



# Engineering Standard

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SAES-L-109

13 October 2012

Selection of Flanges, Stud Bolts and Gaskets

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Document Responsibility: Piping Standards Committee

## Saudi Aramco DeskTop Standards

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## 1 Scope

- 1.1 This standard defines mandatory requirements governing the selection of metallic pipe flanges (hereinafter called “flanges”), gaskets, and stud bolts for pressure piping within the scope of [SAES-L-100](#).
- 1.2 This standard supplements ASME B31.1, ASME B31.3, ASME B31.4 and ASME B31.8 codes.

## 2 Conflicts and Deviations

- 2.1 Any conflicts between this standard and other applicable Saudi Aramco Engineering Standards (SAESs), Materials System Specifications (SAMSSs), Standard Drawings (SASDs), or industry standards, codes, and forms shall be resolved in writing by the Company or Buyer Representative through the Manager, Consulting Services Department of Saudi Aramco, Dhahran.
- 2.2 Direct all requests to deviate from this standard in writing to the Company or Buyer Representative, who shall follow internal company procedure [SAEP-302](#) and forward such requests to the Manager, Consulting Services Department of Saudi Aramco, Dhahran.

## 3 References

The selection of material and equipment, and the design, construction, maintenance, and repair of equipment and facilities covered by this standard shall comply with the latest edition of the references listed below, unless otherwise noted.

### 3.1 Saudi Aramco References

Saudi Aramco Engineering Procedure

[SAEP-302](#)

*Instructions for Obtaining a Waiver of a Mandatory Saudi Aramco Engineering Requirement*

Saudi Aramco Engineering Standards

[SAES-J-100](#)

*Process Flow Metering*

[SAES-L-100](#)

*Applicable Codes and Standards for Pressure Piping Systems*

[SAES-L-101](#)

*Regulated Vendor List for Pipes, Fittings and Gaskets*

[SAES-L-110](#)

*Limitations on Pipe Joints and Components*

### Saudi Aramco Materials System Specifications

<a href="#"><u>02-SAMSS-011</u></a>	<i>Forged Steel Weld Neck Flanges for Low and Intermediate Temperatures</i>
<a href="#"><u>09-SAMSS-107</u></a>	<i>Qualification Requirements and Application of Composite Fluoropolymer/Ceramic Coatings to Fasteners</i>

### Saudi Aramco Standard Drawings

<a href="#"><u>AE-036438</u></a>	<i>Lap Joint Flanges, 54"-60" NPS, Class 300 RJ</i>
<a href="#"><u>AC-036443</u></a>	<i>Lap Joint Flanges, 26"-48" NPS, Class 600 RJ</i>
<a href="#"><u>AC-036486</u></a>	<i>Lap Joint Flanges, 26"-48" NPS, Class 300 RJ</i>
<a href="#"><u>AD-036630</u></a>	<i>Installation of Jack Screws for Flanged Joints</i>
<a href="#"><u>AD-036631</u></a>	<i>Spectacle Pl. Bld/Spacer, Class 125 Cast Iron Flanges FF</i>
<a href="#"><u>AD-036633</u></a>	<i>Spectacle Pl. Bld/Spacer, Class 150 RF</i>
<a href="#"><u>AD-036636</u></a>	<i>Spectacle Pl. Bld/Spacer for Class 600 RF</i>
<a href="#"><u>AD-036731</u></a>	<i>Spectacle Pl. Bld/Spacer for Class 250 RFCI and CL300 RF</i>
<a href="#"><u>AD-036734</u></a>	<i>Spectacle Pl. Bld/Spacer for Class 600 RJ</i>
<a href="#"><u>AD-036735</u></a>	<i>Spectacle Pl. Bld/Spacer for Class 900 RJ</i>
<a href="#"><u>AD-036736</u></a>	<i>Spectacle Pl. Bld/Spacer for Class 1500 RJ</i>
<a href="#"><u>AA-036792</u></a>	<i>Swivel Ring Flanges, 8"-48" NPS, Class 300-1500 RJ</i>

## 3.2 Industry Codes and Standards

### American Petroleum Institute

<i>API SPEC 6A</i>	<i>Specification for Wellhead and Christmas Tree Equipment</i>
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### American Society of Mechanical Engineers

