PIP INSH1000
Hot Service Insulation Materials
and 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.

This Practice is subject to revision at any time.

© Process Industry Practices (PIP), Construction Industry Institute, The University of Texas at Austin, 3925 West Braker Lane (R4500), Austin, Texas 78759. PIP member companies and subscribers may copy this Practice for their internal use. Changes or modifications of any kind are not permitted within any PIP Practice without the express written authorization of PIP. Authorized Users may attach addenda or overlays to clearly indicate modifications or exceptions to specific sections of PIP Practices. Authorized Users may provide their clients, suppliers and contractors with copies of the Practice solely for Authorized Users’ purposes. These purposes include but are not limited to the procurement process (e.g., as attachments to requests for quotation/purchase orders or requests for proposals/contracts) and preparation and issue of design engineering deliverables for use on a specific project by Authorized User’s client. PIP’s copyright notices must be clearly indicated and unequivocally incorporated in documents where an Authorized User desires to provide any third party with copies of the Practice.

PRINTING HISTORY
October 1997   Issued   August 2007   Editorial Revision   August 2018   Complete Revision
October 2005   Complete Revision   February 2011   Reaffirmation with Editorial Revision

Not printed with State funds
# PIP INSH1000
## Hot Service Insulation Materials and Installation Specification

**Table of Contents**

1. **Scope** ................................................. 4
2. **References** ........................................ 4
   2.1 Process Industry Practices ............... 4
   2.2 Industry Codes and Standards .......... 4
3. **Definitions** ......................................... 4
4. **Requirements** ............................... 5
   4.1 Project Scope ........................................ 5
   4.2 Materials .............................................. 5
   4.3 Storage and Handling of Insulation Materials ........................................ 6
   4.4 Installation Requirements ............... 6
   4.5 Quality Plan ........................................... 15
   4.6 Inspection ............................................. 15
   4.7 Repairs ............................................... 16

**Data Forms**

- **INSH1000-D001** – Documentation Requirements Sheet
- **INSH1000-D002** – Hot Service Insulation System Project-Specific Requirements
- **INSH1000-D003** – Extent of Hot-Service Insulation
- **INSH1000-D010** – Calcium Silicate Insulation System for Pipe and Equipment
- **INSH1000-D011** – Expanded Perlite Insulation System for Pipe and Equipment
- **INSH1000-D012** – Mineral Wool Preformed Pipe Sections Insulation System
- **INSH1000-D013** – Mineral Wool Board Insulation System for Equipment
- **INSH1000-D014** – Mineral Wool Blanket Insulation System for Pipe and Equipment
- **INSH1000-D015** – Glass Fiber Preformed Pipe Sections Insulation System
- **INSH1000-D016** – Glass Fiber Board Insulation System for Equipment
- **INSH1000-D017** – Glass Fiber Blanket Insulation System for Pipe and Equipment
- **INSH1000-D018** – Cellular Glass Block and Fabricated Sections Insulation System

---

**Data Forms**

The following data forms shall be part of this Practice only if indicated on the purchaser’s completed Documentation Requirements Sheet.

