**APPLICATION MANUAL AND GUIDELINES FOR**
Pyrocrete® 341

**DOCUMENT No.:** 042220-SFRM-PC341-A
**DATE:** September, 2021

## DOCUMENT CONTENTS

## SECTION -. REVISION SUMMARY

| Revision | Date | Amendments |
|---|---|---|
| A | 04.22.20 | First revision |
| B | 09.18.20 | Add Appendix C, to include Handling, Storage and Erection |
| C | 09.01.21 | Update Appendix A to include multi-temperature assessments. Multiple updates to reflect change in material net weight and water volume. Add density conversation factors to section 6.2.1. |

## SECTION -. PREFACE

### Audience

We assume that applicators of Carboline products understand the terminology associated with our products and the various pieces of spray equipment and application techniques.

The installation of the Pyrocrete® 341 spray fire resistive material shall be performed only by contractor personnel trained and/or qualified by Carboline in the installation of the materials.

### Locating Information

This guide incorporates a number of aids to help you locate information easily.

- Document Contents
- Figure and Table Listings
- Page Headers and Footers
- Frequent Section, Subsection, and Topic Headings

### Numbering System

To avoid a cumbersome numbering system, only chapters, sections, and subsections have a numerical designation. For example, “2.3.1” represents Chapter 2, Section 3, Subsection 1.

Illustrations, drawings and design details generally appear at the end of this document in the appendix section.

### Breakdown of Information

Frequent section and subject headings highlight other significant information within a chapter. Heading type style and indentations indicate the level of importance for the topics.

### Related Publications and Documents

This document occasionally refers to other Guides, data sheets, or specifications that may be helpful. Copies are available from Carboline.

*Other documents that may be helpful, include:*

• OSHA - Occupational Safety and Health Administration Safety Rules
• Pyrocrete® 341 Material Safety Data Sheet
• Power tools, hand tools or other mechanical equipment operating procedures.

### Safety Precautions

Pyrocrete® 341 materials weigh approximately 50 pounds (22.7 kg) per bag. Caution should be taken when lifting and moving the material to prevent injury.

**Installation Notes**

The installation steps and procedures in this application guide were prepared with the best available data. All of the steps and procedures presented in this application guide are based upon tests. As additional test and installation data becomes available, including revised installation procedures, Carboline may update and modify this guide.

Note: This is a general Application Manual and cannot cover all possible situations which may arise in the field. For technical assistance, contact Carboline's Fireproofing Technical Service Group at: 1-800-848-4645.

## **SECTION 1.** INTRODUCTION

### 1.1 INTRODUCTION

This Application Manual describes the requirements for the installation of Pyrocrete® 341 sprayed fire resistive materials to steel surfaces for the petrochemical market, based on the requirements of UL 1709, ISO 22899-1 and ISO 20088-1.

For the application to any other substrates, markets or specifications, contact Carboline Technical Service or your local Carboline Sales Representative.

### 1.2 CERTIFIED INSTALLERS

Due to the hydrocarbon environment in which Pyrocrete® 341 is most commonly installed, the need to ensure that systems are installed correctly and in accordance with our listed details is of paramount importance. As such, all Pyrocrete® 341 installations shall be completed by certified and trained installers only, approved by Carboline Company.

## **SECTION 2.** PRODUCT DESCRIPTION

Pyrocrete® 341 is a high-density cementitious fireproofing designed for the fire protection of exterior and interior structural steel.

Pyrocrete® 341 is a minimum average 52 lb./ft³ (832 kg/m³) density, portland cement based, fireproofing material that provides hydrocarbon fire, jet fire and cryogenic spill protection for structural steel. Recommended areas of application include refineries, petrochemical and LNG facilities.

## **SECTION 3.** ENVIRONMENTAL & MATERIAL STORAGE CONDITIONS

### 3.1 MATERIAL STORAGE

Pyrocrete® 341 should be stored indoors, in a dry environment between -20°F - 150°F (-29°C - 66°C). Pyrocrete® 341 must be kept dry or clumping may occur.

### 3.2 SHELF LIFE

Pyrocrete® 341 has a minimum shelf life of 24 months when kept at recommended storage conditions.

## **SECTION 4.** APPLICATION EQUIPMENT

### 4.1 PUMP

Pyrocrete® 341 can be pumped with a wide range of piston, rotor stator and squeeze pumps designed to pump cement and plaster materials including:

- Essick
  - Model FM9/FM5E (Rotor/Stator - 2L4)
- Putzmeister
  - Model S5-EV (Rotor/Stator – 2L6)
- Hy-Flex
  - Model HZ-30E (Rotor/Stator – 2L6)
  - 321E (Piston)
- Strong Mfg.
  - Model Spraymate 60 (Rotor/Stator – 2L6)

### 4.2 MIXER

Use a heavy-duty mortar mixer capable of rotating at 40 rpm with rubber tipped blades, that has a minimum volume of 8 $ft^3$ (227 L).

### 4.3 TROWEL

Standard plasterers hawk and trowel may be used for the application of Pyrocrete® 341. A rubber float may also be used to aid finishing.

### 4.4 MATERIAL HOSE

- Minimum 1” (25.4 mm) I.D. hose with 300 psi minimum bursting pressure.
- For lengths over 50’ (15 m) use 1-1/2” (38 mm) I.D. hose.
- Do not reduce hose diameter by more than ¼” (6.4 mm) per 25’ (7.6 m) unless a tapered conical reduced equipped with swivel fitting is used.
- A 10’ (3 m) length of 1” (25.4 mm) I.D. hose may be added at the gun for use as a whip.
- Maximum hose length of 250’ (76 m)

### 4.5 NOZZLE/GUN

- Binks
  - Part 7E2 (47-49 fluid tip, 3/8” – ½” air cap)
- Graco
  - Part 204000 (3/8” – ½” fluid tip and air cap)
- Speeflo
  - Part 701 (3/8” – ½” fluid tip and air cap)
- Airtech
  - Internal mix with 3/8” – ½” fluid tip.
- Standard plasterers’ gun with 3/8” – ½” fluid tip

### 4.6 COMPRESSOR

Ensure that the air supply is a minimum 22 cfm at 100 psi (689 kPa) and higher when distances longer than 75’ (22 m) are required.

## 4.7 AIR LINE

Use ½” (12.7 mm) I.D. line, with a minimum bursting pressure of 100 psi (689 kPa)

## SECTION 5. SURFACE PREPARATION & REINFORCING MESH/METAL LATH

### 5.1 SURFACE PREPARATION

Prior to the installation of Pyrocrete® 341, the substrate shall be free of all oil, grease, condensation, or other contaminants.

#### 5.1.2 STEEL

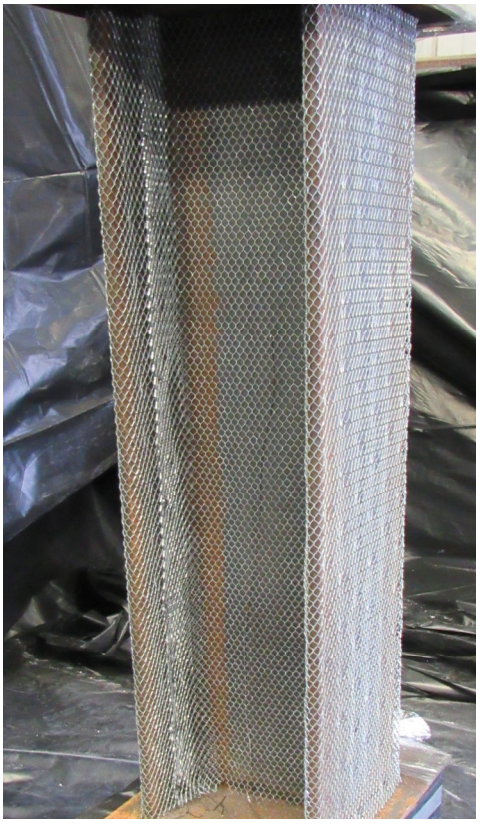
If a protective coating system is required, steel preparation should be done in accordance with the recommended primers product datasheet. Please contact Carboline Fireproofing Technical Service for a list of approved primer systems.

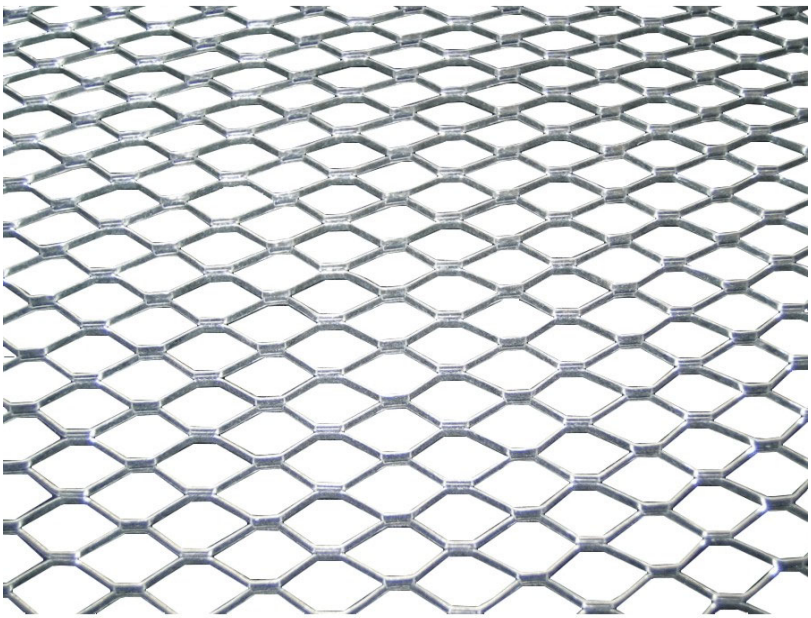
#### 5.1.3 GALVANIZED STEEL

Pyrocrete® 341 is usually applied directly over galvanized surfaces. If a tie-coat primer is required, please contact Carboline Fireproofing Technical Service for recommendations.

### 5.2 REINFORCING MESH/METAL LATH

In accordance with the tested design details for Pyrocrete® 341, a minimum 2.5 lb./yd2 (1.36 kg/m2) galvanized metal lath shall be pre-bent and tie wired into place in accordance the tested design. Optionally, beam furring clips or electrically welded, pneumatic, self-tapping screws, studs or mechanical fasteners may be used as a fixing aid to secure the lath in place to the steel substrate, prior to the application of Pyrocrete® 341.





## SECTION 6. MIXING & DENSITY PROCEDURES

### 6.1 MIXING

Pyrocrete® 341 shall be mixed to a consistent and uniform texture, in accordance with the following procedure:

Note: A water metering device is a mandatory requirement with all Pyrocrete® applications. Please use a calibrated 5-gallon pail to verify water meter accuracy.

a. Ensure that the equipment is clean, and free from any debris or other material that would affect the mix process.
b. Set mixer speed at 35-40 RPM.
c. With the blades rotating, being to add fresh, clean potable water. Target water level is 4.5 gallons (17.03 liters), +/- 0.5 gallons (1.89 liters). Total water not to exceed 5.0 gallons (18.9 liters) per 50 lb. (22.7 kg) bag of material.
d. With mixer running slowly, add Pyrocrete® 341 powder.
e. Mix for 3 – 5 minutes (10 minutes maximum) until a homogenous mortar-like consistency is achieved.
f. The mix may appear dry, do not add additional water and allow time for the material to “wet-out”
g. Stop the mixer and verify the wet density. Reference 6.2 for information on target wet density. If target has not been achieved:
    a. To increase the density, add additional clean, potable water.
    b. To decrease the density, increase the mix time and/or varying the speed of the blades. Please be cautious not to over mix the material beyond the maximum time, as noted.
h. Once the target wet density has been achieved, determine the amount of water and mix time, and use for subsequent mixes.
i. Restart the mixer to re-blend the material prior to releasing int the hopper.
j. Always ensure the entire mix has been dumped and the mixer is empty prior to mixing subsequent batches.
k. Mixed Pyrocrete® 341 can be used for upto 6 hours at 70°F (21°C). The pot life of the material ends when the material thickens and becomes unusable. Do not re-temper the material.

### 6.2 DENSITY

Wet density measurements are critical to obtaining correct dry densities. When verifying wet densities of Pyrocrete® 341 please use the following procedures:

TARGET WET DENSITY

| PRODUCT | WATER/55 lb. BAG (Gallons) | MIXER DENSITY | UNIT |
|---|---|---|---|
| Pyrocrete® 341 | 4.5 | 76 – 82 (1217 – 1313 kg/m3) | PCF (KG/M3) |

EQUIPMENT

a. 1-liter (1000 cc) polyethylene cup
b. Small metal spatula
c. Scale accurate to 1 gram

PROCEDURE

a. Weigh the empty polyethylene cup to the nearest gram, then tare the scale.
b. Use the spatula to completely fill the cup with mixer material (do not tamp)

c. Remove the excess material on top by placing the vertical edge of the spatula on the top edge of the cup. Use a sawing motion to level the mixed Pyrocrete® 341 flush with the top of the cup.
d. Weigh the filled cup to the nearest gram.
e. Record the weight of the material in grams. This value equals the wet density in grams/liter and kg/$m^3$.
f. To calculate the weight of the material in lf.$ft^3$, multiply the value in grams/liter by 0.0624.

6.2.1 DENSITY CONVERSION CHARTS

Conversion factors for alternate cup sizes to measure wet density are supplied below:

| Cup Used | Conversation Factor |
|---|---|
| 6 oz. | 0.351 |
| 7 oz. | 0.301 |
| 8 oz. | 0.263 |
| 12 oz. | 0.175 |
| 16 oz. | 0.132 |

## SECTION 7. APPLICATION PROCEDURES

### 7.1 GENERAL

Pyrocrete® 341 may be applied by spray and/or trowel.

Material build will depend on application method, weather conditions and equipment used.

### 7.2 APPLICATION

ENVIRONMENTAL CONDITIONS

The application of Pyrocrete® 341 should be in accordance with the environmental conditions as described below and as shown on the PDS.

| Condition | Material | Surface | Ambient | Humidity |
|---|---|---|---|---|
| Minimum | 40°F (4°C) | 40°F (4°C) | 40°F (4°C) | 0% |
| Maximum | 100°F (38°C) | 125°F (52°C) | 110°F (43°C) | 95% |

SURFACE PREPERATION

a. Prior to the installation of Pyrocrete® 341, the substrate shall be free of all oil, grease, condensation, or other contaminants.

PRIMER/PROTECTIVE COATING SYSTEM

b. If a protective coating system is required, steel preparation should be done in accordance with the recommended primer product datasheet. Please contact Carboline Fireproofing Technical Service for a list of approved primer systems.

MESH REINFORCEMENT

c. In accordance with the tested design details for Pyrocrete® 341, a minimum 2.5 lb./yd2 (1.36 kg/m2) galvanized metal lath shall be pre-bent and tie wired into place. As a fixing aid, lath may also be secured using powder actuated fasteners, welded studs, high temperature adhesive stick pins, self-tapping screws or beam furring clips.

MIXING

d. Mix Pyrocrete® 341 with 4.5 gallons (17.03 liters) (+/- 0.5 (1.89 liters) gallons) of clean, potable water per 50 lb. (22.7 kg) bag of material
e. Mix for 3-5 minutes (10 minutes maximum) until a homogenous mortar-like consistency is achieved.
f. Verify wet density.
g. For detail mixing instructions, please refer to section 6.1 of this application guide.

PUMP

h. Wash equipment/pump hopper down with water and fill the hopper with a minimum of 2 gallons of clean potable water.
i. Ensure the orifice and cap have been removed from the spray nozzle.
j. Ensure the air stem is pulled back to minimize any restrictions.
k. Once Pyrocrete® 341 has been mixed, start the equipment/pump and discharge the water from the hopper into the material lines.
l. When the hopper is almost empty, rotate and dump the mixed Pyrocrete® 341 into the hopper.

m. Continuing pumping until the Pyrocrete® 341 at the nozzle is of normal consistency.
n. Shut off the pump and install nozzle orifice.
o. Restart the pump and adjust air accordingly to obtain desired surface texture.

APPLICATION

p. For all applications, material build will depend on application method, weather conditions and equipment used.
q. Allow the applied Pyrocrete® 341 to set for 2 hours at 70°F (21°C) before applying additional lifts to the required thickness.
r. Carboline recommends that the total required thickness be applied within a 24-hour period. If this is not possible, the preceding coats should be left as sprayed or scored after application. Pyrocrete® 341 must be dampened with water before the application of additional lifts.
s. Fresh Pyrocrete® 341 must be protected from rain or running water for 24 hours at 70°F (21°C).
t. All lifts should be applied monolithically to the entire perimeter of the steel section.
u. At no time shall Pyrocrete® 341 be applied at a thickness less than ¼" (6.4 mm) or "skim" coated.
v. The maximum time to achieve the full thickness is 3 days at 70°F (21°C) and 50% R.H.

Note: Do not start work if ambient temperatures are expected to drop below 35°F (2°C) for 24 hours after application.

FINISHING

Pyrocrete® 341 can be left as sprayed or finished with a trowel to improve the surface appearance and general aesthetics of the applied product.

SEALERS / TOPCOATS

Topcoats are generally not required, and do not form part of the fire resistive tested system(s). In severely corrosive environments, topcoats may be used for added durability and chemical resistance. Please contact Carboline Fireproofing Technical Service for a selection of topcoats most suited to the end use environment.

w. If a topcoat is required, apply Carboguard 1340 to the Pyrocrete® 341 as a surface seal coat. Carboguard 1340 shall be thinned 25% with Carboline Thinner # 2. The application of Carboguard 1340 may be applied 24 hours after the final application of Pyrocrete® 341. Please review the Carboguard 1340 PDS for minimum and maximum cure times.
x. Alternatively, Carboguard 1340 WB can be applied as a surface sealant. Please view the Carboguard 1340 WB PDS for further information.
y. Prior to the application of a topcoat system, the surface hardness of Pyrocrete® 341 should be a minimum Shore DO 64 as measured with a durometer.

TERMINATION POINTS/CAULKING

For exterior use, all exposed top and/or side termination points of Pyrocrete® 341 should be caulked with Acrilast Caulk II, TREMstop® Fyre-Sil GG or approved equivalent to prevent water incursion.

CLEANUP

Pump, mixer and hose should be cleaned with clean, potable water at least once every 6 hours at 70°F (21°C), and more often at higher temperatures. Sponges should be run through the hoses to remove residual material. Wet Pyrocrete 341 overspray must be cleaned up with soapy or clean, potable water. Cured overspray may require chipping and/or scraping to remove.

SAFETY

Follow all safety precautions on the product Safety Data Sheets. It is recommended that personal protective equipment be worn, including spray suits, gloves, eye protection and respirators. Mixer personnel should wear respirators with replaceable disposable filter masks, protective goggles, gloves and eye shields protection. All fireproofing products can be slippery when wet and therefore proper precautions must be taken. It is suggested that caution signs be posted to alert other trades.

