

Engineering Standard

SAES-G-005

28 February 2005

Centrifugal Pumps

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Saudi Aramco DeskTop Standards

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1 Scope

This Standard defines the minimum mandatory requirements governing the design and installation of centrifugal pumps excluding submersible pumps that are covered by SAES-G-007. Pumps having driver rating equal to or less than 25 HP and are in community water or sewage services are not required to comply with this standard. This Standard may not be attached to or made a part of purchase orders.

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

<i>SAEP-302</i>	<i>Instructions for Obtaining a Waiver of a Mandatory Saudi Aramco Engineering Requirement</i>
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Saudi Aramco Engineering Standards

<i>SAES-B-009</i>	<i>Fire Protection and Safety Requirements for Offshore Production Facilities</i>
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<i>SAES-B-017</i>	<i>Firewater System Design</i>
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Saudi Aramco Materials System Specifications

<i>17-SAMSS-503</i>	<i>Severe Duty Totally Enclosed Squirrel Cage Induction Motors to 250 HP</i>
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<i>30-SAMSS-001</i>	<i>Diesel Engines</i>
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<i>31-SAMSS-004</i>	<i>Centrifugal Pumps</i>
<i>31-SAMSS-012</i>	<i>Shaft Sealing System for Centrifugal and Rotary Pumps</i>
<i>32-SAMSS-009</i>	<i>General Purpose Steam Turbines</i>
<i>32-SAMSS-013</i>	<i>Lubrication, Shaft Sealing and Control Oil Systems</i>

Saudi Aramco Forms and Data Sheets

<i>2741-ENG & 2741-M-ENG</i>	<i>Centrifugal Pump Data Sheet for Horizontal Pumps and Vertical In-Line Pumps</i>
<i>2748-ENG & 2748-M-ENG</i>	<i>Centrifugal Pump Data Sheet for Vertical Suspended Pumps</i>

Saudi Aramco Inspection Requirements

<i>Form 175-310500</i>	<i>Pumps: ASME Centrifugal, Horizontal, End Suction Single Stage, or Vertical In-Line</i>
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Saudi Aramco Standard Drawings

<i>AD-036080</i>	<i>Conical Pump Suction Screen for Raised Face Flanges, Pipe Sizes 2, 3, and 4 in</i>
<i>AD-036495</i>	<i>Conical Pump Suction Screen for Raised Face Flanges, Pipe Sizes 6, 8, 10, 12 and 14 in</i>
<i>AC-036688</i>	<i>Conical Pump Suction Screen for Class 150 and 300 Flanges, Pipe Sizes 16 in and larger</i>
<i>AD-036821</i>	<i>Material Guide for Centrifugal Pumps</i>

3.2 Industry Codes and Standards

American Society of Mechanical Engineers

<i>ASME B73.1</i>	<i>Specification for Horizontal, End Suction Centrifugal Pumps for Chemical Process</i>
<i>ASME B73.2</i>	<i>Specification for Vertical In-Line Centrifugal Pumps for Chemical Process</i>

National Fire Protection Association

<i>NFPA 20</i>	<i>Standard for the Installation of Stationary Pumps for Fire Protection</i>
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Institute of Electrical and Electronics Engineers, Inc.

IEEE 252

Test Procedure for Polyphase Induction Motors

4 Design

4.1 General

4.1.1 All pumps in hydrocarbon service shall comply with 31-SAMSS-004.

Exceptions:

- *Vertical suspended pumps in sump service having driver ratings not exceeding 37 kW (50 HP);*
- *Vertical suspended pumps in oily water and storm water applications;*
- *ASME pumps, as defined in paragraph 4.1.3;*
- *Horizontal self priming pumps in sump services.*

4.1.2 Between bearings pumps and vertical suspended pumps in utility water service having driver ratings in excess of 112 kW (150 HP) shall comply with 31-SAMSS-004.

4.1.3 Only when space limitations do not permit the use of horizontal ASME B73.1 pumps will vertical ASME B73.2 pumps be acceptable.

ASME pumps shall be used for non-hydrocarbon services with the exception of domestic sewage and sewage effluent provided that:

- a) Discharge pressure does not exceed 1900 kPa gauge (275 psig);
- b) Suction pressure does not exceed 520 kPa gauge (75 psig);
- c) The temperature of the pumped liquid is not less than 0°C (32°F) and does not exceed 120°C (250°F);
- d) The vapor pressure of the pumped liquid is less than 207 kPa abs (30 psia) at the maximum operating temperature;
- e) The driver nameplate rating (excluding any service factor) does not exceed 112 kW (150 HP).

When any of the above limitations is exceeded, the pump shall comply with 31-SAMSS-004.

ASME pumps may also be used for hydrocarbon service provided that, in addition to a), b) and e), above:

1. The temperature of the pumped liquid is not less than 0°C (32°F) and does not exceed 65°C (150°F);
2. The vapor pressure of the pumped liquid is less than 172 kPa abs (25 psia) at the maximum operating temperature. (The intent is to utilize ASME pumps in hydrocarbon services in bulk plants, to limit their use in process facilities and to prohibit their use in any hydrocarbon service more volatile than gasoline, regardless of operating temperature or pressure).