**INSH1000-D001** – Documentation Requirements Sheet

**INSH1000-D002** – Hot Service Insulation System Project-Specific Requirements

**INSH1000-D003** – Extent of Hot-Service Insulation

**INSH1000-D010** – Calcium Silicate Insulation System for Pipe and Equipment

**INSH1000-D011** – Expanded Perlite Insulation System for Pipe and Equipment

**INSH1000-D012** – Mineral Wool Preformed Pipe Sections Insulation System

**INSH1000-D013** – Mineral Wool Board Insulation System for Equipment

**INSH1000-D014** – Mineral Wool Blanket Insulation System for Pipe and Equipment

**INSH1000-D015** – Glass Fiber Preformed Pipe Sections Insulation System

**INSH1000-D016** – Glass Fiber Board Insulation System for Equipment

**INSH1000-D017** – Glass Fiber Blanket Insulation System for Pipe and Equipment

**INSH1000-D018** – Cellular Glass Block and Fabricated Sections Insulation System
<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>INSH1000-D019</td>
<td>Polyisocyanurate Insulation System</td>
</tr>
<tr>
<td>INSH1000-D020</td>
<td>Ceramic Fiber Blanket Insulation System</td>
</tr>
<tr>
<td>INSH1000-D021</td>
<td>Glass Fiber Needled Blanket Insulation System</td>
</tr>
<tr>
<td>INSH1000-D022</td>
<td>Flexible Elastomeric Cellular Thermal Insulation System for Pipe and Equipment</td>
</tr>
<tr>
<td>INSH1000-D023</td>
<td>Rigid Cellular Phenolic Thermal Insulation System for Pipe and Equipment</td>
</tr>
<tr>
<td>INSH1000-D024</td>
<td>User-Defined Thermal Insulation System for Pipe and Equipment</td>
</tr>
<tr>
<td>INSH1000-D025</td>
<td>Silica Aerogel Insulation System for Pipe and Equipment</td>
</tr>
<tr>
<td>INSH1000-F001</td>
<td>Calcium Silicate Insulation for HC ASTM C533 Type I (mm)</td>
</tr>
<tr>
<td>INSH1000-F002</td>
<td>Calcium Silicate Insulation for PP ASTM C533 Type I (mm)</td>
</tr>
<tr>
<td>INSH1000-F003</td>
<td>Calcium Silicate Insulation – Combined Table ASTM C533 Type I (mm)</td>
</tr>
<tr>
<td>INSH1000-F004</td>
<td>Cellular Glass Insulation for HC ASTM C552 (mm)</td>
</tr>
<tr>
<td>INSH1000-F005</td>
<td>Cellular Glass Insulation for PP ASTM C552 (mm)</td>
</tr>
<tr>
<td>INSH1000-F006</td>
<td>Cellular Glass Insulation – Combined Table ASTM C552 (mm)</td>
</tr>
<tr>
<td>INSH1000-F007</td>
<td>Fiberglass Insulation for HC ASTM C547, Type 1 / C612, Type I (mm)</td>
</tr>
<tr>
<td>INSH1000-F008</td>
<td>Fiberglass Insulation for PP ASTM C547, Type 1 / C612, Type I (mm)</td>
</tr>
<tr>
<td>INSH1000-F009</td>
<td>Fiberglass Insulation – Combined Table ASTM C547, Type 1 / C612, Type I (mm)</td>
</tr>
<tr>
<td>INSH1000-F010</td>
<td>Mineral Wool Insulation for HC ASTM C547, Type II or III / C612, Type IVB (mm)</td>
</tr>
<tr>
<td>INSH1000-F011</td>
<td>Mineral Wool Insulation for PP ASTM C547, Type II or III / C612, Type IVB (mm)</td>
</tr>
<tr>
<td>INSH1000-F012</td>
<td>Mineral Wool Insulation – Combined Table ASTM C547, Type II or III / C612, Type IVB (mm)</td>
</tr>
<tr>
<td>INSH1000-F013</td>
<td>Expanded Perlite Insulation for HC ASTM C610 (mm)</td>
</tr>
<tr>
<td>INSH1000-F014</td>
<td>Expanded Perlite Insulation for PP ASTM C610 (mm)</td>
</tr>
<tr>
<td>INSH1000-F015</td>
<td>Expanded Perlite Insulation – Combined Table ASTM C610 (mm)</td>
</tr>
<tr>
<td>INSH1000-F016</td>
<td>Polysiocyanurate for HC ASTM C591, Type II or IV (mm)</td>
</tr>
<tr>
<td>INSH1000-F017</td>
<td>Polysiocyanurate Insulation for PP ASTM C591, Type II or IV (mm)</td>
</tr>
<tr>
<td>INSH1000-F018</td>
<td>Polysiocyanurate Insulation – Combined Table ASTM C591, Type II or IV (mm)</td>
</tr>
<tr>
<td>INSH1000-F019</td>
<td>Elastomeric Foam Insulation for HC ASTM C534, Grade 3 (mm)</td>
</tr>
<tr>
<td>INSH1000-F020</td>
<td>Elastomeric Foam Insulation for PP ASTM C534, Grade 3 (mm)</td>
</tr>
<tr>
<td>INSH1000-F021</td>
<td>Elastomeric Foam Insulation – Combined Table ASTM C534, Grade 3 (mm)</td>
</tr>
<tr>
<td>INSH1000-F022</td>
<td>Phenolic Foam Insulation for HC ASTM C1126, Type III, Grade 1 (mm)</td>
</tr>
<tr>
<td>INSH1000-F023</td>
