TECHNICAL SPECIFICATION

CENTRIFUGAL PUMPS
(AMENDMENTS/SUPPLEMENTS TO API 610)

DEP 31.29.02.30-Gen.

December 1998
(DEP Circular 52/99 has been incorporated)

DESIGN AND ENGINEERING PRACTICE

PREFACE

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They are based on the experience acquired during their involvement with the design, construction, operation and maintenance of processing units and facilities, and they are supplemented with the experience of Group Operating companies. Where appropriate they are based on, or reference is made to, national and international standards and codes of practice.

The objective is to set the recommended standard for good design and engineering practice applied by Group companies operating an oil refinery, gas handling installation, chemical plant, oil and gas production facility, or any other such facility, and thereby to achieve maximum technical and economic benefit from standardization.

The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where DEPs may not cover every requirement or diversity of condition at each locality. The system of DEPs is expected to be sufficiently flexible to allow individual operating companies to adapt the information set forth in DEPs to their own environment and requirements.

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NOTE: In addition to DEP publications there are Standard Specifications and Draft DEPs for Development (DDDs). DDDs generally introduce new procedures or techniques that will probably need updating as further experience develops during their use. The above requirements for distribution and use of DEPs are also applicable to Standard Specifications and DDDs. Standard Specifications and DDDs will gradually be replaced by DEPs.

TABLE OF CONTENTS

APPENDICES

PART I INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for centrifugal pumps.

This DEP is a revision of the DEP of the same number dated December 1990.

This DEP is based on API Standard 610, eighth edition, August 1995. Part II of this DEP amends, supplements and deletes various clauses of API 610.

All clauses of API 610 not modified by this DEP shall remain valid as written.

This DEP shall be used in conjunction with data/requisition sheet DEP 31.29.02.93-Gen.

1.2 DISTRIBUTION, APPLICABILITY AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIOP and SIEP, the distribution of this DEP is confined to companies forming part of the Royal Dutch/Shell Group or managed by a Group company, and to Contractors and Manufacturers nominated by them (i.e. the distribution code is "F", as defined in DEP 00.00.05.05-Gen.).

This DEP is intended for use in oil refineries, chemical plants, gas plants, exploration and production facilities and, where applicable, supply/marketing installations.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this DEP the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned with the object of obtaining agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

The **Contractor** is the party which carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project, or operation or maintenance of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier/Vendor** is the party which manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The **Purchaser** may be the Contractor or the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets.

Other documents referenced by this DEP are listed in (Part III).

1.5 BULLETS

A round bullet in the margin next to a clause in API 610 indicates either that alternative requirements are possible and a decision by the Purchaser is required or that further

information is to be provided by the Purchaser. This decision/information shall be indicated in the space provided on the data/requisition sheet. In some cases these decisions have already been made by the amendment to the API clause in this DEP, effectively eliminating the bullet. In other cases this DEP is silent and the Purchaser remains responsible for making the decision or providing the required information. In some of these latter situations this DEP considers that the Purchaser should remain silent since the option available is not normally required or recommended. A summary of the category into which the bullets fall is shown in Table 1 below (referring to the bulleted paragraph numbers in API 610):

COLUMN A	COLUMN B	COLUMN C
1.2.2	2.1.27	2.1.3
2.1.9	2.9.2.12	2.1.17
2.1.11	2.10.3.	2.1.22
2.1.14	2.11.3.5.4	2.1.29
2.2.4	3.3.6	2.7.3.17
2.3.3.3	3.3.13	2.7.3.19
2.3.3.11	3.3.18	2.7.3.20
2.7.3	3.5.1.4	2.7.3.21
2.9.2.11	4.1.4	2.8.2.6
2.11.1.1	4.1.6	2.9.2.2
2.11.1.7	4.2.3.1	2.9.2.9
2.11.2.5	4.2.3.2	2.11.1.8
2.11.3.5.6	4.3.1.2	2.11.1.11
3.1.5	4.3.2.5	2.11.4.5
3.1.6	4.3.3.1.2	3.1.1
3.2.2	4.3.4	3.1.2
3.4.2.2	4.4.1	3.1.3
3.4.3.1	5.1.3.3	3.5.2.6
3.4.3.2	5.2.5.2.4	
3.4.3.3	5.2.6.1	
3.5.2.10.1	5.2.6.3	
4.2.1.3	5.2.6.5	
4.2.2.1	5.2.6.6	
4.3.3.1.3	5.2.7	
5.1.2.4	5.2.8.5	
5.1.2.7	5.3.4.1	
5.2.2.2	5.3.7.3.5	
5.2.6.2 b	5.3.8.2	
5.2.9.2	5.3.9.7	
	5.3.11.9	
	5.3.12.6	
	6.1.3	
	6.2.3.(l).	
	6.2.5	

Column A = API paragraphs in which the bullet is effectively eliminated by this DEP

Column B = API paragraphs in which the bullet remains but for which this DEP does not provide a decision. The data/requisition sheets do not provide specific spaces for such decisions/information; consequently the Purchaser's decision on these items shall be included under "Additional Requirements" or in the purchase order.

Column C = Paragraphs in which a bullet remains and action is required by the Purchaser (in the space provided on the data/requisition sheet)

PART II AMENDMENTS/SUPPLEMENTS TO API 610, EIGHTH EDITION

SECTION 1 GENERAL

1.1 SCOPE

Refer also to (Part 1 - Introduction) of this DEP in conjunction with this clause.

1.1.3 Add to this clause:

Vertical, in-line, close-coupled pumps shall also comply with the requirements of BS 4082-1, Class R.

Pumps intended for fire-fighting duty shall also comply with NFPA-20.

1.2.2 Replace this clause by:

The pump shall have SI dimensions unless otherwise specified by the Principal.

1.3 CONFLICTING REQUIREMENTS

Replace this clause by:

In the case of conflict between documents relating to the inquiry or order, the following hierarchy of documents shall apply:

- *upper level:* purchase order and variations thereto;
- *second level:* data/requisition sheets and drawings;
- *third level:* this DEP.

1.4 DEFINITION OF TERMS

Add to this clause:

The terms listed below, as used in this DEP and/or the data/requisition sheet, are defined as follows:

1.4.58 Add new clause:

Continuous operation

States the intention that operation will be uninterrupted for a period of at least 24 000 hours at the specified operating conditions.

1.4.59 Add new clause:

Intermittent operation

An operation which includes intentional starts and stops.

1.4.60 Add new clause:

Hazardous service

Any service in one or more of the following categories:

Category 1:

- Liquids containing hydrogen sulphide in concentrations above 600 mg/kg.
- Liquids consisting of, or containing lethal substances as indicated on the data/requisition sheet. Examples of lethal substances include, but are not limited to, HF acid, phenol, ethylene oxide, concentrated sulphuric acid.

Category 2:

- Liquids consisting of, or containing very toxic substances as indicated on the data/requisition sheet. Examples of very toxic substances include, but are not limited to, benzene, toluene, MEK.
- Hydrocarbon liquids at an operating temperature above their auto-ignition temperature.

Category 3:

- Hydrocarbon liquids with a seal chamber vapour pressure, higher than 5 bar (abs).
- Hydrocarbon services of butane or lighter.

NOTE: In the text of this DEP, no distinction is made between the above categories. These categories are used for selecting the shaft sealing system (see DEP 31.29.00.33-Gen.).

1.4.61 Add new clause:

Multistage pumps

Pumps with three (3) or more stages.

