Process Industry Practices
Refractory

PIP RFSF1000
Ceramic Fiber Refractory Material 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 RFSF1000
## Ceramic Fiber Refractory Material Specification

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1. Introduction

1.1 Purpose
This Practice describes the requirements for the certification and prequalification of ceramic fiber refractory materials used to construct refractory linings of fired heaters and other process equipment.

1.2 Scope
This Practice provides a basis for selection, purchase, and quality control of ceramic fiber refractory materials before installation.

This Practice describes the material property, testing, documentation, storage, packaging and shipping requirements of the following types of ceramic fiber refractories:

a. Refractory ceramic fiber
b. Bio-soluble ceramic fiber

This Practice does not include mineral wool, fiberglass, and other non-refractory fiber insulation materials.

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 RFIA1000 – Refractory Anchor and Accessory Installation Details (under development)
- PIP RFSA1000 – Refractory Anchor and Accessory Specification (under development)
- PIP RFTA1000 – Refractory Anchor and Accessory Installation Qualification, Inspection, and Testing

2.2 Industry Codes and Standards
- American Society for Testing and Materials (ASTM)
  - ASTM C201 – Standard Test Method for Thermal Conductivity of Refractories
  - ASTM E1172 – Standard Practice for Describing and Specifying a Wavelength-Dispersive X-ray Spectrometer
  - ASTM E1184 – Standard Practice for Determination of Elements by Graphite Furnace Atomic Absorption Spectrometry
  - ASTM E1479 – Standard Practice for Describing and Specifying Inductively-Coupled Plasma Atomic Emission Spectrometers
2.3 Other References


3. Definitions

bio-soluble ceramic fiber: Ceramic fiber refractory material that contains greater than 18 weight percent CaO+MgO and is in accordance with the European Union’s regulatory health, safety, and environmental requirements for bio-solubility. This is also known as bio-persistence fiber or alkaline earth silicate (AES) fiber. The minimum continuous use temperature of bio-soluble fiber is 890°C (1630°F).

blanket: Flexible ceramic fibrous insulating material of determinate dimension and without binder

board: Substantially rigid flat sheet produced from bulk fiber and binder

bulk fiber: Loose form of ceramic fiber refractory

ceramic fiber refractory: Refractory made of either refractory ceramic fiber or bio-soluble ceramic fiber materials

compliance data sheet: Data sheet provided by the manufacturer listing physical and chemical property values that the manufacturer certifies or guarantees will be met by each sample tested using the specified procedures in Appendix A

continuous use limit temperature: The maximum temperature to which the ceramic fiber refractory can be continuously exposed for extended periods (a minimum of 20 years) of operation. This temperature is the maximum temperature for which shrinkage, in accordance with ASTM C892, is less than 1 percent after 24 hour exposure.

hot face: Refractory surface exposed to the process temperature

manufacturer: The party that produces the ceramic fiber refractory material and/or the final product form (e.g., blanket, modules, etc.)

module: A prefabricated unit which can be applied as an individual lining block

owner: Party who owns the facility wherein the refractory lining is to be used

paper: A flexible, substantially flat, sheet produced from ceramic fiber refractory and binder, with a thickness not greater than 6 mm (1/4 inch)

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

refractory ceramic fiber: Ceramic fiber refractory made of alumino-silicate materials with a minimum continuous use temperature of 980°C (1800°F)

rigidizer: A proprietary inorganic hardening agent applied to the ceramic fiber refractory hot face in order to improve its resistance to gas flow

rope: Flexible, braided, product form of ceramic fiber refractory
shot: Particles of unfiberized melted materials formed during the production of ceramic fiber refractory

supplier: Party responsible for providing the ceramic fiber refractory lining materials

textile: Cloth, tape, sleeve, or other forms manufactured from ceramic fiber refractory

4. Requirements

4.1 General

4.1.1 Candidate Materials

Manufacturer of the ceramic fiber refractory material shall provide refractory performance record of service in the same or very similar application for evaluation by the purchaser.

Comment: Adherence to technical data is not sufficient to ensure adequate ceramic fiber refractory performance. Technical data is a means of characterizing a candidate material as being (or not being) a reasonable choice for a given application.

4.1.2 Conflicts, Exceptions, Substitutions, and Deviations

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

4.1.2.2 All exceptions, substitutions, and deviations to the requirements of this Practice and in referenced documents shall be approved by the purchaser.

