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Communication #

Sam,

Here is the body of your report. I had our Documents and Distribution group remail it to you.

Regards,
Shawn

File R18955

Project 98NK40433

DATE

REPORT

on

# STEEL COLUMNS PROTECTED WITH INTUMESCENT MAT MATERIAL

No Fire Technologies, Inc.
Upper Saddle River, NJ

## GENERAL

The subject of this report is the description of the construction and results of seven full-scale fire tests and conducted on steel column assemblies of various sizes. Each assembly was protected with a thickness of ceramic blanket and an intumescent wrap material. The test dates and column sizes are listed in the following table:

| Test Date | Column Size |
|---|---|
| 5-16-00 | W10X49 |
| 5-17-00 | W10X49 |
| 5-22-00 | W12X120 |
| 5-23-00 | W8X21 |
| 5-24-00 | W12X120 |
| 7-24-00 | W8X21 |
| 7-25-00 | W10X49 |

The ceramic blanket was identified as Durablanket and manufactured by Unifrax. The Matt Material was manufactured by No Fire Technologies Inc. and identified as the S-Barrier system. The materials were applied to the columns as described under "Protection of Test Assembly."

The object of this investigation was to determine the minimum column size required to provide a fire resistance rating of 1, 1-1/2, and 2 h when protected with various thicknesses of the ceramic blanket and the S-Barrier system when subjected to a fire exposure in accordance with the Standard, Fire Tests of Building Construction and Materials, ANSI/UL 263 (ASTM E119, NFPA No. 251)

This investigation was supplemented by other tests and examinations designed to furnish information regarding the composition and physical properties of the materials used and the practicability of handling and application

# DESCRIPTION

## MATERIALS:

Steel Columns (Full-Scale) - The steel columns used in the test assemblies measured 8 ft-3 in. between the bottom and top concrete caps. The structural steel columns were sizes W8X21, W10X49, and W12X120 and made from ASTM A36 steel.

Steel Columns(Small-Scale) – The steel tube columns used in the environmental portion of the program measured 6 in. by 6 in. by 3/16 in. wall thickness and were 2 ft. long.

Steel Band Strips - The nominal 18 gauge steel band strips measured approximately 1 in. wide and were cut to the desired length.

Ceramic Blanket - The ceramic blanket was identified as Durablanket-S and manufactured by Unifrax. The 1/2 in. thick ceramic blanket was supplied in rolls. The density of the material was 8 $lb/ft^3$.

Matt Material - The nominal 15.5 $oz/yd^2$, 0.208 in. thick intumescent wrap was supplied in rolls. This material was designated as Type S Barrier. The production of this material was witnessed by a representative of Underwriters Laboratories Inc. and will be placed under Follow-Up Service.

Steel Foil Wrap - The Steel foil wrap was supplied in rolls. The thickness of the foil wrap measured approximately 0.002 in.

Steel Wire - The 18 gauge stainless steel tie wire was supplied in rolls and cut to the desired length.

## PROTECTION OF ASSEMBLIES:

The steel columns were protected by workmen in the employ of the submitter under the observation of members of Underwriters Laboratories, Inc. technical staff.

The column assemblies were constructed in accordance with the methods indicated by the submitter. The 1/2 in. thick ceramic blanket, when used, was cut into pieces approximately 48 in. wide and wrapped around the columns to the desired thickness with a 3 in. overlap. Prior to wrapping the ceramic blanket around the columns, steel band strips were placed around the column at the center and quarter points. Once the ceramic blanket was wrapped to the desired thickness, it was held in place with masking tape. The ceramic blanket was covered with the 0.002 in. thick steel foil wrap. The intumescent mat material was then placed over the aluminum foil wrap and secured in place with the 18 gauge stainless steel tie wire spaced approximately 8 in. OC over the length of the column. The horizontal butt joints were covered with a nominal 4

in. wide piece of ceramic blanket having the same thickness as the base layer. This ceramic blanket was then covered with an additional piece of intumescent matt material having a width of approximately 5 in. A stainless steel tie wire was used to secure the butt joint in place.