<i>ASME B16.5</i>	<i>Pipe Flanges and Flanged Fittings</i>
<i>ASME B16.20</i>	<i>Ring Joint Gaskets and Grooves for Steel Pipe Flanges</i>
<i>ASME B16.21</i>	<i>Nonmetallic Flat Gaskets for Pipe Flanges</i>
<i>ASME B16.25</i>	<i>Buttwelding Ends</i>

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<i>ASME B16.36</i>	<i>Orifice Flanges</i>
<i>ASME B16.47</i>	<i>Large Diameter Flanges</i>
<i>ASME B31.1</i>	<i>Power Piping</i>
<i>ASME B31.3</i>	<i>Process Piping</i>
<i>ASME B31.4</i>	<i>Liquid Transportation Systems for Hydrocarbons, Liquid Petroleum Gas, Anhydrous Ammonia, and Alcohols</i>
<i>ASME B31.8</i>	<i>Gas Transmission and Distribution Piping Systems</i>
<i>ASME SEC VIII D1</i>	<i>Boiler and Pressure Vessel Code</i>

American Society for Testing and Materials

<i>ASTM A193</i>	<i>Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature Service</i>
<i>ASTM D1418</i>	<i>Standard Practice for Rubber and Rubber Latexes - Nomenclature</i>

Norsok Standards

<i>Norsok Standard L-005</i>	<i>Compact Flanged Connections</i>
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## 4 Definitions

**Normal Fluid Service** per ASME B31.3.

**Category D Fluid Service** per ASME B31.3.

## 5 General Requirements

5.1 Flanges that are not covered by any Saudi Aramco standards or the referenced industry standards shall be designed in accordance with ASME SEC VIII D1, Appendix 2; and ASME SEC VIII D1 Section UG-34 for blind flanges.

*Commentary Notes:*

*The design and the dimensions of non-standards ring-joint facings shall be reviewed by chairman of the piping standard committee. The dimensions shall be compatible to the selected gaskets.*

5.2 Use of components which requires special analysis or proof testing (e.g., ASME B31.3, paragraph 304.7.2) shall be subject to review and approval by the Chairman of the Piping Standards Committee in CSD prior to specification and procurement.

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- 5.3 Flanges, stud bolts and gaskets shall be procured from approved manufacturers per the requirements of [SAES-L-101](#) and the SAP list.
- 5.4 Insulating joints shall comply with the mechanical requirements of this standard. They shall be installed as required by the Cathodic Protection Standards for pipelines or for Stray Current Protection on loading lines.
- 5.5 Orifice flanges shall comply with ASME B16.36 and [SAES-J-100](#).
- 5.6 Jackscrews shall be used to facilitate flange separation for maintenance. When flange separators are used, jackscrews are not required.
- 5.6.1 Flanges equipped with jackscrews shall be designed in accordance with Saudi Aramco Standard Drawing [AD-036630](#) or similar approved design.
- 5.6.2 For orifice flanges, jackscrews shall be installed at 3 and 9 o'clock positions.
- Commentary Notes:*
- Joint assemblies which often require frequent separation include orifice plates, spectacle plates, spacers, screens, and drop-out spools.*
- 5.7 Pipe joints shall be according to ASME B16.25 and [SAES-L-110](#). The flange welding ends shall be according to applicable ASME/API standards.

## 6 Flange Type Selection and Limitations

- 6.1 Weld Neck Flanges
- Weld neck flanges should be the primary selection for flanged joints in metallic piping systems of 2-inch NPS and larger.
- 6.2 Slip-on Flanges
- 6.2.1 Slip-on flanges are allowed only for category D services.
- 6.2.2 Slip-on flanges and reducing slip-on flanges shall not be used in the following services:
- Flange sizes 20 inches and larger
  - Severe cyclic conditions
  - Piping system subject to mechanical vibration.
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- 6.2.3 Slip-on flanges are required to be double-welded. The flange sealing face shall be free from scratches, weld burns, etc.

*Commentary Note:*

*A double-welded slip-on flange has a weld between the pipe and the flange hub and between the pipe and the bore of the flange.*

- 6.2.4 Slip-on flanges shall not be fabricated from blind flanges.

6.3 Lap-joint Flanges

The use of lap-joint flanges shall be avoided and subject to the following limitations and conditions:

- 6.3.1 Lap-joint flanges shall not be used for severe cyclic conditions or in areas subject to high mechanical vibration.
- 6.3.2 Lap-joint flanges are allowed for:
- Easy alignment of bolt holes
  - Special applications to avoid welding dissimilar metals where the pipe stub-end is made from high alloy material and the flange body is made from carbon steel.
- 6.3.3 The lapped flange and stub-end design shall be in accordance with ASME SEC VIII D1, Appendix-2.
- 6.3.4 Lapped flange shall be in accordance with Standard Drawings [AE-036438](#), [AC-036443](#), and [AC-036486](#) for sizes larger than 24-inch NPS.

