



ASTM E136-95
Standard Test Method for Behavior of
Materials in a Vertical Tube Furnace at 750°C
Carboline Pyrocrete 40

Project No. 13900-103857

September 24, 1998

Prepared for:

Carboline Company
350 Hanley Ind. Ct.
St. Louis, MO 63144
314-644-1000

Omega Point Laboratories, Inc.
16015 Shady Falls Road
Elmendorf, Texas 78112-9784
210-635-8100 / FAX: 210-635-8101 / 800-966-5253
www.opl.com / e-mail: moreinfo@opl.com

ABSTRACT

The specimens submitted by Carboline Company and identified as "Carboline Pyrocrete 40" were tested in accordance with ASTM E136-95 Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C. The samples passed the test criteria.

THE TEST SPECIMEN PASSED THIS TEST.

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This report contains a total of six pages.

Servando Romo
Servando Romo
Fire Test Technologist

Date: 9/30/98

Reviewed and approved:

Ernst L. Schmidt, Jr.
Ernst L. Schmidt, Jr.
Manager, Small Scale Testing

Date: 9/30/98



I. INTRODUCTION

This report describes the results of the ASTM E136-94 Standard Method of Test for Behavior of Materials in a Vertical Tube Furnace at 750° C.

This standard should be used to measure and describe the properties of materials, products, or assemblies in response to heat and flame under controlled laboratory conditions and should not be used to describe or appraise the fire hazard or fire risk of materials, products, or assemblies under actual fire conditions. However, results of this test may be used as elements of a fire risk assessment which takes into account all of the factors which are pertinent to an assessment of the fire hazard of a particular end use.

II. PURPOSE

The results of the ASTM E136-94 test method may be used to characterize those materials which do not support combustion under the specified test conditions (750° C). The method is not intended to be used for laminated or coated materials. Materials passing the test are permitted limited flaming, glowing and mass loss.

III. DESCRIPTION OF TEST SPECIMENS

The test specimens were prepared by the client. Each piece measured 1.5 in. x 1.5 in. x 2.0 in. thick and were held with 16 x 16 mesh nichrome wire cloth to insert into the furnace.. A hole was made in the geometric center of each specimen in order to insert a thermocouple from the top. Another thermocouple was placed along one side face.

IV. TEST PROCEDURE

The specimens were conditioned at $60^{\circ} \pm 3^{\circ}\text{C}$ for a minimum of twenty-four hours and a maximum of forty-eight hours, then stored in a desiccator for at least one hour. The furnace temperature was stabilized at $750 \pm 5.5^{\circ}\text{C}$ ($1382^{\circ} \pm 10^{\circ}\text{F}$). Each specimen was inserted into the furnace chamber and kept there until failure or until all temperature rise had ceased.



V. RESULTS AND OBSERVATIONS

Specimens submitted by: Carboline Company

Date received: September 24, 1998

Date tested: September 22, 1998

Specimen ID: Carboline Pyrocrete 40

Description of specimen: Cementitious Fireproofing

Test Notes: No smoke or flames seen on any of the samples.

The results of these tests are presented in the following table:

Specimen Number	Initial Wt. (g)	Final Wt. (g)	Wt. Loss (%)	Furnace Temp. at Start of Test (°C)	Max. Surface Temp. (°C)	Max. Interior Temp. (°C)
1	53.48	44.77	16.29	750	735	705
2	50.02	41.81	16.41	750	729	705
3	54.64	46.07	15.68	750	736	709

VI. CONCLUSIONS

The test specimens described in this report, and tested as described herein, **Passed** the requirements of ASTM E 136-95.