1.4.62 Add new clause:

Abrasive service

Any service in which there is an expected wear rate of 0.1 mm per year or more, or where particle sizes exist larger than 100 µm in quantities exceeding 100 mg/kg.

1.4.63 Add new clause:

Vital, essential and non-essential services

These terms are defined as follows:

	SAFETY EQUIPMENT	**OTHER EQUIPMENT**		
	SERVICE CATEGORY			
	VITAL	**ESSENTIAL**		**NON-ESSENTIAL**
		Non-spared equipment	**Spared equipment**	
Definition	A service in which failure of equipment causes an **unsafe condition** of the plant or installation resulting in **jeopardy to life** and/or **major damage** (fire, explosion etc.).	A service in which failure of equipment renders a plant or process unit **inoperable** or **reduces performance** to a level **unacceptable** to the Principal.	A service in which failure of equipment renders a plant or process unit **inoperable** or **reduces performance** to a level **unacceptable** to the Principal.	All other services.
Selection Criteria	Equipment shall be adequately spared to ensure 100% availability of the service under all circumstances	A decision not to install spare equipment is based upon economic considerations and proven equipment availability. Non-spared equipment availability may be upgraded by means of additional Capex to match required plant availability.	Installed spare equipment is normally selected where potential losses due to equipment outage greatly outweigh equipment Capex. Sparing philosophy shall be economically evaluated and is typically 2x100% or 3x50%.	Economic evaluation required to justify spared equipment.
Driver Selection Criteria	Independent power sources shall be selected to ensure 100% service availability		Independent power sources may be selected, for start-up and utility availability reasons	
Examples	- *firewater pumps with diesel and motor drives;* - *ESD systems;* - *EIA compressor.*	- *HCU feed pump;* - *HCU recycle compressor;* - *FCCU main air compressor;* - *FD and ID fans.*	- *BFW pumps;* - *fractionator bottom pumps;* - *fresh gas compressors (HCU).*	- *drinking water pumps;* - *sewage pumps.*

SECTION 2 BASIC DESIGN

2.1 GENERAL

2.1.8 Replace the last sentence of the Note by:

The Net Positive Suction Head Available (NPSHA) shall exceed the Net Positive Suction Head Required (NPSHR) by at least 1 metre throughout the range from minimum continuous stable flow up to and including the rated capacity. If the suction pressure at the pump is less than atmospheric, this margin shall be at least 2 metres. From rated capacity up to 125% of best efficiency point the NPSHR shall not exceed the NPSHA.

2.1.9 Add to this clause:

Suction specific speeds above 6 730 require the Principal's approval.

NOTE: The units in the formula used to calculate the above value of suction specific speed are as follows:
- Flow rate in litres per second;
- Rotational speed in revolutions per minute;
- NPSH in metres.

2.1.11 Replace the first sentence of this clause by:

Pumps shall have stable head/capacity curves which continuously rise by at least 5% from rated capacity to shut-off. The gradient of the tangent to the curve shall continuously decrease from 125% of the best efficiency point to minimum continuous stable flow and shall remain positive.

2.1.12 Add to this clause:

Pump shaft and bearing design shall also take into consideration the hydraulic forces occurring during operation between the duty point and minimum flow.

2.1.14 Replace this clause by:

2.1.14 Noise control

2.1.14.1 Limits

The Contractor shall comply with DEP 31.10.00.31-Gen. and thereby communicate to the Vendor the specified equipment noise limitations by using data sheet DEP 31.10.00.94-Gen., which forms part of the requisition. The Vendor is responsible for assuring that these equipment noise limitations have been specified.

2.1.14.2 Information to be submitted with the tender

The Vendor shall submit guaranteed sound power levels and sound pressure levels (including octave band spectrum) of the equipment, together with any other relevant information as requested in the data sheet, DEP 31.10.00.94-Gen. The Vendor shall indicate what special silencing measures, if any, are proposed in order to meet the specified levels.

2.1.15 Add to this clause:

The numbers of vanes in impellers shall be different to the numbers of vanes in diffusers. On pumps with two or more stages the impeller/diffuser configuration shall be staggered to avoid coincidence of pressure pulses.

2.1.18 Replace this clause by:

Cooling jackets for seal chambers, bearings and pedestals shall be integrally cast or of welded design. The coolant passage shall allow cleaning, flushing and draining of the entire passageway. Only cooling chambers for bearing brackets may be equipped with O-ring sealed covers to facilitate cleaning.

2.1.29 Add to this clause:

The Manufacturer shall indicate in his proposal any special protection required by the Purchaser.

Pumps shall be suitable for uncovered, outdoor installation, and continuous operation at a tilt angle of three degrees in any direction. For Floating Production Storage and Offtakes (FPSOs) the maximum tilt angle can be substantially larger than 3 degrees. The actual static and dynamic displacement requirements for these applications shall be specified separately. Pumps in essential services shall be capable of normal operation up to and including the maximum angles specified, pumps in non-essential services shall be capable of surviving, but not necessarily be capable of operating, at these maximum angles.

Pumps for offshore or tropical installations shall be suitable for an outdoor marine environment with 100% relative humidity.

2.1.30 Add new clause:

For balancing axial thrust in multi-stage pumps, only the following arrangements shall be used, either singly or in combination:

- individually balanced impellers or opposed arrangements of impellers;
- a balancing piston.

A balancing piston shall not be used if the pumped liquid is abrasive as defined in (1.4.62).

2.2 PRESSURE CASINGS

2.2.4 Replace this clause by:

Amended per Circular 52/99

The maximum allowable working pressure shall apply to all parts referred to in the definition of pressure casing (see 1.4.40).

The pressure rating of the pump body and the cover of vertical, in-line, close-coupled pumps shall be in accordance with BS 4082-1, Class R.

2.2.6 Replace clause a) by:

A pumping temperature of 100 °C or higher.

Add to clause c):

For any liquid at pressures above 7 MPa (1 000 psi) the Manufacturer shall submit data to the Purchaser to demonstrate successful previous application.

Add to this clause:

Multi-stage pumps of radial split construction shall be of double-casing design.

2.3 NOZZLE AND PRESSURE CASING CONNECTIONS

2.3.1.1 Replace this clause by:

All pumps shall have flanged suction and discharge nozzles of equal ASME pressure/temperature ratings. Screw-on flanges shall not be used. Horizontal pumps with an operating temperature above 200 °C shall have top suction and discharge nozzles.

2.3.2 SUCTION AND DISCHARGE NOZZLES

2.3.2.3 Replace this clause by:

Bronze flanges shall be flat faced and shall be in accordance with ASME B16.24.

2.3.2.4 Add to this clause:

..... subject to approval by the Principal.

2.3.3 PRESSURE CASING CONNECTIONS

2.3.3.4 Replace this clause by:

All auxiliary connections to the pressure casing shall be fitted with flanged stubs, full-penetration welded to the casing. Socket welded connections shall not be used. Integral flanges may be used.

2.3.3.7 Replace the first sentence of this clause by:

Openings shall not be furnished unless they are essential, in which case they shall be located away from high-velocity areas. The provision and location of openings shall be identified in the vendor's proposal and shall be subject to the approval of the Principal.

2.3.3.11 Replace this clause by:

Pressure gauge connections shall not be provided.

2.4 EXTERNAL NOZZLE FORCES AND MOMENTS

Add new clause:

2.4.6 In order to provide maximum resistance to mechanical forces transmitted by the pipework in duties at a service temperature above 200 °C, the vertical projection of the centre lines of the principal nozzles of pumps shall pass within the pump casing support boundaries. A separate extended suction nozzle support beside each pump pedestal is not acceptable.