## **SECTION 8.** REPAIR PROCEDURES

The following repair procedures have been provided as general information. If you are in doubt or unsure on how to approach any repairs to damaged Pyrocrete® 341, please contact Carboline Fireproofing Technical Service.

### 8.1 MAINTENANCE REPAIR PROCEDURES

a. To remove damaged Pyrocrete® 341 use a cold chisel, air chisel, or circular saw with a masonry blade.
b. To patch the repair or damaged area:
    a. Remove the Pyrocrete to expose the lath for a 2” border around the patch area. The undamaged Pyrocrete® 341 should be cut to the lath leaving a 90° face or butt edge.
    b. Ensure that all loose material and dust residue has been removed.
    c. Touch up primer if applicable.
    d. If the lath was damaged in removal, cut new 2.5 lb. galvanized lath to cover the exposed area, including the 2” border of the existing lath. Attach the new lath to the existing lath using galvanized tie-wire or mechanical fasteners.
    e. Wet the existing Pyrocrete®341 butt edges with clean, potable water.
    f. Apply the Pyrocrete® 341 to the thickness required for the desired hourly rating.
    g. Do not featheredge Pyrocrete® 341.
    h. Do not apply Pyrocrete® 341 less than 1/4” thickness at any time.
    i. In exterior applications, allow Pyrocrete® 341 a minimum of 4 days cure before applying caulk and topcoats.

### 8.2 CRACK REPAIR PROCEDURES

Observed hairline cracks that may appear, of which are less than 1/8” (3.18 mm) will not impair the fire resistive rating of Pyrocrete® 341.

For all cracks that are greater than 1/8” (3.18 mm), please route and repair in accordance with the following procedure:

a. To cosmetically cover the crack, it is suggested to either caulk using Acrilast Caulk II or sacking the surface.
b. Remove the fireproofing along the crack to the existing lath. The width of the repair should be a minimum of 1” with a butt joint finish.
c. Clean away any loose debris and all dust residue.
d. Wet the edges of the existing Pyrocrete® 341 using clean potable water.
e. Apply freshly mixed Pyrocrete® 341 to the thickness required for the design hourly rating.
f. Do not featheredge Pyrocrete® 341.
g. Do not apply Pyrocrete® 341 at less than 1/4” (6.4 mm) thickness at any time.
h. In exterior applications, allow the Pyrocrete® 341 to cure a minimum of 4 days before applying caulk or topcoats.

## **SECTION 9.** INSPECTION & QUALITY CONTROL GUIDANCE

### 9.1 GENERAL

The importance of quality control should not be overlooked. Carboline recommends that as a minimum Pyrocrete® 341 shall be inspected and tested daily to record the following:

- Environmental Conditions
  - Ambient/Substrate Temperature
  - Relative Humidity
  - Dew Point
- Material Storage Conditions
- Surface Preparation
- Lathing & Mixing
  - Batch # (s) of Pyrocrete® 341 used
  - Water Consumption/Bag
  - Wet Density (minimum 2 x daily)
- Equipment
- Application Procedures
- Thickness
  - Record Thickness measurements in accordance with specification requirements on testing. If no section exists, for guidance only, follow Technical Manual 12-A or SSPC-PA2.
  - Carboline recommends that thickness measurements be taken using a 6” ruler, or instrument with a rounded edge, so the lath is not penetrated.
  - The thickness is measured from the face of the lath, not the steel.
- Additional Comments
- Non-conformance Reporting

Quality Assurance/Quality Control Templates have been provided for reference only, attached to Appendix C of this manual.

## **APPENDIX A.** UL DESIGN DETAILS

UL Product iQ™

# BYBU.XR747 - Fire-resistance Ratings - ANSI/UL 1709

Design/System/Construction/Assembly Usage Disclaimer

- Authorities Having Jurisdiction should be consulted in all cases as to the particular requirements covering the installation and use of UL Certified products, equipment, system, devices, and materials.
- Authorities Having Jurisdiction should be consulted before construction.
- Fire resistance assemblies and products are developed by the design submitter and have been investigated by UL for compliance with applicable requirements. The published information cannot always address every construction nuance encountered in the field.
- When field issues arise, it is recommended the first contact for assistance be the technical service staff provided by the product manufacturer noted for the design. Users of fire resistance assemblies are advised to consult the general Guide Information for each product category and each group of assemblies. The Guide Information includes specifics concerning alternate materials and alternate methods of construction.
- Only products which bear UL's Mark are considered Certified.

## Fire-resistance Ratings - ANSI/UL 1709

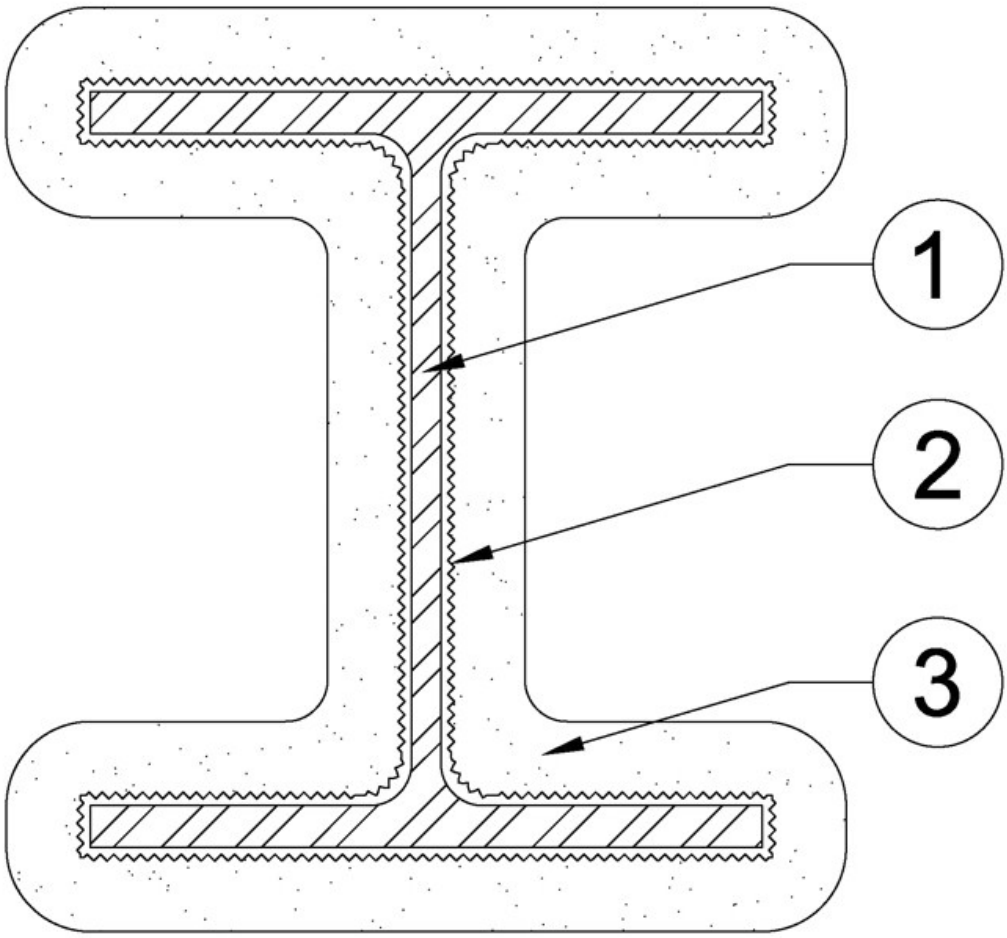
BYBU - Fire-resistance Ratings - ANSI/UL 1709

See General Information for Fire-resistance Ratings - ANSI/UL 1709

Design No. XR747

July 30, 2021

**Ratings — 1, 2, 2-1/2, 3, 4 Hr**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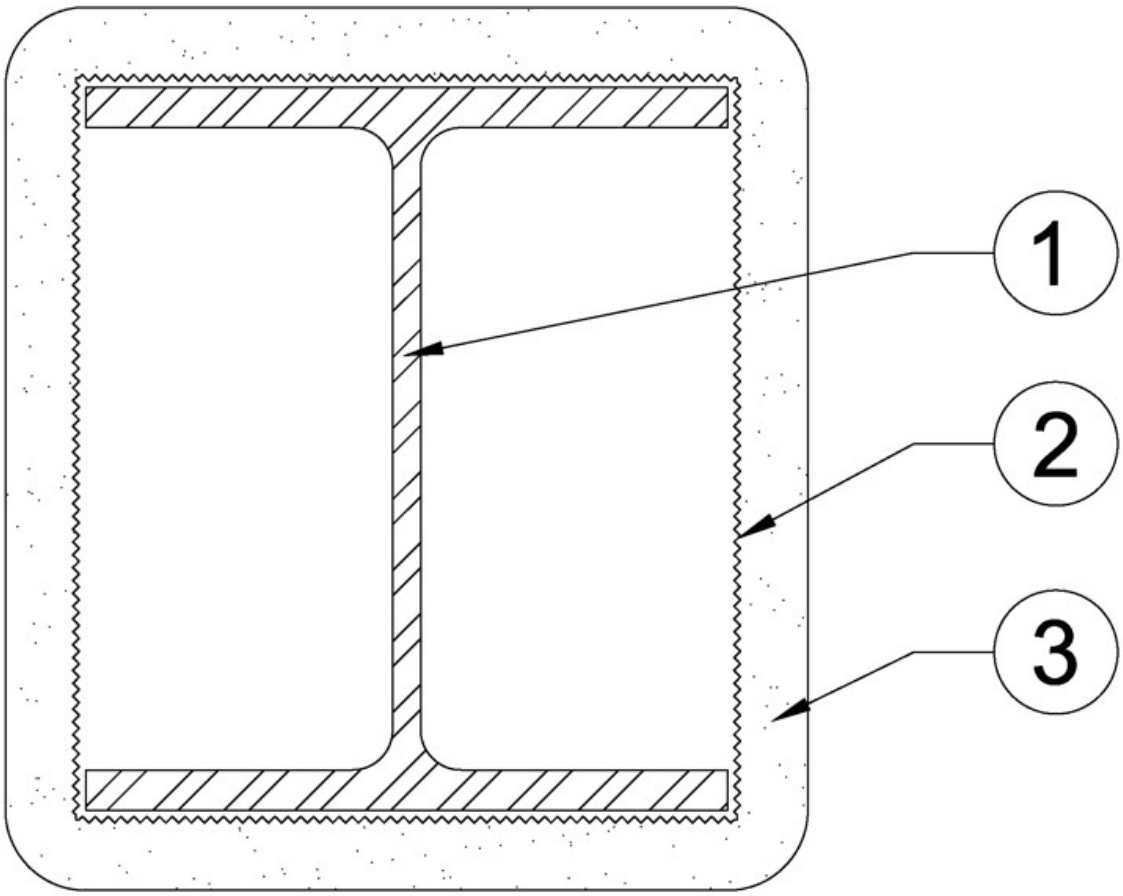


1. **Steel Column —** Min size of column W8×10 with bare steel or galvanized steel.

2. **Reinforcing Mesh —** Galvanized expanded steel lath, weighing 2.5 lb per sq yd., with a minimum average distance between face of lath and steel surface of a 1/4 inch. Lath overlapped a minimum of 1 in. at joints and tied together with steel wire spaced vertically a maximum of 12 in. OC.

3. **Spray-Applied Fire Resistive Materials* —** See table below for appropriate thickness. Thicknesses are measured to the surface of the lath. Prepared by mixing with water according to instructions on each bag of mixture. Mixture can be spray or trowel applied in one or more coats, directly to the column through the reinforcing mesh, which must be clean and free of dirt, loose scale and oil. The material is keyed into the lath. Min avg density of 52 pcf, with min individual value of 47 pcf. For method of density determination, see Design Information Section, Sprayed Material. Surface of material may be lightly finished with a trowel.

| | | Min Required Thickness (in.) for Hourly Rating Period (min) | | | | |
|---|---|---|---|---|---|---|
| **W/D** | **Hp/A** | **60** | **120** | **150** | **180** | **240** |
| 0.33 | 406 | 13/16 | 1-1/4 | 1-1/2 | 1-1/16 | N/A |
| 0.43 | 312 | 13/16 | 1-3/16 | 1-3/8 | 1-5/8 | N/A |
| 0.57 | 235 | 11/16 | 1-1/8 | 1-5/16 | 1-1/2 | N/A |
| 0.63 | 214 | 11/16 | 1-1/16 | 1-1/4 | 1-1/2 | 1-7/8 |
| 0.68 | 197 | 11/16 | 1-1/16 | 1-1/4 | 1-7/16 | 1-13/16 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 0.75 | 179 | 5/8 | 1 | 1-3/16 | 1-7/16 | 1-3/4 |
| 0.84 | 160 | 9/16 | 15/16 | 1-1/8 | 1-3/8 | 1-11/16 |
| 0.90 | 149 | 9/16 | 15/16 | 1-1/8 | 1-5/16 | 1-11/16 |
| 1.00 | 134 | 1/2 | 7/8 | 1-1/8 | 1-5/16 | 1-5/8 |
| 1.10 | 122 | 1/2 | 7/8 | 1-1/16 | 1-1/4 | 1-5/8 |
| 1.20 | 112 | 1/2 | 13/16 | 1-1/16 | 1-1/4 | 1-9/16 |
| 1.30 | 103 | 7/16 | 13/16 | 1 | 1-3/16 | 1-9/16 |
| 1.40 | 96 | 7/16 | 13/16 | 1 | 1-3/16 | 1-1/2 |
| 1.50 | 89 | 3/8 | 3/4 | 15/16 | 1-1/8 | 1-1/2 |
| 1.60 | 84 | 3/8 | 3/4 | 15/16 | 1-1/8 | 1-7/16 |
| 1.63 | 82 | 3/8 | 3/4 | 15/16 | 1-1/8 | 1-7/16 |
| 1.70 | 79 | 3/8 | 11/16 | 7/8 | 1-1/16 | 1-7/16 |
| 1.73 | 77 | 5/16 | 11/16 | 7/8 | 1-1/16 | 1-7/16 |
| 1.80 | 74 | 5/16 | 11/16 | 7/8 | 1-1/16 | 1-7/16 |
| 1.90 | 71 | 5/16 | 5/8 | 13/16 | 1 | 1-3/8 |
| 2.00 | 67 | 5/16 | 5/8 | 13/16 | 1 | 1-3/8 |
| 2.10 | 64 | 5/16 | 5/8 | 13/16 | 15/16 | 1-5/16 |
| 2.20 | 61 | 1/4 | 9/16 | 3/4 | 15/16 | 1-5/16 |
| 2.30 | 58 | 1/4 | 9/16 | 3/4 | 7/8 | 1-1/4 |
| 2.40 | 56 | 1/4 | 1/2 | 11/16 | 7/8 | 1-1/4 |
| 2.50 | 54 | 1/4 | 1/2 | 11/16 | 13/16 | 1-3/16 |
| 2.52 | 53 | 3/16 | 1/2 | 11/16 | 13/16 | 1-3/16 |

**CARBOLINE CO** — Type Pyrocrete 341, investigated for UL2431 Outdoor (Exterior), Heavy Industrial Environmental Classification Category I-A purpose including Specific Chemical Exposure, and also evaluated for Acid Spray Exposure in UL1709, 4th edition.

**For product Alternate Limiting Temperature Tables click here:** XR747-1

**For product Hydrocarbon Certification Report click here:** BYFH.R7209

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

Last Updated on 2021-07-30

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# Alternate Temperature Assessment

**Issued: July 30, 2021**

**UL Category Code: CHPX**

**Product: Type Pyrocrete 341**

**Report ID: XR747-1**

**COMPANY:**

**CARBOLINE CO**
**350 HANLEY INDUSTRIAL CT**
**SAINT LOUIS, MO, 63144-1510**
**USA**

Type Pyrocrete 341 spray-applied fire resistive material is a cementitious mixture applied for fire resistance protection of structural steel framing members. This report is limited to the analysis and alternate limiting temperature thicknesses for the type of structural steel (e.g. column) as shown in the table here within.

During the standard UL 1709 evaluation, the thickness of the fire resistive material is established based on limiting steel temperatures of 1000°F (538°C) average limit and 1200°F (649°C) individual limit for columns. Based on the fire tests conducted and the performance of the fire resistive material, alternate limiting temperature thickness tables have been established. An alternate limiting temperature table is a UL design specific matrix that identifies the appropriate coating thickness for a selected steel size, limiting steel temperature, and a specified time duration. These tables are provided as additional information only, for implementation by Authorities Having Jurisdiction. The UL 1709 test method has a similar approach for establishing fire resistance ratings and therefore lends itself to this type of engineering analysis. This information is intended to be used in conjunction with the specified UL Design only. All requirements specified in the UL Design shall be met to achieve the appropriate analysis.

Refer to UL File R7209 for product Classification under category Spray-applied Fire-resistive Materials (CHPX), and Column Design No. XR747 for the fire resistance ratings developed in accordance with UL1709. The alternate limiting temperature thicknesses are intended to be used in conjunction with UL Design No. XR747 only. All required components specified in the referenced UL Design shall remain as required components to achieve the time periods shown using the alternate limiting temperature thicknesses. Only the version of UL Design No. XR747 as shown on Product iQ at **www.ul.com** is considered current.

Type Pyrocrete 341 spray-applied fire resistive material described in this report shall be identified by a marking bearing the report holder's name or UL file number, the product name and the UL Classification Mark. The validity of this alternate temperature assessment is contingent upon this identification appearing on the product.

