



AC Hotel

2-Hour Steel Stair Structural Frame

Prepared By:

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REPORT

Project Overview

SERA Architects is designing the AC Hotel in Downtown Portland. The building is 14 stories, type IA construction. Full protection is provided by automatic sprinklers and fire alarm system. Steel structure is being used to support the stairs. The steel will be rated to 2 hours.

Applicable Code

2014 Oregon Structural Specialty Code (OSSC)

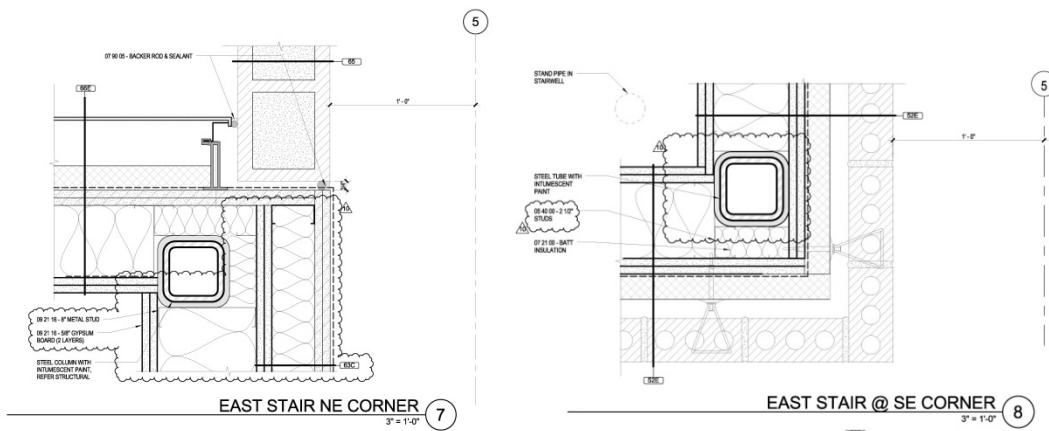
2014 Oregon Fire Code

Approach

- Fire-resistance rating requirements of the intumescent coating for the beams and columns will be compared with the rating provided by manufacturer for beams.
- Fire-resistance rating of the steel stair structural frame is 2-hour fire-resistance rated in all locations except where beams and columns connect.
- Fireproofing of the beam-column connections will be detailed as recommended by coating manufacturer.
- Engineering judgement and commentary are provided in the conclusion section.

Proposed Design

The steel structural frame is located in a 2 hour rated wall assembly (see below). The columns and beams support exterior and interior wall assemblies and roof assembly only and do not support a floor assembly.



The steel stair structural frame is composed of HSS beams and columns that have been factory treated with intumescent fire-resistant coatings to achieve a 2-hour fire-resistance rating. The thickness of the intumescent coating for the beams and columns is based on A/P ratio for HSS sections in column tests for the size of the HSS steel members in test CC/IF 180-03. HSS section protection is provided equivalent protection for beams based on comparison of beam protection for W section and HSS beam

2-Hour Primary Structural Frame

protection by test UL Design X790 and CC/IF 180-01. The size of the beams is as follows:

Beam Sizes:

- HSS8x6x1/4
- HSS14x6x5/16
- HSS12x6x5/16
- HSS12x4x5/8

The intumescent coating is not applied where the columns connect to the beams. Gaps occur at the beam-column connections that vary from 1/2-inch to 1/4-inch. Fireproofing of the gaps will be provided by compressed mineral wool to fill the gaps. Compressed mineral wool will be required to fill the entire cavity of the gap. The mineral wool and beam-column connections will then be covered with intumescent coating applied per the manufacturer's instructions, based on testing by Intertek (refer to CC/IF 180-03), to achieve a 2-hour rating. Compressed mineral wool is used as a backing material in multiple UL listed assemblies.

Fire Resistance Assembly Table

The table below provides information on the thickness of intumescent paint applied to beams and columns. Provided as well is the proposed thickness of intumescent paint for the beam-column connection.