6.4 Swivel ring flanges

Swivel ring flanges for underwater pipe tie-in shall be in accordance with Saudi Aramco Standard Drawing [AA-036792](#) or, if proprietary, in accordance with ASME SEC VIII D1, Appendix 2.

6.5 Ball swivel flanges

The ball swivel flanges is not permitted.

6.6 Compact flanged connections

Compact flanged connections, which are tapered flat face with self-energized ring gasket, designed and fabricated in accordance with Norsok Standard L-005

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are acceptable for offshore platforms.

6.7 Clamp-type flanges

Clamp-type flanges (connectors) shall conform to API SPEC 6A or shall be proprietary connectors of a design based on ASME SEC VIII and approved by the Chairman, Piping Standards Committee.

6.8 The following flange classes shall not be used:

6.8.1 ASME Class 400 carbon steel flanges for sizes smaller than 30-inch.

6.8.2 ASME Class 75 for any size and material.

6.9 The use of regular blind flanges tapped with smaller pipe is permitted provided that they meet the size ratio requirements addressed in Table 1.

**Table 1 - Maximum Size for the Allowed Bore in the Blind Flanges**

Size of NPS Flanges <sup>1</sup>	Maximum NPS for Tapped Pipe <sup>2</sup>
4"	1½"
6"	2"
8"-14	3"
16" and larger	4"

**Notes:**

1. The bore shall be at the center of the blind flanges.
2. The pipe branch shall be integrally reinforced such as welding boss or weldolet.

## 7 Flange Dimensional Requirements

7.1 Dimensions of 24 inch flanges and smaller shall comply where applicable with ASME B16.5.

7.2 Dimensions of 26 inch flanges and larger shall comply where applicable with ASME B16.47 series A.

*Commentary Note:*

*Dimensionally, ASME B16.47 Series A flanges are identical to MSS SP-44 flanges.*

7.3 API SPEC 6A flanges shall be type 6B rating 3000 and above, 1½-inch through 10-inch NPS.

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*Commentary Note:*

*The flange standard API Spec 6A and ASME 16.5 are similar dimensionally. Welding neck ASME 900 can match API 6A 3000. This normally used to attach the flowlines with the wellhead piping system.*

- 7.4 Dimensions of 26 inch and larger of weld neck and blind flanges as specified by the Saudi Aramco Standard drawings shall not be used for new installation except only to match an existing flange or split tees for hot tap and stopples.

*Commentary Note:*

*Saudi Aramco has stopped using Company standards drawings for new installation based on CSD report CSD-L-272/05 "ASME Large Diameter Flanges in Lieu of Saudi Aramco Drawings".*

- 7.5 Swivel Ring Flanges

These flange assemblies shall comply with Saudi Aramco Standard Drawings [AA-036792](#).

- 7.6 Lapped Joint Flanges

The flange assemblies for 26" and above shall comply with Saudi Aramco Standard Drawings [AE-036438](#), [AC-036443](#) and [AC-036486](#) for Lapped Joint flanges.

- 7.7 Gray cast iron flanges shall comply with ASME 16.1.

- 7.8 The dimensional standards and bolt patterns of nonmetallic flanges shall comply with the corresponding dimension of the mating metallic flanges.

## **8 Flange Facings**

- 8.1 Flange face surface finish shall meet the requirements of ASME 16.5, 16.47 or API 6A as applicable. For hydrogen service, flange facing surface finish for raised face shall not exceed Ra 3.2 micrometers (125 microinch).

- 8.2 Low strength flanges such as cast iron shall have a flat face with full face gaskets. Low strength bolts shall be used for low strength flanges.

- 8.3 Unless otherwise specified in this standard, raised face flanges in ratings up to Class 600 shall be used at design temperatures from minus 50 to 425°C.

- 8.4 Ring joint flanges for use with ring joint gaskets per ASME B16.20 shall be used for:

- Flanges in Class 900 and higher ratings,
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- Underwater pipelines in Class 300 and higher ratings,
- Design temperatures in excess of 480°C,
- API SPEC 6A Type 6B flanges,
- Hydrogen service in Class 300 and higher ratings.

