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ASSESSMENT REPORT

on

**The Fire Resistance Performance of Steel I-Shaped Column
Sections Protected with a Cementitious Based Coating
Referenced Pyrocrete 241**

Carboline Co
350 Hanley Industrial CT
St Louis
MO, 63144
USA

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Underwriters Laboratories Inc.
333 Pfingsten Road, Northbrook, IL 60062-2096 USA

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1. Introduction

This report presents an assessment of the ability of a cementitious coating referenced Pyrocrete 241, to fire protect structural steel sections when exposed to heating conditions meant to simulate fires burning hydrocarbon fuels.

The data which forms the basis of this assessment was obtained from tests in accordance with BS 476: Part 20: 1987 on I-Section tall and short column sections which were subjected to the heating conditions as specified in Appendix D of this standard.

This assessment relates to I-shaped steel section columns protected with Pyrocrete 241. The assessment covers periods of fire resistance up to 240 minutes and for critical steel temperatures ranging from 400 Deg. C to 600 Deg. C.

2. Assumptions

It is assumed that the protection material will be applied to the steel sections in a similar manner to that used for the tested sections referred to in this report.

3. Basic Test Data

The supporting fire test evidence is provided by the test reports which are referenced in Section 9 of this report.

Underwriters Laboratories Inc, Project No: 10CA58792 (Pyrocrete 241)

Report on a fire resistance test utilising the heating conditions specified in Appendix D of BS 476: Part 20: 1987 (Hydrocarbon testing)

The test was performed on a tall I-section column and number of short I-section columns protected with Pyrocrete 241, for assessment purposes. The appropriate details of which are summarised in the body of this report.

4. Assessment Procedure

For fire protection coatings such as Pyrocrete 241 the required thickness of protection for a given steel section and fire resistance period can be assessed by numerical regression analysis.

The numerical regression analysis is a statistical approach which has time to reach a specified design temperature, steel temperature, section factor and protection thickness as variables.

The multiple linear regression is performed using the following equation:

$$t = a_0 + a_1 d_p V/A + a_2 d_p$$

Where

t	=	time to design steel temperature (mins)
d_p	=	thickness of protection material (mm)
A/V	=	section factor (m^{-1})
a_0-a_3	=	regression coefficients

Transposition of equation to determine protection thickness gives

$$d_p = \frac{t - a_0}{(a_1 V/A + a_2)}$$

The tall column section provided evidence of performance for 'stickability' under standard hydrocarbon fire test conditions and temperature data derived from appropriate short sections was used in the predictive analysis.

The details of each specimen, i.e. the section factor (the ratio of the heated perimeter to cross sectional area - A/V), the protection thickness and the duration of heating required for the sections to reach a specified steel temperature were used as input data for the analysis.

The analysis adopted a numerical regression analysis approach.

5. Analysis of Data

Test Data/Critical Steel Temperatures

The test report 10CA58792 (Pyrocrete 241) included a tall I-section column and short I-section column sections which were used to derive the thermal properties of the coating.

The test demonstrated the ability of the coating to remain attached to the sections at elevated temperatures and for prolonged periods.

Test experience shows that fully loaded I-section columns with passive fire protection usually maintain loadbearing capacity at a temperature of at least 550°C.

The test demonstrated no loss of material for the sections including the tall column for the periods of the test.

For the purpose of this report the following critical steel temperatures 400°C, 450°C, 500°C, 550°C and 600°C have been adopted for I-section column protection.

Temperature Data

The appropriate data to be used in the analysis is taken from the test report referenced in Section 9 of this report and a summary is given in Table A as follows.

Table A

Ref	Serial Size	Section Factor m ⁻¹	Mean Thickness mm	Time to Reach (minutes)				
				400°C	450°C	500°C	550°C	600°C
SC 1	W12 x 136	73.6	15.5	65	75	86	98	113
SC 2	W12 x 136	73.6	26.5	124	139	157	176	199
SC 3	W10 x 60	132.7	24.8	81	90	100	112	125
SC 4	W10 x 60	131.3	37.4	155	170	187	204	224
SC 5	W8 x 35	183.9	15.9	43	49	55	61	69
SC 6	W8 x 35	183.3	45.5	199	214	230	247	267
SC 14	W8 x 18	277	45.4	175	187	201	215	230
SC 15	W14 x 455	28.6	8.6	81	96	113	122*	144*
TC 17	W8 x 35	183	46.0	205	221	239	257	279

*The time for SC15 has been adjusted conservatively by 10 minutes at critical temperatures 550°C and 600°C to maintain a coefficient of determination (r^2) in excess of 0.95. This was considered conservative considering previous fire test data which shows that heavy steel sections exceed predicted endpoint times due to the amount of steel present.