The thickness of ceramic blanket material applied to each test assembly is shown in the following table:

| Test Date | Column Size | Thickness of Ceramic Blanket, In. |
|---|---|---|
| 5-16-00 | W10X49 | 0 |
| 5-17-00 | W10X49 | 1/2 |
| 5-22-00 | W12X120 | 1/2 |
| 5-23-00 | W8X21 | 1/2 |
| 5-24-00 | W12X120 | 0 |
| 7-24-00 | W8X21 | 1 |
| 7-25-00 | W10X49 | 1 |

Prior to testing the above mentioned column assemblies, eight tube columns were subjected to the simulated environmental exposures conditions as follows:

1. Control: - Conditioned at room temperature as the control against which the exposed samples are to be compared.

2. Aging: - Accelerated aging of the protective material was simulated by placing the sample in a circulating air-oven at 158 ± 5 °F (70 ± 2.7 °C) for 270 days.

3. 10 Day High Humidity: - A high humidity condition was simulated by placing the sample in a controlled humidity of 97-100 percent at 95 ± 3 °F (35 ± 1 °C) for 10 days.

4. 180 Day High Humidity: - A high humidity condition was simulated by placing the sample in a controlled humidity of 97-100 percent at 95 ± 3 °F (35 ± 1 °C) for 180 days.

Two tube columns were tested for each of the above mentioned conditions, one with a top coat and one without a top coat.

# TEST RECORD GENERAL

FIRE ENDURANCE TESTS:

The fire endurance tests were conducted in accordance with the Standard "Fire Tests of Building Construction and Materials," UL 263 (ASTM E119).

## DESCRIPTION OF SAMPLES

The column assemblies were protected as described in this report under the section entitled "Protection of Test Assemblies." Each test assembly consisted of a steel column member with either 0, 1/2, or 1 in. of ceramic blanket as shown in Table I. Prior to placing each column assembly in the furnace, there was no evidence of delamination of the protection material.

## METHOD

The column assemblies were placed in the furnace and exposed to flame of controlled extent and severity in accordance with the Standard Time-Temperature Curve. Eight thermocouples, distributed around the column in two levels of four thermocouples each, measured the temperatures in the furnace chamber as shown in ILL. 1.

The temperatures of the steel column were measured by 14 thermocouples peened into the steel, located at four levels as shown in Appendix A, ILL. 2.

# TEST RECORD NO. 1

Tube Size: 6 in.x 6 in.x 3/16 in.
Test Date: December 1, 1999
Test Assembly No: Environmentals

Character and Distribution of Fire - The furnace fire was luminous and well distributed, and the temperatures followed the time-temperature curve outlined in the Standard, ANSI/UL 263. Plots of the average furnace temperatures and the UL 263 time-temperature curve are shown on ILL. 3 and the tabulated furnace temperatures are shown in App. A, pages 1-4.

Observation During The Test - The following are observations of the column assembly during testing. All reference to dimensions are approximate.

During the first 3 min, the sheet metal jacket deflected in such a manner that indentations approximately 2 in. to 4 in. in diameter were present throughout the entire length of the column assembly. After 4 min, flames were issuing around the horizontal joints. The S-Barrier began intumescing approximately 5 min after the start of the fire endurance test. From approximately 5 minutes to the end of each test period, no significant changes occurred.

Temperature of the Steel Column - The temperature of the steel columns are shown in App. B, Pages 1 through 16.

Limiting temperatures are reached when the average temperature at any one level reaches 1000° F or when the individual temperature reading reaches 1200° F. The limiting average temperature was reached at 42.5 min. by the four thermocouples located at Level B-B. At that time the maximum individual thermocouple reading was 1059.5 °F.

# TEST RECORD NO. 2

Column Size: W10X49
Protection Thickness: 0 in.
Test Date: May 16, 2000
Test Assembly No. 1

Character and Distribution of Fire - The furnace fire was luminous and well distributed, and the temperatures followed the time-temperature curve outlined in the Standard, ANSI/UL 263. Plots of the average furnace temperatures and the UL 263 time-temperature curve are shown on ILL. 4 and the tabulated furnace temperatures are shown in App. A, pages 5-6.

Observation During The Test - The following are observations of the column assembly during testing. All reference to dimensions are approximate.

During the first 3 min, the sheet metal jacket deflected in such a manner that indentations approximately 2 in. to 4 in. in diameter were present throughout the entire length of the column assembly. After 4 min, flames were issuing around the horizontal joints. The S-Barrier began intumescing approximately 5 min after the start of the fire endurance test. From approximately 5 minutes to the end of each test period, no significant changes occurred.

Temperature of the Steel Column - The temperature of the steel columns are shown in App. B, Pages 17 through 21.

Limiting temperatures are reached when the average temperature at any one level reaches 1000° F or when the individual temperature reading reaches 1200° F. The limiting average temperature was reached at 42.5 min. by the four thermocouples located at Level B-B. At that time the maximum individual thermocouple reading was 1059.5 °F.

