed value. This can be neglected for timber elements.

5.2.3. Application of the test load.

In a fire resistance test, a uniformly distributed load can be simulated by a number of equal, statistically equivalent spot loads. Details for different types of elements are given in Chapter 2.

- The load must be applied not less than 30 minutes before the thermal attack. Before starting the fire test, stabilization of the deformation of the supports and load equipment must be achieved.

- The level and distribution of the load must be kept constant.

- The overall accuracy of the load level shall be better than $\pm$ 5 %. It shall be monitored continuously.

- For details on the application of loading see also Chapter 2.

(*) This grading should follow national codes or standards but a detailed description of the timber in terms of the criteria used for the grading has to be given in the test report.

5.3. Measurements on test specimen.

5.3.1. Temperature.

5.3.1.1. Temperature of the unexposed surface of test components by means of fixed thermocouples.

- The temperatures on the unexposed surface of test components shall be measured at intervals not exceeding 2 minutes by applying thermocouples as specified in chapter 3.4.1. to the surface of the test component.
- Details concerning the location of fixed thermocouples for the different types of elements are given in Chapter 2.
- There it is also specified which of the fixed thermocouples are taken into account for calculation of the mean temperature of the unexposed surface.

5.3.1.2. Temperature of the unexposed surface by means of a movable thermocouple.

The temperature must, furthermore, be measured at any point which seems to attain the highest temperature at any given time during the test. This temperature shall be measured either by means of additional fixed thermocouples and/or the movable thermocouple as defined in § 3.4.1.

A particularly critical area is the periphery of the component ; hence the temperature must be measured as close to the edge of the specimen as specified in Chapter 2.

Other critical areas are joints and the bottom of corrugated surfaces : their temperature is measured as specified in Chapter 2, if the dimensions of the movable thermocouples allow it.

5.3.1.3. Temperatures inside the test component.

Temperatures inside the test specimen are measured by means of thermocouples with a wire diameter of not more than 0,7 mm. Each

junction shall be soldered or welded. A suitable way of fixing shall be chosen in function of the application.
The wires of the thermocouples for measuring the temperature inside the test specimen should follow the isotherm through the hot junction as closely as possible for a distance of at least 25 mm, starting from the junction.

5.3.2. Integrity.

(i) Any flaming on the unexposed face of the specimen and its duration have to be recorded.

(ii) The cotton pad, shall be held for 30 seconds (unless it ignites earlier) at a distance of 20-25 mm from any opening on the unexposed side, and places where flames, even of shorter duration, occur.

The time and position at which the cotton-wool first ignited must be recorded. The pad must not be re-used.

Note :
Ignition of the cotton pad includes glowing as well as flaming (both during application and after removal) of the pad (see ISO definition : combustion with emission of visible light).

Charring of the pad without glowing does not mean ignition.

5.3.3. Deformation and load-bearing capacity.

Where the rate of deformation is a performance criterion, (beams, floors and columns) the deformation at the points specified in Chapter 2 must be measured and recorded at intervals of 1 minute, for other elements at intervals not exceeding 5 minutes.
For a load-bearing wall or partition, the time at which the specimen collapses (i.e. when it can no longer support the test load) shall be measured.

5.4. Other observations during the test.

Throughout the test, observations shall be made of all changes and occurences which are not criteria of performance but which are relevant for the behaviour in fire, including for example, the emission of smoke or other vapours at the unexposed face of a separating element and the formation of openings and cracks and their size. Nevertheless, combustibility of these gases has not to be checked by a pilot flame. Where possible the following properties and characteristics shall also be noted during the whole test period :

(a) deformation which can facilitate an analysis of the structural behaviour of the element and an application of the test results ;

(b) other phenomena which are of importance for the load-bearing capacity of the element, such as cracking, splitting and structural transformation of materials ;

(c) the temperature distribution in the interior of the test specimen in such a manner that it provides a satisfactory basis for estimating the function and the behaviour of the specimen during the test.

5.5. Duration of test.

The test is continued until one or more performance criteria are no longer satisfied, except other agreement with the sponsor. It shall be terminated earlier in case of danger.

SECTION VI : CRITERIA AND CLASSIFICATION

6.1. Criteria.

1. The fire-resistance of a building component shall be expressed as a function of the time during which that component, under the given thermal and mechanical conditions can perform its function.

   This function shall be assessed in accordance with the following performance criteria :

   - stability (R)
   - integrity (E)
   - thermal insulation (I).

2. The fire-resistance of a building component shall be expressed in minutes. This shall be the number of minutes rounded down to the whole number closest to the result of the experimental measurement.

3. Performance criteria - Definition :

   (i) Stability "R" - only applicable for load-bearing structures. Depending on the type of element and the use for which it is intended, it will be considered to have failed :
   - when it collapses, or
   - when its rate of deformation exceeds the value given in Chapter 2, or

   Note :
   For non-load-bearing structures R is deemed to be satisfied as long as E is satisfied.

   (ii) Integrity "E" - only applicable to elements with separating function. The test component shall be considered to have failed when the cotton pad referred to in § 5.3.2. ignites, or when sustained flaming (*) of the specimen occurs (see § 5.3.2.).

(*) Flames of 10 s. duration without interruption are deemed to be sustained.

(iii) Thermal insulation "I" - only applicable for elements with separating function.

The test element shall be considered to have failed when

(a) the average temperature of the non-exposed surface exceeds by more than 140 K the initial average temperature ;

(b) the maximum temperature of the unexposed surface exceeds by more than 180 K the initial average temperature ;

(c) the criteria E or R are reached.

6.2. Classification.

If more than one test had to be carried out (see Chapter 2), the classification shall be based on the worst result. The classification shall be expressed in the following form :

R.E.I.-time :	Time during which all three criteria stability, integrity and thermal insulation are satisfied.
R.E. -time :	Time during which the two criteria stability and integrity are satisfied.
R. -time :	Time during which the criterion of stability is satisfied.

The time is expressed in one of the following figures :
15, 30, 45, 60, 90, 120, 180, 240, 360.

The measured time is rounded down to the abovementioned figures. Thus the following classes are defined : REI 15, REI 30, REI 45,... RE 15, RE 30, ... R 15, R 30 ... .

So a building element with a stability of 155 minutes, an integrity of 80 minutes and a terhmal insulation of 42 minutes is classified as follows : REI 30
RE 60
R 120

SECTION VII : TEST REPORT

1. A test report, the detailed contents of which are described in Chapter 3, shall be drawn up in respect of each building element subject to classification.

2. The heading of the report must indicate that the test was carried out in compliance with the provisions of this document, to which reference shall be made.

3. No test report is made if R, E and I $<$ 15 minutes.

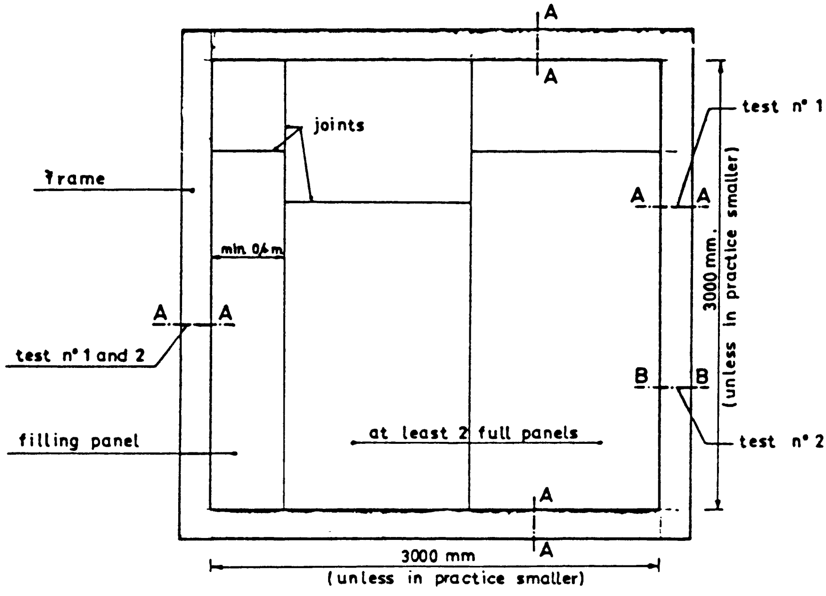


fig. 2.1/1

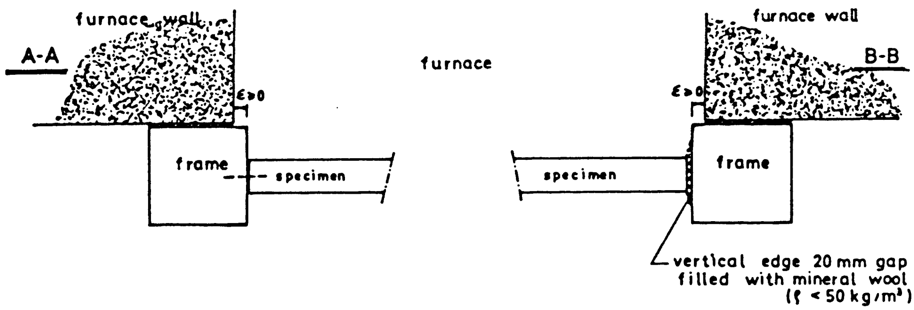


fig. 2.1/2

Chapter 2

Section I : NON-LOAD-BEARING WALLS AND PARTITIONS

1. Design of specimen and exposure conditions. (fig. 2.1./1.)

1.1. Design of specimen.

- The dimensions of the specimen are 3 m x 3 m unless in practice smaller.
- Partitions must have at least two full panels and at least two vertical joints. If there are horizontal joints in practice at least one is included.
- Partitions provided with compensators (adaption for the height) are tested with the compensators in mid position.

1.2. Frame

A closed stiff frame has to be used which does not allow elongation of specimens nor rotation of frame members during the test.

For example : reinforced concrete 200 x 200 mm for light partitions.

Care must be taken to avoid deformation of the frame members due to heating during the test (protection if necessary). If the dimensions of the opening have to be reduced this has to be done maintaining the requirements of stiffness for the parts adjacent to the specimen, for example : with masonry or concrete.

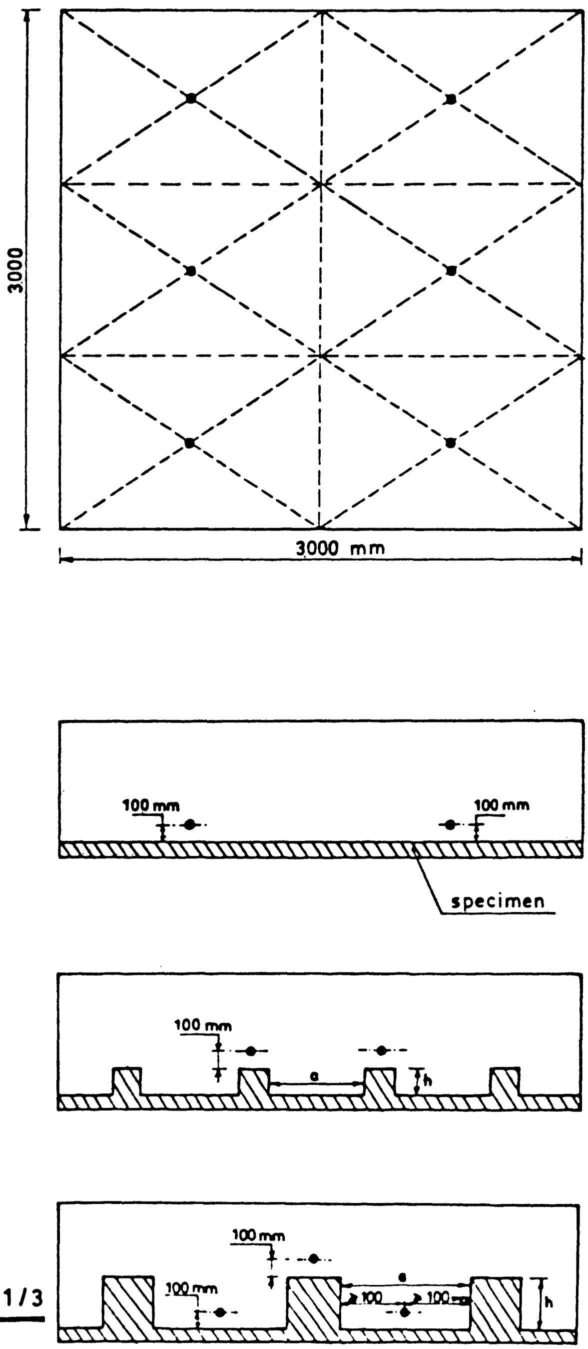
The dimensions of the frame must be such that all four edges of the specimen are exposed : $\epsilon \geqslant 0$ (fig. 2.1./2.).
The material of the frame adjacent to the specimen satisfies $\rho = 2000 \pm 500$ kg/m3. Refractory material is advised.

1.3. Exposure conditions. (fig. 2.1./2.)

Two situations have to be simulated.

Test n° 1 : 4 edges fixed as in practice.

Test n° 2 : 3 edges fixed as in practice,
1 vertical edge (of full element) without restraint (e.g. the gap between test element and frame filled with mineral wool).



a < 250 mm
or
h < 250 mm

a and h ≥ 250 mm

fig. 2.1/3

2. Furnace thermocouples. (fig. 2.1./3)

At least 1 thermocouple per 1,5 m2 specimen surface is used with a minimum of 5 thermocouples (that means at least 6 thermocouples for a 3 x 3 m specimen).

The hot junction of the furnace thermocouples is situated at 100 mm from the majority surface of the specimen, at the start of the test.

Distance shall remain between 50 and 150 mm during the test.
The thermocouples are equally distributed.
Example : see fig. 2.1./3.

