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REPORT

Determination of the contribution to the fire resistance of structural steel members by an applied profiled reactive water-based fire protective system type ENVIROGRAF® EP/FS/IN/EX, according to EN 13381-8:2013
Assessment report - numerical regression

Report no.	2019-Efectis-R000576
Sponsor	Intumescent Systems Ltd Envirograf House Barfrestone CT15 7JG DOVER UNITED KINGDOM
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Project number	ENL-18-000645
Date of issue	April 2019
Number of pages	27

CONTENTS

1. SUBJECT

The purpose of this investigation is to assess the contribution of an applied profiled ENVIROGRAF® EP/FS/IN/EX white water-based intumescent coating to the fire resistance of structural steel members. A number of tests on loaded beams, reference beams, short I and H section columns and a tall H section column were performed according to the European standard EN 13381-8:2013. This report provides the assessment of the test data using the numerical regression method.

2. INVESTIGATION

Contribution, according to EN 13381-8:2013, to the fire resistance of structural steel members by an applied profiled ENVIROGRAF® EP/FS/IN/EX white water-based intumescent coating. The method for processing the results is the numerical regression assessment method as described in EN 13381-4:2013 annex E.

3. SPONSOR

Intumescent Systems Ltd
Envirograf House
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4. LOCATION AND DATE OF THE INVESTIGATION

<u>loaded beam and unloaded reference beam</u>

- Laboratory: Efectis Nederland BV, Bleiswijk, The Netherlands;
- Test date: 16 November 2018
- Efectis report: 2019-Efectis-R000566

<u>loaded beam, unloaded reference beam and 5 unloaded short columns</u>

- Laboratory: Efectis Nederland BV, Bleiswijk, The Netherlands;
- Test date: 20 November 2018
- Efectis report: 2019-Efectis-R000566

<u>8 unloaded short columns and 1 unloaded tall column</u>

- Laboratory: Efectis Nederland BV, Bleiswijk, The Netherlands;
- Test date: 23 November 2018
- Efectis report: 2019-Efectis-R000566

5. TEST SPECIMENS

For a description of the test specimens and the method of application of the protection system we refer to the test report mentioned in the table below. A summary of the test specimens used for the assessment according to EN 13381-8:2013 (numerical regression method) is given in the table below.

5.1 TEST SPECIMENS

Test specimen	**Type**	**Average protecting thickness** µm	**Actual section factor** m^{-1}	**Test date**	**Report**
Loaded beam	IPE 400	264	164	16-11-2018	2019-Efectis-R000566
Reference beam	IPE 400	271	165	16-11-2018	2019-Efectis-R000566
Loaded beam	IPE 400	2933	165	20-11-2018	2019-Efectis-R000566
Reference beam	IPE 400	2896	164	20-11-2018	2019-Efectis-R000566
Unloaded short column	IPE 80	1126	434	20-11-2018	2019-Efectis-R000566
Unloaded short column	IPE 80	2169	431	20-11-2018	2019-Efectis-R000566
Unloaded short column	IPE 80	2675	429	20-11-2018	2019-Efectis-R000566
Unloaded short column	IPE 200	1161	288	20-11-2018	2019-Efectis-R000566
Unloaded short column	IPE 200	2294	300	20-11-2018	2019-Efectis-R000566
Unloaded short column	HEM 280	270	74	23-11-2018	2019-Efectis-R000566
Unloaded short column	HEM 280	1182	75	23-11-2018	2019-Efectis-R000566
Unloaded short column	HEM 280	2358	75	23-11-2018	2019-Efectis-R000566
Unloaded short column	HEA 300	285	165	23-11-2018	2019-Efectis-R000566
Unloaded short column	HEA 300	2171	165	23-11-2018	2019-Efectis-R000566
Unloaded short column	HEA 300	3013	165	23-11-2018	2019-Efectis-R000566
Unloaded short column	IPE 200	269	287	23-11-2018	2019-Efectis-R000566
Unloaded short column	IPE 200	2696	296	23-11-2018	2019-Efectis-R000566
Unloaded tall column	HEA 300	2938	165	23-11-2018	2019-Efectis-R000566

5.2 DIMENSIONS OF THE TEST SPECIMENS

Test specimen	Type	Height h mm	Width b mm	Thickness web t_w mm	Thickness flange t_f mm	Perimeter P mm	Area A mm^2	Actual section Factor A_m/V m^{-1}
Loaded beam	IPE400	402	182	8.55	13.5	1333	8120	164
Reference beam	IPE400	402	182	8.45	13.45	1333	8065	165
Loaded beam	IPE400	402	182	8.55	13.35	1333	8068	165
Reference beam	IPE400	402	182	8.55	13.45	1333	8103	164
Short column	IPE 80	82	46	4.2	5.25	340	783	434
Short column	IPE 80	82	46	4.2	5.3	340	787	431
Short column	IPE 80	82	46	4.25	5.3	339	791	429
Short column	IPE 200	200	101	6	8.15	792	2749	288
Short column	IPE 200	203	101	5.7	7.9	798	2663	300
Short column	HEM 280	315	285	19.3	32.6	1731	23403	74
Short column	HEM 280	315	290	19.7	31.85	1751	23424	75
Short column	HEM 280	315	290	19.1	31.85	1752	23273	75
Short column	HEA 300	290	301	8.55	14.1	1767	10727	165
Short column	HEA 300	290	301	8.6	14	1767	10681	165
Short column	HEA 300	290	300	8.6	14.1	1763	10711	165
Short column	IPE 200	200	101	5.9	8.3	792	2759	287
Short column	IPE 200	200	101	5.8	7.95	792	2674	296
Tall column	HEA 300	290	300	8.6	14.1	1763	10711	165

6. PROTECTION SYSTEM

6.1 TEST SPECIMENS

The applied profiled reactive fire protection system consists of a fire protection of ENVIROGRAF® EP/FS/IN/EX white water-based intumescent coating on a ENVIROGRAF® EP/FS/WBP water-based primer. The method of application to the reference beams and the short columns was the same as that for the loaded beams and tall column.

- Thickness: See this report;
- The reactive fire protection system was applied by brush. The larger thicknesses of base coat were applied in multiple layers of about 1 mm thickness each.

7. ASSESSMENT OF THE RESULTS

7.1 CORRECTION OF THE TIMES TO REACH CERTAIN STEEL TEMPERATURES OF THE COLUMNS (MECHANICAL BEHAVIOUR)

From the measured steel temperatures of the loaded beams, the unloaded reference beams and the unloaded tall column characteristic temperatures were determined according to par. 3.1.11 in EN 13381-8:2013. With the times to reach certain characteristic temperatures correction factors were determined. In agreement with Annex D of EN 13381-8:2013, for the correction at temperatures above the characteristic temperature at which failure of the loaded section occurred, the minimum observed correction factor just before failure is used. The temperature correction factors for a fire protection of ENVIROGRAF® EP/FS/IN/EX white water-based intumescent coating on a ENVIROGRAF® EP/FS/WBP water-based primer are given in figure 6.1.