Commentary Note:

ASME B73.1 pumps are acceptable for application in equipment lube oil systems.

- 4.1.4 Pumps in firewater service, including jockey pumps shall comply with the requirements of NFPA 20 and SAES-B-017 or SAES-B-009. Main and emergency firewater pumps shall operate at a maximum speed of 1800 RPM. Horizontal jockey pumps may operate at 3600 RPM. Vertically suspended jockey pumps shall not exceed 1800 RPM unless approved by the Rotating Equipment Standards Committee Chairman.

Note: Firewater pumps do not require UL/FM listing.

- 4.1.5 Vendor's standard design shall be provided when:
- a) Vertical suspended pumps having driver ratings not exceeding 37 kW (50 HP) are in sump service;
 - b) Vertical suspended pumps in oily water and storm water applications;
 - c) Pumps, regardless of driver rating, are in molten sulfur service;
 - d) Horizontal self priming pumps are in sump service with a suction lift not exceeding 6 m (20 ft) and a rated capacity not exceeding 30 L/s (500 USGPM);
 - e) Pumps are in domestic sewage or sewage effluent service;
 - f) Between bearings pumps and vertical suspended pumps are in utility water service, having driver ratings up to 112 kW (150 HP).

- 4.1.6 All pumps, including those which are exempt from the scope of 31-SAMSS-004, ASME B73.1 or ASME B73.2 requirements, must still comply with this Engineering Standard.

- 4.1.7 Pump Type Selection
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- 4.1.7.1 Horizontal pumps shall be used unless suction conditions or space limitations prohibit their application. The use of horizontal overhung double suction or horizontal overhung two stage pumps is not acceptable.
 - 4.1.7.2 Vertically suspended double casing pumps shall be used if suction conditions prohibit the use of horizontal pumps.
 - 4.1.7.3 Maximum operating speed of vertically suspended pumps shall not exceed 1800 RPM unless approved by the Rotating Equipment Standards Committee Chairman.
 - 4.1.7.4 For vertically suspended pumps, an open lineshaft shall be used if the distance between the normal liquid level and the centerline of the pump discharge nozzle is 23 m (75 ft) or less. Applications exceeding this shall utilize an enclosed lineshaft. Alternatively, consideration shall be given to the use of electric submersible pumps complying with 31-SAMSS-010 and SAES-G-007.
 - 4.1.7.5 Non-metallic side discharge pumps may be used in sump service provided that all of the following conditions are met:
 - a) The selection of a metallic type pump is unsuitable due to anticipated corrosion rates > 127 micrometers/year (5 mils/year).
 - b) The pump driver rating does not exceed 37 kW (50 HP).
 - c) The maximum discharge pressure does not exceed 1,040 kPa gauge (150 psig).
 - 4.1.7.6 Horizontal direct drive self priming pumps may be used for oily water sump services when the suction lift does not exceed 6 m (20 ft) and the rated capacity does not exceed 30 L/s (500 USGPM). If self priming pumps are used to discharge into pressurized system, an automatic air release valve or continuous bleed with orifice shall be provide.
 - 4.1.7.7 Sealless pumps shall be provided for caustic, acid and sour water services if the motor nameplate rating does not exceed 112 kW (150 HP). All sealless pumps shall be self venting and shall be designed to permit complete drainage prior to dismantling. The use of a sealless pump in glycol or amine
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services is acceptable but not mandatory. For applications where the motor rating exceeds 112 kW (150 HP) or where sealless pumps are not suitable for the service, sealed pumps shall be used. Magnet Drive Pumps shall not be used if the pumped liquid contains ferrous or iron oxide particles and no external clean flush is available.

4.1.7.7.1 Canned Motor Pumps

- a) Canned motor pumps may be used for all sealless pump services.
- b) If secondary containment of the process liquid is required or if the operating temperature exceeds 93°C (200°F), a canned motor pump shall be used.
- c) A bearing wear monitor and switch for alarm purposes shall be provided for each pump.
- d) Pumps equipped with variable speed controllers and which operate at speeds in excess of 3,600 RPM require approval by the Rotating Equipment Standards Committee Chairman.
- e) Stator housing and liner hydrostatic tests are required for each pump. The test pressure shall be the pump MAWP.
- f) A dielectric test using a polarization index ratio based on one minute and ten minute readings, in accordance with IEEE 252, is required for each motor.
- g) A thermal device shall be installed in the motor stator winding to trip the motor on high winding temperature.
- h) A low power switch shall be provided to protect the pump against dry run operation.

4.1.7.7.2 Magnet Drive Pumps (Synchronous or Eddy Current), in accordance with ASME B73.1

- a) The operating speed of magnet drive sealless pumps shall not exceed 3,600
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RPM. The maximum liquid temperature shall not exceed 93°C (200°F).