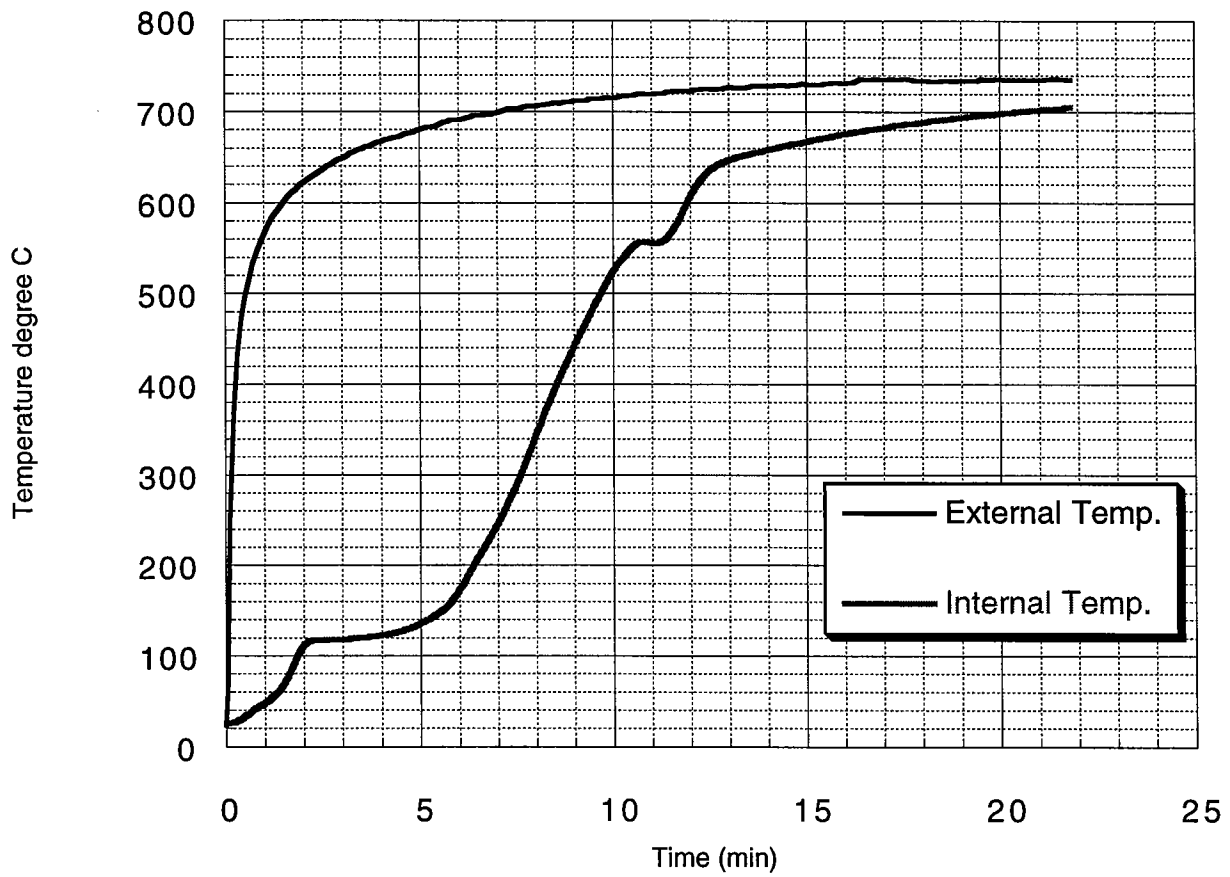


APPENDIX

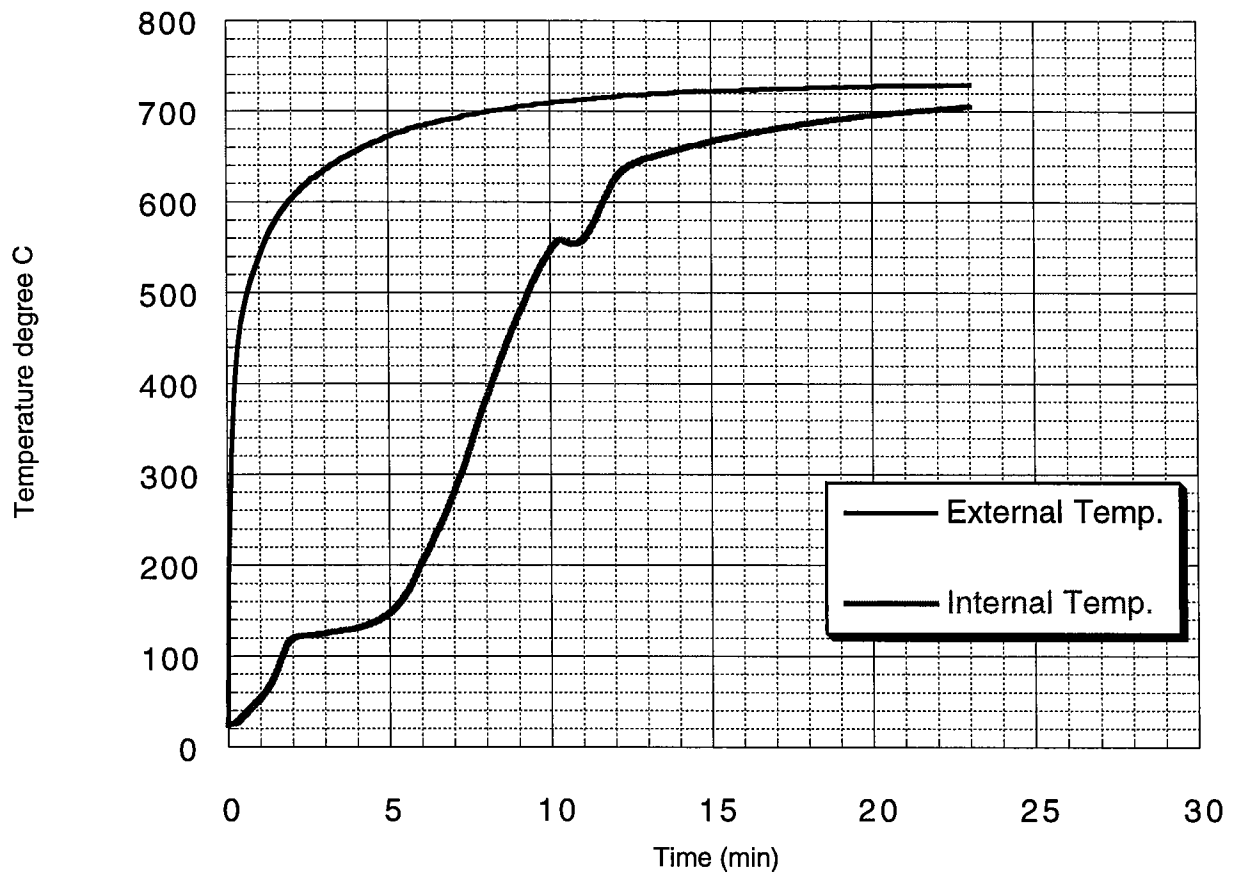
GRAPHS



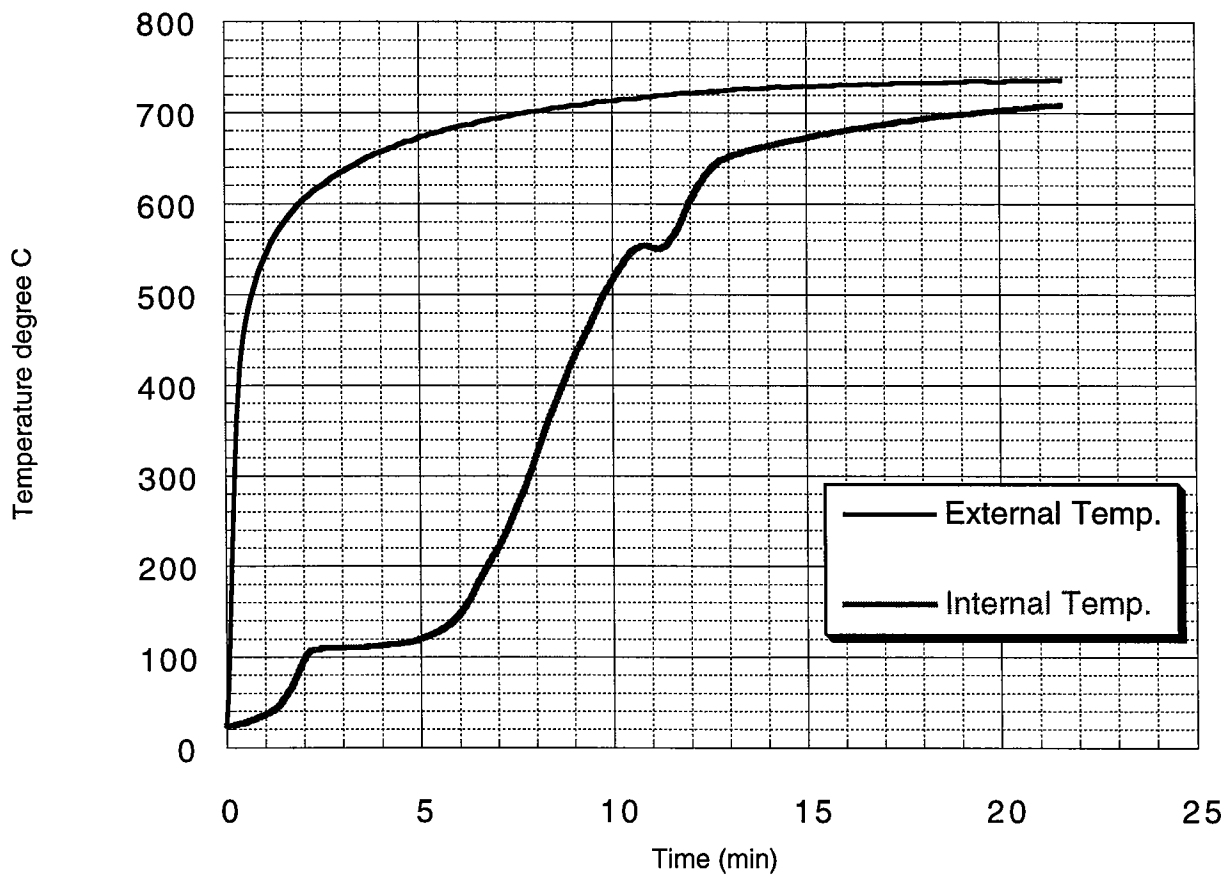
ASTM E-136 103857-1



ASTM E-136 103857-2



ASTM E-136 103857-3





November 10, 2005

TITLE: ASTM D790 Flexural Strength/Maximum Strain of Pyrocrete 40

REFERENCE: L578-151

DOCUMENT ACCESS NO.: 09594

PURPOSE: Measure the flexural strength and maximum strain of Pyrocrete 40 by a modified ASTM D790-99 "Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials".