Add new clause:

2.4.7 End-supports on overhung pumps shall not be threaded (e.g. for the purpose of adjustment on-line).

2.6 WEAR RINGS

2.6.1 Add to this clause:

On certain vertical multi-stage suspended pumps, and subject to the approval of the Principal, wear rings may be fitted only on the casing.

2.6.2 Add to this clause:

The minimum hardness of wear rings shall be 225 HB except where restricted by Appendix 1 of this DEP.

2.6.3 Replace this clause by:

Renewable wear rings shall have a shrink fit and shall be locked by three axial set screws or by tack welding at three points. Wear rings shall not be U-shaped.

2.6.4.1 Add to this clause:

Special wear ring constructions, including provisions for clean fluid flushing, may be considered for pumps in abrasive service (1.4.62); in which case the Manufacturer shall demonstrate reliability of the pump design in comparable duties.

2.6.4.2 Replace the last sentence of this clause by:

For materials with higher galling tendencies, and/or for operation at temperatures above 260°C, 0.3 millimetres shall be added to these diametral clearances.

2.7 MECHANICAL SHAFT SEALS

2.7.1 Add to this clause:

To ensure selection of the optimum mechanical seal and seal auxiliary facilities for the duty specified, the pump manufacturer shall be responsible for the engineering co-ordination, installation and performance of its auxiliary facilities such as circulation, injection, quenching and cooling, as required for the seal selected by the seal manufacturer.

2.7.2 Add to this clause:

…… and DEP 31.29.00.33-Gen., Shaft sealing systems for centrifugal and rotary pumps.

2.8 DYNAMICS

2.8.3.7 Add to this clause:

For vertical, close-coupled, in-line pumps vibration readings shall be taken on both bearings of the electric motor driver in the horizontal plane at 90° to each other. For vertical pumps with a flexible coupling additional readings shall be taken at the pump top bearing.

2.9 BEARINGS AND BEARING HOUSINGS

2.9.1 Bearings for horizontal pumps

2.9.1.1 Add to this clause:

Hydrodynamic bearings shall be used for any of the following conditions :

a. Journal sizes greater than 150 mm.

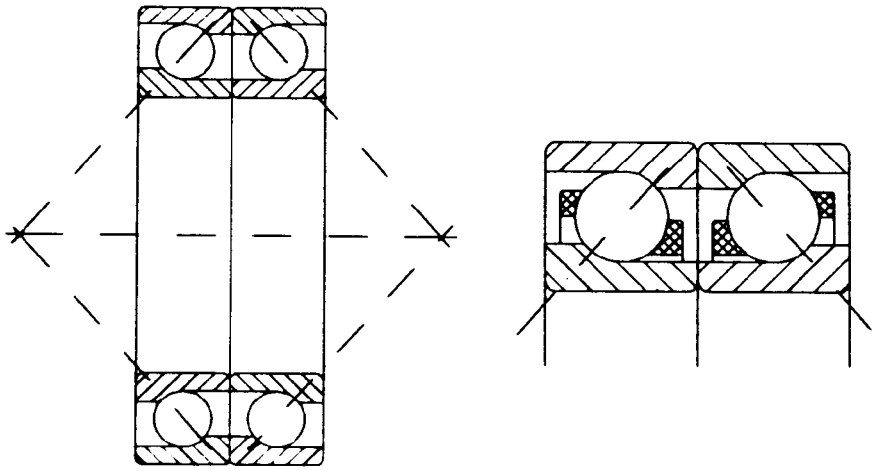
b. If the lubricant supply is force-fed

c. If the pump is in a non-spared essential service.

2.9.1.5 Add to this clause:

Note "Back to Back" installation is the same as bearings fitted in "0" arrangement. See Figure 1 below.

Figure 1 Back-to-back or "0" arrangement



2.9.1.6 Add new clause:

Rolling element bearings shall have brass cages, or another metal if this is not possible.

2.11 MATERIALS

2.11.1 General

2.11.1.1 Replace this clause by:

The materials of construction shall be in accordance with Appendix 1 of this DEP.

2.11.1.4 Delete this clause.

2.11.1.7 Replace this clause by:

The Manufacturer shall furnish material certificates in accordance with ISO 10474, of the type indicated in the table below:

PART	INSPECTION CLASS	
	II	I
	ISO 10474 CERTIFICATE TYPE	
Pressure casing (including bolting)	3.1.B	3.1.B
Auxiliary process fluid piping (including all pressure-containing components such as fittings, valve bodies etc.)	3.1.B	3.1.B
Impeller/shaft	3.1.B	3.1.B
Sleeves	3.1.B	3.1.B
Wear rings	3.1.B	3.1.B
Throttle bushings	2.1	3.1.B
Mechanical seals	2.1	3.1.B
Diffusers	2.1	3.1.B

The inspection classes II and I in the table above are defined in (4.2.2.1.1).

Marking is required for all pressure casings. Only low-stress stamps (dot-type or round-nosed with a minimum radius of 0.25 mm) shall be used for hard-die stamping.

For items manufactured from austenitic stainless steel or nickel alloys the marking shall be applied by stencil using a water-insoluble ink which contains no injurious substances such as metallic pigments, sulphur, sulphides or chlorides which could attack or harmfully affect the material.

The stamping/marking shall include:

- material manufacturer's symbol identical to the symbol on the material certificate;
- material identification;
- heat, charge or batch number to relate to the material certificate;
- heat treatment symbol or code, where applicable;
- non-destructive testing symbol or code, where applicable;
- size and schedule, where applicable;
- hydrostatic test pressure, where applicable.

NOTE If the size of the item does not permit complete marking, the above identification marks may be substituted by a unique code which is fully traceable to the material certificate for the item.

2.11.1.11 Replace this clause by:

All materials for components exposed to hydrogen sulphide in concentrations exceeding

100 mg/kg or exceeding the limits prescribed by NACE MR0175 shall conform to the requirements of NACE MR0175 as well as the requirements of Appendix 1. Renewable wear rings that, for proper pump performance, must be hardened above the limits of NACE MR0175 are acceptable. If approved by the Purchaser, instead of furnishing renewable wear rings, wear surfaces may be hardened by the application of a suitable coating.

All external bolting on the casing and seal glands shall also conform to the above requirements even if NACE MR0175 restricts the requirement to enclosed bolting.

2.11.2 Castings

2.11.2.3 Add to this clause:

Repairs may be made by welding or plugging only if permitted by the material specification, and then only in accordance with the procedures detailed below.

2.11.2.3.1 Add to this clause:

Prior to performing any weld repair on wrought material or any major* weld repair on cast material, the Manufacturer shall submit details of the proposed weld repairs for Purchaser's approval, along with the relevant WPS (Welding Procedure Specification) and PQR (Procedure Qualification Record).

After weld repair the material shall be suitably heat-treated if required by the relevant material specification.

A major* weld repair shall always be followed by a suitable heat treatment.

Details of all major* weld repairs, and of the heat treatment where applicable, shall be recorded on a drawing and reported to the Purchaser.

*Note Weld repair of a casting is defined as "major" if a repair weld has a depth of more than 50% of the wall thickness or has a length of more than 150 mm in one or more directions, or if the total surface area of all repairs on the casting exceeds 10% of the total casting surface area. A weld repair necessitated by a leaking pressure test is also classed as "major".

2.11.2.3.2 Add to this clause:

Details of all repairs shall be recorded on a drawing and reported to the Principal, who shall be informed of the need for plugging before any repair is carried out.