Member Type	Member Size	Thickness (inches) Intumescent Paint	Fire Rating (hr)
Beam	HHS8x6x1/4	0.36	2
	HHS14x6x5/16	0.35	2
	HHS12x6x5/16	0.33	2
	HHS12x4x5/8	0.35	2
Beam-Column Connection	½" to ¼" gap at connection	Compressed mineral wool as per manufacturer's recommendation covered w/ 0.36 inches intumescent paint	2

Beam Analysis

Engineering analysis by Code Unlimited is based on comparison of 2 tests using ASTM E119 test standards.

ASTM E119 test beams in restrained conditions using thermocouples placed along the beam. Conditions of acceptance require the thermocouple to not exceed 1300 degrees at a single location or average of 1100 degrees for all 4 thermocouples. ASTM E119 states that the beam be part of a floor or roof assembly in a design load condition. The floor or roof assembly provides a load for the duration of the test and acts to absorb and dissipate the heat horizontally away from the top of the beam, allowing the beam to be exposed to fire from only 3 sides. In this condition the beam is not supporting a floor or roof assembly, therefore in a minimally loaded condition where it only supports interior and exterior wall loads. The beams will only be exposed to fire from the interior stairwell or an exterior building. The interior stairwell will have minimal fuel load as the code prohibits combustible material in the stair. The heat from a fire in the stair will not produce a heat flux capable of exceeding the temperatures in the conditions of acceptance for beams in ASTM E119, therefore an internal fire is not the worst case fire scenario. Heat flux from a fire from an adjacent building is the worst case fire scenario on the beam. The exterior skin of the building reviewed is of non-combustible materials with a continuous insulation blanket and will not add to the fuel load of the external fire. Exterior insulation required will provide some insulating quality between the fuel load and the beams being reviewed. This condition is better protected from heat than the heat flux on a beam used to determine protection required in the ASTM E119 tests and provides a conservative measure for using comparative analysis of beam protection established using ASTM E119 tests.

UL Design X790 shows a direct comparison of thickness of SFRM coating to achieve 2 hour fire protection between W section and HSS sections. By showing that the thickness required for a W section beam with a W/D ratio to achieve 2 hour protection and the thickness required for a HSS section used in this project, a direct comparison of W section protection and HSS section protection can be shown.

CC/IF 180-01 shows thicknesses required to provide 2 hour protection of W section beams using the specified product. By comparing the the thicknesses required by CC/IF 180-01 for W/D ratios in UL X790, equivalency of thicknesses required for a HSS section beam to achieve 2 hour protection can be shown.

The thickness of intumescent coating shown in the table above is based on manufacture recommendations based on Intertek test CC/IF 180-03, for HSS columns.

- UL X790 – shows comparisons of thickness of intumescent coating for W section beams and HSS section beams.
- CC/IF 180-01 – shows thickness of Thermo Lag 100 for beams based on W/D ratio of W section beams.

Analysis of protection of the HSS 8x6x1/4 beam is as follows:

- UL Design X790 shows that a W8 x 21 with a W/D of 0.57 requires 1.4375" of protection for 2 hour rating.
- UL Design X790 shows that a HSS 8x6x1/4 requires 1.375" of protection for 2 hour rating.
- CC/IF 180-01 shows that a beam with a W/D ratio of 0.56 requires 0.36" of Thermo Lag 100 for 2 hour rating.
- Therefore, since the HSS 8 x 6 x ¼ requires less intumescent coating thickness than required for a W section with a W/D ratio of 0.57, the 0.36" of intumescent provides more than 2 hour protection based on CC/IF 180-01 for a W section beam with a W/D ratio of 0.56.