6. Output Values of Data

The test specimens generated coefficient of determination (r^2) values in excess of 0.95, these values are shown in the table below.

Critical Temperature	400°C	450°C	500°C	550°C	600°C
r^2 Value	0.95	0.95	0.95	0.96	0.95

The following tables show a comparison of the actual and predicted times to reach the specified steel temperatures, together with the calculated percentage differences for each section.

Ref	Actual time to 400°C minutes	Modified Predicted time to 400°C minutes	Difference minutes	% Difference
SC 1	65	65.6	0.6	0.9
SC 2	124	136.3	12.3	9.9
SC 3	81	95.7	14.7	18.1
SC 4	155	162.3	7.3	4.7
SC 5	43	42.5	-0.5	-1.2
SC 6	199	185.4	-13.6	-6.8
SC 14	175	168.3	-6.7	-3.8
SC 15	81	57.6	-23.4	-28.9
TC 17	205	187.9	-17.1	-8.3
			SUM	-15.4

Ref	Actual time to 450°C minutes	Modified Predicted time to 450°C minutes	Difference minutes	% Difference
SC 1	75	75.8	0.8	1.1
SC 2	139	152.5	13.5	9.7
SC 3	90	105.9	15.9	17.7
SC 4	170	176.8	6.8	4.0
SC 5	49	48.6	-0.4	-0.8
SC 6	214	199.3	-14.7	-6.9
SC 14	187	179.4	-7.6	-4.1
SC 15	96	70.2	-25.8	-26.9
TC 17	221	201.9	-19.1	-8.6
			SUM	-14.8

Ref	Actual time to 500°C minutes	Modified Predicted time to 500°C minutes	Difference minutes	% Difference
SC 1	86	86.7	0.7	0.8
SC 2	157	171.1	14.1	9.0
SC 3	100	116.9	16.9	17.0
SC 4	187	193.4	6.4	3.4
SC 5	55	54.3	-0.7	-1.3
SC 6	230	215.3	-14.7	-6.4
SC 14	201	191.7	-9.3	-4.6
SC 15	113	84.3	-28.7	-25.4
TC 17	239	218.1	-20.9	-8.7
			SUM	-16.3

Ref	Actual time to 550°C minutes	Modified Predicted time to 550°C minutes	Difference minutes	% Difference
SC 1	98	96.2	-1.8	-1.8
SC 2	176	187.6	11.6	6.6
SC 3	112	127.5	15.5	13.8
SC 4	204	209.7	5.7	2.8
SC 5	61	59.8	-1.2	-2.0
SC 6	247	232	-15.0	-6.1
SC 14	215	205.7	-9.3	-4.3
SC 15	122*	95.3	-26.7	-22.9
TC 17	257	235	-22.0	-8.6
			SUM	-21.4

Ref	Actual time to 600°C minutes	Modified Predicted time to 600°C minutes	Difference minutes	% Difference
SC 1	113	110.7	-2.3	-2.0
SC 2	199	211.1	12.1	6.1
SC 3	125	141.3	16.3	13.0
SC 4	224	229.8	5.8	2.6
SC 5	69	67.5	-1.5	-2.2
SC 6	267	250.6	-16.4	-6.1
SC 14	230	219.7	-10.3	-4.5
SC 15	144	114.3	-29.7	-20.6
TC 17	279	253.9	2-25.1	-9.0
			SUM	-22.7

The negative sum at each of the critical temperatures generally indicates a that the prediction is conservative.

7. Extrapolation in Thickness

Current UK assessment principles generally allow for an approximate 10% extrapolation in thickness provided no significant loss of material occurs. In addition and where considered appropriate the extrapolation was based on section factor rather than thickness.

It is therefore considered appropriate to provide an assessment for I-sections within the following range of thickness subject to the above comment regarding section factor.