2.11.3.3 Replace the last sentence of this clause by:

Inspection of nozzle welds is specified in (4.2.2)

2.11.3.4.1 Add to this Clause:

Further inspection of plate material is specified in (4.2.2).

2.11.4 Replace this clause by:

The minimum temperature for which the equipment has to be suitable (under any operating or upset conditions) shall be specified on the data/requisition sheet. If this temperature is 0 °C or below, the materials of pressure-containing parts shall satisfy DEP 30.10.02.31-Gen.

SECTION 3 ACCESSORIES

3.1 DRIVERS

3.1.4 Add to this clause:

On motor driven, vertical close-coupled pumps, the motor rating shall be sufficient to permit shop testing with water. An overload of 10% on the motor at the duty point may be allowed during the test period with the approval of the motor manufacturer

If standard performance test requirements would lead to unnecessary oversizing of the motor, an alternative proposal shall be submitted to the Principal for approval.

3.1.5 Add to this clause:

Electric motor drivers shall be in accordance with DEP 33.66.05.31-Gen.

3.1.8 Add to this clause:

Electric motors for vertical close-coupled pumps shall be designed to carry double the maximum up-thrust and double the maximum down-thrust the pump may develop while starting, stopping or operating at any capacity, or while being tested on water. The maximum thrust load shall be calculated at twice the internal clearances specified in (2.6.4.2). See also (5.3.5.2). The pump vendor shall supply thrust data to the electric motor supplier and approve bearing selection.

3.1.9 Replace this clause by:

Steam turbine drivers shall be sized to deliver continuously 110 per cent of the maximum power required for the Purchaser's specified conditions.

Steam turbines shall comply with DEP 31.29.60.30-Gen. or DEP 31.29.60.31-Gen., whichever is applicable. Gas turbines shall comply with DEP 31.29.70.31-Gen.

3.1.10 Replace this clause by:

Gears shall be in accordance with API 677, except that gears in services operating at absorbed power above 750 kW shall be in accordance with DEP 31.29.00.32-Gen.

Add new clause:

3.1.13 Internal combustion engines shall comply with EEMUA 107 if located in an area classified as Zone 1 or Zone 2.

3.2 COUPLINGS AND GUARDS

3.2.8 Add to this clause:

Couplings on essential non-spared equipment operating at any speed shall meet the requirements of API 671 for component balancing and assembled balance check. Couplings specified for duties at absorbed power greater than 750 kW shall conform to API 671 and shall incorporate a safety device designed to prevent separation in the event of membrane failure.

3.2.12 Add to this clause:

Guards shall be made of one of the following spark-resisting materials:

1) Aluminium or aluminium alloys with a maximum content of 2% magnesium or 0.2% copper.

2) Copper or copper based alloys (e.g. brass, bronze).

3.2.13 Add new clause:

The coupling guard shall be sufficiently rigid to ensure that rubbing cannot result from

deflection caused by normal body mass (90 kg) applied horizontally or vertically.

The design and construction of the guard shall prevent hand contact with moving parts.

3.3 BASE PLATES

3.3.9 Add to this clause:

When precision cementitious or epoxy grouting is specified in the purchase order, it shall conform to Appendix L of API 610.

3.3.14 Replace the first two sentences of this clause by:

Alignment positioning screws shall be provided for all drivers and gearboxes to facilitate longitudinal and transverse horizontal adjustments.

3.4 INSTRUMENTATION

Replace 3.4.1, 3.4.2 and 3.4.3 by:

The instrumentation required shall be as specified in the data/requisition sheet and shall comply with DEP 32.31.09.31-Gen.

3.5 PIPING AND APPURTENANCES

3.5.1 General

3.5.1.1 Replace the last sentence of this clause by:

Piping, gaskets and valves for the pumped fluid and auxiliary systems shall be in accordance with the piping classes specified by the Principal.

3.5.1.9 Replace this clause by:

Piping fabrication shall be by welding or bending, with joints provided only where disassembly is necessary for maintenance purposes. These joints shall be flanged.

Screwed connections may be used only for seal gland plates and shall not be seal-welded. Pipe bushings and socket welded fittings shall not be used.

Auxiliary piping shall be piped to terminal connections at the edge of the pump baseplate.

3.5.2.6 Delete this clause.

3.5.2.8 Delete this clause.

3.5.2.10.1 Replace the first sentence of this clause by:

Flanges shall be used in place of socket-welded unions.

SECTION 4 INSPECTION, TESTING AND PREPARATION FOR SHIPMENT

4.1 GENERAL

4.1.4 Add to this clause:

If requested, a copy of the agreed inspection plan shall be forwarded to the Principal for review and/or approval.

4.1.5 Add to this clause:

Measuring equipment for inspection and testing shall be selected such that it has a resolution and accuracy at least five times finer than the tolerance of the parameter being measured. Similarly, standards against which a piece of equipment is calibrated shall be at least five times as accurate as the equipment being calibrated.

Only measuring equipment which can be demonstrated to have been previously calibrated satisfactorily and still be within its documented calibration period (interval) shall be used for inspection and testing.

Care shall be taken with respect to dampening devices which can affect the accuracy of measurements.

4.1.8 Add new clause:

Each pump shall be inspected and tested in accordance with this DEP.

4.2 INSPECTION

4.2.2 MATERIAL INSPECTION

4.2.2.1 General

Add to this clause:

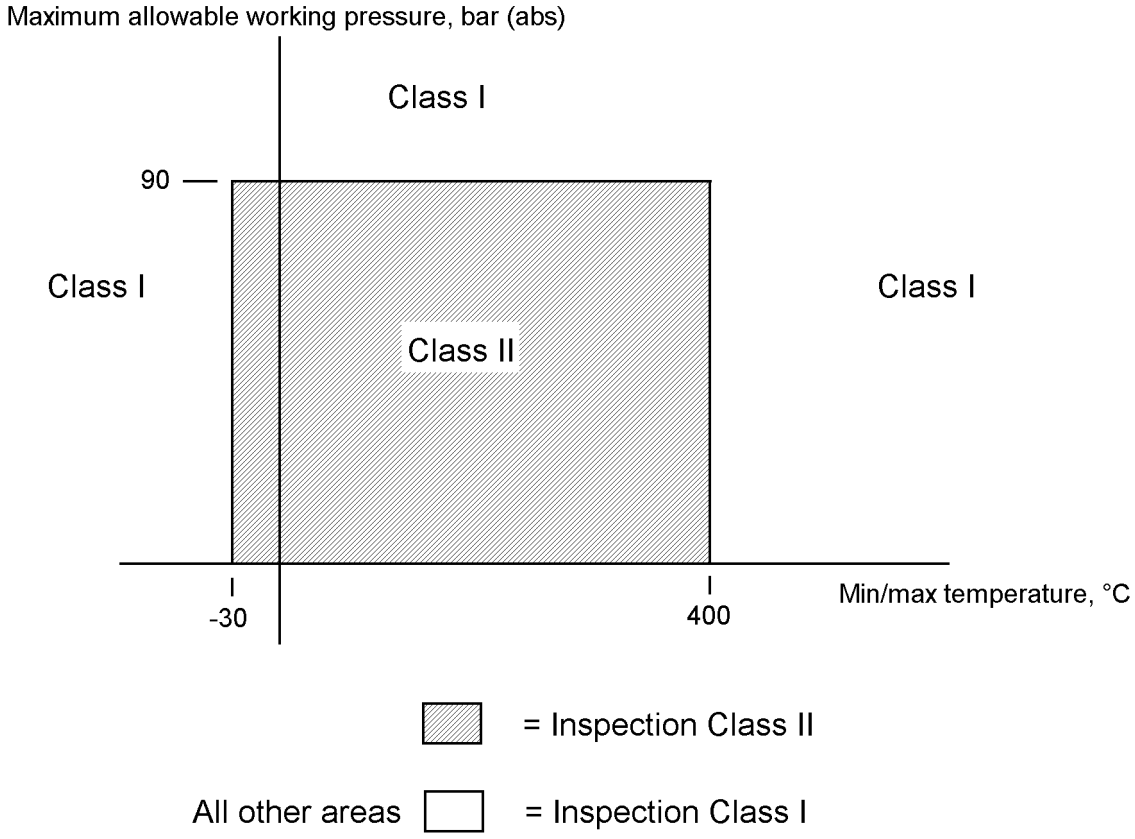
There are two inspection classes (I and II), the selection of which is determined by (4.2.2.1.1). After selection of the inspection class, the required inspections are specified in (4.2.2.1.2).