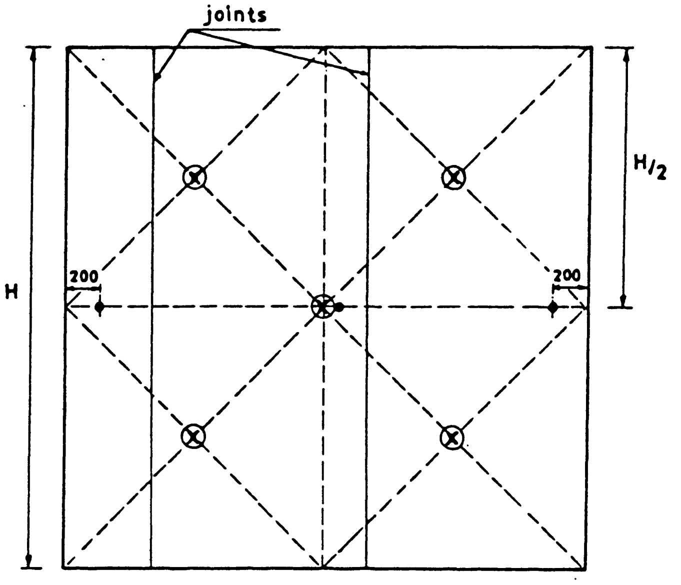
3. Measurements on test specimen.

3.1. Surface temperature.

- At least five fixed thermocouples are used for measuring the mean surface temperature. Their location is given in fig. 2.1./4. and would need to be changed if one of these points is at a place with no representative thermal insulation (e.g. : near joints, edges, studs, metal connections or screws).
- For determining the maximum temperatures of the surface, at any place, fixed or movable thermocouples are used where high temperatures are expected. At the location of the joint it has to be avoided to measure gas temperatures by the thermocouples (see fig. 2.1./5a).
- At the fixed edges temperature should be measured by a movable thermocouple, as close as possible to the edge of the specimen (see fig. 2.1./5b).
- In case of grooved surfaces, the temperature of the bottom of the groove is not taken into account provided the groove is more narrow than 12 mm. (fig. 2.1./5c).
- Thermal insulation is not considered at the unfixed edge within a zone of 100 mm width (Test n° 2).

3.2. Integrity measurement.

- In Test n° 2 the cottonwool pad is not applied nearer than 100 mm to the free vertical side of the specimen.



● Location of measuring points for deformation (non mandatory)
x Location of thermocouples for determining the mean surface temperature.

fig. 2.1/4

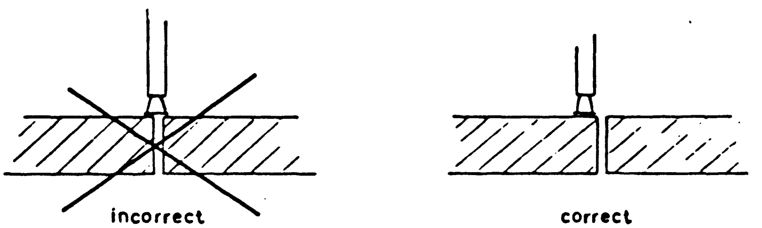


fig. 2.1/5a

- At this side flames emerging from the gap between specimen and frame are not taken into account.

3.3. Deformation measurement.

- The location of the (non-mandatory) measuring points for deformation is given in figure 2.1./4.

- The measuring interval is 5 minutes.

4. Number of tests.

The number of tests has to be deduced from fig. 2.1./6.

5. Performance criteria.

No specifications are applied additional to those given in Chapter 1.

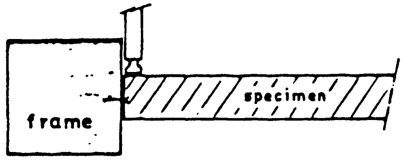


fig. 2.1/5 b

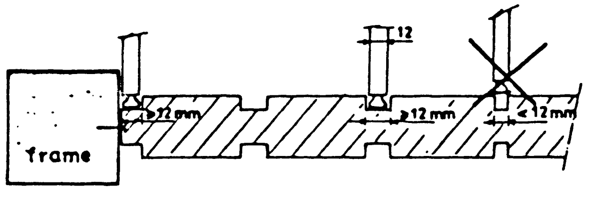


fig. 2.1/5 c

fig. 2.1/6 a

Symmetrical wall or partition

Start with test 1 and test 2

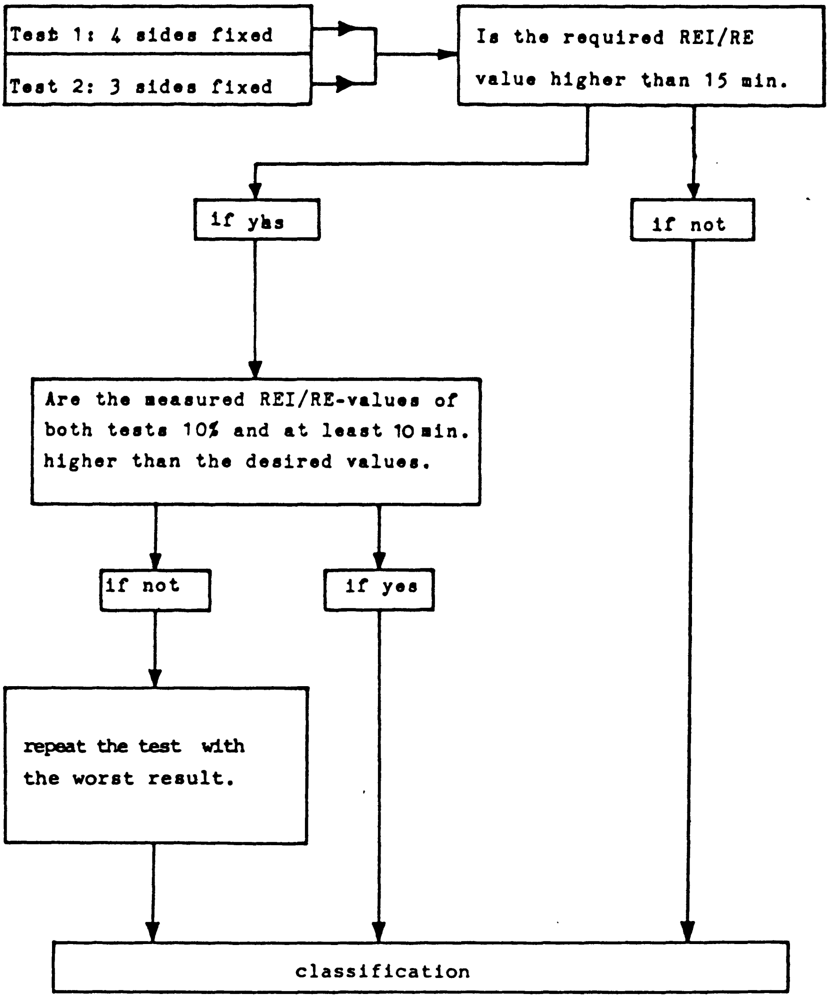
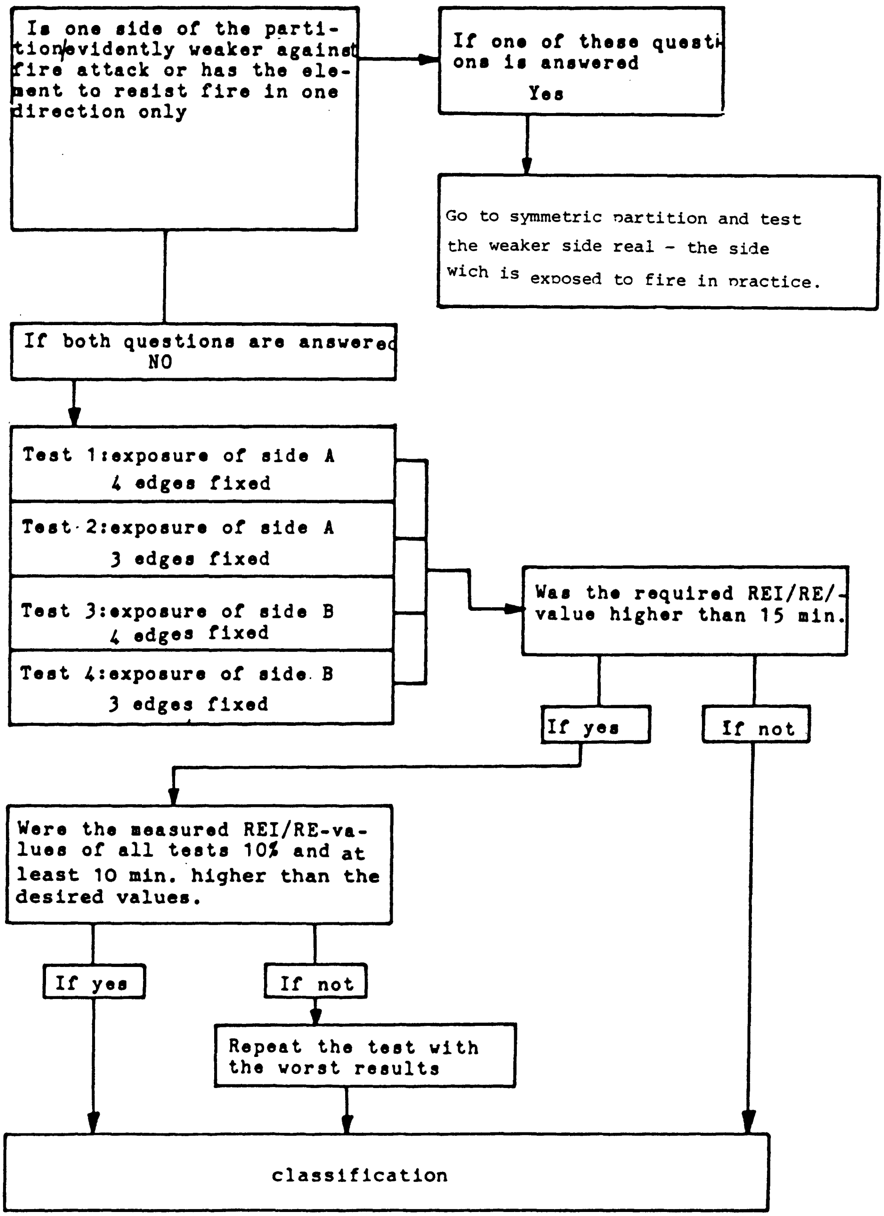
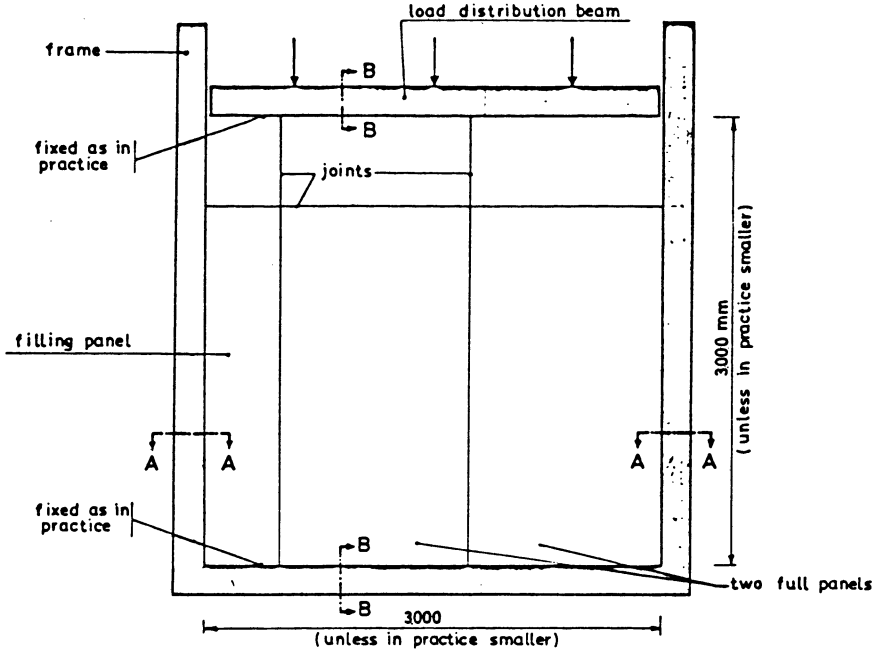


fig. 2.1/6 b

Assymetrical wall or partition





section A-A and B-B : see fig. 2.2/4

fig. 2.2/1

Load distribution beams

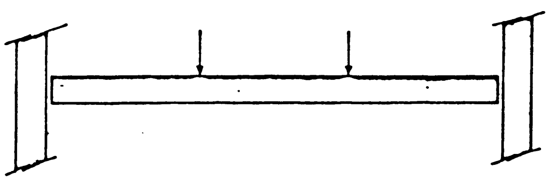


fig. 2.2/2 a

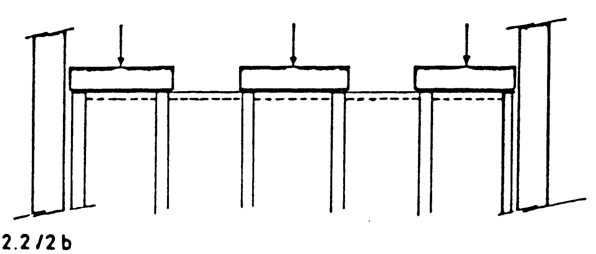


fig. 2.2/2 b

Section II : LOADBEARING WALLS AND PARTITIONS.

1. Design of specimen and exposure conditions.

1.1. Design of specimen.

- The dimensions of the specimen are 3 m x 3 m unless in practice smaller.
- Partitions must have at least two full panels and at least two vertical joints. If there are horizontal joints in practice at least one is included.

1.2. Frame.

- A stiff frame has to be used, able to transmit the forces of the loading system to the specimen with very limited deformation of the beams, so that the load distribution is not influenced by this deformation. For ex. : reinforced concrete 20 x 20 cm for light partitions. (see fig. 2.2./1).