8.5 The assembly of different type of flange faces is not permitted.

*Commentary Notes:*

*Subject to approval of the Piping Standards Committee Chairman, a raised face may be removed from a raised face flange to convert it to a flat face flange provided that it meets the ASME codes requirements. Refer to paragraphs 6.3.2 of ASME B16.5 and 6.1.3 of ASME B16.47.*

8.6 Tongue-and-groove facing or male-and-female facing joints shall not be used.

## 9 Bore of Welding Neck Flanges

The bore of welding neck flanges shall be according to the applicable ASME/API standards. The flange bore shall be smaller or equal to the pipe bore.

## 10 Flange Material Specifications

10.1 The flange material shall be compatible with the pipe material for the intended service. The selected flange material specifications shall have pressure/temperature rating according to the flange dimensional standards as applicable.

### 10.2 Weld Neck Flanges

- 10.2.1 The material specifications requirements for carbon steel and alloy steel flanges shall be in accordance with [02-SAMSS-011](#). For other materials, the requirements shall be as per the applicable ASTM.
- 10.2.2 For carbon steel, refer to [Table 2](#) of this standard to select the applicable ASTM for flange class 150 to 1500 ratings.

**Table 2 - Recommended Weld Neck Flange Materials**

	ASME Mat'l Group	Design Temperature	CL 150	CL 300	CL 600	CL 900	CL 1500
			Nominal Size Inch				
<b>Mat'l Group 1 (36 KSI SMYS)</b>							
ASTM A105 N	1.1	-20 to 425°C	2 - 24	2 - 24	2 - 12	NA	NA
ASTM A350 LF2 Cl.2	1.1	-20 to 400°C	2 - 60	2 - 60	2 - 48	2 - 36	2 - 24
ASTM A350 LF2 Cl.1	1.1	-45 to 345°C	2 - 60	2 - 60	2 - 48	2 - 36	2 - 24
<b>Mat'l Group 2 (60 KSI SMYS)</b>							
ASTM A707 L3 CL3	1.7	-30 to 230°C	2 - 60	2 - 48	2 - 36	2 - 24	2 - 12
ASTM A350 LF6 CL2	1.2	-30 to 375°C	2 - 36	2 - 36	2 - 24	2 - 18	2 - 8
ASTM A707 L5 CL3	1.7	-30 to 230°C	NA	50 - 60	38 - 60	26 - 48	14 - 30
<b>Mat'l Group 3 (65 KSI SMYS)</b>							
ASTM A859 A CL2	1.7	-30 to 230°C	2 - 60	2 - 60	2 - 48	2 - 30	2 - 30
<b>Mat'l Group 4 (75 KSI SMYS)</b>							
ASTM A707 L5 CL4	1.7	-30 to 230°C	2 - 60	2 - 60	2 - 60	2 - 48	2 - 30

**Notes:**

- 1) All [02-SAMSS-011](#) materials may be used wet sour service. Unless otherwise specified, manufacturers may substitute materials within limits described in [02-SAMSS-011](#) paragraph 4.3.
- 2) NA = not applicable; NR = not recommended.
- 3) ASME/ANSI ratings are only valid at temperatures shown above.

10.2.3 The flange and the pipe should have equal yield strength. For flanges with pipe of unequal yield strength, the following may be acceptable:

- a) Flange under material group number 1 in Table 2 may be used with grade X42 pipe, up to 24-inch NPS.
- b) Flange under material group number 1 in table 2 may be used with grade X52 pipe up to 12-inch NPS.
- c) Flange under material group number 2 in Table 2 may be used with grades X42, X52, X65 and X70 pipe.
- d) Flange under material group number 3 in Table 2 may be used with grades X70.
- e) Flange under material group number 4 in Table 2 may be used with grades X70 pipe.

*Commentary Note:*

*In all cases, the design wall thickness for the flange shall meet the pipe design conditions at the butt weld joint. The wall thickness for the flanges will be more than the pipe wall thickness.*

- 10.2.4 For low alloy and stainless steel, ASTM A182 shall be selected. The flange and the pipe material chemical composition shall be the same.

