

Engineering Standard

04 July 2022

SAES-L-109

Selection of Flanges, Stud Bolts, and Gaskets

Document Responsibility: Piping Standards Committee

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Summary of Changes

Paragraph Number		Change Type (Addition, Modification, Deletion, New)	Technical Change(s)
Previous Revision (27 June 2019)	Current Revision (04 July 2022)		
3.1	3.1	Modification	Add new reference 02-SAMSS-014-Metallic Piping Gaskets.
3.2	3.2	Modification	Deleted reference to ASME B16.1 as the relevant paragraph 7.7 deleted. Added reference to ASTM A320 which is referenced in the table 5 section 13.2.1.
7.7	-	Deletion	Deleted the requirements for gray cast iron flanges as they are not used in process piping.
-	12.2	New	Add requirements for fugitive emissions as part of decarbonization requirements.
-	12.3	New	Add reference to new 02-SAMSS-014-Metallic Piping Gaskets.
12.3.4	12.5.4	Modification	Added requirements to use carbon steel outer ring.
12.4	12.6	Modification	Editorial: Removed brand name.
12.8.1	12.10.1	Modification	Clarified the use of sheet gaskets.
13.5.2	13.5.2	Modification	Editorial: Removed brand name.

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

Any conflicts between this document and other applicable Mandatory Saudi Aramco Engineering Requirements (MSAERs) shall be addressed to the EK&RD Coordinator.

Any deviation from the requirements herein shall follow internal company procedure SAEP-302.

3 References

All referenced specifications, standards, codes, drawings, and similar material are considered part of this engineering standard to the extent specified, applying the latest version, unless otherwise stated.

3.1 Saudi Aramco References

Saudi Aramco Engineering Procedures

SAEP-302 Waiver of a Mandatory Saudi Aramco Engineering Requirement

Saudi Aramco Engineering Standards

SAES-A-133 Internal Corrosion Protection Requirements

SAES-J-100 Process Measurement

SAES-L-100 Applicable Codes and Standards for Pressure Piping Systems

SAES-L-110 Limitations on Pipe Joints and Components

Saudi Aramco Materials System Specifications

02-SAMSS-011 Forged Steel and Alloy Flanges

02-SAMSS-014 Metallic Piping Gaskets

09-SAMSS-107 Qualification and Application Requirements of Fluoropolymer/Ceramic Coatings on Fasteners

Saudi Aramco Standard Drawings

AE-036438-001 Lap Joint Flanges and Stub Ends, 54-60 NPS, Class 300RJ

AC-036443-001 Lap Joint Flanges and Stub Ends Large Size Class 600 RJ

AC-036486-001	Lap Joint Flanges and Stub Ends Large size 300 RJ
AC-036630-001	Installation of Jack Screws for Flanged Joints
AD-036631-001	Spectacle Pl. Bld/Spacer, Class 125 Cast Iron Flanges
AD-036633-001	Spectacle Pl. Bld/Spacer, Class 150 RF Flanges
AD-036636-001	Spectacle Pl. Bld/Spacer for Class 600 RF Flanges
AD-036731-001	Spectacle Pl. Bld/Spacer for CL300 RF Flanges
AD-036734-001	Spectacle Pl. Bld/Spacer for Class 600 Oct. RJ Flanges
AD-036735-001	Spectacle Pl. Bld/Spacer for Class 900 Oct. RJ Flanges
AD-036736-001	Spectacle Pl. Bld/Spacer for Class 1500 RJ Flanges
AA-036792-001	Flange and Ring Details Swivel Ring Flanges

3.2 Industry Codes and Standards

American Petroleum Institute

API SPEC 6A Specification for Wellhead and Christmas Tree Equipment

American Society of Mechanical Engineers

ASME B16.5 Pipe Flanges and Flanged Fittings: NPS ½ through NPS 24
ASME B16.20 Metallic Gaskets for Pipe Flanges
ASME B16.21 Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.36 Orifice Flanges
ASME B16.47 Large Diameter Steel Flanges: NPS 26 through NPS 60
ASME B16.48 Line Blanks
ASME B31.1 Power Piping
ASME B31.3 Process Piping
ASME B31.4 Pipeline Transportation Systems for Liquid and Slurries
ASME B31.8 Gas Transmission and Distribution Piping Systems
ASME SEC VIII D1 Rules for Construction of Pressure Vessels