  The dimensions of the frame must be such that all four edges of the specimen are exposed. ($\varepsilon \geqslant 0$)

- Care must be taken to avoid deformation of the frame members due to heating during the test (protection if necessary).
- Load distribution beams :

(a) In case of walls without studs a stiff load distribution beam should be used with a length equal to the width of the specimen and directly in contact with it. The part of the beam adjacent to the specimen is made of concrete over a height of minimum 0,2 m (see fig. 2.2./2a).
The stiffness of these beams is such as to limit the maximum deflection to a value not greater than 1/1000 at the maximum load.

(b) In case of walls or partitions with studs the loading system shall be such that by its deformations during the test the constancy of the load on each stud is not influenced (see fig. 2.2./2b).

- Care is taken to avoid friction between the load distribution beam and the studs of the frame.

- The load distribution beam can be either on top or at the bottom of the specimen.

- The horizontal frame members are such that no rotation along their longitudinal axes, nor translation perpendicular to the plane of specimen can occur.

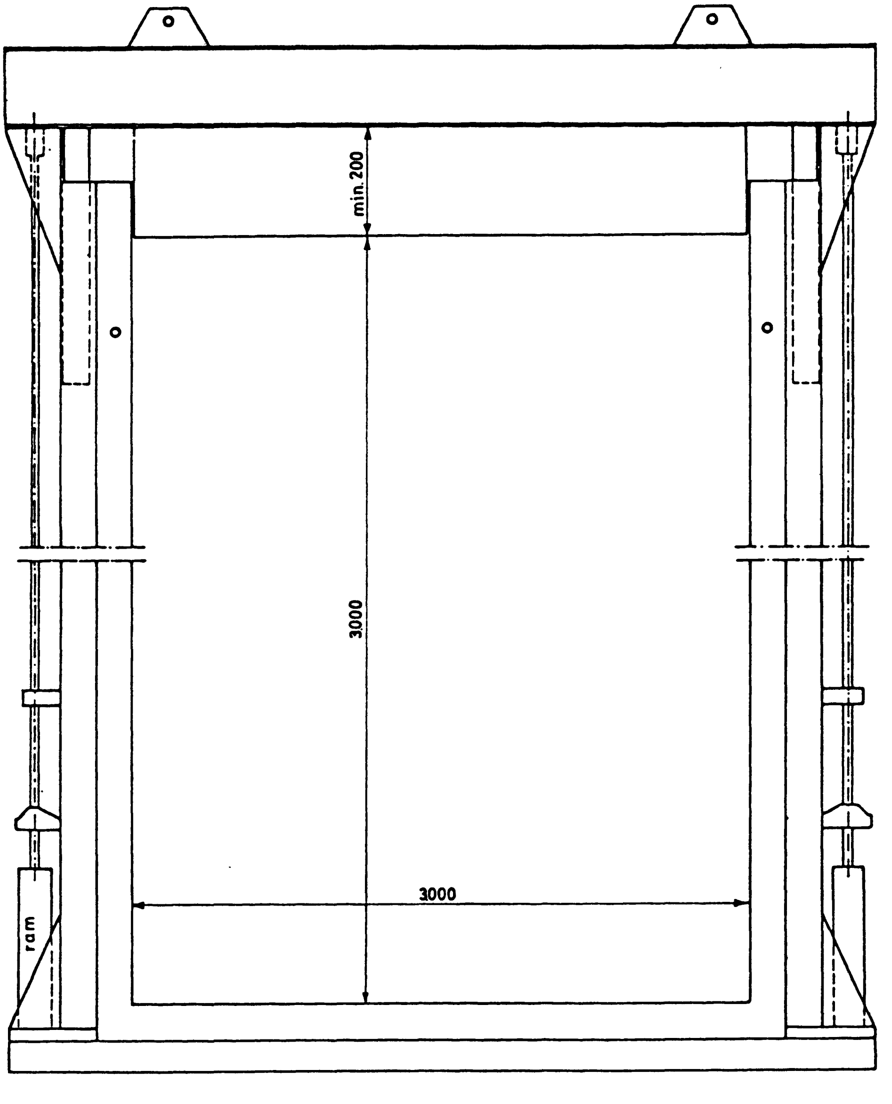


fig. 2.2/3 : Example of test frame for load bearing wall

- Vertical movement of the floating beam must be possible with a minimum of friction, guaranteeing the accuracy required for the load ($\pm$ 5 %). The material of the frame adjacent to the specimen satisfies :
  = 2,0 $\pm$ 0,5 kg/dm3.
- An example of a suitable test frame for load-bearing walls is given in fig. 2.2./3.

Note : The arrangements of intermediate members at top and bottom in order to adjust the clear space of the frame to the dimension of the specimen can only be used if no additional horizontal movement and rotation are created.

1.3. Exposure conditions. (fig. 2.2./4.)

All 4 edges of the specimen are exposed. The two horizontal edges are fixed as in practice. The two vertical edges are free. The gap between frame and specimen are filled with mineral wool $\rho \leqslant$ 50 kg/m3 and have a width of 20 mm.

2. Loading
   - For the calculation of the load the specimen considered is centrically loaded.
   - In order to avoid unsymmetrical loading the loadplane of the specimen should coincide with the midplane of the frame.
   - If the load-bearing capacity of a partition is based on the presence of studs, the test load is determined by the number of studs present, and not by the width of the specimen.
   - In case of walls or partitions with studs the loading points are applied like in practice (exactly coinciding with the studs or between them).
3. Furnace thermocouples.

At least 1 thermocouple per 1,5 m2 specimen surface is used with a minimum of 5 thermocouples (that means at least 6 thermocouples for a 3 x 3 m specimen).
The hot junction of the furnace thermocouples is situated at 100 mm from the majority surface of the specimen, at the start of the test.

Distance shall remain between 50 and 150 mm during the test. The thermocouples are equally distributed.

<u>Example</u> : see fig. 2.2./5.

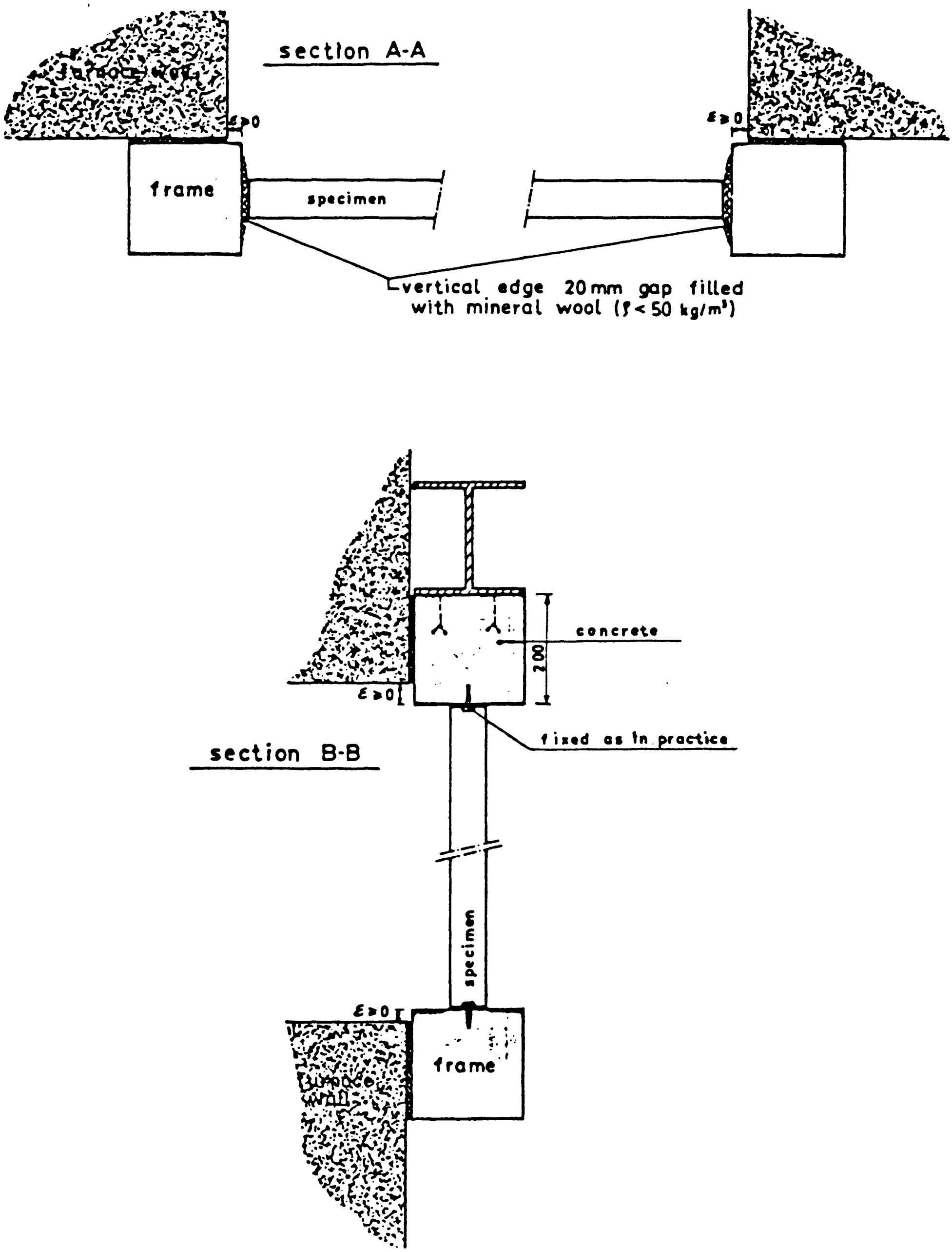

section A-A
frame
specimen
ε≥0
ε≥0
vertical edge 20mm gap filled with mineral wool (ρ < 50 kg/m³)
concrete
200
ε≥0
fixed as in practice
section B-B
specimen
ε≥0
frame

fig. 2.2/4

4. Measurements on test specimens.

4.1. Surface temperatures. (fig. 2.2./6.)

- At least five fixed thermocouples are used for measuring the mean surface temperature. They are located as shown in fig. 2.2./6. Their location would need to be changed if one of these points is at a place with no representative thermal insulation (e.g. : near joints, edges, studs, metal connections or screws).
- For determining the maximum temperature of the surface, at any place, fixed or movable thermocouples are used where high temperatures are expected. At the location of the joint it has to be avoided to measure gas temperature by the thermocouples (see fig. 2.2./7a). No thermocouple is applied closer than 100 mm to the unfixed vertical edges of a partition.
- At the fixed horizontal edges temperature should be measured by a movable thermocouple, as close as possible to the edge of the specimen (fig. 2.2./7b).
- In case of grooved surfaces, the temperature of the bottom of the groove is not taken into account provided the groove is more narrow than 12 mm. (Fig. 2.2./7c).
- Thermal insulation is not considered at the unfixed edge within a zone of 100 mm width.

4.2. Integrity measurement.

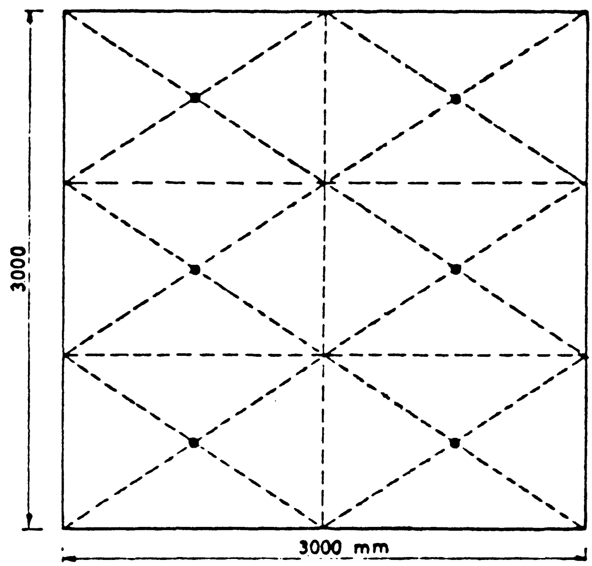
- The cottonwool pad is not applied nearer than 100 mm to the vertical sides of the specimen.
- Flames emerging from the gap between specimen and frame are not taken into account.

4.3. Deformation measurement.

- The location of the (non-mandatory) measuring points for deformation is given in figure 2.2./6.
- The measuring interval is 5 minutes.

5. Number of tests.

The number of tests has to be deduced from fig. 2.2./8.