4.1.3 Regulations and Material Safety Data Sheets (MSDS)

4.1.3.1 Ceramic fiber refractory materials shall be in accordance with all applicable federal, state, and local codes and regulations on storage, handling, safety, and environmental requirements.

4.1.3.2 The latest issue of the applicable manufacturer’s MSDS shall be provided for each installation site and complied with during the installation of ceramic fiber refractory linings.

4.1.4 Material Properties Information

4.1.4.1 The latest issue of the applicable manufacturer’s product data sheets, compliance data sheets, and installation instructions shall be provided for each installation site and complied with during the installation of ceramic fiber refractory linings.

4.1.4.2 Ceramic fiber refractory materials compliance data sheets shall be provided by the manufacturer in accordance with Appendix A of this Practice.

4.1.4.3 Compliance data sheets shall list the physical and chemical property values that the manufacturer certifies or guarantees to be met by each sample tested using the specified procedure in accordance with Appendix A, Table A-1.
4.1.4.4 Compliance data sheets shall be in accordance with the requirements of Appendix A or manufacturer’s guaranteed values if more stringent.

*Comment:* For example, for ceramic fiber refractory containing zirconia, Appendix A requires a minimum zirconia content of 15 weight percent and the manufacturer guarantees 17 weight percent for their product; therefore, the minimum acceptable zirconia content is 17 weight percent.

4.1.4.5 If alternate product property values are agreed upon with the purchaser, the alternate values shall be shown as an addendum to the compliance data sheets for the specific project.

4.2 Refractory Properties

4.2.1 General

4.2.1.1 The ceramic fiber refractory purchased for each installation site shall be suitable for the intended service and of the type specified in the contract documents (e.g., purchaser’s specifications and drawings). The type shall be as defined in Appendix A of this Practice.

4.2.1.2 Ceramic fiber refractory materials shall not contain asbestos.

4.2.1.3 Ceramic fiber refractory materials which contain chromium oxide that may convert into hexavalent chrome shall be considered as hazardous material and shall be addressed accordingly. Determination of the potential formation of hexavalent chrome and guidance on handling of hazardous material is beyond the scope of this Practice.

4.2.2 Certification

4.2.2.1 General

1. Certification means confirmation that the material to be considered is in accordance with the required chemistry and properties for the specified application.

2. Ceramic fiber refractory products shall be certified before being considered for use.

3. Certification may include testing of ceramic fiber refractory properties.

4. Testing methods and procedures, and the resultant property values shall be in accordance with the requirements of Appendix A of this Practice and the manufacturer’s guaranteed values for the applicable ceramic fiber refractory types.

4.2.2.2 Sampling

1. Samples shall be taken from randomly selected manufactured ceramic fiber refractory product.

2. A previously unopened container of ceramic fiber refractory shall be used for the preparation of specimens for testing.
4.2.3 Testing

1. The requirements of this section shall apply to the properties listed on the manufacturer’s compliance data sheets to evaluate candidate materials for a refractory type as defined by Appendix A of this Practice.

2. The specimen requirements (i.e., preparation, number, and shape) and testing for each property shall be in accordance with the applicable ASTM test procedures listed in Appendix A of this Practice.

3. Testing, by the manufacturer, shall include bulk density, chemistry, thermal conductivity, shot content, and continuous use temperature.

4. For bio-soluble ceramic fiber refractory, evidence from the manufacturer shall be provided that the fiber is exempt from carcinogenic classification in accordance with Note Q of Commission Directive 97/69/EC.

5. The average of the test result values for specimens making up the sample shall be in accordance with the requirements of Appendix A of this Practice or, if more stringent, the manufacturer’s compliance data sheet.

4.2.3 Material Prequalification

4.2.3.1 General

1. The requirements of this section shall be used for prequalification of ceramic fiber refractory material.

Comment: Prequalification testing is intended to determine if the product has been properly manufactured and can be expected to perform similarly to previously manufactured product of the same brand identification that has been certified for the application.

2. Each type of ceramic fiber refractory to be shipped to the installation site shall be certified to be in accordance with the required test values before shipment from the manufacturer’s facility.

3. Samples shall be tested at the manufacturer’s facility or, if specified by purchaser, at an independent laboratory approved by purchaser.

4. If purchaser chooses to witness the testing, purchaser shall be notified of the time and place of the testing as specified in the contract documents. Notice shall be given far enough in advance of the testing so that purchaser may arrange to be present.
4.2.3.2 Sampling

1. A sample shall be taken from each production line at each manufacturing facility for each product for each day.

2. For modules sampling shall be of the fiber before fabrication of the modules. A sample shall be taken from each production line at each manufacturing facility for each product for each day.

