TECHNICAL SPECIFICATION

SHAFT SEALING SYSTEMS FOR CENTRIFUGAL AND ROTARY PUMPS (AMENDMENTS/SUPPLEMENTS TO API 682)

DEP 31.29.00.33-Gen.

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DESIGN AND ENGINEERING PRACTICE

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PART I INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for shaft seals and their related seal systems for centrifugal and rotary pumps. In addition, it also gives recommendations for the selection of seals and seal systems.

This DEP is based on and shall be used in conjunction with API 682, first edition October 1994. Part II of this DEP amends, supplements and deletes various clauses of API 682. Clauses of API 682 that are not mentioned shall remain valid as written.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIOP or SIEP, the distribution of this document is confined to companies forming part of the Royal Dutch/Shell Group or managed by a Group company, and to Contractors and Manufacturers/Suppliers 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, gas plants, chemical plants and oil and gas 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, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP that 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 objective of obtaining agreement to follow this DEP 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, commissioning or management of a project or operation of a facility. The Principal may 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 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 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 standards or documents referenced to in this DEP are listed in (Part III). Unless otherwise specified, they shall be fully applicable regarding the requirements in the clause in which they are referred to.

In Part II of this DEP, the use of the term "this DEP" means API 682 as amended by this DEP.

PART II AMENDMENTS/SUPPLEMENTS TO API 682

SECTION 1 GENERAL

1.1 SCOPE

1.1.1 Replace this clause by:

This specification covers the minimum requirements for shaft seals and related sealing systems for centrifugal and rotary pumps. The applications addressed in this specification cover sealing duties for pumps with a working temperature range of -40 to +450 °C and a maximum allowable working pressure range of 1 to 250 bar (abs).

1.1.3 Replace the first sentence of this clause by:

This standard applies to the equipment and equipment types commonly supplied for the specified service(s) which, as such, will meet the objective of at least three years of uninterrupted service while complying with the specified emission regulations.

1.2 ALTERNATIVE DESIGNS

Add to this clause:

The acceptance of alternative designs is subject to the approval of the Principal.

Seal Manufacturers shall review all seal applications. The seal Manufacturer shall notify the Principal if, according to their best practice and experience with seals in similar applications, a deviation from the requirements in the data sheets or this DEP would result in equal or improved sealing.

1.3 CONFLICTING REQUIREMENTS

Replace this clause by:

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

- upper level : purchase order and variations thereto
- second level : data/requisition sheets, drawings and, if applicable, “Procurement Initiatives”
- third level : API 682 as amended by this DEP.

1.4 DEFINITION OF TERMS

Add new clauses:

1.4.5.6 Hazardous service

For the purpose of this specification hazardous service for mechanical seals and their related seal systems is defined as a 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 in the data/requisition sheet. Examples of lethal substances include but are not limited to: HF acid, phenol, concentrated sulphuric or nitric acid.

Category 2:

- Liquids consisting of or containing **very toxic** substances as indicated in the data/requisition sheet. Examples of very toxic substances include, but are not limited to, benzene, toluene, MEK, ethylene oxide.
- 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 (C4) or lighter**.

1.4.5.7 Service definitions

The terms **vital service**, **essential service** and **non-essential service** are defined in Appendix 7.

Add new clause:

1.6 VENDOR RESPONSIBILITIES

1.6.1 The mechanical seal Vendor shall be responsible for the design and performance of the entire shaft sealing system. This includes the mechanical seal cartridge and the complete seal harness.

The seal Manufacturer shall remain responsible for the seal meeting the requirements of 1.1.3. It is recognised that in this respect there are factors beyond the control of the Manufacturer which may influence the ability of the equipment to comply with these requirements.

1.6.2 The seal Vendor and his major sub-suppliers shall have an implemented and effective quality system. This should comply with ISO 9001 or an equivalent standard acceptable to the Principal.

Add new clause:

1.7 SEAL SELECTION

1.7.1 Mechanical seal application details shall be as specified in the data/requisition sheets of the pump or the seal itself. The data sheet for seals is DEP 31.29.00.94-Gen.

Seals shall be selected to achieve a minimum of three years of uninterrupted operation.

Dual seals shall be applied in the following services:

1. Hazardous services (see 1.4.56).
2. Services in which the required three year operation cannot be ensured with a single seal application due to the physical or chemical properties of the liquid to be sealed.
3. Services in which it is not permitted for the pumped liquid to enter the flare or atmosphere. In this case, dual pressurised seals shall be applied.

Seals and seal arrangements and seal harnesses shall be selected in accordance with Appendix 6. Part 1 of Appendix 6 presents the requirements of this sub-section in graphical form. Part 2 of Appendix 6 presents the requirements for dual seal arrangements and their related seal plans and harnesses.

The following applications need the specific approval of the Principal:

- Plan 54 for dual seals in Cat. 1 liquid services
- Dual unpressurized tandem seals with Plan 52 in Cat. 2 services
- Single seals with Auxiliary seals, other than dry gas seal types.

1.7.2 Proposals for alternative dry gas seal arrangements instead of standard dual seal applications are subject to the approval of the Principal and shall be limited to the following:

1) A single liquid seal and a dry gas back-up seal arrangement may be considered only for liquids not classified as hazardous and liquids as defined in 1.4.56, Category 3;

2) Dual pressurised dry gas seal arrangements with a pressurised nitrogen barrier may only be considered for liquids that are not classified as hazardous and have a maximum

vapour pressure at pumping temperature of 1.05 bar (abs). Careful attention shall be paid in this application to ensure a reliable nitrogen supply system.

1.7.3 For some special products Appendix 8 provides specific application details and material requirements. The seal Manufacturer may propose alternatives to these requirements, subject to the approval of the Principal.

SECTION 2 SEAL DESIGN

2.1 STANDARD SEAL TYPES AND ARRANGEMENTS

2.1.5 Replace the third sentence of this clause by:

The inner seals of arrangement 2 mechanical seals shall be designed with a positive means of retaining the sealing components. They shall be designed with sufficient closing force to prevent the faces from opening upon pressurisation of the buffer fluid to the maximum specified back pressure from the connecting flare or vent system or 4.5 bar (abs), whichever is higher. In the design for this condition the prevailing normal suction pressure of the pump may be taken into account.

2.1.6 Add to this clause:

A back-to-back or face-to-face seal arrangement shall be considered if the required differential pressure across the inner seal (due to a specified high barrier pressure versus a low seal chamber pressure) is considered too high to ensure a reliable operation with a tandem arrangement.

2.1.8 Add to this clause:

This requirement is not applicable to vertical close coupled pumps.

2.2 GENERAL

2.2.1 Add to this clause:

The maximum static sealing pressure (MSSP) of mechanical seals shall be at least as indicated below:

- For single seals and dual seals in tandem the MSSP of each seal shall be at least equal to the maximum static seal chamber pressure that can occur in the pump. Unless otherwise specified, this shall be the shut-off pressure of the pump at maximum suction pressure.
- For dual seals in back-to-back or face-to-face arrangement the MSSP of the outer seal shall be at least the maximum static seal chamber pressure in the pump. Unless otherwise specified, this shall be the shut-off pressure of the pump at maximum suction pressure.

2.2.7 Add to this clause:

Unless otherwise specified by the Principal, single mechanical seals in vacuum service shall be of the metal bellows type and shall be suitable for the lowest specified static or dynamic seal chamber pressure.

2.2.8 Add to this clause:

Assembly bolting of seal cartridges shall have sufficient strength to withstand the force needed to remove the cartridge from the pump, taking into account the high friction which may be present due to deposits between the shaft and the shaft sleeve.

2.3 SEAL CHAMBER AND GLANDS

2.3.3.1 Add to this clause:

Pumps which have the physical layout of the seal chamber dictated by the pump design (e.g. in vertical high speed pumps) and, as such, are not able to meet the seal chamber dimensional requirements stated in table 1 or 2 shall comply with them as far as possible and practical. Any non-fulfilment of the requirements in table 1 or 2 is subject to the approval of the Principal.