CONCLUSION: Pyrocrete 40 has a flexural strength of 136 psi and a maximum strain of 0.0094 in./in.

PROCEDURE:

- I. Materials
 - A. Pyrocrete 40 free film cast at 1 inch thick.
 - B. Cure free film 8 weeks minimum at 70-80°F/40-80% RH.
 - C. Cut free film into 1 inch wide by 8 inch long strips.
- II. Testing
 - A. Measure thickness and width of samples using a micrometer.
 - B. Test the force needed to break the specimens and the distance it flexes using an Instron model 1122
 - 1. Use the 3 point loading method in the ASTM D790 procedure with a 6 inch span.
 - 2. Crosshead speed at 0.02 in./min.
- III. Calculations
 - A. Flexural strength = $3PL/2bd^2$
 - B. Maximum strain = $6Dd/L^2$
 - D = deflection (in.)
 - d = thickness (in.)
 - L = span (in.)
 - P = load at breaking point (lbs)
 - b = width (in.)

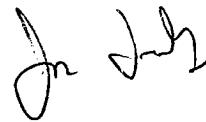
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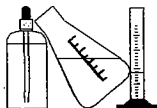


RESULTS:

Sample	Thickness	Width	Span	Load	Deflection	Flexural Strength	Maximum Strain
1	0.99	1.07	6	15.7	0.06	135	0.0099
2	1.12	1.17	6	18.8	0.06	115	0.0112
3	0.99	1.05	6	16.4	0.05	143	0.0083
4	0.99	1.09	6	15.0	0.04	126	0.0066
5	0.99	1.04	6	16.9	0.07	149	0.0116
6	0.99	1.07	6	16.8	0.06	144	0.0099
Average						136	0.0094



Jon Furlong
Advanced Chemist
Fireproofing Products Division



January 19, 1999

TITLE: ASTM E760 Impact Testing of Pyrocrete 40

REFERENCE: L578-157

DOCUMENT ACCESS NO.: 09412

PURPOSE: Determine impact resistance of Pyrocrete 40 tested in accordance to ASTM E760 "Effect of Impact on Bonding of Sprayed Fire-Resistive Material Applied to Structural Members."

CONCLUSIONS: There is no effect to Pyrocrete 40 and it is rated as passing the ASTM E760.

PROCEDURE:

- I. System
 - A. 2' x 12' concrete filled cellular deck, consisting of
 - 1. 2' x 12' x 0.060" noncomposite fluted decking with cells 1-1/2" deep, 6" on center.
 - 2. 2' x 12' x 0.048" galvanized steel plate, welded to the bottom of the deck.
 - 3. Two 4" x 24" x 0.048" galvanized steel end plates.
 - 4. Two 4" x 12' x 0.048" galvanized steel side plates.
 - 5. Poured in place concrete with a minimum compressive strength of 3000 psi.
 - B. Pyrocrete 40 @ 1/2".
- II. Application
 - A. Spray apply the Pyrocrete 40 at 1/2" to the center 10' of the underside of the deck.
 - B. Cure the Pyrocrete 40 for one month @ ambient and when weight equilibrium is reached.
- III. Testing
 - A. Determine the density of the applied Pyrocrete 40 by the ASTM E605.
 - B. Prepare a sand filled canvas bag with a total weight of 60 lbs.
 - C. Support the deck by its bare ends with the Pyrocrete 40 facing downward.
 - D. Hoist the sand filled bag 48" above the specimen, then drop it onto the top of the deck in the center.
 - E. Note the condition of the Pyrocrete 40 and any cracking, spalling or delamination that may have occurred.

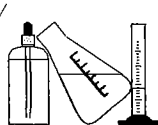
RESULTS: ASTM E605 Dry Density: 40 pounds per cubic foot

ASTM E760 Impact Testing: There was no effect to the Pyrocrete 40 by impacting the deck with a 60 lb. sand filled bag.

Jon Furlong
Advanced Chemist
Fireproofing Products Division

From the Carboline Research & Development Laboratory

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However, no guarantee of accuracy is given or implied.



February 3, 1999

TITLE: Modified ASTM E736 Cohesion/Adhesion Strength Testing of Pyrocrete 40 to Smooth Steel.

REFERENCE: L578-42

DOCUMENT ACCESS NO.: 09377

PURPOSE: Determine the cohesive/adhesive strength of Pyrocrete 40 to smooth steel by the modified ASTM E736-92 procedure.

SUMMARY OF RESULTS: The average adhesive strength of Pyrocrete 40 to smooth steel is 1,317 pounds per square foot.

