PIP RFSB2000
Brick Refractory Installation Specification
PURPOSE AND USE OF PROCESS INDUSTRY PRACTICES

In an effort to minimize the cost of process industry facilities, this Practice has been prepared from the technical requirements in the existing standards of major industrial users, contractors, or standards organizations. By harmonizing these technical requirements into a single set of Practices, administrative, application, and engineering costs to both the purchaser and the manufacturer should be reduced. While this Practice is expected to incorporate the majority of requirements of most users, individual applications may involve requirements that will be appended to and take precedence over this Practice. Determinations concerning fitness for purpose and particular matters or application of the Practice to particular project or engineering situations should not be made solely on information contained in these materials. The use of trade names from time to time should not be viewed as an expression of preference but rather recognized as normal usage in the trade. Other brands having the same specifications are equally correct and may be substituted for those named. All Practices or guidelines are intended to be consistent with applicable laws and regulations including OSHA requirements. To the extent these Practices or guidelines should conflict with OSHA or other applicable laws or regulations, such laws or regulations must be followed. Consult an appropriate professional before applying or acting on any material contained in or suggested by the Practice.

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# PIP RFSB2000
## Brick Refractory Installation Specification

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1. Introduction

1.1 Purpose

This Practice provides requirements for installation of brick refractory linings.

1.2 Scope

This Practice describes the requirements for installation of brick refractory linings in process equipment and piping. Installation methods include preparation, laying, and repair of the brick linings. This Practice also describes requirements for firing installed or repaired brick linings, if required.

2. References

Applicable parts of the following Practices, industry codes and standards, and references shall be considered an integral part of this Practice. The edition in effect on the date of contract award shall be used, except as otherwise noted. Short titles are used herein where appropriate.

2.1 Process Industry Practices (PIP)

- PIP CTSL1000 – Application of Internal Linings
- PIP RFIA1000 – Refractory Anchor and Accessory Installation Details (under development)
- PIP RFSA1000 – Refractory Anchor and Accessory Material Specification (under development)
- PIP RFSB1000 – Brick Refractory Material Specification (under development)
- PIP RFSF1000 – Ceramic Fiber Refractory Material Specification
- PIP RFSF2000 – Ceramic Fiber Refractory Installation Specification
- PIP RFSM1000 – Monolithic Refractory Material Specification
- PIP RFSM2000 – Monolithic Refractory Installation Specification
- PIP RFTA1000 – Refractory Anchor and Accessory Installation Qualification, Inspection, and Testing
- PIP RFTB1000 – Brick Refractory Installation Qualification, Inspection, and Testing
- PIP RFTF1000 – Ceramic Fiber Refractory Installation Qualification, Inspection, and Testing
- PIP RFTM1000 – Monolithic Refractory Installation Qualification, Inspection, and Testing
2.2 Industry Codes and Standards

- American Petroleum Institute (API)
  - API Standard 936 – Refractory Installation Quality Control - Inspection and Testing Monolithic Refractory Linings and Materials
- ASTM International
- The Society for Protective Coatings (SSPC)
  - SSPC-SP3 – Power Tool Cleaning
  - SSPC-SP7/NACE No. 4 – Brush-Off Blast Cleaning

3. Definitions

Terms used in this Practice are defined in accordance with ASTM C71, API Standard 936, and as follows:

brick: Pre-fired shapes

compliance data sheet: Data sheet provided by the manufacturer listing property values that the manufacturer certifies or guarantees will be met by each sample tested

dense brick: Brick other than IFB

IFB: Insulating fire brick

laying: Placement of brick and, if required, mortar to form the brick lining

purchaser: Party who awards the contract to the supplier. Purchaser may be the owner or the owner’s authorized agent.

purchaser’s inspector: Purchaser’s authorized representative with authority to act in the interest of, and on behalf of, purchaser in all quality assurance matters

supplier: Party responsible for furnishing and/or installing the brick refractory lining

4. Requirements

4.1 General

4.1.1 Conflicts, Exceptions, Substitutions, and Deviations

4.1.1.1 All conflicts between the referenced documents and this Practice shall be submitted in writing to purchaser for clarification and resolution before proceeding.

4.1.1.2 All exceptions, substitutions, and deviations to the requirements of this Practice and in referenced documents shall be approved by purchaser.
4.1.2 Regulations and Material Safety Data Sheets (MSDS)

4.1.2.1 Refractory materials shall be in accordance with all applicable federal, state, and local codes and regulations on storage, handling, safety, and environmental requirements.

