

SCOPE

- I 1.1 This practice covers material selection, installation, inspection, and testing of linings for fired heaters, including combustion air, flue gas ducting and stacks.
- I 1.2 **An asterisk (*)** indicates that a decision by the Purchaser is required or that additional information is furnished by the Purchaser.

SUMMARY OF ADDITIONAL REQUIREMENTS

- I ↗ 2.1 **Table 1** lists the practices, standards and specification which shall be used with this practice.

TABLE 1

PRACTICES			
IP 18-12-1 Positive Materials Identification		IP 20-1-1 Inspection of Equipment and Material	
STANDARDS AND SPECIFICATION			
API Standards 560 Fired Heaters for General Refinery Service API Recommended Practice RP 936 Refractory Installation Quality Control Guidelines ASTM Standards C 27 Standard Classification of Fireclay and High Alumina Refractory Brick C 109 Compressive Strength of Hydraulic Cement Mortars (Using 2 in. or 50 mm Cube Specimens)		ASTM Standards (Cont) C 133 Cold Crushing Strength and Modulus of Rupture of Refractory Brick and Shapes C 860 Determining Consistency of Refractory Concretes C 862 Preparing Refractory Concrete Specimens by Casting C 865 Firing Refractory Concrete Specimens C 155 Insulating Firebrick SSPC Specification SP7 Brush Off Blast Cleaning	

- I 2.2 **The castable or ceramic fiber manufacturer's requirements** shall be followed in addition to the requirements of this practice.

DOCUMENTATION

- I 3.1 **The following information** shall be supplied to the Purchaser for all castables for review and approval:
 - a. Any changes from information supplied for bid review
 - b. Applicable physical properties of refractory product to be installed, including:
 - 1. Composition.
 - 2. Cold crushing strength, permanent linear change, dry density.
 - 3. Maximum continuous service temperature.
 - 4. Thermal expansion from ambient temperature to specified use temperature.
 - 5. Thermal conductivity at specified use temperature.
 - c. Installation procedures, including:
 - 1. Packaging and storage.
 - 2. Age of packed mixed castable on the specified date of shipment.
 - 3. Surface preparation.
 - 4. Installation equipment and techniques.
 - 5. Water ratio to be used.
 - 6. Method of curing and dryout.
 - d. Final design details, including:
 - 1. Anchor types, materials, size and spacing.
 - 2. Expansion joints.
 - 3. Edging and joint details.
 - S e. Material Safety Datasheets

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(This practice is appropriate for attachment to Inquiry or Purchase Document)

- I 3.2 **The following information** shall be supplied to the Purchaser for all ceramic fiber insulation for review and approval:
 - a. Linear change at maximum and operating temperature.
 - b. Thermal conductivity in installed condition at design temperature.
 - c. Density.
 - d. Installation and blanket joint and anchoring details.
 - e. Installation procedures.
- S * f. Materials Safety Data Sheets (for purchase and use within the USA). For other conditions of purchase and use, vendor shall furnish information on safety precautions to be taken during application for personnel protection.
- g. Any changes from information supplied for bid review.
- h. Anchor type, material, size, spacing and welding procedure and testing methods.
- i. Mill tests on all anchor material.
- j. Final design details including expansion joints, corners, etc.
- I 3.3 The **following information** shall be supplied to the Purchaser for all brick for review:
 - a. Composition of brick.
 - b. Compressive strength, both hot and cold.
 - c. Coefficient of linear change.
 - d. Design of expansion joints.
 - e. Description of mortar to be used.
 - f. Details of support shelves and tie-backs.
 - g. Any changes from information supplied for bid review.
- I 3.4 The **final records** to be submitted to Owner's Engineer for castable linings are:
 - a. Approved dryout schedule.
 - b. Quality control test reports.
 - c. Mill tests on all anchor material.
- R * 3.5 **Shipping and handling procedures** for all equipment with linings installed elsewhere than job site shall be submitted to the Purchaser for review by the Owner's Engineer.

MATERIALS

GENERAL

- S,E 4.1 **Asbestos** or asbestos containing materials are not permitted.

ALL CASTABLES

- R 4.2 **Materials containing calcium silicate type binders** (Portland cement) shall not be used at temperatures over 1000°F (540°C).
- R * 4.3 Proposals to use **castables having sodium or potassium silicate** binders shall be submitted to Purchaser for approval by the Owner's Engineer.



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- R 4.4 **Physical properties of castables** in this paragraph are the minimum acceptable requirements for selection of refractory type, e.g., "Light Weight". The values which have to be met by the installed refractory, during testing, are to be the manufacturer's advertised values for the chosen refractory, within the range shown in **Par. 11.2**.

CASTABLE TYPE	DRY INSTALLED DENSITY lb/cu ft (1)(2)(3)	MINIMUM COMPRESSIVE STRENGTH psi (2)(3)	PERMANENT LINEAR CHANGE %, max (2)	SERVICE TEMPERATURE LIMIT °F (3)
1. Very Light Weight	20 to 45	30	- 2.0	≥ 1500
2. Light Weight	45 to 75	300	- 1.2	≥ 2000
3. Medium Weight	75 to 115	500	- 1.0	≥ 2000
4. Heavy Weight	115 to 150	2000	- 0.8	≥ 2400
5. Dense	>150	5000	- 0.8	≥ 2400

Notes:

- (1) In the installed condition after drying at 220°F (105°C) for 18 hours (established by cube specimens for cast and panel tests for gunned applications).
(2) As determined by test procedure described herein.
(3) Acceptable metric equivalents:

lb/cu ft	kg/m ³	psi	kPa	°F	°C
20	320	30	207	220	105
45	7720	300	2070	1500	815
75	1200	500	3450	2000	1100
115	1840	2000	13800	2400	1313
150	2400	5000	34500		

- R 4.5 **A packaged mixed castable** shall be installed within four months of the initial acceptance tests, or within three months of each succeeding satisfactory requalification test.
R 4.6 **Proposals** to use castables containing metal or other fibers must be approved by the Owner's Engineer.
R 4.7 **All castable** shall be packaged, factory premixed by the manufacturer; no field mixes are acceptable.