American Society for Testing and Materials

ASTM A193 Standard Specification for Alloy-Steel and Stainless Steel
Bolting Materials for High Temperature Service
ASTM A194 Carbon and Alloy Steel Nuts for Bolts for High Pressure
and/or High Temperature Service
ASTM A320 Standard Specification for Alloy-Steel and Stainless Steel
Bolting for Low-Temperature Service

ASTM D1418 Standard Practice for Rubber and Rubber Latexes -
Nomenclature

National Association of Corrosion Engineers

NACE MR0175/ISO 15156 Petroleum and Natural Gas Industries Materials for
Use in H₂S-Containing Environments in Oil and Gas
Production

Norsok Standards

Norsok Standard L-005 Compact Flanged Connections

4 Terminology

4.1 Definitions

Normal Fluid Service: per ASME B31.3.

Category D Fluid Service: per ASME B31.3.

Sour Service: per SAES-A-133.

5 General Requirements

- 5.1 Flanges that are not covered by any Saudi Aramco standards or the referenced industry standards shall be designed per the applicable code (ASME B31.1, B31.3, B31.4, and B31.8) in accordance with ASME SEC VIII D1, Appendix 2; and ASME SEC VIII D1 Section UG-34 for blind flanges.

5.1.1 The flange shall be rated for the design pressure per the applicable code (ASME B31.3, B31.4, and B31.8).

5.1.2 Allowable stresses shall meet the applicable code requirements (ASME B31.3, B31.4, and B31.8).

5.1.3 The dimensions shall be compatible with the selected gaskets and mating equipment flanges, if any.

- 5.2 Flanges, stud bolts, and gaskets shall be procured from approved manufacturers per the requirements listed on SAP.

- 5.3 Orifice flanges shall comply with ASME B16.36 and SAES-J-100.

- 5.4 Jackscrews may be used to facilitate flange separation for maintenance. When flange separators are used, jackscrews are not required.

Flanges equipped with jackscrews shall be designed in accordance with Saudi Aramco Standard Drawing AC-036630-001 or similar approved design.

Note:

Joint assemblies, which often require frequent separation, include orifice plates, spectacle plates, spacers, screens, and drop-out spools.

5.5 The flange-to-pipe joint shall be according to SAES-L-110.

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 normal fluid and 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 inch NPS and larger
- Flange rating 300 and higher
- Severe cyclic conditions
- Sour services
- Piping system subject to mechanical vibration.

6.2.3 Slip-on flanges are required to be double-welded. The flange sealing face shall be free from scratches, weld burns, etc.

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-036438-001, AC-036443-001, and AC-036486-001 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-036792-001 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 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

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 NPS.

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. The pipe branch shall be integrally reinforced such as welding boss or weldolet.

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

Flange NPS	Maximum size for Tapped Pipe mm (NPS)
4	38 (1 ½)
6	51 (2)
8-14	76 (3)
16 and larger	101 (4)

7 Flange Dimensional Requirements

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

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

Note:

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

7.3 Dimensions of flanges in wellhead piping shall comply with API SPEC 6A type 6B or 6BX.

7.3.1 The minimum flange length for 6BX flanges does not include the length required for the weld bevel. This extra length needed for the weld bevel shall be added to the minimum flange length shown in API SPEC 6A.

7.3.2 API 6BX flanges shall have transition pieces to connect with the piping in accordance with [02-SAMSS-011](#).

Note:

The flange standard API SPEC 6A Type 6B and ASME B16.5 are similar dimensionally.

Welding neck ASME 900 can match API SPEC 6A Type 6B.

This normally used to attach the flowlines with the wellhead piping system.

7.4 Dimensions of 26-inch NPS 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.

7.5 Swivel Ring Flanges

These flange assemblies shall comply with Saudi Aramco Standard Drawing [AA-036792-001](#).

7.6 Lapped Joint Flanges

The flange assemblies for 26-inch NPS and above shall comply with Saudi Aramco Standard Drawings [AE-036438-001](#), [AC-036443-001](#), and [AC-036486-001](#) for Lapped Joint flanges.

