test report

Title:

The Fire Resistance Performance Of Suspended Ceiling Assembly Incorporating Light Fittings Protecting Loadbearing I Section Steel Beams In Accordance With BS 476: Part 23: 1987, Clause 5

WF Report No:

148051

Date:

10th November 2005

Notified Body No:

0833

UKAS TESTING
0249

warringtonfire
global safety
TESTING

Summary

Objective

To determine the fire resistance performance of a specimen of a suspended ceiling incorporating light fittings, when tested in accordance with BS 476: Part 23: 1987, Clause 5.

Summary of Tested Specimens

The specimen had nominal dimensions of 4000 mm long by 3000 mm wide and consisted of an exposed metal tee suspended grid system. The main runners of the grid system spanned the 4000 mm length of the furnace chamber. A single layer of square edge ceiling tiles referenced ''Prima – BP9121M3B/01', nominally 595 mm wide by 595 mm long by 16 mm thick, was laid into the grid system. The ceiling was installed such that an air cavity with a depth of approximately 375 mm was formed above it.

The ceiling incorporated four downlights of differing diameters referenced 'FR1004 LV', 'FR1003 S LV', 'FR1002 S LV' and FR1001 S LV'

The effective protection offered by the suspended ceiling to the loadbearing steel beams is evaluated by the use of the loadbearing capacity failure criterion specified in BS 476: Part 20: 1987. The result obtained was as follows:

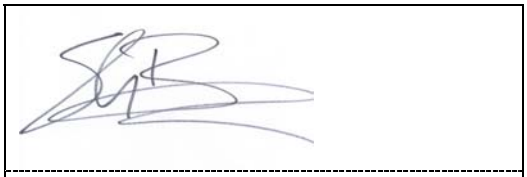
Test Results:

Loadbearing capacity 108 minutes

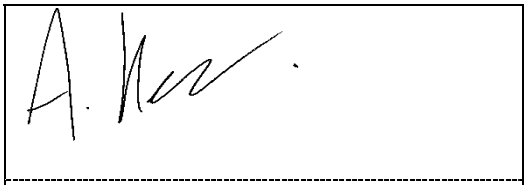
The test was discontinued after a period of 109 minutes

Date of Test 13th July 2005

Signatories



Responsible Officer
S. Baker*
(Technical Officer)



Approved
A. Kearns*
(Technical Consultant)

* For and on behalf of warringtonfire.

Report Issued

Date 10th November 2005

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Test Procedure

Introduction

The specimen tested was of a suspended ceiling. The test was conducted in accordance with Clause 5 of BS 476: Part 23: 1987, 'Methods for determination of the fire resistance of elements of construction'. This test report should be read in conjunction with that Standard and with BS 476: Part 20: 1987, 'Methods for determination of the fire resistance of elements of construction (general principles)'.

The specimen was judged on its ability to provide fire protection to hot rolled steel 'I' section beams of serial size 203mm by 133mm by 30kg/m to BS EN 10025: 1993, Grade S275, each having a nominal section factor of 210m $^{-1}$ (three sided exposure).

Fire Test Study Group / EGOLF

Certain aspects of some fire test specifications are open to different interpretations. The Fire Test Study Group and EGOLF have identified a number of such areas and have agreed Resolutions which define common agreement of interpretations between fire test laboratories which are members of the Groups. Where such Resolutions are applicable to this test they have been followed.

Instruction to test

The test was conducted on the 13th July 2005 at the request of Sealite Company Limited, the sponsor of the test.

Test Specimen Construction

A comprehensive description of the test construction is given in the Schedule of Components. The description is based on a detailed survey of the specimens and information supplied by the sponsor of the test.

Installation

The ceiling assembly and light fittings were installed by a representatives of the client within a refractory concrete lined, steel support frame on the 12th July 2005.

Sampling

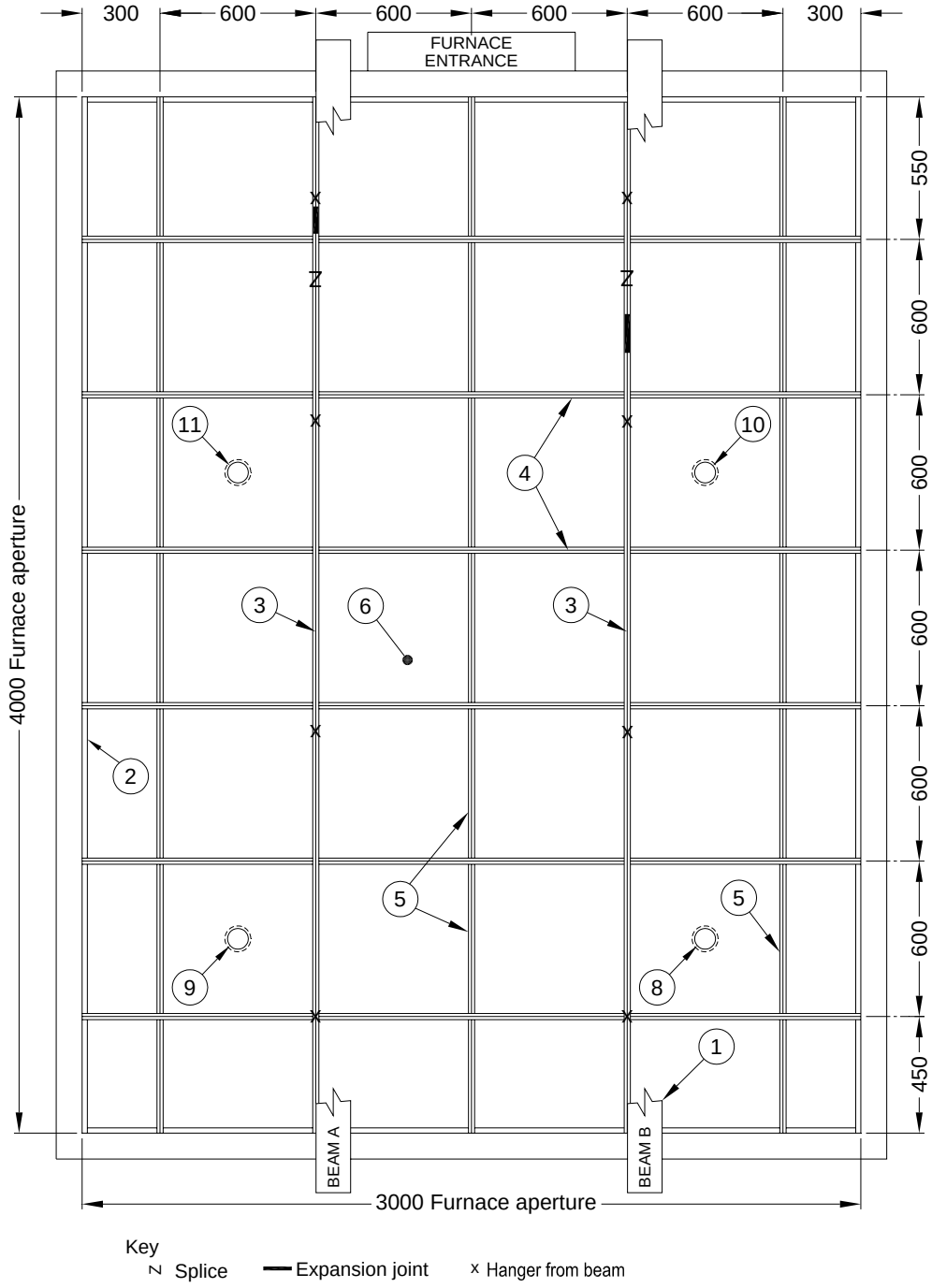
warringtonfire was not involved in any selection or sampling procedures of the assembly or any of its components.