2.3.10 Replace this clause by:

The dynamic seal chamber pressure for single seals and for the inner seal of an unpressurized dual tandem seal arrangement shall exceed the maximum liquid vapour pressure at maximum seal chamber liquid temperature by at least 3.5 bar or 10%, whichever is higher.

In addition, for liquids with a seal chamber vapour pressure above 10 bar (abs), the seal chamber pressure and temperature of the liquid shall be such that a temperature rise of 10 °C will not result in vapour formation.

The margins required above shall be achieved by raising the seal chamber pressure to the required pressure. The first choice is to apply seal flush plan 11 for a hydraulically balanced pump impeller or plan 13 for a hydraulically unbalanced pump impeller design. Alternatively the margin may be achieved by lowering the seal chamber temperature by applying seal flush plan 21 or 23.

If the pump differential head is too low to achieve the above required margins, the Manufacturer shall provide alternative proposals, subject to the approval of the Principal, in order to ensure an adequate seal environment.

2.3.12 Add to item "e" of this clause:

…. in conjunction with a fixed orifice in the seal flush supply or return line.

2.3.14 Read the comment of this clause in conjunction with clause 2.3.18.

2.3.18.1 Add to this clause:

This vent connection shall be provided with a flanged valve and blind flange. The vent valve and blind flange shall be of AISI 316L stainless steel unless otherwise specified by the Principal.

Gland plates shall have a drain connection if they have a throttle bushing or an auxiliary sealing device.

2.3.19 Add to this clause:

Unless otherwise specified, the connection between seal piping and the gland plate shall be full penetration butt welded, if the pressure class of the pump and the flanges is ANS rating class 900 or higher.

2.4 SHAFT SLEEVES

2.4.1 Add to this clause:

In applications where the shaft requires corrosion protection, an intermediate sleeve of the same material as the seal shaft sleeve shall be provided between the impeller and the seal shaft sleeve. Appropriate sealing devices shall be installed between the sleeves and the impeller in order to ensure complete protection of the shaft.

2.4.2 Add to this clause:

Shaft sleeves for pusher type seals shall have a hard face coating at the area of the dynamic sealing element, unless otherwise specified or approved by the Principal. Coatings shall be fully compatible with the pump liquid and the barrier or buffer liquid.

The approval of the Principal is required for the type of coating and the application procedure of the coating for seal sleeves in corrosive services.

2.4.4.1 Add to this clause:

If dual pressurised seal arrangements for Category 1 liquids (see 1.4.56) are applied, an additional O-ring seal between the shaft and the sleeve shall be located at the outboard end of the sleeve. The space in between the two O-rings under the sleeve shall be buffered with the barrier liquid by means of two holes drilled in the shaft sleeve.

2.4.10.3 Add to this clause:

Designs using set screws for positioning the shaft sleeve in seals, which have to seal against an MSSP of more than 50 bar (abs), are subject to the approval of the Principal.

2.4.10.4 In this clause, replace the words "When specified by the purchaser or recommended by the seal Manufacturer," **by** "If the MSSP of the seal exceeds 50 bar (abs),"

Add to this clause:

Alternative designs to the split ring construction require the specific approval of the Principal.

SECTION 3 MATERIALS

3.1 GENERAL

Add to this clause:

Seal materials shall comply with NACE MR0175 for services with H_2S levels defined therein.

3.2 SEAL FACES

3.2.2 Add to this clause:

Carbon ring material for seal faces shall be suitable for continuous operation at the highest temperature specified for the pump in which the seal is incorporated.

Alternatively, silicon carbide material may be used if approved by the Principal.

3.5 SECONDARY SEALING COMPONENTS

3.5.2 Replace this clause by:

Fluoroelastomers shall not be used in seals operating at a pumping temperature above 175 °C. Perfluoroelastomers shall not be used in seals operating at a pumping temperature above 240 °C.

If alternatives are available that are equal to or better than perfluoroelastomers in the applicable service, they may be applied subject to the approval of the Principal".

3.5.3 Add new clause:

O-rings made of solid PTFE material shall not be used.

3.6 METAL BELLOWS

Add to this clause:

Alternative bellows materials for standard seals may be used if they have a proven service record in the specified duty and if approved by the Principal.

SECTION 4 ACCESSORIES

4.1 AUXILIARY PIPING SYSTEMS

4.1.5 Replace this clause by:

Auxiliary piping systems shall not use tubing unless approved by the Principal. Piping shall have flanged connections unless otherwise approved by the Principal.

Primary seal plans, such as 11, 13, 21, 23 and 32, shall be executed in piping with welded or flanged connections.

4.1.8 In the first sentence of this clause, delete the words "Unless otherwise approved by the purchaser",

Replace the last two sentences of this clause by:

Threaded connections shall be limited to the final connections at the gland plate only. The last flanged connection before the gland plate shall be made with a lap joint flange at the gland plate side in order to facilitate proper flange alignment after maintenance.

Pipe bushings and seal welds shall not be used. Socket welds shall be used only with the approval of the Principal.

4.1.18 Add to the beginning of the first sentence of this clause:

"On the gland plate, ..."

4.1.21 Add new clause:

If the non-insulated wall temperature of seal system piping and components is higher than 70 °C, personnel protection shall be provided on those parts which are within the reach of personnel.

4.2 MECHANICAL SEAL FLUSH/COOLING SYSTEMS (Group I)

Add to this clause:

However, the seal Manufacturer shall remain responsible for the combined performance of the seal and seal system in accordance with this specification.

Standard seal flush plans 12, 22, 31 and 41 shall not be used.

4.3 QUENCH SYSTEM (Group II)

Add to this clause:

d. If applied, the quench harness shall include a fixed metering orifice for the required quenching capacity for each mechanical seal. In the steam piping to the seal an appropriate steam trap and condensate drain shall be installed as close as practical to the pump in order to ensure a dry steam supply to the gland plate.

e. The quench drain shall be routed to the base plate drain.

4.5 ACCESSORIES AND AUXILIARY SYSTEM COMPONENTS

4.5.1 Cyclone Separator

Replace this clause by:

Cyclone separators shall not be used unless approved by the Principal for a specific application.

4.5.2.1.2 Add to the beginning of the first sentence of this clause:

"Unless otherwise specified..."

4.5.3 Add to this clause:

For plans 21, 23, 52 and 53 modified, air cooling shall be the first choice. Water cooling for plan 53 modified in hazardous services is subject to the approval of the Principal.

4.5.3.6 Add new clause:

The construction of the cooler and its line up shall allow full accessibility to the cooling water side for cleaning purposes.

4.5.4 Add to this clause:

Liquid barrier seal systems shall be in accordance with (4.5.4.5).

The type of barrier seal system arrangement shall be specified on the mechanical seal data sheet. A dual seal barrier system may contain either a fluid or a clean dry inert gas (e.g. nitrogen) in a dual pressurised gas seal application or a dry gas back-up seal application.

4.5.4.1 Add to this clause:

", where applicable for the selected seal barrier system".

4.5.4.1.1 Replace this clause by:

Plan 52 systems shall be provided with a separate reservoir for each seal.

Plan 53 M systems shall be provided with a separate accumulator for each pump.

4.5.4.2.1 Add to this clause:

Reservoirs for atmospheric or low pressure buffer liquid and accumulators for pressurised barrier liquid shall be sized for a manual refill interval time of at least 25 days based on the seal leakage rate specified by the seal Manufacturer without compromising the specified seal life time.

4.5.4.3.9 Replace this clause by:

All connections to the reservoir shall be welded with welding neck flanges in accordance with the specifications stated on the requisition.

4.5.4.5 Add new clause:

Barrier seal systems are given in clauses 4.5.4.5.1 through 4.5.4.5.3.

The use of any type of barrier seal system other than those specified below is subject to the approval of the Principal.

Low pressure or non-pressurised buffer liquid systems shall be in accordance with Appendix 4, plan 52 system.