I-Section Columns

Minimum thickness: 7.7 mm (Minimum tested less about 10%)

Maximum thickness: 50.6 mm (Maximum tested on the tall column plus about 10%)

8. Limits of Applicability

The method of protection should be as described in the appropriate test report.

Please be informed that Underwriters Laboratories Inc. (UL) neither selected the samples nor determined whether the samples were representative of production samples. The test results apply only to the actual samples tested.

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9. Conclusions

An assessment of the ability of a cementitious coating known as Pyrocrete 241 to protect structural steel I-section columns utilising the hydrocarbon heating requirements of BS476: Part 20: 1987 has been undertaken.

The specified hydrocarbon heating conditions as given in Appendix D of BS476: Part 20: 1987.

The data which forms the basis of this assessment was obtained from a test to BS 476: Part 20: 1987, containing tall I-section column and short I-section column which were subjected to the specified heating conditions.

This assessment related to I-section column sections only, for periods of fire resistance up to 240 minutes.

The assessment method used was a numerical regression analysis.

Tables 1 to 5 show the results of the analysis of the data.

10. Validity

This assessment is issued on the basis of test data and information available at the time of issue.

If contradictory evidence becomes available to Underwriters Laboratories Inc the assessment will be unconditionally withdrawn and Carboline Co will be notified in writing. Similarly the assessment is invalidated if the assessed construction is subsequently tested because actual test data is deemed to take precedence over an expressed opinion.

The assessment is valid initially for a period of five years i.e. until 1st August 2016, after which time it is recommended that it be returned for re-appraisal.

The appraisal is only valid provided that no other modifications are made to the tested construction other than those described in this report.

11. Summary of Primary Supporting Evidence

Underwriters Laboratories Inc

File R7209 Project 10CA58792 (Pyrocrete 241)

Report on a fire test which utilised the heating conditions specified in Appendix D of BS 476: Part 20: 1987 (Hydrocarbon testing). The test was carried out on nine I-section columns protected with various thicknesses of Pyrocrete 241.

The test has shown the coating suffered no adverse effects for the 300 minutes duration of the test.

Test Sponsor : Carboline Co
Test Date : 29th March 2011

12. Declaration by Carboline Co

We the undersigned confirm that we have read and complied with the obligations placed on us by UL.

We confirm that the component or element of structure, which is the subject of this assessment, has not to our knowledge been subjected to a fire test to the Standard against which the assessment is being made.

We agree to withdraw this assessment from circulation should the component or element of structure be the subject of a fire test to the Standard against which this assessment is being made.

We are not aware of any information that could adversely affect the conclusions of this assessment.

If we subsequently become aware of any such information we agree to cease using the assessment and ask Underwriters Laboratories Inc to withdraw the assessment.

Signed:

For and on behalf of:

13. Signatories

Report by:



***Simon Baker**

Senior Project Engineer
Building Materials and Life Safety

Reviewed by:



***Patrick A Zeeveld**

Staff Engineer
Fire Protection Division

*For and on behalf of Underwriters Laboratories Inc.

The assessment report is not valid unless it incorporates the declaration duly signed by the applicant. This is included in Section 11 to this report.

REPORT ISSUED: 17 October 2011

Table 1 - Four Sided protection to I-Section Columns at 400 Deg.C

Section Factor m-1	Thickness of Pyrocrete 241 for Period of Fire Resistance (mm)						
	30 minutes	60 minutes	90 minutes	120 minutes	150 minutes	180 minutes	240 minutes
30	7.7	9.1	12	14.9	17.8	20.7	26.5
35	7.7	10	13.2	16.4	19.6	22.8	29.2
40	7.7	10.8	14.3	17.7	21.2	24.6	31.5
45	7.9	11.6	15.2	18.9	22.6	26.3	33.7
50	8.3	12.2	16.1	20	23.9	27.8	35.6
55	8.7	12.8	16.9	21	25.1	29.2	37.3
60	9.1	13.4	17.6	21.9	26.2	30.4	38.9
65	9.4	13.9	18.3	22.7	27.1	31.5	40.4
70	9.8	14.3	18.9	23.5	28	32.6	41.7
75	10	14.7	19.4	24.2	28.9	33.6	43
80	10.3	15.1	20	24.8	29.6	34.4	44.1
85	10.6	15.5	20.4	25.4	30.3	35.3	45.1
90	10.8	15.8	20.9	25.9	31	36	46.1
95	11	16.2	21.3	26.5	31.6	36.7	47
100	11.2	16.4	21.7	26.9	32.2	37.4	47.9
105	11.4	16.7	22.1	27.4	32.7	38	48.7
110	11.6	17	22.4	27.8	33.2	38.6	49.5
115	11.7	17.2	22.7	28.2	33.7	39.2	50.2
120	11.9	17.5	23	28.6	34.1	39.7	-
125	12	17.7	23.3	28.9	34.6	40.2	-
130	12.2	17.9	23.6	29.3	35	40.7	-
135	12.3	18.1	23.8	29.6	35.3	41.1	-
140	12.4	18.2	24.1	29.9	35.7	41.5	-
145	12.5	18.4	24.3	30.2	36	41.9	-
150	12.7	18.6	24.5	30.4	36.4	42.3	-
155	12.8	18.7	24.7	30.7	36.7	42.6	-
160	12.9	18.9	24.9	30.9	37	43	-
165	13	19	25.1	31.2	37.2	43.3	-