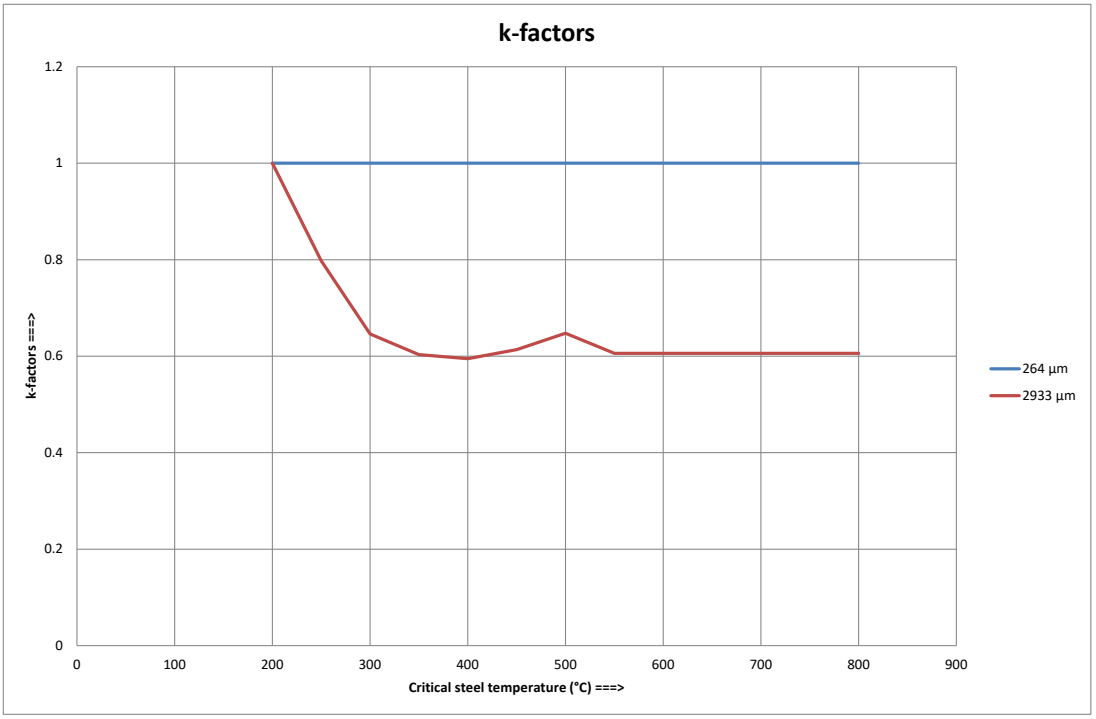

Figure 6.1 Temperature correction factors for both beam tests

These correction factors were, according to EN 13381-8:2013, applied to the times to reach certain overall mean temperatures in the columns.

7.2 NUMERICAL REGRESSION

A multiple linear regression analysis is conducted in accordance with EN 13381-8:2013 par E.5, using the formula.

$$t = a_0 + a_1 d_p + a_2 \frac{d_p}{A_m/V} + a_3 \theta_a + a_4 d_p \theta_a + a_5 d_p \frac{\theta_a}{A_m/V} + a_6 \frac{\theta_a}{A_m/V} + a_7 \frac{1}{A_m/V}$$

Wherein:

t	is the corrected time to reach design temperature θ_a in minutes
d_p	is the actual protection thickness in mm
A_m/V	is the measured section factor in m^{-1}
a_0 t/m a_7	are the regression coefficients
θ_a	is the design steel temperature in °C

The constants a_0 t/m a_7 are determined using linear regression techniques following the criteria of EN 13381-8:2013 :

a) For each short section the predicted time to reach the design temperature shall not exceed the corrected time by more than 15%;
b) The mean value of all percentage differences as calculated in a) shall be less than zero;
c) A maximum of 30% of all individual values of all percentage differences as calculated in a) shall be more than zero.
d) The results of the analysis which satisfy a) to c) above shall also comply with the following rules provided all other parameters remain constant:
    1) the thickness of the fire protection material increases with fire resistance time
    2) as the section factor increases the fire resistance time increases
    3) as the fire resistance time increases the temperature increases
    4) as thickness increases temperature decreases
    5) as section factor increases the temperature increases
    6) as section factor increases thickness increases

The results of the calculation are:

$$t = -4.23832 + 1.274782 d_{\mathrm{p}} + 402.0613 \frac{d_{\mathrm{p}}}{A_{\mathrm{m}}/V} + 0.025202 \theta_{\mathrm{a}} + 0.000431 d_{\mathrm{p}} \theta_{\mathrm{a}} + (-0.64332) d_{\mathrm{p}} \frac{\theta_{\mathrm{a}}}{A_{\mathrm{m}}/V} + 2.771673 \frac{\theta_{\mathrm{a}}}{A_{\mathrm{m}}/V} + (-604.291) \frac{1}{A_{\mathrm{m}}/V}$$

7.3 GRAPHS

Based on the formula above two sets of data were calculated:

- Graphs in Figure 11.1 to 11.9 in which for a specific design steel temperature (350 to 750°C in steps of max. 50°C) the relation between the fire resistance and the section factor is given for a certain protection thickness.
- Tables in Chapter 12 which give the required thickness for a certain fire resistance (in minutes) for a given critical steel temperature and section factor.

8. CONCLUSION

The fire resistance of structural steel members protected with a fire protection of ENVIROGRAF® EP/FS/IN/EX white water-based intumescent coating on a ENVIROGRAF® EP/FS/WBP water-based primer may according to EN 13381-8:2013 be determined using figures 11.1 t/m 11.9 and the tables in chapter 12 under the conditions given in chapter 9 of this report.

9. CONDITIONS AND FIELD OF APPLICATION

The section factor has to be determined according to figure 1 of EN 13381-8:2013.

The figures 11.1 to 11.9 and the tables in chapter 12 are only valid under the conditions mentioned below.

For beams:

- 251 µm ≤ d_p ≤ 3080 µm (thickness)
- 147.6 m^{-1} ≤ A_m/V ≤ 477.4 m^{-1} (section factor)
- 350°C ≤ θ_a ≤ 750°C

For columns:

- 269 µm ≤ d_p ≤ 3085 µm (thickness)
- 66.6 m^{-1} ≤ A_m/V ≤ 477.4 m^{-1} (section factor)
- 350°C ≤ θ_a ≤ 750°C

For section factors for beams and columns below the extended minimum, the same thickness as that applied to the extended minimum section factor shall be applied.

The above extensions are confined to each section type i.e. the permitted extensions for beams are not appropriate for columns and vice versa. Similarly, those extensions applied to I or H sections may not be applied to hollow sections and vice versa.

The results of the assessment are applicable to all other grades of steel to that tested and as given in EN 10025-1 as specified in 6.1 and with the limitations given therein.

The results of the analysis for columns can be applied to beams exposed on all four sides up to the maximum dry film thickness predicted from the appropriate loaded beam test. In order for this to apply, it is necessary for beams to have been tested accordance with 6.2.1 of EN 13381-8:2013.
If the figures in chapter 11 or the tables in chapter 12 are used, intermediate values for the critical steel temperature may be interpolated using linear interpolation.
The results in chapter 11 and 12 are valid for three and four sided profiled protection.

The assessment is applicable to the method of application used in the test specimen preparation.

The results of the assessment are also applicable to fabricated sections.

P.W.M. Kortekaas
Senior Project leader resistance to fire

Ir. T. Rakovec
Project leader fire engineering

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Project leader resistance to fire

10. MEASURED CORRECTED TIMES VS CALCULATED TIMES

Critical steel temperature °C	Measured thickness mm	Section factor m^{-1}	Tmeas min	Tcalc min	Tcalc/Tmeas
350	0.27	74	12.66	10.56	0.834
350	1.182	75	19.43	13.93	0.717
350	2.358	75	19.44	18.38	0.946
350	0.285	165	9.51	7.51	0.79
350	2.171	165	19.09	12.22	0.64
350	3.013	165	15.27	14.32	0.938
350	0.269	287	6.27	6.41	1.021
350	1.161	288	10.26	8.22	0.801
350	2.294	300	11.82	10.42	0.882
350	2.696	296	9.81	11.27	1.149
350	1.126	434	8.46	7.49	0.886
350	2.169	431	8.89	9.41	1.059
350	2.675	429	11.66	10.35	0.888
400	0.27	74	15.15	13.58	0.896
400	1.182	75	22.6	16.56	0.733
400	2.358	75	21.08	20.53	0.974
400	0.285	165	11.59	9.56	0.825
400	2.171	165	22.57	13.95	0.618
400	3.013	165	18.1	15.9	0.879
400	0.269	287	8	8.12	1.016
400	1.161	288	12.74	9.86	0.774
400	2.294	300	14.2	11.95	0.842
400	2.696	296	11.54	12.77	1.106
400	1.126	434	11.11	9.01	0.811
400	2.169	431	10.66	10.88	1.02