Protection of the HSS 14x6x5/16, 12x6x5/16, and 12x4x5/8 beams is as follows:

- UL Design X790 shows that a W8 x 40 with a W/D of 0.84 requires 1.125" of protection for 2 hour rating.
- UL Design X790 shows that:
 - HSS 14x6x5/16 requires 1.125" of protection for 2 hour rating.
 - HSS 12x6x5/16 requires 1.125" of protection for 2 hour rating.
 - HSS 12x4x5/8 requires 0.6875" of protection for 2 hour rating.
- CC/IF 180-01 shows that a beam with a W/D ratio of 0.84 requires 0.29" of Thermo Lag 100 for 2 hour rating.
- Therefore, since the HSS 14 x 6 x 5/16 requires equivalent intumescent coating thickness as required for a W section with a W/D ratio of 0.84, the 0.35" of intumescent provides more than 2 hour protection based on CC/IF 180-01 for a W section beam with a W/D ratio of 0.84.
- Therefore, since the HSS 12 x 6 x 5/16 requires equivalent intumescent coating thickness as required for a W section with a W/D ratio of 0.84, the 0.33" of intumescent provides more than 2

hour protection based on CC/IF 180-01 for a W section beam with a W/D ratio of 0.84.

- Therefore, since the HSS 12 x 4 x 5/8 requires less intumescent coating thickness than required for a W section with a W/D ratio of 0.84, the 0.35" of intumescent provides more than 2 hour protection based on CC/IF 180-01 for a W section beam with a W/D ratio of 0.84.

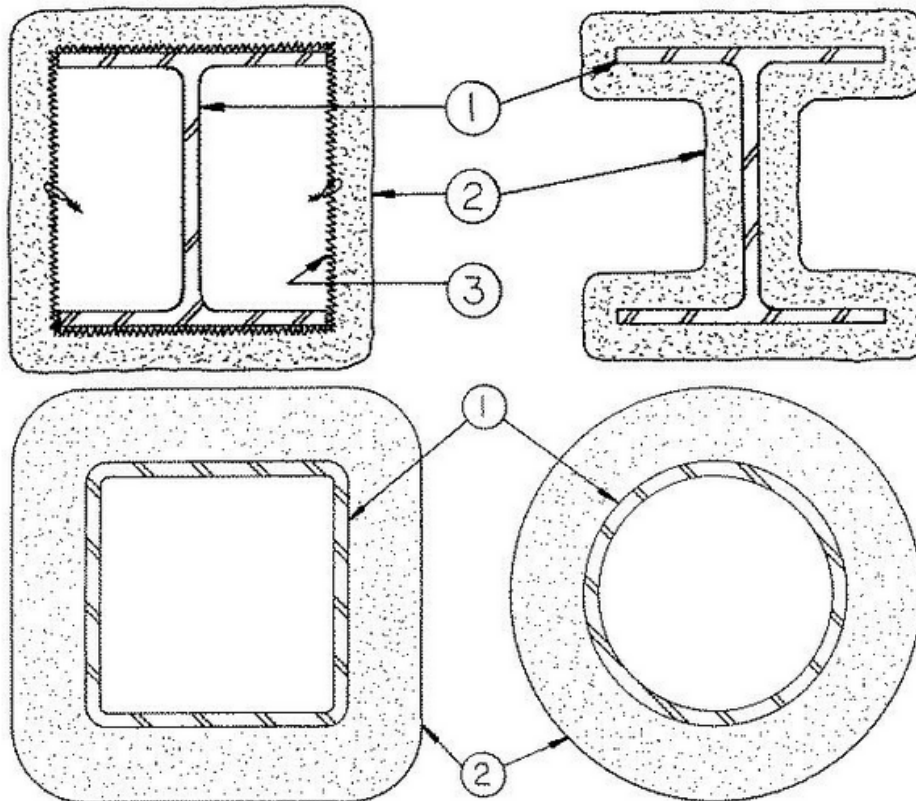
The engineering analysis shows that the required thickness of Carboline Thermo Lag 100 intumescent coating for 2 hour fire protection for HSS beams can be based on thickness required for W section beams based on W/D ratios.

Design No. X790

November 17, 2014

Ratings — 1, 1-1/2, 2, 3 and 4 Hr.

* Indicates such products shall bear the UL or cUL Certification Mark for jurisdictions employing the UL or cUL Certification (such as Canada), respectively.



1. **Steel Column, Steel Pipe or Steel Tube** — Wide flange steel column (W) or steel circular pipe (SP) or steel square or rectangular tube (ST), min sizes as shown in the tables below.