## Appendix A – Alternate Limiting Temperature Tables

### Table A1 – Alternate Limiting Temperature 250°C (Metric)

| W/D | Hp/A | Min Required Thickness (mm) for Hourly Rating Period (min) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15 | 30 | 45 | 60 | 90 | 120 | 150 | 180 | 240 | 300 |
| 0.33 | 406 | 18 | 20 | 24 | 27 | 37 | 45 | NR | NR | NR | NR |
| 0.40 | 335 | 18 | 20 | 23 | 27 | 35 | 43 | NR | NR | NR | NR |
| 0.50 | 268 | 16 | 18 | 23 | 26 | 34 | 42 | NR | NR | NR | NR |
| 0.60 | 223 | 15 | 16 | 21 | 24 | 32 | 40 | NR | NR | NR | NR |
| 0.70 | 191 | 13 | 16 | 20 | 23 | 32 | 39 | 43 | NR | NR | NR |
| 0.80 | 167 | 10 | 15 | 18 | 23 | 31 | 37 | 40 | 43 | 50 | NR |
| 0.84 | 160 | 10 | 13 | 18 | 21 | 31 | 37 | 40 | 42 | 47 | 51 |
| 0.90 | 149 | 10 | 13 | 18 | 21 | 31 | 37 | 40 | 42 | 47 | 51 |
| 1.00 | 134 | 10 | 13 | 18 | 21 | 29 | 37 | 40 | 42 | 47 | 51 |
| 1.10 | 122 | 10 | 13 | 16 | 21 | 29 | 37 | 40 | 42 | 47 | 51 |
| 1.20 | 112 | 8 | 13 | 16 | 21 | 29 | 37 | 40 | 42 | 47 | 51 |
| 1.30 | 103 | 8 | 12 | 16 | 20 | 29 | 37 | 40 | 42 | 47 | 51 |
| 1.40 | 96 | 8 | 12 | 16 | 20 | 29 | 37 | 40 | 42 | 47 | 51 |
| 1.50 | 89 | 8 | 12 | 15 | 20 | 29 | 35 | 40 | 42 | 47 | 51 |
| 1.60 | 84 | 8 | 10 | 15 | 20 | 27 | 35 | 40 | 42 | 47 | 51 |
| 1.70 | 79 | 8 | 10 | 15 | 20 | 27 | 35 | 40 | 42 | 47 | 51 |
| 1.80 | 74 | 8 | 10 | 15 | 18 | 27 | 35 | 40 | 42 | 47 | 51 |
| 1.90 | 71 | 7 | 10 | 13 | 18 | 27 | 35 | 40 | 42 | 47 | 51 |
| 2.00 | 67 | 7 | 8 | 13 | 18 | 27 | 35 | 40 | 42 | 47 | 51 |
| 2.10 | 64 | 7 | 8 | 13 | 18 | 26 | 35 | 40 | 42 | 47 | 51 |
| 2.20 | 61 | 7 | 8 | 13 | 18 | 26 | 35 | 40 | 42 | 47 | 51 |
| 2.30 | 58 | 7 | 8 | 13 | 16 | 26 | 35 | 40 | 42 | 47 | 51 |
| 2.40 | 56 | 7 | 7 | 12 | 16 | 26 | 35 | 40 | 42 | 47 | 51 |
| 2.50 | 54 | 7 | 7 | 12 | 16 | 26 | 35 | 40 | 42 | 47 | 51 |
| 2.52 | 53 | 5 | 7 | 12 | 16 | 26 | 35 | 40 | 42 | 47 | 51 |

**Table A2 – Alternate Limiting Temperature 482°F (Imperial)**

| W/D | Hp/A | Min Required Thickness (in.) for Hourly Rating Period (min) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15 | 30 | 45 | 60 | 90 | 120 | 150 | 180 | 240 | 300 |
| 0.33 | 406 | 11/16 | 3/4 | 15/16 | 1 1/16 | 1 7/16 | 1 3/4 | NR | NR | NR | NR |
| 0.40 | 335 | 11/16 | 3/4 | 7/8 | 1 1/16 | 1 3/8 | 1 11/16 | NR | NR | NR | NR |
| 0.50 | 268 | 5/8 | 11/16 | 7/8 | 1 | 1 5/16 | 1 5/8 | NR | NR | NR | NR |
| 0.60 | 223 | 9/16 | 5/8 | 13/16 | 15/16 | 1 1/4 | 1 9/16 | NR | NR | NR | NR |
| 0.70 | 191 | 1/2 | 5/8 | 3/4 | 7/8 | 1 1/4 | 1 1/2 | 1 11/16 | NR | NR | NR |
| 0.80 | 167 | 3/8 | 9/16 | 11/16 | 7/8 | 1 3/16 | 1 7/16 | 1 9/16 | 1 11/16 | 1 15/16 | NR |
| 0.84 | 160 | 3/8 | 1/2 | 11/16 | 13/16 | 1 3/16 | 1 7/16 | 1 9/16 | 1 5/8 | 1 13/16 | 2 |
| 0.90 | 149 | 3/8 | 1/2 | 11/16 | 13/16 | 1 3/16 | 1 7/16 | 1 9/16 | 1 5/8 | 1 13/16 | 2 |
| 1.00 | 134 | 3/8 | 1/2 | 11/16 | 13/16 | 1 1/8 | 1 7/16 | 1 9/16 | 1 5/8 | 1 13/16 | 2 |
| 1.10 | 122 | 3/8 | 1/2 | 5/8 | 13/16 | 1 1/8 | 1 7/16 | 1 9/16 | 1 5/8 | 1 13/16 | 2 |
| 1.20 | 112 | 5/16 | 1/2 | 5/8 | 13/16 | 1 1/8 | 1 7/16 | 1 9/16 | 1 5/8 | 1 13/16 | 2 |
| 1.30 | 103 | 5/16 | 7/16 | 5/8 | 3/4 | 1 1/8 | 1 7/16 | 1 9/16 | 1 5/8 | 1 13/16 | 2 |
| 1.40 | 96 | 5/16 | 7/16 | 5/8 | 3/4 | 1 1/8 | 1 7/16 | 1 9/16 | 1 5/8 | 1 13/16 | 2 |
| 1.50 | 89 | 5/16 | 7/16 | 9/16 | 3/4 | 1 1/8 | 1 3/8 | 1 9/16 | 1 5/8 | 1 13/16 | 2 |
| 1.60 | 84 | 5/16 | 3/8 | 9/16 | 3/4 | 1 1/16 | 1 3/8 | 1 9/16 | 1 5/8 | 1 13/16 | 2 |
| 1.70 | 79 | 5/16 | 3/8 | 9/16 | 3/4 | 1 1/16 | 1 3/8 | 1 9/16 | 1 5/8 | 1 13/16 | 2 |
| 1.80 | 74 | 5/16 | 3/8 | 9/16 | 11/16 | 1 1/16 | 1 3/8 | 1 9/16 | 1 5/8 | 1 13/16 | 2 |
| 1.90 | 71 | 1/4 | 3/8 | 1/2 | 11/16 | 1 1/16 | 1 3/8 | 1 9/16 | 1 5/8 | 1 13/16 | 2 |
| 2.00 | 67 | 1/4 | 5/16 | 1/2 | 11/16 | 1 1/16 | 1 3/8 | 1 9/16 | 1 5/8 | 1 13/16 | 2 |
| 2.10 | 64 | 1/4 | 5/16 | 1/2 | 11/16 | 1 | 1 3/8 | 1 9/16 | 1 5/8 | 1 13/16 | 2 |
| 2.20 | 61 | 1/4 | 5/16 | 1/2 | 11/16 | 1 | 1 3/8 | 1 9/16 | 1 5/8 | 1 13/16 | 2 |
| 2.30 | 58 | 1/4 | 5/16 | 1/2 | 5/8 | 1 | 1 3/8 | 1 9/16 | 1 5/8 | 1 13/16 | 2 |
| 2.40 | 56 | 1/4 | 1/4 | 7/16 | 5/8 | 1 | 1 3/8 | 1 9/16 | 1 5/8 | 1 13/16 | 2 |
| 2.50 | 54 | 1/4 | 1/4 | 7/16 | 5/8 | 1 | 1 3/8 | 1 9/16 | 1 5/8 | 1 13/16 | 2 |
| 2.52 | 53 | 3/16 | 1/4 | 7/16 | 5/8 | 1 | 1 3/8 | 1 9/16 | 1 5/8 | 1 13/16 | 2 |

**Table A3 – Alternate Limiting Temperature 300°C (Metric)**

| W/D | Hp/A | Min Required Thickness (mm) for Hourly Rating Period (min) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15 | 30 | 45 | 60 | 90 | 120 | 150 | 180 | 240 | 300 |
| 0.33 | 406 | 18 | 20 | 23 | 26 | 34 | 42 | NR | NR | NR | NR |
| 0.40 | 335 | 18 | 18 | 21 | 26 | 32 | 40 | NR | NR | NR | NR |
| 0.50 | 268 | 16 | 16 | 21 | 24 | 32 | 39 | NR | NR | NR | NR |
| 0.60 | 223 | 13 | 16 | 20 | 23 | 31 | 39 | 43 | NR | NR | NR |
| 0.70 | 191 | 12 | 15 | 18 | 21 | 29 | 37 | 42 | 45 | NR | NR |
| 0.78 | 172 | 10 | 13 | 18 | 21 | 27 | 35 | 40 | 43 | 50 | NR |
| 0.80 | 167 | 10 | 13 | 16 | 21 | 27 | 35 | 39 | 42 | 48 | NR |
| 0.84 | 160 | 10 | 13 | 16 | 20 | 27 | 35 | 39 | 42 | 47 | 51 |
| 0.90 | 149 | 10 | 13 | 16 | 20 | 27 | 35 | 39 | 42 | 47 | 51 |
| 1.00 | 134 | 10 | 12 | 16 | 20 | 26 | 34 | 39 | 42 | 47 | 51 |
| 1.10 | 122 | 8 | 12 | 15 | 20 | 26 | 34 | 39 | 42 | 47 | 51 |
| 1.20 | 112 | 8 | 12 | 15 | 18 | 26 | 34 | 39 | 42 | 47 | 51 |
| 1.30 | 103 | 8 | 12 | 15 | 18 | 26 | 34 | 39 | 42 | 47 | 51 |
| 1.40 | 96 | 8 | 10 | 13 | 18 | 24 | 32 | 39 | 42 | 47 | 51 |
| 1.50 | 89 | 8 | 10 | 13 | 18 | 24 | 32 | 39 | 42 | 47 | 51 |
| 1.60 | 84 | 8 | 10 | 13 | 16 | 24 | 32 | 39 | 42 | 47 | 51 |
| 1.70 | 79 | 8 | 10 | 13 | 16 | 24 | 32 | 39 | 42 | 47 | 51 |
| 1.80 | 74 | 7 | 8 | 12 | 16 | 24 | 32 | 37 | 42 | 47 | 51 |
| 1.90 | 71 | 7 | 8 | 12 | 15 | 23 | 31 | 37 | 42 | 47 | 51 |
| 2.00 | 67 | 7 | 8 | 12 | 15 | 23 | 31 | 37 | 42 | 47 | 51 |
| 2.10 | 64 | 7 | 8 | 12 | 15 | 23 | 31 | 37 | 42 | 47 | 51 |
| 2.20 | 61 | 7 | 7 | 10 | 15 | 23 | 31 | 37 | 42 | 47 | 51 |
| 2.30 | 58 | 7 | 7 | 10 | 13 | 21 | 31 | 37 | 42 | 47 | 51 |
| 2.40 | 56 | 7 | 7 | 10 | 13 | 21 | 29 | 37 | 42 | 47 | 51 |
| 2.50 | 54 | 7 | 7 | 8 | 13 | 21 | 29 | 37 | 42 | 47 | 51 |
| 2.52 | 53 | 5 | 5 | 8 | 13 | 21 | 29 | 37 | 42 | 47 | 51 |

**Table A4 – Alternate Limiting Temperature 572°F (Imperial)**

| W/D | Hp/A | Min Required Thickness (in.) for Hourly Rating Period (min) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15 | 30 | 45 | 60 | 90 | 120 | 150 | 180 | 240 | 300 |
| 0.33 | 406 | 11/16 | 3/4 | 7/8 | 1 | 1 5/16 | 1 5/8 | NR | NR | NR | NR |
| 0.40 | 335 | 11/16 | 11/16 | 13/16 | 1 | 1 1/4 | 1 9/16 | NR | NR | NR | NR |
| 0.50 | 268 | 5/8 | 5/8 | 13/16 | 15/16 | 1 1/4 | 1 1/2 | NR | NR | NR | NR |
| 0.60 | 223 | 1/2 | 5/8 | 3/4 | 7/8 | 1 3/16 | 1 1/2 | 1 11/16 | NR | NR | NR |
| 0.70 | 191 | 7/16 | 9/16 | 11/16 | 13/16 | 1 1/8 | 1 7/16 | 1 5/8 | 1 3/4 | NR | NR |
| 0.78 | 172 | 3/8 | 1/2 | 11/16 | 13/16 | 1 1/16 | 1 3/8 | 1 9/16 | 1 11/16 | 1 15/16 | NR |
| 0.80 | 167 | 3/8 | 1/2 | 5/8 | 13/16 | 1 1/16 | 1 3/8 | 1 1/2 | 1 5/8 | 1 7/8 | NR |
| 0.84 | 160 | 3/8 | 1/2 | 5/8 | 3/4 | 1 1/16 | 1 3/8 | 1 1/2 | 1 5/8 | 1 13/16 | 2 |
| 0.90 | 149 | 3/8 | 1/2 | 5/8 | 3/4 | 1 1/16 | 1 3/8 | 1 1/2 | 1 5/8 | 1 13/16 | 2 |
| 1.00 | 134 | 3/8 | 7/16 | 5/8 | 3/4 | 1 | 1 5/16 | 1 1/2 | 1 5/8 | 1 13/16 | 2 |
| 1.10 | 122 | 5/16 | 7/16 | 9/16 | 3/4 | 1 | 1 5/16 | 1 1/2 | 1 5/8 | 1 13/16 | 2 |
| 1.20 | 112 | 5/16 | 7/16 | 9/16 | 11/16 | 1 | 1 5/16 | 1 1/2 | 1 5/8 | 1 13/16 | 2 |
| 1.30 | 103 | 5/16 | 7/16 | 9/16 | 11/16 | 1 | 1 5/16 | 1 1/2 | 1 5/8 | 1 13/16 | 2 |
| 1.40 | 96 | 5/16 | 3/8 | 1/2 | 11/16 | 15/16 | 1 1/4 | 1 1/2 | 1 5/8 | 1 13/16 | 2 |
| 1.50 | 89 | 5/16 | 3/8 | 1/2 | 11/16 | 15/16 | 1 1/4 | 1 1/2 | 1 5/8 | 1 13/16 | 2 |
| 1.60 | 84 | 5/16 | 3/8 | 1/2 | 5/8 | 15/16 | 1 1/4 | 1 1/2 | 1 5/8 | 1 13/16 | 2 |
| 1.70 | 79 | 5/16 | 3/8 | 1/2 | 5/8 | 15/16 | 1 1/4 | 1 1/2 | 1 5/8 | 1 13/16 | 2 |
| 1.80 | 74 | 1/4 | 5/16 | 7/16 | 5/8 | 15/16 | 1 1/4 | 1 7/16 | 1 5/8 | 1 13/16 | 2 |
| 1.90 | 71 | 1/4 | 5/16 | 7/16 | 9/16 | 7/8 | 1 3/16 | 1 7/16 | 1 5/8 | 1 13/16 | 2 |
| 2.00 | 67 | 1/4 | 5/16 | 7/16 | 9/16 | 7/8 | 1 3/16 | 1 7/16 | 1 5/8 | 1 13/16 | 2 |
| 2.10 | 64 | 1/4 | 5/16 | 7/16 | 9/16 | 7/8 | 1 3/16 | 1 7/16 | 1 5/8 | 1 13/16 | 2 |
| 2.20 | 61 | 1/4 | 1/4 | 3/8 | 9/16 | 7/8 | 1 3/16 | 1 7/16 | 1 5/8 | 1 13/16 | 2 |
| 2.30 | 58 | 1/4 | 1/4 | 3/8 | 1/2 | 13/16 | 1 3/16 | 1 7/16 | 1 5/8 | 1 13/16 | 2 |
| 2.40 | 56 | 1/4 | 1/4 | 3/8 | 1/2 | 13/16 | 1 1/8 | 1 7/16 | 1 5/8 | 1 13/16 | 2 |
| 2.50 | 54 | 1/4 | 1/4 | 5/16 | 1/2 | 13/16 | 1 1/8 | 1 7/16 | 1 5/8 | 1 13/16 | 2 |
| 2.52 | 53 | 3/16 | 3/16 | 5/16 | 1/2 | 13/16 | 1 1/8 | 1 7/16 | 1 5/8 | 1 13/16 | 2 |

**Table A5 – Alternate Limiting Temperature 350°C (Metric)**

| W/D | Hp/A | Min Required Thickness (mm) for Hourly Rating Period (min) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15 | 30 | 45 | 60 | 90 | 120 | 150 | 180 | 240 | 300 |
| 0.33 | 406 | 18 | 18 | 21 | 24 | 32 | 39 | 45 | NR | NR | NR |
| 0.40 | 335 | 18 | 18 | 21 | 24 | 31 | 37 | 45 | NR | NR | NR |
| 0.50 | 268 | 16 | 16 | 20 | 23 | 29 | 37 | 43 | NR | NR | NR |
| 0.60 | 223 | 15 | 15 | 18 | 21 | 27 | 35 | 42 | 47 | NR | NR |
| 0.70 | 191 | 15 | 15 | 16 | 20 | 26 | 34 | 40 | 43 | NR | NR |
| 0.80 | 167 | 13 | 13 | 16 | 20 | 26 | 32 | 39 | 42 | 48 | NR |
| 0.84 | 160 | 12 | 12 | 15 | 18 | 24 | 32 | 37 | 40 | 47 | 51 |
| 0.90 | 149 | 12 | 12 | 15 | 18 | 24 | 32 | 37 | 40 | 47 | 51 |
| 1.00 | 134 | 12 | 12 | 15 | 18 | 24 | 31 | 37 | 40 | 47 | 51 |
| 1.10 | 122 | 12 | 12 | 15 | 18 | 24 | 31 | 37 | 40 | 47 | 51 |
| 1.20 | 112 | 12 | 12 | 13 | 16 | 23 | 31 | 35 | 40 | 47 | 51 |
| 1.30 | 103 | 10 | 10 | 13 | 16 | 23 | 31 | 35 | 40 | 47 | 51 |
| 1.40 | 96 | 10 | 10 | 13 | 16 | 23 | 29 | 35 | 40 | 47 | 51 |
| 1.50 | 89 | 10 | 10 | 12 | 15 | 23 | 29 | 35 | 40 | 47 | 51 |
| 1.60 | 84 | 10 | 10 | 12 | 15 | 21 | 29 | 35 | 40 | 47 | 51 |
| 1.70 | 79 | 8 | 8 | 12 | 15 | 21 | 27 | 34 | 40 | 47 | 51 |
| 1.80 | 74 | 8 | 8 | 10 | 15 | 21 | 27 | 34 | 40 | 47 | 51 |
| 1.90 | 71 | 8 | 8 | 10 | 13 | 20 | 27 | 34 | 40 | 47 | 51 |
| 2.00 | 67 | 8 | 8 | 10 | 13 | 20 | 27 | 34 | 40 | 47 | 51 |
| 2.10 | 64 | 7 | 7 | 10 | 13 | 20 | 26 | 34 | 40 | 47 | 51 |
| 2.20 | 61 | 7 | 7 | 8 | 12 | 20 | 26 | 32 | 40 | 47 | 51 |
| 2.30 | 58 | 7 | 7 | 8 | 12 | 18 | 26 | 32 | 40 | 47 | 51 |
| 2.40 | 56 | 7 | 7 | 8 | 12 | 18 | 26 | 32 | 40 | 47 | 51 |
| 2.50 | 54 | 7 | 7 | 7 | 10 | 18 | 24 | 32 | 40 | 47 | 51 |
| 2.52 | 53 | 5 | 5 | 7 | 10 | 18 | 24 | 32 | 40 | 47 | 51 |