Loading Conditions

A total load of 8134 kg was applied to the beam by four point loads produced by hydraulic rams. The rams were positioned at distance 1/8, 3/8, 5/8 and 7/8 of the span of the beam, as shown in Figure 2. The applied load, together with the dead load, was calculated to develop the maximum permissible stress in bending. The load was kept constant for 108 minutes, after which time it was removed from the beam.

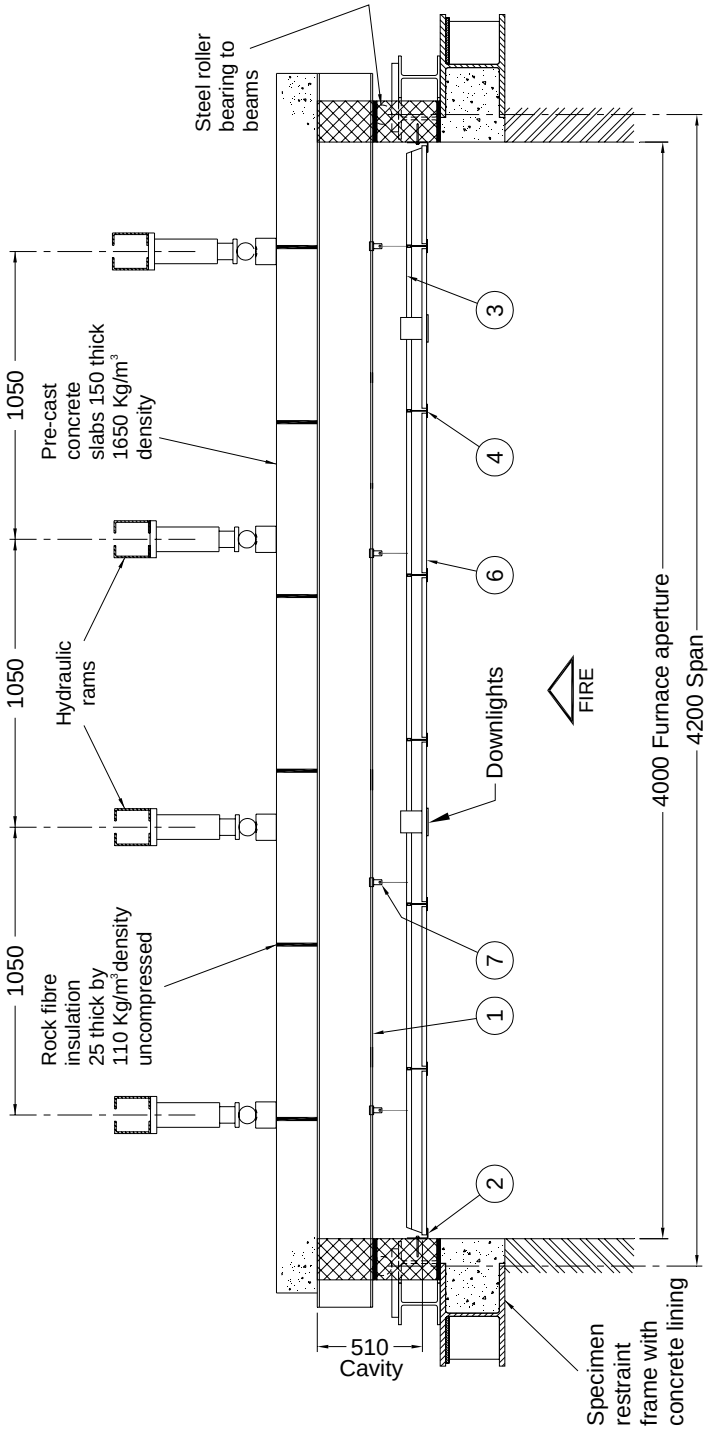
Test Specimen

Figure 1- General Plan of Test Specimen



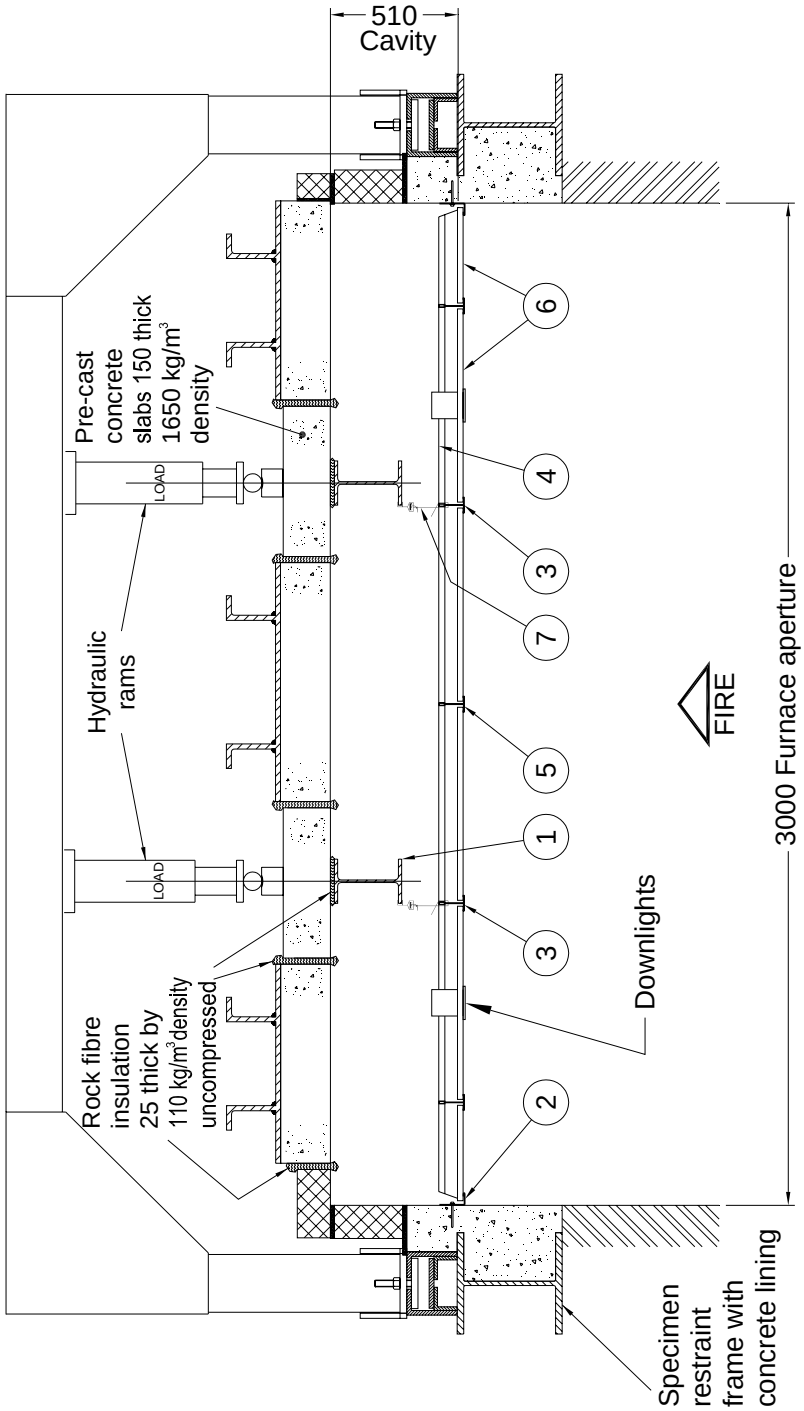
Do not scale. All dimensions are in mm

Figure 2 – Longitudinal Section



Do not scale. All dimensions are in mm

Figure 3 – Lateral Section



Do not scale. All dimensions are in mm

Figure 4 – Details of Downlights

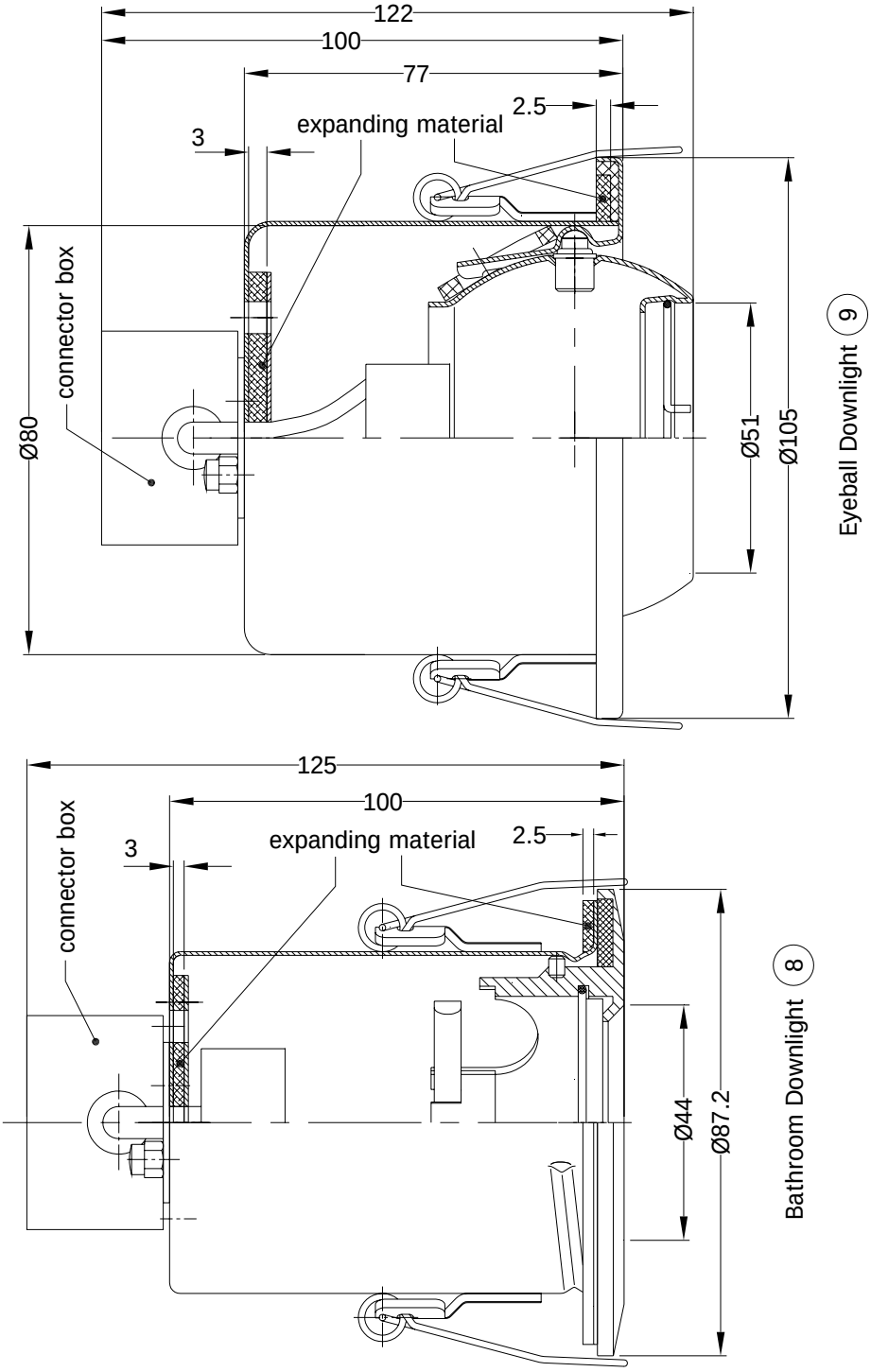


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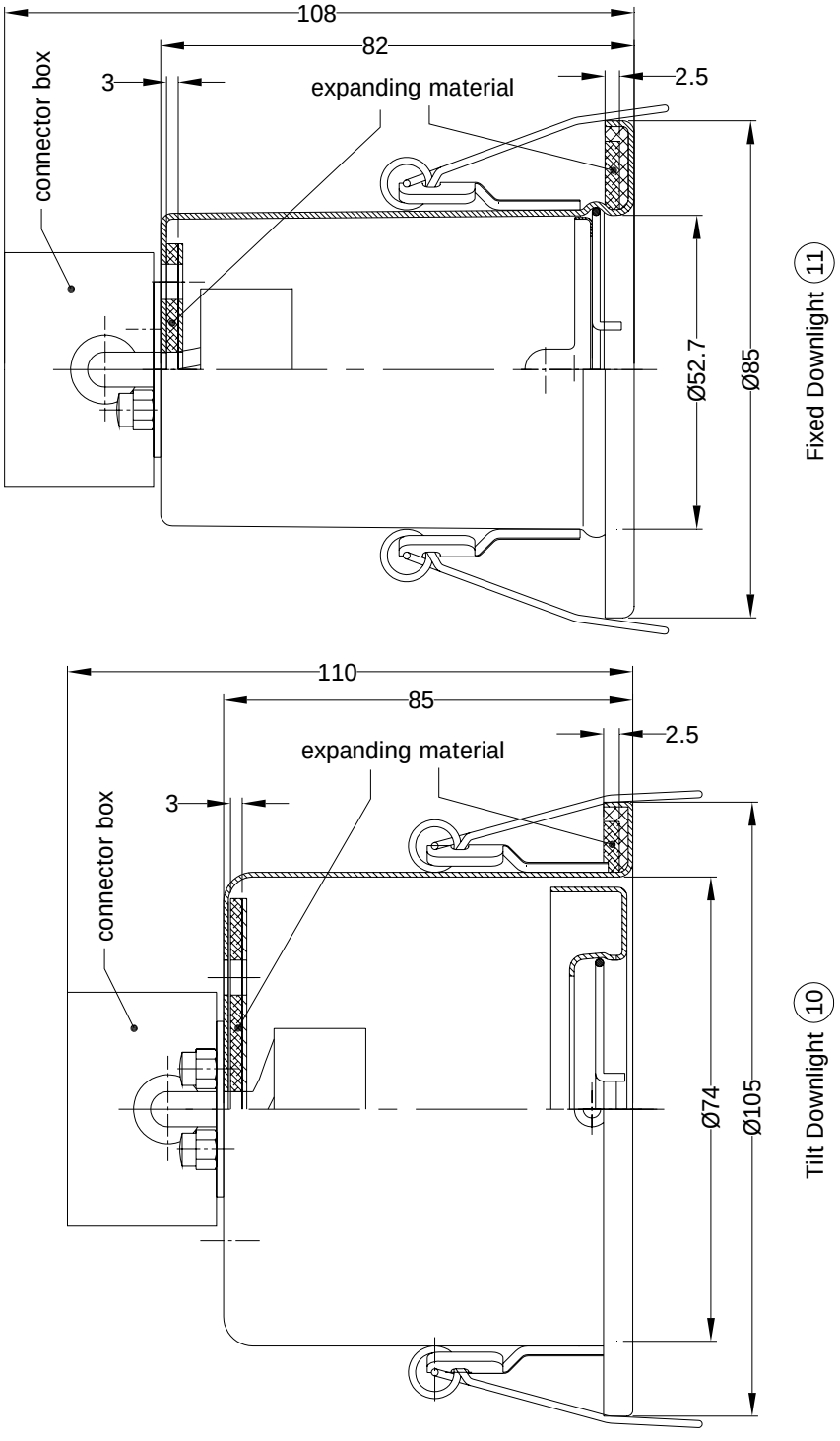
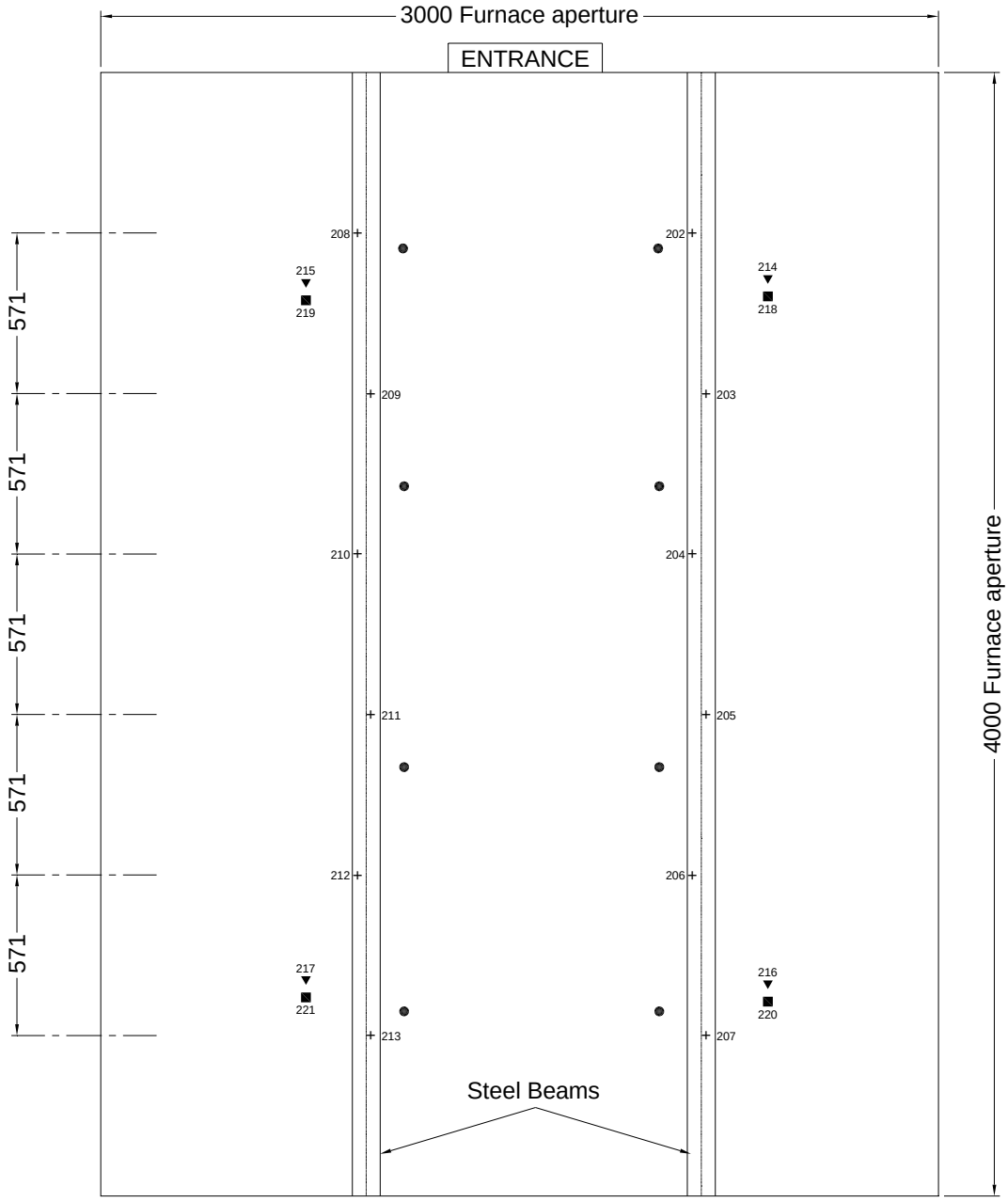