4.2.3.3 Testing

1. The requirements of this section shall apply to the properties listed on the manufacturer’s compliance data sheets to evaluate candidate materials for a refractory type as defined by Appendix A of this Practice.

2. The specimen requirements and testing for each property shall be in accordance with the applicable ASTM test procedure listed in Appendix A of this Practice.

3. Testing shall include bulk density, chemistry, and shot content for each sample.

4. Testing for thermal conductivity and continuous use temperature shall be one for each product in each order.

5. For bio-soluble ceramic fiber refractory, evidence from the manufacturer shall be provided that the fiber is exempt from carcinogenic classification in accordance with Note Q of Commission Directive 97/69/EC.

6. The average of the test result values for specimens making up the sample shall be in accordance with the requirements of Appendix A of this Practice or, if more stringent, the manufacturer’s compliance data sheet or other values agreed with purchaser.

7. The results of the material prequalification testing shall be provided to purchaser. In addition to the test results, the following information shall be provided:
   a. Product brand name
   b. Manufacturer’s name
   c. Plant of manufacture
   d. Date of manufacture
   e. Production line identification
   f. Date of testing
   g. Testing agency name
4.3 Ceramic Fiber Refractory Lining Accessories

4.3.1 Anchors for Non-Modular Lining

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

4.3.2 Anchors for Modular Lining

4.3.2.1 Modules shall be provided in accordance with manufacturer’s approved installation procedure, using the manufacturer’s proprietary anchor system.

4.3.2.2 The anchor assembly shall be located a maximum of 50 mm (2 inches) from the module cold face.

4.3.2.3 Anchorage shall be provided over at least 80 percent of the module width.

4.3.2.4 Module internal hardware shall be austenitic stainless steel or nickel alloy in accordance with PIP RFSA1000, Table 1.

4.4 Ceramic Fiber Refractory Modules

4.4.1 Modules shall be 300 by 300 mm (12 by 12 inches) and minimum 100 mm (4 inches) thick.

Comment: For irregular shapes (e.g., outside bends), modules of larger dimensions can be required.

4.4.2 Folded blanket modules shall be provided in a pre-compressed condition.

4.5 Bulk Fiber

Lubricated bulk fiber shall be used to pack nozzles and other confined spaces.

4.6 Blanket

4.6.1 Blanket shall be provided in maximum dimensions consistent with the design.

4.6.2 Blanket shall be provided in the specified thickness, and may be provided in a greater width and/or length from which the installed width and/or length can be cut with minimal wastage.

4.6.3 Maximum bundle weight shall be 25 kg (55 pounds).

4.7 Board

4.7.1 Board for hot face service shall be provided in the specified thickness, and may be provided in the specified installed size or a larger size from which the installed width and length can be cut with minimal wastage.

4.7.2 Board for expansion joint service shall be provided in the specified thickness, and may be provided in the installed size or a larger size from which the installed depth and length can be cut with minimal wastage.

4.8 Miscellaneous Ceramic Fiber Refractory Materials

4.8.1 Ceramic fiber refractory paper, rope, textile, and other products shall be in accordance with the project specification.
4.8.2 Material and service temperature of the rigidizer shall be compatible with the material of the ceramic fiber refractory lining to which the rigidizer is applied and the service condition to which the rigidizer is exposed.

4.9 Shipping and Storage of Materials

4.9.1 General

Materials shall be kept in their original and unopened packaging and kept dry until ready for use.

4.9.2 Packaging

4.9.2.1 Ceramic fiber refractory shall be shipped in polyethylene-lined boxes grouped on pallets.

4.9.2.2 The boxes on each pallet shall be enclosed by plastic (i.e., polyethylene) stress or shrink-wrap.

4.9.2.3 The wrap shall cover all sides of the shipment, including the underside, between the boxes and the pallet.

4.9.2.4 The wrap shall be completely sealed so that moisture cannot enter or become trapped within the wrap.

4.9.2.5 The wrap shall not be removed, cut, or opened until the refractory is to be used.

4.9.2.6 The ceramic fiber refractory shall be protected from mechanical damage.

4.9.3 Marking

4.9.3.1 Each box and pallet of material shall include the following information:

a. Product brand name
b. Manufacturer’s name
c. Plant of manufacture
d. Date of manufacture
e. Production line identification
f. Size (i.e., thickness, length, and width) and density
g. Weight of bulk fiber