**Table A6 – Alternate Limiting Temperature 662°F (Imperial)**

| W/D | Hp/A | Min Required Thickness (in.) for Hourly Rating Period (min) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15 | 30 | 45 | 60 | 90 | 120 | 150 | 180 | 240 | 300 |
| 0.33 | 406 | 11/16 | 11/16 | 13/16 | 15/16 | 1 1/4 | 1 1/2 | 1 3/4 | NR | NR | NR |
| 0.40 | 335 | 11/16 | 11/16 | 13/16 | 15/16 | 1 3/16 | 1 7/16 | 1 3/4 | NR | NR | NR |
| 0.50 | 268 | 5/8 | 5/8 | 3/4 | 7/8 | 1 1/8 | 1 7/16 | 1 11/16 | NR | NR | NR |
| 0.60 | 223 | 9/16 | 9/16 | 11/16 | 13/16 | 1 1/16 | 1 3/8 | 1 5/8 | 1 13/16 | NR | NR |
| 0.70 | 191 | 9/16 | 9/16 | 5/8 | 3/4 | 1 | 1 5/16 | 1 9/16 | 1 11/16 | NR | NR |
| 0.80 | 167 | 1/2 | 1/2 | 5/8 | 3/4 | 1 | 1 1/4 | 1 1/2 | 1 5/8 | 1 7/8 | NR |
| 0.84 | 160 | 7/16 | 7/16 | 9/16 | 11/16 | 15/16 | 1 1/4 | 1 7/16 | 1 9/16 | 1 13/16 | 2 |
| 0.90 | 149 | 7/16 | 7/16 | 9/16 | 11/16 | 15/16 | 1 1/4 | 1 7/16 | 1 9/16 | 1 13/16 | 2 |
| 1.00 | 134 | 7/16 | 7/16 | 9/16 | 11/16 | 15/16 | 1 3/16 | 1 7/16 | 1 9/16 | 1 13/16 | 2 |
| 1.10 | 122 | 7/16 | 7/16 | 9/16 | 11/16 | 15/16 | 1 3/16 | 1 7/16 | 1 9/16 | 1 13/16 | 2 |
| 1.20 | 112 | 7/16 | 7/16 | 1/2 | 5/8 | 7/8 | 1 3/16 | 1 3/8 | 1 9/16 | 1 13/16 | 2 |
| 1.30 | 103 | 3/8 | 3/8 | 1/2 | 5/8 | 7/8 | 1 3/16 | 1 3/8 | 1 9/16 | 1 13/16 | 2 |
| 1.40 | 96 | 3/8 | 3/8 | 1/2 | 5/8 | 7/8 | 1 1/8 | 1 3/8 | 1 9/16 | 1 13/16 | 2 |
| 1.50 | 89 | 3/8 | 3/8 | 7/16 | 9/16 | 7/8 | 1 1/8 | 1 3/8 | 1 9/16 | 1 13/16 | 2 |
| 1.60 | 84 | 3/8 | 3/8 | 7/16 | 9/16 | 13/16 | 1 1/8 | 1 3/8 | 1 9/16 | 1 13/16 | 2 |
| 1.70 | 79 | 5/16 | 5/16 | 7/16 | 9/16 | 13/16 | 1 1/16 | 1 5/16 | 1 9/16 | 1 13/16 | 2 |
| 1.80 | 74 | 5/16 | 5/16 | 3/8 | 9/16 | 13/16 | 1 1/16 | 1 5/16 | 1 9/16 | 1 13/16 | 2 |
| 1.90 | 71 | 5/16 | 5/16 | 3/8 | 1/2 | 3/4 | 1 1/16 | 1 5/16 | 1 9/16 | 1 13/16 | 2 |
| 2.00 | 67 | 5/16 | 5/16 | 3/8 | 1/2 | 3/4 | 1 1/16 | 1 5/16 | 1 9/16 | 1 13/16 | 2 |
| 2.10 | 64 | 1/4 | 1/4 | 3/8 | 1/2 | 3/4 | 1 | 1 5/16 | 1 9/16 | 1 13/16 | 2 |
| 2.20 | 61 | 1/4 | 1/4 | 5/16 | 7/16 | 3/4 | 1 | 1 1/4 | 1 9/16 | 1 13/16 | 2 |
| 2.30 | 58 | 1/4 | 1/4 | 5/16 | 7/16 | 11/16 | 1 | 1 1/4 | 1 9/16 | 1 13/16 | 2 |
| 2.40 | 56 | 1/4 | 1/4 | 5/16 | 7/16 | 11/16 | 1 | 1 1/4 | 1 9/16 | 1 13/16 | 2 |
| 2.50 | 54 | 1/4 | 1/4 | 1/4 | 3/8 | 11/16 | 15/16 | 1 1/4 | 1 9/16 | 1 13/16 | 2 |
| 2.52 | 53 | 3/16 | 3/16 | 1/4 | 3/8 | 11/16 | 15/16 | 1 1/4 | 1 9/16 | 1 13/16 | 2 |

**Table A7 – Alternate Limiting Temperature 400°C (Metric)**

| W/D | Hp/A | Min Required Thickness (mm) for Hourly Rating Period (min) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15 | 30 | 45 | 60 | 90 | 120 | 150 | 180 | 240 | 300 |
| 0.33 | 406 | 18 | 18 | 21 | 24 | 31 | 37 | 43 | NR | NR | NR |
| 0.40 | 335 | 18 | 18 | 20 | 23 | 29 | 35 | 42 | NR | NR | NR |
| 0.50 | 268 | 16 | 16 | 18 | 21 | 27 | 34 | 40 | NR | NR | NR |
| 0.60 | 223 | 15 | 15 | 18 | 21 | 26 | 32 | 39 | 43 | NR | NR |
| 0.70 | 191 | 13 | 13 | 16 | 20 | 24 | 31 | 39 | 42 | NR | NR |
| 0.80 | 167 | 12 | 12 | 15 | 18 | 24 | 31 | 37 | 40 | 47 | NR |
| 0.84 | 160 | 12 | 12 | 15 | 18 | 23 | 29 | 35 | 39 | 45 | NR |
| 0.90 | 149 | 12 | 12 | 15 | 16 | 23 | 29 | 35 | 39 | 45 | 51 |
| 1.00 | 134 | 12 | 12 | 13 | 16 | 23 | 29 | 35 | 39 | 45 | 51 |
| 1.10 | 122 | 10 | 10 | 13 | 16 | 21 | 27 | 35 | 39 | 45 | 51 |
| 1.20 | 112 | 10 | 10 | 13 | 15 | 21 | 27 | 34 | 39 | 45 | 51 |
| 1.30 | 103 | 10 | 10 | 12 | 15 | 21 | 27 | 34 | 37 | 45 | 51 |
| 1.40 | 96 | 10 | 10 | 12 | 15 | 20 | 26 | 34 | 37 | 45 | 51 |
| 1.50 | 89 | 10 | 10 | 12 | 13 | 20 | 26 | 32 | 37 | 45 | 51 |
| 1.60 | 84 | 8 | 8 | 10 | 13 | 20 | 26 | 32 | 37 | 45 | 51 |
| 1.70 | 79 | 8 | 8 | 10 | 13 | 20 | 26 | 32 | 37 | 45 | 51 |
| 1.80 | 74 | 8 | 8 | 10 | 12 | 18 | 24 | 31 | 35 | 45 | 51 |
| 1.90 | 71 | 8 | 8 | 8 | 12 | 18 | 24 | 31 | 35 | 45 | 51 |
| 2.00 | 67 | 8 | 8 | 8 | 12 | 18 | 24 | 31 | 35 | 45 | 51 |
| 2.10 | 64 | 7 | 7 | 8 | 10 | 16 | 23 | 29 | 35 | 45 | 51 |
| 2.20 | 61 | 7 | 7 | 8 | 10 | 16 | 23 | 29 | 35 | 45 | 51 |
| 2.30 | 58 | 7 | 7 | 7 | 10 | 16 | 23 | 29 | 34 | 45 | 51 |
| 2.40 | 56 | 7 | 7 | 7 | 8 | 15 | 21 | 27 | 34 | 45 | 51 |
| 2.50 | 54 | 7 | 7 | 7 | 8 | 15 | 21 | 27 | 34 | 45 | 51 |
| 2.52 | 53 | 5 | 5 | 5 | 8 | 15 | 21 | 27 | 34 | 45 | 51 |

**Table A8 – Alternate Limiting Temperature 752°F (Imperial)**

| W/D | Hp/A | Min Required Thickness (in.) for Hourly Rating Period (min) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15 | 30 | 45 | 60 | 90 | 120 | 150 | 180 | 240 | 300 |
| 0.33 | 406 | 11/16 | 11/16 | 13/16 | 15/16 | 1 3/16 | 1 7/16 | 1 11/16 | NR | NR | NR |
| 0.40 | 335 | 11/16 | 11/16 | 3/4 | 7/8 | 1 1/8 | 1 3/8 | 1 5/8 | NR | NR | NR |
| 0.50 | 268 | 5/8 | 5/8 | 11/16 | 13/16 | 1 1/16 | 1 5/16 | 1 9/16 | NR | NR | NR |
| 0.60 | 223 | 9/16 | 9/16 | 11/16 | 13/16 | 1 | 1 1/4 | 1 1/2 | 1 11/16 | NR | NR |
| 0.70 | 191 | 1/2 | 1/2 | 5/8 | 3/4 | 15/16 | 1 3/16 | 1 1/2 | 1 5/8 | NR | NR |
| 0.80 | 167 | 7/16 | 7/16 | 9/16 | 11/16 | 15/16 | 1 3/16 | 1 7/16 | 1 9/16 | 1 13/16 | NR |
| 0.84 | 160 | 7/16 | 7/16 | 9/16 | 11/16 | 7/8 | 1 1/8 | 1 3/8 | 1 1/2 | 1 3/4 | NR |
| 0.90 | 149 | 7/16 | 7/16 | 9/16 | 5/8 | 7/8 | 1 1/8 | 1 3/8 | 1 1/2 | 1 3/4 | 2 |
| 1.00 | 134 | 7/16 | 7/16 | 1/2 | 5/8 | 7/8 | 1 1/8 | 1 3/8 | 1 1/2 | 1 3/4 | 2 |
| 1.10 | 122 | 3/8 | 3/8 | 1/2 | 5/8 | 13/16 | 1 1/16 | 1 3/8 | 1 1/2 | 1 3/4 | 2 |
| 1.20 | 112 | 3/8 | 3/8 | 1/2 | 9/16 | 13/16 | 1 1/16 | 1 5/16 | 1 1/2 | 1 3/4 | 2 |
| 1.30 | 103 | 3/8 | 3/8 | 7/16 | 9/16 | 13/16 | 1 1/16 | 1 5/16 | 1 7/16 | 1 3/4 | 2 |
| 1.40 | 96 | 3/8 | 3/8 | 7/16 | 9/16 | 3/4 | 1 | 1 5/16 | 1 7/16 | 1 3/4 | 2 |
| 1.50 | 89 | 3/8 | 3/8 | 7/16 | 1/2 | 3/4 | 1 | 1 1/4 | 1 7/16 | 1 3/4 | 2 |
| 1.60 | 84 | 5/16 | 5/16 | 3/8 | 1/2 | 3/4 | 1 | 1 1/4 | 1 7/16 | 1 3/4 | 2 |
| 1.70 | 79 | 5/16 | 5/16 | 3/8 | 1/2 | 3/4 | 1 | 1 1/4 | 1 7/16 | 1 3/4 | 2 |
| 1.80 | 74 | 5/16 | 5/16 | 3/8 | 7/16 | 11/16 | 15/16 | 1 3/16 | 1 3/8 | 1 3/4 | 2 |
| 1.90 | 71 | 5/16 | 5/16 | 5/16 | 7/16 | 11/16 | 15/16 | 1 3/16 | 1 3/8 | 1 3/4 | 2 |
| 2.00 | 67 | 5/16 | 5/16 | 5/16 | 7/16 | 11/16 | 15/16 | 1 3/16 | 1 3/8 | 1 3/4 | 2 |
| 2.10 | 64 | 1/4 | 1/4 | 5/16 | 3/8 | 5/8 | 7/8 | 1 1/8 | 1 3/8 | 1 3/4 | 2 |
| 2.20 | 61 | 1/4 | 1/4 | 5/16 | 3/8 | 5/8 | 7/8 | 1 1/8 | 1 3/8 | 1 3/4 | 2 |
| 2.30 | 58 | 1/4 | 1/4 | 1/4 | 3/8 | 5/8 | 7/8 | 1 1/8 | 1 5/16 | 1 3/4 | 2 |
| 2.40 | 56 | 1/4 | 1/4 | 1/4 | 5/16 | 9/16 | 13/16 | 1 1/16 | 1 5/16 | 1 3/4 | 2 |
| 2.50 | 54 | 1/4 | 1/4 | 1/4 | 5/16 | 9/16 | 13/16 | 1 1/16 | 1 5/16 | 1 3/4 | 2 |
| 2.52 | 53 | 3/16 | 3/16 | 3/16 | 5/16 | 9/16 | 13/16 | 1 1/16 | 1 5/16 | 1 3/4 | 2 |

**Table A9 – Alternate Limiting Temperature 427°C (Metric)**

| W/D | Hp/A | Min Required Thickness (mm) for Hourly Rating Period (min) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15 | 30 | 45 | 60 | 90 | 120 | 150 | 180 | 240 | 300 |
| 0.33 | 406 | 18 | 18 | 21 | 24 | 29 | 35 | 42 | NR | NR | NR |
| 0.40 | 335 | 18 | 18 | 20 | 23 | 29 | 35 | 42 | NR | NR | NR |
| 0.50 | 268 | 16 | 16 | 18 | 21 | 27 | 34 | 40 | 45 | NR | NR |
| 0.60 | 223 | 15 | 15 | 16 | 20 | 26 | 32 | 39 | 43 | NR | NR |
| 0.70 | 191 | 13 | 13 | 16 | 18 | 24 | 31 | 37 | 42 | NR | NR |
| 0.80 | 167 | 12 | 12 | 15 | 18 | 23 | 29 | 35 | 40 | 47 | NR |
| 0.84 | 160 | 12 | 12 | 15 | 16 | 23 | 29 | 35 | 39 | 45 | 51 |
| 0.90 | 149 | 12 | 12 | 13 | 16 | 21 | 27 | 34 | 39 | 45 | 51 |
| 1.00 | 134 | 10 | 10 | 13 | 16 | 21 | 27 | 34 | 39 | 45 | 51 |
| 1.10 | 122 | 10 | 10 | 13 | 15 | 21 | 27 | 34 | 37 | 45 | 51 |
| 1.20 | 112 | 10 | 10 | 12 | 15 | 21 | 26 | 32 | 37 | 45 | 51 |
| 1.30 | 103 | 10 | 10 | 12 | 15 | 20 | 26 | 32 | 37 | 45 | 51 |
| 1.40 | 96 | 10 | 10 | 12 | 13 | 20 | 26 | 32 | 35 | 45 | 51 |
| 1.50 | 89 | 8 | 8 | 12 | 13 | 20 | 24 | 31 | 35 | 45 | 51 |
| 1.60 | 84 | 8 | 8 | 10 | 13 | 18 | 24 | 31 | 35 | 45 | 51 |
| 1.70 | 79 | 8 | 8 | 10 | 12 | 18 | 24 | 31 | 35 | 45 | 51 |
| 1.80 | 74 | 8 | 8 | 10 | 12 | 18 | 23 | 29 | 34 | 45 | 51 |
| 1.90 | 71 | 8 | 8 | 8 | 12 | 16 | 23 | 29 | 34 | 45 | 51 |
| 2.00 | 67 | 8 | 8 | 8 | 10 | 16 | 23 | 27 | 34 | 45 | 51 |
| 2.10 | 64 | 7 | 7 | 8 | 10 | 16 | 21 | 27 | 32 | 45 | 51 |
| 2.20 | 61 | 7 | 7 | 7 | 10 | 15 | 21 | 27 | 32 | 45 | 51 |
| 2.30 | 58 | 7 | 7 | 7 | 8 | 15 | 21 | 26 | 32 | 45 | 51 |
| 2.40 | 56 | 7 | 7 | 7 | 8 | 15 | 20 | 26 | 32 | 45 | 51 |
| 2.50 | 54 | 7 | 7 | 7 | 8 | 13 | 20 | 26 | 31 | 45 | 51 |
| 2.52 | 53 | 5 | 5 | 5 | 8 | 13 | 20 | 26 | 31 | 45 | 51 |