Figure 5 – Details of Downlights



Do not scale. All dimensions are in mm

Figure 6 – Plan of Thermocouple Positions



Key to thermocouple positions

- ■ Air at mid-cavity height
- ▼ Upper face of ceiling membrane
- ● Furnace 100mm below ceiling
- \+ Lower flange of steel beam

Numbers adjacent to thermocouples are WFRC logging numbers

Do not scale. All dimensions are in mm

Schedule of Components

(Refer to Figures 1 to 4)
(All values are nominal unless stated otherwise)
(All other details are as stated by the sponsor)

Item		Description
1. Steel Beams		
Type	:	I Section beam
Material	:	Mild steel to BSEN10025: 1990, Grade S275
Size		
i. overall	:	203 mm x 133 mm
ii. weight	:	30 kg/m
iii. span	:	4200 mm
2. Perimeter Trim		
Manufacturer	:	Armstrong World Industries Inc.
Reference	:	BPT1932H.
Material	:	Mild steel angle with steel capping.
Overall size	:	19 mm wide x 32 mm high
Details of Fixings		
i. reference	:	Masonry nails
ii. material	:	Galvanised/zinc
iii. size	:	3 mm diameter x 25 mm long
iv. centres	:	450 mm.
3. Main Tee		
Manufacturer	:	Armstrong World Industries Inc.
Reference	:	Prelude 31 40 32 A
Material	:	Hot dipped galvanised mild steel with a mild steel capping to the bottom flange.
Overall size	:	24 mm wide x 42.5 mm high x 3600 mm manufactured length.
Grid centres	:	1200 mm.
Expansion allowance	:	3 mm between perimeter trim and ends of tees
Fixing method	:	Ends were laid onto flanges of perimeter trim and suspended from steel beams at 1200 mm centres with wire hangers (item 7) at positions shown on Figure 1.
4. Cross Tee		
Manufacturer	:	Armstrong World Industries Inc.
Reference	:	Prelude XL^2 , 31 30 51 B
Material	:	Hot dipped galvanised mild steel with a mild steel capping to the bottom flange.
Overall size	:	24 mm wide x 38 mm high x 1200 mm long.
Grid centres	:	600 mm.
Expansion allowance	:	3 mm between perimeter trim and ends of tees
Fixing method	:	Click fitted into slots along main-tees and laid onto flanges of perimeter trim.

