MANUAL

PUMPS - TYPE SELECTION

DEP 31.29.02.11-Gen.

July 1998

DESIGN AND ENGINEERING PRACTICE

PREFACE

DEP (Design and Engineering Practice) publications reflect the views, at the time of publication, of:

Shell International Oil Products B.V. (SIOP)
and
Shell International Exploration and Production B.V. (SIEP)
and
Shell International Chemicals B.V. (SIC)

The Hague, The Netherlands,

and other Service Companies.

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.

When Contractors or Manufacturers/Suppliers use DEPs they shall be solely responsible for the quality of work and the attainment of the required design and engineering standards. In particular, for those requirements not specifically covered, the Principal will expect them to follow those design and engineering practices which will achieve the same level of integrity as reflected in the DEPs. If in doubt, the Contractor or Manufacturer/Supplier shall, without detracting from his own responsibility, consult the Principal or its technical advisor.

The right to use DEPs is granted by SIOP, SIEP or SIC, in most cases under Service Agreements primarily with companies of the Royal Dutch/Shell Group and other companies receiving technical advice and services from SIOP, SIEP or SIC. Consequently, three categories of users of DEPs can be distinguished:

1) Operating companies having a Service Agreement with SIOP, SIEP, SIC or other Service Company. The use of DEPs by these Operating companies is subject in all respects to the terms and conditions of the relevant Service Agreement.

2) Other parties who are authorized to use DEPs subject to appropriate contractual arrangements.

3) Contractors/subcontractors and Manufacturers/Suppliers under a contract with users referred to under 1) or 2) which requires that tenders for projects, materials supplied or - generally - work performed on behalf of the said users comply with the relevant standards.

Subject to any particular terms and conditions as may be set forth in specific agreements with users, SIOP, SIEP and SIC disclaim any liability of whatsoever nature for any damage (including injury or death) suffered by any company or person whomsoever as a result of or in connection with the use, application or implementation of any DEP, combination of DEPs or any part thereof. The benefit of this disclaimer shall inure in all respects to SIOP, SIEP, SIC and/or any company affiliated to these companies that may issue DEPs or require the use of DEPs.

Without prejudice to any specific terms in respect of confidentiality under relevant contractual arrangements, DEPs shall not, without the prior written consent of SIOP and SIEP, be disclosed by users to any company or person whomsoever and the DEPs shall be used exclusively for the purpose for which they have been provided to the user. They shall be returned after use, including any copies which shall only be made by users with the express prior written consent of SIOP and SIEP. The copyright of DEPs vests in SIOP and SIEP. Users shall arrange for DEPs to be held in safe custody and SIOP or SIEP may at any time require information satisfactory to them in order to ascertain how users implement this requirement.

All administrative queries should be directed to the DEP Administrator in SIOP.

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

1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for the type selection and basic design of pumps.

This DEP is primarily intended for pumps in vital and essential duties, but not for refrigerated product service, which is covered by DEP 31.29.06.30-Gen.

This DEP is a revision of the DEP of the same number dated July 1983. This edition no longer covers testing and installation of pumps; testing requirements are specified in the relevant DEP for the equipment concerned and installation requirements are specified in DEP 31.29.00.10-Gen.

1.2 DISTRIBUTION

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 nominated by them (i.e. the distribution code is "C", as defined in DEP 00.00.05.05-Gen.).

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

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, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this document 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 document as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

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

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

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 the Principal.

The word **shall** indicates a requirement.

The works **should** indicates a recommendation.

1.3.2 Specific definitions

Continuous operation	Uninterrupted operation by a pump and its auxiliaries for a period of at least 24 000 hours at the specified operating conditions.

Intermittent operation Any operation which is not classed as continuous operation. Examples are:
- Pumps started up and stopped automatically at intervals by process-operated controls;
- Pumps started up and stopped manually for batch transfer;

Pump types:

heavy-duty A pump complying with API 610, API 674, API 675, API 676 and/or BS 4082 class R.

alternative designs
- Process pumps built to a standard other than API, e.g. DIN, CHEM, ANSI, BS 4082 class L;
- Vertical high speed pumps;
- Sealless pumps; canned and magnetic drive;
- Fire fighting pumps according to NFPA-20

Service categories:

essential service See Appendix 1

non-essential service See Appendix 1

vital service See Appendix 1

Service types:

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.

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 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.).

Non-corrosive or mildly corrosive service

See also Appendix 1 in DEP 31.29.02.30 Gen.