<td>Phenolic Foam Insulation for PP ASTM C1126, Type III, Grade 1 (mm)</td>
</tr>
<tr>
<td>INSH1000-F024</td>
<td>Phenolic Foam Insulation – Combined Table ASTM C1126, Type III, Grade 3 (mm)</td>
</tr>
<tr>
<td>INSH1000-F025</td>
<td>User-Defined Insulation for HC (mm)</td>
</tr>
<tr>
<td>INSH1000-F026</td>
<td>User-Defined Insulation for PP (mm)</td>
</tr>
<tr>
<td>INSH1000-F027</td>
<td>User-Defined Insulation – Combined Table (mm)</td>
</tr>
<tr>
<td>INSH1000-F028</td>
<td>Silica Aerogel Insulation for HC (mm)</td>
</tr>
<tr>
<td>INSH1000-F029</td>
<td>Silica Aerogel Insulation for PP (mm)</td>
</tr>
<tr>
<td>INSH1000-F030</td>
<td>Silica Aerogel Insulation – Combined Table (mm)</td>
</tr>
<tr>
<td>INSH1000-F031</td>
<td>Calcium Silicate Insulation for HC ASTM C533 Type I (mm)</td>
</tr>
<tr>
<td>INSH1000-F032</td>
<td>Calcium Silicate Insulation for PP ASTM C533 Type I (mm)</td>
</tr>
<tr>
<td>INSH1000-F033</td>
<td>Calcium Silicate Insulation – Combined Table ASTM C533 Type I (mm)</td>
</tr>
<tr>
<td>INSH1000-F034</td>
<td>Cellular Glass Insulation for HC ASTM C552 (mm)</td>
</tr>
<tr>
<td>INSH1000-F035</td>
<td>Cellular Glass Insulation for PP ASTM C552 (mm)</td>
</tr>
<tr>
<td>INSH1000-F036</td>
<td>Cellular Glass Insulation – Combined Table ASTM C552 (mm)</td>
</tr>
<tr>
<td>INSH1000-F037</td>
<td>Fiberglass Insulation for HC ASTM C547, Type 1 / C612, Type I (mm)</td>
</tr>
<tr>
<td>INSH1000-F038</td>
<td>Fiberglass Insulation for PP ASTM C547, Type 1 / C612, Type I (mm)</td>
</tr>
<tr>
<td>INSH1000-F039</td>
<td>Fiberglass Insulation – Combined Table ASTM C547, Type 1 / C612, Type I (mm)</td>
</tr>
<tr>
<td>INSH1000-F040</td>
<td>Mineral Wool Insulation for HC ASTM C547, Type II or III / C612, Type IVB (mm)</td>
</tr>
<tr>
<td>INSH1000-F041</td>
<td>Mineral Wool Insulation for PP ASTM C547, Type II or III / C612, Type IVB (mm)</td>
</tr>
<tr>
<td>INSH1000-F042</td>
<td>Mineral Wool Insulation – Combined Table ASTM C547, Type II or III / C612, Type IVB (mm)</td>
</tr>
<tr>
<td>INSH1000-F043</td>
<td>Expanded Perlite Insulation for HC ASTM C610 (mm)</td>
</tr>
<tr>
<td>INSH1000-F044</td>
<td>Expanded Perlite Insulation for PP ASTM C610 (mm)</td>
</tr>
<tr>
<td>INSH1000-F045</td>
<td>Expanded Perlite Insulation – Combined Table ASTM C610 (mm)</td>
</tr>
<tr>
<td>INSH1000-F046</td>
<td>Polysiocyanurate for HC ASTM C591, Type II or IV (mm)</td>
</tr>
<tr>
<td>INSH1000-F047</td>
<td>Polysiocyanurate Insulation for PP ASTM C591, Type II or IV (mm)</td>
</tr>
</tbody>
</table>
INSH1000-FM012 – Mineral Wool Insulation –
   Combined Table ASTM C547, Type II or III / C612, Type IVB (mm)
INSH1000-FM013 – Expanded Perlite Insulation
   for HC ASTM C610 (mm)
INSH1000-FM014 – Expanded Perlite Insulation
   for PP ASTM C610 (mm)
INSH1000-FM015 – Expanded Perlite Insulation
   – Combined Table ASTM C610 (mm)
INSH1000-FM016 – Polyisocyanurate for HC
   ASTM C591, Type II or IV (mm)
INSH1000-FM017 – Polyisocyanurate Insulation
   for PP ASTM C591, Type II or IV (mm)
INSH1000-FM018 – Polyisocyanurate Insulation –
   Combined Table ASTM C591, Type II or IV (mm)
INSH1000-FM019 – Elastomeric Foam Insulation
   for HC ASTM C534, Grade 3 (mm)
INSH1000-FM020 – Elastomeric Foam Insulation
   for PP ASTM C534, Grade 3 (mm)
INSH1000-FM021 – Elastomeric Foam Insulation –
   Combined Table ASTM C534, Grade 3 (mm)
INSH1000-FM022 – Phenolic Foam Insulation for
   HC ASTM C1126, Type III, Grade 1 (mm)
INSH1000-FM023 – Phenolic Foam Insulation for
   PP ASTM C1126, Type III, Grade 1 (mm)
INSH1000-FM024 – Phenolic Foam Insulation –
   Combined Table ASTM C1126, Type III, Grade 3 (mm)
INSH1000-FM025 – User-Defined Insulation for
   HC (mm)
INSH1000-FM026 – User-Defined Insulation for
   PP (mm)
INSH1000-FM027 – User-Defined Insulation –
   Combined Table (mm)
INSH1000-FM028 – Silica Aerogel Insulation for
   HC (mm)
INSH1000-FM029 – Silica Aerogel Insulation for
   PP (mm)
INSH1000-FM030 – Silica Aerogel Insulation –
   Combined Table (mm)
1. **Scope**