PROCEDURE:

- I. **System**
 - A. Smooth mild carbon steel panels (14" x 14" x 1/4")
 - B. Pyrocrete 40
 - C. Bottle screw cap with hook (3-1/4" diameter x 1/2" deep)
 - D. Two component epoxy adhesive
 - E. Instron Model 1122
- II. **Application**
 - A. Degrease and solvent wipe the panels.
 - B. Spray apply the Pyrocrete 40 at 3/4" over 14" x 12" area on each panel.
 - C. Cure the Pyrocrete 40 for one month minimum at ambient laboratory conditions.
 - D. Attach the hook assembly to the Pyrocrete 40.
 1. Fill the lid with the epoxy adhesive.
 2. Place the inverted lid, so that the adhesive contacts the surface of Pyrocrete 40. Hold in place until the adhesive becomes rigid.
 3. Allow the adhesive to cure for 24 hours minimum before testing.
- III. **Testing**
 - A. Attach each panel to the Instron.
 - B. Pull off the lid with the Instron set at a crosshead speed of 0.2 inches/minute. Record the force required to pull off the lid and the type of failure.
 - C. Calculate the cohesive/adhesive strength by dividing the force by the area of the lid.

From the Carboline Research & Development Laboratory


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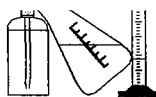
RESULTS:

Panel	Force	Cohesive/Adhesive Strength	Type of Failure
1	58.00 lbs.	1,006 psf	Pyrocrete Adhesion Failure
2	150.00 lbs.	2,603 psf	Pyrocrete Adhesion Failure
3	32.00 lbs.	555 psf	Pyrocrete Adhesion Failure
4	70.00 lbs.	1,215 psf	Pyrocrete Adhesion Failure
5	69.06 lbs.	1,208 psf	Pyrocrete Adhesion Failure
Average	75.92 lbs.	1,317 psf	

DISCUSSION:

The ASTM E736-92 "Standard Test Method for Cohesion/Adhesion of Sprayed Fire-Resistive Materials Applied to Structural Members" specifies the use of urethane foam as the adhesive and a spring load scale with a maximum capacity of 66 pounds to measure the adhesion force. With a maximum load of 66 pounds, the highest measurable bond strength is 1,145 pounds per square foot. The Instron was used instead of the scale to get the actual cohesion/adhesion strength. Epoxy adhesive was used since the Pyrocrete 40 adhesive strength is greater than the urethane foam.


Richard Haley
Lab Technician
Fireproofing Products Division



February 11, 1999

TITLE: ASTM E-937 Corrosion Testing of Pyrocrete 40.

REFERENCE: L578-114

**DOCUMENT
ACCESS NO.:** 09425

PURPOSE: Test for corrosion caused by Pyrocrete 40 by the ASTM E-937 "Corrosion of Steel by Sprayed Fire-Resistive Material Applied to Structural Members."

CONCLUSION: Pyrocrete 40 does not cause corrosion per the ASTM E-937. The following weight losses due to corrosion were measured:

Primed Steel	0.00 g/mm ²
Galvanized Steel	0.00 g/mm ²
Unprimed Steel	0.00 g/mm ²

- PROCEDURE:**
- I. Systems
 - A. Steel
 1. Four 8" x 8" x 0.125" (64 in² or 41,920 mm²) mild carbon steel panels
 2. Two 8" x 8" x 0.125" (64 in² or 41,920 mm²) galvanized steel panels
 - B. Carboline Shop Primer I
 - C. Pyrocrete 40
 - II. Preparation
 - A. Gritblast the mild carbon steel panels
 - B. Record the weights of all of the panels to the nearest 0.1 gram.
 - C. Apply the Carboline Shop Primer I to two of the mild carbon steel panels.
 - D. Spray apply 1" of Pyrocrete 40 to one side of the panels.
 - E. Seal the uncoated edges and backsides of all of the panels with Carboline Shop Primer I.
 - F. Cure the Pyrocrete 40 at 70°-80°F, 30-80% relative humidity until the panels reach a constant weight (one month minimum).

From the Carboline Research & Development Laboratory

The technical data furnished are true and accurate to the best of our knowledge
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carboline

III. Testing

A. Ambient Panels

1. Remove the Pyrocrete 40 and primer from one panel of each system.
2. Wire brush any corrosion from the panels.
3. Solvent wipe the panels.
4. Record the weight of each of the panels.

B. Humidity Chamber Panels

1. Place one panel of each system into a humidity chamber at 90°F and 70% relative humidity for 240 hours.
2. Remove the panels from the humidity chamber.
3. Remove the Pyrocrete 40 and primer from the panels.
4. Wire brush any corrosion from the panels.
5. Solvent wipe the panels.
6. Record the weight of each of the panels.

C. Calculate the weight loss due to corrosion by:

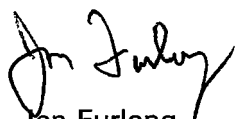
$$D = \frac{(W_{\text{initial}} - W_{\text{final}})_{\text{humidity chamber}} - (W_{\text{initial}} - W_{\text{final}})_{\text{ambient}}}{\text{Area}}$$

RESULTS:

See Table 1 for the summary of results.