3000
3000 mm

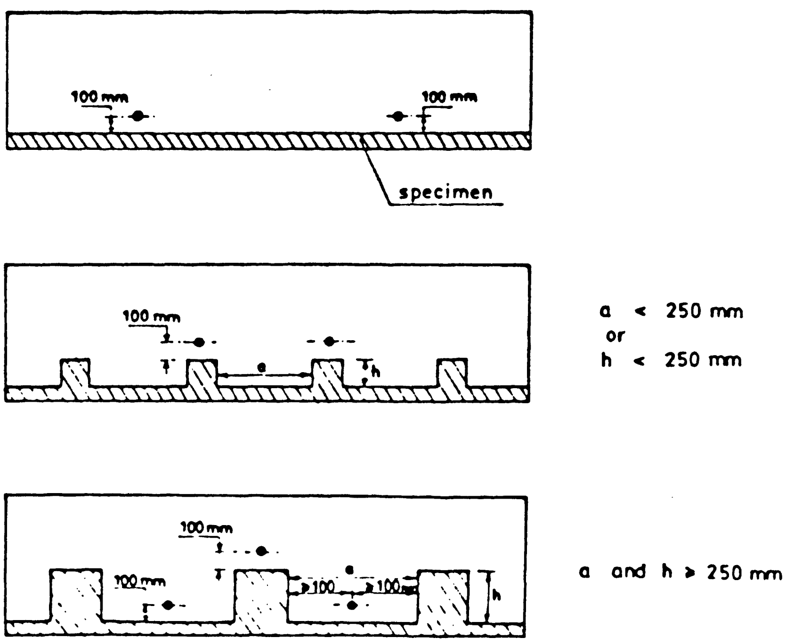
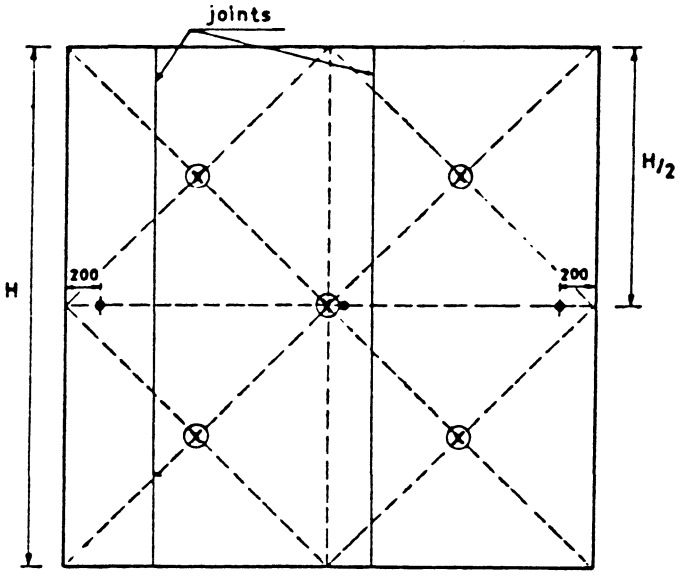

100 mm
100 mm
specimen
100 mm
a
h
a < 250 mm
or
h < 250 mm
100 mm
100 mm
a
≥100
≥100
h
a and h ≥ 250 mm

fig. 2.2/5



● Location of measuring points for deformation

x Location of thermocouples for determining the mean surface temperature.

fig. 2.2/6

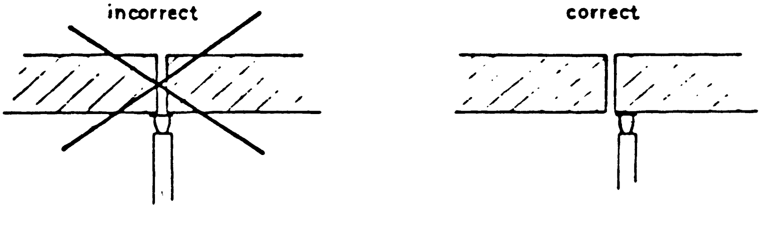


fig. 2.2/7a

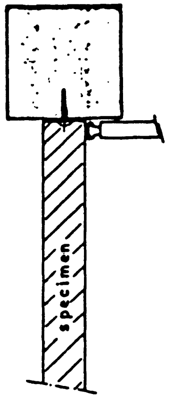


fig. 2.2/7b

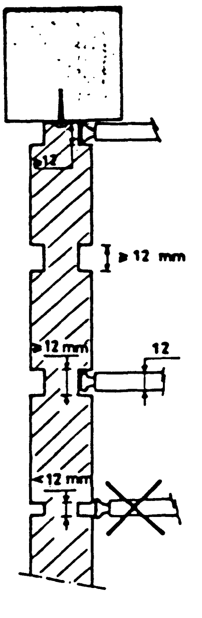


fig. 2.2/7c

fig. 2.2/8a

Symmetrical load bearing wall or partition.

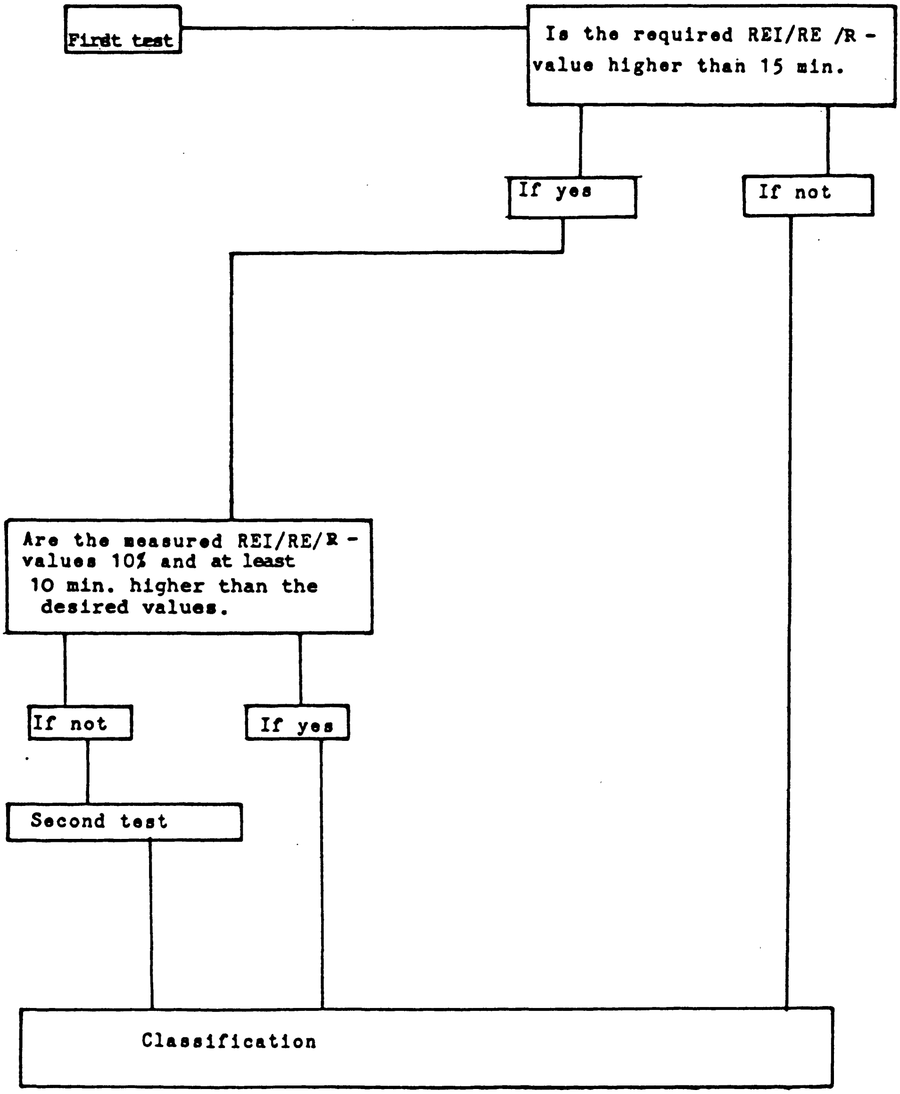
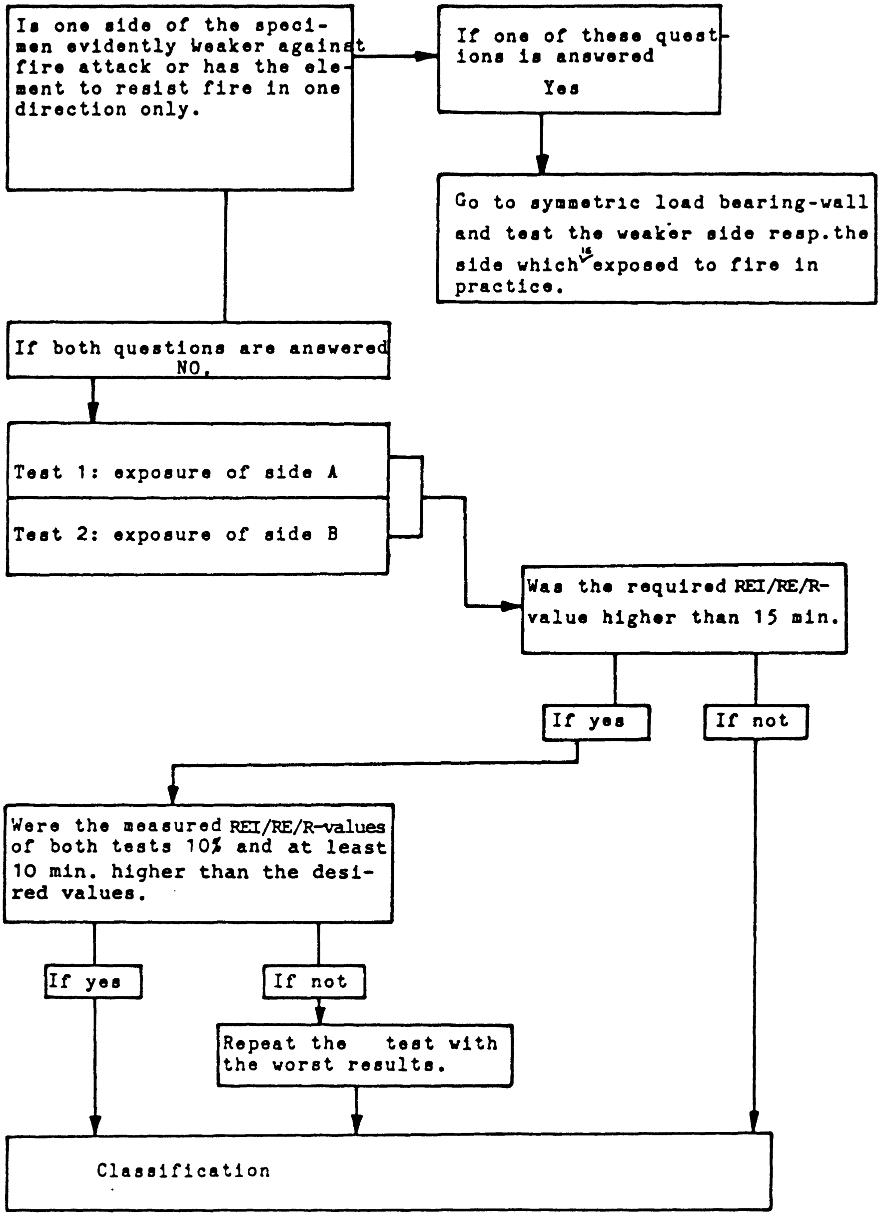


fig. 2.2/8b

Assymetrical load bearing wall or partition



6. Performance criteria.

No specifications are applied additional to those given in Chapter 1.

Note : These tests do not give information on integrity and insulation failure at sides of the wall, because edges, as they occur in practice, are not included in the tests.

SECTION III : COLUMNS

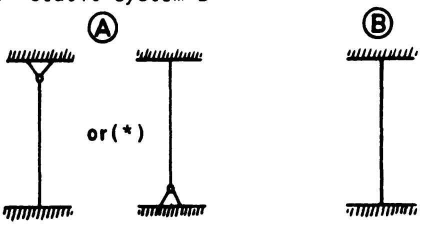
1. Design of specimen and exposure conditions.

1.1. Design of specimen.

- The heated length of the specimen is 3 m unless smaller in practice. The unheated length of the specimen at top and bottom may not exceed 0,25 m.
- If the void between a steel column and a box type cladding is closed during the test (no connection to the outside of the furnace), it must be closed in practice too, because this point is of a great importance on the test result. A warning in this respect has to be introduced in the test report.
  In the opposite case the connection tube between the void and the outside of the furnace must have a cross-section of about 20 % of the cross-section of the void and be situated at the top.

1.2. Static system.

- Both of the following static systems have to be tested.
  Test n° 1 : Static system A
  Test n° 2 : Static system B



If e.g. by calculation it can be checked that one of the two static systems will give the worst results the test with the other static system can be deleted.

- As the end conditions can influence very strongly the test result, special care has to be taken in order to avoid friction in the hinges and to have full restraint at the restrained ends.
- For static system A either bidirectional hinges are used or the hinge must allow buckling in the direction of the weakest side.

* FOOTNOTE : Both possibilities are left open because of existing furnaces. For reasons of temperature distribution, it is preferred to have the hinge at the bottom.

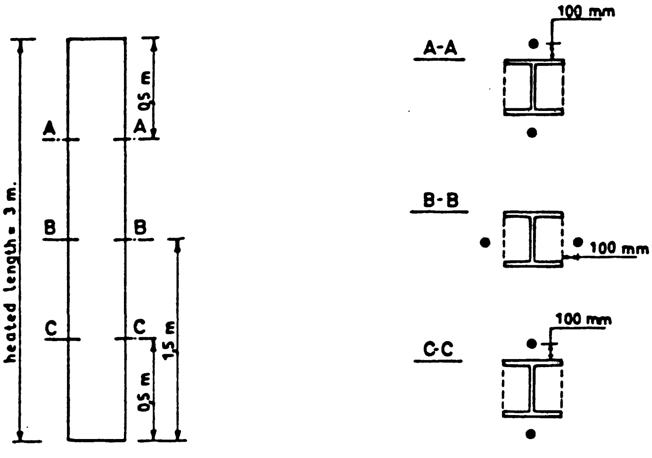


fig. 2.3/1

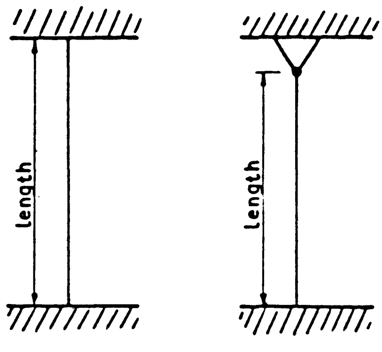


fig. 2.3/3

1.3. Exposure conditions.

- Free standing columns must be exposed to fire on all sides.
- columns with one face resting against a wall must be exposed to fire in such a way that the thermal attack is applied to their three free faces.
- columns partly or wholly built into a wall (with at least one face visible) must be exposed to fire under conditions simulating these situations.
- columns likely to be stressed by fire on two opposite faces (the other two faces being protected by adjacent walls) must be exposed to thermal attack in simulation of this situation.