**Table A10 – Alternate Limiting Temperature 800.6°F (Imperial)**

| W/D | Hp/A | Min Required Thickness (in.) for Hourly Rating Period (min) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15 | 30 | 45 | 60 | 90 | 120 | 150 | 180 | 240 | 300 |
| 0.33 | 406 | 11/16 | 11/16 | 13/16 | 15/16 | 1 1/8 | 1 3/8 | 1 5/8 | NR | NR | NR |
| 0.40 | 335 | 11/16 | 11/16 | 3/4 | 7/8 | 1 1/8 | 1 3/8 | 1 5/8 | NR | NR | NR |
| 0.50 | 268 | 5/8 | 5/8 | 11/16 | 13/16 | 1 1/16 | 1 5/16 | 1 9/16 | 1 3/4 | NR | NR |
| 0.60 | 223 | 9/16 | 9/16 | 5/8 | 3/4 | 1 | 1 1/4 | 1 1/2 | 1 11/16 | NR | NR |
| 0.70 | 191 | 1/2 | 1/2 | 5/8 | 11/16 | 15/16 | 1 3/16 | 1 7/16 | 1 5/8 | NR | NR |
| 0.80 | 167 | 7/16 | 7/16 | 9/16 | 11/16 | 7/8 | 1 1/8 | 1 3/8 | 1 9/16 | 1 13/16 | NR |
| 0.84 | 160 | 7/16 | 7/16 | 9/16 | 5/8 | 7/8 | 1 1/8 | 1 3/8 | 1 1/2 | 1 3/4 | 2 |
| 0.90 | 149 | 7/16 | 7/16 | 1/2 | 5/8 | 13/16 | 1 1/16 | 1 5/16 | 1 1/2 | 1 3/4 | 2 |
| 1.00 | 134 | 3/8 | 3/8 | 1/2 | 5/8 | 13/16 | 1 1/16 | 1 5/16 | 1 1/2 | 1 3/4 | 2 |
| 1.10 | 122 | 3/8 | 3/8 | 1/2 | 9/16 | 13/16 | 1 1/16 | 1 5/16 | 1 7/16 | 1 3/4 | 2 |
| 1.20 | 112 | 3/8 | 3/8 | 7/16 | 9/16 | 13/16 | 1 | 1 1/4 | 1 7/16 | 1 3/4 | 2 |
| 1.30 | 103 | 3/8 | 3/8 | 7/16 | 9/16 | 3/4 | 1 | 1 1/4 | 1 7/16 | 1 3/4 | 2 |
| 1.40 | 96 | 3/8 | 3/8 | 7/16 | 1/2 | 3/4 | 1 | 1 1/4 | 1 3/8 | 1 3/4 | 2 |
| 1.50 | 89 | 5/16 | 5/16 | 7/16 | 1/2 | 3/4 | 15/16 | 1 3/16 | 1 3/8 | 1 3/4 | 2 |
| 1.60 | 84 | 5/16 | 5/16 | 3/8 | 1/2 | 11/16 | 15/16 | 1 3/16 | 1 3/8 | 1 3/4 | 2 |
| 1.70 | 79 | 5/16 | 5/16 | 3/8 | 7/16 | 11/16 | 15/16 | 1 3/16 | 1 3/8 | 1 3/4 | 2 |
| 1.80 | 74 | 5/16 | 5/16 | 3/8 | 7/16 | 11/16 | 7/8 | 1 1/8 | 1 5/16 | 1 3/4 | 2 |
| 1.90 | 71 | 5/16 | 5/16 | 5/16 | 7/16 | 5/8 | 7/8 | 1 1/8 | 1 5/16 | 1 3/4 | 2 |
| 2.00 | 67 | 5/16 | 5/16 | 5/16 | 3/8 | 5/8 | 7/8 | 1 1/16 | 1 5/16 | 1 3/4 | 2 |
| 2.10 | 64 | 1/4 | 1/4 | 5/16 | 3/8 | 5/8 | 13/16 | 1 1/16 | 1 1/4 | 1 3/4 | 2 |
| 2.20 | 61 | 1/4 | 1/4 | 1/4 | 3/8 | 9/16 | 13/16 | 1 1/16 | 1 1/4 | 1 3/4 | 2 |
| 2.30 | 58 | 1/4 | 1/4 | 1/4 | 5/16 | 9/16 | 13/16 | 1 | 1 1/4 | 1 3/4 | 2 |
| 2.40 | 56 | 1/4 | 1/4 | 1/4 | 5/16 | 9/16 | 3/4 | 1 | 1 1/4 | 1 3/4 | 2 |
| 2.50 | 54 | 1/4 | 1/4 | 1/4 | 5/16 | 1/2 | 3/4 | 1 | 1 3/16 | 1 3/4 | 2 |
| 2.52 | 53 | 3/16 | 3/16 | 3/16 | 5/16 | 1/2 | 3/4 | 1 | 1 3/16 | 1 3/4 | 2 |

**Table A11 – Alternate Limiting Temperature 450°C (Metric)**

| W/D | Hp/A | Min Required Thickness (mm) for Hourly Rating Period (min) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15 | 30 | 45 | 60 | 90 | 120 | 150 | 180 | 240 | 300 |
| 0.33 | 406 | 18 | 18 | 20 | 23 | 29 | 35 | 40 | NR | NR | NR |
| 0.45 | 298 | 16 | 16 | 18 | 21 | 27 | 34 | 39 | 45 | NR | NR |
| 0.50 | 268 | 16 | 16 | 18 | 21 | 26 | 32 | 39 | 43 | NR | NR |
| 0.60 | 223 | 15 | 15 | 16 | 20 | 26 | 31 | 37 | 42 | NR | NR |
| 0.70 | 191 | 13 | 13 | 15 | 18 | 24 | 29 | 35 | 40 | NR | NR |
| 0.80 | 167 | 12 | 12 | 15 | 16 | 23 | 27 | 34 | 39 | 47 | NR |
| 0.84 | 160 | 12 | 12 | 13 | 16 | 21 | 27 | 34 | 39 | 45 | 51 |
| 0.90 | 149 | 10 | 10 | 13 | 16 | 21 | 27 | 32 | 37 | 45 | 51 |
| 1.00 | 134 | 10 | 10 | 13 | 15 | 21 | 26 | 32 | 37 | 45 | 51 |
| 1.10 | 122 | 10 | 10 | 13 | 15 | 20 | 26 | 32 | 37 | 45 | 51 |
| 1.20 | 112 | 10 | 10 | 12 | 15 | 20 | 26 | 31 | 35 | 43 | 51 |
| 1.30 | 103 | 10 | 10 | 12 | 13 | 20 | 24 | 31 | 35 | 43 | 51 |
| 1.40 | 96 | 10 | 10 | 12 | 13 | 18 | 24 | 31 | 35 | 43 | 51 |
| 1.50 | 89 | 8 | 8 | 10 | 13 | 18 | 24 | 29 | 34 | 43 | 51 |
| 1.60 | 84 | 8 | 8 | 10 | 12 | 18 | 23 | 29 | 34 | 43 | 51 |
| 1.70 | 79 | 8 | 8 | 10 | 12 | 16 | 23 | 27 | 34 | 43 | 51 |
| 1.80 | 74 | 8 | 8 | 10 | 12 | 16 | 21 | 27 | 32 | 42 | 51 |
| 1.90 | 71 | 8 | 8 | 8 | 10 | 16 | 21 | 27 | 32 | 42 | 51 |
| 2.00 | 67 | 7 | 7 | 8 | 10 | 15 | 21 | 26 | 32 | 42 | 51 |
| 2.10 | 64 | 7 | 7 | 8 | 8 | 15 | 20 | 26 | 31 | 42 | 51 |
| 2.20 | 61 | 7 | 7 | 7 | 8 | 15 | 20 | 26 | 31 | 42 | 51 |
| 2.30 | 58 | 7 | 7 | 7 | 8 | 13 | 20 | 24 | 31 | 40 | 51 |
| 2.35 | 57 | 7 | 7 | 7 | 8 | 13 | 20 | 24 | 29 | 40 | 51 |
| 2.40 | 56 | 7 | 7 | 7 | 7 | 13 | 18 | 24 | 29 | 40 | 51 |
| 2.50 | 54 | 7 | 7 | 7 | 7 | 13 | 18 | 23 | 29 | 40 | 51 |
| 2.52 | 53 | 5 | 5 | 5 | 7 | 12 | 18 | 23 | 29 | 40 | 51 |

**Table A12 – Alternate Limiting Temperature 842°F (Imperial)**

| W/D | Hp/A | Min Required Thickness (in.) for Hourly Rating Period (min) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15 | 30 | 45 | 60 | 90 | 120 | 150 | 180 | 240 | 300 |
| 0.33 | 406 | 18 | 18 | 20 | 23 | 29 | 35 | 40 | NR | NR | NR |
| 0.45 | 298 | 16 | 16 | 18 | 21 | 27 | 34 | 39 | 45 | NR | NR |
| 0.50 | 268 | 16 | 16 | 18 | 21 | 26 | 32 | 39 | 43 | NR | NR |
| 0.60 | 223 | 15 | 15 | 16 | 20 | 26 | 31 | 37 | 42 | NR | NR |
| 0.70 | 191 | 13 | 13 | 15 | 18 | 24 | 29 | 35 | 40 | NR | NR |
| 0.80 | 167 | 12 | 12 | 15 | 16 | 23 | 27 | 34 | 39 | 47 | NR |
| 0.84 | 160 | 12 | 12 | 13 | 16 | 21 | 27 | 34 | 39 | 45 | 51 |
| 0.90 | 149 | 10 | 10 | 13 | 16 | 21 | 27 | 32 | 37 | 45 | 51 |
| 1.00 | 134 | 10 | 10 | 13 | 15 | 21 | 26 | 32 | 37 | 45 | 51 |
| 1.10 | 122 | 10 | 10 | 13 | 15 | 20 | 26 | 32 | 37 | 45 | 51 |
| 1.20 | 112 | 10 | 10 | 12 | 15 | 20 | 26 | 31 | 35 | 43 | 51 |
| 1.30 | 103 | 10 | 10 | 12 | 13 | 20 | 24 | 31 | 35 | 43 | 51 |
| 1.40 | 96 | 10 | 10 | 12 | 13 | 18 | 24 | 31 | 35 | 43 | 51 |
| 1.50 | 89 | 8 | 8 | 10 | 13 | 18 | 24 | 29 | 34 | 43 | 51 |
| 1.60 | 84 | 8 | 8 | 10 | 12 | 18 | 23 | 29 | 34 | 43 | 51 |
| 1.70 | 79 | 8 | 8 | 10 | 12 | 16 | 23 | 27 | 34 | 43 | 51 |
| 1.80 | 74 | 8 | 8 | 10 | 12 | 16 | 21 | 27 | 32 | 42 | 51 |
| 1.90 | 71 | 8 | 8 | 8 | 10 | 16 | 21 | 27 | 32 | 42 | 51 |
| 2.00 | 67 | 7 | 7 | 8 | 10 | 15 | 21 | 26 | 32 | 42 | 51 |
| 2.10 | 64 | 7 | 7 | 8 | 8 | 15 | 20 | 26 | 31 | 42 | 51 |
| 2.20 | 61 | 7 | 7 | 7 | 8 | 15 | 20 | 26 | 31 | 42 | 51 |
| 2.30 | 58 | 7 | 7 | 7 | 8 | 13 | 20 | 24 | 31 | 40 | 51 |
| 2.35 | 57 | 7 | 7 | 7 | 8 | 13 | 20 | 24 | 29 | 40 | 51 |
| 2.40 | 56 | 7 | 7 | 7 | 7 | 13 | 18 | 24 | 29 | 40 | 51 |
| 2.50 | 54 | 7 | 7 | 7 | 7 | 13 | 18 | 23 | 29 | 40 | 51 |
| 2.52 | 53 | 5 | 5 | 5 | 7 | 12 | 18 | 23 | 29 | 40 | 51 |

**Table A13 – Alternate Limiting Temperature 500°C (Metric)**

| W/D | Hp/A | Min Required Thickness (mm) for Hourly Rating Period (min) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15 | 30 | 45 | 60 | 90 | 120 | 150 | 180 | 240 | 300 |
| 0.33 | 406 | 18 | 18 | 20 | 23 | 27 | 34 | 39 | 45 | NR | NR |
| 0.40 | 335 | 18 | 18 | 18 | 21 | 27 | 32 | 39 | 43 | NR | NR |
| 0.50 | 268 | 16 | 16 | 18 | 20 | 26 | 31 | 37 | 42 | NR | NR |
| 0.60 | 223 | 15 | 15 | 16 | 18 | 24 | 29 | 35 | 40 | NR | NR |
| 0.70 | 191 | 13 | 13 | 15 | 18 | 23 | 27 | 34 | 39 | 48 | NR |
| 0.80 | 167 | 12 | 12 | 13 | 16 | 21 | 26 | 32 | 37 | 45 | NR |
| 0.84 | 160 | 10 | 10 | 13 | 15 | 20 | 26 | 31 | 37 | 45 | 51 |
| 0.90 | 149 | 10 | 10 | 13 | 15 | 20 | 24 | 31 | 35 | 43 | 51 |
| 1.00 | 134 | 10 | 10 | 12 | 15 | 20 | 24 | 29 | 35 | 43 | 51 |
| 1.10 | 122 | 10 | 10 | 12 | 13 | 20 | 24 | 29 | 35 | 43 | 51 |
| 1.20 | 112 | 10 | 10 | 12 | 13 | 18 | 23 | 29 | 34 | 42 | 51 |
| 1.30 | 103 | 10 | 10 | 12 | 13 | 18 | 23 | 27 | 34 | 42 | 51 |
| 1.40 | 96 | 8 | 8 | 10 | 12 | 16 | 21 | 27 | 32 | 42 | 51 |
| 1.50 | 89 | 8 | 8 | 10 | 12 | 16 | 21 | 26 | 32 | 40 | 51 |
| 1.60 | 84 | 8 | 8 | 10 | 12 | 16 | 21 | 26 | 31 | 40 | 51 |
| 1.70 | 79 | 8 | 8 | 10 | 10 | 15 | 20 | 26 | 31 | 39 | 51 |
| 1.80 | 74 | 8 | 8 | 8 | 10 | 15 | 20 | 24 | 29 | 39 | 51 |
| 1.90 | 71 | 8 | 8 | 8 | 10 | 13 | 20 | 24 | 29 | 39 | 51 |
| 2.00 | 67 | 7 | 7 | 8 | 8 | 13 | 18 | 23 | 29 | 37 | 51 |
| 2.10 | 64 | 7 | 7 | 8 | 8 | 13 | 18 | 23 | 27 | 37 | 51 |
| 2.20 | 61 | 7 | 7 | 7 | 8 | 12 | 16 | 23 | 27 | 37 | 51 |
| 2.30 | 58 | 7 | 7 | 7 | 7 | 12 | 16 | 21 | 26 | 35 | 51 |
| 2.40 | 56 | 7 | 7 | 7 | 7 | 12 | 16 | 21 | 26 | 35 | 51 |
| 2.50 | 54 | 7 | 7 | 7 | 7 | 10 | 15 | 20 | 24 | 35 | 51 |
| 2.52 | 53 | 5 | 5 | 5 | 5 | 10 | 15 | 20 | 24 | 35 | 51 |

**Table A14 – Alternate Limiting Temperature 932°F (Imperial)**

| W/D | Hp/A | Min Required Thickness (in.) for Hourly Rating Period (min) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15 | 30 | 45 | 60 | 90 | 120 | 150 | 180 | 240 | 300 |
| 0.33 | 406 | 11/16 | 11/16 | 3/4 | 7/8 | 1 1/16 | 1 5/16 | 1 1/2 | 1 3/4 | NR | NR |
| 0.40 | 335 | 11/16 | 11/16 | 11/16 | 13/16 | 1 1/16 | 1 1/4 | 1 1/2 | 1 11/16 | NR | NR |
| 0.50 | 268 | 5/8 | 5/8 | 11/16 | 3/4 | 1 | 1 3/16 | 1 7/16 | 1 5/8 | NR | NR |
| 0.60 | 223 | 9/16 | 9/16 | 5/8 | 11/16 | 15/16 | 1 1/8 | 1 3/8 | 1 9/16 | NR | NR |
| 0.70 | 191 | 1/2 | 1/2 | 9/16 | 11/16 | 7/8 | 1 1/16 | 1 5/16 | 1 1/2 | 1 7/8 | NR |
| 0.80 | 167 | 7/16 | 7/16 | 1/2 | 5/8 | 13/16 | 1 | 1 1/4 | 1 7/16 | 1 3/4 | NR |
| 0.84 | 160 | 3/8 | 3/8 | 1/2 | 9/16 | 3/4 | 1 | 1 3/16 | 1 7/16 | 1 3/4 | 2 |
| 0.90 | 149 | 3/8 | 3/8 | 1/2 | 9/16 | 3/4 | 15/16 | 1 3/16 | 1 3/8 | 1 11/16 | 2 |
| 1.00 | 134 | 3/8 | 3/8 | 7/16 | 9/16 | 3/4 | 15/16 | 1 1/8 | 1 3/8 | 1 11/16 | 2 |
| 1.10 | 122 | 3/8 | 3/8 | 7/16 | 1/2 | 3/4 | 15/16 | 1 1/8 | 1 3/8 | 1 11/16 | 2 |
| 1.20 | 112 | 3/8 | 3/8 | 7/16 | 1/2 | 11/16 | 7/8 | 1 1/8 | 1 5/16 | 1 5/8 | 2 |
| 1.30 | 103 | 3/8 | 3/8 | 7/16 | 1/2 | 11/16 | 7/8 | 1 1/16 | 1 5/16 | 1 5/8 | 2 |
| 1.40 | 96 | 5/16 | 5/16 | 3/8 | 7/16 | 5/8 | 13/16 | 1 1/16 | 1 1/4 | 1 5/8 | 2 |
| 1.50 | 89 | 5/16 | 5/16 | 3/8 | 7/16 | 5/8 | 13/16 | 1 | 1 1/4 | 1 9/16 | 2 |
| 1.60 | 84 | 5/16 | 5/16 | 3/8 | 7/16 | 5/8 | 13/16 | 1 | 1 3/16 | 1 9/16 | 2 |
| 1.70 | 79 | 5/16 | 5/16 | 3/8 | 3/8 | 9/16 | 3/4 | 1 | 1 3/16 | 1 1/2 | 2 |
| 1.80 | 74 | 5/16 | 5/16 | 5/16 | 3/8 | 9/16 | 3/4 | 15/16 | 1 1/8 | 1 1/2 | 2 |
| 1.90 | 71 | 5/16 | 5/16 | 5/16 | 3/8 | 1/2 | 3/4 | 15/16 | 1 1/8 | 1 1/2 | 2 |
| 2.00 | 67 | 1/4 | 1/4 | 5/16 | 5/16 | 1/2 | 11/16 | 7/8 | 1 1/8 | 1 7/16 | 2 |
| 2.10 | 64 | 1/4 | 1/4 | 5/16 | 5/16 | 1/2 | 11/16 | 7/8 | 1 1/16 | 1 7/16 | 2 |
| 2.20 | 61 | 1/4 | 1/4 | 1/4 | 5/16 | 7/16 | 5/8 | 7/8 | 1 1/16 | 1 7/16 | 2 |
| 2.30 | 58 | 1/4 | 1/4 | 1/4 | 1/4 | 7/16 | 5/8 | 13/16 | 1 | 1 3/8 | 2 |
| 2.40 | 56 | 1/4 | 1/4 | 1/4 | 1/4 | 7/16 | 5/8 | 13/16 | 1 | 1 3/8 | 2 |
| 2.50 | 54 | 1/4 | 1/4 | 1/4 | 1/4 | 3/8 | 9/16 | 3/4 | 15/16 | 1 3/8 | 2 |
| 2.52 | 53 | 3/16 | 3/16 | 3/16 | 3/16 | 3/8 | 9/16 | 3/4 | 15/16 | 1 3/8 | 2 |