DISCUSSION:

1. The dry density of the Pyrocrete 40 applied to the panels was 42 lbs./ft³ when measured by the ASTM E-605 test method for the density of fire resistive materials.
2. Under the ASTM E-937 test procedure, corrosion is given by the difference in weight loss per unit surface area between the panels exposed to the high humidity/temperature chamber and the panels cured under ambient conditions. The accuracy of the weight loss is dependent on how well the Pyrocrete 40 and the primer is cleaned. The wire brush removal of the Pyrocrete 40 and any possible corrosion products combined with the chemical stripping of the primer can cause weighing errors over one half gram.



Jon Furlong
Advanced Chemist
Fireproofing Products

TABLE 1

SYSTEM	EXPOSURE	PRE-TEST WEIGHT	POST-TEST WEIGHT	WEIGHT LOSS
Primed Mild Carbon Steel	Ambient	1095.3 grams	1095.3 grams	0.0 grams
Primed Mild Carbon Steel	Humidity Chamber	1013.1 grams	1013.1 grams	0.0 grams
Galvanized Steel	Ambient	1144.3 grams	1144.3 grams	0.0 grams
Galvanized Steel	Humidity Chamber	1112.7 grams	1112.7 grams	0.0 grams
Unprimed Mild Carbon Steel	Ambient	1092.3 grams	1092.3 grams	0.0 grams
Unprimed Mild Carbon Steel	Humidity Chamber	1096.5 grams	1096.5 grams	0.0 grams

Primed Mild Carbon Steel

$$D = \frac{(0.0 \text{ g}) - (0.0 \text{ g})}{41,290 \text{ mm}^2} = 0.00 \text{ g/mm}^2$$

Galvanized Steel

$$D = \frac{(0.0 \text{ g}) - (0.0 \text{ g})}{41,290 \text{ mm}^2} = 0.00 \text{ g/mm}^2$$

Unprimed Mild Carbon Steel

$$D = \frac{(0.0 \text{ g}) - (0.0 \text{ g})}{41,290 \text{ mm}^2} = 0.00 \text{ g/mm}^2$$

Bodycote Industrial Testing . 2350 South 7th Street . St. Louis . Missouri . U S A . 63104-4296

Tel: (314) 771-7111 . Fax: (314) 771-9573

Test Certificate

CARBOLINE COMPANY
350 HANLEY INDUSTRIAL COURT
ST LOUIS
MO

63144

Attn: JON FURLONG

CRT No S805010 : Issue 2
Ord No 33462 LAB

Date Tested 07/24/98
Date Reported 07/31/98

Item - Pyrocrete 40 Sample for Compression Testing

Identity - L533-89-138

Specification- No Product Specification Applicable

Compression Testing - ASTM E761

	Dimensions [in]	Area [in ²]	GL [in]	YL [lbs]	YS [psi]	UCL [lbs]	UCS [psi]	%E1	%RA	Comments
01:Compression Testing	6" X 6"	36	NA	N/A	N/A	20800	578	N/A	N/A	Nil
02:Compression Testing	6" x 6"	36	NA	N/A	N/A	22000	611	N/A	N/A	Nil

Certificate Comments

Load rate - .05"/min.

Average UCS = 594 psi

SAMPLE COMMENTS:

061: Cracked and flaked at 12,000 lbs.

063: Cracked and flaked at 11,700 lbs.

Approved by Douglas A. Vivian, P.E.

...*D.A. Vivian*.....
For and on authority of
Bodycote Industrial Testing

Bodycote Industrial Testing . 2350 South 7th Street . St. Louis . Missouri . U S A . 63104-4296
Tel: (314) 771-7111 . Fax: (314) 771-9573

Test Certificate

CARBOLINE COMPANY
350 HANLEY INDUSTRIAL COURT
ST LOUIS
MO

63144

REF No S802150 : Issue 1
Ord No PO 33208 LAB

Date Tested 04/03/98
Date Reported 04/03/98

Attn: MR. Jon Furlong

Item - Thermal Conductivity on Pyrocrete 40

Specification- ASTM C177

Thermal Conductivity - ASTM C177			
	Position	Details	Comments
01:Coating Material	Pyrocrete 40	per ASTM C177	Thermal Conductivity by Guarded Hot Plate Method

Certificate Comments

Test Method ASTM C177, Steady-State Heat Flux Measurement and Thermal Transmission Properties by means of the Guarded-Hot Plate Apparatus.