- streams with no corrosive elements and with a service temperature not exceeding 400°C
- streams containing sulphur compounds and naphthenic acids with an acid value in excess of 0.5 mg KOH/g but with a service temperature not exceeding 230 °C
- streams containing sulphur compounds and naphthenic acids with an acid value up to but not exceeding 0.5 mg KOH/g and with a service temperature not exceeding 330 °C
- de-aerated boiler feed water and condensate
- stripped sour water
- caustic soda at a service temperature not exceeding 50°C
- caustic soda with a concentration up to but not exceeding 10% by weight at a service temperature not exceeding 70°C
- all concentrations of lean ADIP/DEA/MEA (Sulfinol) at a service temperature not exceeding 70°C.

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 (6).

2. GENERAL

2.1 BID EVALUATION

2.1.1 Procedure

Separate data/requisition sheets exist for pumps and seals; these shall be used so that pump and seal duty can be dealt with independently. The applicable data/requisition sheets are DEP 31.29.02.93-Gen. for centrifugal pumps and DEP 31.29.00.94-Gen for seals.

Initial bids for pumps shall not include the seals; the sealing method shall be evaluated and selected separately. In a final bid the selected pump vendor(s) shall include the selected sealing method. The seal vendor shall supply all hardware, seal and systems to the pump vendor.

2.1.2 Vendor selection

The list of Manufacturers from which the Contractor intends to procure pumps and seals shall be subject to the approval of the Principal. If the Principal has supply agreements in place with any of the agreed Manufacturers he shall specify if they are to be applied. If so, the Principal shall provide copies of these agreements to the Contractor. The Contractor shall then comply with his responsibilities stated in the supply agreements.

2.2 VARIETY OF PUMPS

Every effort shall be made to optimise the spares stock levels needed to be kept by Operating Units by rationalising the variety of makes and types of pumps, drivers and auxiliary equipment selected for any particular project.

This rationalisation shall be applied stringently so far as it does not interfere with the selection of an optimal pump for the specified operating conditions.

2.3 PROTOTYPE PUMPS

In all respects selected pumps shall be within the range of the manufacturer's proven experience and shall not involve the use of any prototype design or components. In selecting equipment, care shall be taken to ensure that prospective vendors do not exceed the ratings of their design in their efforts to offer competitively.

2.4 OPERATING DATA

All necessary operating data shall be stated on the data/requisition sheets. This shall also cover any special operating requirements such as mode of operation (parallel or series), or operating with fluids of different properties or at different operating temperatures, or being required to operate at or below minimum continuous thermal or stable flow (which will require minimum flow by-pass features).

3. TYPE SELECTION

3.1 GENERAL

Process pumps in vital service shall be of the heavy duty type.

Process pumps in essential service shall be of the heavy duty type, except if it will not give the required reliability and availability (24 000 hours continuous operation). In the latter case, an alternative design may be selected and the pump shall be spared. Examples of such cases are:

- high capacity, e.g. cooling water pumps;
- low specified capacity, < 1 m^3/hr (centrifugal pump);
- unavailability of suitable hydraulic design due to liquid properties, e.g. abrasive, clogging, depositing;
- unavailability of suitable materials due to liquid properties.

Pumps in non-essential service may be of any type and shall be selected on the basis of an economic evaluation.

3.1 HEAVY DUTY PUMPS

Pumps shall be selected from the types given below. Within each group, the various types are listed in descending order of preference.

Single-stage centrifugal pumps:

- vertical, in-line, close-coupled pumps;
- horizontal, single suction, back-pull-out pumps;
- vertical high speed pumps;
- horizontal, double suction pumps, with the impeller supported between bearings.

Two-stage centrifugal pumps:

- horizontal radial split pumps, with impellers supported between bearings.

NOTE: Single stage vertical high speed pumps may be considered as a second choice to the above types.

Multi-stage horizontal centrifugal pumps, maximum 12 stages:

- single casing pumps axially split;
- double casing pumps with inner casing axially/radially split.

NOTES: 1. Vertical high speed pumps may be considered as a second choice to the above types.

2. Double casing pumps in abrasive service shall be axially split.

Vertical suspended centrifugal pumps:

- cantilever pumps;
- wet pit single-stage;
- wet pit, two-stage and multi-stage.

NOTE: In selecting one of the above, the selection of horizontal self priming pumps shall also be evaluated.

- dry pit double casing multistage pumps.