OBSERVATIONS AFTER TESTS:

The appearance of the column assembly before and after the fire test are shown in ILLS. 5 and 6 respectively.

# TEST RECORD NO. 3

Column Size: W10X49
Protection Thickness: 1/2 in.
Test Date: May 17, 2000
Test Assembly No. 2

Character and Distribution of Fire - The furnace fire was luminous and well distributed, and the temperatures followed the time-temperature curve outlined in the Standard, ANSI/UL 263. Plots of the average furnace temperatures and the UL 263 time-temperature curve are shown on ILL. 7 and the tabulated furnace temperatures are shown in App. A, pages 7-8.

Observation During The Test - The following are observations of the column assembly during testing. All reference to dimensions are approximate.

During the first 3 min, the sheet metal jacket deflected in such a manner that indentations approximately 2 in. to 4 in. in diameter were present throughout the entire length of the column assembly. After 4 min, flames were issuing around the horizontal joints. The S-Barrier began intumescing approximately 5 min after the start of the fire endurance test. From approximately 5 minutes to the end of each test period, no significant changes occurred.

Temperature of the Steel Column - The temperature of the steel columns are shown in App. B, Pages 22 through 26.

Limiting temperatures are reached when the average temperature at any one level reaches 1000° F or when the individual temperature reading reaches 1200° F. The limiting average temperature was reached at 82.5 min. by the four thermocouples located at Level B-B. At that time the maximum individual thermocouple reading was 1043.0 °F.

OBSERVATIONS AFTER TESTS:

The appearance of the column assembly before the fire test is shown in ILLS. 8.

# TEST RECORD NO. 4

Column Size: W12X120
Protection Thickness: 1/2 in.
Test Date: May 22, 2000
Test Assembly No. 3

Character and Distribution of Fire - The furnace fire was luminous and well distributed, and the temperatures followed the time-temperature curve outlined in the Standard, ANSI/UL 263. Plots of the average furnace temperatures and the UL 263 time-temperature curve are shown on ILL. 9 and the tabulated furnace temperatures are shown in App. A, pages 9-12.

Observation During The Test - The following are observations of the column assembly during testing. All reference to dimensions are approximate.

During the first 3 min, the sheet metal jacket deflected in such a manner that indentations approximately 2 in. to 4 in. in diameter were present throughout the entire length of the column assembly. After 4 min, flames were issuing around the horizontal joints. The S-Barrier began intumescing approximately 5 min after the start of the fire endurance test. From approximately 5 minutes to the end of each test period, no significant changes occurred.

Temperature of the Steel Column - The temperature of the steel columns are shown in App. B, Pages 27 through 36.

Limiting temperatures are reached when the average temperature at any one level reaches 1000° F or when the individual temperature reading reaches 1200° F. The limiting average temperature was reached at 127.5 min. by the four thermocouples located at Level B-B. At that time the maximum individual thermocouple reading was 1022.8 °F.

OBSERVATIONS AFTER TESTS:

The appearance of the column assembly before and after the fire test is shown in ILLS. 10 and 11 respectively.

# TEST RECORD NO. 5

Column Size: W8X21
Protection Thickness: 1/2 in.
Test Date: May 23, 2000
Test Assembly No. 4

Character and Distribution of Fire - The furnace fire was luminous and well distributed, and the temperatures followed the time-temperature curve outlined in the Standard, ANSI/UL 263. Plots of the average furnace temperatures and the UL 263 time-temperature curve are shown on ILL. 12 and the tabulated furnace temperatures are shown in App. A, pages 13-14.

Observation During The Test - The following are observations of the column assembly during testing. All reference to dimensions are approximate.

During the first 3 min, the sheet metal jacket deflected in such a manner that indentations approximately 2 in. to 4 in. in diameter were present throughout the entire length of the column assembly. After 4 min, flames were issuing around the horizontal joints. The S-Barrier began intumescing approximately 5 min after the start of the fire endurance test. From approximately 5 minutes to the end of each test period, no significant changes occurred.

Temperature of the Steel Column - The temperature of the steel columns are shown in App. B, Pages 37 through 41.

Limiting temperatures are reached when the average temperature at any one level reaches 1000° F or when the individual temperature reading reaches 1200° F. The limiting average temperature was reached at 60 min. by the four thermocouples located at Level C-C. At that time the maximum individual thermocouple reading was 1038.8 °F.

