TECHNICAL SPECIFICATION

ROTATING DISC CONTACTORS

DEP 31.22.01.31-Gen.

December 1995

DESIGN AND ENGINEERING PRACTICE

PREFACE

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Shell International Oil Products B.V. (SIOP)
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Shell International Exploration and Production B.V. (SIEP)
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The Hague, The Netherlands,

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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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APPENDICES

1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for rotating disc contactors (RDCs). Sections 3 through 10 cover the design, fabrication, shop inspection and testing and delivery. Sections 11 through 13 cover the installation, site testing and maintenance.

This DEP is a revision and combination of two previous publications, DEP 31.22.01.31-Gen. and DEP 61.22.01.31-Gen., both dated October 1982.

DEP 61.22.01.31-Gen. is herewith withdrawn.

Requirements for RDCs made of glass-fibre reinforced epoxy are excluded from the scope of this DEP.

1.2 DISTRIBUTION, INTENDED USE 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/Suppliers nominated by them (i.e. the distribution code is "F", as described in DEP 00.00.05.05-Gen.).

This DEP is intended for use in oil refineries, chemical plants, gas plants, oil and gas production facilities, and 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

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 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.

1.3.2 Specific definitions

The **drive** is the prime mover.

The **driving unit** consists of the prime mover and the speed reducer.

The **requisition** is the vehicle used to exchange information prior to order placement, using the appropriate data/requisition sheets (e.g. DEP 31.22.01.93-Gen. for rotating disc contactors, DEP 33.66.05.93-Gen. for electric motors).

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 (14).

2. GENERAL DESCRIPTION OF AN RDC

An RDC consists of a vertical cylindrical vessel, divided by a series of stator rings into a number of equally spaced compartments. A rotor disc supported by a shaft is centred in each compartment (see Appendices 1 and 2).

The diameter of the discs is smaller than the inside diameter of the stator rings, thus permitting assembly and withdrawal of the rotor for installation and maintenance.

The feed inlets at the top and bottom are placed tangential to the direction of rotation. The settling zones at the top and bottom are separated from the contacting zone by means of a wide-mesh grid.

The liquid with the higher density enters the RDC at the top. The liquid with the lower density enters at the bottom and flows upwards, counter-currently to the descending liquid of higher density. Rotation of the rotor will cause one of the liquids to become dispersed in the other. Variation of the rotor speed provides a simple means of controlling the droplet size of the dispersed phase and thereby the efficiency of the RDC.

The rotor is driven at the top by either a variable-speed electric motor or an electric motor with a variable-speed transmission. The rotor shaft is suspended from a spherical roller thrust bearing at the top and centred by a bottom sleeve bearing and, depending on the size of the RDC, by one or more intermediate sleeve bearings.

If intermediate bearings are used, the rotor shaft consists of two or more parts, connected to each other by a rigid coupling.

The top bearing is oil-bath lubricated, while the bottom bearing and the intermediate bearing, if applicable, are lubricated by the product in the RDC.

During rotation of the rotor, the shaft is sealed by a mechanical seal. Above the mechanical seal two auxiliary lip seals are installed to prevent excessive losses of product in the event of a mechanical seal failure (see Appendix 3).

A vent/drain line is connected to the chamber between the mechanical seal and auxiliary lip seals to carry away any leakage of product to a safe location.

The mechanical seal housing shall be continuously flushed to prevent fouling, to remove any gas accumulation around the seal faces and for cooling purposes.

Below the mechanical seal a stationary seal and inflatable seal are installed, which will be used in the event of a mechanical seal failure, but only when the rotor is stationary.

Following a mechanical seal failure, the inflatable seal is pressurised with nitrogen from an external supply. In this way the contents of the RDC will be isolated from the damaged seal.

The stationary sealing is obtained by lowering the rotor shaft onto a stationary sealing flange containing an O-ring.

The intent of this design arrangement is to continue operation with the rotor in the stationary position and to carry out mechanical seal repairs while the vessel remains under operating pressure.

3. BASIC DESIGN REQUIREMENTS

The RDC shall meet the requirements specified in the requisition and shall be capable of continuous operation (i.e. uninterrupted operation for a period of at least 16 000 hours at the specified operating conditions) without undue noise and vibration. It shall incorporate all the design features indicated on Standard Drawing S 23.101 and the following standard drawings mentioned therein: S 23.104, S 23.105 and S 23.106.

The Manufacturer shall be responsible for the detailed design, including:

- The required motor power.
- The correct sizing of the vessel wall thickness.
- The correct sizing of the vessel accessories.
- The correct sizing and construction of the shaft and disc.
- The correct sizing of speed transmission, couplings, bearings and shaft seals.

If constructional deviations could affect the Principal's installation instructions as mentioned in Section 11 of this DEP, the Manufacturer shall supply additional instructions.

For material selection of the gaskets, see also report MF 94-0960.

4. DESIGN AND ENGINEERING

4.1 VESSEL

The design of the vessel shall be in accordance with the applicable pressure vessel code as stated by the Principal, which shall be:

- BS 5500, as amended and supplemented by DEP 31.22.10.32-Gen., or
- ASME VIII, as amended and supplemented by DEP 31.22.20.31-Gen.

4.1.1 Skirt

The RDC shall be provided with a cylindrical skirt. Anchor bolts shall straddle the centre lines of the RDC. For details of the skirt and base, reference is made to S 20.001 and S 20.004, respectively.

4.1.2 Nozzles

The feed inlet nozzles should be placed either tangential to the direction of rotation of the rotor, or normal, with a tangential tube to the wall, see S 23.101. For the tangential nozzles, the distance from the centre line of the inlet nozzles to the vessel centre line shall be as large as permitted by code requirements.

The outlet nozzles shall be provided with a vortex breaker, see S 10.010. For general nozzle details, see S 10.101.

4.1.3 Manholes

The vessel shall be provided with a manhole both at the top and the bottom. In those cases where an intermediate bearing is installed an additional manhole shall be provided, see S 23.101 and DEP 31.22.10.32-Gen.

A DN 600 manhole shall be installed if the compartment has to be entered by personnel wearing protective clothing and/or fresh air breathing equipment.

4.1.4 Internals

The grid supports and lugs for tie rods of the bearings shall be welded to the vessel wall by means of continuous fillet welds.

The attachment of the stator rings shall be designed as indicated on S 23.101. The flange welded to the stator ring shall fit closely to the vessel wall. To facilitate this the flange shall have slits at regular intervals to 50% of its depth. The slits shall terminate in 4 mm diameter holes. Stator rings shall be attached to the vessel wall by means of continuous fillet seal welds along the upper edge of the flange to prevent stress corrosion cracking by the fluids handled. Any other type of attachment shall be approved by the Principal.

The minimum plate thickness shall be either 10 mm or D/200 (mm), whichever is greater.

The edges at the inside diameter of the stator rings shall be chamfered, see S 23.101.

4.1.5 Top davit

If specified in the requistion, a davit shall be provided at the top of the RDC to handle the driving unit, top bearing and shaft sealing.

4.2 GRIDS AND SLEEVES

In order to separate the contacting zone from the settling zone, a top grid and a bottom grid shall be installed, see S 23.106. Sleeves around the rotor shaft shall be installed to prevent liquid turbulence in the settling zones, see S 23.101 and S 23.105.

4.3 ROTOR ASSEMBLY AND BEARINGS

The rotor shall be suspended from a spherical roller thrust bearing, guided by a self-aligning

sleeve bearing at the bottom, and shall be driven from the top. A bearing with a conical shaft sleeve shall be avoided due to the difficult adjustment and maintenance.