Rotary pumps:

- screw pumps;
- gear pumps;
- lobe pumps;
- vane pumps.

Reciprocating pumps:

- plunger type;
- diaphragm type.

3.2 CENTRIFUGAL PUMPS FOR VITAL AND ESSENTIAL SERVICE

The choice of pump depends mainly on the operating pressure, differential head, operating temperature, volume flow rate, physical characteristics of the pumped liquid, suction specific

speed and Net Positive Suction Head Available (NPSHA).

If more than one pump type is considered technically suitable, the final selection should be based on a life-cycle cost evaluation, taking into account standardization, efficiency, suction specific speed, NPSH margin and minimum stable thermal flow.

3.2.1 Pressure

Heavy-duty pumps shall be selected regardless of the operating pressure.

The design pressure for pump casings shall be the same for both the suction side and the discharge side.

For design pressures above 69.5 bar (ga) axial split casings may be used only if approved by the Principal.

3.2.2 Temperature

Axial split casings shall not be used for operating temperatures above 100 °C.

3.2.3 Flow

Pumps with rated capacities of 300 l/s or greater shall be selected within 10% of the best efficiency point (BEP).

3.2.4 NPSH

The Net Positive Suction Head Required (NPSHR) shall assume that the pump is handling water; no corrections shall be made for other liquids.

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.

For liquids containing dissolved gases, to avoid cavitation damage due to vapour induced flow path restrictions, NPSHA shall be 1.5 x NPSHR, with a minimum margin of 5 metres between NPSHA and NPSHR. This shall apply over the operating range, which shall not be outside 70% to 110% of BEP flow.

The maximum impeller tip speed in sulfinol and carbonate service shall be 45 m/s; for these services the Manufacturer shall provide evidence of successful applications in similar duties and the Principal's approval of pump selection is required.

3.2.5 Physical characteristics

3.2.5.1 Non-corrosive or mildly corrosive liquids

Vertical in-line close-coupled pumps in accordance with BS 4082, Class R shall be selected if the operating conditions are within the following limits:

- the differential head is not greater than 200 metres of liquid;
- the capacity is not greater than 400 m^3/h;
- the temperature is between minus 25°C and plus 200 °C.

3.2.5.2 Corrosive service and abrasive service

If material loss due to corrosion or abrasion cannot be excluded the pump selected shall be of the volute type.

The impeller tip speed shall be restricted to minimise the corrosive/abrasive effects. The advice of the pump manufacturer, based on his experience, shall he sought in this respect.

Pumps with bearings lubricated by the pumped liquid shall not be selected.

3.2.6 Suction specific speed

The suction specific speed shall be calculated by the Manufacturer from the formulae in API 610 and shall be stated in the proposal.

Pumps with a suction specific speed above 6 730 shall not be selected without the approval of the Principal.

NOTE: In the calculation of this suction specific speed the units used are flow rate in litres per second, NPSH in metres and rotational speed in revolutions per minute.

The Manufacturer shall indicate the stable operation range in which recirculation effect is absent.

Pumps proposed for selection which exceed this suction specific speed limit shall be NPSH tested.

Shaft deflection measurement over the pump operating range and/or frequency analysis to detect cavitation shall be performed if specified by the Principal. During the pump performance test there shall be no sign of cavitation (either vibration or noise).

3.3 ALTERNATIVE DESIGNS

If operating requirements and/or liquid properties preclude the economic application of a heavy-duty pump, alternative designs may be offered if they have a lower life cycle cost. The Manufacturer shall provide sufficient evidence of successful application and the selection shall be subject to the approval of the Principal.

Alternative designs shall follow API design principles as far as possible.

Examples of alternative designs are:

- open impeller and vortex type pumps;
- propeller pumps;
- self priming pumps;
- seal-less pumps: magnetic drive, canned, wet motor;
- lined pumps;
- pumps with non-metallic wetted parts.

Magnetic drive pumps shall not be selected if:

- the product temperature is higher than 200 °C;
- the power is greater than 55 kW;
- the service is hazardous (see 1.3.2).

Canned motor and magnetic drive pumps may be selected only if all the following are satisfied:

- the product does not contain any solid particles;
- the product cannot crystallise;
- the product kinematic viscosity is not greater than 40 mm^2/s;
- the temperature difference between boiling point and suction temperature is at least 20 °C;

  NOTE: subject to pump cooling design this delta-T limit may be reconsidered.
- NPSH margin from 70% to 120% of flow is at least 2 metres.