2. **Spray-Applied Fire Resistive Materials*** — Applied by mixing with water and spraying in one or more coats to the thicknesses shown below, to steel surfaces which are clean and free of dirt, loose scale, and oil. Min average and min individual density of 15 and 14 pcf, for Types 300, 300AC, 300ES, 300HS, 300N, 3000, 3000ES and SB. For Types 400AC and 400ES min average and min individual density of 22 and 19 pcf, respectively. For method of density determination, see Design Information Section, Sprayed Material.

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X790

Wide Flange Structural Steel Columns

CAFCO® 300 Series, CAFCO® 400 & ISOLATEK® Type 300 Series, ISOLATEK® Type 400

ASTM Desig.	W/D	Metric Desig.	M/D	Hp/A	1-Hour	1-1/2 Hour	2-Hour	3-Hour	4-Hour
W8 x 67	1.37	W200 x 100	80.8	97.8	1/2	11/16	15/16	1-3/8	1-13/16
58	1.2	86	70.8	111.7	1/2	3/4	1	1-1/2	2
48	1	71	59.0	134.0	9/16	13/16	1-1/8	1-5/8	2-1/8
40	0.84	59	49.6	159.5	9/16	13/16	1-1/8	1-5/8	2-1/8
35	0.74	52	43.7	181.1	5/8	15/16	1-1/4	1-13/16	2-5/16
31	0.66	46	38.9	203.0	11/16	1	1-5/16	1-7/8	2-3/8
28	0.68	42	40.1	197.0	5/8	15/16	1-1/4	1-13/16	2-5/16
24	0.59	36	34.8	227.1	11/16	1	1-5/16	1-7/8	2-3/8
21	0.57	31	33.6	235.1	13/16	1-1/8	1-7/16	2	2-9/16
18	0.49	27	28.9	273.4	13/16	1-1/8	1-7/16	2	2-9/16
15	0.48	22	28.3	279.1	13/16	1-1/8	1-7/16	2	2-9/16
13	0.42	19	24.8	319.0	15/16	1-1/4	1-9/16	2-1/8	2-11/16
10	0.33	15	19.5	406.0	15/16	1-1/4	1-9/16	2-1/8	2-11/16