The oil-lubricated spherical roller thrust bearing shall be designed for a lifetime of at least 25 000 operating hours of the RDC.

The clearances of the bottom bearing and intermediate bearing, if applicable, shall be clearly stated on the Manufacturer's drawing.

The bottom bearing and intermediate bearing, if applicable, shall be positioned in the centre of the vessel by means of adjustable tie rods connected to the shell, see S 23.101 and S 23.105.

Where required because of the size and/or critical speed considerations of the rotor, intermediate self-aligning sleeve bearings shall be provided. The rotor assembly shall then be divided into sections joined by a rigid coupling to facilitate assembly and disassembly.

The rotor discs shall be assembled on the shaft as indicated on S 23.105. The edges at the outside diameter of the rotor discs shall be chamfered.

The shaft journals at the sleeve bearings should be provided either with a Colmonoy 6 or Stellite 6 weld overlay hard facing and shall be machined as specified by the bearing Supplier.

The first lateral critical speed (based on the 1st order natural frequency in air) of the rotor assembly shall be at least 50% above the maximum RDC speed of rotation.

The design of the sleeve bearings shall be such that they are lubricated by the product in the RDC. The material of the bearing bushings should be graphite/glass-fibre reinforced PTFE or other suitable material subject to Principal's approval. The bushings shall be positively located in the bearing housing by means of a press fit, and held in position with suitable radial pegs which shall be of the same material as the bearing bushing. It is the Manufacturer's responsibility to select the correct method to prevent rotation of the bushing in the bearing housing. The method applied will depend on the expansion factor of the material grade used, the size of the bearing and the temperature of the liquid.

The sleeve may expand at a higher rate than the surrounding metal housing due to the differences in thermal expansion coefficients and/or product absorption. This shall be taken into account in the design.

The design shall allow for thermal differential expansion between the vessel and the rotor shaft.

NOTE: If the RDC is provided with an intermediate bearing, provisions for removal and subsequent inspection of this bearing shall be incorporated. To this end it should be possible to lift the upper part of the rotor shaft sufficiently.

4.4 ROTOR SHAFT SEALING

The shaft sealing arrangement shall consist of the following main items, see S 23.104:

- Mechanical seal;
- Auxiliary lip seals;
- Stationary seal;
- Inflatable seal.

4.4.1 Mechanical seals

The mechanical seal arrangements and materials shall be as specified in the requisition. To ensure selection of the optimum mechanical seal and seal auxiliary facilities for the duty specified, the RDC Manufacturer shall make available to the seal Manufacturer concerned a copy of the requisition.

The seal Manufacturer shall recommend alternative mechanical seal materials if he considers the specified combination unsuitable. In all cases the seal Manufacturer shall indicate the type and grade of the materials. Seal types and materials shall be approved by the Principal. The material specification of the O-rings (e.g. Viton or PTFE composite) for

sealing between the rotating seal parts and the shaft sleeve shall be as specified in the requisition or other suitable material subject to the Principal's approval. The RDC Manufacturer shall be responsible for the engineering co-ordination, installation and performance of the mechanical seal and its auxiliary facilities such as circulation, injection, quenching and cooling.

Normally a single mechanical seal shall be selected. As a minimum, double seals shall be applied where specified by DEP 31.29.02.30-Gen.

All components of the seals and seal systems shall withstand the design pressure and the design temperature of the RDC at running conditions. The mechanical seal shall have provisions for venting the seal chamber to ensure that it is completely filled with liquid prior to start-up.

The axial and radial clearances between the static and rotating parts of the top bearing shall be taken into account when calculating the lateral movements of the mechanical seal faces.

The auxiliary lip seals are installed to prevent excessive losses of product in the event of mechanical seal failure. The material specification of the lip seals (e.g. Viton or PTFE composite) shall be as specified in the requisition or other suitable material subject to the Principal's approval.

The shaft sleeve should be provided with either a Colmonoy 6 or Stellite 6 hard facing at the location of the auxiliary lip seals and the seal of the rotating seal face carrier. Thermal spraying may be applied (to the Manufacturer's standard) if approved by the Principal.

A 3/4-inch NPT connection shall be provided at the highest possible location in the mechanical seal housing for connecting a flushing line. The purpose of this line is to vent the seal chamber prior to start-up and to flush liquid to and from the seal housing to remove any gas accumulation around the seal faces, to cool them and to prevent fouling. The direction of the flow will depend on the product handled. The flow quantity shall be advised by the seal Supplier. A flow indicator shall be installed in the flushing line to check the flow.

A 3/4-inch NPT connection shall be provided between the mechanical seal and lip seals for connecting a vent or drain line. The purpose of this line is to carry away any leakage of product to a safe location.

All seal piping shall be welded or bent; flanged joints shall be provided only where disassembly is necessary for maintenance purposes.

Screwed connections may be used only for seal gland plates and they shall not be seal-welded. Socket welded fittings shall not be used.

Unless otherwise specified, seal piping components shall be of AISI 316L material unless the connecting piping class is of non-metallic material.

A stationary seal and an inflatable seal shall be located below the mechanical seal. The intent of the stationary seal is to be able to continue the operation of the RDC with the rotor in the stationary position in the event of mechanical seal failure, and to carry out mechanical seal repairs under full operating pressure of the vessel. The sealed position of the stationary seal is achieved by lowering the rotor shaft by means of unscrewing the top bearing cover flange.

For large RDCs a hydraulic device in the bearing cover flange may be considered for lowering the rotor shaft, and for raising it after a mechanical seal repair. See the alternative detail on S 23.104.

The material specification of the inflatable seal (e.g. Viton or PTFE composite) shall be as specified in the requisition or other suitable material subject to the Principal's approval. On mechanical seal failure, it shall be possible to pressurise the cuff, thus isolating the contents of the RDC from the damaged seal. For this purpose an external supply of nitrogen at a pressure of 8-10 bar above the operating pressure at the top of the RDC shall be available.

The Manufacturer of the RDC shall take into account the seal Supplier's recommendation for seal dimensions, tolerances, clearances and surface finish of the various parts.

The process conditions at the seals shall be stated on the requisition.

4.5 DRIVING UNIT

4.5.1 General

The driving unit primarily consists of either an electric motor with a variable-speed transmission or a variable speed electric motor. If necessary, it shall also include a reduction gear box. The complete unit shall be mounted on a suitable support. A vertical driving unit should be applied.

4.5.2 Electric motor

The RDC shall be driven by an electric motor, which shall be designed in accordance with DEP 33.66.05.31-Gen. or DEP 33.66.05.33-Gen. The RDC and its driver shall be suitable for continuous operation and the area classification as stated on the electric motor requisition.

It shall be possible to start and stop the motor by means of a remote control unit, the switch of which is located near the motor, and provisions shall also be made to stop the motor at ground level near the RDC.

If a vertical driving unit is used, a flange-mounted motor shall be applied.

Care shall be taken that the drive end bearing of the electric motor is capable of accepting the forces associated with the belt drive, if applied.

4.5.3 Variable-speed transmission

The speed variator shall be of the stepless variable type, equipped with a hand wheel for manual speed control. A hydraulic variator is preferred; however, for capacities less than 7.5 kW, a mechanical type may be considered.

The speed variator shall be designed in such a way that speed reduction from specified maximum to minimum of the output shaft is also possible when the electric motor is switched off.

The variator shall be provided with a limit switch to prevent starting of the electric motor in any position other than minimum.