OBSERVATIONS AFTER TESTS:

The appearance of the column assembly before and after the fire test is shown in ILLS. 13 and 14 respectively.

# TEST RECORD NO. 6

Column Size: W12X120
Protection Thickness: 0 in.
Test Date: May 24, 2000
Test Assembly No. 5

Character and Distribution of Fire - The furnace fire was luminous and well distributed, and the temperatures followed the time-temperature curve outlined in the Standard, ANSI/UL 263. Plots of the average furnace temperatures and the UL 263 time-temperature curve are shown on ILL. 15 and the tabulated furnace temperatures are shown in App. A, pages 15-16.

Observation During The Test - The following are observations of the column assembly during testing. All reference to dimensions are approximate.

During the first 3 min, the sheet metal jacket deflected in such a manner that indentations approximately 2 in. to 4 in. in diameter were present throughout the entire length of the column assembly. After 4 min, flames were issuing around the horizontal joints. The S-Barrier began intumescing approximately 5 min after the start of the fire endurance test. From approximately 5 minutes to the end of each test period, no significant changes occurred.

Temperature of the Steel Column - The temperature of the steel columns are shown in App. B, Pages 42 through 46.

Limiting temperatures are reached when the average temperature at any one level reaches 1000° F or when the individual temperature reading reaches 1200° F. The limiting average temperature was reached at 67.5 min. by the four thermocouples located at Level B-B. At that time the maximum individual thermocouple reading was 1130.7 °F.

OBSERVATIONS AFTER TESTS:

The appearance of the column assembly before and after the fire test is shown in ILLS. 16 and 17 respectively.

# TEST RECORD NO. 7

Column Size: W8X21
Protection Thickness: 1 in.
Test Date: July 24, 2000
Test Assembly No. 6

Character and Distribution of Fire - The furnace fire was luminous and well distributed, and the temperatures followed the time-temperature curve outlined in the Standard, ANSI/UL 263. Plots of the average furnace temperatures and the UL 263 time-temperature curve are shown on ILL. 18 and the tabulated furnace temperatures are shown in App. A, pages 17-20.

Observation During The Test - The following are observations of the column assembly during testing. All reference to dimensions are approximate.

During the first 3 min, the sheet metal jacket deflected in such a manner that indentations approximately 2 in. to 4 in. in diameter were present throughout the entire length of the column assembly. After 4 min, flames were issuing around the horizontal joints. The S-Barrier began intumescing approximately 5 min after the start of the fire endurance test. From approximately 5 minutes to the end of each test period, no significant changes occurred.

Temperature of the Steel Column - The temperature of the steel columns are shown in App. B, Pages 47 through 61.

Limiting temperatures are reached when the average temperature at any one level reaches 1000° F or when the individual temperature reading reaches 1200° F. The limiting average temperature was reached at 77.5 min. by the four thermocouples located at Level A-A. At that time the maximum individual thermocouple reading was 1026.7 °F.

# TEST RECORD NO. 8

Column Size: W10X49
Protection Thickness: 1 in.
Test Date: July 25, 2000
Test Assembly No. 7

Character and Distribution of Fire - The furnace fire was luminous and well distributed, and the temperatures followed the time-temperature curve outlined in the Standard, ANSI/UL 263. Plots of the average furnace temperatures and the UL 263 time-temperature curve are shown on ILL. 19 and the tabulated furnace temperatures are shown in App. A, pages 21-22.

Observation During The Test - The following are observations of the column assembly during testing. All reference to dimensions are approximate.

During the first 3 min, the sheet metal jacket deflected in such a manner that indentations approximately 2 in. to 4 in. in diameter were present throughout the entire length of the column assembly. After 4 min, flames were issuing around the horizontal joints. The S-Barrier began intumescing approximately 5 min after the start of the fire endurance test. From approximately 5 minutes to the end of each test period, no significant changes occurred.

Temperature of the Steel Column - The temperature of the steel columns are shown in App. B, Pages 62 through 66.

Limiting temperatures are reached when the average temperature at any one level reaches 1000° F or when the individual temperature reading reaches 1200° F. The limiting average temperature was reached at 102.5 min. by the four thermocouples located at Level B-B. At that time the maximum individual thermocouple reading was 1048.2 °F.

OBSERVATIONS AFTER TESTS:

The appearance of the column assembly before and after the fire test is shown in ILLS. 20 and 21 respectively.