Results:

$$"K" = \left(\frac{\text{Btu.in.}}{\text{hr.ft}^2.\text{F}} \right)$$

1.06

$$\lambda = \left(\frac{\text{W}}{\text{m.K}} \right)$$

0.15

Approved by James E. Zivic

.....
For and on authority of
Bodycote Industrial Testing

STEINER TUNNEL SUMMARY OF RESULTS

ENGINEER :JOE TREADWAY

TECHNICIAN :SLY SMITH

FILE NO. :R7209

TEST DATE :11/5/98

ASSIGNMENT NO. :98NK38905

TEST CODE :11059807

APPLICANT :CARBOLINE

TEST NO :1

MATERIAL :PYROCRETE TYPE 40

MOUNTING :IRCB

FLAME SPREAD RESULTS

Distance (ft.) Time (sec)

Calculated Flame Spread (CFS): 0.00

Flame Spread Index (FSI): 0

Duration of test : 10 min

Time to Ignition : 0 sec

Maximum Flame Spread : ft prior to 10 minutes

Actual area under the Flame Spread Curve (ft.-min.) : 0.0

SMOKE RESULTS

Calculated Smoke Developed (CSD) : 9.1

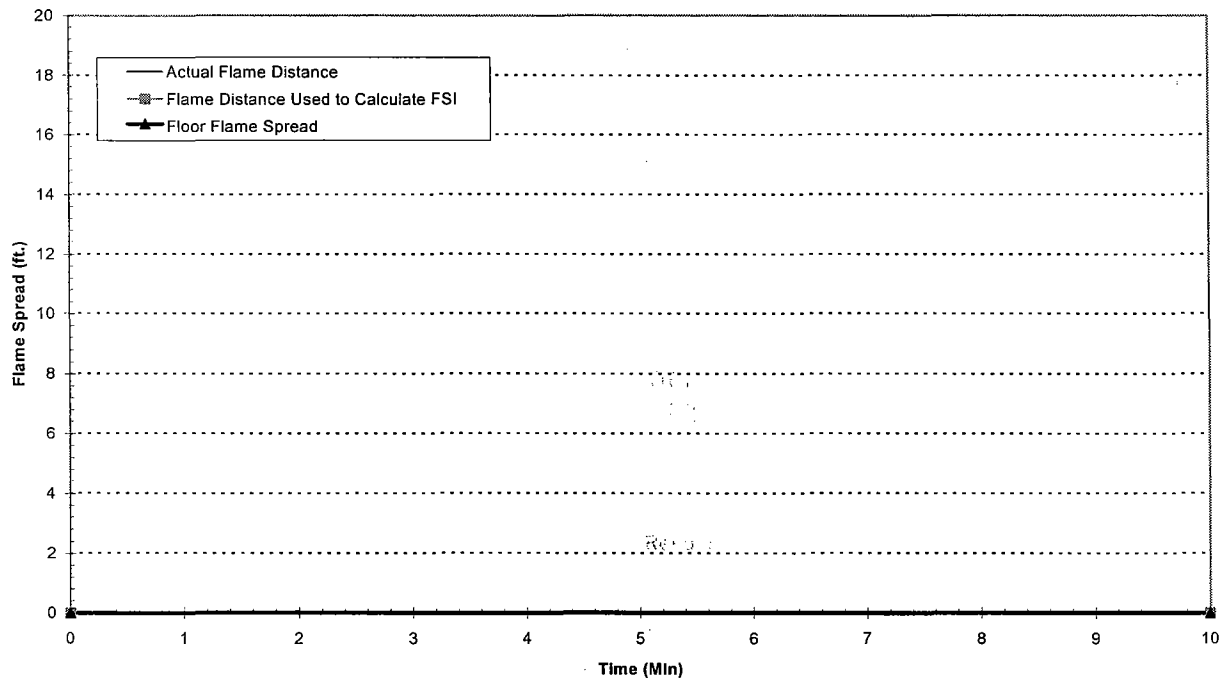
Smoke Developed Index(SDI): 10

Area under the Smoke Curve : 0.32 square inches

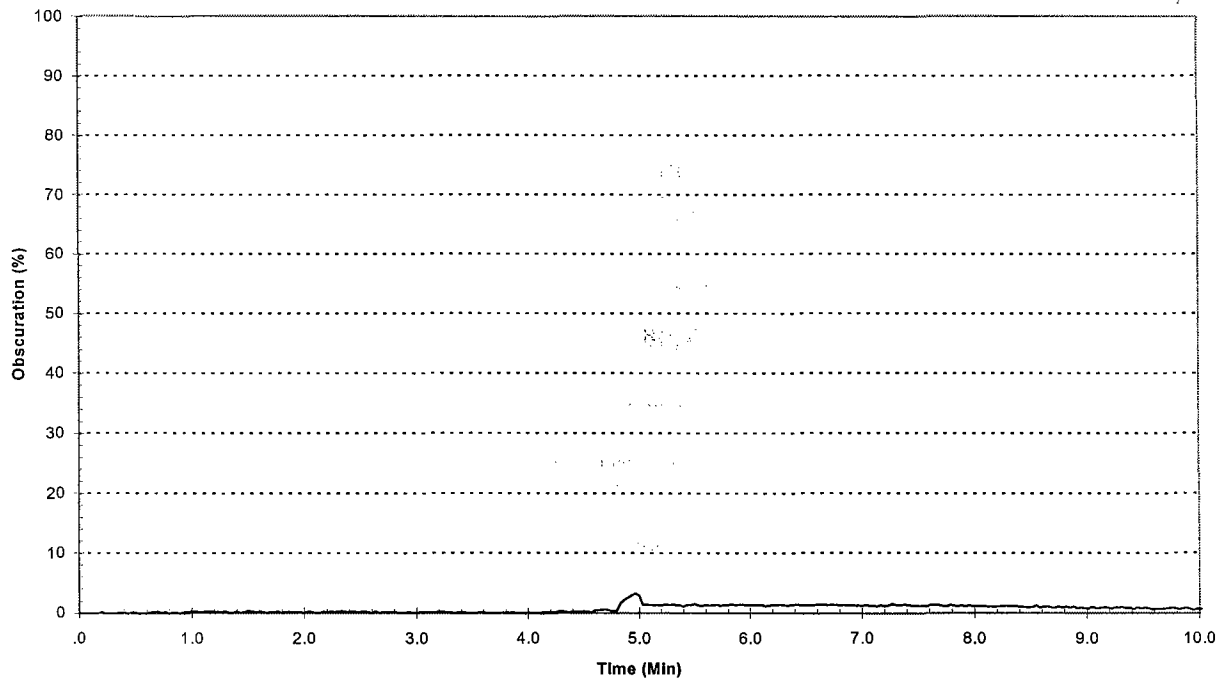
Area under the Red Oak Curve : 3.54 square inches

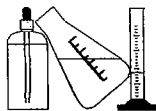
Steiner Tunnel Results PYROCRETE TYPE 40

Flame Spread Results



Smoke Results





November 11, 2005

TITLE: Impact Resistance of Pyrocrete 40

REFERENCE: L578-30

DOCUMENT ACCESS NO.: 09595

PURPOSE: Determine if Pyrocrete 40 can resist a minimum 20 foot-pound impact when tested by a modified ASTM D2794 "Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact)".

CONCLUSION: Pyrocrete 40 can withstand a 20 foot-pound impact without cracking or delamination.

PROCEDURE:

I. System

A. Three 6" x 6" x 1/8" sand blasted steel panels.
B. 3.4 galvanized self-furring metal lath.
C. Pyrocrete 40 @ 1"

II Testing

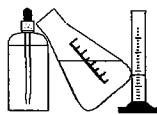
A. Galvanized metal lath wrapped around the panels and tie wired together. Pyrocrete 40 applied to one side of each panel and troweled smooth.
B. Panels cured 6 weeks minimum before testing.
C. Impact each Pyrocrete 40 panel by dropping a 2 pound steel ball from a 10 foot height onto the center of the panel. Note any cracking, delamination or other effects.