**Table 1 (continued)- Four Sided protection to I-Section Columns at
400 Deg.C**

Section Factor m-1	Thickness of Pyrocrete 241 for Period of Fire Resistance (mm)						
	30 minutes	60 minutes	90 minutes	120 minutes	150 minutes	180 minutes	240 minutes
170	13.1	19.2	25.3	31.4	37.5	43.6	-
175	13.2	19.3	25.5	31.6	37.8	43.9	-
180	13.2	19.4	25.6	31.8	38	44.2	-
185	13.3	19.6	25.8	32	38.2	44.5	-
190	13.4	19.7	25.9	32.2	38.5	44.7	-
195	13.5	19.8	26.1	32.4	38.7	45	-
200	13.5	19.9	26.2	32.6	38.9	45.2	-
205	13.6	20	26.4	32.7	39.1	45.5	-
210	13.7	20.1	26.5	32.9	39.3	45.7	-
215	13.7	20.2	26.6	33	39.5	45.9	-
220	13.8	20.3	26.7	33.2	39.6	46.1	-
225	13.9	20.4	26.8	33.3	39.8	46.3	-
230	13.9	20.4	27	33.5	40	46.5	-
235	14	20.5	27.1	33.6	40.1	46.7	-
240	14	20.6	27.2	33.7	40.3	46.9	-
245	14.1	20.7	27.3	33.9	40.4	47	-
250	14.1	20.7	27.4	34	40.6	47.2	-
255	14.2	20.8	27.5	34.1	40.7	47.4	-
260	14.2	20.9	27.5	34.2	40.9	47.5	-
265	14.3	21	27.6	34.3	41	47.7	-
270	14.3	21	27.7	34.4	41.1	47.8	-
275	14.4	21.1	27.8	34.5	41.2	48	-
280	14.4	21.1	27.9	34.6	41.4	48.1	-
285	14.4	21.2	28	34.7	41.5	48.2	-
290	14.5	21.3	28	34.8	41.6	48.4	-
295	14.5	21.3	28.1	34.9	41.7	48.5	-
300	14.6	21.4	28.2	35	41.8	48.6	-
305	14.6	21.4	28.3	35.1	41.9	48.7	-