This Practice provides requirements for materials and installation of hot service insulation systems on the external surfaces of piping and equipment, ambient to 649°C (1200°F).

This Practice describes requirements for hot service insulation materials and accessories, storage and handling of materials, insulation application, extent of insulation, and documentation.

*Comment:* Use of this Practice for contractual purposes requires the purchaser to make specific choices and to assemble additional supporting documents. Listing of or reference to supporting documents within this Practice does not imply suitability for specific designs.

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 INTG1000 – *Insulation Inspection Checklist*

2.2 **Industry Codes and Standards**

- American Petroleum Institute (API)
  - API 521 – *Guide for Pressure-Relieving and Depressuring Systems*
  
  American Petroleum Institute

- American Society for Testing and Materials (ASTM)
  - ASTM C450 – *Prefabrication and Field Fabrication of Thermal Insulating Fitting Covers for NPS Piping, Vessel Lagging, and Dished Head Segments*
  - ASTM C795 – *Specification for Wicking-Type Thermal Insulation for Use over Austenitic Stainless Steel*
  - ASTM C871 – *Chemical Analysis of Thermal Insulation Materials for Leachable Chloride, Fluoride, Silicate and Sodium Ions*
  - ASTM C1728 – *Standard Specification for Flexible Aerogel Insulation*

3. **Definitions**

*owner:* Party who owns the facility wherein the insulation system will be used

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

*supplier:* Party responsible for providing the insulation materials and installing the insulation system
4. Requirements

4.1 Project Scope

4.1.1 Documents required to define the scope of the work are listed on Purchaser’s Data Sheet PIP INSH1000-D001.

4.1.2 Project specific insulation on piping and equipment shall be in accordance with Purchaser’s Data Sheet PIP INSH1000-D002. This data sheet describes the surfaces to be insulated and the materials to be used.

4.1.3 The extent of insulation is listed on Purchaser’s Data Sheet PIP INSH1000-D003.

4.1.3.1 This data sheet defines the extent of insulation by surface or component for each insulation type code required for the project.

4.1.3.2 The extent of equipment insulation may also be defined by the purchaser for individual items.

4.1.4 Insulation materials shall be in accordance with Purchaser’s Data Sheets as required in accordance with Purchaser’s Data Sheet PIP INSH1000-D001. These data sheets define requirements for specific insulation materials and accessories.

4.1.5 Systems requiring additional insulation specifications beyond Practices shall be covered by purchaser’s documentation.

4.2 Materials

4.2.1 Insulation and accessory materials shall be furnished in accordance with the requirements of this Practice, including the specific class, grade, or type.

4.2.2 Asbestos shall not be used as a component in the manufacture of insulation and accessory materials.

4.2.3 Materials shall be new and shall be used before the expiration date.

4.2.4 Sealant, mastics, and adhesives shall be supplied in factory-sealed containers.

4.2.5 Multilayer calcium silicate and expanded perlite pipe insulation shall be ordered factory-nested.

4.2.6 All materials shall be qualified for use on austenitic stainless steel in accordance with ASTM C795.

4.2.6.1 If requested, test reports shall be furnished.

4.2.6.2 A chemical analysis shall be provided in accordance with ASTM C871 for all materials. This chemical analysis shall not vary by more than 50 percent from the chemical analysis of the production lot tested in accordance with ASTM C692.

4.2.7 Use of materials other than those specified in this Practice requires prior written approval of the purchaser.

4.2.8 Requests for substitutions of materials shall be included as an alternate in the proposal.
4.2.9 Requests for substitutions of materials after contract award are not permitted.

4.2.10 All mastics, cements, adhesives, caulks, labels, marking pens, and tapes that come in contact with stainless steel shall have a maximum leachable chloride content of less than 50 ppm, when tested in accordance with ASTM C871.

4.2.11 Curved segments and beveled lags shall be manufactured to specific inside diameters that assure complete inside and outside diameter closure.

4.2.12 Fabricated insulation shall conform to with ASTM C450 and the Adjunct.

4.3 Storage and Handling of Insulation Materials

4.3.1 From delivery to the installed finished product, insulation materials shall at all times be protected from the elements and have adequate drainage.

4.3.2 Insulation materials shall be handled and stored in accordance with the manufacturer’s printed recommendations.

4.3.3 Mastics, adhesives, and sealers that are exposed to temperatures outside the recommended temperature ranges during storage shall be removed from the site and replaced with new material.

4.3.4 Materials that have exceeded shelf life and dates shall be removed from the site and replaced with new material.

4.4 Installation Requirements

4.4.1 General

4.4.1.1 All materials shall be stored, mixed, thinned, and applied in accordance with the manufacturer’s printed instructions.

4.4.1.2 All conflicts between this Practice and the manufacturer’s printed instructions shall be brought to the attention of the purchaser for resolution.

4.4.1.3 Authorization to proceed with application of insulation shall be obtained in writing from the purchaser.

4.4.1.4 Unless otherwise specified, insulation shall not be applied until completion of the following has been verified:

a. Required hydrostatic and/or pneumatic pressure testing

b. Application of required substrate protective coating systems, including touch-up of previously applied coatings

c. Installation and testing of required tracing systems

d. Cleaning of surfaces that require insulation

4.4.1.5 Temporary terminations of installed insulation shall be adequately protected at all times.

4.4.1.6 All insulation shall be smooth and free from cracks, voids, gaps and depressions greater than 3 mm (1/8 inch).
4.4.1.7 All cracks, voids, gaps, and depressions in the insulation greater than 3 mm (1/8 inch) shall be refitted and not filled.

4.4.2 Insulation Layering

4.4.2.1 Unless otherwise specified by purchaser, piping and equipment insulation shall be applied as a multiple layer for operating temperatures of 316 °C (600 °F) and higher.

4.4.2.2 Personnel protection insulation shall be applied as a double layer for thicknesses greater than 100 mm (4 inches).