*Commentary Note:*

*For ASTM A 335 Gr P11 pipe material, ASTM A182 Gr F11 flange should be selected for pipe. For ASTM A312 Gr TP 304L, ASTM A182 Gr F304L should be selected.*

### 10.3 Blind Flanges

For ASME flanges, one of the following materials should be selected:

- A105N, from - 20°C to 425°C;
- A350 LF2 Cl 1, from - 45°C to 425°C;
- A516 Gr 70 N, from - 45°C to 425°C.

- 10.4 Material for API SPEC 6A shall follow the requirements of [02-SAMSS-011](#) and Table 4 of the API spec. ASTM A707 L3 CL3 QT should be used for welding neck flanges and blind flanges.

## 11 Spectacle Plates Blinds and Blanks

- 11.1 The piping design shall include provision for spectacle plates or blanks and spacers at flanged joints as required for pressure testing, for blinding off during repairs or inspection for positive product segregation or for other operating reasons.
- 11.2 The design wall thickness of all spectacle blinds and blanks shall be determined in accordance with ASME B31.3. Spectacle plates and blinds shall be in accordance with Saudi Aramco standards drawings addressed in [Table 3](#). For unlisted spectacle plate blinds and blanks, ASME 16.48 shall be used. The design of the spectacle plate blinds and blanks shall be identical to the Saudi Aramco standard drawings.
- 11.3 The surface finish for the gasket seat area shall meet flange dimensional standards (ASME B16.5, ASME 16.47, API 6A).
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**Table 3**

<b>NPS Range</b>	<b>Class</b>	<b>Facing</b>	<b>Standard Drawing</b>
2 - 48	125	FF	<a href="#">AD-036631</a>
2 - 48	150	RF	<a href="#">AD-036633</a>
54 - 60	250, 300	RF	<a href="#">AD-036731</a>
2 - 48	250, 300	RF	<a href="#">AD-036731</a>
2 - 48	600	RF	<a href="#">AD-036636</a>
2 - 30	600	RJ	<a href="#">AD-036734</a>
2 - 24	900	RJ	<a href="#">AD-036735</a>
2 - 24	1500	RJ	<a href="#">AD-036736</a>

## 12 Gaskets

12.1 Gaskets shall be suitable for the intended service and compatible with the flange facing, rating and bolting.

### 12.2 Metallic Ring Joint Gaskets

12.2.1 Octagonal ring joint gaskets Type R, per ASME 16.20 shall be used with API SPEC 6A Type 6B flanges and ASME RTJ flange type.

12.2.2 Ring-joint gasket materials shall be selected based on suitability for the service conditions.

12.2.3 Rubber coated ring joint gaskets may be used for severely corroded services. Soft iron or low carbon steel may be used for the ring type joint material.

### 12.3 Spiral Wound Gaskets

12.3.1 Spiral wound gaskets shall be according to ASME B16.20.

12.3.2 Filler material for spiral wound gaskets shall be suitable for the intended design conditions.

12.3.2.1 In oxidizing environments, the maximum temperature for graphite filler material is limited to 425°C.

12.3.2.2 Filler materials that deteriorate at elevated temperatures, e.g., Teflon, shall not be used in hydrocarbon services.

12.3.3 For general hydrocarbons and process hydrocarbon services including steam, ASME B16.20 spiral wound gaskets with 316 stainless steel winding and high purity flexible graphite filler shall be used for raised face flanges.

12.3.4 The inner and the outer rings material shall match the flanges material. ||

12.3.5 Outer rings are required for all pipe sizes. Inner rings are required for the following flanges:

- Flanges size 24" and larger;
- Flange class 900# and above where applicable; ||
- Spiral wound gaskets with PTFE filler materials;
- Flanges in vacuum services. ||

#### 12.4 Metal Grooved (Kammprofile) Gaskets

Metal Grooved (Kammprofile) gaskets with graphite sealing facing material and outer centering ring shall be used as an alternative to spiral wound gaskets in piping system subjected to pressures and fluctuating conditions, temperature differential across the flange face and bolt stress relaxation.

#### 12.5 PIKOTEK or Equivalent Gaskets

PIKOTEK gaskets shall not be used in refineries and gas plants. The PIKOTEK gaskets shall not be used in services operating at 280°F and higher.

For water corrosive services where flange face corrosion is a concern, the following option may be considered:

- Gaskets with Teflon sealed, glass reinforced epoxy laminated to 316 stainless steel core.