Item		Description
5. Secondary Cross Tee		
Manufacturer	:	Armstrong World Industries Inc.
Reference	:	Prelude XL^2 , 31 20 21 A
Material	:	Hot dipped galvanised mild steel with a mild steel capping to the bottom flange.
Overall size	:	24 mm wide x 30 mm high x 600 mm long.
Grid centres	:	1200 mm.
Expansion allowance	:	3 mm between perimeter trim and ends of tees
Fixing method	:	Click fitted into slots along cross-tees and laid onto flanges of perimeter trim.
6. Tiles		
Manufacturer	:	Armstrong World Industries Inc.
Reference	:	Prima – BP9121M3B/01
Pattern	:	Fine Fissued.
Material	:	Mineral fibre.
Thickness	:	15 mm
Overall size	:	595 mm x 595 mm
Edge shape	:	Square.
Fixing method	:	Laid onto flanges of perimeter trim, main-tees and cross-tees using 4 no. hold down clips per tile reference ‘universal AH002’.
7. Wire Hanger		
Material	:	Hot dipped galvanised wire complete with steel caddy clip reference BE-9-12
Diameter	:	2 mm
8. Downlight		
Manufacturer	:	Sealite Company Ltd.
Reference	:	FR1004 LV
Type	:	Low voltage bathroom downlight
Material	:	Steel and glass
Overall size	:	87.2 mm diameter
Fixing method	:	Retained by 2 no. spring steel clips
Details of expanding material		
i. manufacturer	:	Sealite Company Ltd.
ii. reference	:	IS001
iii. material	:	Intumescent fibrous sheet, ceramic fibre sheet, intumescent graphite, polyvinyl alcohol.
9. Downlight		
Manufacturer	:	Sealite Company Ltd.
Reference	:	FR1003 S LV
Type	:	Low voltage eyeball downlight
Material	:	Steel and glass
Overall size	:	105 mm diameter
Fixing method	:	Retained by 2 no. spring steel clips
Details of expanding material	:	Details as Item 8

Item		Description
10. Downlight		
Manufacturer	:	Sealite Company Ltd.
Reference	:	FR1002 S LV
Type	:	Low voltage tilt downlight
Material	:	Steel and glass
Overall size	:	105 mm diameter
Fixing method	:	Retained by 2 no. spring steel clips
Details of expanding material	:	Details as Item 8
11. Downlight		
Manufacturer	:	Sealite Company Ltd.
Reference	:	FR1001 S LV
Type	:	Low voltage fixed downlight
Material	:	Steel and glass
Overall size	:	85 mm diameter
Fixing method	:	Retained by 2 no. spring steel clips
Details of expanding material	:	Details as Item 8

Instrumentation

General

The instrumentation was provided in accordance with the requirements of the Standard.

Furnace

Eight thermocouples, distributed over a plane 100 mm from the underside of the ceiling, were provided to monitor the temperature of the furnace atmosphere. The furnace was controlled so that its mean temperature complied with the requirements of BS 476: Part 20: 1987, Clause 3.1.

General

Thermocouples were provided to monitor the unexposed surface of the specimens and the output of all instrumentation was recorded at no less than one minute intervals as follows:

Thermocouples 202 to 207 Beam A and 208 to 213 Beam B

At twelve positions, six uniformly distributed along the length of each 'I' beam, to record the steel temperature. The thermocouples were equally spaced and positioned on the inside of the lower flange of each beam, mid-way between the web and the toe of the flange and staggered either side of the beam's web.

Thermocouples 214 to 217

At four positions on the upper surface of the ceiling tiles, one approximately positioned in each of the four quadrants of the ceiling.

Thermocouples 218 to 221

At four positions mid-height of the air cavity within the assembly, coincident with the positions of the thermocouples fixed to the ceiling tiles

The locations and reference numbers of the various unexposed surface thermocouples are shown in Figure 6.

Deflection

Linear deflection transducers were provided at mid-span on the unexposed surface of each loaded beam to record their deflection.

Furnace Pressure

The atmospheric pressure within the furnace chamber was controlled to maintain equilibrium relative to the atmospheric pressure of the laboratory at a position 100 mm below the soffit of the ceiling.

Test Observations

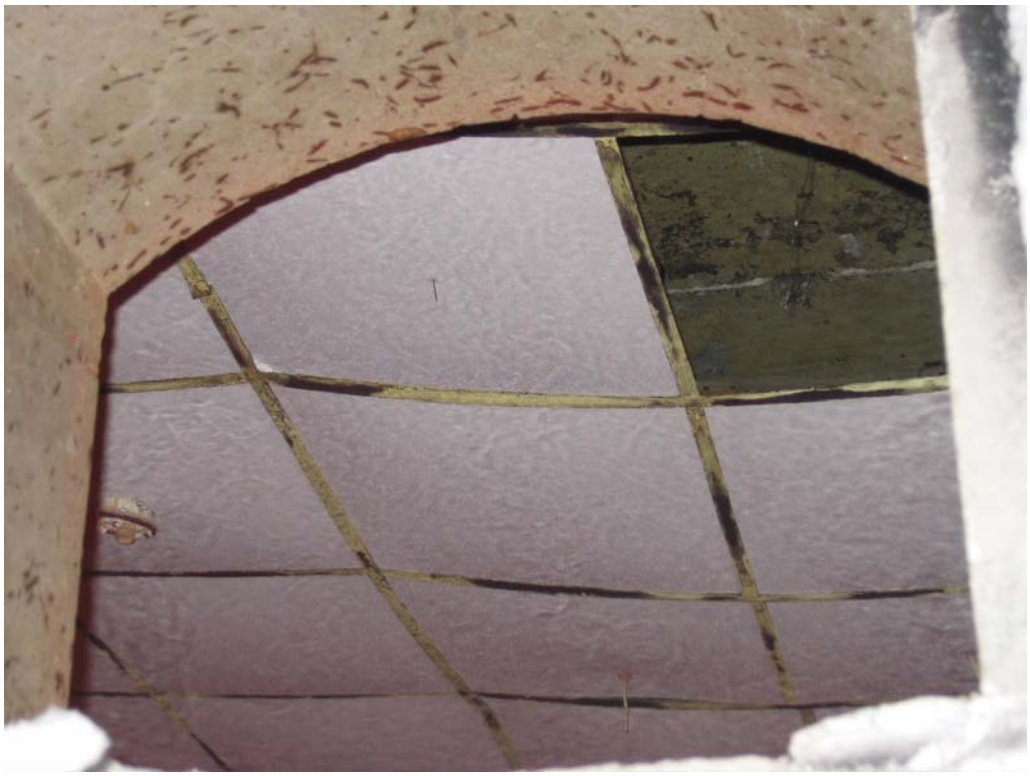
Time		All observations are from the exposed face unless noted otherwise.
mins	**secs**	The ambient air temperature in the vicinity of the test construction was 16°C at the start of the test with a maximum variation of 1°C during the test.
00	**00**	**The test commences.**
10	**00**	All tiles remain in place, ceiling remains flat in appearance.
25	**00**	All ceiling tiles remain in place.
30	**00**	Loadbearing capacity criteria continues to be satisfied.
45	**00**	The corners of some of the tiles have started to lift slightly.
47	**30**	All tiles including ones with light fittings remain attached.
55	**00**	All tiles remain in place.
60	**00**	Loadbearing criteria remains intact.
66	**30**	Tiles on the right centre run as viewed from entrance have sagged slightly, enough for a through gap into air cavity.
69	**10**	The tile continues to sag, through gap approximately 25-35mm. Other tiles have continued to lift at corners.
82	**00**	The tile has now sagged approximately 100-150mm on one edge, but still all tiles remain in place.
89	**30**	Two complete edges of the tile now detached but the tile remains in place.
90	**00**	Load bearing criteria remains intact.
105	**00**	All tiles with light fittings remain in place.
105	**30**	The first tile has now fully detached.
108	**53**	**Load bearing failure is deemed to occur.**
109	**10**	**The test is discontinued.** All tiles housing light fittings remain intact.