- b) The synchronous magnet torque rating shall exceed the maximum torque of the pump with maximum diameter impeller from minimum continuous stable capacity to 120% of rated capacity by the following factors, based on the calculated torque of the coupling:

Calculated Torque Nm	Calculated Torque ft-lbf	Synchronous Coupling Rating Factor
<50	<37	1.25
50 - 150	37 - 111	1.15
>150	>111	1.10

- c) If two or more synchronous magnet drive pumps on the same purchase order and of identical type, rating, materials and design conditions are presented for inspection as a batch, one static torque test is acceptable. Otherwise, a static torque test is required for each pump.
- d) The magnetic coupling torque rating shall exceed the maximum torque rating of the pump with maximum diameter impeller from minimum continuous stable capacity to 120% of rated capacity by a minimum of 10%.
- e) Magnet drive pumps having metallic containment shells shall be provided with containment shell temperature monitoring.
- f) A low power switch shall be provided to protect the pump against dry run operation.

4.1.8 Unit responsibility for the complete pump train including driver, gear, oil system(s), etc., shall be assigned to the pump manufacturer. Exception may be made when the driver is a diesel engine, special purpose steam turbine or combustion gas turbine.

4.2 Rated Operating Conditions

- 4.2.1 The NPSHA at 120% of rated flow shall be determined from the maximum liquid temperature with corresponding vapor pressure.
 - 4.2.2 Viscosity correction factors, per the Hydraulic Institute Standard, shall be applied. Extrapolation is not recommended. Correction factors for water are 1:1:1. Limitations on use of viscous liquid performance correction chart are:
 - a) Use only for pumps of conventional hydraulic design, in the normal operating range, with open or closed impellers. DO NOT use for mixed flow or axial flow pumps or for pumps of special hydraulic design for either viscous or non-uniform liquids.
 - b) Use only on Newtonian (uniform) liquids. Gels, slurries and other non-uniform liquids may produce widely varying results, depending on the particular characteristics of the liquids.
 - 4.2.3 When determining the rated suction pressure, the minimum expected suction pressure shall be specified.
 - 4.3 Hydraulic Performance
 - 4.3.1 For high energy water injection pumps, as defined by API STD 610, strong emphasis shall be placed on evaluation of Vendor's references for similar impellers operating successfully under similar conditions and verification of the 40,000 hours NPSH curve. The first stage impeller inlet geometry and rated operating conditions shall be submitted, together with the Vendor's references for similar impellers, through the Company or Buyer Representative for review and approval by the Rotating Equipment Standards Committee Chairman.
 - 4.3.2 All pumps shall have a performance curve which rises continuously to shutoff. The head rise from the rated head to shutoff shall not be less than 10% of the rated head.
 - 4.3.3 For ASME pumps and pumps to manufacturer's standard design, the rated capacity shall not be less than 60% and shall not exceed 110% of the capacity at best efficiency point.
 - 4.3.4 For all pumps, the NPSHR shall not exceed the specified NPSHA over the range of minimum continuous stable capacity to 120% of the rated capacity. For variable speed pumps, the above NPSH requirements apply for all speeds required to meet the specified operating conditions.
 - 4.3.5 For all pumps, the suction specific speed, based on the NPSH required for 3% first stage head drop at best efficiency capacity, shall not
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exceed 6,710 (11,000 in U.S. units).

4.4 Casing Design

- 4.4.1 The maximum allowable working pressure of horizontal and vertical in-line pump casings and the discharge heads of vertically suspended pumps shall be at least equal to the sum of the maximum suction pressure and the differential pressure developed at shut-off with the maximum diameter impeller installed and at maximum speed.
- 4.4.2 Minimum casing design temperature shall be at least equal to the maximum flow temperature. For pumps handling liquids which may autorefrigerate, the minimum design temperature shall be the lowest liquid temperature which would occur as a result of rapid reduction in liquid pressure to 25% of the pump design operating pressure.
- 4.4.3 The maximum allowable working pressure (MAWP) of the bowl and column assemblies of vertical suspended pumps shall be at least equal to the maximum differential pressure developed by the bowl assembly at shut-off with maximum impeller diameter and at maximum speed.
- 4.4.4 The details of threading shall be in accordance with ASME B1.1/ASME B1.13M or other internationally approved standard.

4.5 Shaft Sealing

- 4.5.1 Packing is required for main firewater pumps and for non hydrocarbon slurry pumps. Jockey pumps shall have mechanical seals.
- 4.5.2 Manufacturer standard sealing arrangement is acceptable for horizontal self priming pumps in oily water and sewage services. For open lineshaft design, vertically suspended pumps in oily water, raw water or sea water lift service shall be provided with a bleed type discharge head bushing and a labyrinth seal. The design of the labyrinth seal shall be submitted for review and approval by the Rotating Equipment Standards Committee Chairman. If a labyrinth seal is not available, then grease lubricated packing may be used, subject to the approval of the Rotating Equipment Standards Committee Chairman.
- 4.5.3 Mechanical seals for pumps complying with 31-SAMSS-004, with the exception of integrally geared pumps, shall be in accordance with 31-SAMSS-012 and Table 1, Mechanical Seal Selection Guide. Mechanical seals for ASME pumps and for pumps to manufacturer's standard design shall be in accordance with Table 1, Mechanical Seal Selection Guide.

When applying the Mechanical Seal Selection Guide, the following shall be observed:

- a) Seal leakage systems, when required by service conditions, are included in the scope of supply of the pump Vendor unless otherwise specified.
- b) Mechanical seal selection for services not listed in the Mechanical Seal Selection Guide is subject to the review and approval of the Rotating Equipment Standards Committee Chairman.
- c) Dry hydrocarbons contain less than 0.2% water by weight.
- d) The classification code in this guide is based on API STD 610, 8th Edition.