2. Loading.

The load is applied centrically and calculated accordingly.

Special care has to be taken to avoid excentricity of the loading and lack of parallelism between the restrained ends of the column and the support(s), because of the extreme influence on the test result due to creation of uncontrolled and unknown bending moments. It is advised to check the bending moment in relation to the load before the test, by strain gauges.

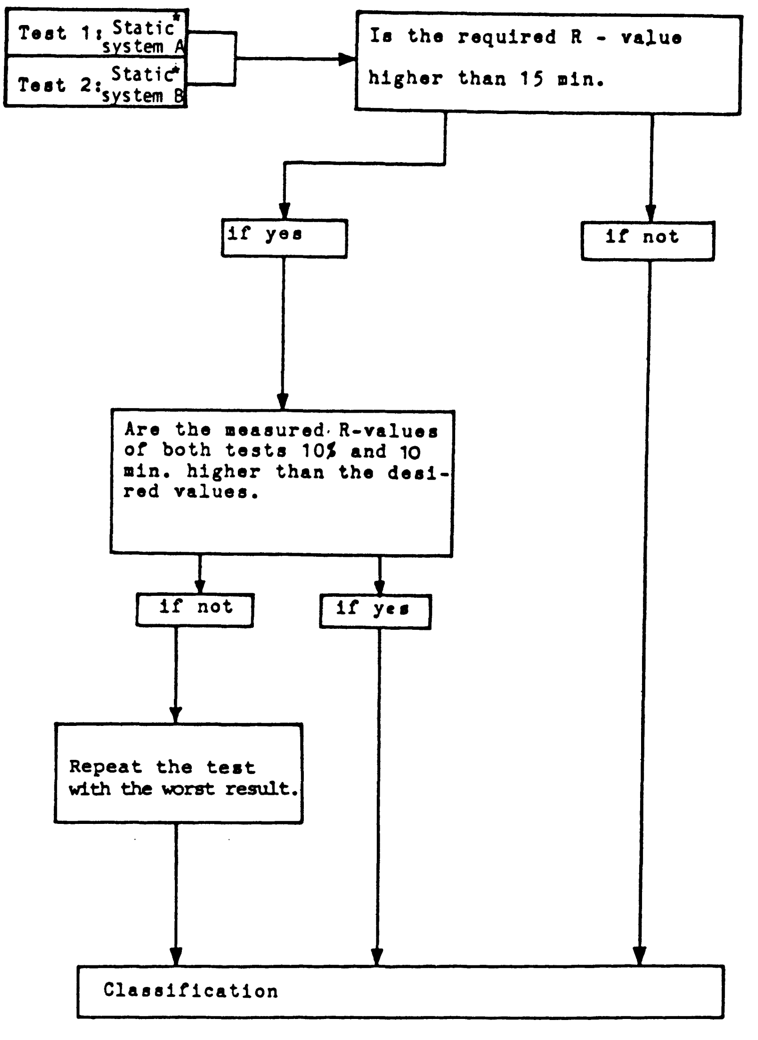
3. Furnace thermocouples.

At least 3 x 2 thermocouples are used.

These thermocouples are placed at a distance of 100 mm from the outer surface of the specimen at the beginning of the test (see fig. 2.3./1.).

fig. 2.3/2

Number of tests



* Footnote :

If e.g. by calculation it can be checked that one of the two static systems will give the worst results the test with the other static system can be deleted.

4. Measurements on test specimen.

4.1. Specimen thermocouples.

If temperature at the surface or inside the specimen is measured, it should be done in the same horizontal plane of the furnace thermocouples.

4.2. Elongation measurement.

The change in length of the specimen is continuously measured.

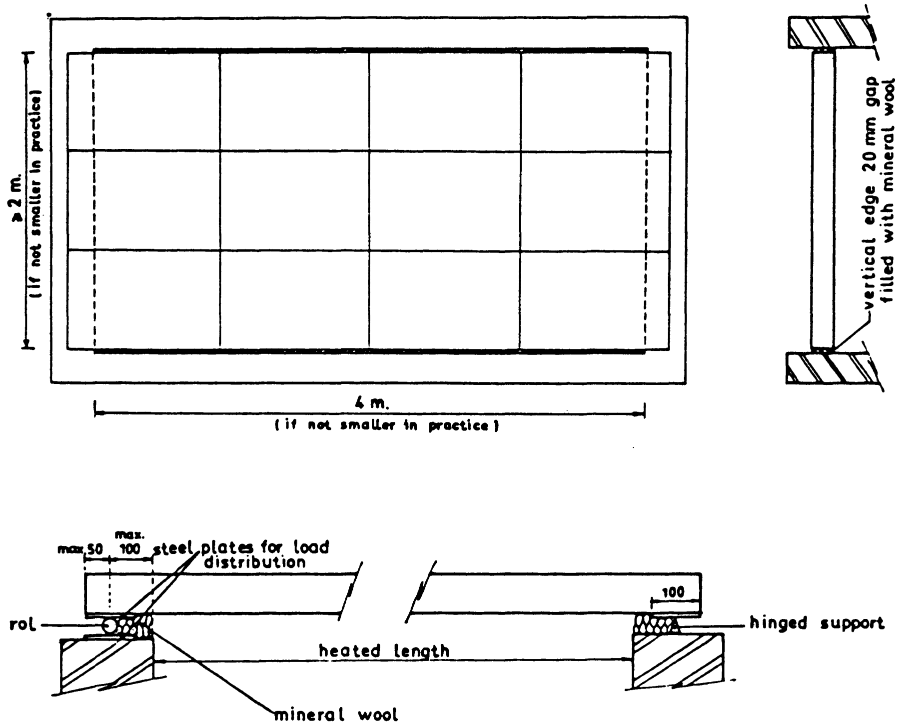
5. Number of tests.

The number of tests has to be deduced from fig. 2.3./2.

6. Performance criteria.

- If the test component is formed of materials which disintegrate or rupture under the combined effect of fire and load, as indicated above, the end-of-test criterion shall be collapse or rupture of the component.

- if the test component is formed of materials which deform continuously under the combined effect of fire and load, the end-of-test criterion shall be the rate of deformation of the component, which must not exceed 3 mm/m length. min. (see fig. 2.3/3.). Here deformation is defined as the decrease of the length between both ends of the specimen.



≥ 2 m.
(if not smaller in practice)
4 m.
(if not smaller in practice)
vertical edge 20 mm gap
filled with mineral wool
max. 50
max. 100
steel plates for load
distribution
100
rol
hinged support
heated length
mineral wool

fig. 2.4/1

1. Design of specimen and exposure conditions.

1.1. Floors at two sides supported.

1.1.1. Design of specimen. (fig. 2.4./1.)

- The specimen has a width of at least 2 m (*) and a heated length of 4 m unless in practice smaller.
- At least two joints in each direction are included in the test specimen if in practice there are joints in this direction.

1.1.2. Mounting of the specimen. (**)

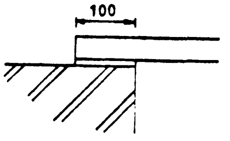
- At the long edges of the specimen a gap with a width of 20 mm between the specimen and the furnace wall is left in order to guarantee free deflection of the specimen. This gap should be filled with mineral wool.
- Each specimen is provided with one rolling and with one hinged support. An example of such support is shown in fig. 2.4./1. Extreme care is taken to avoid friction at the rolling support and to allow elongation and deflection.
- The difference between span and heated length may not exceed two times 100 mm.
- The difference between the total length and the span may not exceed two times 50 mm.
- Hollow floors are tested with the voids closed at the ends.

(*) The requirement of having two joints in the direction of the span can involve to test specimen with a greater width.

(**) In cases where the above test arrangement does not cover the fire behaviour of the practical end conditions (e.g. the junction between prefabricated floors and light weight partitions) the practical end conditions have to be included in the test arrangement.

1.2. Floors at four sides supported.

The specimen is laid on the furnace walls, the top of which must be smooth and in the same plane in such a way, that all four sides of the specimen are supported by a plane area of 10 cm width. The heated area shall be 3 m x 4 m (if not smaller in practice).



2. Loading.

The loading shall be carried out such as to produce stresses of the same magnitude as could be produced normally with fullsize elements when subjected to the design load i.e. the same maximum bending moment and the same maximum sheer forces.
Instead of a uniformly distributed load a number of equal, statically equivalent spot loads can be applied.
This means at least 1 loading point per m2.
In case of floors with load bearing members (e.g. timber joints) the loading points shall be located partially above the load bearing members, (each member being loaded with the same load) partially between them.

The loading points are distributed over the load bearing members and between them in such a way that in the member and also in the floor between them similar stresses occur as those belonging to the theoretical stresses caused by a theoretical uniformly distributed load.

The surface area of the loading spots shall not be smaller than 0,0225 m2 in order to avoid high concentration of local stresses. It shall not be greater than 0,0625 m2 in order to avoid significant effect on the cooling and surface temperature of the unexposed face. For timber floors the smaller loading points are advised. The overall area of the horizontal projection of the spots where loading is applied shall not exceed 10 % of the area exposed to fire in order to avoid too great influence on the thermal insulation of the specimen. The loading can be done either by dead load or by a hydraulic system. If with hydraulic loading, a load

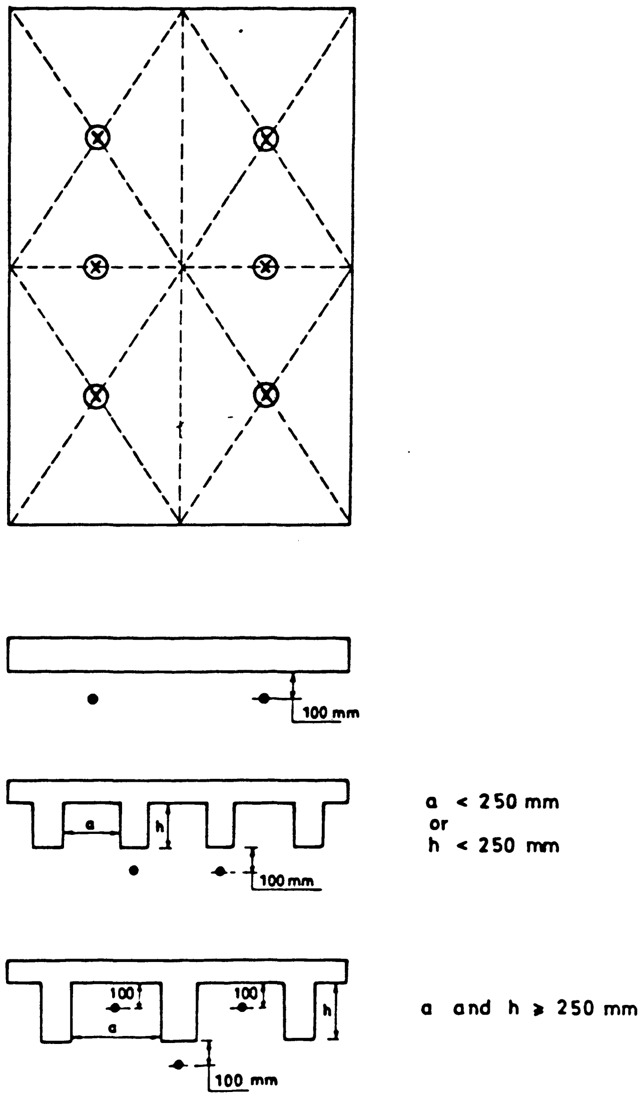


fig. 2.4/2

distribution system is applied, special care must be taken of the maintenance of the uniformity of the load distribution in all directions at deformation of the specimen. This can be done by choosing a roll-support on one side and a Δ-support at the other side of each load distribution profile.

The jacks and the profiles used to introduce loads on the floor shall be fitted to the load distribution system by hinges.

3. Furnace thermocouples.

- At least one thermocouple per 1,5 m2 specimen surface is used with a minimum of five thermocouples (that means at least six thermocouples for a 2 x 4 m specimen and at least nine thermocouples for a 3 x 4 specimen).
- The hot junction of the furnace thermocouples is situated at 100 mm from the majority of the lower surface of the specimen at the start of the test.
  Distance shall remain between 50 and 150 mm during the test. The thermocouples are equally distributed.
  Example : see fig. 2.4./2.

4. Measurements on test specimen.

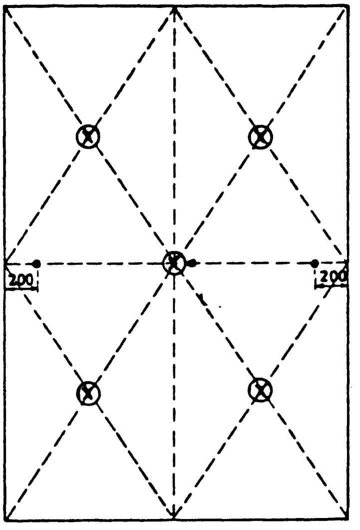
4.1. Surface temperature. (fig. 2.4./3.)

- At least five fixed thermocouples are used for determining the mean surface temperature.
- The location has to be changed if one of these points is at a place which is not representative for thermal insulation (e.g. joints, beams or metal connections). If necessary, additional thermocouples are attached - but not nearer than 100 mm to the long edges of a specimen supported on two sides.
- For determining the maximum temperatures of the surface, fixed or movable thermocouples are used at any place where high

temperatures are expected (mandatory) (except nearer than 100 mm to the long edges of a two sides supported specimen).

4.2. Integrity measurement.

- For floors at two sides supported, the cottonwool pad is not applied nearer than 100 mm to the long sides of the specimen.



• Location of measuring points for deformation

x Location of thermocouples for determining the mean surface temperature.

fig. 2.4 /3

- Frames emerging from the gap between specimen and frame are not taken into account.