Table 2 - Four Sided protection to I-Section Columns at 450 Deg.C

Section Factor m-1	Thickness of Pyrocrete 241 for Period of Fire Resistance (mm)						
	30 minutes	60 minutes	90 minutes	120 minutes	150 minutes	180 minutes	240 minutes
30	7.7	8	10.6	13.2	15.8	18.4	23.6
35	7.7	8.8	11.7	14.6	17.5	20.3	26.1
40	7.7	9.6	12.7	15.8	19	22.1	28.3
45	7.7	10.3	13.6	17	20.3	23.7	30.4
50	7.7	10.9	14.5	18	21.6	25.1	32.2
55	7.7	11.5	15.2	19	22.7	26.4	33.9
60	8.1	12	15.9	19.8	23.7	27.6	35.4
65	8.4	12.5	16.6	20.6	24.7	28.7	36.9
70	8.7	12.9	17.1	21.3	25.6	29.8	38.2
75	9	13.3	17.7	22	26.4	30.7	39.4
80	9.3	13.7	18.2	22.7	27.1	31.6	40.5
85	9.5	14.1	18.7	23.2	27.8	32.4	41.6
90	9.7	14.4	19.1	23.8	28.5	33.2	42.6
95	9.9	14.7	19.5	24.3	29.1	33.9	43.5
100	10.1	15	19.9	24.8	29.7	34.6	44.3
105	10.3	15.3	20.3	25.2	30.2	35.2	45.2
110	10.5	15.6	20.6	25.7	30.7	35.8	45.9
115	10.7	15.8	20.9	26.1	31.2	36.4	46.6
120	10.8	16	21.2	26.5	31.7	36.9	47.3
125	11	16.2	21.5	26.8	32.1	37.4	48
130	11.1	16.5	21.8	27.2	32.5	37.9	48.6
135	11.2	16.7	22.1	27.5	32.9	38.3	49.1
140	11.4	16.8	22.3	27.8	33.3	38.7	49.7
145	11.5	17	22.5	28.1	33.6	39.1	50.2
150	11.6	17.2	22.8	28.4	33.9	39.5	-
155	11.7	17.3	23	28.6	34.3	39.9	-
160	11.8	17.5	23.2	28.9	34.6	40.3	-
165	11.9	17.6	23.4	29.1	34.9	40.6	-

**Table 2 (continued) - Four Sided protection to I-Section Columns at
450 Deg.C**

Section Factor m-1	Thickness of Pyrocrete 241 for Period of Fire Resistance(mm)						
	30 minutes	60 minutes	90 minutes	120 minutes	150 minutes	180 minutes	240 minutes
170	12	17.8	23.6	29.3	35.1	40.9	-
175	12.1	17.9	23.7	29.6	35.4	41.2	-
180	12.2	18	23.9	29.8	35.7	41.5	-
185	12.3	18.2	24.1	30	35.9	41.8	-
190	12.3	18.3	24.2	30.2	36.1	42.1	-
195	12.4	18.4	24.4	30.4	36.4	42.3	-
200	12.5	18.5	24.5	30.6	36.6	42.6	-
205	12.6	18.6	24.7	30.7	36.8	42.8	-
210	12.6	18.7	24.8	30.9	37	43.1	-
215	12.7	18.8	24.9	31.1	37.2	43.3	-
220	12.8	18.9	25.1	31.2	37.4	43.5	-
225	12.8	19	25.2	31.4	37.5	43.7	-
230	12.9	19.1	25.3	31.5	37.7	43.9	-
235	12.9	19.2	25.4	31.6	37.9	44.1	-
240	13	19.3	25.5	31.8	38	44.3	-
245	13	19.3	25.6	31.9	38.2	44.5	-
250	13.1	19.4	25.7	32	38.4	44.7	-
255	13.1	19.5	25.8	32.2	38.5	44.8	-
260	13.2	19.6	25.9	32.3	38.6	45	-
265	13.2	19.6	26	32.4	38.8	45.2	-
270	13.3	19.7	26.1	32.5	38.9	45.3	-
275	13.3	19.8	26.2	32.6	39	45.5	-
280	13.4	19.8	26.3	32.7	39.2	45.6	-
285	13.4	19.9	26.4	32.8	39.3	45.8	-
290	13.5	19.9	26.4	32.9	39.4	45.9	-
295	13.5	20	26.5	33	39.5	46	-
300	13.5	20.1	26.6	33.1	39.6	46.2	-
305	13.6	20.1	26.7	33.2	39.7	46.3	-