4.6 Bearings and Bearing Housings

4.6.1 Bearings shall be oil lubricated unless exempt from the scope of 31-SAMSS-004 or ASME B73.1 and ASME B73.2. Anti-friction bearings of pumps exempt from these specifications may be grease lubricated. With the exception of pumps having external lube oil system, the following shall be installed on the bearing housings of oil lubricated pumps:

- Constant level oiler
- Level sight glass
- A drainable sight glass (installed under the bearing housing).

If oil mist lubrication is specified, it shall be of the purge oil mist type.

4.6.2 The upthrust and downthrust values for vertical pumps quoted by the Vendor shall be the maximum forces expected at any point on the full curve.

It shall be verified that the values listed are within the bearing design criteria of the driver or transmission unit which absorbs the rotor thrust.

4.7 Materials of Construction

4.7.1 The metallurgy application guide of Table 2 provides a listing of most liquids pumped. The liquid pumped shall be identified from the table together with the corresponding "Materials Code(s)". The applicable material code shall be specified on the Data Sheet(s) 2741-ENG & 2741-M-ENG / 2748-ENG & 2748-M-ENG.

ASTM Standard numbers and material grades offered shall be in compliance with (or be superior to) the applicable ASTM Standard numbers and material grades listed on Standard Drawing AD-036821.

To enable the manufacturer to complete the required material designations, Standard Drawing AD-036821 must be attached to the Quotation Request or Purchase Order.

4.7.2 Materials of construction for special fluids not listed on Standard Drawing AD-036821 may be based on information provided in publications, recommendations provided by pump manufacturers or other accepted sources. In such cases, the material selection as proposed by the manufacturer shall be reviewed and approved in writing by the Rotating Equipment Standards Committee Chairman.

4.7.3 General Notes

- a) Substitute equivalent or superior materials shall be reviewed and approved in writing by the Rotating Equipment Standards Committee Chairman. For any requested materials substitution, sufficient data shall be provided by the Vendor to justify the substitution. This data shall include but shall not be limited to physical, mechanical and corrosion resistance properties.
- b) For pumps in compliance with ASME B73.1 and ASME B73.2, the ASME material code equivalent to or better than the appropriate code listed in the following "Material Selection Guide" may be used, subject to the review and approval of the Rotating Equipment Standards Committee Chairman.
- c) The Material Selection Guide indicates the minimum requirements.

4.8 Couplings and Guards

4.8.1 Lubricated couplings are not permitted.

4.8.2 For horizontal pumps, vertical in-line and vertically suspended pumps having thrust bearings and not driven by reciprocating engines, flexible disc pack or diaphragm type couplings are required.

4.8.3 Rigid adjustable spacer type couplings are required for vertical in-line and vertically suspended pumps not having thrust bearings.

4.8.4 Elastomeric type couplings or couplings having comparable torsional stiffness are required for pumps driven by reciprocating engines. The

use of elastomeric couplings, or couplings having comparable torsional stiffness, for other applications requires the approval of the Rotating Equipment Standards Committee Chairman. Elastomeric members shall not deteriorate due to exposure to a hydrocarbon environment.

4.9 Drivers

4.9.1 The drivers for ASME pumps and for pumps to manufacturer's standard design shall be sized in accordance with the following table:

Driver Nameplate Rating		Percentage of Pump Rated Power
kW	HP	
<22	<30	125
22-55	30-75	115
>55	>75	110

4.9.2 For ASME pumps and pumps to manufacturer's standard design, electric motor drivers shall be in accordance with 17-SAMSS-503, diesel engines shall be in accordance with 30-SAMSS-001 and steam turbine drivers shall be in accordance with 32-SAMSS-009.

4.10 Mounting Plates

Horizontal Pumps

A baseplate is required for grouted, permanently installed equipment. An oil field skid is required for equipment which may be temporarily used for the specified service or frequently relocated.

Vertical Pumps

Sump mounted vertical pumps shall be provided with a grouted, permanently installed soleplate or surface plate to which the mounting plate or flange of the pump will attach. Removal of the pump for maintenance shall not require removal of the grouted soleplate or surface plate. Studs shall be installed in the soleplate or surface plate to match the pump mounting plate or flange. The only exception to this requirement is when sump pumps are mounted on a steel sump cover plate. In this case, the sump cover plate shall have studs installed to match the pump mounting plate or flange.

4.11 Piping

Specify if drain and/or vent piping within the confines of the baseplate, including block valves and flanged terminations at the edge of the baseplate,

shall be supplied by the pump Vendor. Services for which the pump Vendor could supply such provisions are toxic liquids or liquids which could vaporize at atmospheric conditions, thereby creating a potential flammable hazard.

4.112 Utilities

Specify type of cooling water available, i.e., raw water, sea water, etc., along with inlet temperature and pressure. The Vendor shall complete the remaining information.