4.3. Deformation measurement.

Point of deformation measurement.
If the floor consists of more than one element, the deformation is measured at the centre of each element.

5. Number of tests.

The number of tests has to be deduced from fig. 2.4./4.

6. Performance criteria.

Besides the criteria described in part one, for isotatically supported floors the stability criterion shall be the rate of deformation of the component, which must not exceed :

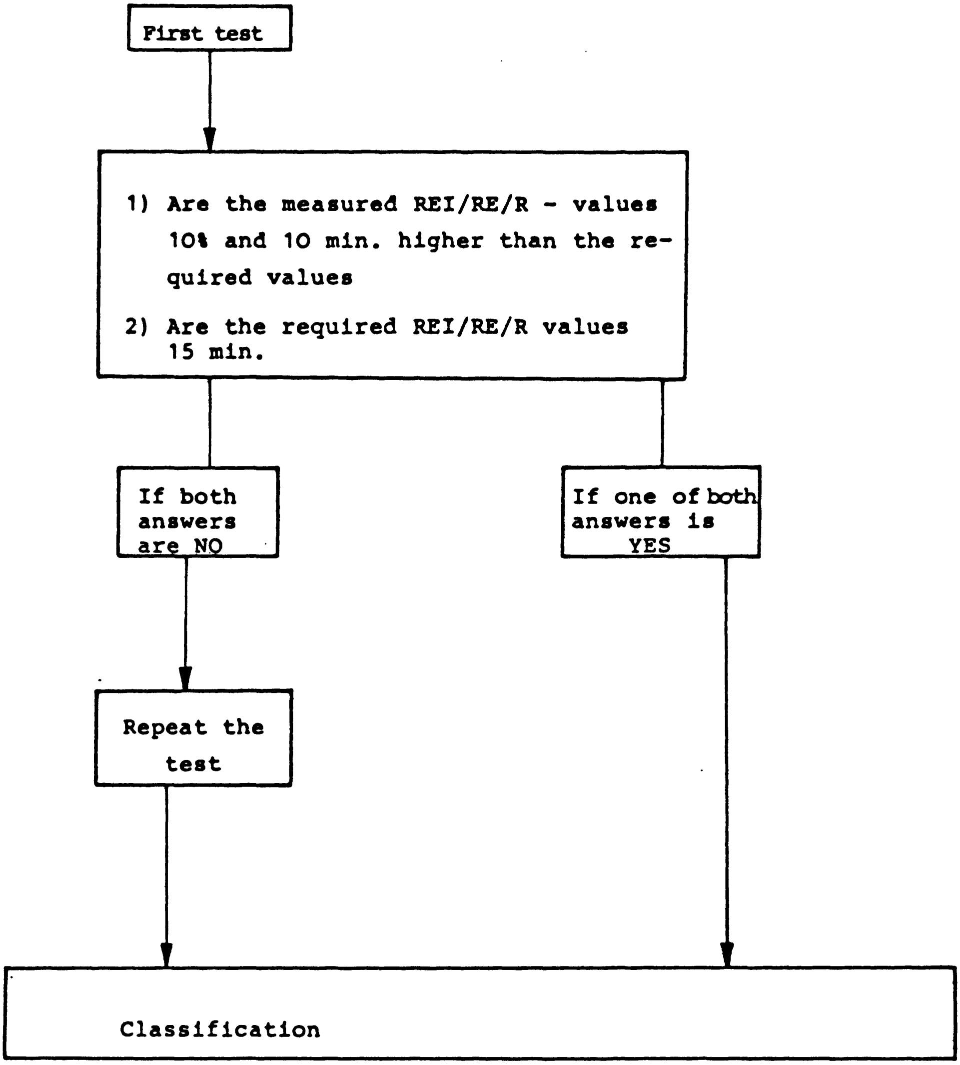
$$\Delta f/\Delta t = L^2 / \ (9000h)$$

L	= the span in mm
h	= calculation height in mm (*)
Δf	= the increase of the deformation in mm during a time interval t of one minute
Δt	= the time interval of one minute
$\Delta F/\Delta t$	= the rate of deformation in mm/min.

(*) h is the maximum height used for the calculation of the moment of intertia (I,W).

fig. 2.4 / 4

Number of tests



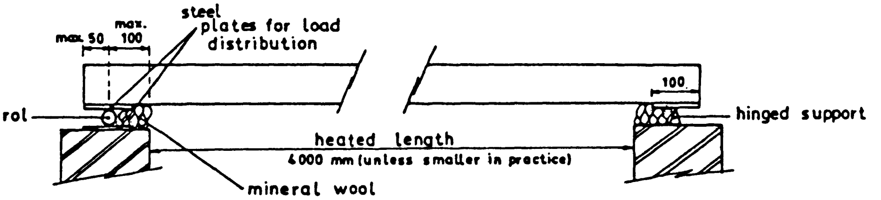


fig. 2.5/1

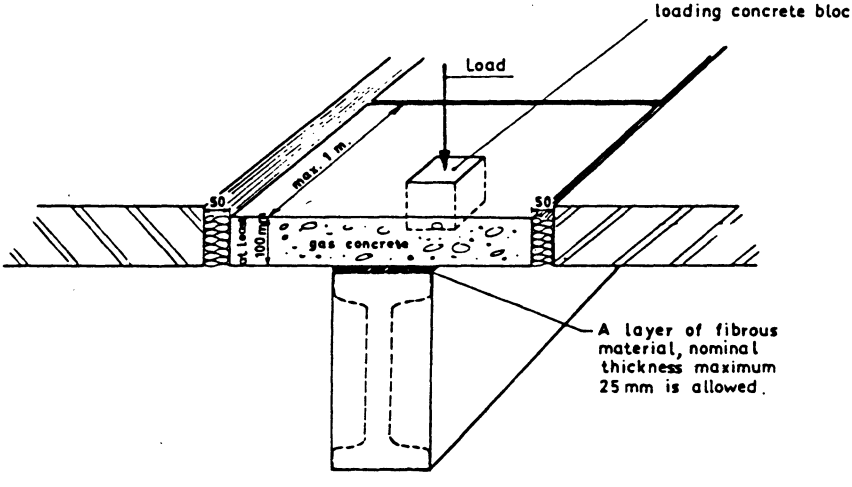


fig. 2.5/2

Section V : BEAMS.

1. Design of specimen and exposure conditions.

Note : Composite floor-beam elements are tested following Section IV.

1.1. Design of specimen. (fig. 2.5./1.)

- The beams are exposed to the fire over a length of 4 m unless smaller in practice.
- If the void between the steel beams and a box type cladding is closed during the test (no connection to the outside of the furnace), it must be closed in practice too, because this point is of a great importance on the test result. A warning of this respect has to be introduced in the test report. In the opposite case the connection tube between the void and the outside of the furnace must have a cross section of about 20 % of the cross section of the void and be situated at the top.

1.2. Static system.

The test is performed with both ends of the beam freely supported allowing free elongation and deflection of the beam.

1.3. Mounting of the specimen. (fig. 2.5./1. and 2.5./2.)

- The span is not more than two times 0,1 m longer than the heated length.
- The cold ends of the beam are not longer than two times 0,15 m unless different in practice.
- If the specimen itself is not containing a topping, the topping of the test specimen should be a gas concrete slab having sections not longer than 1 m.

  At the loading points the gas concrete topping is replaced by concrete blocks (see fig. 2.5./2.).

  Protecting claddings may not be fixed to the topping unless it is done so in practice.

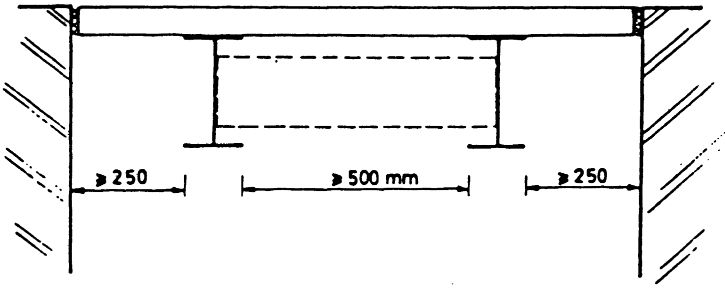


fig. 2.5/3

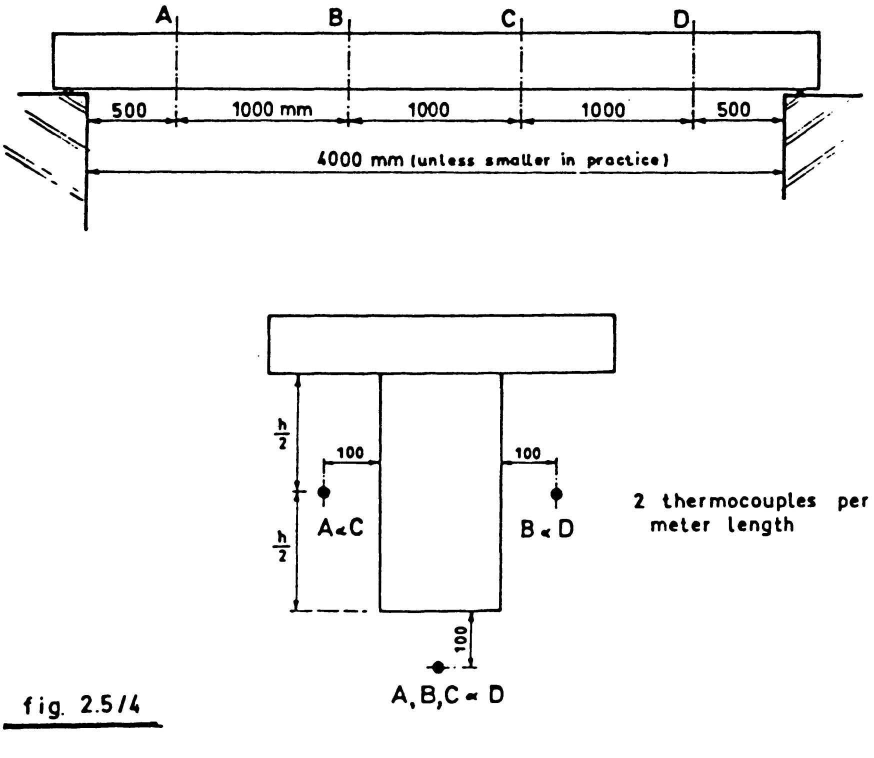


fig. 2.5/4

- The loading system must be articulated so that it can follow the deformation of the test piece.
- The test arrangement must provide lateral stability, e.g. by testing two parallel beams. Such a test arrangement is given in fig. 2.5./3. The clear space between the specimens is $\geqslant$ 500 mm, the clear space between specimens and furnace wall $\geqslant$250 mm.

- In some cases special precautions must be taken in order to prevent torsional deformation along the long axis of the beams, at the ends.

1.4. Exposure conditions

- Beams must have their three faces simultaneously exposed to thermal attack, the fourth face (i.e. the upper face) being protected.

  The vertical sides are exposed over the full height like in practice.
- Beams with four free faces, all of which can be attacked by fire, must be exposed to thermal attack in simulation of this situation. The distance from the upper side of the beam to the topping of the furnace is at least equal to the width of the beam.

2. Loading

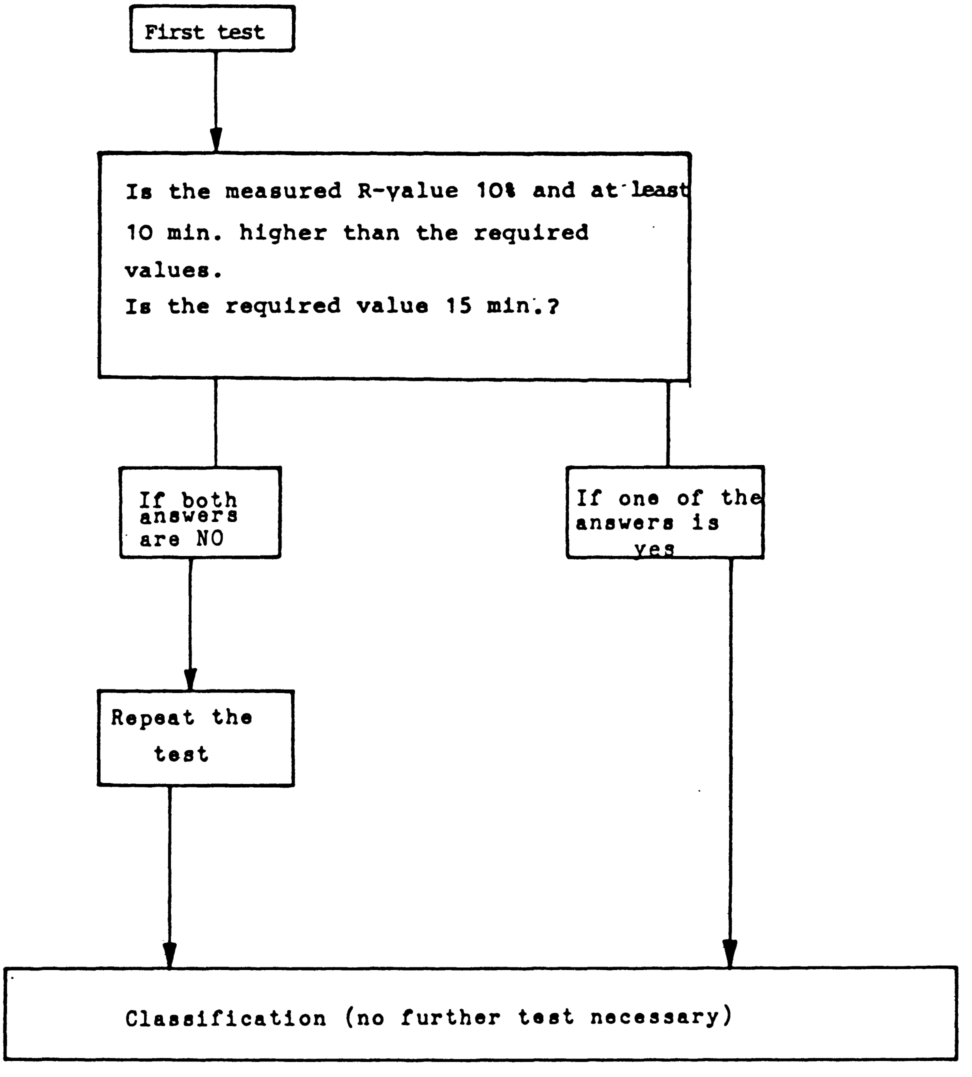
- The loading shall be carried out such as to produce stresses of the same magnitude as could be produced normally with full-size element when subjected to the design load, i.e. the same maximum bending moment and the same maximum shear forces.