400	2.675	429	13.24	11.79	0.89
450	0.27	74	17.76	16.6	0.934
450	1.182	75	25.63	19.19	0.749
450	2.358	75	23.39	22.68	0.969
450	0.285	165	13.58	11.61	0.855
450	2.171	165	25.89	15.67	0.605
450	3.013	165	21.48	17.48	0.814
450	0.269	287	9.66	9.84	1.019
450	1.161	288	15.28	11.49	0.752
450	2.294	300	16.64	13.48	0.81
450	2.696	296	13.57	14.26	1.05
450	1.126	434	13.45	10.53	0.783
450	2.169	431	12.68	12.35	0.974
450	2.675	429	15.47	13.23	0.855
500	0.27	74	20.5	19.62	0.957
500	1.182	75	28.59	21.81	0.763
500	2.358	75	26.2	24.83	0.948
500	0.285	165	15.54	13.66	0.879
500	2.171	165	29.27	17.39	0.594
500	3.013	165	25.23	19.06	0.755
500	0.269	287	11.33	11.56	1.021
500	1.161	288	17.48	13.13	0.751
500	2.294	300	19.17	15	0.782
500	2.696	296	15.73	15.75	1.001
500	1.126	434	15.72	12.05	0.767
500	2.169	431	14.73	13.81	0.938
500	2.675	429	18	14.67	0.815
550	0.27	74	23.37	22.64	0.969
550	1.182	75	30.65	24.44	0.797

550	2.358	75	27.05	26.97	0.997
550	0.285	165	17.49	15.71	0.898
550	2.171	165	30.32	19.12	0.631
550	3.013	165	25.73	20.64	0.802
550	0.269	287	13.11	13.28	1.013
550	1.161	288	18.8	14.77	0.785
550	2.294	300	20	16.53	0.826
550	2.696	296	16.31	17.25	1.058
550	1.126	434	17.23	13.57	0.788
550	2.169	431	15.56	15.28	0.982
550	2.675	429	18.67	16.11	0.863
600	0.27	74	26.7	25.66	0.961
600	1.182	75	33.09	27.06	0.818
600	2.358	75	29.14	29.12	0.999
600	0.285	165	19.48	17.76	0.912
600	2.171	165	32.37	20.84	0.644
600	3.013	165	27.57	22.21	0.806
600	0.269	287	14.91	15	1.006
600	1.161	288	20.43	16.4	0.803
600	2.294	300	21.53	18.05	0.838
600	2.696	296	17.6	18.74	1.065
600	1.126	434	18.58	15.09	0.812
600	2.169	431	16.96	16.75	0.988
600	2.675	429	20.18	17.55	0.87
650	0.27	74	30.72	28.68	0.934
650	1.182	75	35.88	29.69	0.828
650	2.358	75	31.45	31.27	0.994
650	0.285	165	21.71	19.81	0.913
650	2.171	165	34.58	22.56	0.653

650	3.013	165	29.39	23.79	0.81
650	0.269	287	16.86	16.72	0.991
650	1.161	288	22.07	18.04	0.817
650	2.294	300	22.99	19.58	0.851
650	2.696	296	18.83	20.23	1.075
650	1.126	434	20.23	16.61	0.821
650	2.169	431	18.33	18.21	0.994
650	2.675	429	21.68	18.99	0.876
700	0.27	74	35.65	31.71	0.889
700	1.182	75	39.46	32.32	0.819
700	2.358	75	34.4	33.41	0.971
700	0.285	165	24.71	21.87	0.885
700	2.171	165	37.06	24.29	0.655
700	3.013	165	31.54	25.37	0.804
700	0.269	287	19.43	18.44	0.949
700	1.161	288	23.87	19.68	0.825
700	2.294	300	24.51	21.1	0.861
700	2.696	296	20.03	21.73	1.085
700	1.126	434	21.86	18.13	0.83
700	2.169	431	19.77	19.68	0.996
700	2.675	429	23.21	20.43	0.88
750	0.27	74	43.63	34.73	0.796
750	1.182	75	45.67	34.94	0.765
750	2.358	75	38.57	35.56	0.922
750	0.285	165	29.32	23.92	0.816
750	2.171	165	40.83	26.01	0.637
750	3.013	165	34.31	26.95	0.785
750	0.269	287	23.66	20.16	0.852
750	1.161	288	26.53	21.31	0.803

750	2.294	300	26.3	22.63	0.861
750	2.696	296	21.3	23.22	1.09
750	1.126	434	24.34	19.65	0.807
750	2.169	431	21.56	21.15	0.981
750	2.675	429	24.73	21.87	0.885

Criterion	Value
Max. unsafe	1.149
Cumulative deviation	-364.22
Percentage safe side	85.50%

11. DESIGN GRAPHS

Figure 11.1 Fire resistance as function of the section factor and the coating thickness for a critical steel temperature of 350°C.

Figure 11.2 Fire resistance as function of the section factor and the coating thickness for a critical steel temperature of 400°C.

Figure 11.3 Fire resistance as function of the section factor and the coating thickness for a critical steel temperature of 450°C.

Figure 11.4 Fire resistance as function of the section factor and the coating thickness for a critical steel temperature of 500°C.

Figure 11.5 Fire resistance as function of the section factor and the coating thickness for a critical steel temperature of 550°C.

Figure 11.6 Fire resistance as function of the section factor and the coating thickness for a critical steel temperature of 600°C.

Figure 11.7 Fire resistance as function of the section factor and the coating thickness for a critical steel temperature of 650°C.

Figure 11.8 Fire resistance as function of the section factor and the coating thickness for a critical steel temperature of 700°C.

Figure 11.9 Fire resistance as function of the section factor and the coating thickness for a critical steel temperature of 750°C.