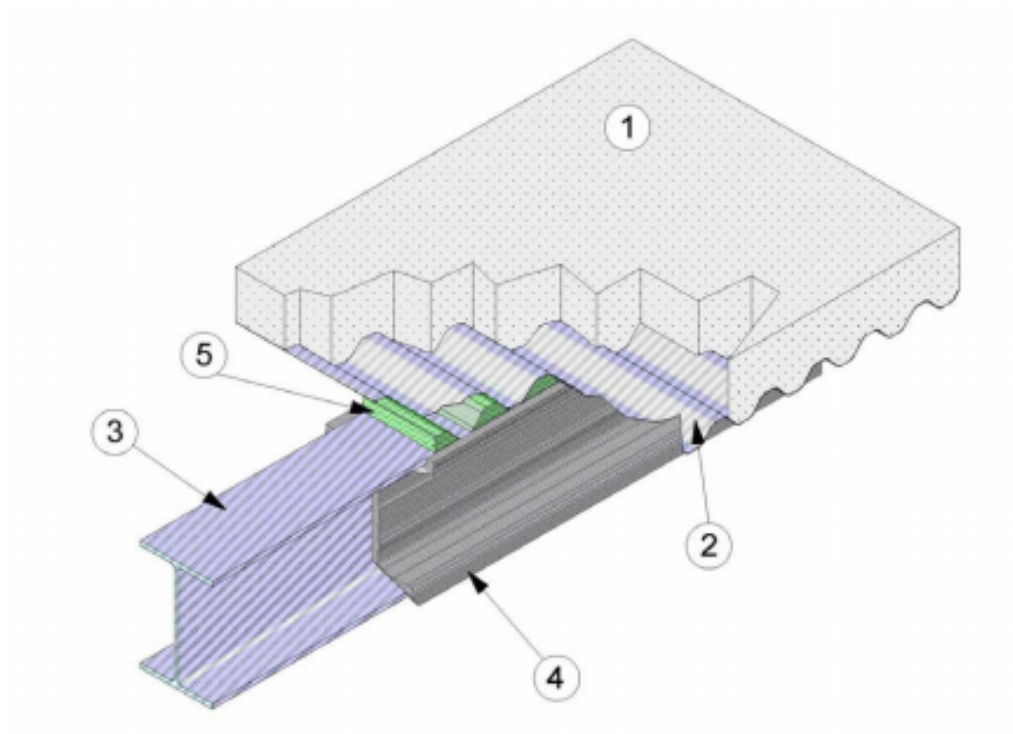
X790

Structural Steel Rectangular Tube Columns

CAFCO® 300 Series, CAFCO® 400 & ISOLATEK® Type 300 Series, ISOLATEK® Type 400

ASTM Desig.	Wall Thk	A/P	Metric Desig.	M/D	Hp/A	1-Hour	1-1/2 Hour	2-Hour	3-Hour	4-Hour
14 x 6	1/2	0.48	356 x 152 x 12.7	92	85.9	3/8	9/16	7/8	1-3/8	1-13/16
	3/8	0.36	x 9.5	70.8	111.7	7/16	3/4	1	1-9/16	2-1/8
	5/16	0.30	x 7.9	59.6	132.6	1/2	13/16	1-1/8	1-3/4	2-5/16
	1/4	0.24	x 6.4	48.4	163.3	11/16	1	1-3/8	2	2-11/16
12 x 6	5/8	0.58	305 x 152 x 15.9	111	71.2	5/16	7/16	11/16	1-1/8	1-9/16
	1/2	0.47	x 12.7	91.5	86.4	3/8	9/16	7/8	1-3/8	1-13/16
	3/8	0.36	x 9.5	70.2	112.6	7/16	3/4	1	1-9/16	2-1/8
	5/16	0.30	x 7.9	59	134.0	1/2	13/16	1-1/8	1-3/4	2-5/16
	1/4	0.24	x 6.4	48.8	162.0	11/16	1	1-3/8	2	2-11/16
12 x 4	3/16	0.18	x 4.8	36.6	216.0	3/4	1-1/16	1-7/16	2-1/16	2-11/16
	5/8	0.58	305 x 102 x 15.9	109.2	72.4	5/16	7/16	11/16	1-1/8	1-9/16
	1/2	0.47	x 12.7	90.3	87.5	3/8	9/16	7/8	1-3/8	1-13/16
	3/8	0.36	x 9.5	69.6	113.6	7/16	3/4	1	1-9/16	2-1/8
	5/16	0.30	x 7.9	59	134.0	1/2	13/16	1-1/8	1-3/4	2-5/16
	1/4	0.24	x 6.4	47.8	165.4	11/16	1	1-3/8	2	2-11/16
	3/16	0.18	x 4.8	36	219.6	3/4	1-1/16	1-7/16	2-1/16	2-11/16
8 x 6	1/2	0.46	203 x 152 x 12.7	88.5	89.3	3/8	9/16	7/8	1-3/8	1-7/8
	3/8	0.35	x 9.5	68.4	115.6	7/16	3/4	1	1-9/16	2-1/8
	5/16	0.30	x 7.9	57	138.7	1/2	13/16	1-1/8	1-3/4	2-5/16
	1/4	0.24	x 6.4	47.2	167.5	11/16	1	1-3/8	2	2-11/16
	3/16	0.18	x 4.8	36	219.6	3/4	1-1/16	1-7/16	2-1/16	2-11/16

Carboline Company
CC/IF 180-01
Restrained or Unrestrained Beam
Thermo-Lag E100, Thermo-Lag E100 S
ASTM E119-12a
CAN/ULC S101-07 Restricted Load Maximum 65% of design load
Assembly Rating – See Table CC/IF 180-01



1. **FLOOR/CEILING ASSEMBLY** - Use a fire-rated floor/ceiling assembly consisting of normal weight or lightweight (minimum 105 pcf, 1682 kg/m³) reinforced concrete. Thickness of concrete Floor ceiling assembly must comply with designated fire resistive rating.
2. **FLUTED STEEL FLOOR UNITS** - Corrugated steel decking, minimum 1-1/2 inch deep (38 mm), minimum 20 Ga.
3. **STEEL STRUCTURAL BEAM** - Use steel sections, I-beam or W-beam, sized in accordance with the Table CC/IF 180-01.