Table 3 - Four Sided protection to I-Section Columns at 500 Deg.C

Section Factor m-1	Thickness of Pyrocrete 241 for Period of Fire Resistance(mm)						
	30 minutes	60 minutes	90 minutes	120 minutes	150 minutes	180 minutes	240 minutes
30	7.7	7.7	9.3	11.6	13.9	16.2	20.8
35	7.7	7.8	10.4	12.9	15.5	18	23.1
40	7.7	8.5	11.3	14.1	16.9	19.6	25.2
45	7.7	9.2	12.2	15.2	18.1	21.1	27.1
50	7.7	9.8	13	16.1	19.3	22.5	28.9
55	7.7	10.3	13.7	17	20.4	23.8	30.5
60	7.7	10.8	14.3	17.9	21.4	24.9	32
65	7.7	11.3	15	18.6	22.3	26	33.3
70	7.9	11.7	15.5	19.4	23.2	27	34.6
75	8.2	12.1	16.1	20	24	27.9	35.8
80	8.4	12.5	16.6	20.6	24.7	28.8	36.9
85	8.7	12.8	17	21.2	25.4	29.6	38
90	8.9	13.2	17.5	21.8	26.1	30.4	38.9
95	9.1	13.5	17.9	22.3	26.7	31.1	39.9
100	9.3	13.8	18.3	22.8	27.2	31.7	40.7
105	9.5	14.1	18.6	23.2	27.8	32.4	41.5
110	9.6	14.3	19	23.6	28.3	33	42.3
115	9.8	14.6	19.3	24	28.8	33.5	43
120	10	14.8	19.6	24.4	29.2	34.1	43.7
125	10.1	15	19.9	24.8	29.7	34.6	44.4
130	10.3	15.2	20.2	25.1	30.1	35.1	45
135	10.4	15.4	20.4	25.5	30.5	35.5	45.6
140	10.5	15.6	20.7	25.8	30.9	36	46.1
145	10.6	15.8	20.9	26.1	31.2	36.4	46.7
150	10.8	16	21.2	26.4	31.6	36.8	47.2
155	10.9	16.1	21.4	26.6	31.9	37.1	47.7
160	11	16.3	21.6	26.9	32.2	37.5	48.1
165	11.1	16.4	21.8	27.1	32.5	37.9	48.6

**Table 3 (continued) - Four Sided protection to I-Section Columns at
500 Deg.C**

Section Factor m-1	Thickness of Pyrocrete 241 for Period of Fire Resistance(mm)						
	30 minutes	60 minutes	90 minutes	120 minutes	150 minutes	180 minutes	240 minutes
170	11.2	16.6	22	27.4	32.8	38.2	49
175	11.3	16.7	22.2	27.6	33.1	38.5	49.4
180	11.4	16.9	22.3	27.8	33.3	38.8	49.8
185	11.4	17	22.5	28	33.6	39.1	50.2
190	11.5	17.1	22.7	28.3	33.8	39.4	50.5
195	11.6	17.2	22.8	28.4	34.1	39.7	-
200	11.7	17.3	23	28.6	34.3	39.9	-
205	11.8	17.4	23.1	28.8	34.5	40.2	-
210	11.8	17.6	23.3	29	34.7	40.4	-
215	11.9	17.7	23.4	29.2	34.9	40.7	-
220	12	17.8	23.5	29.3	35.1	40.9	-
225	12	17.8	23.7	29.5	35.3	41.1	-
230	12.1	17.9	23.8	29.6	35.5	41.3	-
235	12.2	18	23.9	29.8	35.7	41.5	-
240	12.2	18.1	24	29.9	35.8	41.7	-
245	12.3	18.2	24.1	30.1	36	41.9	-
250	12.3	18.3	24.2	30.2	36.2	42.1	-
255	12.4	18.4	24.3	30.3	36.3	42.3	-
260	12.4	18.4	24.4	30.4	36.5	42.5	-
265	12.5	18.5	24.5	30.6	36.6	42.6	-
270	12.5	18.6	24.6	30.7	36.7	42.8	-
275	12.6	18.7	24.7	30.8	36.9	43	-
280	12.6	18.7	24.8	30.9	37	43.1	-
285	12.7	18.8	24.9	31	37.1	43.3	-
290	12.7	18.8	25	31.1	37.3	43.4	-
295	12.7	18.9	25.1	31.2	37.4	43.6	-
300	12.8	19	25.2	31.3	37.5	43.7	-
305	12.8	19	25.2	31.4	37.6	43.8	-