CERAMIC FIBERS

(Materials shall be in accordance with the requirements for ceramic fibers in API Standard 560.)

BRICK

- R 4.8 Maximum **permanent linear change** shall be -0.1 percent, after heating to 1500°F (815°C).
R * 4.9 **Support shelf material** shall be approved by the Owner's Engineer.
R 4.10 The **mortar** shall be non-slagging, airset type chemically compatible with the refractory up to the rated temperature of the brick.

ANCHORS AND ANCHOR COMPONENTS

- 4.11 For the purpose of material selection, anchor temperature is considered to be the same as the refractory or ceramic fiber temperature at the tip of the anchor or anchor component.
4.12 Austenitic materials shall be supplied less than 250 Brinell hardness before bending to avoid brittle failures. Equivalent values on other scales, such as Rockwell C can be used (i.e., less than 25 R_C).
4.13 **Anchor supplier** shall verify material quality of all metallic anchor and components by submitting mill tests to the Owner's Engineer.

MATERIAL LIMITATIONS, EXPOSURE TO SULFUR AND VANADIUM ENVIRONMENT

- R 4.14 When the fuel fired contains sulfur and/or vanadium compounds within the limits prescribed below, the following shall govern:

FUEL FIRED CONTAINS:	MATERIAL RESTRICTIONS	OTHER REQUIREMENTS OF THE LINING SYSTEM
Oil ≥ 0.5% (mass) S Gas ≥ 0.5% vol H ₂ S (> 250 vppm SO ₂ in flue gas)	"Facing" to be Medium Weight or heavier castable or brick and total concentration of free alkali, MgO and iron in the aggregate shall be less than 15%. - Binder for facing and back-up shall be calcium aluminate cement. - Carbon Steel anchors prohibited. - Multi layer Ceramic Fiber blanket per Par. 4.18	Protective coating to prevent acid corrosion to be applied to fired heater casing (floors, walls, arch, convection section) except for the lining systems described in Par. 4.17. See Par 4.18 for ceramic fiber lining requirements.
> 400 ppm (mg/kg) Vanadium (including Na)	"Facing" to be Heavy Weight or Dense castable or brick with overall Al ₂ O ₃ content 40% min, with not less than 40% Al ₂ O ₃ in aggregate and a Si O ₂ content 35% max.	—

- R * 4.15 When fired heaters are designed for **on stream water washing of tubes**, "facing" material shall be Medium Weight or heavier.
- R 4.16 **Protective coating to prevent acid corrosion** of fired heater casing shall be a flake filled polyester equal to Carboline Company 1601SG or a vinyl ester such as Plasite Protective Coating Company, Plasite 4310. Surface preparation and coating application shall be per the following:
- Surface preparation:** White Metal Blast Cleaning.
 - Application:** 2 coats, 40 mil (1000 µm) total dry film thickness.
- R,C 4.17 **Lining systems not requiring a protective coating.** Where the fuel fired equals or exceeds the sulfur limits of Par. 4.14, the protective coating is not required for the following lining systems:
- Multi-layer castable**, where the "Facing" is Medium Weight or heavier and not less than 3 in. (75 mm) thick.
 - Single-layer castable lining**, where the Medium Weight or heavier castable is not less than 3 in. (75 mm) thick, and is in direct contact with the casing.
 - Ceramic fiber blanket** hot face with a Medium Weight or heavier castable back-up consisting of not less than 3 in. (75 mm) thick, and is in direct contact with the casing.
- R 4.18 Where the fuel fired equals or exceeds the sulfur limits of Par 4.14, **multi layered ceramic fiber linings** shall have two layers of 2 mil thick stainless steel vapor barrier placed between layers where the temperature is between 480 to 750°F (250 to 400°C). Individual foil panels shall have an 8 in. (203 mm) minimum overlap. Overlap joints and all penetrations shall be sealed with sodium silicate cement. No casing protective coating is required. Where the fuel is less than the sulfur limits of Par. 4.14, multi layered ceramic fiber lining may be used with a single vapor barrier or the casing must have a protective coating.

CASTABLE DESIGN (SINGLE OR MULTI-LAYER)

EXPANSION JOINTS

- R 5.1 When **panel precast construction is used**, the space between adjacent panels shall be no more than 1/4 in. (6 mm) at the hot face surface. This space shall be packed with a ceramic fiber blanket material having a service temperature limit of at least 300°F (170°C) above the hot face design temperature.

ANCHORS

- R 5.2 Acceptable anchor designs for single and multi-layer linings are shown in [Figure 1](#). Anchors shall be constructed with straight tines and are required for each lining layer.
- R 5.3 When lining thickness is less than or equal to 3 in. (75 mm) the anchor spacing shall be reduced to 6 in. (150 mm) pitch, i.e., 1 per 36 sq. in. (1 per 230 sq. cm).
- R 5.4 Anchors are required for shop installed floor refractory, but not field installed floor refractory.