4. DESIGN REQUIREMENTS

4.1 CENTRIFUGAL PUMPS

Centrifugal pumps shall comply with DEP 31.29.02.30-Gen.

Fire water pumps shall also comply with NFPA 20.

Some additional requirements which should be considered when specifying a centrifugal pump are specified below.

4.1.1 Lubrication

Grease-lubricated bearings may be used only if approved by the Principal.

Pump lubrication systems shall not be shared.

Where water cooling of the bearing housing is required and cleanliness of the cooling water cannot be guaranteed an oil circulation system with oil tank and cooler shall be selected instead.

4.1.2 Oil mist lubrication

For installations where a number of pumps are located in close proximity to each other, the application of oil mist lubrication may be considered.

The design of the bearing housing and of the oil mist lubrication distribution system shall be in accordance with DEP 31.29.00.30-Gen.

4.1.3 Mechanical seals

Mechanical seals and seal systems shall comply with DEP 31.29.00.33-Gen. Mechanical seals shall be selected and designed for a guaranteed 3-year operating period. Mechanical seals shall be applied for all pumps except fire-fighting pumps and vertical cooling water pumps.

Seals and seal systems shall be selected and engineered by the seal manufacturer. Seals and systems shall be evaluated and selected separate from the pump. The pump manufacturer is responsible for the co-ordination of engineering and installation of the selected seal and seal system.

Seal manufacturers invited to bid shall be selected up front according to end user preference.

Mechanical seals which comply with DEP 31.29.00.33-Gen. (API 682) will often not fit in a non-API 610 pump and therefore an alternative seal may be used for such pumps (in which case the seal shall follow the same principles as the DEP).

4.1.4 Operating temperatures

For liquid temperatures below minus 25 °C, a vertical-type pump with a dual mechanical seal and an isolation chamber between the pump housing and sealing chamber shall be specified, using methanol or another suitable fluid as the sealing medium.

Vertical high speed pumps may be offered as an alternative provided proven experience is available.

4.1.5 Special applications

Nitrogen-buffered gas seals may be considered if there is a reliable source of nitrogen available.

4.1.6 Cooling

Air cooling is the preferred method.

The use of cooling water on the stuffing box jacket, bearing bracket and pedestal is left to the discretion of the pump and seal supplier, but the API requirements for seal and bearing

life shall be met (also for non-API pumps).

The cooling water piping arrangement shall conform to API 610, Appendix D, Figure D-4 and Figure D-5.

4.1.7 Baseplates

Drain-rim or drain-pan base plates with raised lip shall be specified. Base plates shall be the Manufacturer's heavy duty standard (API) design. The base plate shall not be modified to create space for auxiliary equipment such as seal systems and lub oil systems, unless it has been evaluated as the most economic life-cycle solution. Base plate drains shall be connected to the drain system.

4.2 ROTARY POSITIVE DISPLACEMENT PUMPS

Rotary positive displacement pumps shall conform to API 676.

Some additional requirements which should be considered when specifying a rotary pump are specified below.

4.2.1 Bearings

In order to keep the number of shaft seals to a minimum, rotary pumps handling clean, abrasive-free, non-corrosive liquids with lubricating properties shall be provided with internal bearings lubricated by the pumped liquid.

In all other cases, pumps shall be provided with oil-lubricated bearings and timing gears in separate housings. Constant level sight feed oilers shall be provided.

4.2.2 Seals

The requirements for centrifugal pumps (4.1.3) shall apply.

4.2.3 Pressure relief

A separate pressure relief valve in the discharge shall be provided to protect the pump and its associated piping system.

4.2.4 Baseplates

See (5.1.5).

4.3 RECIPROCATING AND METERING PUMPS

Reciprocating positive displacement pumps shall comply with DEP 31.29.12.30-Gen.

The selected pumps shall be within the Manufacturer's actual field experience of operating temperature, maximum working pressure, materials of construction, pump speed and pumped liquid properties. Diaphragm pumps with direct mechanical actuation shall not be selected.

Some additional requirements which should be considered when specifying reciprocating pumps are specified below.

4.3.1 Distance pieces

Distance pieces shall be provided with gaskets under solid covers.

4.3.2 Pulsation dampers

Pulsation dampers shall be used to reduce pulsations in the liquid flow entering and being discharged from the pumps. Acoustic-type pulse dampers should be used for reciprocating pumps whenever possible.