4.4.2.3 If applying single-layer insulation, other than hinged pipe covering and flexible aerogel blanket, the circumferential butt joints of each half section shall be staggered.

4.4.2.4 If applying double-layer or multiple-layer insulation, each succeeding layer shall be staggered to the longitudinal and circumferential joint of the layer beneath. All joints of all layers shall be staggered.

4.4.2.5 Each layer of double-layer or multiple-layer insulation shall be held in place separately.

4.4.3 Insulation Securement

4.4.3.1 Except as modified in accordance with 4.4.3.2 and 4.4.3.6, insulation up to 300 mm (12 inches) O.D. shall be held in place with minimum 1.2 mm (0.048 inch) diameter Type 304 stainless steel tie wire.

4.4.3.2 Cellular glass and polyisocyanurate foam insulation up to 300 mm (12 inches) O.D. may be held in place with fiberglass reinforced pressure-sensitive tape.

4.4.3.3 Insulation 300 mm (12 inches) O.D. to 600 mm (24 inches) O.D. shall be held in place with 13 mm (0.5 inch) wide by 0.50 mm (0.020 inch) thick Type 304 stainless steel bands and wing seals.

4.4.3.4 Insulation above 600 mm (24 inches) O.D. shall be held in place with 19 mm (0.75 inch) wide by 0.50 mm (0.020 inch) thick Type 304 stainless steel bands and wing seals.

4.4.3.5 All cut ends of wire shall be embedded into the insulation.

4.4.3.6 Flexible aerogel blanket may be secured with fiberglass reinforced tape (up to 250°C (482°F)), wire or banding at no more than 450 mm (18 inches) centers.

1. On piping and equipment over 150 mm (6 inches) diameter, 19 mm (3/4 inch) stainless steel bands shall always be placed around the outermost layer and spaced 450 mm (18 inches) apart. Smaller sizes, 150 mm (6 inches) and less, may be secured with wire or bands.

2. On installations greater than four layers, additional intermediate banding shall be installed over every fourth layer.
4.4.3.7 For securement of aerogel blanket insulation on vessel heads until permanent jacketing is installed, any of the following is acceptable. The chosen method shall be approved by Owner’s Engineer:
1. Approved non-chloride-containing spray adhesive
2. Capacitance discharge (CD) pins
3. Footed pins adhered with pressure-sensitive non-chloride-containing adhesive (PSA)
4. Non-chloride-containing high temperature caulk (for in-service installation on equipment at elevated temperatures)

4.4.4 **Metal Jacketing**

4.4.4.1 If fire protection is required in accordance with *API 521*, stainless steel jacketing shall be installed on equipment and piping.

4.4.4.2 If aluminum jacketing is provided on lines with an operating temperature exceeding 400 °C (750 °F), stainless steel jacketing shall be used at points of contact with insulated surface.

4.4.4.3 Exposed edges of metal jacketing shall be machine-bent or rolled to eliminate sharp edges.

4.4.5 **Metal Jacketing Securement**

4.4.5.1 Metal jacketing to 600 mm (24 inches) O.D. shall be held in place with 13 mm (0.5 inch) wide by 0.50 mm (0.020 inch) thick Type 304 stainless steel bands and wing seals.

4.4.5.2 Metal jacketing above 600 mm (24 inches) O.D. shall be held in place with 19 mm (0.75 inch) wide by 0.5 mm (0.020 inch) thick Type 304 stainless steel bands and wing seals.

4.4.5.3 Jacket banding shall be spaced on maximum 300 mm (12 inch) centers.

4.4.6 **Screws**

4.4.6.1 Screws shall be self-drilling No. 8 by 13 mm (1/2 inch) stainless steel, with EPDM (ethylene propylene diene monomer rubber) washers.

4.4.6.2 Screw heads shall be hex, Phillips recessed round, round, hex-slotted, or pan type.

4.4.7 **Insulation System Expansion Provisions**

4.4.7.1 Expansion joints shall be provided for rigid insulation materials on all piping and horizontal equipment in accordance with Table 1.

4.4.7.2 Expansion joints shall be provided below insulation supports on vertical piping, except if above an elbow at the bottom of a pipe run or directly above the pipe flanges.

4.4.7.3 The expansion joint spacing shown in Table 1 shall be the maximum distance allowable between restraint points in the insulation system.

*Comment:* Restraint points are typically pipe supports, pipe fittings, branch connections, flanges, and valves.
### Table 1 – Expansion Joints

<table>
<thead>
<tr>
<th>Operating Temperature Range °C (°F)</th>
<th>Expansion Joint Spacing, mm (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Horizontal Piping and Equipment</td>
</tr>
<tr>
<td>Up to 38 (100)</td>
<td>18000 (60)</td>
</tr>
<tr>
<td>39 to 93 (101 to 200)</td>
<td>18000 (60)</td>
</tr>
<tr>
<td>94 to 149 (201 to 300)</td>
<td>9000 (30)</td>
</tr>
<tr>
<td>150 to 204 (301 to 400)</td>
<td>4500 (15)</td>
</tr>
<tr>
<td>205 to 260 (401 to 500)</td>
<td>3600 (12)</td>
</tr>
<tr>
<td>261 to 371 (501 to 700)</td>
<td>2700 (9)</td>
</tr>
<tr>
<td>372 to 482 (701 to 900)</td>
<td>1800 (6)</td>
</tr>
<tr>
<td>483 to 649 (901 to 1200)</td>
<td>1800 (6)</td>
</tr>
</tbody>
</table>

4.4.7.4 If piping runs have distances between insulation restraint points that exceed those shown in Table 1, insulation expansion joints located approximately midway between the restraint points shall be provided.