5 Installation

5.1 Layout

- 5.1.1 Pumps shall be located for convenience of process, operating and maintenance requirements. The pump train arrangement shall ensure safe and easy access to all equipment train components for operation and maintenance purposes.
- 5.1.2 Provisions for isolation, venting and draining the pump shall be installed to permit internal inspection, repair or dismantling.
- 5.1.3 Wherever possible, when more than one identical pump train is required, the design of the equipment trains, the auxiliary baseplate(s), the connecting piping, cabling, wiring, etc., shall be identical in layout, construction and accessibility.

5.2 Piping

- 5.2.1 Piping systems shall be designed such that forces and moments imposed on the pump nozzles under any operating conditions do not exceed those allowed by the pump design.
 - 5.2.2 The suction piping shall be designed to prevent the formation of gas or air pockets. Sufficient venting provisions shall be included.
 - 5.2.3 Suction piping to all pumps, with the exception of vertically suspended double casing pumps and horizontal self priming pumps, shall have a straight length of pipe of at least 5 times the suction nozzle diameter immediately upstream of the nozzle. Pumps having suction piping diameter up to 4 inches and can not comply with this requirement due to space limitation may be approved by the Rotating Equipment Standards Committee Chairman.
 - 5.2.4 Reducers in suction piping shall be of the eccentric type with the flat uppermost and shall be located upstream of the straight pipe length
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immediately upstream of the suction nozzle of the pump. In the event of there being insufficient space to accommodate the straight length of piping immediately upstream of the pump, a specially fabricated reducer shall be provided for direct connection to the pump suction nozzle. This reducer shall be eccentric with the flat uppermost and shall have a taper angle not exceeding 12 degrees.

- 5.2.5 Temporary strainers in accordance with Standard Drawings AC-036688, AD-036080 or AD-036495 shall be used during the commissioning and initial operating period of new plants to prevent foreign objects from entering the pump.

If strainers are required beyond commissioning and initial operating period, they shall be "T" or "Y" type with minimum ½ inch openings and at least 150% flow area. If strainers are used on long-term basis, a differential pressure switch across the strainer shall be installed and shall alarm on high differential pressure.

Strainers shall be installed in a manner that facilitates frequent strainer removal and cleaning. The strainers shall be located in an easily accessible location.

- 5.2.6 A check valve shall be installed on the discharge piping of each pump. It shall be located upstream of the discharge valve. Low lift seawater pumps discharging directly into an open canal are excluded from this requirement.

- 5.3 The Vendor's General Arrangement (G.A.) or outline drawings shall include all data required to install the pump on its foundation. In addition to nozzles, shaft centerline and baseplate foundation bolt coordinates, it shall contain coordinates of all connections to be hooked up at site such as auxiliary piping connections, main and auxiliary power terminal boxes, etc. G.A. drawings shall also show Buyer's references and the main rating data of equipment components.

6 Testing and Inspection

- 6.1 When witnessed testing is required, a hold to the production schedule of the unit shall be applied until the tests are performed.

All pumps shall be tested at rated speed. If this is not feasible, the Vendor shall advise his proposed vibration acceptance criteria at his specified derated speed. Vibration data and bearing temperatures shall be recorded.

- 6.2 Requirements on hydrostatic pressure testing, running and performance testing shall be completed in accordance with the Test Requirements for Centrifugal
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Pumps, Section 6.6 below.

- 6.3 Pumps shall be dismantled in the event of unsatisfactory performance, NPSH or running tests or if mutually agreed upon by the Vendor and the Buyer.
- 6.4 Vibration measurements shall be taken and recorded for all certified or witnessed tests of pumps complying with 31-SAMSS-004 and ASME B73.1 or ASME B73.2.
- 6.5 Test requirements are given in Table 3.
- 6.6 Requirements for documentation certification and witnessing of test shall be as specified on Inspection Form 175-310600 for pumps complying to 31-SAMSS-004 and Inspection Form 175-310500 for ASME B73.1 and ASME B73.2 pumps.

28 February 2005

Revision Summary
Major revision.

Table 1 – Mechanical Seal Selection Guide

Dry Hydrocarbon Service - Vapor Pressure = or < 100 kPa abs (14.7 psia)
 at Pumping Temperature

Temperature °C (°F)	-40 to 0 (-40 to 32)	1 to 93 (33 to 200)
Seal Code	BSAHN (Note 1)	BSTFN (Note 2)
API STD 682 Seal Type (Note 3)	A	A
Seal Flush Plan w/ Suspended Solids	N/A	31 (Note 4)
w/o Suspended Solids	Horizontal: 11 Vertical: 13	Horizontal: 11 Vertical: 13
Quench Plan / Type	51 / Methanol (Note 5)	None

Dry Hydrocarbon Service - Vapor Pressure = or < 100 kPa abs (14.7 psia)
 at Pumping Temperature

Temperature °C (°F)	94 to 149 (201 to 300)	>149 (>300)
Seal Code	BSTFN	BSTZN (Notes 6 & 7)
API STD 682 Seal Type	A (Note 3)	C
Seal Flush Plan w/ Suspended Solids	41 or 32 (Note 4)	32 (Note 11)
w/o Suspended Solids	21 or 23	32 (Note 11)
Quench Plan / Type	None	62 / Steam