Test Photographs

The exposed face of the test construction prior to testing

The exposed face of the test construction after testing

The exposed face of the test construction after testing



Load Calculation

Depth of section (D)	:	207 mm
Breadth of section (B)	:	133 mm
Thickness of flange (T)	:	9.4 mm
Thickness of web (t)	:	6.3 mm
Mass per metre (m)	:	284.7258 N/m
Moment of inertia (I)	:	2.792551E+07 mm^4
Distance of neutral axis to base of beam (y)	:	103.5 mm
Effective span of the beam (L)	:	4200 mm

Maximum allowable bending stress to BS 449: Part 2: 1969, Table 2

f	=	165 N/mm^2

Percentage of allowable bending stress required during the test

f1	=	100%
Required bending moment	=	$fI/y = wL^2/8$ Nmm
Therefore w	=	$8f1I/yL^2$
where w	=	load per metre in N/m
w	=	8x165x2.792551E+07 /101.5x4200x4200
w	=	20189.99 N/m
Concrete topping slab		
Depth	=	140 mm
Width	=	400 mm
Mass per metre	=	906.444 N/m

Total self weight of beam and topping	=	1191.17 N/m
Required imposed load to produce required bending stress	=	20189.99 – 1191.17 N/m
	=	18998 N/m
Therefore total imposed load	=	8134 kg

Using four point loads at $^1/_8$, $^3/_8$, $^5/_8$ and $^7/_8$ span equivalent to wL/4.

Point loads required = 2033 kg

Calculation made by

S Baker
Technical Officer
Fire Resistance Department

Checked by

S Hankey
Technical Consultant
For and on behalf of
warringtonfire

Temperature and Deflection Data

Mean Furnace Temperature, Together With The Temperature/Time Relationship Specified In The Standard

Time Mins	Specified Furnace Temperature Deg. C	Actual Furnace Temperature Deg. C
0	20	31
5	576	561
10	678	663
15	739	735
20	781	774
25	815	815
30	842	838
35	865	861
40	885	875
45	902	903
50	918	917
55	932	930
60	945	944
65	957	954
70	968	964
75	979	980
80	988	991
85	998	998
90	1006	1005
95	1014	1018
100	1022	1026
105	1029	1028
109	1035	1017

Individual And Mean Temperatures Recorded On Beam A

Time Mins	T/C Number 2 Deg. C	T/C Number 3 Deg. C	T/C Number 4 Deg. C	T/C Number 5 Deg. C	T/C Number 6 Deg. C	T/C Number 7 Deg. C	Mean Temperature Deg. C
0	21	22	22	22	22	22	22
5	25	28	29	31	29	29	29
10	57	61	66	65	67	60	63
15	94	103	115	110	115	99	106
20	136	144	161	153	162	141	150
25	172	181	198	190	201	177	187
30	205	214	232	224	234	209	220
35	235	246	264	254	264	238	250
40	265	276	296	284	292	265	280
45	296	309	325	313	320	290	309
50	325	338	353	341	346	315	336
55	353	366	378	367	371	339	362
60	376	388	399	388	390	360	384
65	397	407	418	407	409	380	403
70	416	424	434	423	426	398	420
75	431	438	447	437	442	416	435
80	445	452	462	451	461	438	452
85	459	466	476	466	481	463	469
90	473	480	489	482	505	498	488
95	489	492	505	502	537	539	511
100	501	505	522	525	566	570	532
105	514	519	541	546	593	597	552
109	535	541	570	573	643	633	583

Individual And Mean Temperatures Recorded On Beam B

Time Mins	T/C Number 8 Deg. C	T/C Number 9 Deg. C	T/C Number 10 Deg. C	T/C Number 11 Deg. C	T/C Number 12 Deg. C	T/C Number 13 Deg. C	Mean Temperature Deg. C
0	24	25	25	*	25	25	25
5	32	34	33		30	30	32
10	63	70	81		64	63	68
15	102	115	133		113	101	113
20	144	158	182		164	147	159
25	180	196	224		207	185	198
30	214	233	260		244	217	234
35	245	268	293		274	246	265
40	273	300	322		300	273	294
45	301	330	350		326	299	321
50	327	357	377		350	324	347
55	352	382	401		376	349	372
60	374	402	421		396	370	393
65	395	420	440		419	392	413
70	413	436	455		443	416	433
75	428	451	468		465	450	452
80	443	465	482		488	490	474
85	457	479	495		514	530	495
90	471	492	509		543	575	518
95	485	507	522		571	611	539
100	499	521	536		595	636	557
105	513	537	550		626	666	578
109	314	558	577		690	716	571

* Thermocouple Malfunction

Individual Temperatures Recorded On The Upper Surface Of The Ceiling Tiles

Time Mins	T/C Number 14 Deg. C	T/C Number 15 Deg. C	T/C Number 16 Deg. C	T/C Number 17 Deg. C	Mean Temperature Deg. C
0	26	23	24	24	24
5	72	67	72	77	72
10	205	191	205	231	208
15	298	293	291	313	299
20	338	337	329	355	340
25	367	368	358	375	367
30	381	384	371	383	380
35	388	392	381	394	389
40	400	404	395	410	402
45	417	423	416	430	422
50	437	443	437	448	441
55	454	460	454	465	458
60	466	472	466	475	470
65	479	487	479	489	484
70	492	504	490	502	497
75	506	522	502	515	511
80	522	547	516	529	529
85	536	576	528	542	546
90	557	604	540	555	564
95	587	624	551	567	582
100	614	641	562	582	600
105	637	665	576	595	618
109	659	*	592	611	621

* Thermocouple Malfunction

Individual Temperatures Recorded Within The Air Cavity

Time Mins	T/C Number 18 Deg. C	T/C Number 19 Deg. C	T/C Number 20 Deg. C	T/C Number 21 Deg. C	Mean Temperature Deg. C
0	24	23	24	23	24
5	46	64	62	89	65
10	97	152	181	211	160
15	122	196	234	251	201
20	143	229	252	274	225
25	157	242	267	285	238
30	173	259	283	298	253
35	187	283	309	319	275
40	201	299	325	335	290
45	216	317	344	352	307
50	232	340	366	372	328
55	247	359	385	389	345
60	264	376	394	405	360
65	277	392	409	418	374
70	295	415	419	429	390
75	311	456	424	443	409
80	331	502	433	456	431
85	351	541	442	469	451
90	399	575	454	482	478
95	431	588	464	495	495
100	462	600	471	504	509
105	490	626	481	518	529
109	517	863	487	537	601