4. **FIRE-RESISTIVE COATING** - Refer to Table CC/IF 180-01 for specific application thickness of fire resistive coating.

CERTIFIED MANUFACTURER:
Carboline Company

CERTIFIED PRODUCT: Fire-
resistive Coating

MODEL: Thermo-Lag E100,
Thermo-Lag E100 S

Intumescent Fireproofing - Spray
or paint in one or more coats
according to manufacturer's

Date Created: 10-31-2013
Project No: 101157661SAT-013A

Intertek

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instructions to the required thickness.

MODEL: Any Intertek certified mineral wool or ceramic fiber blanket model that meets the criteria below.

5. LISTED MANUFACTURER: Any Intertek certified mineral wool or ceramic fiber blanket manufacturer that meets the criteria below.

CERTIFIED PRODUCT: Insulation

FLUTE FILLER – Completely fill the flutes between steel structural beam (Item 3) and the fluted steel floor unit (Item 2) with 4 pcf mineral wool or 4 pcf ceramic fiber blanket.

Table CC/IF 180-01											
HP/A	W/D	60 min.		90 min.		120 min.		150 min.		180 min.	
1/m	lb/ft/in	mm	in	mm	in	mm	in	mm	in	mm	in
30	4.46	3.0	0.12	3.0	0.12	3.0	0.12	3.0	0.12	3.3	0.13
40	3.34	3.0	0.12	3.0	0.12	3.0	0.12	3.5	0.14	4.2	0.17
50	2.67	3.0	0.12	3.0	0.12	3.3	0.13	4.2	0.17	5.0	0.20
60	2.23	3.0	0.12	3.0	0.12	3.8	0.15	4.8	0.19	5.8	0.23
70	1.91	3.0	0.12	3.2	0.13	4.3	0.17	5.4	0.21	6.5	0.26
75	1.78	3.0	0.12	3.3	0.13	4.5	0.18	5.7	0.22	6.8	0.27
80	1.67	3.0	0.12	3.5	0.14	4.7	0.19	5.9	0.23	7.2	0.28
85	1.57	3.0	0.12	3.7	0.15	4.9	0.19	6.2	0.24	7.5	0.30
90	1.49	3.0	0.12	3.8	0.15	5.1	0.20	6.5	0.26	7.8	0.31
95	1.41	3.0	0.12	3.9	0.15	5.3	0.21	6.7	0.26	8.1	0.32
100	1.34	3.0	0.12	4.1	0.16	5.5	0.22	6.9	0.27	8.4	0.33
110	1.22	3.0	0.12	4.3	0.17	5.9	0.23	7.4	0.29	8.9	0.35
120	1.11	3.0	0.12	4.6	0.18	6.2	0.24	7.8	0.31	9.4	0.37
130	1.03	3.1	0.12	4.8	0.19	6.5	0.26	8.2	0.32	9.9	0.39
140	0.95	3.3	0.13	5.0	0.20	6.8	0.27	8.6	0.34	10.3	0.41
150	0.89	3.4	0.13	5.2	0.20	7.1	0.28	8.9	0.35	10.7	0.42
160	0.84	3.6	0.14	5.4	0.21	7.3	0.29	9.2	0.36	11.2	0.44
170	0.79	3.7	0.15	5.6	0.22	7.4	0.29	9.5	0.37	11.6	0.46
180	0.74	3.9	0.15	5.8	0.23	7.7	0.30	9.8	0.39	12.0	0.47
190	0.70	4.0	0.16	6.0	0.24	8.0	0.31	10.1	0.40	12.3	0.48
200	0.67	4.1	0.16	6.2	0.24	8.2	0.32	10.4	0.41	12.7	0.50
210	0.64	4.2	0.17	6.3	0.25	8.5	0.33	10.6	0.42	13.0	0.51
220	0.61	4.3	0.17	6.5	0.26	8.7	0.34	10.9	0.43	13.4	0.53
230	0.58	4.5	0.18	6.7	0.26	8.9	0.35	11.1	0.44	13.7	0.54
240	0.56	4.6	0.18	6.9	0.27	9.1	0.36	11.4	0.45	14.0	0.55
250	0.53	4.7	0.19	7.0	0.28	9.3	0.37	11.7	0.46	14.3	0.56
260	0.51	4.8	0.19	7.2	0.28	9.5	0.37	11.9	0.47	14.6	0.57
270	0.50	4.9	0.19	7.3	0.29	9.7	0.38	12.2	0.48	14.9	0.59
280	0.48	5.0	0.20	7.4	0.29	9.9	0.39	12.4	0.49	15.1	0.59
290	0.46	5.0	0.20	7.6	0.30	10.1	0.40	12.6	0.50	15.1	0.59
300	0.45	5.1	0.20	7.7	0.30	10.3	0.41	12.8	0.50	15.4	0.61
302	0.44	5.2	0.20	7.7	0.30	10.3	0.41	12.9	0.51	15.5	0.61