4.2.2.1.1 Add new clause:

Selection of Inspection Class

The inspection class for pump casings shall be determined in accordance with the maximum allowable working pressure/pumping temperature relationship shown in Figure 2, as modified by Notes 1 and 2:

FIGURE 2 INSPECTION CLASSES FOR PRESSURE-CONTAINING CASINGS



Amended per Circular 52/99

NOTES 1. Regardless of the above Figure, Inspection class I shall apply for:
- all pump casings in hazardous service (1.4.60);

2. For double-casing pumps, the outer casing pressure/temperature shall be used in the above Figure to determine the Inspection Class of the outer casing. The inner casing shall be inspected to Class II.

4.2.2.1.2 Add new clause:

Material Inspection Requirements

Having determined the inspection class, the material inspection requirements are given in Table 1 below and the subsequent Notes.

Table 1 Material inspection per inspection class

TYPE OF COMPONENT	REQUIRED MATERIAL INSPECTION (Note 1)	
	INSPECTION CLASS	
	II	**I**
Casing - cast (Note 2)	VI plus MT or PT (critical areas)	VI plus MT or PT (critical areas) plus RT/UT (critical areas)
Casing - wrought (Notes 2, 3)	VI plus MT or PT (critical areas)	VI plus MT or PT (critical areas) plus UT (critical areas)
Nozzle weld	VI plus MT or PT (100%)	VI plus MT or PT (100%) plus RT/UT (100%)
Butt weld	VI plus MT or PT (100%) plus RT (10%)	VI plus MT or PT (100%) plus RT (100%)
Fillet weld	VI plus MT or PT (100%)	VI plus MT or PT
Internals	VI	VI
Auxiliary process piping	VI plus MT or PT (100%) plus RT (10%)	VI plus MT or PT (100%) plus RT (100%)

NOTES 1. VI = Visual Inspection (4.2.2.6)
MT = Magnetic Particle Examination (4.2.2.4)
PT = Liquid Penetrant Examination (4.2.2.5)
RT = Radiographic Examination (4.2.2.2)
UT = Ultrasonic Examination (4.2.2.3)

2. "Casing" includes all items of the pressure boundary of the finished pump casing (e.g. the casing itself and other parts such as nozzles, flanges, etc. attached to the casing). "Critical areas" are inlet nozzle locations, outlet nozzle locations, casing wall thickness changes and packing seal areas. The Manufacturer shall submit, for Purchaser's approval, details of the critical areas proposed to receive MT/PT/RT/UT.

3. "Wrought" material includes forgings, plate and tubulars.

4. Timing of inspection:

- VI/MT/PT shall be performed after final heat treatment (not necessarily after stress relieving for carbon steel material) in the final machined condition.
- RT/UT of castings shall be performed after final heat treatment (not necessarily after stress relieving) but need not be in the final machined condition provided that the thickness is within 20 percent of the final thickness. In any case the radiographic sensitivity indicator (e.g. penetrameter) shall be selected based on the final thickness.
- RT of welds and UT of wrought material and welds shall be performed after final heat treatment (not necessarily after stress relieving). UT of wrought material shall be performed prior to any machining operations (e.g. keyways, drilled holes etc.) which may interfere with the UT examination.

4.2.2.1.3 Add new clause

Casting defects:

If defects are found which necessitate a major weld repair (as defined in 2.11.2.3.1) the casting shall be inspected to the next more severe inspection class unless the initial inspection was already at Class I.

Minor weld repairs shall be inspected to the same inspection class as that for the initial inspection of the casting.

Major weld repairs shall be inspected to the next more severe inspection class than the initial inspection unless the initial inspection was already at Class I, in which case the weld repair shall be inspected at Class I.

4.2.2.3 Ultrasonic Examination (UT)

4.2.2.3.1 Add to this clause:

Where the configuration of the casting makes radiography impossible, it may be replaced by ultrasonic testing

4.2.2.3.2 Add to this clause

UT of wrought material shall be in accordance with ASME V, Article 5. The acceptance criteria shall be as follows:

a) Austenitic forgings

Referring to ASME II, SA-745,

either QL-1 for straight beam, t = 0 to 75 mm

or QL-2 for straight beam, t = 76 to 200 mm

or QA-2 for angle beam, all thicknesses.

b) Non-austenitic forgings

Referring to ASME II, SA-388,

For straight beam examination, back reflection method, no areas shall have a loss of 95 percent or more of the reference back reflection.

For straight beam examination, reference block method, there shall be no indications equal to or larger than the indication received from the reference block constructed with the following flat bottomed holes:

1.5 mm for t = 0 to 37 mm

3 mm for t = 38 to 150 mm

6 mm for t = 151 mm and greater.

For angle beam examination, there shall be no indications equal to or larger than the indication received from the reference notch or amplitude reference line.

c) Plate material

Acceptance criteria in accordance with ASME II, SA-435 or SA-577, depending on the material.

d) Tubular material

Acceptance criteria in accordance with ASME II, SE-213, in which the calibration notch shall take the following form:

- shape shall be rectangular.
- depth shall be maximum 5 percent of the nominal wall thickness.
- length shall be 25 ± 5 mm.
- width shall be no greater than twice the depth.

4.2.2.4 Add to this clause

Magnetic Particle Examination (MT)

MT of castings shall be performed in accordance with ASME VIII, Division 1, Appendix 7.

4.2.2.6 Add new clause

Visual Inspection (VI)

VI shall be performed in accordance with ASME V, Article 9. All surfaces shall be inspected. Acceptance criteria for pressure-containing steel castings shall be in accordance with MSS SP-55. Acceptance criteria for other parts shall be in accordance with the material specification and the Manufacturer's documented procedures.

4.3 TESTING

4.3.1 General

4.3.1.1 Add to Table 4-2:

There shall be no positive tolerance on driver rated power.

4.3.2 Hydrostatic test

4.3.2.1 a) Add to this clause:

All pump pressure-containing parts shall be tested to the same pressure.

4.3.3 Performance test

4.3.3.1.3 Replace this clause by:

The level of leakage during testing shall be less than 3 ml per hour per seal.

4.3.3.2 Replace this clause by:

The performance test shall be conducted as specified in 4.3.3.2.1 through 4.3.3.2.6.

4.3.3.2.1 Add to this clause:

During the performance test the NPSHA on the test stand shall not exceed 110% of the NPSHA specified on the data/requisition sheet. After the normal performance test on five points has been completed, the Manufacturer shall operate the pump at rated point in a stable condition for at least 1 hour for single-stage pumps and at least 2 hours for pumps with two or more stages.