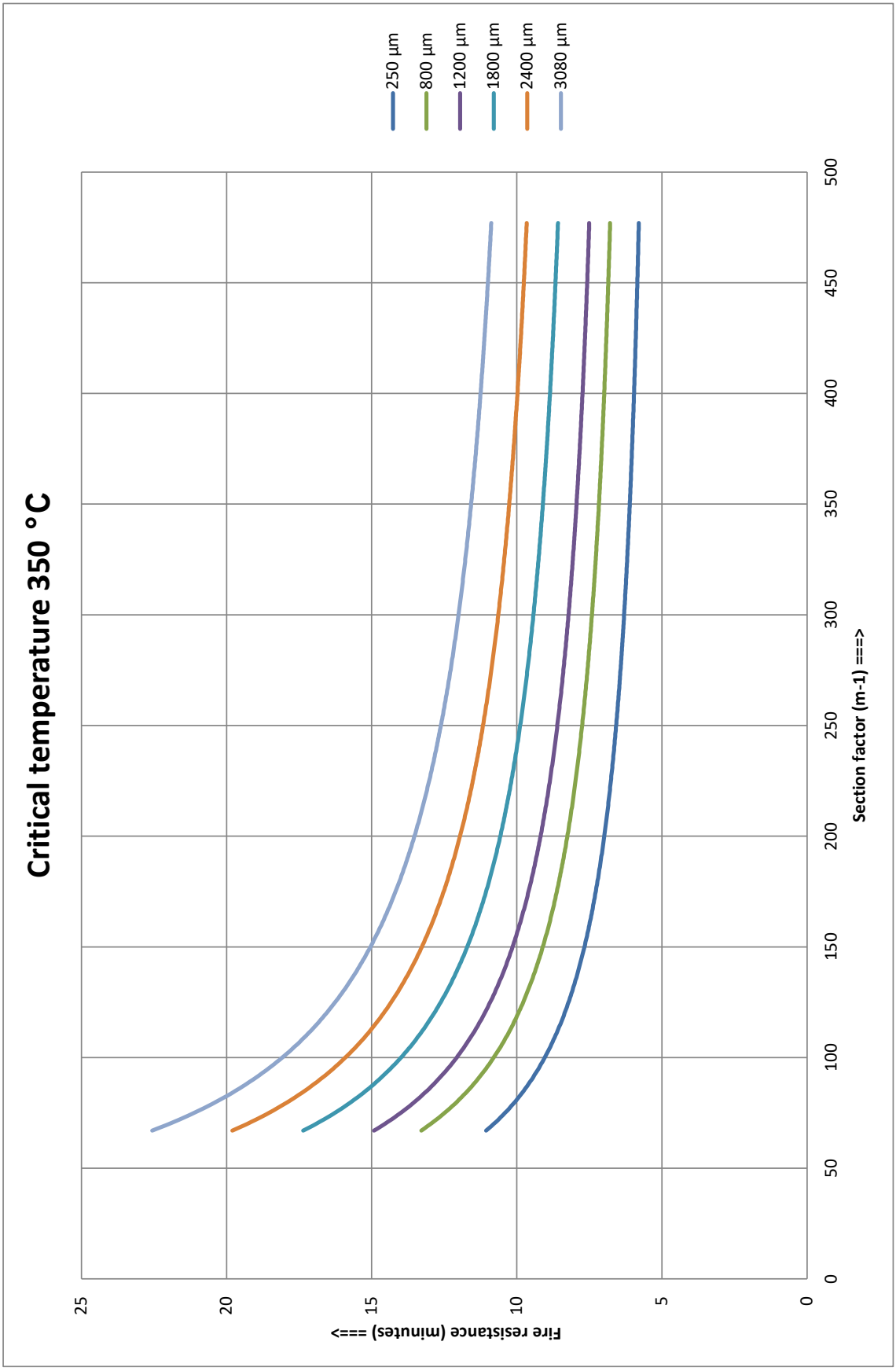

Figure 11.1 critical steel temperature 350°C

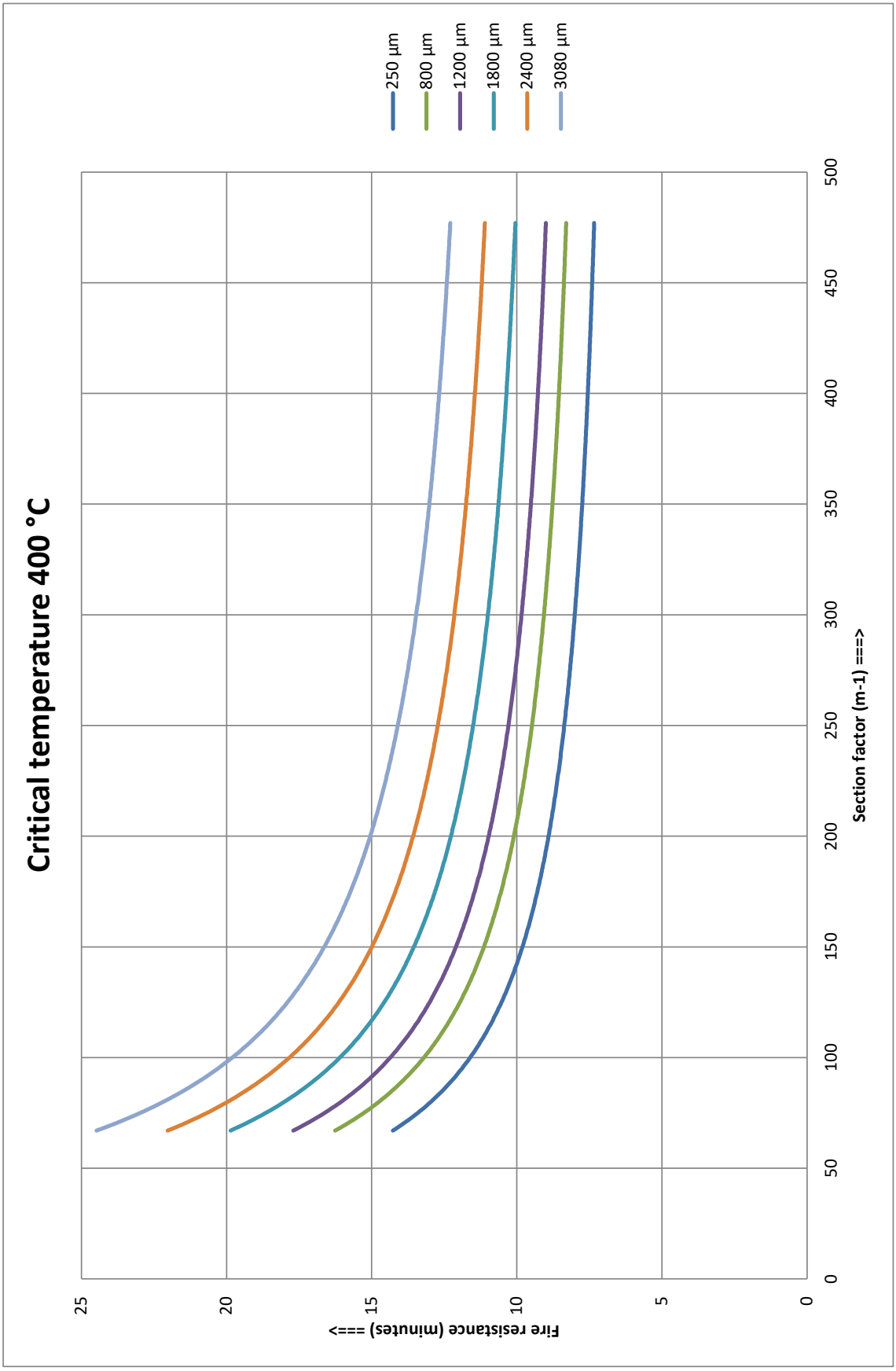

Figure 11.2 critical steel temperature 400°C

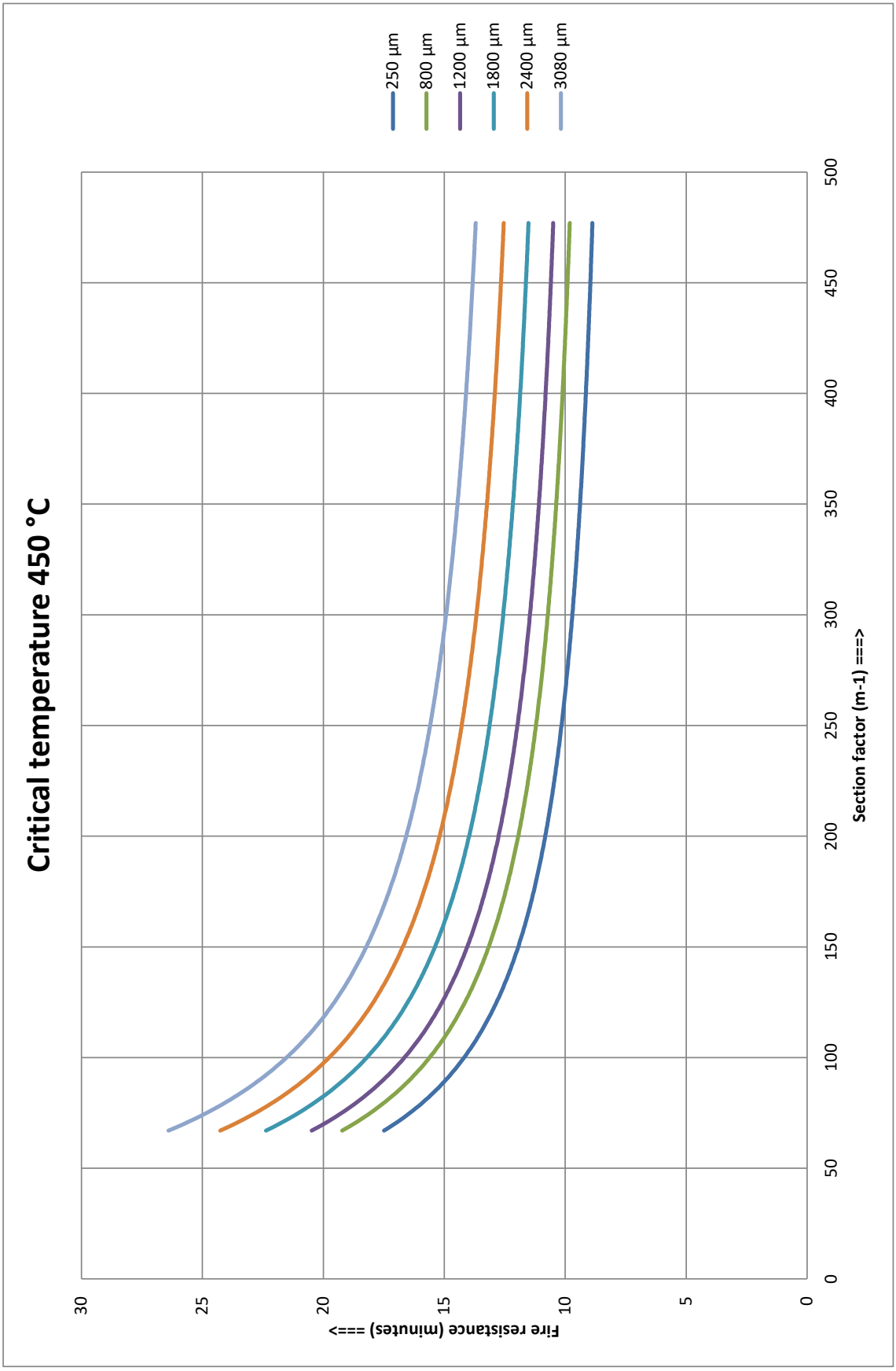

Figure 11.3 critical steel temperature 450°C

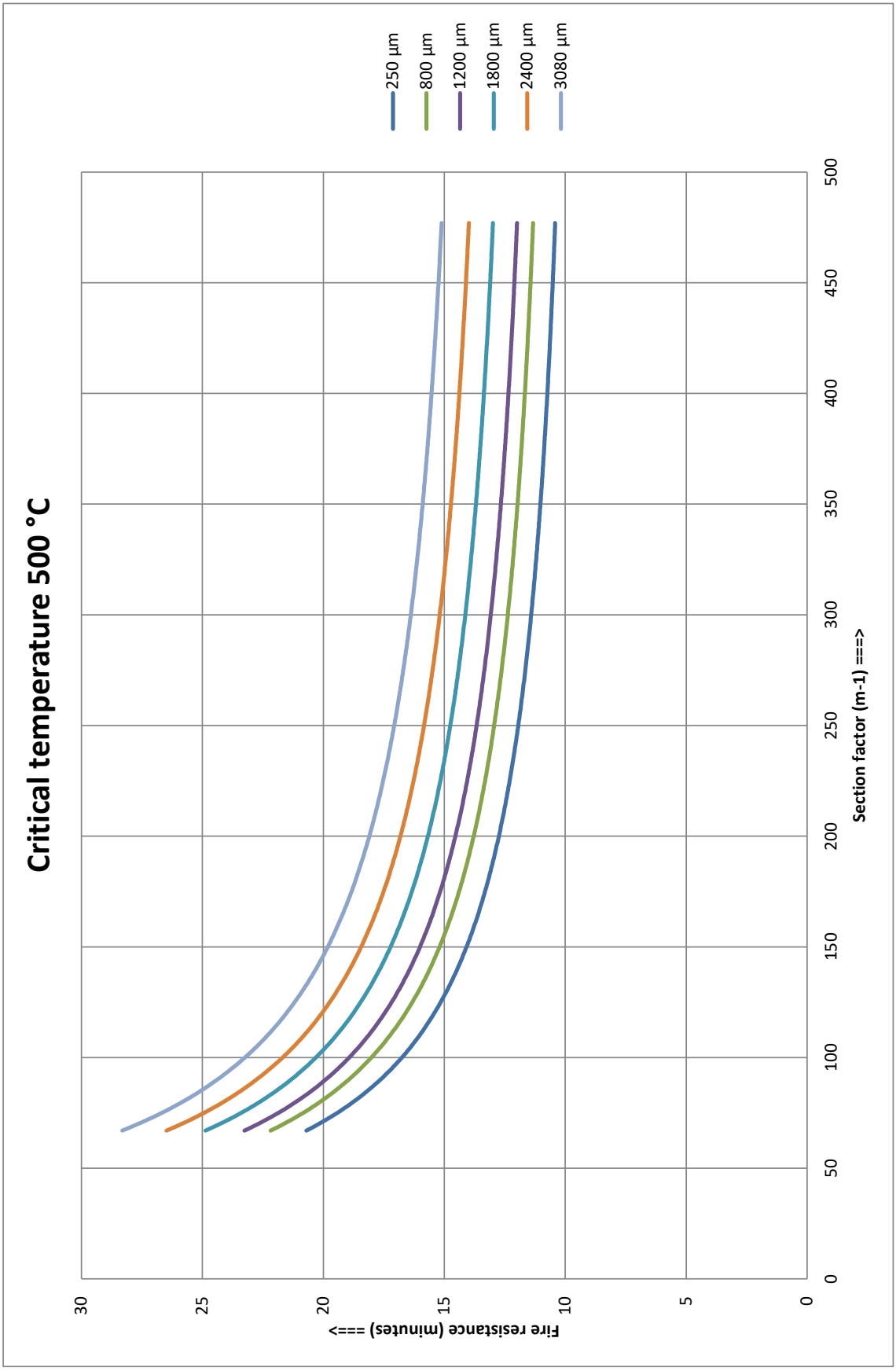

Figure 11.4 critical steel temperature 500°C

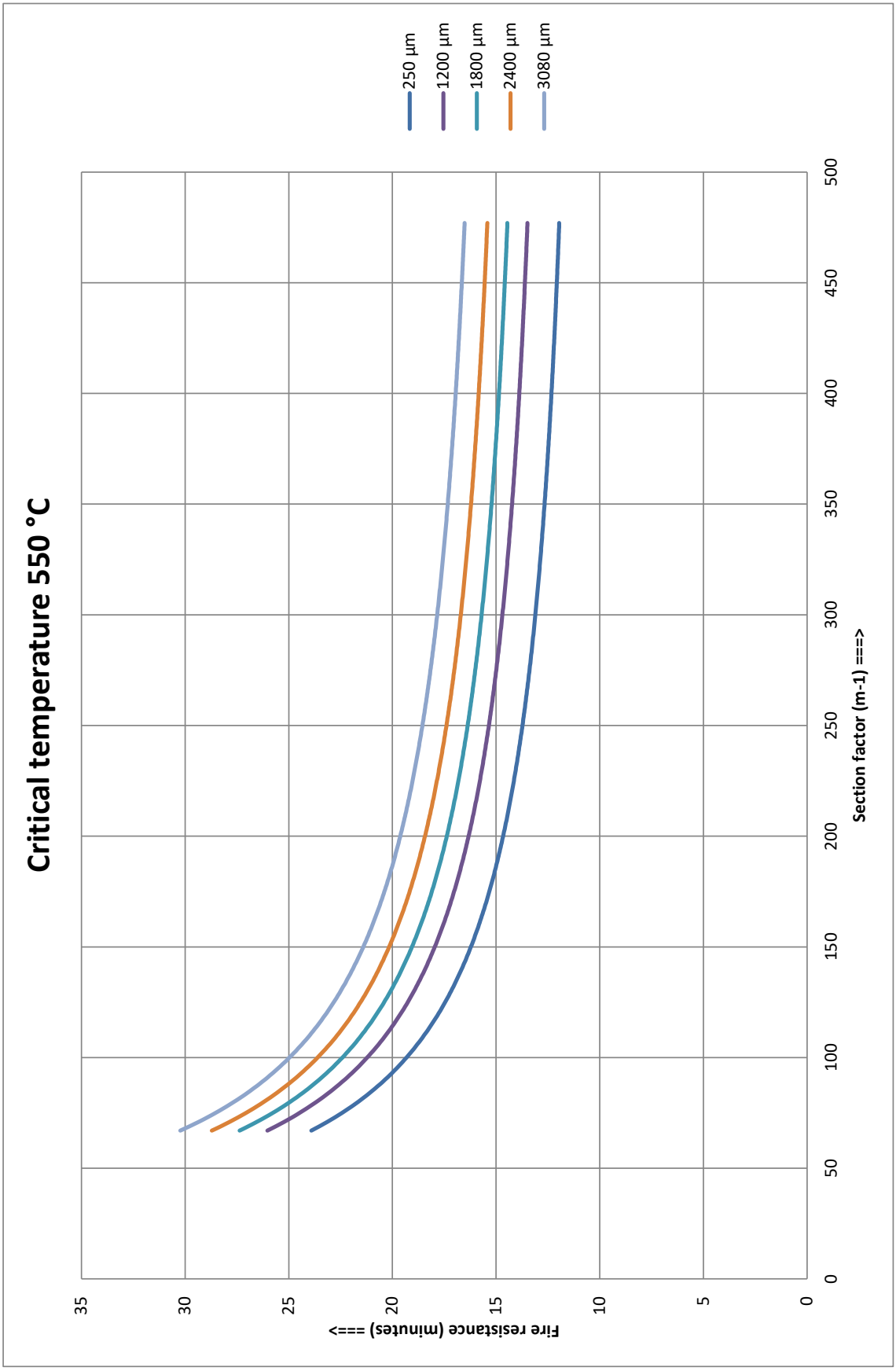

Figure 11.5 critical steel temperature 550°C

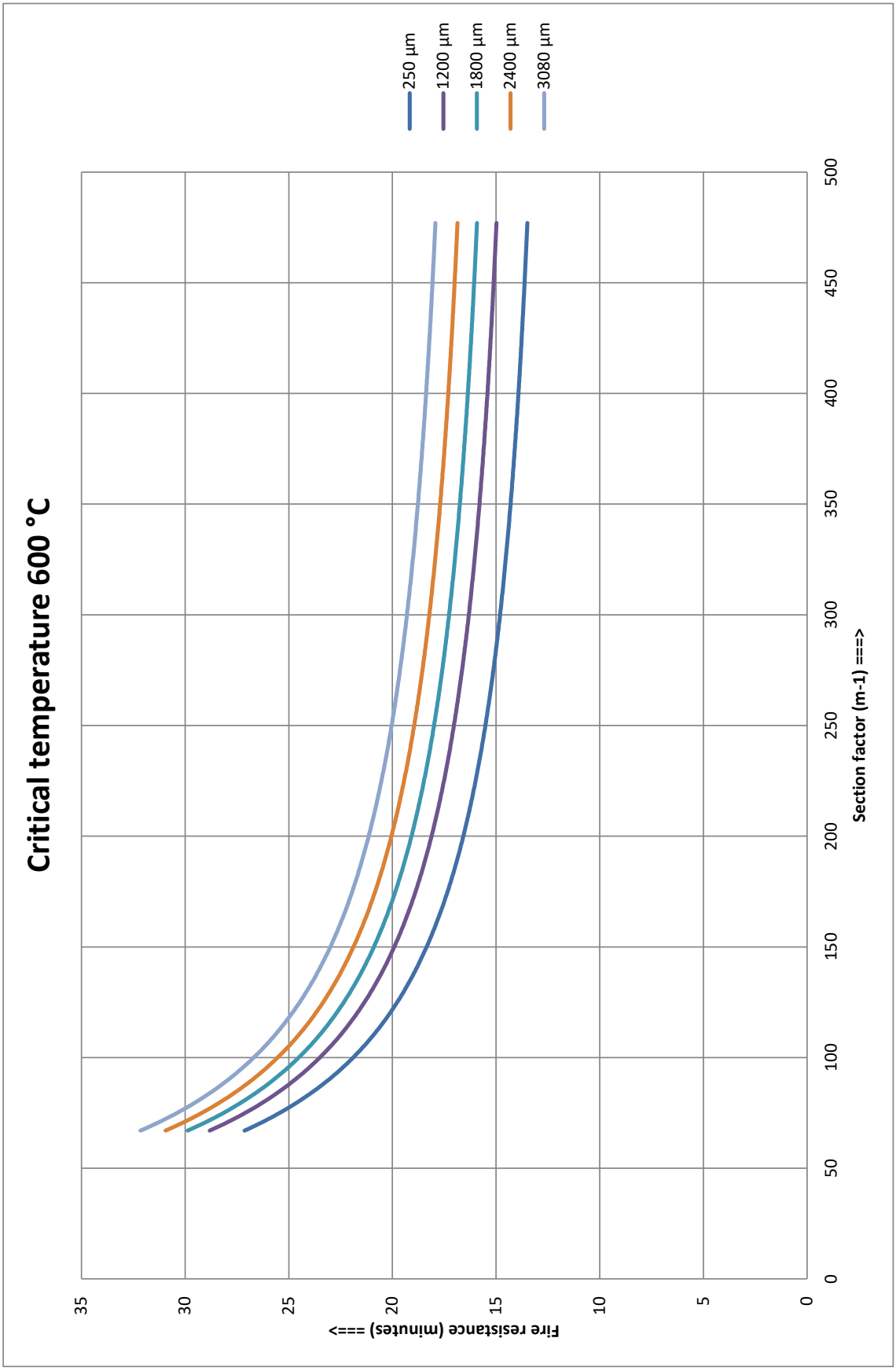

Figure 11.6 critical steel temperature 600°C

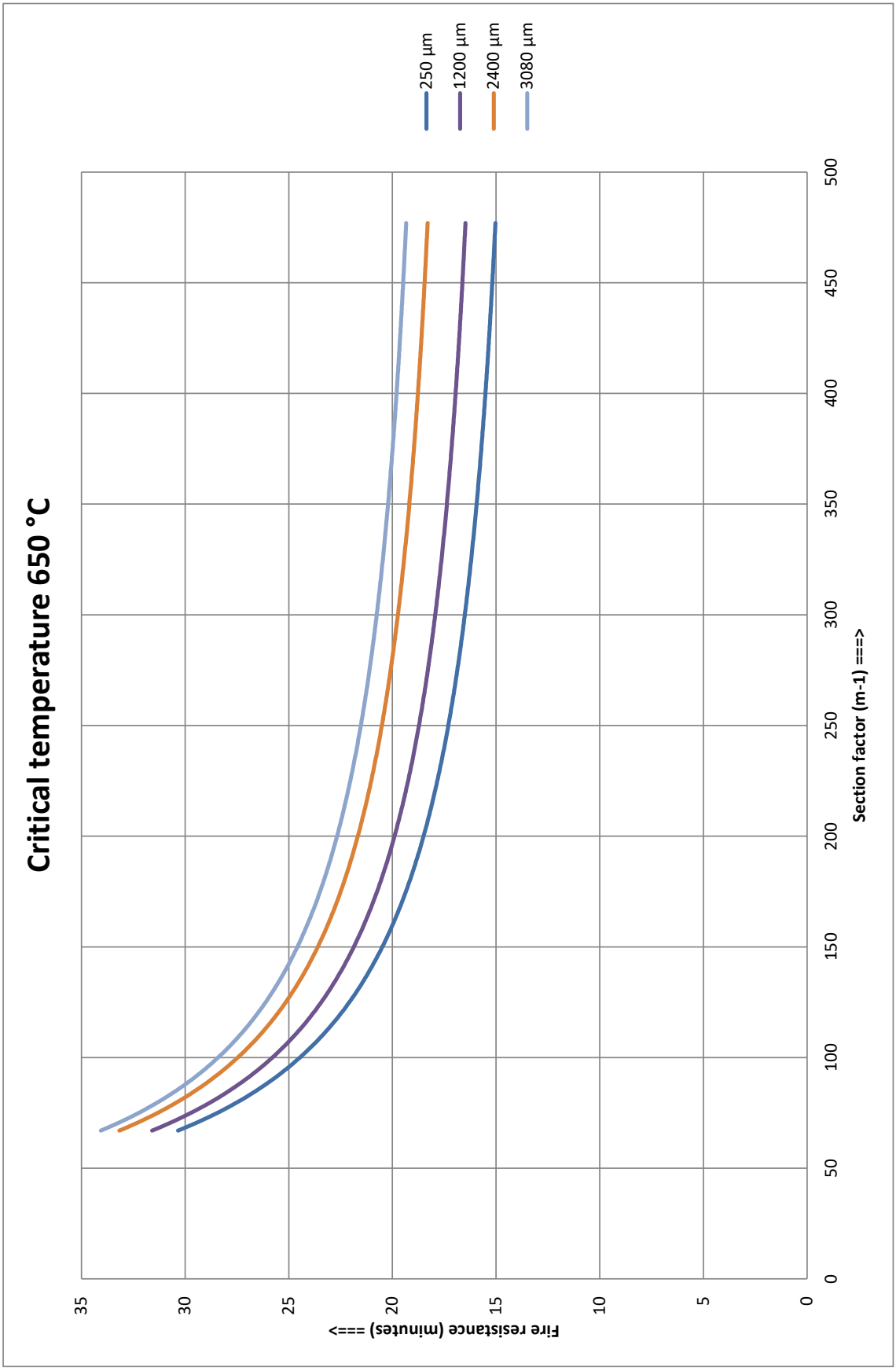

Figure 11.7 critical steel temperature 650°C

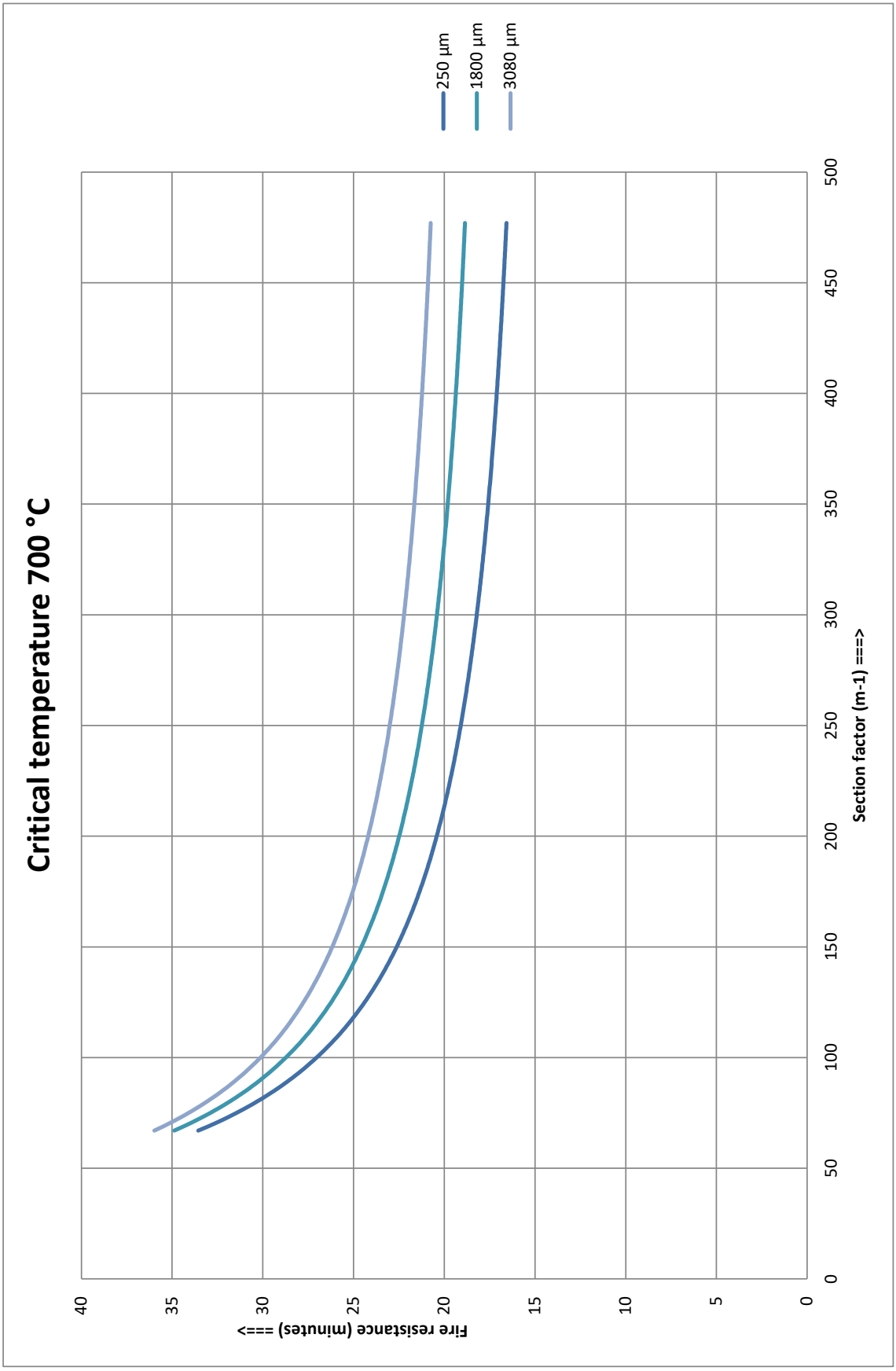

Figure 11.8 critical steel temperature 700°C

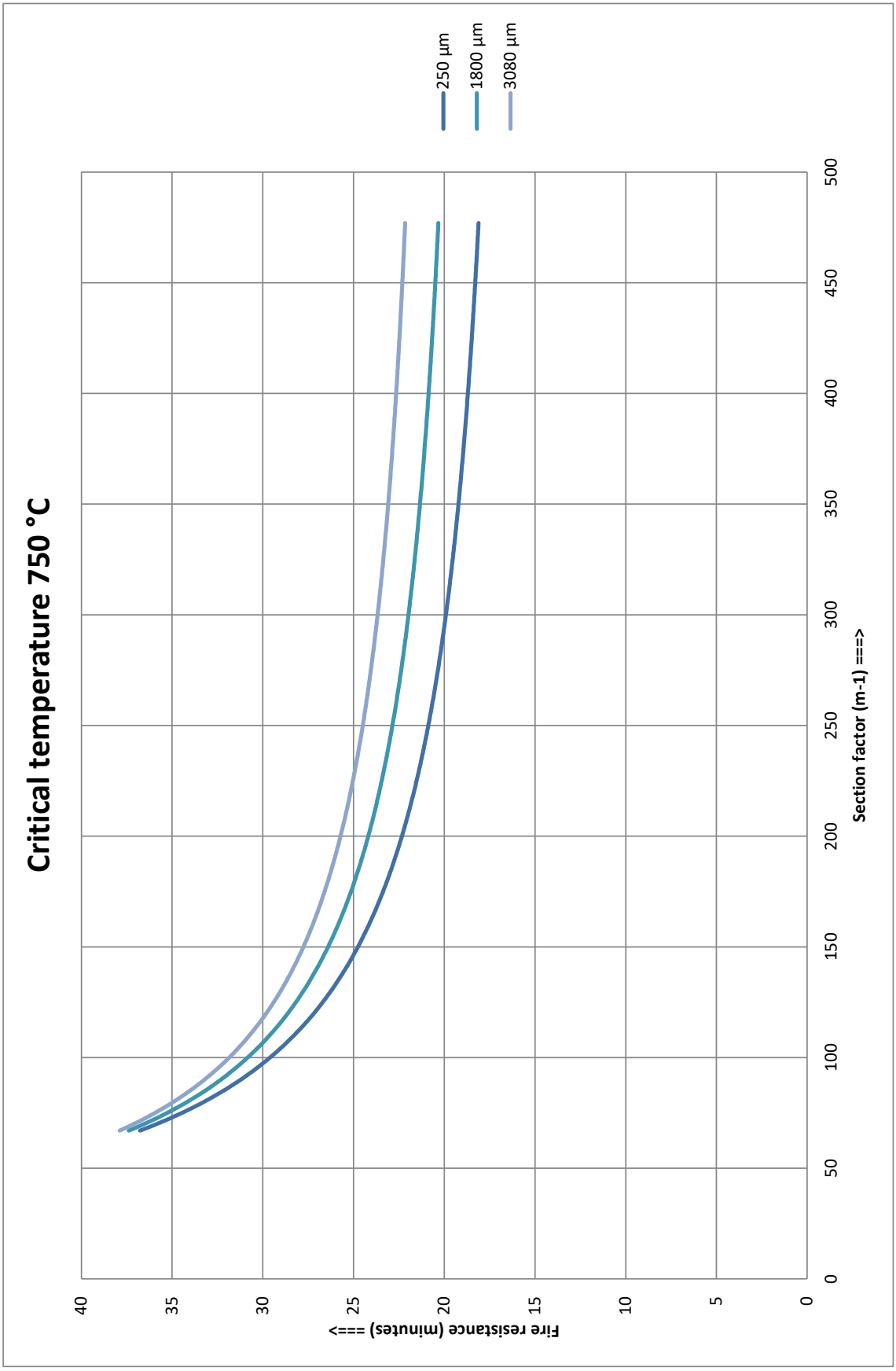

Figure 11.9 critical steel temperature 750°C

12. DESIGN TABLES

Design table 1: Required protection thickness in mm for fire resistance 30 minutes

Section factor (m^{-1})	Design temperature (°C)								
	350	400	450	500	550	600	650	700	750
	Thickness of fire protection material to maintain steel temperature below design temperature (mm)								
0	-	-	-	-	2.936	1.817	0.256	0.256	0.256
66.6	-	-	-	-	2.936	1.817	0.256	0.256	0.256