If a vertical speed variator is used, a flanged fitting spur gear box shall be applied. For the horizontal arrangement a flanged fitting bevel gear box is preferred; however, a flexible coupling between speed variator and gear box is allowed.

The reduction gear box should be designed in accordance with API 677. A worm gear transmission shall not be used.

The speed transmission shall be suitable for continuous service and its maximum output speed shall correspond to the required maximum speed of the RDC shaft.

Provisions for mounting a speed indicator shall be provided if the rotor speed is higher than 60 r/min.

If a belt drive is applied between electric motor and speed transmission, the belts shall be anti-static, and oil resistant. Wedge belts (also known as narrow V-belts) are preferred over V-belts (also known as classical V-belts). The design calculations for belt drives shall be in accordance with BS 3790. For determining the power transmission capability a service factor of 1.3 shall be used.

The belts shall be in accordance with API 1B, BS 3790 or DIN 7753 Part 1 and 2.

Wedge belts or V-belts shall only be used for duties up to 20 kW.

Integral multi-belts of the endless type shall be used for duties from 20 kW to 55 kW.

4.5.4 Couplings

The coupling between the transmission output shaft and the RDC shaft, and the coupling between the speed variator and the gear box, if applicable, shall be of a flexible type, with oil-resistant rubber blocks.

The flexible coupling element between the gearbox and motor shall be in accordance with DIN 28155 or BS 3170.

4.5.5 Guards

The rotating parts of the transmission shall not be left exposed. The belt guards or coupling guards for gear type transmissions shall be made of weatherproof and non-sparking material in accordance with BS 5304. They shall be permanently fixed and sufficiently rigid to prevent contact with moving parts and shall be designed for easy removal and assembly.

4.5.6 Driving unit support

The support for the driving unit shall be of sufficient strength and rigidity, taking into account the unbalanced forces caused by the variable-speed transmission. The value of these forces, if any, shall be obtained from the Supplier of the variable-speed transmission.

4.5.7 Lubricants

The Manufacturer of the RDC shall state which lubricants are required for the driving unit.

4.6 STEAM COILS

The steam heating coils as indicated on S 23.101 shall only be provided if stated on the requisition.

4.7 INSULATION AND FIREPROOFING

The requirements for thermal insulation of the vessel and fireproofing of the skirt shall be stated on the requisition. The design shall be in accordance with the DEP 30.46.00.31-Gen. and DEP 34.19.20.11-Gen. For provisions to be made, reference is made to S 20.002 and S 20.003.

4.8 TOLERANCES

The following tolerances shall apply:

Item	Dimension	Tolerance
Shell	All	In accordance with the pressure vessel code specified by the Principal.
Stator rings	Inside diameter	± 0.15% of nominal inside diameter of ring.
	Deviation in horizontal plane	± 0.15% of nominal shell diameter.
	Spacing	± 1.5% of compartment height.
Rotor discs	Outside diameter	± 0.15% of nominal outside diameter of disc.
	Deviation in horizontal plane	± 0.15% of nominal shell diameter.
	Spacing (the discs shall be placed halfway between the spacing of the stator rings).	± 1.5% of compartment height.
Rotor shaft	Eccentricity of the axis of rotation in relation to the axis of the shell.	shall not exceed 0.5% of the nominal shell diameter.
	Maximum run-out at seal position.	0.15 mm total indicator reading (TIR).

5. NOISE CONTROL

5.1 LIMITS

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

5.2 INFORMATION TO BE SUBMITTED WITH THE TENDER

The Manufacturer 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 Manufacturer shall indicate what special silencing measures, if any, are proposed in order to meet the specified levels.

6. DATA AND INFORMATION TO BE SUBMITTED

6.1 DATA AND INFORMATION TO BE SUBMITTED WITH THE TENDER

The Manufacturer shall submit in his tender sufficient drawings and detailed information to enable a full evaluation of the RDC, including as a minimum:

- The fabrication and engineering documents schedule of the vessel.
- The production and engineering documents schedule of the rotor assembly.
- The name of the proposed Manufacturer of the rotor assembly, if applicable.
- The make, type and sketch of coupling and driver.
- The mass of the completely assembled disc contactor, including motor and gearbox.
- The shaft diameter.
- The make and type of the mechanical seal, main trust bearing, bottom bearing and intermediate bearing if applicable.
- The mechanical seal arrangement drawing and /or other shaft seal details.
- The details of the stationary seal.
- The list of all recommended spare parts for initial and normal operation, as specified in DEP 70.10.90.11-Gen.
- The proposed quality plan.
- A statement of confirmation that there are facilities to perform the shop test run. If facilities are not available, the quotation shall include details of a proposed site test run and post-test inspection.
- Further information specified on the requisition.
- A list containing all deviations from this DEP and the requisition.

6.2 DATA AND INFORMATION TO BE SUBMITTED AFTER AWARD OF ORDER

After award of contract a complete set of engineering documents shall be submitted for approval to the Principal before shop or construction work is commenced. The number and type of documents shall be specified by the Principal.

All documents shall be marked in the right hand bottom corner with the Principal's order and item number, together with the Manufacturer/ Supplier's references.

After approval, certified final documents/ manuals and reproducible transparency drawings of the equipment shall be submitted to the Principal. Number and type of final documents shall be specified by the Principal.

NOTES:
1. All information shall be clear and not open to misinterpretation and shall apply specifically to the equipment supplied.
2. If a site test run will be executed, details of the proposed site test and post test inspection shall be included.

7. FABRICATION

The vessel and the rotor with discs will often be supplied by different manufacturers. Since the RDC, the support structure and the vessel form an integrated unit, close co-operation between these manufacturers is essential. The Manufacturer shall inform the Principal at an early stage about required dimensions of the rotor entry nozzle(s), estimated weights, torques, forces and bending moments acting on the nozzle and intermediate bearing supports which may influence the vessel design.

The Manufacturer shall inform the Principal as soon as possible about any changes in design or other reasons influencing the fabrication of the complete unit.

The fabrication of the vessel shall be in accordance with the applicable pressure vessel code (as amended by DEPs, see (4.1)) specified by the Principal.

8. SHOP INSPECTION AND TESTING

8.1 GENERAL

The RDC shall be inspected and tested at the Manufacturer's works to prove its capability and compliance with the purchase order requirements.

The inspection and testing of the pressure vessel shall be in accordance with the applicable pressure vessel code (as amended by DEPs, see (4.1)) specified by the Principal.

The Principal shall specify if the inspection and tests at Manufacturer's works are to be witnessed by the Principal or if the Principal will perform a document review on the basis of the Manufacturer's quality system (in which case the Manufacturer shall forward all test results and certificates of all tests to the Principal).

8.2 INSPECTION

In order to ensure compliance with the purchase order requirements, the tests and checks to be carried out at the Manufacturer's works shall be in accordance with the Manufacturer's quality system and shall include at least the following:

- General document control and visible check on materials used.
- General check on workmanship and a dimensional check of the rotor and vessel.
- Control of test results.

8.2.1 Pressure vessel

Inspection shall be performed on correct fabrication, mounting, welding and tolerances of all stator rings. For tolerances, see (4.8).

8.2.2 Workmanship and dimensional inspection

The specific RDC inspections shall include the following:

- The straightness of the rotor assembly by lifting and measuring deflections while rotating by hand.
- The correct fabrication, mounting, welding and tolerances of all internal parts such as rotor discs, rotor shaft, bearings and shaft sealing parts. For tolerances, see (4.8).
- The alignment and tolerances of the electric motor, rotating disc shaft and coupling.
- The quantity of oil/lubrication needed for the mechanical seal system

8.3 TESTING

Two shop tests shall be carried out. First, a hydrostatic test to prove the proper functioning of the mechanical seal and the inflatable seal when the shaft is in stationary condition. Second, a twelve-hour mechanical running test to prove the running conditions and mechanical integrity of RDC and driver rotor.