Vertical submerged pumps (turbine type) shall be tested at the five points at minimum submergence of the pump, all conditions shall be stable at each test point.

4.3.3.2.5 Add new clause:

If pressure lubricated systems are used, the lubricating oil temperature shall be held for at least 30 minutes at the value corresponding to the maximum allowable viscosity, and for 30 minutes at the value corresponding to the minimum allowable viscosity. At minimum and maximum viscosity, and at the viscosity corresponding to the normal operating oil temperature, shaft vibration shall be measured and vibration frequency analysed to check for instabilities.

4.3.3.2.6 Add new clause:

Shop tests shall be carried out with an electric motor with known efficiency values.

4.3.3.3.3 Replace Note a) of Table 4-2 by:

The negative tolerance specified here shall be allowed only if the test curve still shows a 5% head rise to shut-off (or 10% for pumps running in parallel).

4.3.3.4.4 Add new clause:

Multi-stage pumps shall be disassembled after the performance test to verify mechanical integrity and to confirm the non-contact of close clearance parts.

If specified by the Purchaser, single-stage and two-stage pumps shall be opened for inspection after the performance test.

4.3.4 Optional tests

4.3.4.1 NPSH test

Add to this clause:

An NPSH test shall be performed in the following cases:

(i) For pumps with a capacity below 1500 m^3/h, if the difference between NPSHA and NPSHR is less than 2 m;

(ii) For pumps with a capacity of 1500 m^3/h or more, if the difference between NPSHA and NPSHR is less than 3 m;

(iii) For pumps handling liquids containing dissolved gas;

(iv) For pumps with a suction specific speed above 6 730 (see 2.1.9);

(v) If specified on the data/requisition sheet

4.3.4.1.2 Replace this clause by:

A 3% drop in head (first stage head on pumps with two or more stages), or an identifiable change in noise and/or vibration, shall be interpreted as indicating performance impairment. The first stage head of pumps with two or more stages shall be measured using a separate connection to the first stage discharge.

Testing with only the first stage installed or by using model pumps is subject to the approval of the Principal.

The NPSHR shall always assume that the pump is handling water; corrections for other liquids shall not be made.

4.3.4.2 Add to this clause:

All pumps for duties with a discharge pressure above 100 bar and/or an absorbed power above 750 kW shall be subjected to a complete unit test with contract driver and all ancillaries.

4.3.4.3 Replace this clause by:

If specified in the purchase order, a sound level test shall be executed on the pump in accordance with EEMUA 140; acceptance criteria shall be as specified in (2.1.14).

4.3.4.4 Add to this clause:

If supplied with the pump, the spare rotor and inner casing assemblies shall be performance tested in the corresponding pressure casing.

4.4 PREPARATION FOR SHIPMENT

4.4.3.7 Replace this clause by:

Threaded openings (where permitted, see 3.5.1.9) shall be provided with steel caps or steel plugs in accordance with 3.5.1.14.

SECTION 5 SPECIFIC PUMP TYPES

5.1 SINGLE STAGE OVERHUNG PUMPS

Add to this clause:

Pump types OH3 and OH4 shall not be used.

5.2 BETWEEN BEARINGS PUMPS

Add to this clause:

Pump type BB4 shall not be used.

5.2.1.2 Replace this clause by:

Pumps for service temperatures below 100 °C in Class 150 systems may be foot mounted

5.2.2 ROTOR

5.2.2.2 Replace this clause by:

Impellers of multi-stage pumps shall be positively locked against axial movement in the direction opposite to normal hydraulic thrust.

5.2.3 RUNNING CLEARANCES

5.2.3.2 Replace this clause by:

Interstage bushings for vertical and horizontal multi-stage pumps handling hydrocarbons shall not be considered as bearings when determining clearances, but clearance shall be determined in accordance with the minimum diametral clearances given in Table 2-2 of API 610.

Special attention shall be paid to running clearances in boiler feed water pumps with regard to hydraulic imbalance and rotor dynamic instability causing undesirable vibration or galling.

5.2.4 DYNAMICS

5.2.4.1.2. Add to this clause:

A shop verification of the unbalanced response analysis shall be made.

5.2.5 BEARINGS AND BEARING HOUSINGS

Add new clause:

5.2.5.1.4 When hydrodynamic radial bearings are provided, provision shall be made for mounting two radial vibration probes adjacent to each bearing.

5.2.5.2.2 Replace this clause by:

The thrust bearing collars shall be replaceable and shall be positively locked to the shaft to prevent fretting.

5.2.6 LUBRICATION

5.2.6.2 Replace clause a) by:

The main oil pump with suction strainer.

Shaft driven oil pumps shall not be used for essential, non-spared pumps. If a positive displacement type of oil pump is supplied, a separate relief valve (not integral with the pump) shall be provided. The relief valve shall not be used for pressure regulation. Horizontal oil pumps shall not be installed on top of the oil reservoir.

Replace clause b) by:

Unless otherwise specified, twin coolers shall be provided for equipment in non-spared essential service. They shall be piped in a parallel arrangement using a continuous flow transfer valve. Each cooler shall be sized to accommodate the total cooling load. The oil-side operating pressure shall be higher than the water-side operating pressure to prevent contamination of the oil in the event of cooler failure.

Each oil cooler shall maintain the luboil supply temperature at or below 49 °C. The cooler shall be a water-cooled shell-and-tube type or a suitable air-cooled type, as specified by the Purchaser. A removable-bundle design shall be used for shell-and-tube coolers with more than 0.46 m^2 of tube surface area. Removable-bundle coolers shall be in accordance with DEP 31.21.01.30-Gen., constructed with a removable channel cover.

Spared pumps shall have single oil coolers.

Add to clause e):

Filters shall have a continuous flow switch-over valve including a pressure equalization line.

Add new clause k):

The lubrication system piping shall be made from AISI 316L.

5.2.9 PREPARATION FOR SHIPMENT

5.2.9.1 Replace this clause by:

If a spare rotor is purchased it shall be crated in a metal container for transportation and storage; the crating method shall be suitable for at least 4 years storage in the vertical position. The container shall be equipped for nitrogen blanketing.

5.2.9.2 Delete this clause.

5.3.3 WEAR PARTS AND RUNNING CLEARANCES

5.3.3.2 Replace the first sentence of this clause by:

Materials of steady bearings and/or interstage bushings of vertical pumps shall be a non-galling combination.

5.3.5 GUIDE BUSHINGS AND BEARINGS

5.3.5.2 Add to this clause:

Thrust bearings for vertical pumps, other than vertical close-coupled pumps, shall be integral with the pump.

5.3.7 ACCESSORIES

5.3.7.3.4 Replace this clause by:

At least four alignment positioning screws shall be provided for each drive train component to facilitate horizontal adjustment within the rabbeted fit.

APPENDICES TO API 610

Appendix B:	Replace by data/requisition sheet DEP 31.29.02.93-Gen.
Appendix G	Replace by Appendix 1
Appendix H:	Replace Tables H-1, H-2 and H-6 by Appendix 1. Tables H-3, H-4 and H-5 remain
Appendix N:	Delete
Appendix Q:	Delete unless specified in the purchase order

PART III REFERENCES

In this DEP, reference is made to the following publications:

NOTE: Unless specifically designated by date, the latest issue of each publication shall be used together with any amendments/supplements/revisions thereto.