7.7 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 B16.5, B16.47, or API SPEC 6A as applicable.

- 8.1.1 When raised face flanges are to be used, the flange facing surface finish shall be 3.2 to 6.4 micrometers Ra (125 to 250 microinch) for all services except hydrogen.
- 8.1.2 When raised face flanges are to be used for hydrogen service, flange facing surface finish for raised face shall be 3.2 to 3.8 micrometers Ra (125 to 150 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. Flanges of other material may have flat face with full face gasket in non-hazardous services limited to rating of Class 150.
- 8.3 Unless otherwise specified in this standard, raised face flanges shall be used in ratings up to Class 600. Using raised face flanges for higher ratings is permitted provided that it is supported by Licensor recommendation or for specialty-designed flange assemblies.
- 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,
 - Underwater pipelines in Class 300 and higher ratings,
 - Design temperatures in excess of spiral wound gaskets filler material temperature limitations specified in Table 3,
 - Hydrogen service if required by the licensor for class 600 or lower.
- 8.5 The assembly of different type of flange faces is not permitted.
- 8.6 Tongue-and-groove facing or male-and-female facing joints shall not be used.
- 8.7 The gasket sealing area of the flange shall not be coated. Galvanizing is exempted if it meets the surface finish requirements.

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 equal or smaller 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 yield strength of the flange material shall be equal or greater than the pipe material. The selected flange material specifications shall have

pressure/temperature rating according to the flange dimensional standards as applicable.

10.2 Weld Neck Flanges

The material specifications requirements for carbon steel and alloy steel flanges shall be in accordance with [02-SAMSS-011](#).

10.3 Blind Flanges

Material for ASME flanges shall follow requirements of [02-SAMSS-011](#).

10.4 API SPEC 6A Flanges

Material for API SPEC 6A shall follow the requirements of [02-SAMSS-011](#) and Table 4 of the API spec.

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.

11.2.1 Spectacle plates and blinds shall be in accordance with Saudi Aramco standards drawings addressed in [Table 2](#).

Note:

The dimensions of spectacle plates for sizes 38-inch NPS and larger in sheet 1 of standard drawings addressed in Table 2 do not fit with flange dimensions of ASME B16.47. Corrected dimensions are provided in a new sheet of the applicable drawing.

11.2.2 For unlisted spectacle plate blinds and blanks, ASME B16.48 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 SPEC 6A).

Table 2 – Spectacle Plates Blinds and Blanks Dimensions

NPS Range	Class	Facing	Standard Drawing
2 - 48	125	FF	AD-036631-001
2 - 48	150	RF	AD-036633-001
54 - 60	250, 300	RF	AD-036731-001

2 - 48	250, 300	RF	AD-036731-001
2 - 48	600	RF	AD-036636-001
2 - 30	600	RJ	AD-036734-001
2 - 24	900	RJ	AD-036735-001
2 - 24	1500	RJ	AD-036736-001

- 11.4** Material for spectacle plates blinds and blanks shall follow the requirements of 02-SAMSS-011.

12 Gaskets

- 12.1** All gaskets shall be suitable for the intended service and design temperature, and compatible with the flange facing, rating, and bolting.

- 12.2** Minimizing fugitive emissions shall be considered in the selection of the gasket type and its specifications. The leakage rate as per **ASME B16.20** shall be followed as a minimum.

- 12.3** All gaskets shall be purchased from approved manufacturers and shall follow the requirements of 02-SAMSS-014.

12.4 Metallic Ring Joint Gaskets

12.4.1 Octagonal ring joint gaskets Type R, per ASME B16.20 shall be used with API SPEC 6A Type 6B flanges and ASME RTJ flange type.

12.4.2 Octagonal ring joint gaskets Type RX, per ASME B16.20 shall be used with API SPEC 6A Type 6BX flanges.

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

12.2.4 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.

12.4.5 Ring joint gaskets in subsea service shall be suitable for both the internal service environment and the external sea environment.

12.5 Spiral Wound Gaskets

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

12.5.2 Filler material for spiral wound gaskets shall be suitable for the intended design conditions and the intended service. The temperature limits for common filler materials are given in Table 3.