  A minimum of two loading points with a minimum distance of 0,5 m between them is required.

- It must be realized that the above conditions do not allow the simulation of beam lengths larger than nearly two times the tested length.

fig. 2.5/5

Number of tests



3. Furnace thermocouples.

At least 2 thermocouples per 1 m length of the specimen are used with a minimum of 6 thermocouples (that means at least 8 thermocouples for a 4 m long specimen).

The hot junction of the furnace thermocouples is situated at 100 mm from the majority surface of the specimen, at the start of the test.

This distance shall remain between 50 and 150 mm during the test. The thermocouples are equally distributed.
Example : see fig. 2.5./4.

4. Measurements on test specimen.

4.1. Specimen thermocouples.

If temperature inside or at the surface of the specimen is measured it should preferably be done in the same vertical plane as the furnace unless an influence of the loading points can be expected there.

4.2. Deformation measurement.

- The deflection of the beam is measured at midspan.
- Zero deflection is the position after applying the load at the beginning of the test.
- The deflection is measured at intervals of 1 minute and hence the rate of deformation is derived.
- Measurement of the elongation and torsion along the longitudinal axis of the beam provides additional non-mandatory information.

5. The number of tests.

The number of tests has to be deduced from fig. 2.5./5.

6. Performance criteria.

- For beams only the 4-criterion is considered.
- For simply supported beams the R-criterion shall be the rate of deformation of the component, which must not exceed :

$\Delta f/\Delta t$	=	$L^2/(9000h)$
L	=	the span in mm
h	=	calculation height mm
Δf	=	the increase of the deformation in mm during a time interval t of one minute
Δt	=	the time interval of one minute
$\Delta f/\Delta t$	=	the rate of deformation in mm/min.

CHAPTER 3

INTRODUCTION

This chapter contains the form and main content of the test reports.
The described data and the order are mandatory. They are considered to be the minimum information. Other points of importance have to be added.
Each report shall give on the first page an indication that the test was fully in line with this document.
When the test procedure or the number of tests are not fully in line with this document no test report refering to this document shall be made.
If special interpretations of this document were necessary because of the nature or application of the building component it shall be explained explicitly in par. 8 of the test report.

Section I : STANDARD REPORT FOR FIRE RESISTANCE TEST ON A NON-LOAD-BEARING WALL OR PARTITION.

1. Identification.
   1.1. Test element.
   1.2. Purpose of test.
   1.3. Reference number and date of the report.
   1.4. Name of testing laboratory.
   1.5. Name of sponsor.
   1.6. Name of manufacturer and the trade name of the test. element or of the main components.
   1.7. Date of manufacture/delivery to the laboratory/ construction in the laboratory.
   1.8. Date of test.

2. Test specimen.
   2.1. The test report should contain a detailed description of the test specimen indicating:

      a. the intended function, (e.g. non-load-bearing wall).

      b. the type, composition and characteristics of the constituent materials and accessories; if one or more constituent materials and accessories are covered by national or international standards, it shall suffice to give an accurate and complete reference to these standards.

      In case there has been made use of typical small elements, e.q. nails, screws, etc..., these parts will be specified and illustrated by drawings in a

      c. suitable scale if necessary.

      c. The system used to join the var ious parts together.

      d. the mounting procedure in the laboratory.

      e. a plan or drawings on the most appropriate scale illustrating the test specimen by means of vertical and horizontal cross-section elevations, containing enough details and all dimensions so that it will always be possible to confirm subsequently the identity of a component with the component that has been subjected to the test.

      f. Photos of the specimen or part of it.

2.2. Conditioning procedure.

2.3. Material properties.

2.3.1. Reinforced concrete wall.

Composition of concrete.

Compressive strength and method od determining it (after 28 days and on day of test).

Density and moisture content on day of test.

2.3.2. Walls of bricks, blocks, panels, etc.

a. Composition of the bricks, blocks, panels, etc.

b. Composition of the mortar or glue.

c. Moisture content on day of test.

2.3.3. Leight weight partitions.

a. Grade(*)and kind of the material used for the studs.

b. Composition of the insulating material. Density and moisture content of the insulating material on day of test.

c. Composition of the lining material. Density and moisture content of the lining material on day of test.

2.3.4. Other non-load-bearing walls and partitions.

Composition of the constituent materials.Denmoisture content of the materials on day of test.

3. Test procedure.

3.1. Mechanical end conditions.

The mechanical end conditions can considerably influence the time of the fire resistance.

For this reason these conditions shall be described in full detail and illustrated by drawings and pictures (see chapter 2).

(*) For timber constructions the grade should follow national codes of standard but a detailed description of the timber in terms of the criteria used for the grading has to be given.

4. Exposure conditions.

The report shall indicate for each test the side on which the wall or partition was directly heated. It should explain in accordance with this document why this side was directly heated.

5. Observations during the test.

5.1 Furnace conditions.

Provide diagrams or tables showing the furnace temperatures recorded (individual readings, mean value and integral, furnace pressure and O_2 content at intervals not exceeding five minutes.

5.2. Performance of the test specimen.

Note the appearance of deformation and its speed of development until the test specimen collapses or the test is interrupted.

If the internal temperature of the test specimen is measured, state how it developed with time and give the position of the measuring points.

Note any other information about the performance of the test specimen during the test, e.g. cracking, softening, loosening of parts of the specimen, etc...

Description of the test specimen after the test including photos.

6. Duration.

State on basis of the stability criterion in respect of each test the time in minutes which elapsed from the beginning until the moment when the test was:

- either interrupted intentionally (stating who requested the interruption).
- or interrupted by failure of the test specimen.

The test result should be given in a table as given below:

TABLE I

Performance criterion	Duration in minutes		
	Test 1	Test 2	Test 3 etc.
Stability	$r_1 = e_1$	$r_2 = e_2$	$r_3 = e_3$
Integrity	e_1	e_2	e_3
Thermal insulation	i_1	i_2	i_3

7. Conclusion.

7.1. Duration values to be used for the classification.

Stability R	:	$r^{1)} =$	(min)
Integrity E	:	$e^{1)} =$	(min)
Thermal insulation	:	$i^{1)} =$	(min).

1) = lowest value given in Table I.

7.2. Classification

REI ....

RE ....

R ....

8. Remarks concerning the application of the test results.
In this chapter guidelines in relation with the applicability limitations, special warnings etc.,(e.g. special mounting and end conditions, warnings concerning the adhesion or corrosion problems with plaster on steel structures) of this test report shall be given.

9. Remarks concerning national special application conditions or instructions etc...... in the country of origin.

Section II : STANDARD REPORT FOR FIRE RESISTANCE TEST ON A LOAD-BEARING WALL OR PARTITION.

1. Identification.
   - 1.1 Test element.
   - 1.2. Purpose of test.
   - 1.3. Reference number and date of the report.
   - 1.4. Name of testing laboratory.
   - 1.5. Name of sponsor.
   - 1.6. Name of manufacturer and the trade name of the test element or the main components.
   - 1.7. Date of manufacture/delivery to the laboratory,/ construction in the laboratory of the test specimen.
   - 1.8. Date of test.

2. Test specimen.
   - 2.1. Description.

     The test report should contain a detailed description of the test specimen, indicating:

     a. the intended function (e.g. load-bearing wall).

     b. the type, of the constituent materials and accessories; if one or more constituent materials and accessories are covered by national or international standards, it shall suffice to give an accurate and complete reference to these standards.
        In case there has been made use of typical small elements, e.g. nails, screws, etc...., these parts will be specified and illustrated by drawings in a suitable scale if necessary.

     c. the systems used to join the various parts together.

     d. the mounting procedure in the laboratory.

     e. a plan or drawings on the most appropriate scale illustrating the test specimen by means of vertical and horizontal cross-section elevations, containing enough details and all dimensions so that it will always be possible to confirm subsequently the identity of a component that has been subjected to the test.

f. Photos of the specimen or part of it.

2.2. Conditioning procedure.

2.3. Material properties.

2.3.1. Reinforced concrete walls.

Composition of concrete.

Compressive strength and mèthod of determining it (after 28 days and on day of test).

Density and moisture content on day of test.

2.3.2. Walls of bricks, blocks, panels, etc....

a. Composition of the bricks, blocks, panals, etc. Compressive strength and/or bending strength of the bricks, blocks, panels, etc. with reference to the used national or international standard.

b. Composition of the mortar or glue compressive strength of the mortar with reference to the used national or international standard.

c. Moisture content on day of test.

2.3.3. Wooden stud partition.

a. grade of wood (*) mechanical strength and Emodulus

b. density and moisture content of wood on day of test.

c. kind of insulating material and density and moisture content on day of test

d. kind and composition of the lining material with density and moisture content on day of test.

(*) For timber constructions the grade should follow national codes of standard but a detailed description of the timber in terms of the criteria used for the grading has to be given.

2.3.4. Other load-bearing partitions.

Composition of the constituent materials.

Density and moisture content on the day of the test.

3. Test procedure.

3.1. Mechanical end conditions.

The mechanical end conditions can considerably influence the time of the fire resistance.
For this reason these conditions shall be described in full detail and illustrated by drawings and pictures (see chapter 2).

3.2. Loading.

3.2.1. Calculation of test load.

The whole calculation and the standards or codes used for the calculation should be given.

3.2.2. Load conditions.

These shall be indicated very clearly, taken into account the following points:

a. Method of applying load : dead or hydraulic load, etc.

b. Information on pre-loading and the moment at which the entire load was applied before thermal attack started.

4. Exposure conditions.

The report shall indicate for each test that the specimen was heated from one side only. It should give the side which was heated and explain in accordance with this document why this side was heated.

5. Observations during the test.

5.1. Furnace conditions.

Provide diagrams or tables showing the furnace temperatures recorded (individual readings, mean value and integral, furnace pressure and O_2 content at intervals not exceeding five minutes.

5.2. Performance of the wall or partition.

Note the appearance of deformation until the test specimen collapses or the test is interrupted.

If the internal temperature of the test specimen is measured, state how it developed with the time and give the position of the measuring points.

Note any other information about the performance of the test specimen during the test, e.g. crackening, loosening of parts of the specimen, opening of joints, etc.

Description of the specimen after the test including photos.

6. Duration.

State on the basis of the stability criterion in respect of each test the time in minutes which elapsed from the beginning until the moment when the test was : either interrupted intentionally - or interrupted by failure of the test specimen.

The test result should be given in a table as given below:

TABLE I

Performance criterion	Duration in minutes.		
	Test 1	Test 2	Test 3 etc.
Stability	r_1	r_2	r_3 etc.
Integrity	e_1	e_2	e_3 etc.
Thermal insulation	i_1	i_2	i_3

7. Conclusion.

7.1. Duration values to be used for the classification:

Stability R : $r^{1)}$ (min)

Intregity E : $e^{1)}$ (min)

Thermal insulation : $i^{1)}$ (min)

1) = Lowest value given in table I.

7.2. Classification:

REI ------

RE ------

R ------

8. Remarks concerning the application of the test results.
In this chapter guidelines in relation with the applicability (limitations or restrictions, special warnings, etc. (e.g. special mounting and end conditions) warnings concerning the adhesion or corrosion problems with plaster on steel structures of this test report shall be given.

9. Remarks concerning national special application conditions or instructions etc. in the country of origin.

Section III : STANDARD REPORT FOR FIRE RESISTANCE TEST ON A COLUMN

1. Identification.
   1.1. Test element.
   1.2. Purpose of test.
   1.3. Reference number and date of the report.
   1.4. Name of testing laboratory.
   1.5. Name of sponsor.
   1.6. Name of manufacturer and the trade-name of the test element or the main composents.
   1.7. Date of the manufacture/delivery to the laboratory/ construction in the laboratory.
   1.8. Date of test.

2. Test specimen.
   2.1. Description.

   The test report should contain a detailed description of the test specimen indicating:

   a. the intended function, e.g. load bearing.
   b. the type of the constituent materials and assessories, if one more constistuent materials and accessories are covered by national or international standards, it shall suffice to give an accurate and complete reference to these standards.
      In case there has been made use of typical small elements, e.g. nails, screws, etc....., these parts will be specified and illustrated by drawings in a suitable scale if necessary.
   c. the systems used to join the various parts together.
   d. the mounting procedure in the laboratory.
   e. a plan or drawings on the most appropriate scale illustrating the test specimen by means of vertical and horizontal cross-sections so that it will always be possible to confirm subsequently the identity of a

component that has been subjected to the test.

f. Photos of specimen or part of it.

2.2. Conditioning procedure.

2.3. Material properties.

2.3.1. Reinforced concrete column.

Composition of concrete including sand and cement. Compressive strength and method of determining it (after 28 days and on day of the test).

Kind of steel (nominal values for yield strength and ultimate strength), form and size. Actual values for yield strength and ultimate tensile strength.

In case of protected concrete columns data should be given concerning the smoothness of the concrete surface especial in relation to the use of oil for removing moulds.