#### 12.6 Insulating Gaskets

12.6.1 Subject to the limitations in paragraphs 12.5, insulating gaskets, PIKOTEK gaskets, or approved equal, with insulating sleeves and washers shall be used for the following:

- a) Insulating dissimilar metal flanged joints with high potential galvanic corrosion (i.e., electrical isolation),
  - b) Insulating joints for cathodic protection.
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12.6.2 Insulating gaskets are not required for the following services:

- Dry hydrocarbon gas service in dry areas
- When the service temperature is above the limitation of non-metallic gasket application.
- When the designer can demonstrate that galvanic corrosion will not occur between the dissimilar metals.
- In flammable services and when the insulating gasket kit is ineffective due to electrical external bonding between the dissimilar metals caused through contacts with pipe supports, structure, etc.

12.7 Metal Jacketed Gasket

Metal jacketed gasket shall not be used in pipe flanges.

12.8 Sheet Gasket

12.8.1 Sheet gaskets shall be according to ASME B16.21. The sheet gasket material shall be suitable for the intended design and service conditions.

12.8.2 Compressed synthetic fiber with oil resistant binder may be used for Class 125 and 150 flat face flanges in non-hazardous services up to a maximum temperature of 230°C.

12.8.3 Full face synthetic rubber gasket, ASTM D1418 Class CSM on flat face flanges, may be used for most acid services up to 70% concentration and to 65°C. For sulfuric acid above 70% concentration (including oleum), and nitric acid (all concentrations), use full face ASTM D1418 class FKM elastomer on flat face flanges.

When raised face flanges are to be used, the flange finish shall be 3.2 to 6.4 micrometers Ra, and the gaskets shall be PTFE-filled spiral wound Alloy 20 stainless steel with stainless steel inner ring. Applications involving other acids must be approved by the Chairman of Piping Standards Committee in CSD.

12.8.4 For plastic flanges, full face gaskets of elastomeric material, 3 mm thick with Shore A Durometer hardness between 50 and 60 may be used. For wet chlorine service and hypochlorite services, the elastomer shall be ASTM D1418 class CSM.

12.9 Proprietary gaskets shall be submitted to the Chairman of Piping Standards Committee in CSD for approval.

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12.10 The gasket contact area of the flange shall not be coated.

### 13 Bolting

13.1 Bolting for flanged joints shall be selected in accordance with ASME B16.5 or ASME B16.47 as minimum.

#### 13.2 Bolting Materials

13.2.1 The material specification for stud bolts and nuts shall be in accordance with Table-4 for the applicable design temperature range and service. Additional restrictions for specific services and applications per applicable codes shall apply. Material selection for temperatures and/or services not listed in Table-4 shall be approved by the Chairman of Piping Standards Committee.

**Table 4 - Material Selection of Bolts and Nuts**

Service Category	Temperature Range °C		ASTM Materials Specification	
	Minimum	Maximum	Stud Bolts	Nuts
Process and general services	- 40	+ 450	A193 Grade B7	A194 Grade 2H
Low temperature services	- 73	+ 450	A320 Grade L7M	A194 Grade 7M
	-101	+ 343	A320 Grade L7	A194 Grade 4 or 7
High temperature services	+ 450	+ 645	ASTM A193 Grade B16	A194 Grade 4
Wet sour services	- 48	+ 450	A193 Grade B7M	A194 Grade 2HM
	- 73	+ 450	A320 Grade L7M	A194 Grade 7M

13.2.2 Low temperature bolting material shall be selected for flanges subjected to auto-refrigeration during flange leakage.

13.2.3 Stud bolts and nuts shall be specified for wet sour services only if they are in direct exposure or potential exposure to the fluid service.

*Commentary Note:*

*Examples of potential exposures to the fluid services are buried, insulated, or shielded flanges.*

13.3 Bolting material installed in aggressive external environment such as offshore and underground piping shall be protected using one of the followings:

- a) Ceramic-fluoropolymer coating per [09-SAMSS-107](#),

- b) Corrosion-resistant alloys,
- c) Painting the exposed portions of the bolts and sealing the gap between flange faces,
- d) Encapsulating the bolted flange connection with heat shrinkable tubing.

#### 13.4 Washers

- 13.4.1 Flat washers under the nuts are required for special cases only, such as on insulating flanges and under the nuts bearing against plastic flanges.
- 13.4.2 Belleville washers may be required for severe cyclic service, and bolt service temperatures above 450°C. Review by the Chairman of Piping Standards Committee in CSD is required.

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**Revision Summary**  
Major revision.  
Editorial revision.