4.9.3.2 Material identification signs shall be posted prominently on all four sides of each pallet.

4.9.3.3 Pallet numbering shall be as follows:

a. Pallets in each shipment shall be identified by lot or order number.

b. The pallet in each shipment shall be numbered consecutively starting with number 1.

c. The total number of pallets in the lot shall be included in the identifying number (e.g., 3 of 7).
Appendix A

Ceramic Fiber Refractory Material Compliance Data Sheets

A.1 Compliance data sheets are applicable to certification and qualification testing of ceramic fiber refractory materials.

A.2 Manufacturer shall develop compliance data sheets for any ceramic fiber refractory material commonly used or marketed.

A.3 Each compliance data sheet shall include a statement of identification as a compliance data sheet.

A.4 Manufacturer shall provide compliance data sheets to purchaser upon request.

A.5 Standard compliance data sheets containing data shown in Table A-1 shall be prepared in advance and retained on file for immediate transmission to purchaser.

A.6 Compliance data sheets shall include all information listed in Table A-1 for the applicable material category.

A.7 Values on the compliance data sheets shall be determined using the test method and temperature listed in Table A-1 for the applicable property. The compliance data sheet shall include the test methods with edition and the issue date of this practice used for each value listed.

A.8 Compliance data sheets shall include a statement similar to the following, “Samples of <<Insert product name>> will meet the values in this compliance data sheet for the listed properties in PIP RFSF1000, Appendix A, Table A-1 if tested in accordance with the specified methods. All tests and listed properties are in accordance with the requirements of PIP RFSF1000, Appendix A.”

A.9 If a test is not applicable to the specific material the words “not applicable” or “N/A” shall be entered into the appropriate place on the compliance data sheet.

A.10 The compliance data sheet shall be signed by an authorized manufacturer’s representative.
### Table A-1. Ceramic Fiber Refractory Material Compliance Requirements (Notes 1, 2, 3, and 4)

<table>
<thead>
<tr>
<th>Description</th>
<th>Refractory Ceramic Fiber</th>
<th>Bio-Soluble Ceramic Fiber</th>
</tr>
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<tbody>
<tr>
<td>Continuous Use Temperature Limit, °C (°F) Minimum (Note 5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Module</td>
<td>1090 (2000)</td>
<td>1180 (2150)</td>
</tr>
<tr>
<td>Layered Blanket</td>
<td>980 (1800)</td>
<td>1070 (1950)</td>
</tr>
<tr>
<td>Maximum Thermal Conductivity - K, W/mK (BTU ft²/HR/°F/in.) per ASTM C 201, tested at 540°C (1000°F) mean temperature</td>
<td>64 Kg/m³ (4 lb/ft³)</td>
<td>0.19 (1.3)</td>
</tr>
<tr>
<td></td>
<td>96 Kg/m³ (6 lb/ft³)</td>
<td>0.17 (1.2)</td>
</tr>
<tr>
<td></td>
<td>128 Kg/m³ (8 lb/ft³)</td>
<td>0.14 (1.0)</td>
</tr>
<tr>
<td>Shot Content per ASTM C 892, Maximum</td>
<td>&lt;30%</td>
<td>&lt;30%</td>
</tr>
<tr>
<td>Al₂O₃, weight percent (Note 6)</td>
<td>&gt; 45</td>
<td>&gt; 46</td>
</tr>
<tr>
<td>SiO₂, weight percent (Note 6)</td>
<td>Balance</td>
<td>Balance</td>
</tr>
<tr>
<td>ZrO₂, weight percent (Note 6)</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>CaO+MgO, weight percent (Note 6)</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Other, weight percent (Note 7)</td>
<td>&lt; 2</td>
<td>&lt; 0.1</td>
</tr>
</tbody>
</table>

**NOTES:**

1. Data is for proprietary, commercial, manufactured materials.
2. Values are the averages of the number of samples in the test.
3. N/A indicates that the property test is not applicable.
4. All values are based upon the specified ASTM test or other noted test method.
5. Continuous use temperature is the maximum temperature for which shrinkage, in accordance with ASTM C 892, is less than 1 percent after 24 hour exposure.
6. Testing shall be in accordance with E1172 or E1479.
7. Testing shall be in accordance with E1184 and either E1172 or E1479.