8.3.1 Hydrostatic test

The hydrostatic test of the mechanical seal shall include the following checks:

- Leakage of the mechanical seal at design pressure by opening vent/drain line between mechanical seal and auxiliary lip seals for an hour.
- Tightness of the stationary seal arrangement at maximum operating pressure (with the rotor at lowered position and the inflatable seal pressurized to 8-10 bar above operating pressure).

After the hydrostatic test, the mechanical seal shall be checked.

8.3.2 Twelve-hour mechanical running test

The Principal shall specify if the mechanical seal shall be installed for the twelve hour mechanical running test. If not, only the shaft sleeve of the mechanical seal shall be mounted. The upper and lower sealing flange of the stationary seal shall be mounted without O-rings (Appendix 3, item number 6). The RDC shall be completely filled with clean water unless otherwise specified by the Principal.

The RDC shall run uninterrupted for twelve-hours at maximum operating speed (see Note below). The following observations shall be recorded at 30 minute intervals:

- The absorbed power in kW.
- The temperature of the driving unit and speed transmission.
- The temperature of the top bearing housing.
- The vibration measured at the driving unit, speed transmission and top bearing housing. The vibration shall not exceed 3 mm/s RMS (root mean square).
- The flushing flow rate for bearing lubrication, if applicable.

Upon completion of this test the speed range of the RDC shall be checked and the absorbed power be recorded at 4 speeds between minimum and maximum operating speed.

The shaft run-out shall be checked where the mechanical seal shaft sleeve is located, through a hole provided in the seal housing and by rotating the RDC shaft by hand.

The running parts, such as bearings and driving unit shall be inspected for smooth running.

NOTE: For RDCs in deasphalting service, this test cannot be carried out with water at maximum operating speed since the electric motor has been rated for propane (specific gravity 0.45). Therefore, the test run using water shall be carried out at approximately 80% of the maximum operating speed to avoid overloading of the electric motor.

9. PROVISIONS FOR TRANSPORT

9.1 CLEANING

After testing has been carried out all parts shall be carefully cleaned and dried. All dirt, rust, water, etc., shall be removed and any oil used for lubrication during the test run shall be drained.

9.2 PRESERVATION

The internal surfaces and parts shall not be painted. The external surfaces of the vessel shall be painted in accordance with DEP 30.48.00.31-Gen.

Machined parts shall be adequately preserved for 6 months' storage in accordance with DEP 70.10.70.11-Gen.

The driving unit shall be preserved in accordance with the Manufacturer's standards.

The mechanical seal and cartridge shall be cleaned and properly capped for dirt-free and dust-free storage.

9.3 TRANSPORTING

Depending on the size, the RDC may be transported with the rotor installed or removed (e.g because of weight limitations). In the former case dummy bearings shall be fitted and, if necessary, supports provided between the rotor and the shell at several locations. In the latter case the rotor shall be transported as a complete assembly on a separate skid, properly supported to prevent damage to the shaft. In both cases, the driving unit, shaft sealing devices and original bearings shall be packed separately.

10. INSTALLATION, OPERATION AND MAINTENANCE MANUALS

The Manufacturer shall supply the installation, operation and maintenance manuals, which should cover at least the activities mentioned in Sections 11, 12 and 13 of this DEP.

11. INSTALLATION

11.1 GENERAL

Unless otherwise specified by the Principal, installation, testing and start up on site will be performed by the Principal.

The installation procedure for RDCs transported without rotor and without internal bolted parts is specified in (11.2).

The installation procedure for RDCs transported complete with rotor is specified in (11.3).

The procedures described are based on the assumption that the RDC is constructed in accordance with Standard Drawings S 23.101, S 23.104, S 23.105 and S 23.106.

The Manufacturer's additional requirements, if any, shall also apply.

11.2 INSTALLATION PROCEDURE FOR RDCs TRANSPORTED WITHOUT ROTOR

The following steps refer to RDCs with a shaft in two sections, see Appendix 1.

For RDCs with a single-shaft arrangement, see Appendix 2, in which case the items marked * are not applicable.

11.2.1 Stage one

1. Erect the vessel in a true vertical position.

*2. Assemble the intermediate bearing completely and fit over the lower section of the rotor, outside the vessel.

*3. Fit the halves of the intermediate coupling to their respective shaft sections.

*4. Hang the intermediate bearing assembly temporarily from the coupling half.

11.2.2 Stage two

1. Install a hydraulic jack, temporarily, in the bottom of the vessel.
2. Insert the bottom bearing support ring, bearing assembly, tie rods and bottom sleeve in the vessel.
3. Install the bottom grid sections and wedge bottom sleeve temporarily to the grid.
4. Install the bottom bearing support ring with adjustable tie rods in the centre of the vessel.
5. Check the centre of the bottom bearing support ring with a plumb line from the centre of the vessel top, and adjust the bottom bearing support ring with the adjustable tie rods. Do not overstress the tie rods.
6. With a crane, insert the lower section of the rotor assembly into the vessel.
7. Install the bottom bearing assembly and bottom sleeve, leaving the rotor suspended from the crane.
8. Support the rotor shaft end with the hydraulic jack (check the approximate axial position of the shaft at the stator rings and rotor discs).

*9. Install tie rods to the intermediate bearing support ring.

*10. Centralise the intermediate bearing with the tie rods.

*11. Release the crane.

*12. Check the centre of the lower section with a plumb line from the centre of the vessel top, and adjust the intermediate bearing with the adjustable tie rods. Do not overstress the tie rods.

11.2.3 Stage three

*1. With a crane, insert the upper section of the rotor assembly into the vessel .

*2. Connect the intermediate coupling halves.

3. Install the top grid sections.

4. Wedge the rotor in the centre position at grid location.

5. Release the crane.

6. Install the top outlet pipe elbow, including vortex breaker.

7. Carefully install the vessel top cover over shaft end. Check the location of the dowel pins or the centering shoulder of girth flanges.

11.2.4 Stage four

NOTE: For item numbers, see Appendix 3.

1. Fit the bottom ring of the inflatable seal, the inflatable seal assembly and the lower sealing flange of the stationary seal with O-rings, including header rings if applicable, in the vessel top cover (items 1-9).

2. Fit the O-ring in the lower sealing flange of the stationary seal (item 6).

3. Fit the upper sealing flange of the stationary seal with O-rings, a split locating ring and a clamp ring (items 10-14).

4. Check the axial position of the shaft, and adjust if necessary with the hydraulic jack the following:

   a. the gap between the upper and lower sealing flange of the stationary seal, as indicated on the Manufacturer's drawing.
   b. the centre position of the top and bottom rotor discs in relation to their respective stator rings, taking into consideration the tolerances given in (4.8).

5. Fit the shaft sleeve of the mechanical seal with O-rings (items 15-17), taking into account the correct position in relation to the 'working length' of the seal as indicated on the Manufacturer's drawing.

6. Fit the rotating parts of the mechanical seal (items 20-26). Ensure that the spring retainer contacts the abutment of the sleeve. Check that the grub screws of the spring retainer are properly tightened. Work the seal against spring pressure to ensure that it is moving freely.