4.5.4.5.1 Variable pressure barrier system

API 682 Plan 53 modified - Type 1 (see Appendix 1).

This barrier system is used for dual pressurised seal arrangements. It is typically used in back-to-back or face-to-face seal arrangements where the barrier system pressure is substantially higher than the normal seal chamber pressure. This system can also be used with dual tandem seals if the individual seal pressure rating permits.

For Category 1 liquids the barrier pressure shall be above the maximum static and dynamic pressure occurring in the pump in any possible offset condition, e.g. the pump maximum discharge pressure.

For Category 2 and 3 liquids and if applicable, other liquids, the barrier pressure shall be set above the maximum seal chamber pressure that can occur during operation of the pump.

The barrier liquid is normally circulated by a pumping ring and is cooled by a finned tube air cooled heat exchanger. The seal Manufacturer shall establish the temperature rise of the

liquid and size the system so that the maximum liquid temperature during operation will not exceed 80 °C. If this requirement results in oversizing of the finned tube cooler, water cooled coolers may be considered, subject to the approval of the Principal.

The system is provided with a bladder-type accumulator which accommodates a liquid volume to compensate for the seal leakage across the inboard and outboard seals.

The gas pre-charge pressure of this bladder-type accumulator, when empty of liquid, shall be 1 bar higher than the highest pressure that can occur in the pump seal chamber as specified above. Bladder-type accumulators shall be pre-charged with nitrogen only. The accumulator shell pressure rating shall exceed the maximum possible supply pressure of the nitrogen pre-charge facilities. Accumulators shall be selected from the Manufacturer's standard range of commercially available pressure designs.

The total working volume in the accumulator is the volume required to fill the accumulator from empty (with pre-charged nitrogen in the bladder) to the maximum barrier system pressure. Typically this volume results in a pressure increase from 4 to 8 bar above the nitrogen pre-charge pressure.

The required operating volume of the accumulator is established by the seal leakage rate (inside and outside seal) and the specified refill frequency of the barrier system. This operating volume shall be limited to 70% of the total working volume, i.e. an emergency reserve of 30% shall be incorporated. This level shall be indicated by means of an appropriate setting of the low pressure alarm on the system. Unless otherwise approved by the Principal, the refill interval shall be at least 25 days.

The refill or topping-up of these barrier systems should be done via a hard piped barrier fluid make-up system which has a positive barrier between its fluid supply side and the barrier fluid header. A typical example is provided in Appendix 5. Each barrier system shall be connected to the header of this make-up system by means of double block valves with a filter in between or spring return ball valves which shall normally be closed and only opened for refilling or topping up. In this way the barrier systems are isolated from each other and cross contamination and pressure disturbance effects are prevented. Depending on location and service conditions, a relief valve may be installed to prevent over-pressurising the system on the liquid side.

Unless otherwise approved by the Principal, individual barrier systems and barrier fluid make-up systems, including barrier fluid header piping, shall be made of austenitic stainless steel. Bladder accumulator shells may be carbon steel. Bladder materials shall be Manufacturer's standard and compatible with the barrier liquid, unless otherwise specified by the Principal.

Each barrier system shall be provided with a permanently attached stainless steel name plate, which shall indicate at least the following:

- Pump item number
- Barrier fluid
- Pre-charge nitrogen pressure
- Minimum and maximum barrier pressure
- Pressure alarm setting
- Year of construction

4.5.4.5.2 Constant differential pressure ratio barrier system

API 682 Plan 53 modified - Type 2 (see Appendix 2).

This system may be used under restricted conditions. It is considered suitable only for clean and non-aggressive, non-corrosive services, typically in low temperature service below minus 25 °C.

The barrier system contains an accumulator with a differential piston-type pressure amplifier whereby a positive differential pressure across the primary seal is maintained at a fixed pressure ratio. This differential pressure is created by the difference between the piston areas of the barrier liquid side and the process pump side of the amplifier and may be increased either by a spring or by a weight.

Cooling can be provided by an internal cooler inside the amplifier or by a separate fin tube or water cooler.

As the barrier fluid of this system may be contaminated by the pump liquid, it shall only be applied in those services where contamination is permitted.

Unless otherwise approved by the Principal, individual barrier systems and barrier fluid make-up systems, including barrier fluid header piping, shall be made of austenitic stainless steel.

4.5.4.5.3 Circulation barrier system

API 682 Plan 54 modified (see Appendix 3).

This barrier system is used for dual pressurised seal arrangements. This system is applied for Category 2 liquids and, subject to the Principal's approval, for H_2S containing liquids in Category 1.

Two basic systems are distinguished:

1. A once-through circulation barrier system, which is based on a slip stream from the process which is returned to the process after having passed through the seals.
2. A full circulation system with partial replenishment to maintain the required degree of barrier liquid cleanliness.

The systems shall have controlled supply and return pressures. The differential pressure between the controlled supply and controlled return pressure should be between 4 bar and 6 bar.

The barrier liquid pressure between the seals shall be set so that leakage of pump liquid into the barrier system is positively prevented, either dynamically or statically. For this reason the barrier pressure in between the dual seals shall be at least 2 bar higher than the maximum pressure that can occur in the pump seal chamber. As far as practical, this maximum pressure shall be the highest discharge pressure of all pumps connected to the system, but allowance may be made for the maximum reverse pressure capabilities of the inner seal in static condition. In this respect, the use of dual pressurised tandem seals may also be considered in order to maintain the inner seal integrity during upset conditions.

The barrier liquid pressure between the seals for plan 54 circulation systems should not exceed 26 bar (abs). If higher pressures are required, the use of individual circulation systems or special plan 53 M, Type 1, arrangements should be evaluated.

In the design of a barrier system for multiple pumps, careful consideration shall be given to the inclusion of high pressure multi-stage pumps. As these high pressure pumps are a potential contamination hazard for the barrier system, the use of dedicated barrier systems for these pumps should be considered. If these pumps are in non-spared essential service (see Appendix 7), separate barrier systems shall be the first choice.

The barrier system shall be designed so that each seal cartridge has facilities to indicate either a primary or secondary seal failure and loss of barrier pressure.

The filtration of the barrier liquid shall be 50 µm. The system shall have at least full flow double filters with continuous transfer valves.

Each seal cartridge shall comprise a block valve, non-return valve, flow indicator, restriction orifice, dual seal, pressure indicator and alarm, restriction orifice, non-return valve, block valve (Appendix 3).

The system shall incorporate double booster pumps. These pumps shall be considered as being in vital service (see Appendix 7), hence a separate power supply (e.g. emergency supply grid) shall be provided. The pumps take suction from an atmospheric reservoir, which is automatically fed from the process through a level control.

The circulating seal liquid stream may be totally or partially routed back to the process. Depending on the degree of contamination a run-down connection to the slops systems shall also be provided to replenish the system.

The system shall be equipped to detect major seal leakage, i.e. by measuring the supply

and return flows of the barrier system and/or tank level.

The operating temperature may vary depending on the selected barrier liquid. If required, insulation and heat tracing of supply and return lines shall be provided to prevent excessive viscosities during start up and/or during off-design conditions. This seal system supply unit shall comply with DEP 31.29.60.32-Gen. Unless otherwise approved by the Principal, the total system including all supply and return piping shall be made of austenitic stainless steel, except for the booster pumps.

4.5.5 BARRIER/BUFFER FLUID SELECTION CRITERIA

4.5.5.1 Add to this clause:

In addition the following shall be observed for barrier liquid for pressurised dual seals:

1) The barrier liquid shall be fully compatible with the pumped liquid (i.e. it would not be considered unacceptable if it were to leak into the pumped liquid). The barrier liquid shall be such that if it leaks into the atmosphere it would not create a hazardous situation or be considered environmentally unacceptable.
2) The barrier liquid shall be able to withstand the maximum and minimum pumping temperature without decomposing or forming solids and/or corrosive/erosive components. At the minimum and maximum pumping temperature it shall have an adequate viscosity.
3) The barrier liquid shall be fully compatible with all materials used in the seals and the seal harnesses.
4) The barrier liquid shall provide adequate lubrication to the seal faces in order to ensure a life time of at least three years.