**Table A15 – Alternate Limiting Temperature 550°C (Metric)**

| W/D | Hp/A | Min Required Thickness (mm) for Hourly Rating Period (min) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15 | 30 | 45 | 60 | 90 | 120 | 150 | 180 | 240 | 300 |
| 0.33 | 406 | 18 | 18 | 18 | 21 | 27 | 32 | 37 | 43 | NR | NR |
| 0.40 | 335 | 18 | 18 | 18 | 21 | 26 | 31 | 37 | 42 | NR | NR |
| 0.50 | 268 | 16 | 16 | 16 | 20 | 24 | 29 | 34 | 40 | NR | NR |
| 0.60 | 223 | 15 | 15 | 15 | 18 | 23 | 27 | 32 | 39 | NR | NR |
| 0.70 | 191 | 13 | 13 | 13 | 16 | 21 | 26 | 31 | 37 | 47 | NR |
| 0.80 | 167 | 13 | 13 | 13 | 15 | 20 | 24 | 29 | 34 | 43 | NR |
| 0.84 | 160 | 12 | 12 | 12 | 15 | 20 | 24 | 29 | 34 | 43 | 51 |
| 0.90 | 149 | 12 | 12 | 12 | 15 | 18 | 23 | 27 | 34 | 43 | 51 |
| 1.00 | 134 | 12 | 12 | 12 | 13 | 18 | 23 | 27 | 32 | 42 | 51 |
| 1.10 | 122 | 12 | 12 | 12 | 13 | 18 | 23 | 27 | 32 | 42 | 51 |
| 1.20 | 112 | 10 | 10 | 10 | 13 | 16 | 21 | 26 | 31 | 40 | 51 |
| 1.30 | 103 | 10 | 10 | 10 | 12 | 16 | 21 | 26 | 31 | 40 | 51 |
| 1.40 | 96 | 10 | 10 | 10 | 12 | 15 | 20 | 24 | 29 | 39 | 51 |
| 1.50 | 89 | 10 | 10 | 10 | 12 | 15 | 20 | 24 | 29 | 39 | 51 |
| 1.60 | 84 | 10 | 10 | 10 | 10 | 15 | 18 | 23 | 27 | 37 | 51 |
| 1.70 | 79 | 8 | 8 | 8 | 10 | 13 | 18 | 23 | 27 | 37 | 51 |
| 1.80 | 74 | 8 | 8 | 8 | 10 | 13 | 18 | 21 | 26 | 35 | 51 |
| 1.90 | 71 | 8 | 8 | 8 | 8 | 12 | 16 | 21 | 26 | 35 | 51 |
| 2.00 | 67 | 8 | 8 | 8 | 8 | 12 | 16 | 21 | 24 | 34 | 51 |
| 2.10 | 64 | 7 | 7 | 7 | 8 | 12 | 15 | 20 | 24 | 34 | 51 |
| 2.20 | 61 | 7 | 7 | 7 | 8 | 10 | 15 | 20 | 24 | 32 | 51 |
| 2.30 | 58 | 7 | 7 | 7 | 7 | 10 | 13 | 18 | 23 | 32 | 51 |
| 2.40 | 56 | 7 | 7 | 7 | 7 | 8 | 13 | 18 | 23 | 31 | 51 |
| 2.50 | 54 | 7 | 7 | 7 | 7 | 8 | 13 | 16 | 21 | 31 | 51 |
| 2.52 | 53 | 5 | 5 | 5 | 5 | 8 | 13 | 16 | 21 | 29 | 51 |

**Table A16 – Alternate Limiting Temperature 1022°F (Imperial)**

| W/D | Hp/A | Min Required Thickness (in.) for Hourly Rating Period (min) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15 | 30 | 45 | 60 | 90 | 120 | 150 | 180 | 240 | 300 |
| 0.33 | 406 | 11/16 | 11/16 | 11/16 | 13/16 | 1 1/16 | 1 1/4 | 1 7/16 | 1 11/16 | NR | NR |
| 0.40 | 335 | 11/16 | 11/16 | 11/16 | 13/16 | 1 | 1 3/16 | 1 7/16 | 1 5/8 | NR | NR |
| 0.50 | 268 | 5/8 | 5/8 | 5/8 | 3/4 | 15/16 | 1 1/8 | 1 5/16 | 1 9/16 | NR | NR |
| 0.60 | 223 | 9/16 | 9/16 | 9/16 | 11/16 | 7/8 | 1 1/16 | 1 1/4 | 1 1/2 | NR | NR |
| 0.70 | 191 | 1/2 | 1/2 | 1/2 | 5/8 | 13/16 | 1 | 1 3/16 | 1 7/16 | 1 13/16 | NR |
| 0.80 | 167 | 1/2 | 1/2 | 1/2 | 9/16 | 3/4 | 15/16 | 1 1/8 | 1 5/16 | 1 11/16 | NR |
| 0.84 | 160 | 7/16 | 7/16 | 7/16 | 9/16 | 3/4 | 15/16 | 1 1/8 | 1 5/16 | 1 11/16 | 2 |
| 0.90 | 149 | 7/16 | 7/16 | 7/16 | 9/16 | 11/16 | 7/8 | 1 1/16 | 1 5/16 | 1 11/16 | 2 |
| 1.00 | 134 | 7/16 | 7/16 | 7/16 | 1/2 | 11/16 | 7/8 | 1 1/16 | 1 1/4 | 1 5/8 | 2 |
| 1.10 | 122 | 7/16 | 7/16 | 7/16 | 1/2 | 11/16 | 7/8 | 1 1/16 | 1 1/4 | 1 5/8 | 2 |
| 1.20 | 112 | 3/8 | 3/8 | 3/8 | 1/2 | 5/8 | 13/16 | 1 | 1 3/16 | 1 9/16 | 2 |
| 1.30 | 103 | 3/8 | 3/8 | 3/8 | 7/16 | 5/8 | 13/16 | 1 | 1 3/16 | 1 9/16 | 2 |
| 1.40 | 96 | 3/8 | 3/8 | 3/8 | 7/16 | 9/16 | 3/4 | 15/16 | 1 1/8 | 1 1/2 | 2 |
| 1.50 | 89 | 3/8 | 3/8 | 3/8 | 7/16 | 9/16 | 3/4 | 15/16 | 1 1/8 | 1 1/2 | 2 |
| 1.60 | 84 | 3/8 | 3/8 | 3/8 | 3/8 | 9/16 | 11/16 | 7/8 | 1 1/16 | 1 7/16 | 2 |
| 1.70 | 79 | 5/16 | 5/16 | 5/16 | 3/8 | 1/2 | 11/16 | 7/8 | 1 1/16 | 1 7/16 | 2 |
| 1.80 | 74 | 5/16 | 5/16 | 5/16 | 3/8 | 1/2 | 11/16 | 13/16 | 1 | 1 3/8 | 2 |
| 1.90 | 71 | 5/16 | 5/16 | 5/16 | 5/16 | 7/16 | 5/8 | 13/16 | 1 | 1 3/8 | 2 |
| 2.00 | 67 | 5/16 | 5/16 | 5/16 | 5/16 | 7/16 | 5/8 | 13/16 | 15/16 | 1 5/16 | 2 |
| 2.10 | 64 | 1/4 | 1/4 | 1/4 | 5/16 | 7/16 | 9/16 | 3/4 | 15/16 | 1 5/16 | 2 |
| 2.20 | 61 | 1/4 | 1/4 | 1/4 | 5/16 | 3/8 | 9/16 | 3/4 | 15/16 | 1 1/4 | 2 |
| 2.30 | 58 | 1/4 | 1/4 | 1/4 | 1/4 | 3/8 | 1/2 | 11/16 | 7/8 | 1 1/4 | 2 |
| 2.40 | 56 | 1/4 | 1/4 | 1/4 | 1/4 | 5/16 | 1/2 | 11/16 | 7/8 | 1 3/16 | 2 |
| 2.50 | 54 | 1/4 | 1/4 | 1/4 | 1/4 | 5/16 | 1/2 | 5/8 | 13/16 | 1 3/16 | 2 |
| 2.52 | 53 | 3/16 | 3/16 | 3/16 | 3/16 | 5/16 | 1/2 | 5/8 | 13/16 | 1 1/8 | 2 |

**Table A17 – Alternate Limiting Temperature 600°C (Metric)**

| W/D | Hp/A | Min Required Thickness (mm) for Hourly Rating Period (min) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15 | 30 | 45 | 60 | 90 | 120 | 150 | 180 | 240 | 300 |
| 0.33 | 406 | 18 | 18 | 18 | 21 | 26 | 31 | 35 | 42 | NR | NR |
| 0.40 | 335 | 18 | 18 | 18 | 20 | 24 | 29 | 35 | 40 | NR | NR |
| 0.50 | 268 | 16 | 16 | 16 | 18 | 23 | 29 | 34 | 39 | NR | NR |
| 0.60 | 223 | 15 | 15 | 15 | 16 | 21 | 27 | 32 | 37 | 47 | NR |
| 0.70 | 191 | 13 | 13 | 13 | 15 | 21 | 26 | 31 | 35 | 45 | NR |
| 0.80 | 167 | 12 | 12 | 12 | 15 | 20 | 24 | 29 | 32 | 43 | NR |
| 0.84 | 160 | 12 | 12 | 12 | 13 | 18 | 23 | 27 | 32 | 42 | 51 |
| 0.90 | 149 | 12 | 12 | 12 | 13 | 18 | 23 | 27 | 32 | 42 | 51 |
| 1.00 | 134 | 10 | 10 | 10 | 13 | 18 | 23 | 26 | 31 | 40 | 50 |
| 1.10 | 122 | 10 | 10 | 10 | 12 | 16 | 21 | 26 | 31 | 40 | 50 |
| 1.20 | 112 | 10 | 10 | 10 | 12 | 16 | 21 | 24 | 29 | 39 | 48 |
| 1.30 | 103 | 10 | 10 | 10 | 12 | 15 | 20 | 24 | 29 | 37 | 47 |
| 1.40 | 96 | 10 | 10 | 10 | 12 | 15 | 20 | 23 | 27 | 37 | 47 |
| 1.50 | 89 | 8 | 8 | 8 | 10 | 13 | 18 | 23 | 27 | 35 | 45 |
| 1.60 | 84 | 8 | 8 | 8 | 10 | 13 | 18 | 21 | 26 | 35 | 45 |
| 1.70 | 79 | 8 | 8 | 8 | 10 | 12 | 16 | 21 | 26 | 34 | 43 |
| 1.80 | 74 | 8 | 8 | 8 | 10 | 12 | 16 | 20 | 24 | 34 | 42 |
| 1.90 | 71 | 8 | 8 | 8 | 8 | 10 | 15 | 20 | 24 | 32 | 42 |
| 2.00 | 67 | 7 | 7 | 7 | 8 | 10 | 15 | 18 | 23 | 31 | 40 |
| 2.10 | 64 | 7 | 7 | 7 | 8 | 10 | 13 | 18 | 21 | 31 | 39 |
| 2.20 | 61 | 7 | 7 | 7 | 7 | 8 | 13 | 16 | 21 | 29 | 39 |
| 2.30 | 58 | 7 | 7 | 7 | 7 | 8 | 12 | 16 | 20 | 29 | 37 |
| 2.40 | 56 | 7 | 7 | 7 | 7 | 7 | 12 | 15 | 20 | 27 | 35 |
| 2.50 | 54 | 7 | 7 | 7 | 7 | 7 | 10 | 15 | 18 | 27 | 35 |
| 2.52 | 53 | 5 | 5 | 5 | 5 | 7 | 10 | 15 | 18 | 26 | 35 |

**Table A18 – Alternate Limiting Temperature 1112°F (Imperial)**

| W/D | Hp/A | Min Required Thickness (in.) for Hourly Rating Period (min) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15 | 30 | 45 | 60 | 90 | 120 | 150 | 180 | 240 | 300 |
| 0.33 | 406 | 11/16 | 11/16 | 11/16 | 13/16 | 1 | 1 3/16 | 1 3/8 | 1 5/8 | NR | NR |
| 0.40 | 335 | 11/16 | 11/16 | 11/16 | 3/4 | 15/16 | 1 1/8 | 1 3/8 | 1 9/16 | NR | NR |
| 0.50 | 268 | 5/8 | 5/8 | 5/8 | 11/16 | 7/8 | 1 1/8 | 1 5/16 | 1 1/2 | NR | NR |
| 0.60 | 223 | 9/16 | 9/16 | 9/16 | 5/8 | 13/16 | 1 1/16 | 1 1/4 | 1 7/16 | 1 13/16 | NR |
| 0.70 | 191 | 1/2 | 1/2 | 1/2 | 9/16 | 13/16 | 1 | 1 3/16 | 1 3/8 | 1 3/4 | NR |
| 0.80 | 167 | 7/16 | 7/16 | 7/16 | 9/16 | 3/4 | 15/16 | 1 1/8 | 1 1/4 | 1 11/16 | NR |
| 0.84 | 160 | 7/16 | 7/16 | 7/16 | 1/2 | 11/16 | 7/8 | 1 1/16 | 1 1/4 | 1 5/8 | 2 |
| 0.90 | 149 | 7/16 | 7/16 | 7/16 | 1/2 | 11/16 | 7/8 | 1 1/16 | 1 1/4 | 1 5/8 | 2 |
| 1.00 | 134 | 3/8 | 3/8 | 3/8 | 1/2 | 11/16 | 7/8 | 1 | 1 3/16 | 1 9/16 | 1 15/16 |
| 1.10 | 122 | 3/8 | 3/8 | 3/8 | 7/16 | 5/8 | 13/16 | 1 | 1 3/16 | 1 9/16 | 1 15/16 |
| 1.20 | 112 | 3/8 | 3/8 | 3/8 | 7/16 | 5/8 | 13/16 | 15/16 | 1 1/8 | 1 1/2 | 1 7/8 |
| 1.30 | 103 | 3/8 | 3/8 | 3/8 | 7/16 | 9/16 | 3/4 | 15/16 | 1 1/8 | 1 7/16 | 1 13/16 |
| 1.40 | 96 | 3/8 | 3/8 | 3/8 | 7/16 | 9/16 | 3/4 | 7/8 | 1 1/16 | 1 7/16 | 1 13/16 |
| 1.50 | 89 | 5/16 | 5/16 | 5/16 | 3/8 | 1/2 | 11/16 | 7/8 | 1 1/16 | 1 3/8 | 1 3/4 |
| 1.60 | 84 | 5/16 | 5/16 | 5/16 | 3/8 | 1/2 | 11/16 | 13/16 | 1 | 1 3/8 | 1 3/4 |
| 1.70 | 79 | 5/16 | 5/16 | 5/16 | 3/8 | 7/16 | 5/8 | 13/16 | 1 | 1 5/16 | 1 11/16 |
| 1.80 | 74 | 5/16 | 5/16 | 5/16 | 3/8 | 7/16 | 5/8 | 3/4 | 15/16 | 1 5/16 | 1 5/8 |
| 1.90 | 71 | 5/16 | 5/16 | 5/16 | 5/16 | 3/8 | 9/16 | 3/4 | 15/16 | 1 1/4 | 1 5/8 |
| 2.00 | 67 | 1/4 | 1/4 | 1/4 | 5/16 | 3/8 | 9/16 | 11/16 | 7/8 | 1 3/16 | 1 9/16 |
| 2.10 | 64 | 1/4 | 1/4 | 1/4 | 5/16 | 3/8 | 1/2 | 11/16 | 13/16 | 1 3/16 | 1 1/2 |
| 2.20 | 61 | 1/4 | 1/4 | 1/4 | 1/4 | 5/16 | 1/2 | 5/8 | 13/16 | 1 1/8 | 1 1/2 |
| 2.30 | 58 | 1/4 | 1/4 | 1/4 | 1/4 | 5/16 | 7/16 | 5/8 | 3/4 | 1 1/8 | 1 7/16 |
| 2.40 | 56 | 1/4 | 1/4 | 1/4 | 1/4 | 1/4 | 7/16 | 9/16 | 3/4 | 1 1/16 | 1 3/8 |
| 2.50 | 54 | 1/4 | 1/4 | 1/4 | 1/4 | 1/4 | 3/8 | 9/16 | 11/16 | 1 1/16 | 1 3/8 |
| 2.52 | 53 | 3/16 | 3/16 | 3/16 | 3/16 | 1/4 | 3/8 | 9/16 | 11/16 | 1 | 1 3/8 |

**Table A19 – Alternate Limiting Temperature 650°C (Metric)**

| W/D | Hp/A | Min Required Thickness (mm) for Hourly Rating Period (min) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15 | 30 | 45 | 60 | 90 | 120 | 150 | 180 | 240 | 300 |
| 0.33 | 406 | 18 | 18 | 18 | 20 | 24 | 29 | 34 | 39 | NR | NR |
| 0.40 | 335 | 18 | 18 | 18 | 20 | 24 | 29 | 34 | 39 | NR | NR |
| 0.50 | 268 | 16 | 16 | 16 | 20 | 24 | 29 | 32 | 37 | 45 | NR |
| 0.60 | 223 | 15 | 15 | 15 | 18 | 24 | 29 | 31 | 35 | 43 | NR |
| 0.70 | 191 | 12 | 12 | 15 | 18 | 24 | 27 | 29 | 34 | 42 | NR |
| 0.80 | 167 | 10 | 10 | 13 | 18 | 23 | 27 | 27 | 32 | 40 | NR |
| 0.84 | 160 | 10 | 10 | 13 | 18 | 23 | 27 | 27 | 31 | 39 | 51 |
| 0.90 | 149 | 10 | 10 | 12 | 18 | 23 | 26 | 27 | 31 | 39 | 51 |
| 1.00 | 134 | 10 | 10 | 12 | 16 | 21 | 26 | 26 | 29 | 39 | 50 |
| 1.10 | 122 | 10 | 10 | 12 | 16 | 21 | 24 | 26 | 29 | 37 | 50 |
| 1.20 | 112 | 8 | 8 | 12 | 15 | 20 | 23 | 24 | 27 | 37 | 48 |
| 1.30 | 103 | 8 | 8 | 10 | 15 | 18 | 23 | 23 | 27 | 35 | 47 |
| 1.40 | 96 | 8 | 8 | 10 | 13 | 18 | 21 | 23 | 26 | 35 | 47 |
| 1.50 | 89 | 8 | 8 | 10 | 13 | 16 | 20 | 21 | 26 | 34 | 45 |
| 1.60 | 84 | 8 | 8 | 10 | 13 | 15 | 20 | 21 | 24 | 34 | 45 |
| 1.70 | 79 | 8 | 8 | 10 | 12 | 15 | 18 | 20 | 24 | 32 | 43 |
| 1.80 | 74 | 8 | 8 | 8 | 12 | 13 | 16 | 20 | 23 | 32 | 42 |
| 1.90 | 71 | 7 | 7 | 8 | 10 | 12 | 15 | 18 | 23 | 31 | 42 |
| 2.00 | 67 | 7 | 7 | 8 | 10 | 12 | 15 | 18 | 21 | 31 | 40 |
| 2.10 | 64 | 7 | 7 | 8 | 8 | 10 | 13 | 16 | 21 | 29 | 39 |
| 2.20 | 61 | 7 | 7 | 7 | 8 | 10 | 12 | 16 | 20 | 29 | 39 |
| 2.30 | 58 | 7 | 7 | 7 | 7 | 8 | 12 | 15 | 20 | 27 | 37 |
| 2.40 | 56 | 7 | 7 | 7 | 7 | 7 | 10 | 15 | 18 | 27 | 35 |
| 2.50 | 54 | 7 | 7 | 7 | 7 | 7 | 8 | 13 | 18 | 26 | 35 |
| 2.52 | 53 | 5 | 5 | 5 | 5 | 5 | 8 | 13 | 18 | 26 | 35 |