4.1.2.2 The latest issue of the refractory manufacturer’s product data sheets, compliance data sheets, application instructions, and MSDS shall be available at the installation site and complied with during the installation of brick refractory linings.

4.1.3 Notification

Purchaser’s inspector(s) shall be given adequate notice before the start of work and prior to all hold points, so the inspector(s) can witness the work.

4.1.4 Preinstallation

4.1.4.1 An installation procedure including surface preparation, laying, and firing (if required) of the completed lining system shall be submitted to purchaser for review and approval before the start of installation. This procedure shall constitute an inspection hold point in accordance with PIP RFTB1000-F.

4.1.4.2 Brick received on site shall be checked for dimensional tolerances and, if required by the installation procedure, sorted by the critical dimension. This shall constitute a hold point in accordance with PIP RFTB1000-F.

Comment: Typically, the critical dimension is thickness which dictates the mortar joint thickness during installation. Excess joint thickness can lead to structural instability of the brick lining. As a minimum, sorting to plus or minus (over or under) the normal dimension is recommended.

4.2 Brick Refractory Lining Accessories

4.2.1 Anchors

Selection, installation, and inspection and testing of anchors and accessories shall be in accordance with PIP RFSA1000, PIP RFIA1000, and PIP RFTA1000, respectively.

4.2.2 Monolithics

Selection, installation, and inspection and testing of monolithic refractories shall be in accordance with PIP RFSM1000, PIP RFSM2000, and PIP RFTM1000, respectively.

4.2.3 Ceramic Fiber

Selection, installation, and inspection and testing of ceramic fiber refractories shall be in accordance with PIP RFSF1000, PIP RFSF2000, and PIP RFTF1000, respectively.
4.3 Surface Preparation and Coating

4.3.1 Requirements for Coated Surfaces

Inspections and tests necessary to assure that surface preparation and coating application are in accordance with the requirements of PIP CTSL1000 shall be completed before refractory installation. Completion of surface preparation and coating application shall each constitute an inspection hold point in accordance with PIP RFTB1000-F.

4.3.2 Requirements for Uncoated Surfaces

4.3.2.1 Immediately before refractory installation, all surfaces to be lined shall be cleaned in accordance with SSPC SP-7/NACE No. 4 standards for grit blasting if either of the following occurs:
   a. Rust, weld slag, oil, dirt, or other foreign materials are present on the surface to be lined
   b. Hydrotesting was performed after the grit blast cleaning for anchor installation

4.3.2.2 After grit blast cleaning, the surfaces to be lined shall be vacuum cleaned to remove all debris. Water shall not be used for washing unless it contains a suitable inhibitor.

4.3.2.3 Use of SSPC SP-3 shall be permitted for limited areas such as spot grinding for repairs.

4.3.2.4 Completion of cleaning before refractory application shall constitute an inspection hold point in accordance with PIP RFTB1000-F.

4.4 Prequalification of Materials and Installation Personnel

4.4.1 Refractory brick and mortar to be installed shall be certified and prequalified in accordance with PIP RFSB1000.

4.4.2 Refractory brick installation personnel shall be prequalified in accordance with PIP RFTB1000. Prequalification shall constitute an inspection hold point in accordance with PIP RFTB1000-F.

4.5 Water Quality and Testing

4.5.1 Mixing water shall be clean and potable (suitable for drinking), with a pH between 6 and 8.

4.5.2 Use of water from the fire fighting system shall not be permitted.

4.5.3 Water shall contain less than 200 ppm chlorides (or less if specified by the refractory material manufacturer) and shall be free of deleterious impurities. When in contact with austenitic stainless steel, the chloride content of water shall not exceed 50 ppm.

4.5.4 Equipment used for storing and handling the water shall be clean, so that no contaminating material is introduced.
4.6 Water-Contaminated Refractory Brick or Mortar

Refractory brick or mortar exhibiting evidence of water contamination shall be retested in accordance with *PIP RFSB1000* before use, regardless of the results of the previous prequalification (or requalification) testing.

4.7 Preparation for Lining Installation

4.7.1 Refractory lining installation shall not begin until after completion of welding, post weld heat treatment, and hydrostatic pressure testing.

4.7.2 Structural members, nozzle extensions, and other items within the limits of the lining shall be wrapped with ceramic fiber to accommodate thermal expansion.