For unpressurised or low pressure dual seals the following shall be observed in the selection of the buffer liquid:

1) The buffer liquid shall be fully compatible with the pumped liquid. The barrier liquid shall be such that if it leaks into the atmosphere it would not create a hazardous situation or be considered environmentally unacceptable.
2) The buffer liquid shall be able to withstand the maximum and minimum pumping temperature without decomposing or forming solids and/or corrosive/erosive components. At the minimum and maximum pumping temperature it shall have an adequate viscosity.
3) The buffer liquid shall be fully compatible with all materials used in the seals and the seal harnesses.
4) The buffer liquid shall provide adequate lubrication to the seal faces in order to ensure a life time of at least three years. In this respect the liquid shall also be checked as to its suitability as a buffer fluid when saturated with the pumped liquid.

4.5.5.2 In this clause, delete the words “When specified, ..”

4.6 BARRIER/BUFFER FLUID AND SEAL FLUSH POSITIVE CIRCULATING DEVICES

4.6.1 Replace the last sentence of this clause by:

The purchaser and mechanical seal **Manufacturer** shall agree upon which type of circulating device shall be provided. The seal **Manufacturer** remains responsible for the performance of the seal and seal system in accordance with this DEP.

4.6.2.1 Add to the end of this clause:

However, this is not limited to Figures C-20 and C-21.

4.6.3.1 Replace the last sentence of this clause by:

The circulation pump shall be selected by the Manufacturer. The type of pump is subject to

the approval of the Principal.

4.6.4.1 After the first sentence of this clause, add new sentence:

The seal Manufacturer shall investigate these characteristics for final acceptance of the fluid to be applied.

SECTION 5 INSTRUMENTATION

5.1 GENERAL

Replace this clause by:

DEP 32.31.09.31-Gen. shall apply.

5.2 Delete this clause

5.3 Delete this clause

5.4 Delete this clause

5.5 Delete this clause

5.6 Delete this clause

5.7 Delete this clause

SECTION 7 MANUFACTURER DATA

7.1 GENERAL

7.1.1 Add to this clause:

If requested by the Principal for specific seal applications, the seal Manufacturer shall provide data on the selected type and grade of the materials used for seal faces and gaskets and on the materials sub-supplier/Manufacturer. It is recognised that this information is not part of the normally supplied seal data and, as such, the contents and details shall be agreed upon by the Principal and the seal Manufacturer.

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.
Data sheet for mechanical seals for centrifugal/rotary pumps	DEP 31.29.00.94-Gen.

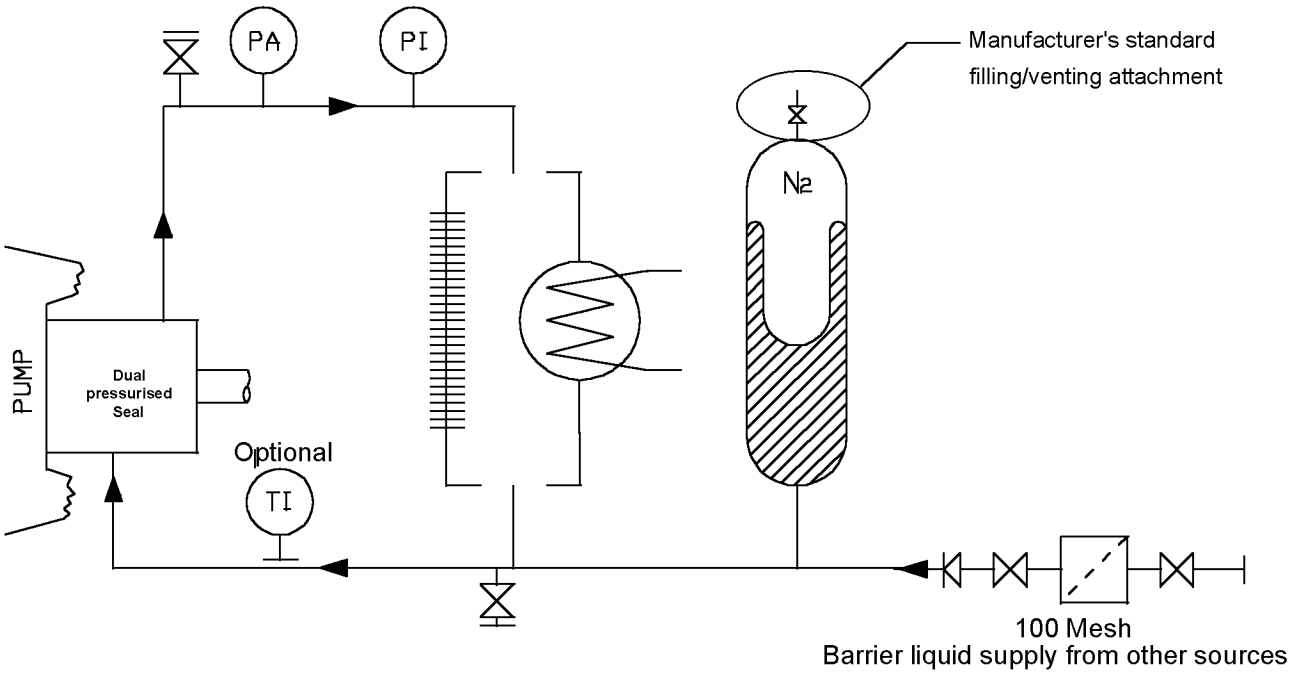
NOTE: Data sheets are contained in the requisitioning binder DEP 30.10.01.10-Gen.)

Lubrication, shaft-sealing and control oil systems for special-purpose applications (amendments/supplements to API Std 614)	DEP 31.29.60.32-Gen.
Instrumentation for equipment packages	DEP 32.31.09.31-Gen.

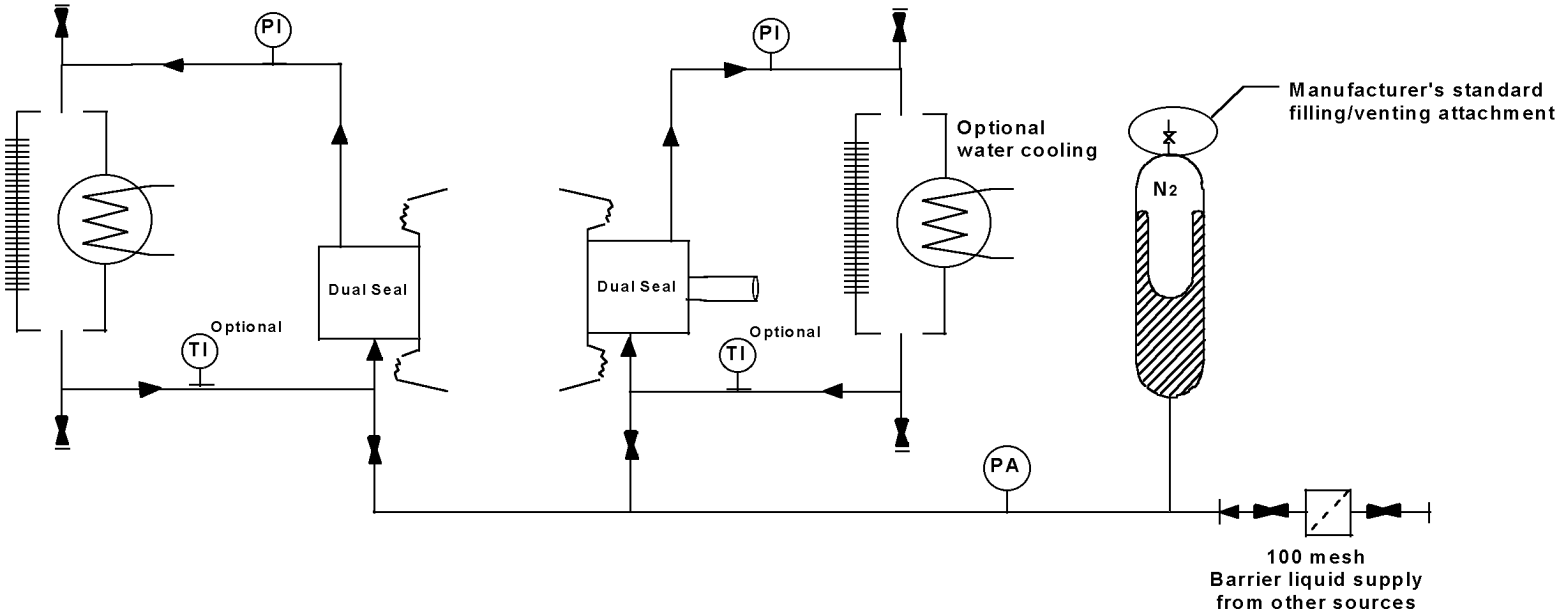
AMERICAN STANDARDS

Shaft sealing systems for centrifugal and rotary pumps	API 682, first edition, October 1994