Dampers shall limit the peak-to-peak pulsation levels at the line side nozzle of the device to 1.5% of line pressure.

4.3.3 Pressure relief

See (4.2.3)

4.3.4 Diaphragms

Double diaphragm pumps shall be specified. Diaphragm failure indication shall be provided.

5. ACCESSORIES

5.1 DRIVERS

Pumps may be driven by electric motors, steam turbines, gas turbines or internal combustion engines according to application, location, fuel availability and economics. The required type of driver shall be indicated in the data/requisition sheet.

5.1.1 Electric motors

Electric motors shall be in accordance with DEP 33.66.05.31-Gen.

5.1.2 Steam turbines

Steam turbines shall be selected in accordance with DEP 31.29.60.10-Gen. and shall comply with DEP 31.29.60.30-Gen. or DEP 31.29.60.31-Gen., whichever is applicable.

The application of steam turbines for standby duties should be avoided.

Vertical turbines shall not be used without the approval of the Principal.

5.1.3 Gas turbines

Gas turbines shall be selected in accordance with DEP 31.29.70.11-Gen. and shall comply with DEP 31.29.70.31-Gen.

5.1.4 Internal combustion engines

Internal combustion engines shall comply with EEMUA 107 if located in a Zone 1 or Zone 2 hazardous area.

5.1.5 Baseplates

The pump and driver shall be mounted and delivered on a common baseplate.

5.1.6 RATING OF DRIVERS

In view of possible operation on heavier or more viscous liquids, e.g. during start-up, electric motor drivers should be capable of developing adequate starting torque to handle such cases.

For small, low power pumps seal losses assuming dual pressurised seal(s) shall be taken into account.

5.2 TRANSMISSIONS

Direct drive shall be selected whenever possible.

VFD or VSDS shall be selected where a variation in speed demand is specified.

Gear units are preferred to belt drives. Belt drives shall not be used for power transmission greater than 25 kW.

5.2.1 Gear units

Gear units in vital service, and in essential non-spared service above 750 kW, shall comply with DEP 31.29.00.32-Gen.

5.2.2 Couplings

Couplings shall be of the forged steel, flexible disc/membrane or diaphragm type with spacers suitable for heavy duty service, except if the Principal approves the use of gear couplings.

Flexible membrane couplings for steam turbine drivers shall not lose transmission capability upon membrane failure.

Couplings for pump units with power ratings above 750 kW shall be in accordance with API

671.

5.2.3 Belts

Belts shall be anti-static and oil resistant. They shall have a polyester core, a neoprene filler and neoprene impregnation.

Belts should be of the toothed type.

6. 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

Data/requisition sheet for equipment noise limitation	DEP 31.10.00.94-Gen.
Installation of rotating equipment	DEP 31.29.00.10-Gen.
Oil mist lubrication systems	DEP 31.29.00.30-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	DEP 31.29.00.33-Gen.
Centrifugal pumps	DEP 31.29.02.30-Gen.
Data/requisition sheet for pumps	DEP 31.29.02.93-Gen.
Data/requisition sheet for seals	DEP 31.29.00.94-Gen.
Centrifugal submerged motor pumps in refrigerated product service	DEP 31.29.06.30-Gen.
Reciprocating positive displacement pumps and metering pumps	DEP 31.29.12.30-Gen.
Steam turbines	DEP 31.29.60.10-Gen.
General-purpose steam turbines	DEP 31.29.60.30-Gen.
Special-purpose steam turbines	DEP 31.29.60.31-Gen.
Combustion gas turbines - Selection, testing and installation	DEP 31.29.70.11-Gen.
Combustion gas turbines	DEP 31.29.70.31-Gen.
Electric motors	DEP 33.66.05.31-Gen.

AMERICAN STANDARDS

Centrifugal pumps for general refinery services	API 610
Mechanical shaft seals	API 682
Special-purpose couplings for refinery services	API 671
Positive displacement pumps, reciprocating	API 674
Positive displacement pumps, controlled volume	API 675
Positive displacement pumps, rotary	API 676

Issued by
American Petroleum Institute,
Publications and Distribution Section.
2101 L Street NW,
Washington, DC 20037, USA

Centrifugal Fire Pumps	NFPA-20

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

BRITISH STANDARDS

External dimensions for vertical in-line centrifugal	BS 4082

pumps

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

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
England.

APPENDIX 1 DEFINITIONS AND EXAMPLES OF VITAL, ESSENTIAL AND NON-ESSENTIAL SERVICES

	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.*