Table 4 - Four Sided protection to I-Section Columns at 550 Deg.C

Section Factor m-1	Thickness of Pyrocrete 241 for Period of Fire Resistance(mm)						
	30 minutes	60 minutes	90 minutes	120 minutes	150 minutes	180 minutes	240 minutes
30	7.7	7.7	8.5	10.6	12.7	14.8	19
35	7.7	7.7	9.5	11.8	14.1	16.5	21.1
40	7.7	7.8	10.4	12.9	15.5	18	23.1
45	7.7	8.4	11.2	13.9	16.7	19.4	24.9
50	7.7	9	11.9	14.8	17.8	20.7	26.5
55	7.7	9.5	12.6	15.7	18.8	21.9	28.1
60	7.7	10	13.2	16.5	19.7	23	29.5
65	7.7	10.4	13.8	17.2	20.6	24	30.8
70	7.7	10.9	14.4	17.9	21.4	24.9	32
75	7.7	11.2	14.9	18.5	22.2	25.8	33.1
80	7.8	11.6	15.4	19.1	22.9	26.7	34.2
85	8.1	11.9	15.8	19.7	23.6	27.4	35.2
90	8.3	12.3	16.2	20.2	24.2	28.2	36.1
95	8.5	12.6	16.6	20.7	24.8	28.8	37
100	8.7	12.8	17	21.2	25.3	29.5	37.8
105	8.9	13.1	17.4	21.6	25.9	30.1	38.6
110	9	13.4	17.7	22	26.3	30.7	39.3
115	9.2	13.6	18	22.4	26.8	31.2	40
120	9.3	13.8	18.3	22.8	27.3	31.7	40.7
125	9.5	14	18.6	23.1	27.7	32.2	41.3
130	9.6	14.2	18.9	23.5	28.1	32.7	41.9
135	9.7	14.4	19.1	23.8	28.5	33.1	42.5
140	9.9	14.6	19.4	24.1	28.8	33.6	43.1
145	10	14.8	19.6	24.4	29.2	34	43.6
150	10.1	15	19.8	24.7	29.5	34.4	44.1
155	10.2	15.1	20	24.9	29.8	34.7	44.5
160	10.3	15.3	20.2	25.2	30.1	35.1	45
165	10.4	15.4	20.4	25.4	30.4	35.4	45.4

**Table 4 (continued) - Four Sided protection to I-Section Columns at
550 Deg.C**

Section Factor m-1	Thickness of Pyrocrete 241 for Period of Fire Resistance(mm)						
	30 minutes	60 minutes	90 minutes	120 minutes	150 minutes	180 minutes	240 minutes
170	10.5	15.6	20.6	25.7	30.7	35.8	45.8
175	10.6	15.7	20.8	25.9	31	36.1	46.3
180	10.7	15.8	21	26.1	31.2	36.4	46.6
185	10.8	16	21.1	26.3	31.5	36.7	47
190	10.9	16.1	21.3	26.5	31.7	36.9	47.4
195	10.9	16.2	21.4	26.7	31.9	37.2	47.7
200	11	16.3	21.6	26.9	32.2	37.5	48
205	11.1	16.4	21.7	27.1	32.4	37.7	48.4
210	11.2	16.5	21.9	27.2	32.6	37.9	48.7
215	11.2	16.6	22	27.4	32.8	38.2	49
220	11.3	16.7	22.1	27.6	33	38.4	49.2
225	11.4	16.8	22.3	27.7	33.2	38.6	49.5
230	11.4	16.9	22.4	27.9	33.3	38.8	49.8
235	11.5	17	22.5	28	33.5	39	50
240	11.5	17.1	22.6	28.1	33.7	39.2	50.3
245	11.6	17.2	22.7	28.3	33.9	39.4	50.5
250	11.6	17.2	22.8	28.4	34	39.6	-
255	11.7	17.3	22.9	28.5	34.2	39.8	-
260	11.7	17.4	23	28.7	34.3	39.9	-
265	11.8	17.5	23.1	28.8	34.5	40.1	-
270	11.8	17.5	23.2	28.9	34.6	40.3	-
275	11.9	17.6	23.3	29	34.7	40.4	-
280	11.9	17.7	23.4	29.1	34.9	40.6	-
285	12	17.7	23.5	29.2	35	40.7	-
290	12	17.8	23.6	29.3	35.1	40.9	-
295	12.1	17.9	23.7	29.4	35.2	41	-
300	12.1	17.9	23.7	29.5	35.4	41.2	-
305	12.1	18	23.8	29.6	35.5	41.3	-