7. Install the seal housing with O-rings (items 27, 28, 29 and 36).

8. Fit the stationary seat of the mechanical seal into the clamp plate, ensuring that the seat contacts the bottom of the recess (items 33-35).

9. After wiping the seal faces perfectly clean, install the clamp plate (item 30).

10. Fit the auxiliary lip seals into the clamp plate, ensuring that they are fitted in the correct way and that they contact the bottom of the recess (items 31 and 32).

11. Fit the drive collar with grub screws onto the mechanical seal shaft sleeve (items 18 and 19). Check that the grub screws are properly tightened.

12. Install the bearing housing, including the oil seal ring and the bottom part of the spherical roller bearing (items 37-41).

13. Install the bearing cover flange, including the top part of the spherical roller bearing; and tighten until the end of travel, and then lock with grub screws (items 42-44). Check that the grub screws are properly tightened.

14. Fit the lower flexible coupling half to the rotor shaft (items 45-48).

15. Fill the top bearing housing with the specified lubricating oil (Shell Tellus Oil C230 or Shell Tivela Oil WA, or equivalent approved by the Principal).

Before and during assembly of the shaft sealing parts and the bearing assembly, the

following points shall apply:

a. Ensure that the seal parts are completely free of all the protective coating material before fitting.
b. Check all parts for cleanliness and take care not to damage the seal faces.
c. When fitting O-rings, take care not to cut or damage them.
d. Use a clean light oil during assembly of various seal parts and do not force the parts together.
e. Fit the dowel pins, where indicated on the Manufacturer's drawing.

11.2.5 Stage five

1. Remove the wedges between the top grid and the shaft.
2. Carefully remove the hydraulic jack, so that the weight of rotor is transferred from the jack to the roller bearing.
3. Check that the rotor can be rotated manually and runs true.
4. Check the radial clearance of the bottom sleeve bearing and the intermediate sleeve bearing, if applicable. If it appears that the shaft is not concentric with the bearings, adjust the bearing housings with adjusting bolts.
5. Check the radial clearance between the shaft and the inflatable seal.
6. Install the top sleeve.
7. To ensure the free axial travel of the rotor when it is to be lowered, if stationary sealing is required, the following check should be made:
   a. Lower the rotor carefully by unscrewing the top bearing cover flange, until the upper flange rests on the lower flange of the stationary seal. Measure the travel distance of the rotor at a location on the coupling or on the shaft end at the bottom bearing.
   b. Raise the rotor by tightening the top bearing cover flange over the same travel distance under a.

(The travel distance, i.e. the gap between the upper and lower sealing flange of the stationary seal shall be indicated on the Manufacturer's drawing).

11.2.6 Stage six

1. Install the support for the driving unit.
2. Fit the upper flexible coupling half to the output shaft of the driving unit.
3. Install the driving unit, and align and connect the flexible coupling halves.
4. Fill the driving unit with lubricant, if applicable, as specified by the Manufacturer.
5. Install the auxiliary piping, such as the flushing line of seal housing, the vent/drain line from the seal housing, the nitrogen supply line to the inflatable seal and the luboil cooling system, if any, of the top bearing housing, ensuring that all piping and connections are perfectly clean.
6. Before closing the manholes, check that the inside of the RDC is completely free from all debris, tools, etc., and if necessary clean the inside using a water hose.

11.3 INSTALLATION PROCEDURE FOR RDCs TRANSPORTED WITH ROTOR

If an RDC is transported complete with the rotor, the installation is simpler. Where applicable, the above-mentioned installation requirements should be followed. The temporary supports between the shell and the rotor shall be removed and the dummy bearings shall be replaced by the original bearings in accordance with the Manufacturer's instructions and the following procedure:

1. After erection of the vessel, suspend the rotor by a crane and remove all temporary supports between the rotor and the vessel.
2. Remove the dummy bearings and fit the intermediate bearing, if applicable, and bottom

bearing.

3. Support the rotor shaft end with a hydraulic jack.
4. For assembly of shaft sealing devices, the top bearing and the driving unit, follow the instructions given in (11.2.4, 11.2.5 and 11.2.6).

12. SITE TESTING

Prior to commissioning the RDC, the general items listed in DEP 61.10.08.11-Gen. shall be checked and/or verified.

Prior to commissioning the unit, a 12-hour test run (if not already performed in the Manufacturer's works), a hydrostatic test and an 8-hour test run at operating pressure using water or gas oil shall be performed.

The 12-hour test run is to check the running conditions of the drive and rotor. The purpose of the hydrostatic test is to check the proper functioning of the mechanical seal and inflatable seal when the shaft is stationary. The purpose of the 8-hour test is to check the proper functioning of the mechanical seal during rotation of the shaft.

12.1 12-HOUR TEST RUN

If the 12-hour test run at Manufacturer's works has not been carried out, this shall be done at site in accordance with the test procedure described in (8). Shaft sealing devices and auxiliary piping shall not be installed during this test run; however, the upper and lower sealing flange (without O-ring) of stationary seal and shaft sleeve of mechanical seal shall be mounted.

Before this test run is performed, the correct rotation of electric motor with regard to rotation of RDC shaft shall be checked. Furthermore, the driving unit should be run for a few hours uncoupled from the RDC rotor shaft to check the running properties and the electrical installation.

12.2 HYDROSTATIC TEST

All shaft sealing devices and auxiliary piping shall be installed. The proper installation, of the threaded piping connections and threaded plugs for servicing the shaft seal system, shall be checked.

1. Fill the vessel with clean water or gas oil (see DEP 61.10.08.11-Gen).

   Open the vent on the top cover of the RDC and the vent on the flushing line to release the air.

2. Close the vents when the vessel is completely filled.
3. Pressurize the vessel to the design pressure of the RDC with a charge pump.
4. Check the mechanical seal for leakage from the vent/drain line between the mechanical seal and auxiliary lip seals. The system should still be tight after one hour. At the same time all connections of piping and instruments, the top cover flange, manhole flanges, etc., shall be checked for leakage.
5. Apply nitrogen to the inflatable seal at a pressure of 8-10 bar above the pressure in the vessel, indicated on the pressure gauge at the top of the RDC.
6. Gradually release the pressure in the seal housing by opening the vent on the flushing line.
7. After the seal housing is depressurized, check that no liquid leaks from the vent on the flushing line, which indicates that inflatable seal is functioning properly.
8. Close the vent on the flushing line.
9. Gradually release the nitrogen pressure from the inflatable seal.
10. During the above operations, check all flange connections for leakage.

12.3 8-HOUR TEST RUN

Further to the procedure as described in (12.2), continue as follows:

1. Open the valve in the flushing line and adjust the flow to between 4 and 5 litres/min (see Note 1).

2. Maintain the maximum operating pressure in the vessel.
3. Switch on the electric motor of the driving unit, taking care that the variable-speed transmission is at minimum speed.
4. Increase the speed of the RDC shaft to maximum speed (see Note 2) with the hand wheel on variable-speed transmission.
5. Run the RDC uninterrupted for 8 hours at maximum operating pressure and speed (see Note 2), observing:
   a. the absorbed power in kW
   b. the temperature of the driving unit and speed transmission
   c. the temperature of the top bearing housing
   d. the flow in the flushing line (see Note 1)
   e. the proper functioning of the mechanical seal (no liquid should leak from vent/drain line between mechanical seal and auxiliary lip seals).
6. Upon completion of the test run, check the speed range of the RDC.
7. After successful completion of the test run, reduce the speed of the RDC shaft to minimum speed and switch off the electric motor of the driving unit.
8. Close the valve in the flushing line and depressurize the vessel.