SHELL STANDARDS

Index to DEP publications and standard specifications	DEP 00.00.05.05-Gen.
Non-metallic materials	DEP 30.10.02.13-Gen
Metallic materials - prevention of brittle fracture	DEP 30.10.02.31-Gen.
Data/requisition sheet for equipment noise limitation	DEP 31.10.00.94-Gen.
Shell and tube heat exchangers (amendments/supplements to TEMA standards)	DEP 31.21.01.30-Gen.
Special purpose gear units for petroleum,chemical and gas industry services (amendments/supplements to API 613)	DEP 31.29.00.32-Gen.
Shaft sealing systems for centrifugal and rotary pumps (amendments/supplements to API 682)	DEP 31.29.00.33-Gen
Pumps - selection, testing and installation	DEP 31.29.02.11-Gen
Data/requisition sheet for centrifugal pumps	DEP 31.29.02.93-Gen.
General-purpose steam turbines (amendments/supplements to API 611)	DEP 31.29.60.30-Gen.
Special-purpose steam turbines	DEP 31.29.60.31-Gen.
Combustion gas turbines (with reference to API 616)	DEP 31.29.70.31-Gen.
Instrumentation for equipment packages	DEP 32.31.09.31-Gen.
Electric motors	DEP 33.66.05.31-Gen.
Guide for the selection of jointing	MESC INF 85/115
Recommended packing makes and styles	MESC SPE 85/200

AMERICAN STANDARDS

Centrifugal pumps for general refinery service	API 610 (8th edition, August 1995)
Special-purpose couplings for refinery service	API 671
General-purpose gear units for petroleum, chemical and gas industry services	API 677

Issued by:
American Petroleum Institute
1220 L Street Northwest
Washington DC. 20005
USA

Cast copper alloy pipe flanges and flanged fittings	ASME B16.24
ASME Boiler and Pressure Vessel Code	
- Material Specifications	ASME II
- Nondestructive Examination	ASME V
- Pressure Vessels	ASME VIII

Issued by:
American Society of Mechanical Engineers
345 East 47th Street
New York NY 10017
USA

Specification for gray iron castings	ASTM A 48
Specification for alloy steel and stainless steel bolting materials for high-temperature service	ASTM A 193
Specification for carbon steel castings, suitable for fusion welding, for high temperature service	ASTM A216
Specification for steel castings, martensitic stainless and alloy for pressure containing parts suitable for high-temperature service	ASTM A217
Specification for Stainless and heat-resisting steel bars and shapes	ASTM A276
Specification for alloy steel bolting materials for low-temperature service	ASTM A320
Specification for steel bars, alloy, standard grades	ASTM A322
Specification for steel castings, austenitic, for high-temperature service	ASTM A351
Specification for steel castings, ferritic and martensitic, for pressure containing parts suitable for low temperature service	ASTM A352
Specification for ferritic ductile iron pressure-retaining castings for use at elevated temperatures	ASTM A395
Specification for austenitic gray iron castings	ASTM A436
Specification for austenitic ductile iron castings	ASTM A439
Specification for castings, nickel and nickel alloy	ASTM A494
Specification for pressure vessel plates, carbon steel, for moderate and lower temperature service	ASTM A516
Specification for castings, iron-chromium, iron-chromium-nickel and nickel base corrosion resistant, for general application	ASTM A743
Specification for castings, iron-chromium-nickel and nickel base corrosion resistant, for severe service	ASTM A744
Standard specification for castings, iron-chromium-nickel-molybdenum corrosion-resistant, duplex (austenitic/ferritic) for general application	ASTM A890
Specification for aluminium bronze sand castings	ASTM B148
Specification for aluminium bronze rod, bar and shapes	ASTM B150
Specification for copper alloy sand castings for general applications	ASTM B584

Specification for non-ferrous nuts for general use	ASTM F467
Specification for nonferrous bolts, hex-cap screws and studs for general use	ASTM F468

Issued by:
American Society for Testing and Materials
1916 Race Street, Philadelphia
19103, USA

Quality standard for steel castings - visual method	MSS SP-55

Issued by:
Manufacturers Standardisation Society
of the Valve and Fittings Industry
5203 Leesburg Pike, Suite 502,
Falls Church, Virginia 22041, USA.

Sulfide stress cracking resistant metallic materials for oil field equipment	NACE MR0175

Issued by:
National Association of Corrosion Engineers
1440 South Creek
Houston, Texas 77084
USA

Centrifugal fire pumps	NFPA-20

Issued by:
National Fire Protection Association
470 Atlantic Avenue
Boston, Massachusetts 02210
USA

BRITISH STANDARDS

Specification for external dimensions for vertical in-line centrifugal pumps	BS 4082-1

Issued by
British Standards Institution,
389 Chiswick High Road,
London W4 4AL,
UK

Noise procedure specification	EEMUA 140
Recommendations for the protection of diesel engines operating in hazardous areas	EEMUA 107

Issued by:
Engineering Equipment and Materials Users Association.
45 Beech Street
London EC2Y 8AD
UK

INTERNATIONAL STANDARDS

Mechanical vibration of rotating and reciprocating machinery - Requirements for instruments for measuring vibration severity	ISO 2954
Steel and steel products - inspection documents	ISO 10474

Issued by:
International Organisation for Standardisation
1, Rue de Varembé
CH-1211 Geneva 20
Switzerland

Copies can also be obtained from national standards organizations

APPENDIX 1 MATERIALS SELECTION

This Appendix provides a selection of the appropriate materials for centrifugal pumps in various services. The pump Manufacturer may offer, for Purchaser's approval, alternative materials if, based on his experience, these would render equal or better service. Such alternate materials shall be clearly indicated in the vendor's proposal as deviating from this DEP.

Table 1 identifies the required pump material groups for various types of fluids to be pumped.

Table 2 then identifies, for each pump material group, the required material specification for the various pump parts.

NOTES:

1. For pump parts designated as ASTM materials in Table 2, all the requirements of the applicable ASTM specification shall be met, along with any other requirements included in Table 2. The title of each ASTM specification is given in "References"(Part III) and a brief description of the selected grades is included as Note 2 below Table 2.

2. For pump parts not designated with an ASTM specification number in Table 2, the **chemical composition** requirements of the appropriate ASTM specification (found in Note 1 below Table 2) shall be met, along with any other requirements included in Table 2 and Note 1.

3. Where carbon or stainless steel has been specified without further qualification, the grade to be used is at Manufacturer's option.

4. Pressure-containing parts shall meet the requirements of DEP 30.10.02.31-Gen. for the particular operating conditions covered therein.

5. Non-metallic materials shall comply with DEP 30.10.02.13-Gen.

6. Packing materials shall comply with MESC SPE 85/200.

7. The gasket design conditions (pressure, temperature and media resistance) of both the pump gaskets and gaskets of the suction and discharge piping shall comply with the piping class and MESC INF 85/115.