**Table A20 – Alternate Limiting Temperature 1202°F (Imperial)**

| W/D | Hp/A | Min Required Thickness (in.) for Hourly Rating Period (min) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15 | 30 | 45 | 60 | 90 | 120 | 150 | 180 | 240 | 300 |
| 0.33 | 406 | 11/16 | 11/16 | 11/16 | 3/4 | 15/16 | 1 1/8 | 1 5/16 | 1 1/2 | NR | NR |
| 0.40 | 335 | 11/16 | 11/16 | 11/16 | 3/4 | 15/16 | 1 1/8 | 1 5/16 | 1 1/2 | NR | NR |
| 0.50 | 268 | 5/8 | 5/8 | 5/8 | 3/4 | 15/16 | 1 1/8 | 1 1/4 | 1 7/16 | 1 3/4 | NR |
| 0.60 | 223 | 9/16 | 9/16 | 9/16 | 11/16 | 15/16 | 1 1/8 | 1 3/16 | 1 3/8 | 1 11/16 | NR |
| 0.70 | 191 | 7/16 | 7/16 | 9/16 | 11/16 | 15/16 | 1 1/16 | 1 1/8 | 1 5/16 | 1 5/8 | NR |
| 0.80 | 167 | 3/8 | 3/8 | 1/2 | 11/16 | 7/8 | 1 1/16 | 1 1/16 | 1 1/4 | 1 9/16 | NR |
| 0.84 | 160 | 3/8 | 3/8 | 1/2 | 11/16 | 7/8 | 1 1/16 | 1 1/16 | 1 3/16 | 1 1/2 | 2 |
| 0.90 | 149 | 3/8 | 3/8 | 7/16 | 11/16 | 7/8 | 1 | 1 1/16 | 1 3/16 | 1 1/2 | 2 |
| 1.00 | 134 | 3/8 | 3/8 | 7/16 | 5/8 | 13/16 | 1 | 1 | 1 1/8 | 1 1/2 | 1 15/16 |
| 1.10 | 122 | 3/8 | 3/8 | 7/16 | 5/8 | 13/16 | 15/16 | 1 | 1 1/8 | 1 7/16 | 1 15/16 |
| 1.20 | 112 | 5/16 | 5/16 | 7/16 | 9/16 | 3/4 | 7/8 | 15/16 | 1 1/16 | 1 7/16 | 1 7/8 |
| 1.30 | 103 | 5/16 | 5/16 | 3/8 | 9/16 | 11/16 | 7/8 | 7/8 | 1 1/16 | 1 3/8 | 1 13/16 |
| 1.40 | 96 | 5/16 | 5/16 | 3/8 | 1/2 | 11/16 | 13/16 | 7/8 | 1 | 1 3/8 | 1 13/16 |
| 1.50 | 89 | 5/16 | 5/16 | 3/8 | 1/2 | 5/8 | 3/4 | 13/16 | 1 | 1 5/16 | 1 3/4 |
| 1.60 | 84 | 5/16 | 5/16 | 3/8 | 1/2 | 9/16 | 3/4 | 13/16 | 15/16 | 1 5/16 | 1 3/4 |
| 1.70 | 79 | 5/16 | 5/16 | 3/8 | 7/16 | 9/16 | 11/16 | 3/4 | 15/16 | 1 1/4 | 1 11/16 |
| 1.80 | 74 | 5/16 | 5/16 | 5/16 | 7/16 | 1/2 | 5/8 | 3/4 | 7/8 | 1 1/4 | 1 5/8 |
| 1.90 | 71 | 1/4 | 1/4 | 5/16 | 3/8 | 7/16 | 9/16 | 11/16 | 7/8 | 1 3/16 | 1 5/8 |
| 2.00 | 67 | 1/4 | 1/4 | 5/16 | 3/8 | 7/16 | 9/16 | 11/16 | 13/16 | 1 3/16 | 1 9/16 |
| 2.10 | 64 | 1/4 | 1/4 | 5/16 | 5/16 | 3/8 | 1/2 | 5/8 | 13/16 | 1 1/8 | 1 1/2 |
| 2.20 | 61 | 1/4 | 1/4 | 1/4 | 5/16 | 3/8 | 7/16 | 5/8 | 3/4 | 1 1/8 | 1 1/2 |
| 2.30 | 58 | 1/4 | 1/4 | 1/4 | 1/4 | 5/16 | 7/16 | 9/16 | 3/4 | 1 1/16 | 1 7/16 |
| 2.40 | 56 | 1/4 | 1/4 | 1/4 | 1/4 | 1/4 | 3/8 | 9/16 | 11/16 | 1 1/16 | 1 3/8 |
| 2.50 | 54 | 1/4 | 1/4 | 1/4 | 1/4 | 1/4 | 5/16 | 1/2 | 11/16 | 1 | 1 3/8 |
| 2.52 | 53 | 3/16 | 3/16 | 3/16 | 3/16 | 3/16 | 5/16 | 1/2 | 11/16 | 1 | 1 3/8 |

## **APPENDIX B.** SHOP APPLICATION & FORMING DETAILS

**PYROCRETE® 341 SHOP APPLICATION INTRODUCTION**

The following guidelines detail the correct techniques for Pyrocrete® 341 shop application, including:

- Project Set-Up
- Substrate Preparation
- Lath Requirements
- Application Procedures
- Finishing & Terminations
- Curing & Handling
- Field Connections

## 1.0 PROJECT SET-UP

- Stage steel to have access to all sides being protected.
- Determine swing radius of the members needed to erect completed steel. Typically, a minimum of a 12” block-out on each side of the holes of primary member.
- Prior to application, define and cover block-outs. Dimensions to be determined by the project team.
- Ensure application conditions in shop facility are within Carboline’s prescribed tolerances.

## 2.0 SUBSTRATE PREPARATION

- Substrates shall be free of dirt, oil, grease, release agent, and loose mill scale.
- Pyrocrete can be applied directly to galvanized steel.
- For carbon steel application requiring a primer, follow surface preparation requirements for approved primer system and/or project specification.

STEEL STAGED FOR APPLICATION

CLEAN GALVANIZED STEEL WITH LATH AND CORNER BEAD

## 3.0 PRIMERS

- Any Corrosion protection or alkaline resistant primers must be approved by Carboline prior to application.
- Use Carboguard surface tolerant epoxies, Carbozinc zinc-rich epoxies or Carbozinc 11.
- Galvanized metal is an acceptable primer for corrosion protection.

STEEL READY FOR PRIMER APPLICATION

## 4.0 LATHING [MESH REINFORCEMENT]

- Use minimum 2.5 lbs./yd² galvanized metal lath.
- Anchoring fasteners can be used as a secondary fixing aid, but do not form part of the fire resistive design.
- Pins for attachment of lath shall be minimum 14-gauge copper coated stud welded pins or powder actuated pneumatic pins secured 12” O.C.
- Typical application utilizes 100% lath contour for Pyrocrete shop and field applications.
- Pyrocrete shall be terminated 6”-12” from the end of the member, or 6”-12” from bolt holes to allow for field erection without damage.
- Lath is overlapped 1” and tie wired 12” O.C.
- Lath shall extend a minimum of 1” beyond the block-out termination to allow for lath overlap when installing field block-outs.

PRE-CUT LATH PRIOR TO APPLICATION

CORNER BEAD INSTALLED FOR THICKNESS CONTROL

## 5.0 APPLICATION

- Pyrocrete shall be mixed and applied in full compliance with the product data sheet and Carboline's written application procedures, outlined in this manual.
- Pyrocrete thickness can be determined by the use of temporary forms or cornerbead, set to the required depth prior to application.
- Pyrocrete is installed in one or more lifts to achieve the required thickness.
- Pyrocrete thickness shall be measured from the lath.
- Pyrocrete shall be applied within stated recoat times.
- Minimum thickness per coat of 1/4".
- All terminations left as 90° butt joints.

FORMS SET TO REQUIRED THICKNESS

PYROCRETE SPRAY APPLIED TO REQUIRED THICKNESS

APPLIED PYROCRETE FINISHED WITH A TROWEL

FINISH PYROCRETE WITH USE OF FORM GUIDES

## 6.0 FINISHING

- Pyrocrete may be installed by spray or trowel.
- Finish using a hand trowel technique for smooth and even texture.
- Finish to match mock-up sample for project.


PYROCRETE INSTALLED TO THICKNESS AND FINISHED WITH TROWEL


REMOVAL OF FORMS AND EDGES FINISHED WITH TROWEL

## 7.0 SEALER/TOPCOATING

- Pyrocrete sealer and topcoat are optional.
- When sealing Pyrocrete, use Carboguard 1340 in compliance with product data sheet instructions. Carboguard 1340 shall be thinned 25%.
- Seal coat can be applied 24 hours after the final application of Pyrocrete.
- Additional chemical or moisture resistance topcoats can then be utilized to meet project requirements.
- Additional topcoats can be applied once material reaches sufficient Shore DO hardness.
- Contact Carboline Fireproofing Technical Service for specific product recommendations.


OPTIONAL CARBOGUARD 1340 APPLIED AS SEALER

## 8.0 TERMINATIONS/CAULKING

- Terminations of Pyrocrete to non-fireproofed steel or dissimilar materials shall be caulked with Acrilast Silicone Caulk II or approved alternate.
- Block-out terminations are left as 90° butt joints and left uncaulked.
- Areas where water may enter such as; top flanges of pipe racks and upper level of vertical column terminations, shall be caulked.
- Terminations to non-fireproofed steel or dissimilar materials shall have the Pyrocrete sloped or chamfered downward to create a positive watershed and facilitate drainage.

TERMINATIONS CAULKED WITH ACRILAST CAULK

## 9.0 CURING & HANDLING

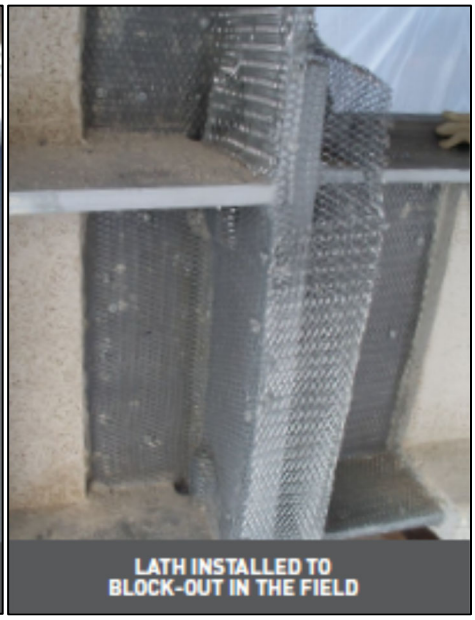
- Pyrocrete is ready to ship when material has sufficient hardness to withstand handling, transportation and off-loading.
- An average Shore DO surface hardness of 64 is required using a Type DO Durometer hardness gauge.
- Steel should be rigged at a block-out or non-fireproofed area.
- Shackles at end holes are safest method for unloading members.
- Stage members on proper dunnage with webs vertical to avoid exposure to ground moisture, ponding water or snow.
- If stacking, use dunnage at non-fireproofed areas to prevent damage.
- Lift from block-outs or shackle to erection tabs or bolt holes. Avoid using chokers against fireproofed surfaces.
- We do not recommend the use of chokers for lifting, transporting or erecting steel areas protected with Pyrocrete, however, if used, preformed wooden sections must be placed against the Pyrocrete to distribute the load.

## 10.0 FIELD CONNECTIONS

- Field applied Pyrocrete shall be mixed and applied in full compliance with the product data sheet and Carboline's written application procedures as detailed herein this application manual.

- Substrate shall be free of all contaminants prior to installing lath 2.5 lbs./yd² galvanized metal lath shall be mechanically affixed to entire surface of the blockout and overlapped with shop applied lath - 1“.
- A 90° butt joint termination to the shop applied fireproofing.
- Mechanically attach lath over bolted connections with lath firmly against the bolts and bolt heads.
- Prior to the application of Pyrocrete to block-outs, the butt surfaces surrounding block-outs shall be thoroughly wetted to prevent dehydration of the fresh material applied in the field.
- The completed thickness of the fireproofing at blockouts shall match the thickness and finish of the shop applied section.
- When sealing Pyrocrete, apply Carboguard 1340 in compliance with product application instructions and
- Section 7.0 of this appendix. Sealer can be applied 24 hours after the final application of Pyrocrete.
- All terminations onto non-fireproofed steel or dissimilar materials shall be caulked with Acrilast Caulk II or approved alternate.

SHOP APPLIED BLOCK-OUT WITH 1" LATH EXTENDED



LATH INSTALLED TO BLOCK-OUT IN THE FIELD

PYROCRETE INSTALLED TO BLOCK-OUT AREA

## **APPENDIX C.** HANDLING, SHIPPING & ERECTION

## HANDLING, SHIPPING & ERECTION GUIDE

### HANDLING

Pyrocrete 341 is ready to ship when material has sufficient hardness to withstand handling, transportation and off-loading.

An average Shore DO surface hardness of 64 is required using a Type DO Durometer hardness gauge.

### LOADING AND UNLOADING

Fireproofed steel is generally loaded and unloaded with a crane to permit maximum loading of each truck. Do not unload fireproofed steel with forklifts, as the steel is nested in ways that forklifts will damage the fireproofing.

### RIGGING

Chokers and chains should not be utilized on the fireproofed portion of the steel members. Shackles at end holes are a generally acceptable practice and provide the best method for unloading steel members.

Follow all site-specific safety standards for handling structural steel.

### DUNNAGE

Steel members should be stored on proper dunnage (on the block out areas) to avoid crushing the Installed Pyrocrete 341. Avoid storing fireproofed steel on the ground (exposure to ponding water, snow, etc.).

### ORIENTATION OF MEMBERS

Steel members should always be stacked with the webs in a vertical position to avoid ponding of water and snow.

Always elevate one end of the steel member to provide positive water drainage.

### STACKING

Where steel members must be double stacked, avoid placing dunnage on the fireproofed surfaces.

### ERECTION

Wherever possible, use erection tabs. Where chokers must be used, use wooden softeners to avoid crushing the fireproofing. *Never use chokers to erect columns.* This will damage the fireproofing and when the fireproofing is crushed, chokers can slide, creating a very unsafe condition.

### SWING RADIUS

When utilizing infill beams, use framing angles. The erector must be aware of the swing radius of the steel member that impacts the fireproofing. Typically, this type of connection has a 12-inch blockout on each side of the holes on the primary member. When the block out dimension is insufficient, the erector is advised to chip out a minimal amount of fireproofing on *one side only*. It is better to chip a minimal amount of fireproofing than to make all the connections unnecessarily large. Safety precautions such as respirators, eye and other protection should be in accordance with OSHA and

site safety requirements. Reference Pyrocrete 341 SDS for additional information.

**CONSIDER GROUND ASSEMBLY**

Pre-assembling the bents on structures that are repetitive in nature will often minimize damage to the fireproofing.

**APPENDIX D.** SINGLE & DOUBLE LEG CORNERBEAD DETAILS

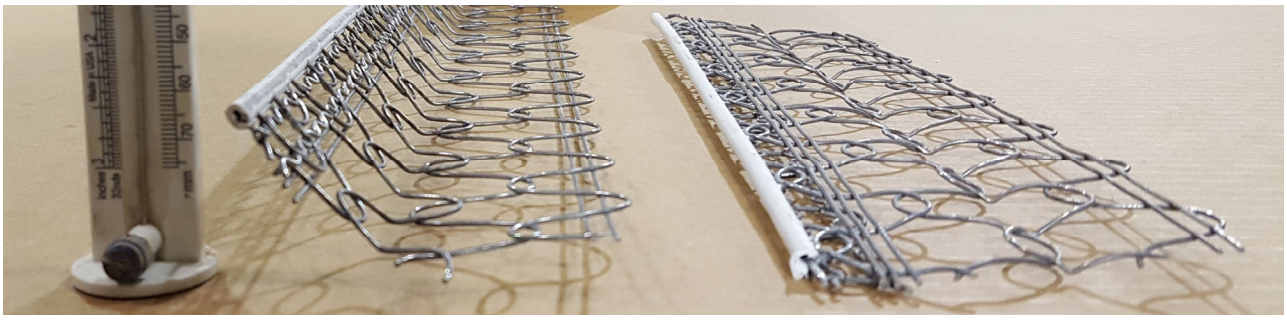
**PYROCRETE® 341 SINGLE CORNERBEAD CONTOUR APPLICATION**

1. Prepare the column for application.
2. Attach lath where required.
3. Calculate the bend point needed to achieve the correct thickness using the single leg corner bead (SLCB). The bend point is measured from the plastic nose and can be calculated using the equation below. The SLCB can be used to achieve a maximum coating thickness of 1-3/4".

$$D \; x \; 1.414 = B$$

B = Bend Point
D = Desired Coating Thickness

4. Bend the SLCB from a 180-degree angle (pictured below on the right) to a 135-degree angle (pictured below on the left) at the bend point found in Step 3.

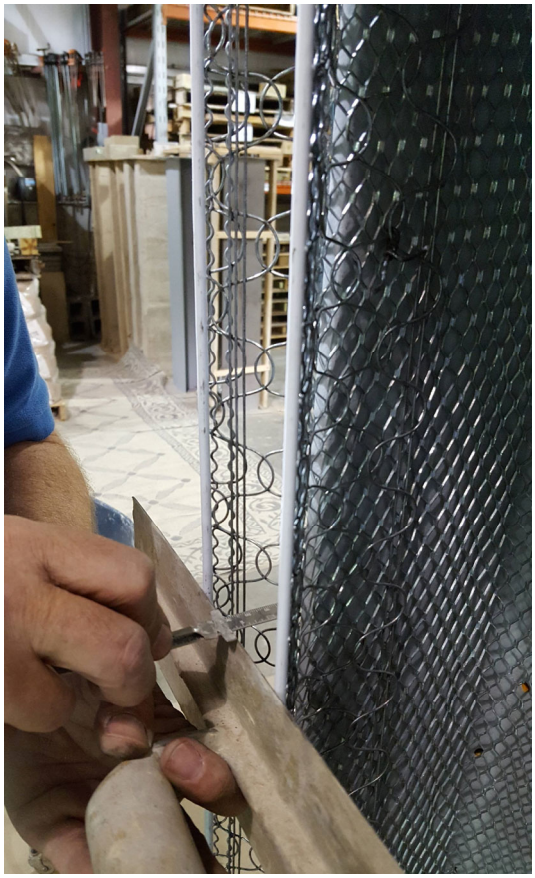


Bent SLCB Flat SLCB

5. Place the SLCB on the flange face and align the bend with the lath on the flange tip.
6. Attach the SLCB using tire wire or Hilti stud at 12" O.C.
7. Attach the SLCB to the inner flange edge following steps 5 and 6.
8. When more than one section of SLCB is used, join the ends together by a needles or Braid inserted in the plastic nose end of both sections. This will bridge the sections and make a smooth joint.