Dry Hydrocarbon Service - Vapor Pressure > 100 kPa abs (14.7 psia)
 at Pumping Temperature

Temperature °C (°F)	-40 to 0 (-40 to 32)	1 to 60 (33 to 140)
Seal Code	BSAHN (Note 1)	BSAFN (Notes 1, 8 & 9)
API STD 682 Seal Type (Note 3)	A	A
Seal Flush Plan w/ Suspended Solids	N/A	31 (Note 4)
w/o Suspended Solids	Horizontal: 11 Vertical: 13	Horizontal: 11 Vertical: 13
Quench Plan / Type	51 / Methanol (Note 5)	None

Table 1 – Mechanical Seal Selection Guide (cont'd)

Dry Hydrocarbon Service -- Vapor Pressure > 100 kPa abs (14.7 psia)
 at Pumping Temperature

Temperature °C (°F)	61 to 149 (141 to 300)	150 to 204 (301 to 400)	>204 >400
Seal Code	BSAFN (Notes 1 & 2)	BSAIN	BSTZN (Notes 6 & 7)
API STD 682 Seal Type	A (Note 3)	A	C
Seal Flush Plan w/ Suspended Solids	32 or 41 (Note 4)	41 (Notes 4)	41 (Notes 4)
w/o Suspended Solids	21 or 23	23	23 -
Quench Plan / Type	None	None	62 / Steam

Wet Crude Service	Vapor Pressure = or <510 kPa abs (75 psia) at Pumping Temp.	Vapor Pressure >510 kPa abs (75 psia) at Pumping Temp.
Temperature °C (°F)	<149 (<300)	<149 (<300)
Seal Code	BSTFN	BSAFN (Note 1)
API STD 682 Seal Type (Note 3)	A	A
Seal Flush Plan (Note 12)	32	32
Quench Plan/Type	None	None

Dry Crude Service	Vapor Pressure = or <510 kPa abs (75 psia) at Pumping Temp.	Vapor Pressure >510 kPa abs (75 psia) at Pumping Temp.
Temperature °C (°F)	<149 (<300)	<149 (<300)
Seal Code	BSTFN	BSAFN (Note 1)
API STD 682 Seal Type (Note 3)	A	A
Seal Flush Plan	Horizontal: 31 Vertical : 31/13	Horizontal: 31 Vertical: 31/13
Quench Plan/Type	None	None

Table 1 – Mechanical Seal Selection Guide (cont'd)

WATER SERVICES	Produced Brine Water	All Other Water Services	All Other Water Services	All Other Water Services
Temperature °C (°F)	All	Up to 60 (Up to 140)	61-93 (141 to 200)	> 93 (>200)
Seal Code	BSTFN	BSTFN (Notes 13 & 14)	BSTFN (Notes 14)	BSTFN (Note 14)
API STD 682 Seal Type (Note 3)	A	A	A	A
Seal Flush Plan w/ Suspended Solids	32 (Notes 15 & 16)	31 or 32 (Note 4)	41 or 32 (Note 17 & 4)	41 or 32 (Note 17 & 4)
w/o Suspended Solids	32 (Note 15 & 16)	11	21	23 or 32
Quench Plan / Type	62 /Raw water (Note 18)	None	None	None

DGA, ADIP & OTHER AMINE SERVICES		
Temperature °C (°F)	Up to 93 (Up to 200)	>94 (>201)
Seal Code	BSTIN (Note 10)	BSTIN (Note 10)
API STD 682 Seal Type (Note 3)	A	A
Seal Flush Plan w/ Suspended Solids (Note 4)	31	41
w/o Suspended Solids	11	23 or 21
Quench Plan / Type	None	None

GLYCOL (TEG) SERVICE			
Temperature °C (°F)	Up to 93 (Up to 200)	94 to 149 (201 to 300)	>149 (>300)
Seal Code	BSTFN	BSTFN	BSTIN
API STD 682 Seal Type (Note 3)	A	A	A
Seal Flush Plan w/Suspended Solids (Note 4)	31 or 32	41 or 32	41 or 32
w/o Suspended Solids	11	23 or 21	23
Quench Plan/Type	None	None	None

Table 1 – Mechanical Seal Selection Guide (cont'd)

CAUSTIC SERVICE		
Temperature °C (°F)	Up to 93 (Up to 200)	94 to 149 (201 to 300)
Seal Code	BSTXN (Note 19)	BSTXN (Note 19)
API STD 682 Seal Type (Note 3)	A	A
Seal Flush Plan w/Suspended Solids (Note 4)	31 or 32 (Water)	41 or 32 (Water)
w/o Suspended Solids	11	23 or 21
Quench Plan/Type	62/Water	62/Water

SODIUM HYPOCHLORITE SERVICE		
Temperature °C (°F)	Up to 93 (Up to 200)	94 to 149 (201 to 300)
Seal Code	BSTFN	BSTFN
API STD 682 Seal Type (Note 3)	A	A
Seal Flush Plan w/Suspended Solids (Note 4)	31 or 32 (Water)	41 or 32 (Water)
w/o Suspended Solids	11	23 or 21
Quench Plan/Type	62/Water	62/Water