4.7.3 Openings through the brick lining shall be preformed or drilled.

4.7.4 Obstructions (e.g., scaffolding) that could interfere with the satisfactory and continuous application of the refractory lining shall be avoided.

4.7.5 Nozzles

4.7.5.1 For brick-lined nozzles, including manways, the lining intersection shall be cut into the main lining hot face surface.

4.7.5.2 If monolithic refractories are used with the brick, packing of the openings with castable shall be in accordance with *PIP RFSM2000*.

4.7.6 Equipment Cleaning

4.7.6.1 Mixers and all other equipment shall be thoroughly cleaned before use.

4.7.6.2 Equipment shall be cleaned at each material change, shift change, and more often if buildup of mortar takes place.

4.7.6.3 All tools used for mixing, transporting, and applying the refractory lining shall be cleaned after each batch and kept free of all deleterious materials.

4.7.7 Work area shall be kept clean and protected to ensure that lining installation can proceed in an orderly manner without incorporating dirt, debris, rain, or other deleterious material into the lining.

4.8 Mortar Installation

4.8.1 Mixing

4.8.1.1 General

1. Full contents of each bag or drum of refractory mortar material shall be used.

2. Use of bags or drums of refractory mortar material that have been left open or damaged shall not be permitted.

3. Mixing of refractory mortar materials from one mortar manufacturer with those from other manufacturers shall not be permitted.

4. Admixtures shall not be added to the refractory mortar as received from the mortar manufacturer.
4.8.1.2 Temperatures

1. Mortar mixing shall be performed in accordance with mortar manufacturer’s temperature recommendations for the specific material and placement conditions.

2. Mix temperature requirements shall be met by one or more of the following methods:
   a. Cooling or heating the material
   b. Cooling or heating the water
   c. Providing a controlled environment for mixing

3. If a mortar manufacturer’s mix temperature recommendation is not available, the temperature of the wet-mixed refractory mortar shall be maintained between 5°C (40°F) and 38°C (100°F).

4. Refractory mortar shall not be exposed to live steam.

4.8.1.3 Equipment

1. Mortar shall be mixed using a mechanical mixer with a clean, dry, stirring paddle.

2. Stainless steel and carbon steel tools and equipment shall be used in contact with the refractory mortar.

3. Aluminum tools and equipment shall not be permitted.

4.8.1.4 Procedure

1. Containers of dry refractory mortar material containing hard lumps (i.e., that cannot be easily broken by hand) shall be discarded.

   Comment: During transportation and storage, refractory materials can compact into lumps. Such lumps are not detrimental to the installation if easily broken by hand.

2. Mortar shall be mixed to a uniform troweling or dipping consistency as applicable for the installation method.

3. The mortar shall be completely free of lumps, dried mortar particles, or foreign materials.

4. The mortar shall be capable of being spread uniformly over a brick surface without dragging, showing evidence of unmixed or foreign material, sagging, or running.

5. Mortar shall be used as provided. Water or other material shall be added only if approved by the mortar manufacturer.

6. Water Addition
   a. Water addition at the mixer shall be based on the following:
      (1) Actual weight of refractory mortar being used
      (2) Application requirements
(3) Water content as determined during the installer prequalification in accordance with PIP RFTB1000

Comment: Sticky (viscous) mortar may be required for overhead applications while a more liquid mortar may be required for dipping.

b. Water shall be accurately measured by volume (graduated containers) or weight as specified in the approved installation procedures.

c. Maximum total water content recommended by the mortar manufacturer and noted on the compliance data sheets for the material shall not be exceeded.

Comment: High or low humidity, wind, and exposure to sunlight can affect the total water content.

7. Post Mixing

a. Mixer shall be discharged directly into a clean metal, plastic, or wood (that has been sealed or lined) container.

b. Refractory mortar shall not be discharged onto the ground.

c. Refractory mortar that misses the container shall not be used.

d. Refractory mortar material that has been premixed may be remixed for conditioning or tempering purposes.

e. Mortar shall be covered during interruption in installation.

4.8.2 Application Conditions

4.8.2.1 Mortar Temperature

1. Unless otherwise specified by the mortar material manufacturer, temperature of refractory mortar shall be greater than 5°C (40°F) before and during application.