RESULTS: The impacts made a 1/2" - 5/8" deep depression in the Pyrocrete 40 but did not cause any cracking or delamination..

Jon Furlong
Advanced Chemist
Fireproofing Products Division

From the Carboline Research & Development Laboratory

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January 19, 1999

TITLE: ASTM E759 Deflection Testing of Pyrocrete 40

REFERENCE: L578-154

DOCUMENT ACCESS NO.: 09413

PURPOSE: Evaluate the effect of deflection on Pyrocrete 40 when tested in accordance to ASTM E759 "Effect of Deflection on Sprayed Fire-Resistive Material Applied to Structural Members."

CONCLUSIONS: There is no effect to Pyrocrete 40 and it is rated as passing the ASTM E759.

PROCEDURE:

- I. System
 - A. 2' x 12' cellular deck consisting of
 1. 2' x 12' x 0.060" noncomposite fluted steel decking with cells 1-1/2" deep, 6" on center.
 2. 2' x 12' x 0.048" galvanized steel base plate welded to the bottom of the fluted deck.
 - B. Pyrocrete 40 @ 1/2"
- II. Application
 - A. Spray apply the Pyrocrete 40 at 1/2" to the center 10' of the underside of the deck.
 - B. Cure the Pyrocrete 40 for one month minimum at ambient and when weight equilibrium is reached.
- III. Testing
 - A. Determine the density of the Pyrocrete 40 by the ASTM E605.
 - B. Support the deck by its bare ends with the Pyrocrete 40 facing downward with a 10' span between supports.
 - C. Apply a vertically centered load to the upper face of the deck until the center of the deck has deflected 1" (1/120 of the span).
 - D. Note the condition of the Pyrocrete 40 and any spalling or delamination that may have occurred.

RESULTS:

ASTM E605 Dry Density: 40 pounds per cubic feet

ASTM E759 Deflection Testing: There was no effect to Pyrocrete 40 at 1" deflection.

Jon Furlong
Advanced Chemist
Fireproofing Products Division

From the Carboline Research & Development Laboratory

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