2.3.2. Steel column.

a. Steel profile : dimensions (nominal and actuel), Steel properties : steel grade, yield strength (nominal and actual). Ultimate tensile strength (nominal and actuel).

b. Protecting materials.
   Composition of the protecting materials.
   Thickness of the material.
   Density of the material on day of test.
   Moisture content on day of test.
   The mounting procedure in the laboratory.

c. Surface treatment of the steel before application of the protection.

2.3.3. Timber column.

For the used timber the following data should be given.

a. Grade of wood (*), mechanical strength and E-modulus.

b. Density and moisture content on day of test.

(*) For timber constructions the grade should follow national codes of standard but a detailed description of the timber in terms of the criteria used for the grading has to be given.

3. Test procedure.

3.1. Mechanical end conditions.

The mechanical end conditions can considerably influence the time of fire resistance.
For this reason these conditions shall be described in full detail and illustrated by drawings and pictures.

3.2. Loading.

3.2.1. Calculation of test load.
The whole calculation and the standards or codes used for the calculation should be given.

3.2.2. Load conditions.
These shall be indicated very clearly taking into account the following points:

a. Way in which the critical loading is applied.
b. Stress distribution in a cross-section before heating at mid height (if measured).
c. Information on preloading and the moment at which the entire load was applied before thermal attack started.

4. Exposure conditions.

The report shall indicate the sides on which the column was directly heated. It shall also contain explanation why one or more sides were exposed to fire. If only a part of the construction element was directly heated it is necessary to illustrate how the unexposed sides were protected by a drawing.
Besides the position and location of the furnace thermocouples should be given in a drawing.

5. Observations during the test.

5.1. Furnace conditions.

Provide diagrams or tables showing the furnace temperatures recorded (individual readings, mean value and integral, furnace pressure and O_2 content at intervals not exceeding five minutes.

5.2. Performance of the test specimen.

Note the appearance of elongation and its speed of development until the test specimen collapses, the elongation criterion is reached or the test is interrupted.

If the internal temperature of the test specimen is measured, state how it developed with time and give the position of the measuring points. Note any other information about the performance of the test specimen during the test, e.g. crackening, softening, loosening of parts of the specimen, etc....

Description of the test specimen after test including photos.

6. Duration.

State on basis of the stability criterion in respect of each test the time in minutes which elapsed from the beginning until the moment when the test was:

- either interrupted intentionally (stating who requested the interruption);
- or interrupted by failure of the test specimen.

The test result should be given in a table as given below:

TABLE I

Performance criterion	Duration in minutes			
	Test 1 Case A[1)]	Test 2 Case A	Test 3 Case B[1)]	Test 4 Case B
Stability R	r_1	r_2	r_3	r_4

7. Conclusion.

7.1. Duration values to be used for the classification.

Stability : R[2)] -------------- minutes.

7.2. Classification.

Stability : R ---------------

1) see also chapter 2.

2) Lowest value of Table I.

8. Remarks concerning application of test results.
   In this chapter guidelines in relation with the applicability, limitation or restrictions, special warnings etc. (e.g. special mounting and end conditions, warnings concerning the adhesion or corrosion problems with plaster on steel structures) of this report shall be given.

9. Remarks concerning national special application conditions or instructions etc.... in the country of origin.

SECTION IV : STANDARD REPORT FOR FIRE RESISTANCE TEST ON A FLOOR WITH AND WITHOUT A CEILING, WITH FIRE ATTACK FROM THE UNDERSIDE ONLY

1. Identification.
   1.1. Test element.
   1.2. Purpose of test.
   1.3. Reference number and date of the report.
   1.4. Name of testing laboratory
   1.5. Name of sponsor.
   1.6. Name of manufacturer and the trade-name of the test element or of the main components.
   1.7. Date of the manufacture/delivery to the laboratory/ construction in the laboratory of the test specimen.
   1.8. Date of the test.

2. Test specimen.
   2.1. Description.

The test report should contain a detailed description of the complete test assembly indicating:

a. the type composition and characteristics of the constituent materials and accessories; if one or more constituent materials and accessories are covered by national or international standards, it shall suffice to give an accurate and complete reference to these standards.
   In case there has been made use of typical small elements, e.g. hangers,nails, screws, etc...., these parts will be specified and illustrated by drawings in a suitable scale if necessary.
b. the systems used to join the various parts together.
c. the mounting procedure in the laboratory.
d. a plan or drawings on the most appropriate scale illustrating the test specimen by means of vertical and horizontal cross-section elevations containing enough details and all dimensions so that it will always be possible to confirm

subsequently the identity of a component with the component that has been subjected to the test.

e. Photos of the specimen or part of it.

2.2. Conditioning procedure.

2.3. Material properties.

2.3.1. Concrete floor.

Composition of concrete including sand and cement.
Compressive strength and method of determining if (after 28 days and on day of test).

Density and moisture content on day of test.
Kind of steel (nominal values for yield strength and ultimate tensile strength) form and size. Actual values for yield strength and ultimate tensile strength.
In case of protected concrete floors protected directly at the underside with sprayed materials, data should be given concerning the smoothness of the concrete surface, the use of oil for removing moulds, because these elements can strongly influence the adherence of the protection on the concrete.

2.3.2. Wooden floor.

For the used timber, the following data should be given:

a. Grade of wood(*)
b. Density and moisture content on day of test.

2.3.3. Ceiling.

The following data should be given:

a. Composition of the ceiling materials
b. density and moisture content of the ceiling materials.
c. kind of material and grade if specified of the layingrid system and hangers if any.

(*) For timber constructions the grade should follow national codes of standard but a detailed description of the timber in terms of the criteria used for the grading has to be given.

3. Test procedure.

3.1. Mechanical end conditions.

The mechanical end conditions can considerably influence the time of fire resistance.
For this reason these conditions shall be described in full detail and illustrated by drawings and pictures (see Part 2).

3.2. Loading.

3.2.1. Calculation of test load.

The whole calculation and the standards or codes used for the calculation should be given.

3.2.2. Load conditions.

These shall be indicated very clearly taking into account the following points:

a. Type of load : concentrated, uniformly distributed, mixed (concentrated and distributed).
b. Method of applying load : dead Load or hydraulic load etc.
c. Information on preloading and the moment at which the entire load was applied before thermal attack started.

4. Exposure conditions.

The report shall indicate the position and location of the furnace thermocouples in a drawing.
Indication that the exposure was only done at the underside.

5. Observations during the test.

5.1. Furnace conditions.

Provide diagrams or tables showing the furnace temperatures recorded (individual readings, mean value and integral) furnace pressure and O_2 content at intervals not exceeding five minutes.

5.2. Performance of the test floor.

Note the appearance of deformation and its speed of development until the test specimen fails or the test is interrupted.
If the internal temperature of the test specimen (e.g. temperature underside floor etc.) is measured, state how it deve-

loped with time and give the position of the measuring points. Note any other information about the performance of the test specimen during the test, e.g. crackening, softening, loosening of parts of the specimen, collapse of the ceiling material etc.....

Description of the specimen after test including photos.

6. Duration.

State on basis of the performance criteria in respect of each test the time in minutes which elapsed from the beginning until the moment when the test was :

- either interrupted intentionnally, stating who requested the interruption)
- or interrupted by failure of the test specimen.

The test result should be given in a table as given below.

TABLE I

Performance criterion	Duration of test in minutes	
	Test 1	Test 2
Stability R	r_1	r_2
Integrity	e_1	e_2
Thermal insulation	i_1	i_2

7. Conclusion.

7.1. Duration values to be sused for the classification.

Stability R : $r^{1)}$ (min)

Integrity E : $e^{1)}$ (min)

Thermal insulation I : $i^{1)}$ (min)

1) = Lowest value given in table I

7.2. Classification

REI : ....

RE : ....

R : ....

8. Remarks on the application of the test results. This test gives information for the fire attack from the underside of the tested floor only. In this chapter guidelines in relation with the applicability, limitations or restrictions, special warnings (e.g. special mounting and end conditions, warnings concerning the adhesion or corrosion problems with plaster on steel structures) of this test report shall be given.

9. Remarks concerning national special application conditions or instructions, etc... in the country of origin.

SECTION V : STANDARD REPORT FOR FIRE RESISTANCE TEST ON A BEAM

1. Identification.
   1.1. Test element.
   1.2. Purpose of test.
   1.3. Reference number and date of the report.
   1.4. Name of testing laboratory.
   1.5. Name of sponsor.
   1.6. Name of manufacturer and the trade-name of the test specimen or of the main components.
   1.7. Date of manufacture/delivery to the laboratory/construction in the laboratory.
   1.8. Date of the test.

2. Test specimen.
   2.1. Description.

   The test report should contain a detailed description of the test specimen indicating:

   a. the intended function, e.g. load bearing.
   b. the type of the constit ent materials and accessories, if one or more constituent materials and accessories are covered by national or international standards, it shall suffice to give an accurate and complete reference to these standards.
      In case there has been made use of typical small elements, e.g. nails, screws, pinspotters etc., these parts will be illustrated in a suitable scale.
   c. the systems used to join the various parts together.
   d. the mounting procedure in the laboratory.
   e. a plan or drawings on the most appropriate scale illustrating the test specimen by means of vertical and horizontal cross-section elevations containing enough details and all dimensions so that it will always be possible to confirm subsequently the identity of a component with the component that has been subjected to the test.
   f. photos of the specimen or part of it.

2.2. Conditioning procedure.

2.3. Material properties.

2.3.1. Reinforced concrete beam.

Composition of concrete incl. sand and cement. Compressive strength and method of determining it (after 28 days and on day of test). Density and moisture content on day of test. Kind of steel (nominal values for yield strength and ultimate tensile strength, from and size. Actual values for yield strength and ultimate tensile strength.

In case of protected concrete beams data should be given concerning the smoothness of the concrete surface especial in relation to the use of oil for removing moulds.

2.3.2. Steel beam.

a. Steel profile : dimensions, nominal and actuel steel grade, steel properties : steel grade, yield strength (nominal and actual values), ultimate tensile strength (nominal and actuel values.)

b. Protecting materials.
   Compositions of the protecting materials.
   Thickness of the material.
   Density of the material on day of test.
   Moisture content on day of test.

c. Surface treatment of the steel before application of the protection.

2.3.3. Timber beam.

For the used timber the following data should be given :

a. Grade of wood (*)

b. Density and moisture content on day of test.

(*) For timber constructions the grade should follow national codes of standard but a detailed description of the timber in terms of the criteria used for the grading has to be given.

3. Test procedure.

3.1. Mechanical end conditions.

The mechanical end conditions can considerably influence the time of fire resistance. For this reason these conditions shall be described in full detail and illustrated by drawings and pictures.

3.2. Loading.

3.2.1. Calculation of test load.

The whole calculation and the standards or codes used for the calculation should be given.

3.2.2. Load conditions.

These shall be indicated very clearly taking into account the following points :

a. Type of load : concentrated, uniformly distributed, mixed (concentrated and distributed).
b. method of applying load : dead load or hydraulic load, etc
c. Information on preloading and the moment at which the entire load was applied before thermal attack started.

4. Exposure conditions.

The report shall indicate the sides on which the beam was directly heated. If the upperside of the beam is not directly heated the composition of the topping materials used to protect the upperside should be given in the report as well as the mounting procedure. Besides the position and location of the furnace thermocouples should be given in a drawing.

5. Observations during the test.

5.1. Furnace conditions.

Provide diagrams or tables showing the furnace temperatures recorded (individual readings, mean value and integral) furnace pressure and O_2 content at intervals not exceeding five minutes.

5.2. Performance of the test beam.

Note the appearance of deformation and its speed of development until the test specimen collapses or the test is inter-

rupted or until the deformation criterion is reached.
If the internal temperature of the test specimen is measured, state how it developed with time and give the position of the measuring points. Note any other information about the performance of the test specimen during the test, e.g. crackening, softerning, loosening of parts of the specimen etc...
Description of the specimen after test including photos.

6. Duration.

State on basis of the stability criterion in respect of each test the time in minutes which elapsed from the beginning until the moment when the test was :

- either interrupted intentionally (stating who requested the interruption)
- or interrupted by failure of the test specimen.

The test result should be given in a table as given below;

TABLE I

Performance criterion	Duration in minutes	
	Test 1	Test 2
Stability R	r_1	r_2

7. Conclusion.

7.1. Duration values to be used for the classification.

Stability R : $r^{1)}$ .... minutes.

1) = Lowest value of table I.

7.2 Classification.

Stability R : ....

8. Remarks concerning the application of test results. In this chapter guidelines in relation with the applicability, limitations or restrictions, special warnings (e.g. special mounting and end conditions, warnings concerning the adhesion or corrosion problems with plaster on steel structures) of this test report shall be given.

9. Remarks concerning national special applications conditions or instructions, etc.... in the country of design.

European Communities — Commission

EUR 8750 — Testing and classification of the resistance to fire of structural building components

J. Dekker, M. Klingelhöfer, P. Vandevelde

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The report concerning 'Testing and classification of the resistance to fire of structural building components' is divided into two parts.

The first part 'Analysis of fire test equipment in EEC laboratories' concerns:
(i) comments on the facilities in the laboratories;
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(iii) operating conditions;
(iv) measuring devices;
(v) loading and end conditions;
(vi) test load;
(vii) criteria and application of test results;
(viii) remarks on test reports.

This first part regroups a vast quantity of information which up until now had never been covered in the same document.

The second part deals with the application of contents from the first part to the establishment of an operational Community method for the testing and classification of fire resistance of structural building components:

(i) load-bearing walls;
(ii) load-bearing partitions;
(iii) non-load-bearing walls;
(iv) non-load-bearing partitions;
(v) simply supported floors (with or without ceilings) with fire attack from the underside only;
(vi) columns;
(vii) simply supported beams.

This second part provides no extrapolation rules.

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