2. Phosphate bonded mortars shall not be permitted to freeze before firing.

3. If an increase in temperature is required, suitable means for heating and/or exterior insulation shall be provided.

4. Refractory mortar shall not be exposed to live steam.

5. Temperature of refractory mortar shall not be greater than 38°C (100°F) before and during application.

6. If a reduction in temperature is required, suitable means for cooling shall be provided.
4.8.2.2 Ambient Conditions

Refractory mortar shall be protected from detrimental ambient conditions, including the following:

a. Elevated temperature or exposure to sunlight causing evaporation of mixing water

b. Windy conditions drying the mix and/or removing fines

c. Exposure to rain or high humidity conditions increasing the water content

d. Dusty environments causing entrainment of foreign materials into the mix

4.8.3 Mortar Application

4.8.3.1 Mortar shall be applied to brick surfaces by one of the following methods:

a. Dipping (i.e., submerging the brick surface into mix mortar of fluid consistency)

b. Brushing (i.e., applying mortar to a brick surface with a stiff brush)

c. Troweling (i.e., applying mortar by buttering a brick surface with a steel trowel)

4.8.3.2 The consistency of the mortar for each technique shall be such that the mortar fills the pores of the brick and produces a mortar joint of the specified thickness, see Sections 4.9.3.3 (b), 4.9.4.2 (2), and 4.9.4.4 (2b).

4.8.3.3 Surfaces that make contact with other brick work shall be coated with mortar of sufficient quantity to completely fill the joint between brick.

4.9 Brick Refractory Installation

4.9.1 General

4.9.1.1 Casings shall be checked for defects, distortions, and joint discontinuities.

4.9.1.2 If any defects, distortions, or joint discontinuities are sufficient to affect the integrity of the brick lining, the problem shall be resolved before installing lining.

4.9.1.3 Minor variations in casings may be compensated for by varying the thickness of the backup layer (e.g., castable refractory or block insulation).

4.9.1.4 Working points shall be established to provide a continuous check of installation. A string line, plumb line, center line, or a similar linear device (e.g., laser) may be used to establish a working point for the location of the hot face surface.
4.9.1.5 Brick installation shall not be started until it is certain the lining can be completed with the material sizes available without excessive use of mortar or cutting of brick. When required by the installation procedure, brick in each course shall be selected from one of the graded groupings as defined by Section 4.1.4.2.

4.9.1.6 Brick less than one half a full brick shall not be permitted.

4.9.1.7 Installation of brick shall be performed by brick masons experienced in industrial refractory construction and qualified in accordance with PIP RFTB1000.

4.9.1.8 Interior (hot face) dimensions of the brickwork shall be maintained within specified tolerances in accordance with project documents, when applicable.

4.9.1.9 All wedge, arch, and key brick shall be installed so that they are keyed in place by adjacent brick work.

4.9.1.10 Installation of brick that is smaller on the back face than on the exposed face shall not be permitted.

4.9.1.11 Anchor brick shall be mortared with air-set bonding mortar.

4.9.1.12 Alternate header and stretcher courses and/or brick of different dimensions shall be used for bonding walls by staggering joints between layers.

4.9.1.13 Mortar shall not be smeared over hot face surfaces of brick linings.

4.9.2 Storage and Handling

4.9.2.1 Materials shall be protected from the weather and kept dry until ready for use.

4.9.2.2 Brick shall be kept clean to facilitate bonding with the mortar.

4.9.2.3 IFB shall not be stacked higher than IFB manufacturer’s recommendation.

4.9.2.4 Brick shall be handled carefully to avoid chipping of edges or cracking.

4.9.3 IFB Linings

4.9.3.1 IFB walls shall be properly anchored, straight and level.

4.9.3.2 Hook anchors shall be inserted carefully so that the brick is not cracked or damaged.

4.9.3.3 Dipped mortar joints shall be used and installed as follows:
   a. All joints shall be filled.
   b. Joints shall be approximately 0.8 mm (1/32 inch) thick. The joint thickness shall not exceed 1.5 mm (1/16 inch).

4.9.3.4 Individual rows of IFB shall not be leveled with excess mortar.

4.9.3.5 IFB shall be dry cut with a saw.
4.9.3.6 If block or fiber insulation is used as a backup layer, IFB shall be pressed tight against the insulation to minimize air gaps and voids. Insulating cement shall be used to fill large gaps and/or small broken areas in the block insulation.

4.9.3.7 As brick are laid, they shall be rubbed firmly into place to ensure minimum joint thickness. Adjacent brick work shall not be disturbed during this process.