4.4.7.5 Expansion joints shall not be required for personnel protection insulation, fibrous insulation on horizontal equipment and piping or for flexible aerogel blanket insulation.

4.4.7.6 Fibrous insulation shall be compressed during installation to ensure that circumferential joints are tightly butted together.

4.4.7.7 Except as modified in accordance with 4.4.7.8, expansion joints shall be provided beneath all insulation support rings on vertical equipment and piping, except for the bottom support ring.

4.4.7.8 Expansion joints should not be provided beneath the insulation support ring if the support is immediately above an elbow or flange.

4.4.7.9 Insulation expansion joints shall be installed in all layers of multiple-layer insulation.

1. Joints in horizontal piping and equipment shall be staggered between layers.
2. Joints installed below insulation supports on vertical piping and equipment shall not be staggered.

4.4.7.10 Insulation expansion joints shall be 25 mm (1 inch) wide and packed tightly with mineral fiber blanket insulation compressed a minimum of 50 percent.
4.4.7.11 Insulation bands securing rigid insulation on equipment in hot service shall incorporate 100 mm (4 inch) long, flat expansion springs in accordance with Table 2.

4.4.7.12 Insulation bands securing fibrous insulation on equipment in hot service shall not require expansion springs.

4.4.7.13 Bands securing equipment insulation weather barrier jacketing in hot service shall incorporate 4-inch (100-mm) long, compression spring assemblies in accordance with Table 2.

Table 2 – Expansion Spring Requirements

<table>
<thead>
<tr>
<th>Equipment O.D.</th>
<th>Normal Operating Temperature</th>
<th>Number of Expansion Devices per Band</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm</td>
<td>inches</td>
<td>°C</td>
</tr>
<tr>
<td>750 &amp; under</td>
<td>30 &amp; under</td>
<td>up to 649</td>
</tr>
<tr>
<td>&gt;750 to 1800</td>
<td>&gt;30 to 72</td>
<td>≤204</td>
</tr>
<tr>
<td>&gt;1800 to 3000</td>
<td>&gt;72 to 120</td>
<td>205 to 649</td>
</tr>
<tr>
<td>&gt;3000 to 3600</td>
<td>&gt;120 to 144</td>
<td>≤204</td>
</tr>
<tr>
<td>&gt;3600</td>
<td>&gt;144</td>
<td>≤66</td>
</tr>
</tbody>
</table>

4.4.8 Pipe Insulation Supports in Vertical Piping

4.4.8.1 If specified by purchaser, vertical piping insulation supports shall be furnished shop-installed by the piping fabricator.

4.4.8.2 If additional vertical piping insulation supports are required, bolt-on supports shall be furnished and field-installed.

4.4.8.3 Design of vertical pipe insulation supports shall be provided in the proposal, and shall be subject to review and approval by purchaser.

4.4.8.4 Location of pipe insulation supports in vertical piping shall consider:
   a. Maximum spacing of supports shall be the same as specified in Table 1 for expansion joints in vertical pipe insulation.
   b. Insulation supports shall be provided above all flanged connections.
   c. Supports above flanged sections shall be located a minimum one stud bolt length plus 25 mm (1 inch) from the back face of the top flange.
d. Insulation supports shall be provided above elbows and tees, if the vertical or diagonal run length is equal to or greater than the maximum spacing allowed in Table 1 for expansion joints in vertical pipe insulation.

e. If required above elbows or tees, supports shall be located 150 mm (6 inches) from the pipe-to-fitting weld.

4.4.8.5 Supports shall provide adequate clearance for the installation of required electric or steam tracers.

4.4.8.6 For flexible aerogel blanket, insulation supports shall be provided on vertical pipe lengths greater than 10 m (30 lin. feet) where the pipe size is greater than 12 NPS and the total thickness of the aerogel blanket insulation is greater than 30 mm (11/4 in.).

4.4.8.7 For all other scenarios, supports for aerogel blanket insulation on piping are not required.

4.4.9 Piping Insulation

4.4.9.1 Insulation for fittings, flanges, and valves shall be fabricated in accordance with ASTM C450 and the Adjunct.

4.4.9.2 Molded insulation fitting covers shall be used, subject to the operating temperature limits of the molded cover material.

4.4.9.3 Socketweld or threaded valves, ells, tees and other fittings shall be insulated with strips of glass fiber-needled blanket, wrapped around the valve or fitting and secured with wire.