HORIZONTAL SULFUR PUMPS	
Seal Code	BSTXP (Note 20)
API STD 682 Seal Type	A
Seal Flush Plan	02
Quench Plan/Type	62/Steam

Seal Selection Guide Notes:

- An auxiliary dry running backup seal shall be supplied instead of a floating throttle bushing. The auxiliary seal code shall be the same as for the primary seal except the third letter will be "P" instead of "A".
 Auxiliary dry running seals shall be face type seals, capable of 25,000 hours of operation in a gas or liquid environment at a pressure up to the set point of the seal leakage detection pressure switch and 1,000 hours of operation in a liquid environment up to the maximum seal chamber conditions.
- If the pumped liquid is MTBE or gasoline containing MTBE, the seal code shall be BSTZN with graphite foil gaskets.
- Type A seals represent the minimum acceptable seal for these services. If approved by the Rotating Equipment Standards Committee Chairman, a bellows seal is an acceptable alternative to the standard Type A seal in applications where the maximum seal chamber pressure does not exceed 1830 kPa abs (265 psia).
- API plans 31 and 41 shall be used only if the pump differential pressure exceeds 175 kPa (25 psi). Otherwise, Plan 32 flush with a compatible clean liquid shall be used.
- The methanol feed system, Plan 51, is not intended to provide a continuous flow of methanol. It is used immediately prior to start-up to prevent or eliminate icing on the atmospheric side of the primary seal.

6. The fourth letter (Z) in the API STD 610 seal code for Type C seals, BSTZN designates a spiral wound gasket for the stationary seal ring gasket and graphite foil for the seal ring-to-sleeve gasket. Substituting graphite foil for the stationary seal ring gasket, seal code BSTRN, is acceptable.
7. For seal chamber pressures of 1830 kPa abs (265 psia) or higher, seal selection must be referred to the Rotating Equipment Division of Consulting Services Department.
8. If the pumped liquid is auto-refrigerant, all secondary sealing elastomers shall be Code H, Nitrile (Buna-N).
9. Seal code BSTFN is acceptable for gasoline services up to 50°C (120°F).
10. For rich DGA services, seal code BSAIN shall be used.
11. Seal flush plan 02 shall be used for asphalt services and may be acceptable for crude vacuum bottom pumps subject to review and approval by the Rotating Equipment Standards Committee Chairman.
12. Plan 31 seal flush is acceptable for wet crude service on all Northern Area offshore GOSPs. For plan 32, the external source flush fluid should be dry crude.

Vertical charge and test trap pumps shall be supplied with a bleed type discharge head bushing sized to ensure that the seal chamber is at suction pressure. For plant startup, pumps shall be supplied with a Plan 31 in addition to Plan 32 seal flush. A check valve shall be installed in both the Plan 31 and Plan 32 seal flush lines to prevent flushing fluid from entering the piping system not in use.
13. Open lineshaft design, vertical suspended pumps in oily water, raw water or sea water lift service shall be provided with a bleed type discharge head bushing and a labyrinth seal instead of a mechanical seal. If a labyrinth seal is not available, then grease lubricated packing may be used, subject to the approval of the Rotating Equipment Standards Committee Chairman.
14. The API seal code for sour water service shall be BSAFN.
15. If a Plan 32 is not available, then the seal shall be an Arrangement 3, dual seal, API STD 610 code BDPFN (the second letter, "D", is pressurized dual, not double). The pressurized barrier fluid system, Plan 54, shall comply with 32-SAMSS-013.
16. Seal flush fluid shall be raw water or sea water without suspended solids, cooled to 60°C (140°F) or below and flushing shall continue after pump shutdown.
17. Exchanger should be designed to maintain the flush fluid at or below 60°C (140°F).
18. Raw water quench is not intended to be continuous. Piping to be installed as a branch off the seal flush line with a dead-man valve downstream of the tee to the quench connection.
19. The elastomer material for code X is Ethylene Propylene Rubber.
20. External seal with single coil spring shall be used. The dynamic elastomer material shall be Viton coated by Teflon. Other elastomers material shall be Viton.

General Mechanical Seal Notes:

- G1. Rotating faces shall be of homogeneous construction. (No weld overlays).
- G2. Cyclone separators shall not be used with a pressure differential less than 175 kPa (25 psi).
- G3. Seal leakage detection is required for any of the following:
 - Single seals with throttle bushings in unstabilized hydrocarbon service;
 - Single seals with throttle bushings in hot hydrocarbon service above 204°C (400°F) with vapor pressure above 100 kPa abs (14.7 psia) at operating temperature;
 - Single seals with throttle bushings in refined hydrocarbon product pipeline pumps;
 - Single seals with auxiliary dry running backup seals;
 - Dual seals.