4.9.4 Dense Firebrick Linings

4.9.4.1 General

1. If castable is used as a backup layer, an expansion allowance shall be provided around metallic anchors within the castable layer to permit thermal movement of the brick hot face and enable the brick wall to expand and contract during operation.

2. The direction and amount of brick anchor movement (Item 1 above) shall be calculated using the expected hot face temperature of the brick lining. Masking tape or ceramic fiber paper of appropriate thickness may be used to wrap anchors to provide the required expansion allowance.

3. If castable is used as a backup layer, brick courses a maximum of 450 mm (18 inches) high shall be laid before castable is installed into the space between brick and casing. A moisture proof barrier that will become permeable when heated to temperatures below 100ºC (212ºF) shall be placed on the cold face of the brick before castable is installed.

4. Hot face surfaces shall be washed (wiped down with a wet cloth) at the end of each day to remove excess mortar.

5. Hot face surfaces shall be inspected for mortar joint voids and any voids shall be pointed up.

6. Dense brick shall be cut with a wet cut diamond masonry saw.

7. Chipping or hammer work shall not be permitted.

8. Removal of small amounts, 3 mm (1/8 inch) or less, of refractory from flat faces or ends of brick shall be performed with a grinding wheel.

9. Feather edge cuts shall not be permitted.

10. Excess mortar shall be struck from the joints using a steel trowel.

4.9.4.2 Joints

1. Sufficient mortar shall be applied to insure that the side joints between the brick are filled completely. The joint shall be 1.5 mm (1/16 inch) thick maximum.

2. Mortar joints between courses of brick shall be approximately 1.5 mm (1/16 inch) thick. For the purpose of compensating for brick tolerances, the thickness may be 3 mm (1/8 inch) maximum.
3. Joints between brick and castable insulation shall be mortared only where castable is in place when brick are installed.

4. As brick are laid, they shall be rubbed firmly into place to ensure minimum joint thickness. Adjacent brick work shall not be disturbed during this process.

5. Brick shall be tapped to seat solidly against the brick upon which it is laid. Only rawhide or plastic headed hammer/mallets shall be used to tap brick into place. Steel headed hammers/mallets shall not be permitted.

**4.9.4.3 Cylindrical Lining**

1. For cylindrical equipment, each course of brick shall be installed in distinct rings that are circumferentially aligned.

2. Longitudinal joints between brick within rings shall be staggered ring to ring.

3. Key brick shall not be less than 2/3 original brick size.

4. Key brick in adjacent rings shall be staggered a minimum of 3 brick apart.

5. The sides of key brick shall be buttered before installation.

6. Metal shims for tightening rings in cylindrical brick linings shall not be permitted.

7. For keying rings, individual key spaces shall be spread using a hydraulic jack, and the key shall be driven into place.

8. Brick fractured during keying shall be removed and replaced.

**4.9.4.4 Heater Floor and Divider Wall**

1. Heater Floor
   a. Firebrick shall be laid flat, 64 mm (2½ inches) thick, on top of the insulating refractory that lines the floor of the heater.
   b. Firebrick shall be laid without mortar.
   c. A gap shall be left between the floor brick and the walls and floor-mounted burner tiles for thermal expansion. The gap shall be filled with ceramic fiber blanket.

2. Heater Divider Wall
   a. Divider walls shall be straight (plumb) and level.
   b. Troweled mortar joints shall be provided. The joints shall be between 0.8 mm (1/32 inch) and 1.5 mm (1/16 inch) thick.
   c. An individual row of brick shall not be leveled with excess mortar.
   d. Consistency in the thickness dimension is critical. All brick within a single course shall be either over or under the nominal thickness.
4.9.5 Expansion Joints

4.9.5.1 Expansion joint locations shall be determined during design of the refractory lining system. Expansion joints shall not be located where exposed to direct flame impingement.

4.9.5.2 Expansion joints shall be kept clean (i.e., free of debris) to permit thermal expansion movement of the wall or other component.

4.9.5.3 If packed expansion joints are specified, the joints shall be filled with flexible packing material in accordance with the design drawing.

4.9.6 Post Installation

4.9.6.1 Before firing, the temperature of the vessel shell and lining shall be maintained between 10°C (50°F) and 40°C (105°F).