9. When positioned correctly, a trowel riding the plastic noses will give the required fireproofing thickness on the flange face and flange edge. The Inner flanges are trimmed to the required thickness by riding the plastic nose while keeping the trowel perpendicular to the web.

Checking flange face thickness



Checking flange tip thickness

**PYROCRETE® 341 DOUBLE CORNERBEAD CONTOUR APPLICATION**

1. Prepare the column for application.
2. Attach lath for a contour application.
3. Measure the width of the lathed flange edge to calculate the required width of the double corner bead piece. The width will be twice the thickness of fireproofing plus the width of the lathed flange edge. Total thickness will be measured from plastic nosed edge to plastic nosed edge.
4. Tie wire the two corner bead pieces together in a U shape to set the required width of the edge face. Use tie wire in 12” O.C. A wood form at the required width will make the attachment easier to tie at the required width. As an alternate to tying together, the two corner pieces could be welded at the required width.
5. Position the centerline of the doubled corner bead over the centerline of the steel edge. Position the face of the doubled corner bead out from the lathed edge to give the required thickness of fireproofing on the column edge. This thickness is measured using a trowel riding on the plastic noses down to the face of the lath.
6. While maintaining the position of the face of the doubled corner bead, flex the two sides down to the lath and tie wire in position. Tie at 12” O.C.
7. Bend or flex the attached corner beads to get the required thicknesses of fireproofing on the flange face and inner flange. Check that the center face of the doubled corner beads is still perpendicular to the steel edge and set at the correct thickness of fireproofing. Flex the tie wired center face down so that the so that no wires stick out when the trowel rides across the plastic noses.
8. If positioned correctly, a trowel riding the plastic noses will give the required fireproofing thickness on the flange face and flange edge. The inner flanges are trimmed to the required thickness by riding the plastic nosed corner bead while keeping the trowel perpendicular to the web.
9. During application of fireproofing, the doubled corner bead must be completely filled with material.

## **APPENDIX E.** QUALITY CONTROL TEMPLATES

TEMPLATES

QUALITY CONTROL FLOW CHART
INSPECTION & HOLD POINTS
TYPICAL INSPECTION EQUIPMENT LIST

## PYROCRETE 341 QUALITY CONTROL FLOW CHART

| ITEM | PROCEDURE / OPERATION | HOLD POINT | INSPECTION | ACCEPTANCE |
|---|---|---|---|---|
| | **Surface Preparation (Where required)** | | | |
| 1 | **Profile (if primer required)** | Yes | Yes | Yes |
| | **Preparation Standard** | Yes | Yes | Yes |
| | **Galvanized Steel** | Yes | Yes | Yes |
| | ***Profile (if primed):*** *Min 40 microns according to ISO 8503 or ASTM D 4417* | | | |
| | ***Preparation Standard:*** *Minimum of Sa 2 according to ISO 8501-1 or SSPC-SP6 or Din 55928* | | | |
| | | | Acceptable? | |
| | | | Yes / No | Remedial Procedures |
| | **Primer Coat** | **Go to 2** | | **Back to Step 1** |
| 2 | **Type(s)** | No | No | Yes |
| | **Thickness** | Yes | Yes | Yes |
| | **Cure** | Yes | Yes | Yes |
| | **Adhesion** | Yes | Yes | Yes |
| | ***Type****: Document compliance with Carboline & Project requirements.* | | | |
| | ***Thickness:*** *Apply primer according to manufacturer's required d.f.t., measurements according to ISO 2808.* | | | |
| | ***Cure:*** *A min 70% of full cure according to manufacturer's data. Adhesion tests to ISO 4624 to confirm. Min acceptable value = project specifications* | | Acceptable | |
| | ***Adhesion:*** *As above, tested to ISO 4624 (ASTM D4541).* | | Yes / No | Remedial Procedures |
| | **Site Organization/Personnel** | **Go to 3** | | **Back to Step 2** |
| 3 | **Up to date/latest Revision of Pyrocrete manual available?** | No | No | Yes |
| | **Up to date project specification available?** | No | No | Yes |
| | **Supervisor in possession of appropriate qualification?** | No | No | Yes |
| | **QC personnel in possession of appropriate qualification?** | No | No | Yes |
| | **Key operatives trained?** | No | No | Yes |
| | ***Visual Inspection:*** *Contractor to document personnel qualifications and have necessary data available.* | | Acceptable | |
| | | | Yes / No | Remedial Procedures |
| | **Equipment** | **Go to 4** | | **Back to Step 3** |
| 4 | **Compliance with Carboline manual and project specifications.** | No | No | Yes |
| | ***Maintenance log/records for pumps and mixing equipment*** | No | No | Yes |
| | ***Calibration records for inspection equipment*** | No | No | Yes |
| | | | Acceptable | |

Yes | No → Remedial Procedures

**Application Conditions** → **Go to 5** / **Back to Step 4**

**5**

| | | | |
|---|---|---|---|
| **Temperature (air)** | Yes | Yes | Yes |
| **Humidity** | Yes | Yes | Yes |
| **Temperature (substrate)** | Yes | Yes | Yes |
| **Adequate weather protection** | Yes | Yes | Yes |
| **Adequate environment control** | Yes | Yes | Yes |
| ***Air Temp and Humidity:*** *To be recorded prior to the start of production and periodically during application (minimum 3 times per 8-hour shift) and according the Pyrocrete product datasheet requirements* | | | |
| ***Substrate Temp:*** *To be recorded at start of shift* | | | |

Acceptable?

Yes | No → Remedial Procedures

**Material storage** → **Go to 6** / **Back to Step 5**

**6**

| | | | |
|---|---|---|---|
| **Temperature Control** | No | Yes | Yes |
| **Cleanliness** | No | No | No |
| **Protection from Environment** | No | No | Yes |
| *Visual checks only* | | | |

Acceptable?

Yes | No → Remedial Procedures

**Raw Material** → **Go to 7** / **Back to Step 6**

**7**

| | | | |
|---|---|---|---|
| **Record Batch Numbers** | No | No | Yes |
| **Certificates** | No | No | Yes |
| **Certificates of conformity to be provided where required by project** | | | |
| *Visual checks only* | | | |

Acceptable?

Yes | No → Update records

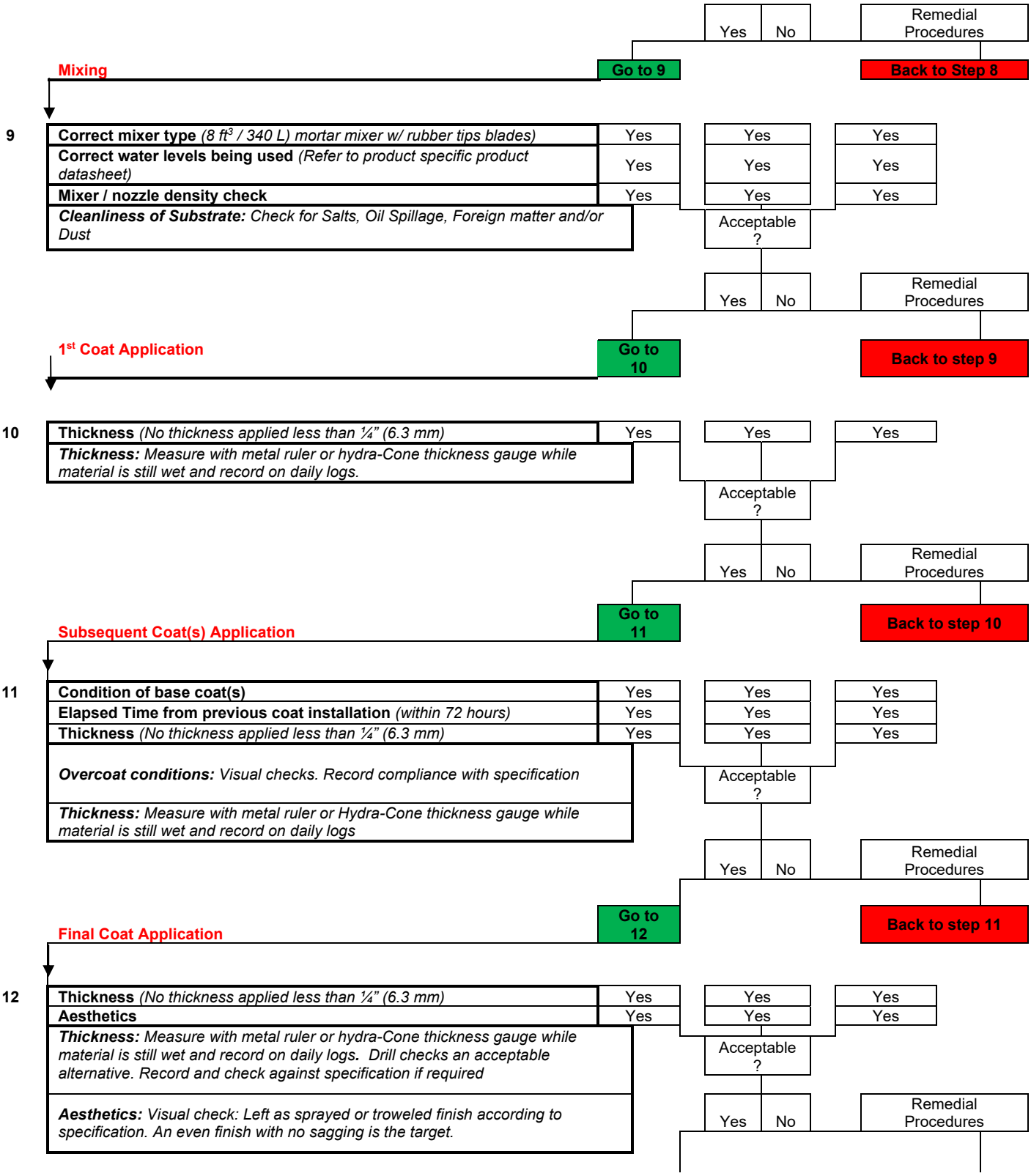
**Go to 8** / **Back to Step 7**

**Installation of Mesh Reinforcement**

**8**

| | | | |
|---|---|---|---|
| **Material type, diameter and length of pin or fastener.** | No | Yes | Yes |
| **Lath type: (2.5 lbs/yd² / 1.85 kg/m² galvanized)** | Yes | Yes | Yes |
| **Pattern and distance between fasteners (12" / 304 mm on center) –** if used as a fixing aid, not required by design | Yes | Yes | Yes |
| **Pin / fastener test conducted?** *First 50 pins, bend to 45° and return to vertical* | Yes | Yes | Yes |
| **Lath installed with minimum 1/4" tolerance from substrate?** | Yes | Yes | Yes |
| **Cornerbead used (depth set)?** | Yes | Yes | Yes |
| **Tie-wire used (gauge)?** | Yes | Yes | Yes |
| **Lath type & overlaps complies with specification?** | Yes | Yes | Yes |
| *Visual checks only* | | | |

Acceptable?


Yes
No
Remedial Procedures
Mixing
Go to 9
Back to Step 8
9
Correct mixer type (8 ft³ / 340 L) mortar mixer w/ rubber tips blades)
Correct water levels being used (Refer to product specific product datasheet)
Mixer / nozzle density check
Cleanliness of Substrate: Check for Salts, Oil Spillage, Foreign matter and/or Dust
Yes
Yes
Yes
Yes
Yes
Yes
Yes
Yes
Yes
Acceptable ?
Yes
No
Remedial Procedures
1st Coat Application
Go to 10
Back to step 9
10
Thickness (No thickness applied less than ¼" (6.3 mm)
Thickness: Measure with metal ruler or hydra-Cone thickness gauge while material is still wet and record on daily logs.
Yes
Yes
Yes
Acceptable ?
Yes
No
Remedial Procedures
Subsequent Coat(s) Application
Go to 11
Back to step 10
11
Condition of base coat(s)
Elapsed Time from previous coat installation (within 72 hours)
Thickness (No thickness applied less than ¼" (6.3 mm)
Overcoat conditions: Visual checks. Record compliance with specification
Thickness: Measure with metal ruler or Hydra-Cone thickness gauge while material is still wet and record on daily logs
Yes
Yes
Yes
Yes
Yes
Yes
Yes
Yes
Yes
Acceptable ?
Yes
No
Remedial Procedures
Final Coat Application
Go to 12
Back to step 11
12
Thickness (No thickness applied less than ¼" (6.3 mm)
Aesthetics
Thickness: Measure with metal ruler or hydra-Cone thickness gauge while material is still wet and record on daily logs. Drill checks an acceptable alternative. Record and check against specification if required
Aesthetics: Visual check: Left as sprayed or troweled finish according to specification. An even finish with no sagging is the target.
Yes
Yes
Yes
Yes
Yes
Yes
Yes
Yes
Yes
Acceptable ?
Yes
No
Remedial Procedures

**Topcoat & Caulking Application** — Go to 13 — Back to step 12

13

| | | | |
|---|---|---|---|
| **Elapsed time from final coat installation prior to applying topcoat** | No | No | Yes |
| **Condition of Pyrocrete** | Yes | Yes | Yes |
| **Seal with Carboguard 1340** *(24-hour minimum cure prior to installing sealer coat if required in specification)* | Yes | Yes | Yes |
| **Terminations sealed with Acrilast Caulk II** *Pyrocrete requires 72 hours minimum and must meet minimum Shore DO requirements prior to applying Acrilast caulk)* | Yes | Yes | Yes |
| **Topcoat Type? / Thickness?** *(if required in specification) Pyrocrete must meet minimum Shore DO requirements prior to installing topcoat over Carboguard 1340 sealer coat* ***Thickness measurements****: according to ISO 2808* | Yes | Yes | Yes |

***Elapsed time:*** *Check with manufacturer's data sheets and document compliance with Carboline requirements*

***Condition of Pyrocrete:*** *Record compliance with Carboline/ maunufacturer's requirements*

***Seal with Carboguard 1340:*** *Check with manufacturer's data sheets and document compliance with Carboline requirements*

***Topcoat Type:*** *Check with manufacturer's data sheets and document compliance with Carboline requirements*

Acceptable?

Yes | No — Remedial Procedures — Back to step 13

## PYROCRETE 341 INSPECTION HOLD POINTS

| No. | Procedure/Operation | Hold Point | Inspection | Document Acceptance/ Compliance | Details |
|---|---|---|---|---|---|
| 1 | Surface Preparation | Y | Y | Y | All aspect of preparation of the substrate to be verified as in accordance with specifications and Carboline requirements. This includes methods of preparation and the standards achieved + confirmation that the necessary standards of cleanliness and environmental control were achieved. |
| 2 | Primer Coat / Galvanized Substrate | Y | N | Y | The specific type of primer coat(s) used must be approved by Carboline. The applied d.f.t. cure of primer and or adhesion characteristics are to be verified as acceptable. Galvanized substrate to be clean and free of all oil, grease, dust , dirt and contamination |
| 3 | Site Organization / Personnel | N | N | Y | Contractor must verify that key site personnel are qualified to apply Pyrocrete. Different projects require a higher % of trained operatives but as a minimum the Site Supervisor, Lead Applicator and QC representative should be able to confirm and document their application qualifications. |
| 4 | Equipment | N | Y | Y | The accepted equipment is listed in the Pyrocrete application manual(s). The contractor shall demonstrate and document that the equipment is in the proper order. This applies to both production and the calibration/operation of measuring / inspection equipment. |
| 5 | Application Conditions | Y | Y | Y | The ambient, substrate and general conditions for the working environment are listed in the Pyrocrete Application Manual. It is the responsibility of the application contractor to adequately show that these have been followed during the application periods for Pyrocrete products |
| 6 | Material storage | Y | Y | Y | The storage condition for Pyrocrete are listed in the Pyrocrete Application Manual The application contractor must be able to show that these conditions have been achieved. |
| 7 | Raw Material | N | N | Y | Contractor must record batch numbers and document those used in production, showing that the material is correct and within the specified shelf life. Confirming also that any ancillary materials used are of the correct type |
| 8 | Installation of Pins / Fasteners / Lath | Y | Y | Y | Contractor must document type, diameter and length of pin or fastener, lath type: (2.5 lbs/yd2 galvanized) Lath must be installed a minimum average of ¼" from the steel substrate, fasteners can be used as a fixing aid in diamond pattern. Pattern and distance between fasteners shall be 12" / 304 mm on center. The first 50 welded pins, bend to 45° and return to vertical and mechanical fasteners must be verified prior to production. The cornerbead, tie-wire gauge and lath type used must be approved by Carboline in writing prior to project start. All lath overlaps, terminations and orientation must comply with Carboline's Pyrocrete Application Manual and design details |
| 9 | Mixing | Y | Y | Y | Contractor must verify that the correct mixer type is used and that the correct water levels and mixer density is being achieved prior to commencing application |
| 10 | Pre-Application (1st Coat) | Y | Y | Y | Contractor must document that the surface is acceptable for over coating with Pyrocrete and that the mixing and spray machinery is functioning correctly |
| 11 | Application (1st Coat) | Y | Y | Y | Wet film thickness checks taken during application and recorded. |

## PYROCRETE 341 TYPICAL INSPECTION EQUIPMENT LIST

| Equipment | Type | Comments |
|---|---|---|
| **WFT Gauge / Ruler** | Metallic | Do not use plastic types.<br>Do not clean gauge with grinding paper or similar mechanical action. Always clean immediately after each measurement.<br>Measurements should be made immediately (within minutes) after application. |
| **Temp/humidity/dewpoint meter** | Electronic | Calibrated regularly. |
| **Sling Psychrometer** | With two fixed thermometers | Make sure that the wet thermometer is moist with preferably distilled water. Sling for two (2) minutes, read, sling for another ½ minute, read, continue until two consecutive readings give the same results. |
| **Dew Point Calculator** | The disc-type is recommended | Consists of two overlapping discs with the same rotation center. |
| **Surface Thermometer** | Mechanical or Electronic | Calibrated regularly, able to read substrate and liquid surface temperatures |
| **Ruler/tape measure** | Steel | Measuring size of steel for calculation purposes. |
| **Vernier Calliper** | Steel | Precise measurements. |
| **Knife** | Folding or safety fitted. | High quality steel, sharp. Preferable with attachment to conduct cross hatch adhesion test where necessary. |
| **Marking Chalk** | | Yellow or white, non-grease. |
| **Filling Knife (Spatula)** | | Keep clean and sharp. |
| **Camera, Flash and Film** | Digital pocket size with built-in electronic flash and video enabled. | Minimum 5 megapixels. |
| **Note Book and Ball Pen** | Carboline Note Book | Use water-proof pens for writing. |
| **Marking Pens** | Permanent Ink Types | Thick felt types, black, red and green. |
| **Sealable plastic bags** | | Isolation of material samples if required. |