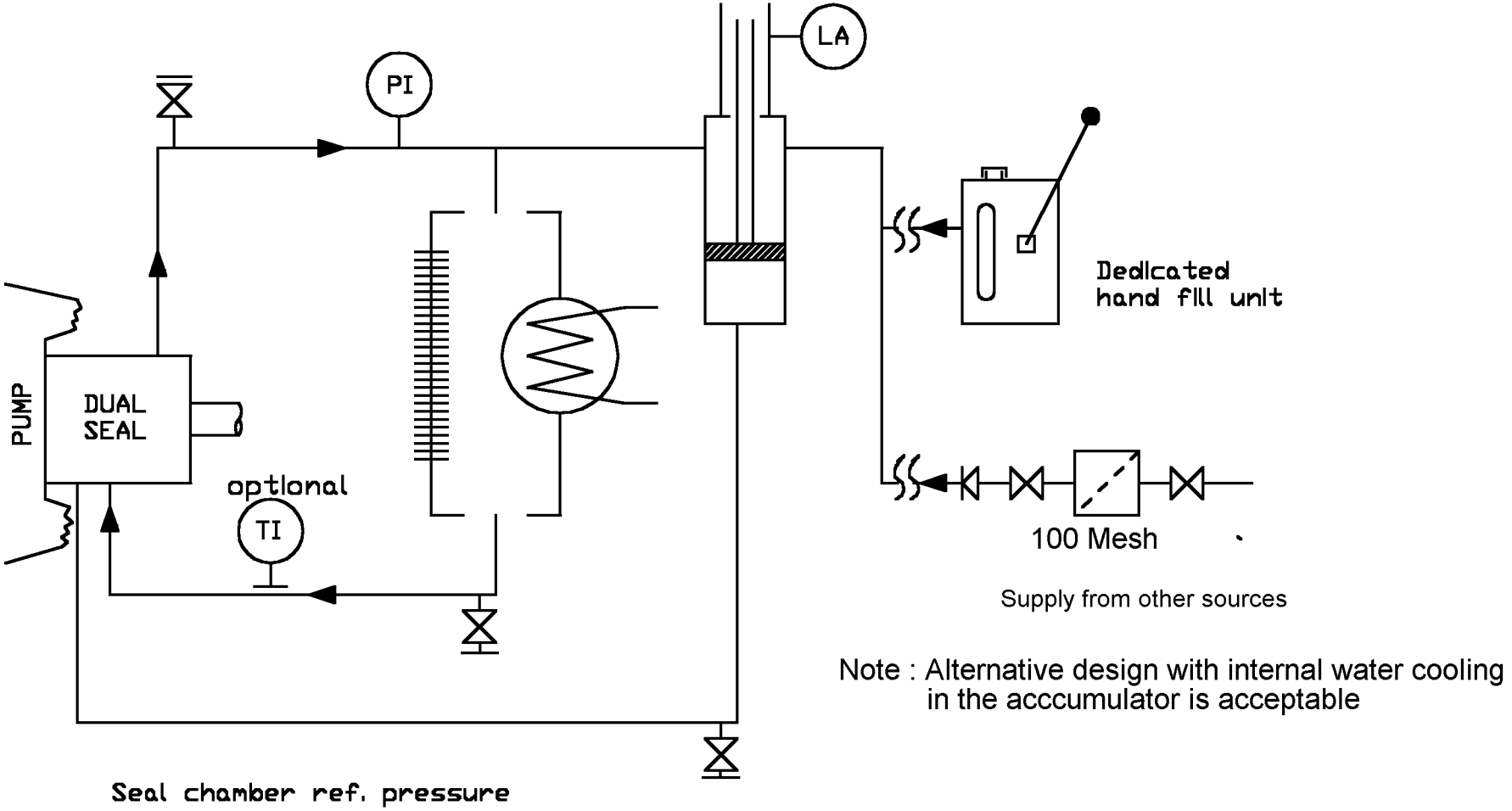
APPENDIX 1 API 682 PLAN 53 MODIFIED, TYPE 1 WITH AIR FIN TUBE OR WATER COOLING



APPENDIX 1A API 682 PLAN 53 MODIFIED, TYPE 1 WITH AIR FIN TUBE OR WATER COOLING FOR BETWEEN BEARINGS PUMP

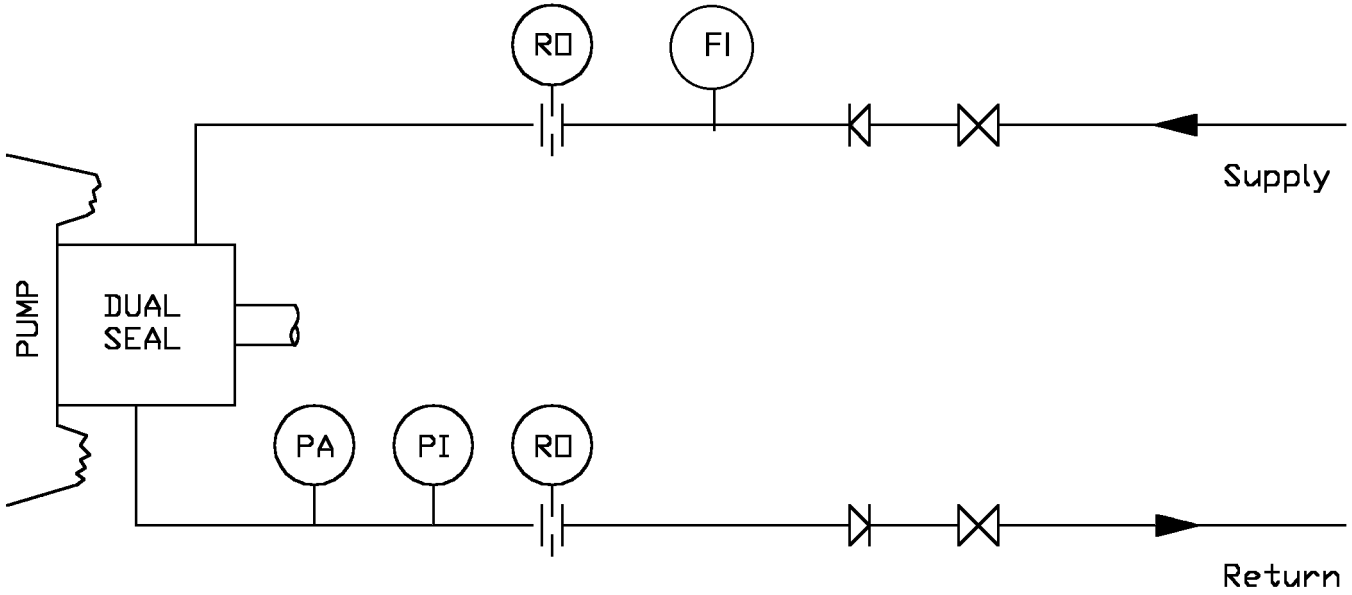


APPENDIX 2 API 682 PLAN 53 MODIFIED, TYPE 2 WITH AIR FIN TUBE OR WATER COOLING

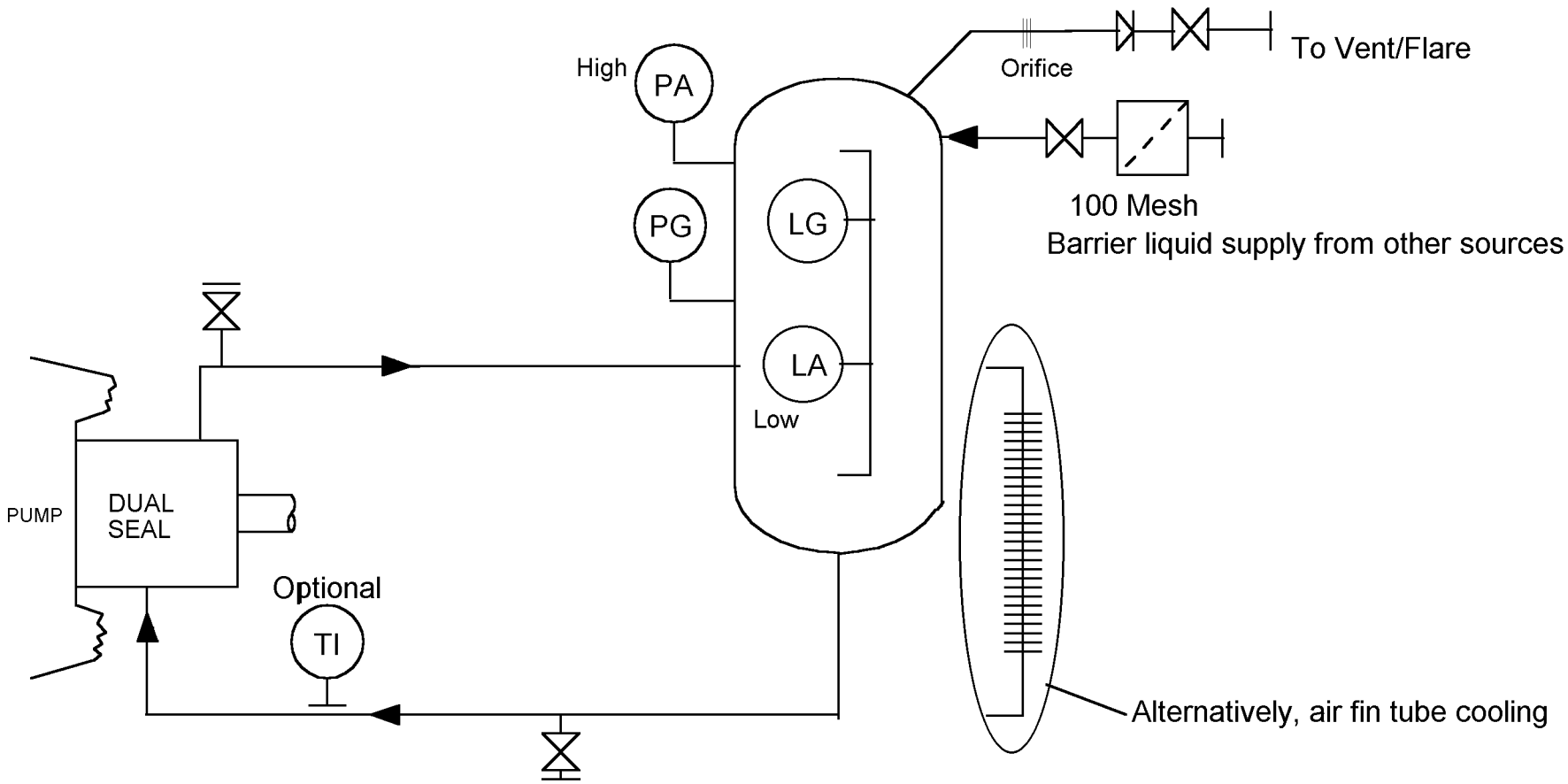


Note : Alternative design with internal water cooling in the acccumulator is acceptable