70	-	-	-	-	-	2.267	0.572	0.256	0.256
80	-	-	-	-	-	-	2.139	0.256	0.256
90	-	-	-	-	-	-	-	1.69	0.256
100	-	-	-	-	-	-	-	2.964	0.752
110	-	-	-	-	-	-	-	-	2.234
120	-	-	-	-	-	-	-	-	-

Design table 2: Required protection thickness in mm for fire resistance 60 minutes

Section factor (m^{-1})	Design temperature (°C)								
	350	400	450	500	550	600	650	700	750
	Thickness of fire protection material to maintain steel temperature below design temperature (mm)								
0	-	-	-	-	-	-	-	-	-
66.6	-	-	-	-	-	-	-	-	-
70	-	-	-	-	-	-	-	-	-
80	-	-	-	-	-	-	-	-	-
90	-	-	-	-	-	-	-	-	-
100	-	-	-	-	-	-	-	-	-
110	-	-	-	-	-	-	-	-	-
120	-	-	-	-	-	-	-	-	-

13. MEAN STEEL TEMPERATURES USED IN THE ANALYSIS IN ACCORDANCE WITH 13.2 OF EN 13381-8:2013)

	HEM 280 270 µm	HEM 280 1182 µm	HEM 280 2358 µm	HEA 300 285 µm	HEA 300 2171 µm	HEA 300 3013 µm	IPE 200 269 µm	IPE 200 1161 µm	IPE 200 2294 µm	IPE 200 2696 µm	IPE 80 1126 µm	IPE 80 2169 µm	IPE 80 2675 µm
Time (min)	Tavg	Tavg	Tavg	Tavg	Tavg	Tavg	Tavg	Tavg	Tavg	Tavg	Tavg	Tavg	Tavg
0	11	11	12	11	11	11	12	11	11	11	11	11	12
1	33	30	21	57	36	32	88	87	70	46	128	92	54
2	56	49	39	113	65	68	173	148	121	99	206	159	106