If no abnormalities have been observed during the test, no further inspection is required.

9. Change the oil in the top bearing housing and driving unit, where applicable, after which the RDC is ready for final commissioning.

NOTES:
1. If the direction of flow in the flushing line is from the seal housing during normal operation of the RDC, the flushing line can be used during the test. If the direction of flow during normal operation is in the reverse direction, the flushing line cannot be used during the test since the proper flushing liquid will not be available. In the latter case it will suffice to open the vent on the flushing line at 15 minute intervals during the test run to check that the seal housing is completely filled with liquid.
2. For RDCs in deasphalting service, this test cannot be carried out with water at maximum operating speed since the electric motor has been rated for propane (specific gravity 0.45). Therefore, the test run using water shall be carried out at approximately 80% of the maximum operating speed to avoid overloading of the electric motor.

13. MAINTENANCE

13.1 GENERAL

During operation, the RDC requires neither special supervision nor maintenance. However, the following items shall be checked at regular intervals:

1. The lubricating oil level in the top bearing housing.
2. The lubricating oil level in the variable-speed transmission of the driving unit, where applicable.
3. Quality of lubricating oil:

   Lubricating oil in the top bearing housing shall be changed either on the basis of quality monitoring or every 6 months. Lubricating oil in the speed transmission shall be changed in accordance with the Manufacturer's instructions.
4. Some parts of the driving unit may need some drops of oil or grease (in accordance with the Manufacturer's instructions).
5. The flow in the flushing lines to and from the seal housing, which should be between 4 and 5 litres/min or as stated by the Manufacturer.
6. Vibration of the driving unit.
7. Available nitrogen pressure for the inflatable seal (8-10 bar above the maximum operating pressure at the top of the RDC).
8. Proper functioning of the speed variator.

Wear or grease on the friction ring, cone contact faces or V-belts (depending on construction) may cause the variator of the mechanical type to slip under heavy load.

If no difficulties are experienced during normal operation, inspection of the shaft sealing devices, bearings and driving unit should be performed once every three years of operation.

The external surafce of the RDC shall be inspected for under-lagging corrosion every three years if the RDC has operated at a temperature below 80 °C.

Paint and insulation shall be inspected at the first opportunity if for any reason the operating temperature has fallen below 0 °C.

Maintenance painting shall be in accordance with DEP 70.48.10.10-Gen.

13.2 MECHANICAL SEAL FAILURE

If a mechanical seal failure is experienced during operation of the RDC, the following procedure shall be carried out:

1. Switch off the electric motor of driving unit.
2. Turn off the flushing liquid to/from the seal housing.
3. Apply nitrogen to the inflatable seal at a pressure of 8-10 bar above the operating pressure at the top of the RDC.
4. To achieve the sealed position of the stationary seal, lower the rotor shaft by unscrewing the top bearing cover flange (see Appendix 3, items 43 and 44) until the flange can easily be moved by hand, which indicates that the upper sealing flange is resting on the lower sealing flange.

   During lowering of the shaft, turn the shaft slightly to reduce the friction between the inflatable seal cuff and the shaft (depending on the construction, it may be necessary to remove the driving unit with support before the shaft can be lowered.
5. When the stationary seal is obtained in this way, gradually release the nitrogen pressure to the inflatable seal and check for any leakage of liquid or gas from the vent on the flushing line. If leakage is observed re-apply nitrogen at the correct pressure (see 13.1).

13.3 REPAIR OF SHAFT SEALING DEVICES

When the rotor shaft has been lowered and a proper stationary seal has been obtained, the top bearing and mechanical seal can be dismantled under full (or, if preferred, limited) operating pressure of the vessel. Although not essential, nitrogen at the correct pressure (13.1) should be supplied to the inflatable seal as an extra safety precaution.

When the rotor shaft has been lowered and leakage of liquid or gas is observed, this may indicate damage to the O-ring (see Appendix 3, item 9) of the stationary seal, and mechanical seal repairs shall not be carried out with the RDC under pressure. In this case, inspection and repair of all sealing devices shall be carried out after the RDC has been taken out of operation and the vessel completely drained.

13.3.1 Dismantling and assembling of top bearing and mechanical seal

This dismantling procedure is based on the assumption that the RDC is out of operation and the vessel has been completely drained. If the RDC is under pressure (and a proper stationary seal has been obtained) the items marked * are not applicable.

Dismantling of top bearing and mechanical seal shall be carried out in the following sequence (see Appendix 3):

1. Drain the lubricating oil from the top bearing housing.
2. Remove the auxiliary piping, i.e. the flushing line of the seal housing, the vent/drain lines from the seal housing and the lubricating oil cooling system, if any, from the bearing housing.
3. Remove the driving unit.
4. Remove the driving unit support.

*5. Insert a hydraulic jack in the bottom of the vessel.

*6. Support the rotor shaft end with the hydraulic jack, so that the weight of rotor is transferred from the top bearing onto the hydraulic jack.

*7. Remove the top sleeve between the RDC top cover and the top grid.

*8. Fit wedges between the rotor shaft and the grid to keep the rotor in the centre position.

9. Remove the flexible coupling half from the rotor shaft (items 45-48).
10. Remove the top bearing cover flange, including the top part of the spherical roller bearing (items 42-44).
11. Remove the bearing housing, including the bottom part of the spherical roller bearing (items 37-41).
12. Remove the drive collar of the mechanical seal shaft sleeve (items 18-19).
13. Remove the clamp plate from the seal housing, including the stationary seat and auxiliary lip seals (items 30-36).
14. Remove the seal housing (items 27-29).
15. Remove the rotating parts of the mechanical seal (items 20-26).
16. Remove the shaft sleeve of the mechanical seal, after having measured the sleeve location on the shaft (items 15-17).

Inspect all sealing parts and the top bearing. If any wear is detected on the rotary seal face and/or the stationary seat (items 26 and 35), return these parts to the seal supplier for re-lapping.

After replacement of the damaged parts and all O-rings of the assembly and auxiliary lip seals, reassembly of the mechanical seal, top bearing and driving unit shall be in the reverse order to that described above and in accordance with the installation procedure given in (11.2.4, 11.2.5 and 11.2.6).

During this procedure attention should be given to the following:

For the setting of the correct position of the mechanical seal shaft sleeve on the shaft, the travel distance (i.e. the gap between the lower and upper sealing flange) should be added to the 'working length' of the mechanical seal.

After the work is finished, the proper installation of the thread connections and the thread plug shall be checked.

13.3.2 Dismantling and reassembly of stationary seal and inflatable seal

If a proper stationary seal cannot be obtained and/or the inflatable seal is leaking, the stationary seal and/or inflatable seal shall be inspected with the RDC out of operation and with the vessel completely drained.

Following the dismantling of the top bearing and mechanical seal, as described in (13.3.1), dismantling of the stationary seal and inflatable seal shall be carried out in the following sequence (see Appendix 3):

1. Remove the clamp ring (items 13 and 14).
2. Remove the split locating ring (item 12).
3. Remove the upper sealing flange with the O-ring of the stationary seal (items 10 and 11).
4. Remove the lower sealing flange of the stationary seal (items 6-9).
5. Remove the inflatable seal with header rings, if applicable (items 2-5).
6. Remove the bottom ring of the inflatable seal (item 1).

Inspect all sealing parts.

After replacement of the damaged parts and all O-rings of the assembly, reassemble the inflatable seal and stationary seal in the reverse order to that described above and in accordance with the installation procedure given in (11.2.4).