4.4.9.4 Valve insulation shall be terminated directly below the packing gland flange and packing follower.

4.4.9.5 Insulation material shall not be applied between the pipe and tracer, except if spacers to prevent local overheating of the pipe are specified.

4.4.10 Equipment Insulation

4.4.10.1 Equipment with vessel shell diameters of 900 mm (36 inches) or less shall have shell insulation extended to cover the heads.

   1. Each head shall be blocked in with an insulation disc, fabricated or cut to match the inside diameter of the insulation.

   2. Nominal disc thickness shall be the thickness required for the shell.

4.4.10.2 Unless specified otherwise, all exposed heads exceeding 900 mm (36 inches) shall be insulated with block insulation.

   1. Block insulation shall be installed full thickness and fit to follow the curvature of the head.

   2. As an alternate to shop-fabricated segments, heads shall be insulated with field fit block if approved by the purchaser.

   3. Scored or V-grooved block shall not be permitted.

4.4.10.3 Unless specified otherwise by purchaser, vertical equipment support legs, lugs, and saddle supports for horizontal equipment shall not be insulated.
4.4.10.4 Insulation on skirt-supported vertical vessels shall be extended past the bottom tangent line, down the exterior surface of the skirt to the bottom insulation support ring.

4.4.10.5 Vessels having skirt inside diameters exceeding 1200 mm (48 inches) shall have the corresponding inside skirt surface insulated.

4.4.10.6 Equipment nozzles connected to bare piping shall have the equipment insulation system terminated on the nozzle and finished with a metallic cover.

4.4.10.7 For insulation of vessel shells, rigid pipe sections or rigid curved radius segments shall be utilized up to the maximum commercially available size.

4.4.10.8 Beveled block insulation for vessel shells shall be used only if shell diameters exceed the commercially available size of curved radius segments.

1. Edge beveling of the block shall be in accordance with ASTM C450 and the Adjunct.
2. Bevels shall be applied to either one or both block edges.

4.4.10.9 Scored block insulation shall not be an acceptable substitute for beveled lags or curved radius segments.

4.4.10.10 Code or other nameplates shall not be covered by insulation.

4.4.11 Machinery Insulation

4.4.11.1 Machinery, such as pumps and turbines, shall be insulated with removable/reusable insulation covers, as designated in PIP INSH1000-D002.

4.4.11.2 If required by purchaser, machinery, such as pumps and turbines, shall be insulated with insulating and finishing cement.

4.4.11.3 Before applying insulating and finishing cement, a layer of 25 mm (1 inch) hexagonal chicken wire mesh or expanded metal lath shall be wrapped around the equipment item to be insulated with a 25 mm (1 inch) overlap at all edges and secured with wire.

4.4.11.4 All cut wire ends shall be turned in so as not to protrude through the finished surface.

4.4.11.5 The insulating and finishing cement shall be mixed and applied according to the manufacturer's recommendations.

4.4.11.6 Insulating and finishing cement shall be applied to the same thickness as the adjoining insulation.

4.4.12 Insulation Types ET and ST

4.4.12.1 If insulation design and installation is included with the electrical tracing system design and installation subcontract, alternate insulation materials and thicknesses, and combinations thereof, shall be utilized, provided the
intent of the specification is satisfied. Such alternates shall be approved by the purchaser.

4.4.12.2 Jacketing for insulation on electrical traced piping shall be installed with bands only.

Comment: Screws and rivets can damage the electrical tracing and shall not be acceptable fasteners for any jacketing installed to finish insulation on electrically traced piping.

4.4.12.3 Screw and rivet fasteners can however be used in the fabrication of removable insulated covers for use over electrically traced piping components.

4.4.12.4 Unless required for personnel protection, tube tracer unions located outside of the pipe or equipment insulation shall not be insulated.

4.4.12.5 Unless required for personnel protection, tracer expansion loops located outside of insulation shall not be insulated.

4.4.12.6 If required for personnel protection, insulation for tracer loops shall be installed in accordance with the following:

a. The tracer shall be wrapped with 3 mm (1/8 inch) thick fiberglass tape, using a 50 percent overlap to provide a 6 mm (1/4 inch) thickness.

b. The fiberglass tape shall be secured with wire on 150 mm (6 inch) centers.

c. The outer surface of the fiberglass tape shall be finished with weather barrier mastic, without reinforcing membrane, applied to a nominal dry film thickness of 2 mm (1/16 inch).

4.4.12.7 Pipe insulation shall be oversized, unless otherwise agreed with purchaser.

4.4.12.8 Grooving or deforming of the insulation to accommodate heat tracing is prohibited.

4.4.12.9 Oversized insulation shall be installed such that the insulation is not loose on the piping.

4.4.13 Insulation Finish

4.4.13.1 Weather barrier jacketing shall be fitted tightly around vessel and piping attachments that pass through the weather barrier jacketing.

4.4.13.2 RTV silicone sealant shall be applied to the extent necessary to prevent the entrance of water around penetrations through the weather barrier jacketing.

4.4.13.3 Circumferential and longitudinal laps in weather barrier jacketing shall be overlapped 50 mm (2 inches) to 75 mm (3 inches).