4.9.6.2 Lining shall not be exposed to moisture or steam until firing has been completed.

4.9.6.3 For chemically bonded mortars, the lining surface shall remain uncovered until firing.

4.10 Firing

4.10.1 Firing of mortared brick linings shall occur as soon as possible after completion of the installation.

4.10.2 Firing may be performed by process heat or temporary heating equipment.

4.10.3 Castable backup linings heat dried before installation of brick shall be dried in accordance with PIP RFSM2000.

4.10.4 A firing plan shall be developed and shall include heat-up/cool-down rates for all control temperature indicators and the maximum difference between temperature indicators.

4.10.5 Firing plan shall be reviewed by the owner’s engineer.

4.10.6 Firing plan shall include a sketch showing the location of heat source(s), blower arrangement, and thermocouple locations.

4.10.7 Components shall be dried by heating from the refractory hot face side only.

4.10.8 Heating shall be monitored using either process or temporary thermocouples to monitor gas temperatures throughout the newly lined area(s).

4.10.9 Heating rates shall be controlled by thermocouples on the brick surface closest to the heat source and at the exit.

4.10.10 Hold temperatures and durations shall be achieved at the exit thermocouples.

4.10.11 Heat source and airflow shall be immediately removed upon completion of the firing schedule, all openings shall be closed, and equipment shall be allowed to cool naturally to 200°C (390°F).

4.10.12 Areas that are not adequate for the maximum firing temperature shall be sealed or otherwise protected from the firing temperatures. The temperature
of these areas and of the metal beneath the lining shall be monitored to ensure that allowable temperature values are not exceeded.

4.10.13 Outer metal surfaces shall not be insulated.

4.10.14 Flow of heated air shall be controlled so that the entire surface of the lining is subjected to the full firing cycle. Back pressure, throttling of the air flow, or other means can be used to assure proper air flow. Dead or low-flow areas shall not be permitted.

4.10.15 During the firing cycle, adequate ventilation shall be provided for escape of moisture.

4.10.16 Firing shall be performed by personnel experienced in the dryout of brick lined equipment. Personnel also shall be experienced in operating the equipment used for firing.

4.11 Repairs

4.11.1 General

4.11.1.1 Brick lining deemed defective in accordance with PIP RFTB1000 shall be repaired.

4.11.1.2 Non-brick lining shall be evaluated and repaired in accordance with applicable Practices (i.e., castable backup in accordance with PIP RFSM2000 and PIP RFTM1000; ceramic fiber backup in accordance with PIP RFSF2000 and PIP RFTF1000).

4.11.2 Repair Procedures

4.11.2.1 Materials and methods of repair shall be approved by the owner’s engineer before a repair is made.

4.11.2.2 If removing brick adjacent to a shell, damage to the shell shall not be permitted.

4.11.2.3 For a multilayer-lining, the defective portion of the hot face shall be removed without removing or disturbing the backup.

4.11.2.4 If anchors or attachment welds are damaged, the anchors shall be replaced in accordance with PIP RFIA1000.

4.11.2.5 Immediately before placement of new brick, sound material adjacent to the repair area shall be cleaned of debris.

4.11.3 Firing of Repaired Lining

4.11.3.1 Repaired areas of an unfired lining shall be fired in conjunction with firing of the overall lining.

4.11.3.2 Patched areas equal to or less than 0.5 square meter (5 square feet) in previously fired linings shall not require a separate firing.

4.11.3.3 Patched areas greater than 0.5 square meter (5 square feet) in previously fired linings shall be fired in accordance with the firing procedure for the original linings.

4.11.3.4 If approved by the owner’s engineer, local heating may be used as an alternative.
4.11.3.5 Means shall be provided to vent steam from all areas of the lining repair.

4.11.3.6 For linings containing hydrocarbon or hydrocarbon residues, firing of repairs shall not be at temperatures greater than 370°C (700°F) at any location.

Comments: Hydrocarbon or hydrocarbon residues are combustible and may ignite at elevated temperatures if oxygen is present.

4.12 Shipping and Storage of Equipment

4.12.1 Shop-installed brick lining shall be prepared for shipment in a manner that ensures delivery to the destination in the original lined and fired condition.

4.12.2 Equipment shall be reinforced using spiders, truing rings, braces, etc. to maintain the equipment shape and prevent damage to the linings during handling and shipment.

4.12.3 All openings shall be sealed, and a means shall be provided to keep linings dry during shipping, storage, and post-erection before the startup.

4.12.4 Proper supports, external bracing, rigging, and lifting techniques shall be used to prevent flexing of the equipment during handling, shipping, and erection.

4.12.5 Orientation of the equipment during shipment and storage shall maintain integrity of the lining.