14. REFERENCES

In this DEP reference is made to the following publications:

NOTE: Unless specifically designated by the date, the latest edition 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.
Thermal insulation for hot services	DEP 30.46.00.31-Gen.
Painting and coating for new construction projects	DEP 30.48.00.31-Gen.
Noise control	DEP 31.10.00.31-Gen.
Data/requisition sheet for equipment noise limitation	DEP 31.10.00.94-Gen.
Data/requisition sheet for a rotating disc contactor	DEP 31.22.01.93-Gen.
Pressure vessels (Amendments/Supplements to BS 5500)	DEP 31.22.10.32-Gen.
Pressure vessels (Amendments/Supplements to ASME Section VIII, Division 1 and Division 2)	DEP 31.22.20.31-Gen.
Centrifugal pumps (Amendments/Supplements to API Std 610)	DEP 31.29.02.30-Gen.
Electric motors - Cage-induction and synchronous type	DEP 33.66.05.31-Gen.
Electrical variable speed drive systems	DEP 33.66.05.33-Gen.
Requisition for electric motors	DEP 33.66.05.93-Gen.
Fire hazards and fireproofing/cold splash protection of steel structures	DEP 34.19.20.11-Gen.
Field inspection prior to commissioning of mechanical equipment	DEP 61.10.08.11-Gen.
The preservation of old and new equipment and piping standing idle	DEP 70.10.70.11-Gen.
Spare parts for initial and normal operation	DEP 70.10.90.11-Gen.
Maintenance painting	DEP 70.48.10.10-Gen.
Asbestos and asbestos substitutes	MF 94-0960

STANDARD DRAWINGS

Vortex breakers	S 10.010
Nozzles to apparatus	S 10.101
Skirts, cylindrical and conical	S 20.001
Skirts with fireproof protection	S 20.002

Support rings for insulation	S 20.003
Anchor bolt ring or lugs and baseplate for columns	S 20.004
Typical drawing of a rotating disc contactor	S 23.101
Typical drawing of shaft sealing and top bearing of a rotating disc contactor	S 23.104
Typical drawing of shaft, intermediate and bottom bearing of a rotating disc contactor	S 23.105
Typical drawing of grids for a rotating disc contactor	S 23.106

AMERICAN STANDARDS

Oil-field V-belting	API 1B
Gear units for refinery services	API 677

Issued by:
American Petroleum Institute
Publications and Distribution Section
1220 L Street Northwest
Washington DC. 20005
USA.

ASME Boiler and Pressure Vessel Code:

Rules for construction of pressure vessels	ASME VIII

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

BRITISH STANDARDS

Specification for flexible couplings for power transmission	BS 3170
Specification for endless wedge belt drives and endless V-belt drives	BS 3790
Code of practice for safeguarding of machinery	BS 5304
Unfired fusion welded pressure vessels	BS 5500

Issued by:
British Standards Institution
389 Chiswick High Road
London W4 4AL
England, United KIngdom.

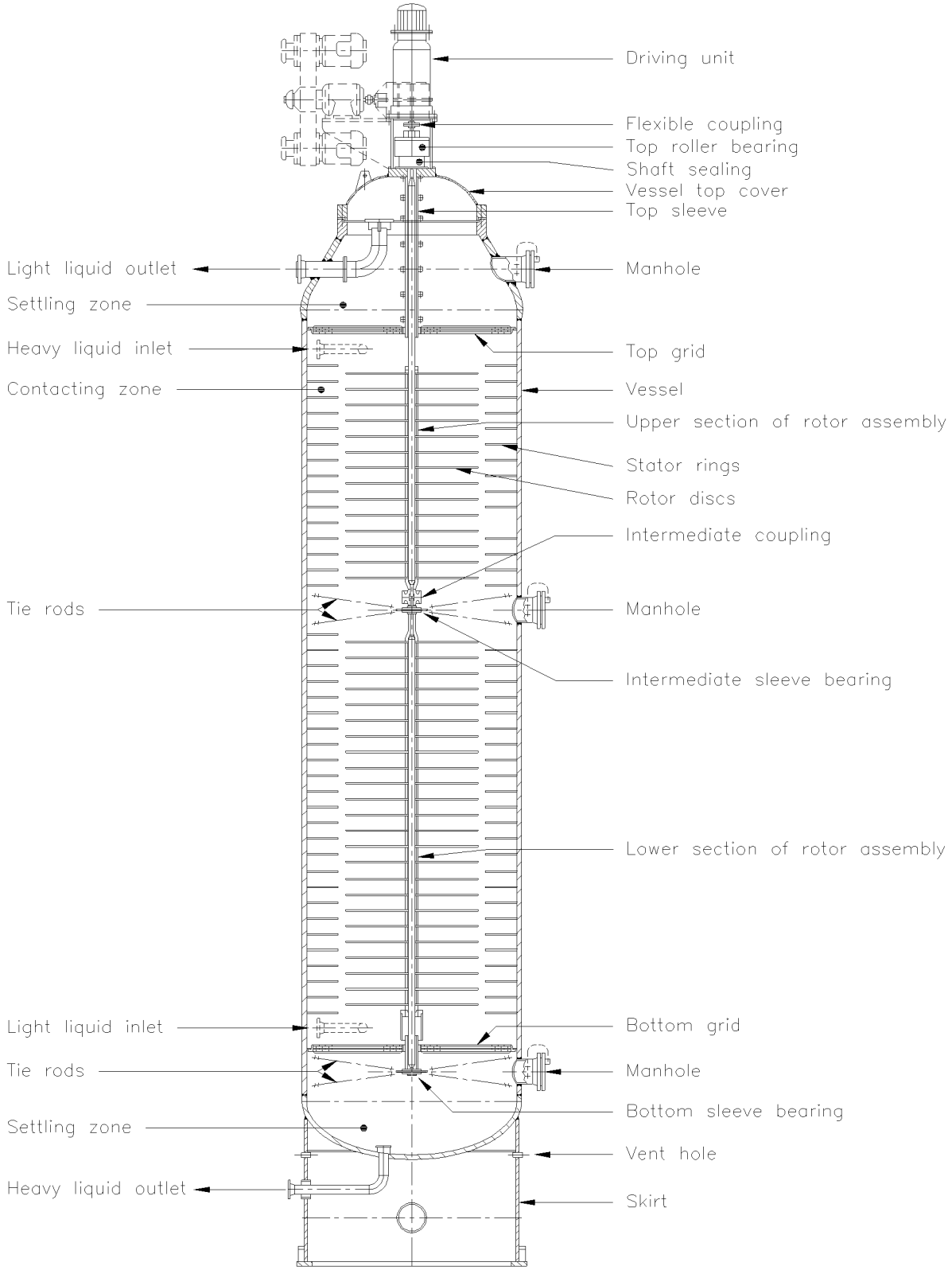
GERMAN STANDARDS

Endless Narrow V-belts for Industrial Purposes; dimensions	DIN 7753
Flanged couplings for carbon and stainless steel agitators; coupling in the agitator vessel; dimensions	DIN 28155