Gap Assembly Analysis

The beams and columns achieve a 2-hour rating by virtue of the factory-applied intumescent coating in all locations except at the connections. The connections achieve a 2-hour rating due to compressed mineral wool filling gaps between the beams and columns and an intumescent coating covering the connections to meet the required by assemblies.

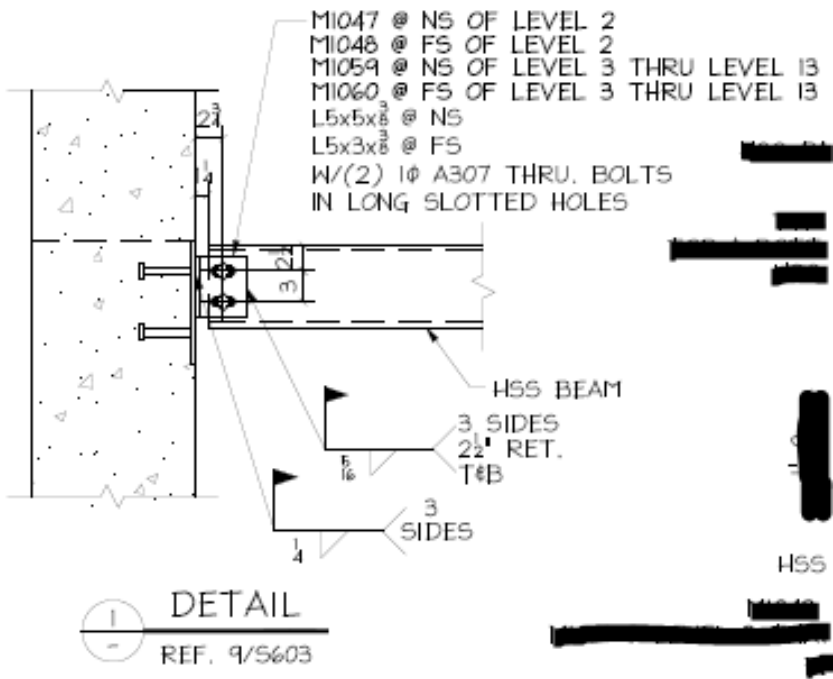


Figure 1: Gap at beam-column connection

Conclusion

The engineering analysis shows that the thickness of Carboline Thermo Lag 100 intumescent coating shown in the Fire Resistance Assembly Table, page 3, will provide 2 hour protection for the beams. The thickness of the intumescent coating on the beams is supported by manufacturer recommendations that thickness of intumescent coating can be the same as required by columns for HSS section size. The statement by the manufacturer is further supported for the condition of this installation of beams, not supporting floor loads, by a letter from Underwriters Laboratories that states that their position is that beams not supporting floor loads can be protected by thickness required by columns, see attached.

The stair structural frame will achieve a 2-hour fire-protection rating as required by the OSSC.



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