3	79	71	53	141	88	92	226	196	159	131	252	198	140
4	103	96	65	168	110	112	275	231	188	157	276	226	168
5	128	118	76	191	132	131	301	256	209	179	294	244	190
6	160	141	93	233	154	151	341	274	225	199	308	261	207
7	193	163	110	271	173	169	370	290	238	216	319	278	221
8	228	185	126	305	189	184	400	304	251	231	331	294	233
9	260	203	141	337	202	197	433	315	262	243	341	306	243
10	287	218	153	360	214	208	461	325	273	260	353	317	253
11	312	230	165	384	225	218	490	338	285	277	368	330	265
12	335	241	176	409	234	228	519	352	297	294	384	343	279
13	357	250	185	434	243	237	547	371	309	312	404	362	294
14	377	260	194	460	251	246	574	387	320	328	423	380	305
15	397	270	203	485	259	256	602	404	330	344	442	400	314
16	416	280	211	510	267	265	628	421	340	360	462	419	323
17	435	289	219	536	275	274	653	439	351	377	482	439	334
18	454	300	227	561	282	283	674	459	364	395	506	462	347
19	473	310	235	587	290	292	693	481	377	413	531	484	363
20	491	321	242	611	298	301	709	504	392	431	557	506	379
21	509	332	251	634	305	309	722	537	411	451	593	538	402
22	526	344	262	654	313	318	734	558	424	472	617	559	418

23	543	356	274	673	320	326	743	585	441	494	645	585	436
24	560	369	286	689	328	334	753	612	458	517	672	611	455