Table 3 - Temperature Limitations of Spiral Wound Gasket Filler Materials

Filler	Temperature Limits
Polytetrafluoroethylene (PTFE)	-180°C to 260°C (-300°F to 500°F)

Graphite	-240°C to 425°C (-400°F to 800°F)
Vermiculite	-180°C to 870°C (-300°F to 1,600°F)

12.5.2.1 PTFE filler shall not be used in hydrocarbon or steam services.

12.5.2.2 Graphite filler used in hydrocarbon or steam services shall be high purity flexible graphite.

12.5.3 Spiral wound gaskets windings shall be made of 316 stainless steel or higher alloy. The use of 304 SS is not allowed.

12.5.4 The inner and the outer rings material shall match the winding material or as specified in the piping line class. Carbon steel outer ring that is painted, metal plated, or otherwise coated to inhibit atmospheric corrosion is also permitted if the line pipe material is carbon steel.

12.5.5 Outer rings are required for all gasket sizes. Inner rings are required as per ASME B16.20 and as per the following flanges:

- Flanges size 24-inch NPS and larger;
- Flange class 900# and above where applicable;
- Flanges in vacuum services.

If specified in the piping class per the licensors recommendations

12.6 Metal Grooved Gaskets

Metal Grooved 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.

12.7 Spring Energized Seal Metal Core with GRE Liner Gaskets

Spring Energized Seal Metal Core with GRE Liner Gaskets shall be suitable for the intended service and design temperature and compatible with the flange facing, rating, and bolting. In process facilities, only fire safe gaskets shall be used.

12.8 Insulating Gaskets

12.8.1 Approved insulation kits (insulating gaskets with insulating sleeves and washers) shall be used for the following:

- Insulating dissimilar metal flanged joints with high potential galvanic corrosion (i.e., electrical isolation),
- Insulating joints for cathodic protection.

12.8.2 Insulation kits 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.
- When the insulation kit is ineffective due to electrical external bonding between the dissimilar metals caused through contacts with pipe supports, structure, etc.

12.9 Metal Jacketed Gasket

Metal jacketed gasket shall not be used in pipe flanges.

12.10 Sheet Gasket

12.10.1 Sheet gaskets shall only be used for flat face flanges. Sheet gaskets shall be according to ASME B16.21. The sheet gasket material shall be suitable for the intended design and service conditions.

12.10.2 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.

12.10.3 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.

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. Alternative material specifications may be accepted if they meet the strength requirements at the service temperature range provided they are evaluated as part of the materials selection philosophy deliverable in the project design stage.

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 and cryogenic services	- 73	+ 450	A320 Grade L7M	A194 Grade 7M
	-101	+ 343	A320 Grade L7	A194 Grade 4 or 7
	-198	+ 50	A193 Grade B8M	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 as per *NACE MR0175/ISO 15156*.

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

- a) Ceramic-fluoropolymer coating per 09-SAMSS-107,
- b) Corrosion-resistant alloys,
- c) Encapsulating the bolted flange connection with heat shrinkable tubing.

13.4 Subsea bolting under Cathodic Protection shall meet the following requirements:

- a) Hardness of the materials shall not exceed 33 HRC.
- b) Alloy steel materials shall exhibit a fully tempered microstructure.
- c) The bolts shall be Ceramic-fluoropolymer coated as per 09-SAMSS-107.

13.5 Washers

13.5.1 Flat washers under the nuts are required for special cases only, such as on insulating flanges and under the nuts bearing against plastic flanges.

13.5.2 Disc spring washers may be required for severe cyclic service, or bolt service temperatures above 450°C.

Document History

04 July 2022	Adding reference to new 02-SAMSS-014 metallic piping gaskets targeting the potential for lower fugitive emissions and loss of containment, leading towards the Decarbonization Business Goal. Incorporate comments submitted in the e-standards website
27 June 2019	Major revision incorporating VE conducted in March 2019 and align with 02-SAMSS-011.
29 January 2018	Editorial revision.
12 January 2015	Minor revision issued after the discussion with the Chairman of the Vessel Standards Committee and the Professional Body Leader to revise the requirement for hydrogen services that have been brought up by Ras Tanura Refinery Clean Fuel Project.
22 July 2014	Revised the Next Planned Update, reaffirmed the content of the document, and reissued as major revision.