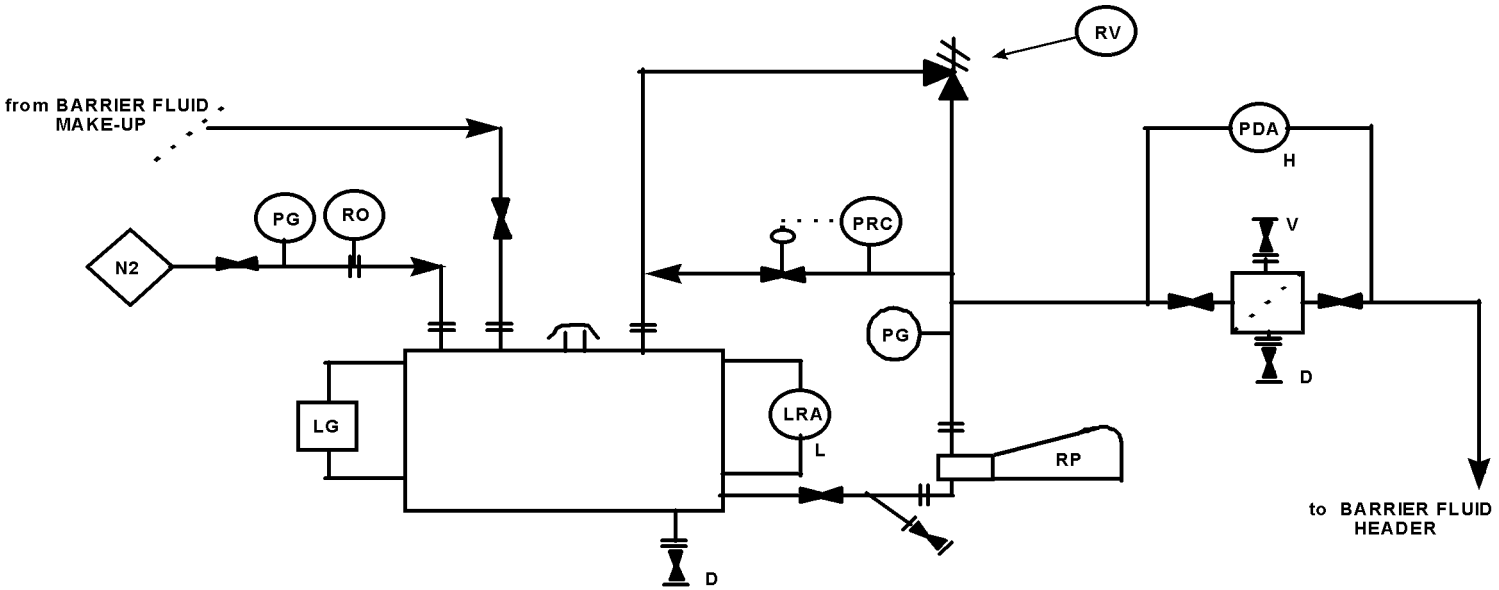
APPENDIX 3 API 682 PLAN 54 MODIFIED



APPENDIX 4 API 682 PLAN 52



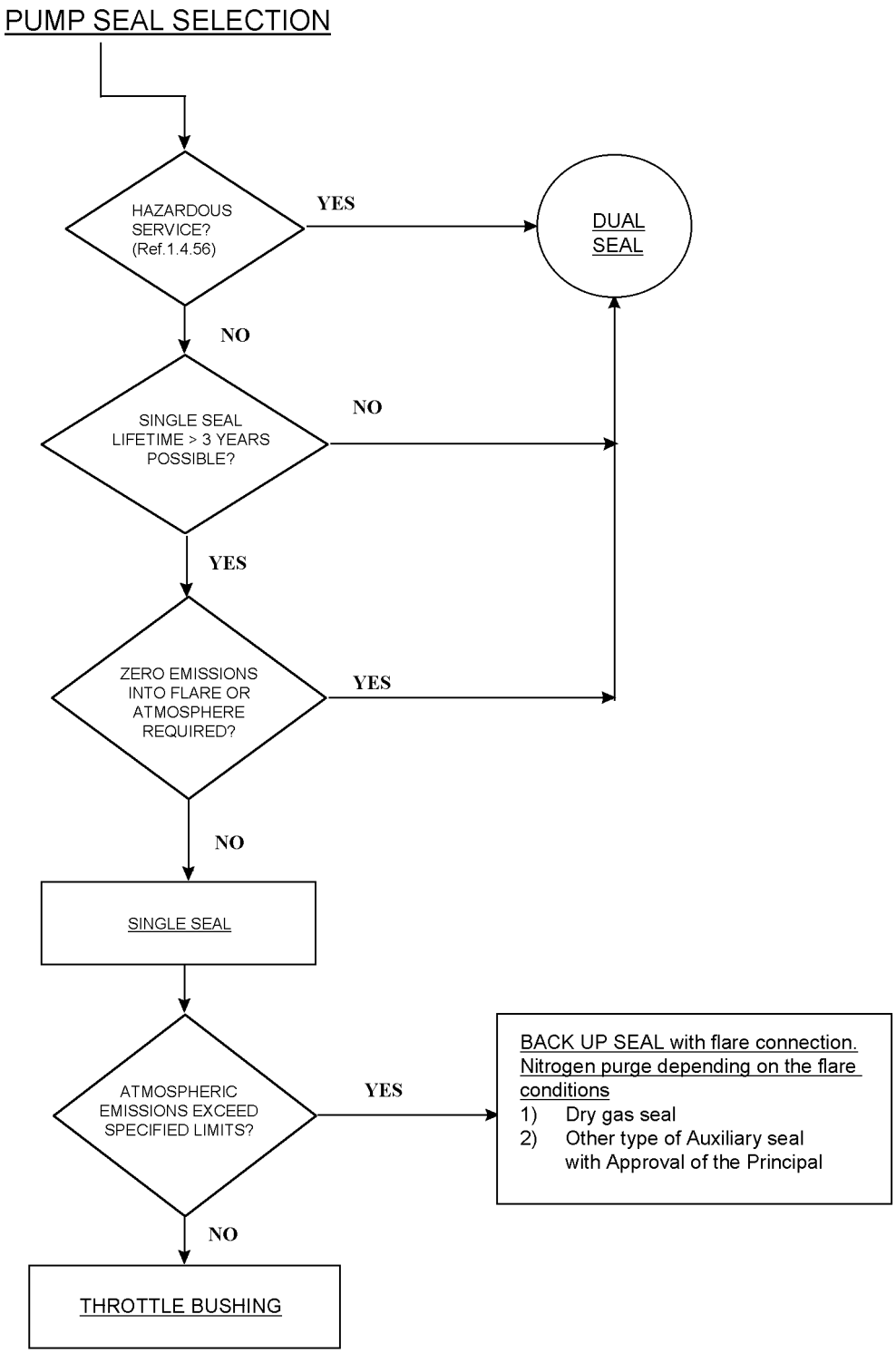
APPENDIX 5 MAKE-UP SYSTEM FOR API PLAN 53 M AND/OR 52 SEAL SYSTEMS



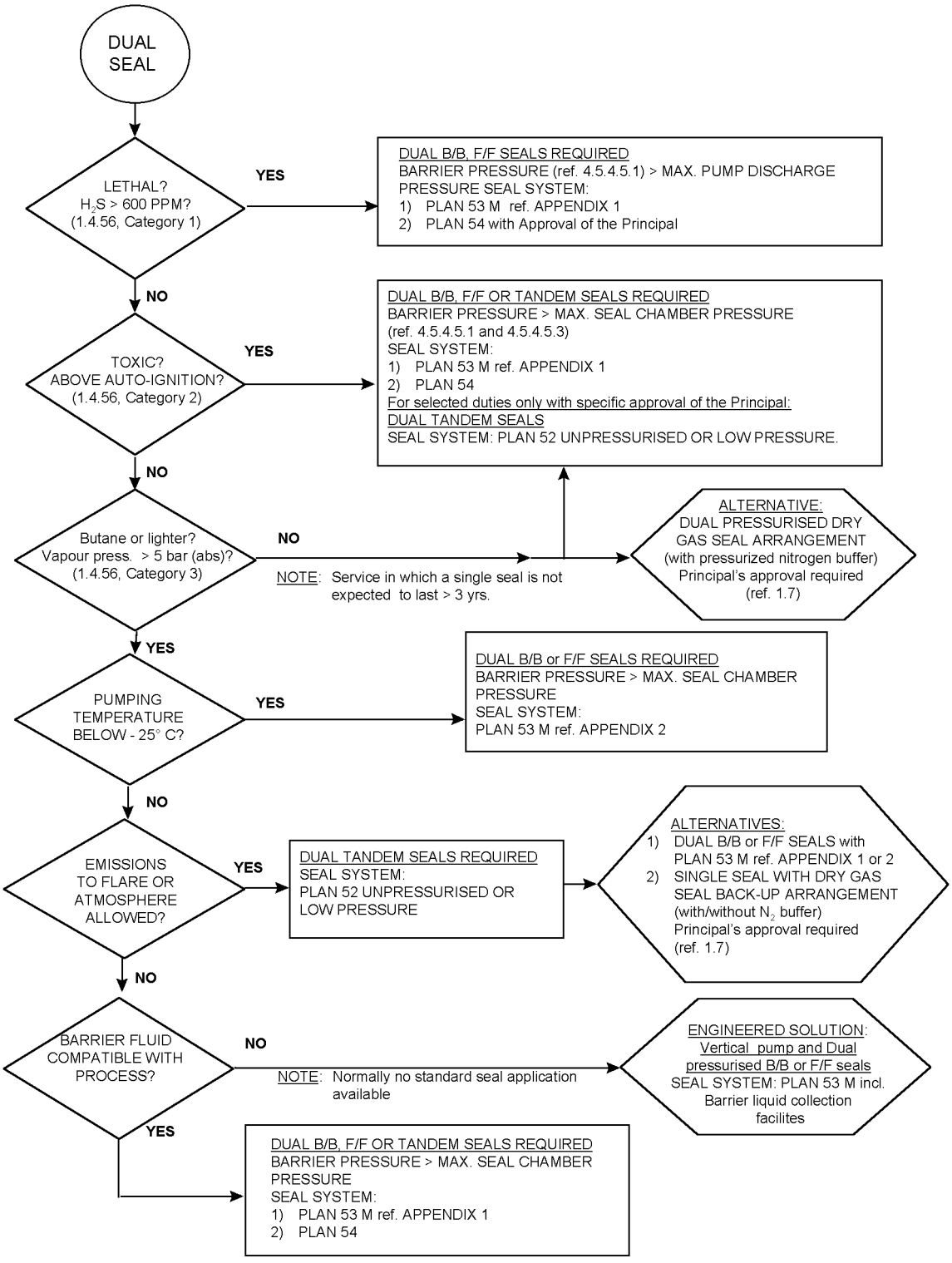
NOTES:

1) Typical pump capacity is 300 l/h
2) LG to be located in sight of the make-up inlet valve
3) Typical reservoir content is 300
   Reservoir design temp. : 100 °C,
   Reservoir design press.: atmospheric
4) Filter to be 10 μm absolute
5) Nitrogen purge only required if barrier fluid is not allowed to be in contact with air.