Table 5 - Four Sided protection to I-Section Columns at 600 Deg.C

Section Factor m-1	Thickness of Pyrocrete 241 for Period of Fire Resistance(mm)						
	30 minutes	60 minutes	90 minutes	120 minutes	150 minutes	180 minutes	240 minutes
30	7.7	7.7	7.7	9.3	11.1	13	16.6
35	7.7	7.7	8.3	10.4	12.4	14.5	18.6
40	7.7	7.7	9.1	11.4	13.6	15.9	20.4
45	7.7	7.7	9.9	12.3	14.8	17.2	22.1
50	7.7	7.9	10.5	13.2	15.8	18.4	23.7
55	7.7	8.4	11.2	14	16.8	19.5	25.1
60	7.7	8.9	11.8	14.7	17.7	20.6	26.4
65	7.7	9.3	12.3	15.4	18.5	21.6	27.7
70	7.7	9.7	12.9	16.1	19.3	22.5	28.9
75	7.7	10	13.4	16.7	20	23.3	30
80	7.7	10.4	13.8	17.3	20.7	24.1	31
85	7.7	10.7	14.3	17.8	21.3	24.9	32
90	7.7	11	14.7	18.3	22	25.6	32.9
95	7.7	11.3	15.1	18.8	22.5	26.3	33.8
100	7.8	11.6	15.4	19.3	23.1	26.9	34.6
105	7.9	11.8	15.8	19.7	23.6	27.5	35.4
110	8.1	12.1	16.1	20.1	24.1	28.1	36.1
115	8.2	12.3	16.4	20.5	24.6	28.6	36.8
120	8.4	12.6	16.7	20.9	25	29.2	37.5
125	8.5	12.8	17	21.2	25.4	29.7	38.1
130	8.7	13	17.3	21.6	25.8	30.1	38.7
135	8.8	13.2	17.5	21.9	26.2	30.6	39.3
140	8.9	13.3	17.8	22.2	26.6	31	39.9
145	9	13.5	18	22.5	27	31.4	40.4
150	9.2	13.7	18.2	22.8	27.3	31.8	40.9
155	9.3	13.9	18.4	23	27.6	32.2	41.4
160	9.4	14	18.7	23.3	27.9	32.6	41.8
165	9.5	14.2	18.9	23.5	28.2	32.9	42.3

**Table 5 (continued)- Four Sided protection to I-Section Columns at
600 Deg.C**

Section Factor m-1	Thickness of Pyrocrete 241 for Period of Fire Resistance(mm)						
	30 minutes	60 minutes	90 minutes	120 minutes	150 minutes	180 minutes	240 minutes
170	9.6	14.3	19	23.8	28.5	33.2	42.7
175	9.7	14.4	19.2	24	28.8	33.6	43.1
180	9.8	14.6	19.4	24.2	29.1	33.9	43.5
185	9.8	14.7	19.6	24.4	29.3	34.2	43.9
190	9.9	14.8	19.7	24.6	29.6	34.5	44.3
195	10	15	19.9	24.8	29.8	34.7	44.6
200	10.1	15.1	20.1	25	30	35	45
205	10.2	15.2	20.2	25.2	30.2	35.3	45.3
210	10.2	15.3	20.3	25.4	30.5	35.5	45.6
215	10.3	15.4	20.5	25.6	30.7	35.8	45.9
220	10.4	15.5	20.6	25.7	30.9	36	46.2
225	10.4	15.6	20.7	25.9	31.1	36.2	46.5
230	10.5	15.7	20.9	26.1	31.2	36.4	46.8
235	10.6	15.8	21	26.2	31.4	36.6	47.1
240	10.6	15.9	21.1	26.4	31.6	36.9	47.4
245	10.7	15.9	21.2	26.5	31.8	37.1	47.6
250	10.7	16	21.3	26.6	31.9	37.2	47.9
255	10.8	16.1	21.4	26.8	32.1	37.4	48.1
260	10.8	16.2	21.5	26.9	32.3	37.6	48.3
265	10.9	16.3	21.6	27	32.4	37.8	48.6
270	10.9	16.3	21.7	27.2	32.6	38	48.8
275	11	16.4	21.8	27.3	32.7	38.1	49
280	11	16.5	21.9	27.4	32.8	38.3	49.2
285	11.1	16.5	22	27.5	33	38.5	49.4
290	11.1	16.6	22.1	27.6	33.1	38.6	49.6
295	11.2	16.7	22.2	27.7	33.2	38.8	49.8
300	11.2	16.7	22.3	27.8	33.4	38.9	50
305	11.2	16.8	22.4	27.9	33.5	39	50.2