25	575	382	297	703	336	343	763	639	476	541	699	637	473
26	590	396	310	716	344	352	774	664	496	565	720	663	491
27	604	411	328	727	353	361	784	689	516	589	737	688	511
28	617	426	346	737	362	370	794	709	538	614	752	712	531
29	630	441	365	746	372	379	803	726	560	640	769	731	551
30	642	457	383	755	381	389	811	742	583	667	785	750	571
31	653	474	402	764	392	400	819	756	606	693	801	770	593
32	664	491	421	774	403	410	826	769	630	720	814	792	614
33	674	508	440	783	414	421	833	781	654	745	827	813	636
34	684	525	458	791	427	431	839	792	678	768	838	832	657
35	694	542	477	800	440	443	845	801	700	792	849	850	678
36	703	560	495	809	453	454	852	811	721	813	858	867	699
37	710	578	513	816	467	466	857	820	739	834	867	883	720
38	716	596	531	824	482	478	863	829	758	853	875	898	743
39	722	612	548	831	497	491	868	836	775	870	880	908	760
40	728	628	565	838	513	504	874	842	792	889	884	915	777
41	735	643	581	845	530	517	879	847	806	906	887	919	793
42	741	657	597	852	547	532	884	851	817	920	890	922	805
43	747	670	613	858	564	547	889	857	831	931	894	925	821
44	751	682	628	865	582	562	894	864	846	941	898	927	837
45	757	693	643	871	599	577	898	872	860	950	911	921	849