The seal leakage detection system shall comply with the following:

- a) A level switch shall be used for leakage detection of seals with throttle bushings in unstabilized hydrocarbon service and in refined hydrocarbon product pipeline service.
 - b) A pressure switch shall be used for leakage detection for seals with auxiliary dry running backup seals. A pressure switch shall also be used for leakage detection for seals in hot hydrocarbon service above 204°C (400°F) with vapor pressure above 100 kPa abs (14.7 psia).
 - c) For dual seal applications, both low level and high pressure switches are required.
 - d) An orifice shall be provided in the seal leakage piping, downstream of the level/pressure switch. The minimum orifice diameter shall be 3.2 mm (1/8 in).
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- e) Level and pressure switches shall be arranged to actuate alarm and/or shutdown. The proof rating of the switches shall be at least 1.5 times the maximum seal chamber pressure.
 - f) The setting of the pressure switch shall be 70 kPa gauge (10 psig).
 - g) Leakage from seals having throttle bushings shall be hard piped to the gravity sewer. Leakage from seals having auxiliary dry running backup seals shall be hard piped to either the pressure sewer or the flare header. A check valve shall be installed downstream of the orifice to prevent flow from the pressure sewer or the flare header into the seal chamber. For pumps provided with dual seals, the valved high point connection of the buffer fluid system shall be hard piped to the pressure sewer or the flare header.
 - h) A time delay relay, adjustable to 30 seconds, to actuate alarm/shutdown shall be provided. This relay shall not be included in the pump vendor's scope of supply.
- G4. The surface of shaft sleeves shall be overlaid under the dynamic secondary sealing elastomers in contact with the pumped liquid. The overlay shall be of a wear resistant material such as Stellite or Colmonoy.
- G5. With the exception of seal springs, all process wetted metal components of seals shall be of the following materials:
- | Fluid Service | Seal Material |
|----------------------|----------------------------|
| Sea water | UNS S 31254 or UNS S 39276 |
| Produced brine water | Inconel 625 or 718 |
| Wet crude | 904 L SS |
| Raw (aquifer) water | 904 L SS |
| All other services | 316 L SS |
- Metal parts not in contact with the medium pumped shall be 316 SS.
If bellows seals are provided, the bellows material shall be Inconel 625 or 718.
Seal springs shall be of Hastelloy C-276.
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Table 2 – Pump Metallurgy Application Guide

	Temperature Range °C (°F)	Material Code	
		Horizontal and Vertical In-Line Pumps	Vertically Suspended Pumps
Dry Hydrocarbon Service ⁽¹⁾			
Sweet	< 0 (< 32) 0 to 400 (32 to 750)	HK HKA2	VK VKA
Sour	0 to 285 (32 to 550) > 285 (> 550)	HKA4 HSX	VKA1 VSX
Wet Hydrocarbon Service ⁽²⁾			
Sweet	All	HKA4	VKA1
Sour	0 to 285 (32 to 550) > 285 (> 550)	HKA4 HSX	VKA1 VSX
Water Services			
Condensate, Demineralized, Treated Cooling Water	All	HKA2	VKA
Boiler Feed Water	≤150 (≤300) > 150 (> 300)	HKA4 HSX	VKA1 VSX
Drinking Water	All	HFB1	VFB1
Raw and Sea Water	All	HSI	VSI
Produced Brine Water	All	HSZ	VSZ
Sour Water	All	HSI	VSI
Domestic Sewage	All	HFB1 or HSI	VFB1 or VSI
Sump Oil/Water Mixture	All	HSI	VSI
Other Fluids			
Molten Sulfur	All	HKA4	VSI
Amine and Glycol	All	HSI	VSI
Acid and Chemicals	All	(3)	(3)

Notes:

- (1) Up to 0.2% water by weight.
- (2) Greater than 0.2% water by weight.
- (3) The Rotating Equipment Standards Committee Chairman shall be consulted regarding selection of specific material grades.

Table 3 – Test Requirements for Centrifugal Pumps ⁽¹⁾

	Manufacturer Standard	ASME & Sealless	31-SAMSS-004
<u>Hydrotest</u> Witnessed Certified	No No ⁽³⁾	No Yes	⁽²⁾ Yes
<u>Running/Performance</u> (5) Witnessed Certified	No No ⁽³⁾	No Yes	⁽²⁾ Yes
<u>NPSH Testing</u> (4) (6) Witnessed Certified	No No ⁽³⁾	No Yes ⁽⁷⁾	⁽²⁾ Yes ⁽⁷⁾

Notes:

- (1) These test requirements apply only to pumps supplied by Vendors known to the Buyer. Pumps ordered from new sources shall be fully witness tested and inspected except for manufacturer standard pumps.
- (2) If more than one pump on the same Purchase Order of identical type, design and design conditions are presented for inspection as a lot, the test requirements shall be as follows:
 - a. For high energy pumps, as defined by API STD 610, all pumps shall be fully witness tested.
 - b. For low energy pumps, one pump, selected at random shall be fully witness tested. The remaining pumps shall be fully shop tested and test certificates shall be provided;
- (3) All tests for pumps in firewater and molten sulfur services shall be certified.
- (4) Open pit sump pumps require a minimum submergence test in lieu of an NPSH test. Sea water intake pumps shall be tested for both NPSH and minimum submergence.
- (5) All pump performance/running tests may be conducted using a shop calibrated driver.
- (6) Sump model testing shall be conducted for all sea water intake systems unless specifically waived by the Rotating Equipment Standards Committee Chairman.
- (7) NPSHR testing shall be performed for all high energy pumps, as defined in API STD 610 paragraph 2.1.15 and on all pumps where the NPSH margin (NPSHA over NPSHR) at 120% of the rated flow is less than 3 feet.