STUDY FOR CLASSIFICATION PURPOSES

The dest dates, column sizes, thickness of ceramic blanket, and temperature end point times are listed in the following table:

| Test Date | Column Size (W/D) | Thickness of Blanket | Temp. End Pt. Time |
|---|---|---|---|
| 5-16-00 | W10X49 (0.83) | 0 | 42.5 |
| 5-17-00 | W10X49 (0.83) | 1/2 | 82.5 |
| 5-22-00 | W12X120 (1.64) | 1/2 | 127.5 |
| 5-23-00 | W8X21 (0.57) | 1/2 | 60.0 |
| 5-24-00 | W12X120 (1.64) | 0 | 67.5 |
| 7-24-00 | W8X21 (0.57) | 1 | 77.5 |
| 7-25-00 | W10X49 (0.83) | 1 | 102.5 |

From the above data, a plot of temperature end point time vs. column size (W/D) was generated for the columns protected with both 1/2 in. and 1 in. of ceramic blanket. A "best fit" line was drawn through each set of data points and the corresponding equation was used to determine the minimum column size necessary to achieve the various hourly ratings. The equation for the best fit line was as follows:

$y = 61.88x + 27.018$ for 1/2 in. of ceramic blanket protection and:

$y = 105.77x + 17.212$ for 1 in. of ceramic blanket protection. Where:

x = column size (W/D)
y = end point time (min.)

For the columns protected with 0 in. of ceramic blanket, only the W12X120 column data was used since the W10X49 column protected with 0 in. reached limiting temperature before 60 minutes, the lowest possible column rating.

| Type of Environmental Exposure | Time to Limiting Temp, min. | Comparison to Control End Time (%) |
|---|---|---|
| Rapid Aging w/ Top Coat | 78 | 100 |
| 180 Day High Humidity w/ Top Coat | 72 | 95 |
| 10 Day High Humidity w/Top Coat | 76 | 100 |
| **Control w/ Top Coat** | **76** | - |
| Rapid Aging | 94 | 90 |
| 180 Day High Humidity | 95 | 91 |
| 10 Day High Humidity | 91 | 88 |
| **Control** | **104** | - |

# CONCLUSIONS

The following conclusions represent the judgment of Underwriters Laboratories Inc. based on the results of the examination, tests and Study for Classification Purposes presented in this Report, as they relate to established principles and previously recorded data.

## FIRE RESISTANCE PROPERTIES:

It is judged that the following systems of Classified Mat Materials installed as described in this Report will afford the indicated rating when applied to a structural steel column whose size is equal to or greater the corresponding W/D.

| Hourly Rating | Thickness of Ceramic Blanket, In. | Minimum Column Size, W/D |
|---|---|---|
| 1 | 0 | 1.64 |
| 1 | 1/2 | 0.59 |
| 1-1/2 | 1/2 | 1.02 |
| 2 | 1/2 | 1.50 |
| 1 | 1 | 0.50 |
| 1-1/2 | 1 | 0.69 |
| 2 | 1 | 1.07 |

Design No. X205 was promulgated based on the above test results. The above table will appear in the design.

These Classifications are based on the temperature limitations of 1000°F average and 1200°F maximum allowable as described under the "Conditions of Acceptance" for structural steel columns in the Standard, "Fire Tests of Building Construction and Materials," Standard UL 263 (ASTM E119, NFPA No. 251, ANSI A2.1).

## PRACTICABILITY:

The column protective system of the type used in this investigation can be readily applied to steel columns by experienced workmen using proper equipment. Material and installation procedures in accordance with those described in this Report are significant factors in the fire resistance of these constructions.

## CONFORMITY:

Three column assemblies were tested in accordance with the Standard, Fire Tests of Building Construction and Materials, UL 263 (ASTM E119, NFPA No. 251, ANSI A2.1).

## FOLLOW-UP PROGRAM:

The column protective system as described herein is judged to be eligible for Classification and Follow-Up Service of Underwriters Laboratories Inc. Under the Service, the manufacturer is authorized to use the Laboratories' Classification Marking on such products which comply with the Follow-Up Service Procedure and any other applicable requirements of

Underwriters Laboratories Inc. Only those products which properly bear the Laboratories' Classification Marking are considered as Classified by Underwriters Laboratories Inc.

The following Classification Markings are to be used on the protective wrap material illustrated below:

UNDERWRITERS LABORATORIES INC. ®

CLASSIFIED
MAT MATERIALS
FIRE RESISTANCE CLASSIFICATION
DESIGN NO. X205

SEE UL FIRE RESISTANCE DIRECTORY

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