4.4.13.4 Unless otherwise specified, insulation surfaces that have not been finished with metal jacketing shall be weatherproofed with membrane-reinforced weather barrier mastic.
1. The membrane-reinforced mastic shall extend under the adjoining metal jacketing for a distance of 75 mm (3 inches) minimum.

2. The membrane-reinforced mastic shall also extend onto uninsulated projections a minimum of 75 mm (3 inches).

4.4.13.5 Weather barrier mastic shall be applied by trowel or brushed on large surfaces and by brush or glove on small surfaces.

4.4.13.6 Two coats of weather-barrier mastic shall be applied in accordance with the material manufacturer’s instructions and the following:

   a. Substrate temperatures shall be within the application temperature range established by the material manufacturer.

   b. Substrate temperature shall be above dew point temperature at the time of application and until the mastic has dried.

   c. Substrate shall be dry if the mastic is applied.

   d. Substrate shall not be subject to freezing temperatures within 24 hours of application.

   e. If weather barrier mastic is scheduled for application over dusty surfaces, the surface shall be primed with suitable primer, as recommended by the weather barrier mastic manufacturer.

   f. Weather barrier mastic shall not be thinned.

   g. Reinforcing membrane shall be applied while first coat is still tacky.

   h. Membrane shall be embedded in first coat of mastic, without wrinkles, so that mastic comes up through the open mesh.

   i. Membrane seams shall be overlapped 50 mm (2 inches).

   j. The second coat of mastic shall be applied before the first coat dries.

   k. All outside corners of insulation shall be rounded and the weather barrier mastic provided with a double layer of reinforcing membrane.

4.4.13.7 After drying, the membrane reinforced weather barrier mastic shall be inspected for imperfections (i.e., cracks, pinholes, openings, or exposed reinforcing membrane). Such imperfections shall be repaired with the same material as originally applied.

4.4.14 Corrosion Monitoring Inspection Ports

   4.4.14.1 Corrosion monitoring inspection ports shall be installed at locations designated by Owner.

   4.4.14.2 Ports shall be positioned so that the inspection point is in the center of the opening.

4.4.15 Protection of Installed Insulation

   4.4.15.1 Installed insulation shall have the required permanent protection or temporary protection applied before the conclusion of work on that day.
4.4.15.2 Installed insulation shall have temporary protection applied if rain or other forms of atmospheric moisture can damage the insulation during each work shift.

4.4.16 **Wet Insulation**

4.4.16.1 Insulation that becomes wet shall be removed and replaced with dry insulation.

4.4.16.2 Wet insulation shall be discarded.

**4.4.17 Work Area Housekeeping**

4.4.17.1 Insulation materials shall be handled and disposed of in accordance with applicable federal, state, and local laws and regulations.

4.4.17.2 Insulation-related materials, such as mastics, shall be handled and applied with care to prevent splattering on adjacent facilities, such as concrete foundations, paving, structural steel, equipment, piping, gauge glasses, instruments, machined surfaces, valve stems, and packing.

4.4.17.3 All mastic over-spray and splatter shall be removed immediately.

4.4.17.4 Flammable materials shall be stored away from ignition sources such as welding operations.

4.4.17.5 Debris from insulation application work shall be removed from the work area on a regular basis and placed in containers at the end of the workday.

**4.5 Quality Plan**

A quality plan shall be provided with the proposal that includes the following:

a. Quality assurance, quality control, and inspection criteria

b. A method of providing the purchaser with verifiable evidence that all aspects of quality are accepted and found acceptable by the supplier’s inspector during the course of the insulation work

c. All elements identified by *PIP INTG1000*

d. Inspection hold points as necessary to assure work can be properly inspected before any additional work is performed that could obscure defective materials or installation

**4.6 Inspection**

4.6.1 All materials, fabrication, and installation work is subject to inspection by the purchaser or the owner.

4.6.2 The purchaser's inspector shall review the quality procedures to verify the following information:

a. Quality procedures are appropriate for the work scope being performed and have been approved by purchaser.

b. The approved quality procedures have been implemented and are being administrated by the quality personnel.

4.6.3 Items that are not in accordance with the purchase order shall be subject to rejection.
4.6.4 Rejected material, fabrication, or installation work shall be replaced at no cost to purchaser.

4.6.5 Unless otherwise specified, INTG1000 shall be used for inspection documentation.

4.7 Repairs

4.7.1 Damage to installed insulation shall be promptly reported to the purchaser. The report shall include the location and nature of the damage.

4.7.2 Damage to insulation weather barrier jacketing shall be repaired immediately if the damage can result in additional damage to the insulation due to water leakage into the system.

4.7.3 Damage to the integrity of weather barrier jacketing applied over water-absorbent insulation (calcium silicate, fiberglass, etc.) shall be of prime concern and shall be given top repair priority.

4.7.4 If permanent repair is not immediately practical, temporary repair of damaged weather barrier jacketing shall be required.

4.7.5 Damaged insulation shall be replaced if the nature of the damage will adversely affect the thermal performance of the system.

4.7.6 Any disputes regarding the need for replacement of insulation shall be referred to the purchaser for resolution.