APPENDIX 6 SEAL SELECTION GRAPH
(part 1 of 2)


PUMP SEAL SELECTION
HAZARDOUS SERVICE? (Ref.1.4.56)
YES
DUAL SEAL
NO
SINGLE SEAL LIFETIME > 3 YEARS POSSIBLE?
NO
YES
ZERO EMISSIONS INTO FLARE OR ATMOSPHERE REQUIRED?
YES
NO
SINGLE SEAL
ATMOSPHERIC EMISSIONS EXCEED SPECIFIED LIMITS?
YES
BACK UP SEAL with flare connection. Nitrogen purge depending on the flare conditions
1) Dry gas seal
2) Other type of Auxiliary seal with Approval of the Principal
NO
THROTTLE BUSHING

SEAL SELECTION GRAPH
(part 2 of 2)


DUAL SEAL
LETHAL? H_2S > 600 PPM? (1.4.56, Category 1)
YES
DUAL B/B, F/F SEALS REQUIRED
BARRIER PRESSURE (ref. 4.5.4.5.1) > MAX. PUMP DISCHARGE PRESSURE SEAL SYSTEM:
1) PLAN 53 M ref. APPENDIX 1
2) PLAN 54 with Approval of the Principal
NO
TOXIC? ABOVE AUTO-IGNITION? (1.4.56, Category 2)
YES
DUAL B/B, F/F OR TANDEM SEALS REQUIRED
BARRIER PRESSURE > MAX. SEAL CHAMBER PRESSURE (ref. 4.5.4.5.1 and 4.5.4.5.3)
SEAL SYSTEM:
1) PLAN 53 M ref. APPENDIX 1
2) PLAN 54
For selected duties only with specific approval of the Principal:
DUAL TANDEM SEALS
SEAL SYSTEM: PLAN 52 UNPRESSURISED OR LOW PRESSURE.
NO
Butane or lighter? Vapour press. > 5 bar (abs)? (1.4.56, Category 3)
NO
NOTE: Service in which a single seal is not expected to last > 3 yrs.
ALTERNATIVE:
DUAL PRESSURISED DRY GAS SEAL ARRANGEMENT (with pressurized nitrogen buffer)
Principal's approval required (ref. 1.7)
YES
PUMPING TEMPERATURE BELOW - 25° C?
YES
DUAL B/B or F/F SEALS REQUIRED
BARRIER PRESSURE > MAX. SEAL CHAMBER PRESSURE
SEAL SYSTEM:
PLAN 53 M ref. APPENDIX 2
NO
EMISSIONS TO FLARE OR ATMOSPHERE ALLOWED?
YES
DUAL TANDEM SEALS REQUIRED
SEAL SYSTEM:
PLAN 52 UNPRESSURISED OR LOW PRESSURE
ALTERNATIVES:
1) DUAL B/B or F/F SEALS with PLAN 53 M ref. APPENDIX 1 or 2
2) SINGLE SEAL WITH DRY GAS SEAL BACK-UP ARRANGEMENT (with/without N_2 buffer)
Principal's approval required (ref. 1.7)
NO
BARRIER FLUID COMPATIBLE WITH PROCESS?
NO
NOTE: Normally no standard seal application available
ENGINEERED SOLUTION:
Vertical pump and Dual pressurised B/B or F/F seals
SEAL SYSTEM: PLAN 53 M incl. Barrier liquid collection facilites
YES
DUAL B/B, F/F OR TANDEM SEALS REQUIRED
BARRIER PRESSURE > MAX. SEAL CHAMBER PRESSURE
SEAL SYSTEM:
1) PLAN 53 M ref. APPENDIX 1
2) PLAN 54

APPENDIX 7 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.*

APPENDIX 8 SEAL SELECTION GUIDE FOR SPECIAL PRODUCTS

Product		**Ethylene Oxide**	**Hydrofluoric Acid**	**Sulphinol**
	Hazardous	Yes **1)**	Yes **2)**	Yes/No **3)**
	Erosive	No	No	No
	Corrosive	Yes, mild	Yes, highly	Yes, mild 4)

Sealed pumps

Seal Selection	Single/ Dual	Dual	Dual	Single/Dual **5)**
	Seal arrangement	refer seal DEP	'Back-to-Back' only	refer seal DEP
	Bellow/ pusher type	Bellow **6)**	Pusher type	Bellow or Pusher type
	Reverse pressure capability	Yes	Yes	Yes, (for Dual seal only)
	Wet/ dry running	Wet	Wet	Wet
	API piping plan(s)	53 mod. or 54	53 mod.+ 32 spec. **7)&8)**	11; 53 mod. or 54
	Barrier/ Buffer liquid	Water	Alkylate	Water
	Flush/ Quench liquid	N/A	Alkylate (Flush)	N/A
Material Selection	Seal face(s)	Silicon Carbide vs. Carbon (or Tu.Carbide)	Silicon Carbide vs. Carbon **9)& 10)**	Silicon Carbide vs. Carbon
	O-ring/ cups/ wedges	PTFE **11)**	Viton O-rings **12)**	Nordel 1070 **13)**
	Lip seals internal	N/A	Pure PTFE	N/A
	Metal parts	316 St.st.	Monel 400	316 St.st.
	Shaft sleeve	316 St.st.	Monel K500	316 St.st.
	Seal end plate (product side)	316 St.st.	Monel 400	316 St.st.
Instrumentation Protection	Low level trip surge drum	Yes	No	No
	High temp trip discharge	Yes	No	No
	Min. flow line to surge drum	Yes	No	No
	Low flow trip min. flow line	No	N/A	N/A
	Auto start	No	No	No
	Gas monitor activates sprinkler	To be discussed	N/A	N/A
	Fire detection activates sprinkler	To be discussed	N/A	N/A
	Low barrier pressure trip	No, (alarm only)	No, (alarm only)	No, (alarm only)
	Low level buffer vessel trip	No, (alarm only)	N/A	N/A

Sealless pumps

	Canned/ Mag drive	Canned	Not Recommended	Not preferred
	Gaskets	PTFE/ graphite	N/A	N/A
	Internals	Stainless Steel	N/A	N/A
	Low level trip surge drum	Yes	N/A	N/A
	High temp trip discharge	Yes	N/A	N/A
	Min. flow line to surge drum	N/A	N/A	N/A
	Low flow trip min. flow line	N/A	N/A	N/A
	Axial displacement	N/A	N/A	N/A
	Radial displacement	N/A	N/A	N/A
	Low flow trip discharge	Yes	N/A	N/A
	Pump level indicator alarm	Yes	N/A	N/A
	High temp trip motor cooling	Yes	N/A	N/A
	Auto start	No	N/A	N/A

Note:

1) Ethylene oxide is very toxic. For sealless pumps, due to detonation risk of EO vapours at temperatures above approximately 500 °C, safeguarding measures shall be taken to prevent hot spots inside the pump casing due to dry running.

2) Hydrofluoric acid is lethal and corrosive. Special precautions shall be taken when handling hardware contaminated with HF.

3) Sulphinol is a mixture of sulfolane (moderately toxic), DIPA and water. Sulphinol in normal form is not considered toxic. Depending on process applications its hazardousness shall be evaluated.

4) Sulphinol will become mildly corrosive when CO_2 or H_2S content increases.

5) Selection of single or double seal depending on hazard classification of the product.

6) Selection of bellows type seal is subject to viscosity of product, otherwise select pusher type seal.

7) If available the plan 32 alkylate flush shall be injected at the inner seal into the pump using a lip seal to prevent HF contamination of the seal barrier.

8) In HF service only aircoolers for plan 53 mod. are acceptable.

9) Silicon carbide shall be alfa-sintered. Material codes: Crane: 277; Flexibox: 0387; BW/IP: YO.

10) Approved Carbons materiall codes are: Crane: P75 (181), Flexibox: Morganite CY9106C (0312); BW/IP: Morganite CY9106C (XX54); SiC/SiC seal face combination may be considered also. Refer manuf. seal drwg. for further details.

11) Dynamic solid PTFE O-rings shall not be used; graphite gaskets may be used as an alternative.

12) Approved Viton O-ring materials are: Viton E60C (DuPont) or Viton V3657-75 (Parker). Other letharged cured Vitons may be used if approved by the Principal.

13) In static services PTFE (encased) O-rings may be used as an alternative.