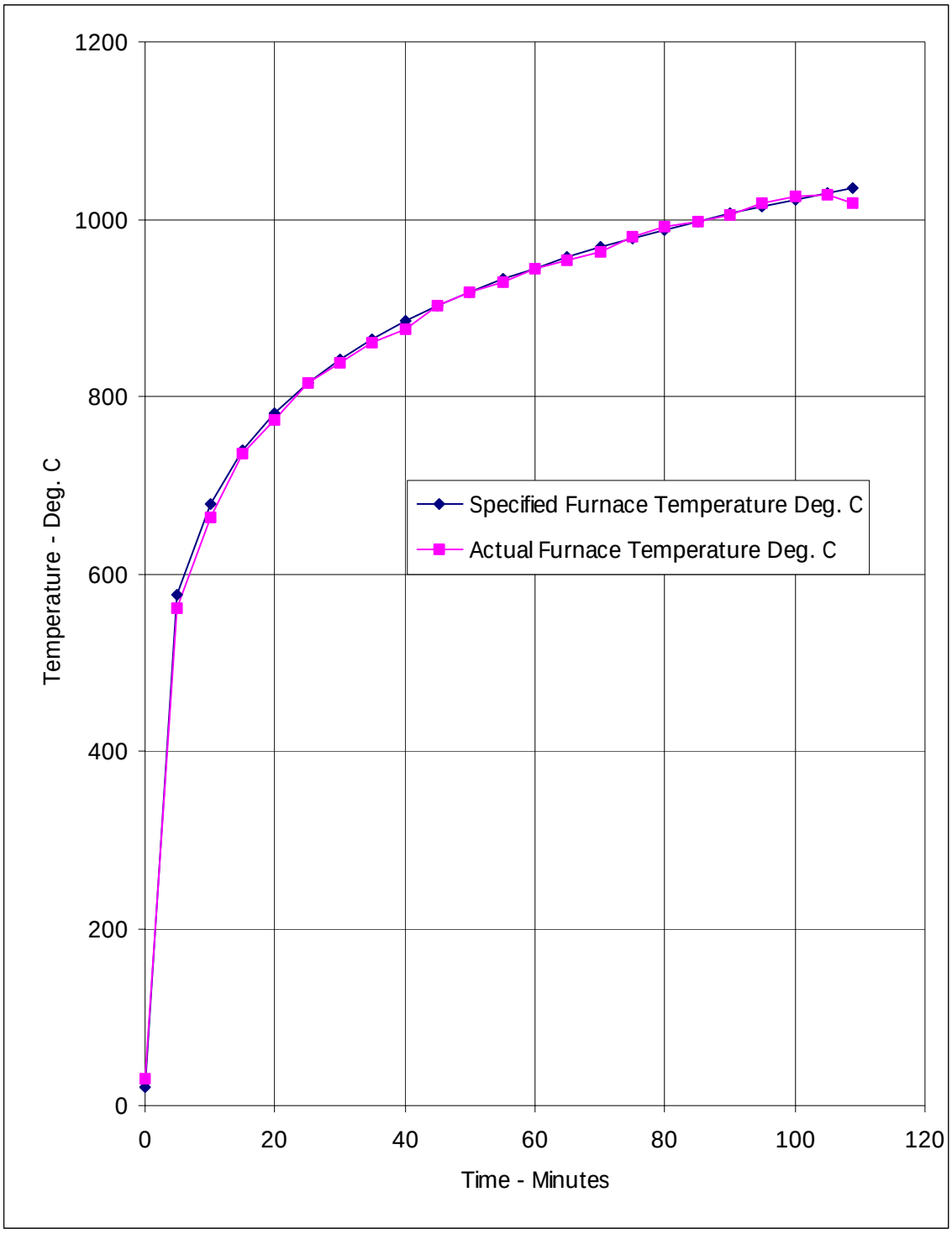
Central Vertical Deflection Of Beam A

Time Mins	Central Vertical Deflection mm	Deflection Rate mm/min
0	0	0
5	0	0
10	4	0
15	7	0
20	9	0
25	11	0
30	12	0
35	14	1
40	16	0
45	18	0
50	19	0
55	20	0
60	20	0
65	19	0
70	21	0
75	22	0
80	23	1
85	23	3
90	27	0
95	31	1
100	40	2
105	55	3
109	84	7