TABLE 1 SELECTION OF PUMP MATERIAL GROUPS

SERVICE GROUP		*PUMPED MEDIUM*	*TEMP (°C)*	*PUMP MATERIAL GROUP*	*NOTES*
a	1	All oil and chemical products, non-corrosive	0 to 450	2	
	2	All oil products, non-corrosive	> 450	9	
	3	Oil products containing naphthenic acids (acid number above 0.5 mg KOH/g) except short residue	240 to 400	12	7
	4	Short residue containing naphthenic acids (acid number above 0.5 mg KOH/g)	> 300	9, 12	7
	5	Oil products containing sulphur compounds	> 300	9, 12	7
	6	Oil products containing a corrosive aqueous phase		12	
	7	Crude distilling unit reflux	≤ 240	2	
b	1	Fresh water, aerated		9,	
	2	Fresh cooling water, air-free closed circuit or inhibited open circuit		2	
	3	Condensate, non-aerated		2	6
	4	Condensate, aerated		9, 12	
	5	Brackish water		15	
	6	Seawater, brine (seawater distiller)		13, 15	
	7	Boiler feed water, aerated		9, 12	
	8	Boiler feed water, de-aerated		2, 12	6
	9	Sour water, pH ≤ 7		12, 15	1
	10	Sour water, pH > 7		12	1
	11	Drain water, slightly acidic, non-aerated		12, 15	
c	1	All products, non-corrosive, low temperatures	0 to -50	7	1
	2		-50 to -105	8, 14	1
	3		-105 to -200	14	2, 3, 4
d	1	Caustic solutions, all concentrations	≤ 45	2	
g	1	Amine lean and fat solvents in amine units		12	
h	1	Amine make-up solutions and sulfolane		2	
j	1	Liquid chlorine, dry (max. 150 mg/kg water)	≤ 65	5	
l	1	Hydrofluoric acid, dry (max. 0.8% weight water), with or without hydrocarbons	≤ 65	4	
	2	Hydrofluoric acid, all concentrations, with or without hydrocarbons		20	
m	1	Liquid sulphur		2	5
o	1	Sulphuric acid, ≤ 10%			8
	2	Sulphuric acid, ≤ 90%			8
	3	Sulphuric acid, > 90%, including oleum			8
	4	Sulphuric acid, ≤ 98%			8
	5	Sulphuric acid, 67 to 98%, with hydrocarbons			8

NOTES:

General: Pump material selection has been brought in line as far as possible with API 610.

1. For certain mildly corrosive conditions, e.g. stripped sour water, pump material group 2 is acceptable. Approval of the Principal is required.
2. For low temperature application reference shall also be made to DEP 30.10.02.31-Gen.
3. Aluminium alloy may be considered if applied in aluminium alloy piping system.
4. For liquid oxygen or liquid nitrogen service, extra precautions are necessary. Approval of the Principal is required.
5. Casing and nozzles steam-jacketed.
6. Pump material group 12 is recommended if oxygen ingress cannot be excluded, e.g. in case of spare pumps.
7. Pumps operating above 300 °C shall be made of parts that received a mechanical stabilization heat treatment to avoid distortion at operating temperature. For AISI-410 type stainless steels, careful tempering will be sufficient. Solution annealed austenitic stainless steel (e.g. A 351-CF8M) shall be stress relieved at 100 °C above the working temperature of the pump, but not exceeding 500 °C.
8. Consult materials and corrosion engineer for pump material selection.

TABLE 2 PUMP MATERIAL GROUP SPECIFICATIONS

Pump Material Group	*Casing*	*Impeller*	*Shaft*	*Casing Wear Ring*	*Impeller Wear Ring*	*Inter-stage Bushings*	*Inter-stage Sleeves*	*Wet Bolting*	*Remarks*
2	ASTM A 216-WCA or WCC (or WCB with max. 0.25% C and carbon equivalent max. 0.45) **or** ASTM A 516-Gr 55, welded and PWHT'd **or** ASTM A 395	ASTM A 48 No. 40 (max. tip speed 55 m/s, max. temp. 200 °C) **or** ASTM A 216-WCA or WCC (or WCB with max. 0.25% C and carbon equivalent max. 0.45) above 200 °C or A744 CF8M	Carbon steel up to 300 °C. ASTM A 322-Gr 4140 above 300 °C	AISI 420 (225-275 HB)	AISI 420 (325-375 HB)	ASTMA 48-No. 60	AISI 420 (325-375 HB)	ASTM A 193-B6	
4	ASTM A 352-LCB	ASTM A 494-M-35-1	Carbon steel with Monel 400 sleeve	Monel 400	Monel 400, overlaid with Colmonoy 6	Monel 400	Monel 400, overlaid with Colmonoy 6	ASTM F 467/468-N05500	
5	ASTM A 352-LCB	ASTM A 743-CA15	Carbon steel	AISI 420 (225-275 HB)	AISI 420 (325-375 HB)	AISI 420 (225-275 HB)	AISI 420 (325-375 HB)	ASTM A 193-B6	- Refer to DEP 30.10.02.31-Gen. - For pumps without a stuffing box
7	ASTM A 352-LCB (impact tested)	ASTM A 48 No. 40 (max. tip speed 55 m/s)	ASTM A 322-Gr 4140 (quenched and tempered)	AISI 420 (225-275 HB)	AISI 420 (325-375 HB)	AISI 420 (225-275 HB)	AISI 420 (325-375 HB)	ASTM A 320-L7	- Refer to DEP 30.10.02.31-Gen. - Consider a pump without a stuffing box in case of service group 11
8	ASTM A 352-LC3	ASTM A 352-LC3	ASTM A 322-Gr 4140 (quenched and tempered)	AISI 420 (225-275 HB)	AISI 420 (325-375 HB)	AISI 420 (225-275 HB)	AISI 420 (325-375 HB)	ASTM A 320-L7	Ref DEP 30.10.02.31-Gen
9	ASTM A 217-CA15 **or** **A487 CA-6NM**	ASTM A 743-CA15	ASTM A 322-Gr 4140 (suitably protected) or 12-14% Cr steel	AISI 420 (225-275 HB)	AISI 420 (325-375 HB)	AISI 420 (225-275 HB)	AISI 420 (325-375 HB)	ASTM A 193-B6	

Pump Material Group	***Casing***	***Impeller***	***Shaft***	***Casing Wear Ring***	***Impeller Wear Ring***	***Inter-stage Bushings***	***Inter-stage Sleeves***	***Wet Bolting***	***Remarks***
12	ASTM A 351-CF8M	ASTM A 744-CF8M	ASTM A 276-Type 316 **or** Up to 300 °C: carbon steel (*suitably protected) **or** Above 300 °C: ASTM A 322-Gr 4140 (*suitably protected) or 12-14% Cr steel	AISI 316	AISI 316, overlaid with Colmonoy 6	AISI 316	AISI 316, overlaid with Colmonoy 6	ASTM A 193-B8M	*Type and execution of protection is subject to Principal's approval
13	ASTM A 890-Gr 5A	ASTM A 890-Gr 5A	UNS S32760	UNS S32760	*UNS S32760	UNS S32760	UNS S32760	UNS S32760	*Heat treated or overlaid such that the impeller wear ring is at least 100 HB harder than the casing wear ring
14	ASTM A 351-CF8	ASTM A 276-Type 304	AISI 304	AISI 304	AISI 304	AISI 304	AISI 304	ASTM A 193-B8	Ref DEP 30.10.02.31-Gen
15	ASTM B 148-C95800	ASTM B 148-C95800	ASTM B 150-**C62300** **or** Monel K-500 **or** Carbon steel (suitably protected)	*ASTM B 148-C95800 **or** ASTM B 150-C63200 **or** Monel K-500	Monel K-500 Min. 250 HB	Monel K-500 Max. 200 HB	Monel K-500 Min. 250 HB	ASTM F 467/468-C63000 **or** ASTM F 467/468-N05500	*All to be maximum 200 HB
20	ASTM A 494-M-35-1	ASTM A 494-M-35-1	Monel K-500	Monel K-500 (max. 200 HB)	Monel K-500 (min. 250 HB)	Monel K-500 (max. 200 HB)	Monel K-500 (min. 250 HB)	ASTM F 467/468-N05500	