46	762	704	657	878	616	593	902	877	871	956	918	918	860
47	768	712	670	884	632	610	906	886	886	962	928	913	875
48	774	719	682	890	648	626	910	897	901	968	936	911	890
49	780	726	693	896	663	642	914	907	914	972	944	911	902
50	786	733	702	902	678	658	918	917	926	975	951	910	912

51	791	740	710	908	692	673	921	926	937	977	954	912	921
52	797	745	718	913	705	687	924	935	947	980	958	914	929
53	803	751	726	918	716	699	928	944	955	982	960	915	936
54	809	758	735	923	725	710	931	952	963	985	963	918	945
55	814	765	743	927	734	721	934	958	970	987	964	921	953
56	820	772	751	932	743	732	937	964	977	989	966	924	960
57	826	778	759	935	751	743	940	969	982	992	967	928	965
58	832	785	766	939	757	752	943	975	987	994	969	932	970
59	838	792	773	942	764	761	946	979	992	996	971	936	973
60	844	799	780	946	770	769	949	982	996	999	972	940	975
61	850	805	786	949	776	777	952	986	1001	1001	974	943	977
62	856	812	792	952	781	784	954	990	1005	1003	974	949	981
63	862	819	798	955	787	790	957	993	1007	1005	976	953	984
64	867	826	804	958	792	797	959	996	1010	1007	977	957	987
65	873	833	810	961	797	804	962	998	1013	1010	980	962	989
66	879	839	816	963	802	810	964	1002	1017	1011	982	970	992