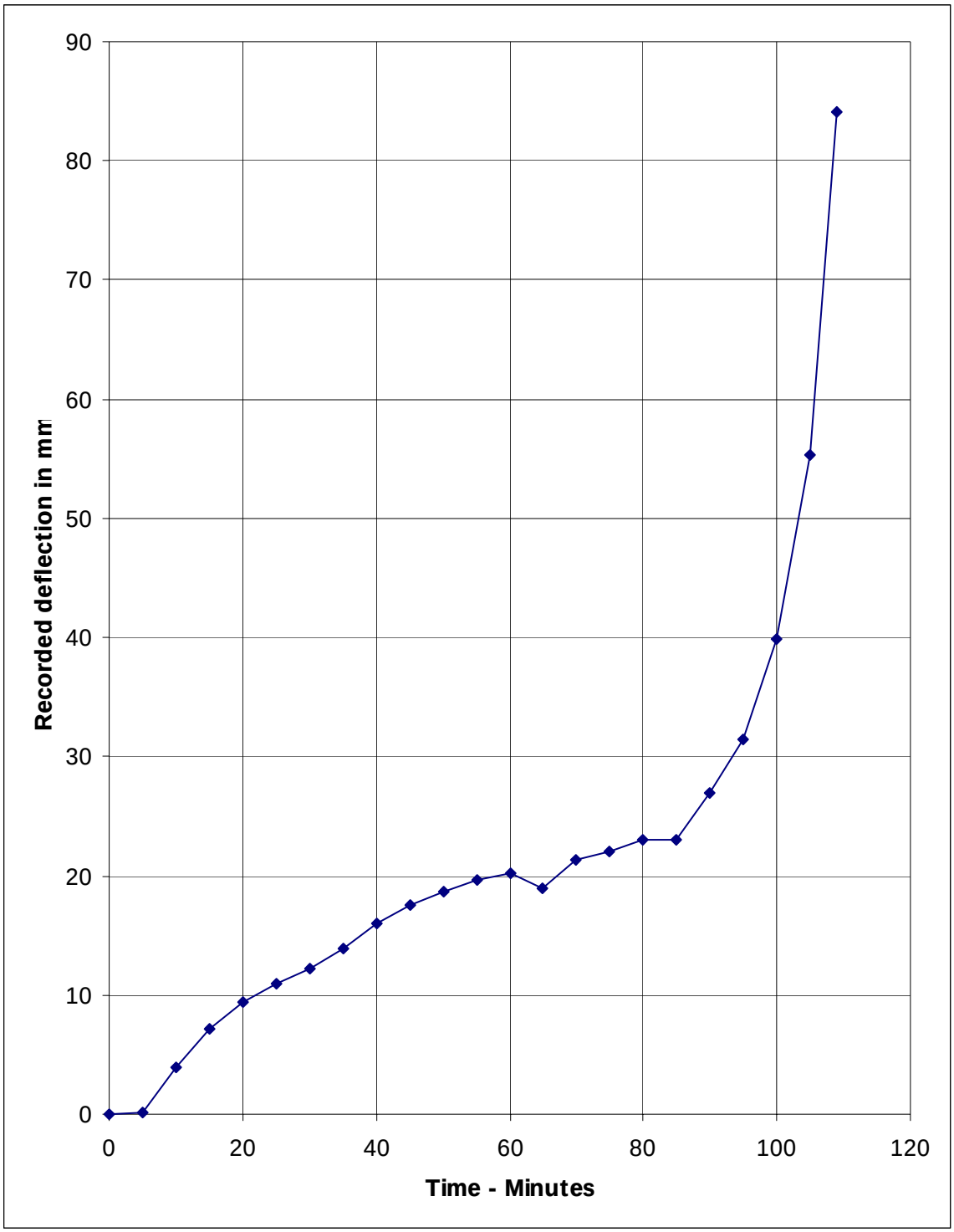
Central Vertical Deflection Of Beam B

Time Mins	Central Vertical Deflection mm	Deflection Rate mm/min
0	0	0
5	0	0
10	4	0
15	8	1
20	10	0
25	12	0
30	14	0
35	16	0
40	17	0
45	18	0
50	19	0
55	20	0
60	20	0
65	21	0
70	21	0
75	22	0
80	23	0
85	26	0
90	30	1
95	37	2
100	48	2
105	65	4
109	144	23

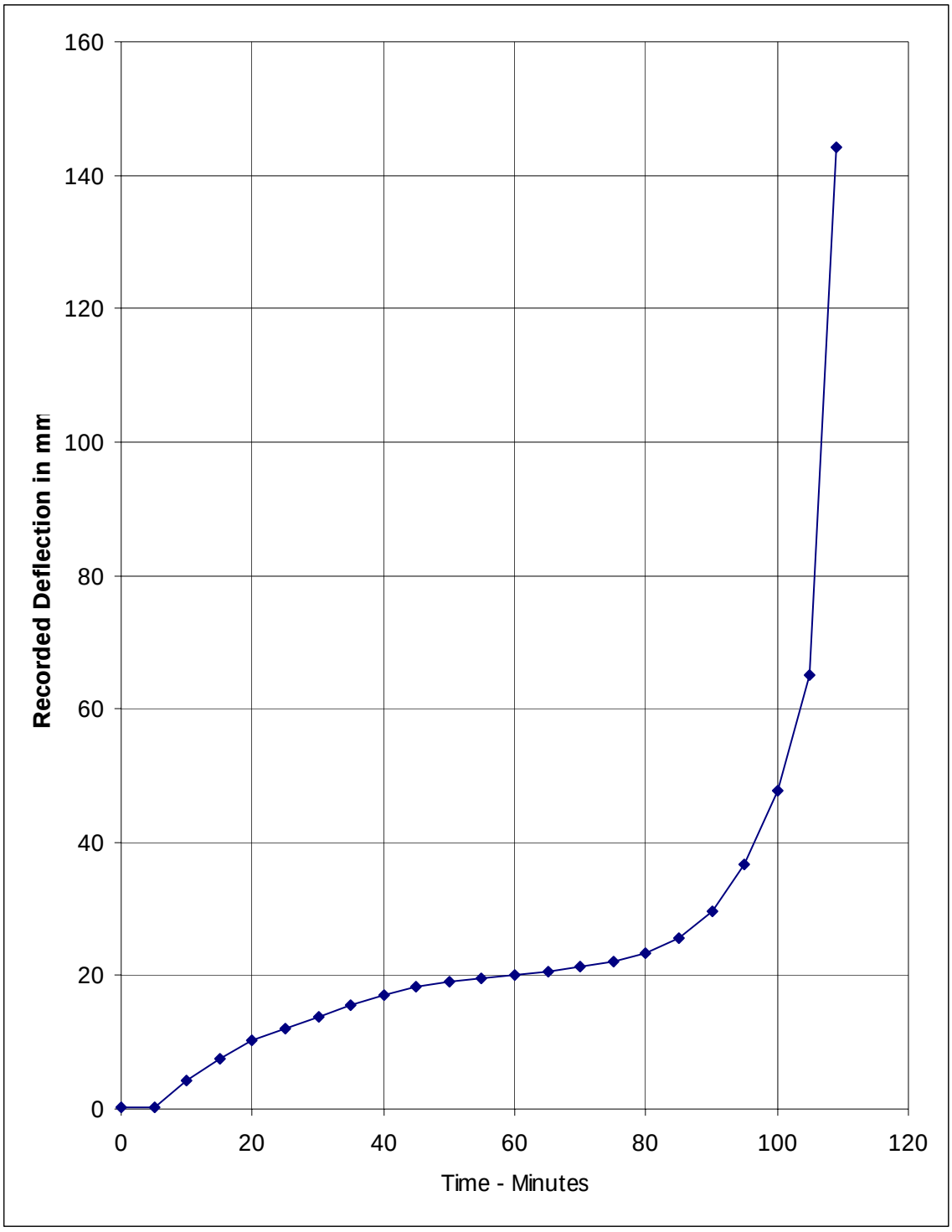
Graph Showing Mean Furnace Temperature, Together With The Temperature/Time Relationship Specified In The Standard



Central Vertical Deflection Of Beam A



Central Vertical Deflection Of Beam B



Performance Criteria and Test Results

Loadbearing Capacity

The maximum allowable deflection and the maximum allowable rate of deflection for the specimen, as specified by BS 476: Part 20: 1987, are calculated as 210 mm and 8.9 mm per minute respectively. The maximum allowable rate of deflection criteria is not applicable until the deflection exceeds 1/30th of the span (i.e. 140 mm). This criterion was satisfied for a period of 108 minutes.

Ongoing Implications

Limitations

The results relate only to the behaviour of the specimen of the element of construction under the particular conditions of test. They are not intended to be the sole criteria for assessing the potential fire performance of the element in use, nor do they reflect the actual behaviour in fires.

The test results relate only to the specimen tested. Appendix A of BS 476: Part 20: 1987 provides guidance information on the application of fire resistance test and the interpretation of test data. Application of the results to assemblies of different dimensions or incorporating different components should be the subject of a design appraisal.

Review

The specification and interpretation of fire test methods are the subject of ongoing development and refinement. Changes in associated legislation may also occur. For these reasons it is recommended that the relevance of test reports over five years old should be considered by the user. The laboratory that issued the report will be able to offer, on behalf of the legal owner, a review of the procedures adopted for a particular test to ensure that they are consistent with current practices, and if required may endorse the test report.

Conclusions

Evaluation against objective

A specimen of an suspended ceiling incorporating light fittings protecting loadbearing steel beams has been subjected to a test in accordance with BS 476: Part 23: 1987, Clause 5, to determine its contribution to the fire resistance of steel beams.

The specimen satisfied the performance requirements specified in the Standard for the periods stated below:

Loadbearing Capacity **:** 108 minutes