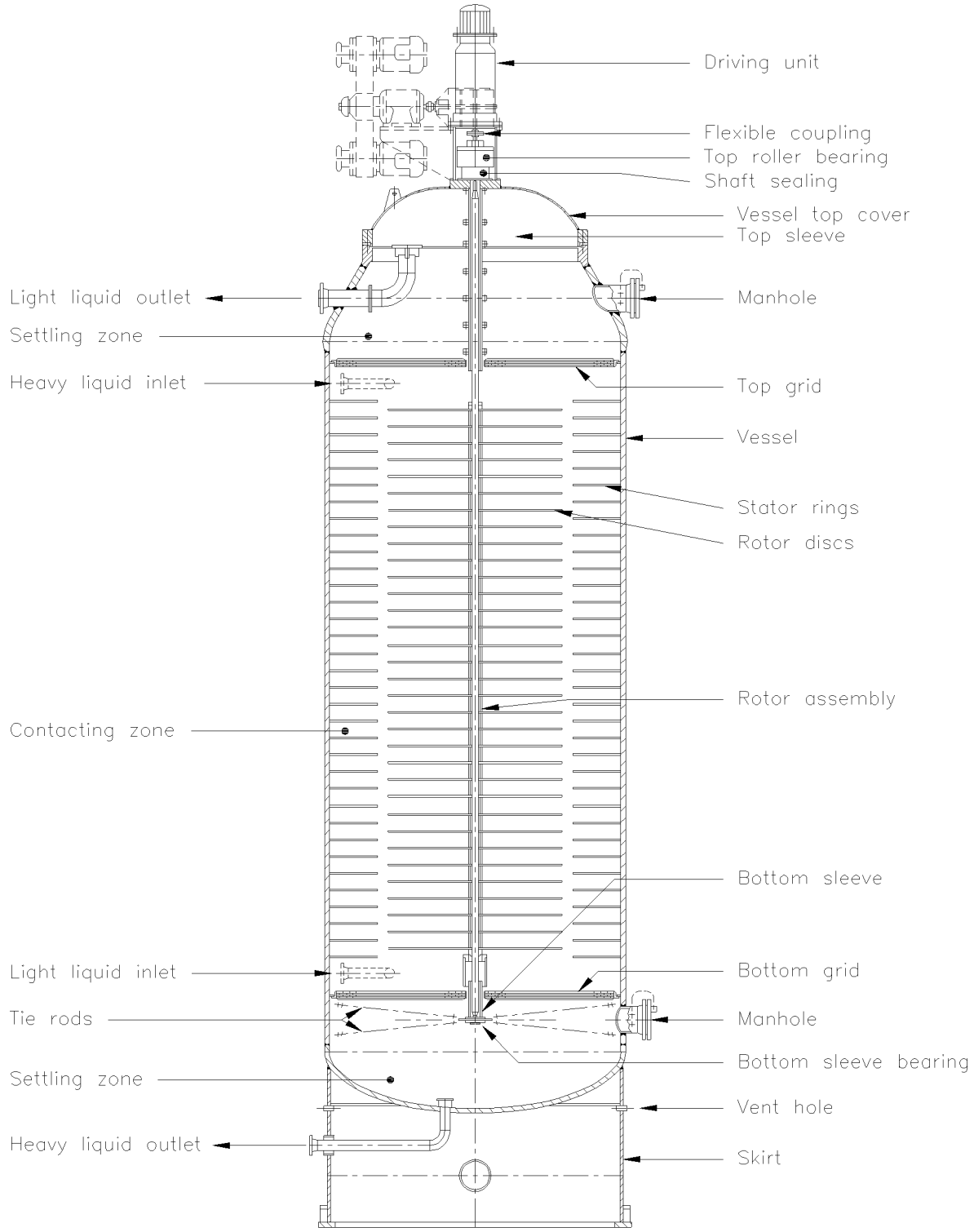
Issued by:
Beuth Verlag GmbH

Burggrafenstrasse 4 - 10
D-1000 Berlin 30
Germany.

APPENDIX 1 RDC WITH SHAFT IN TWO SECTIONS



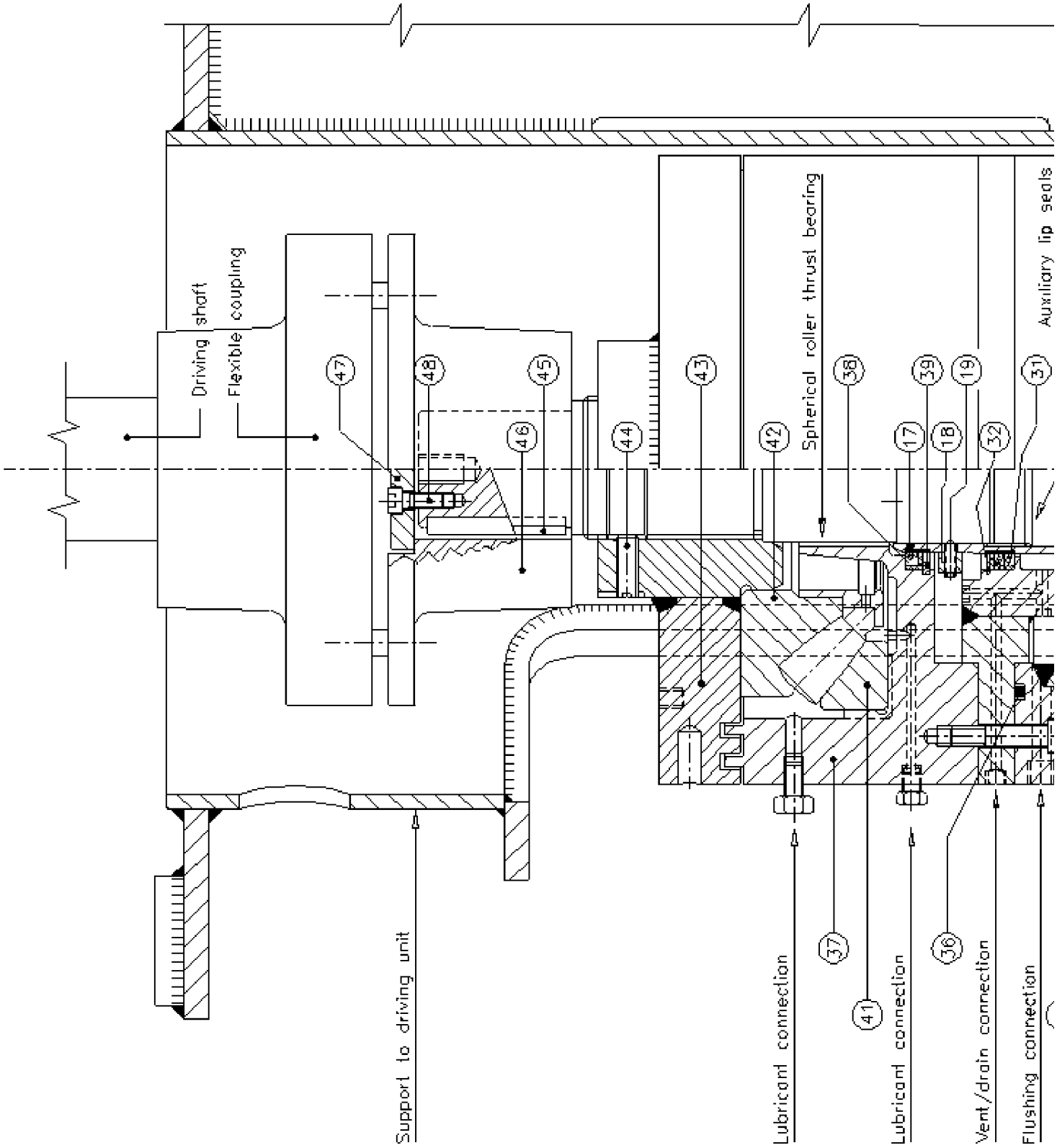
APPENDIX 2 RDC WITH SINGLE SHAFT

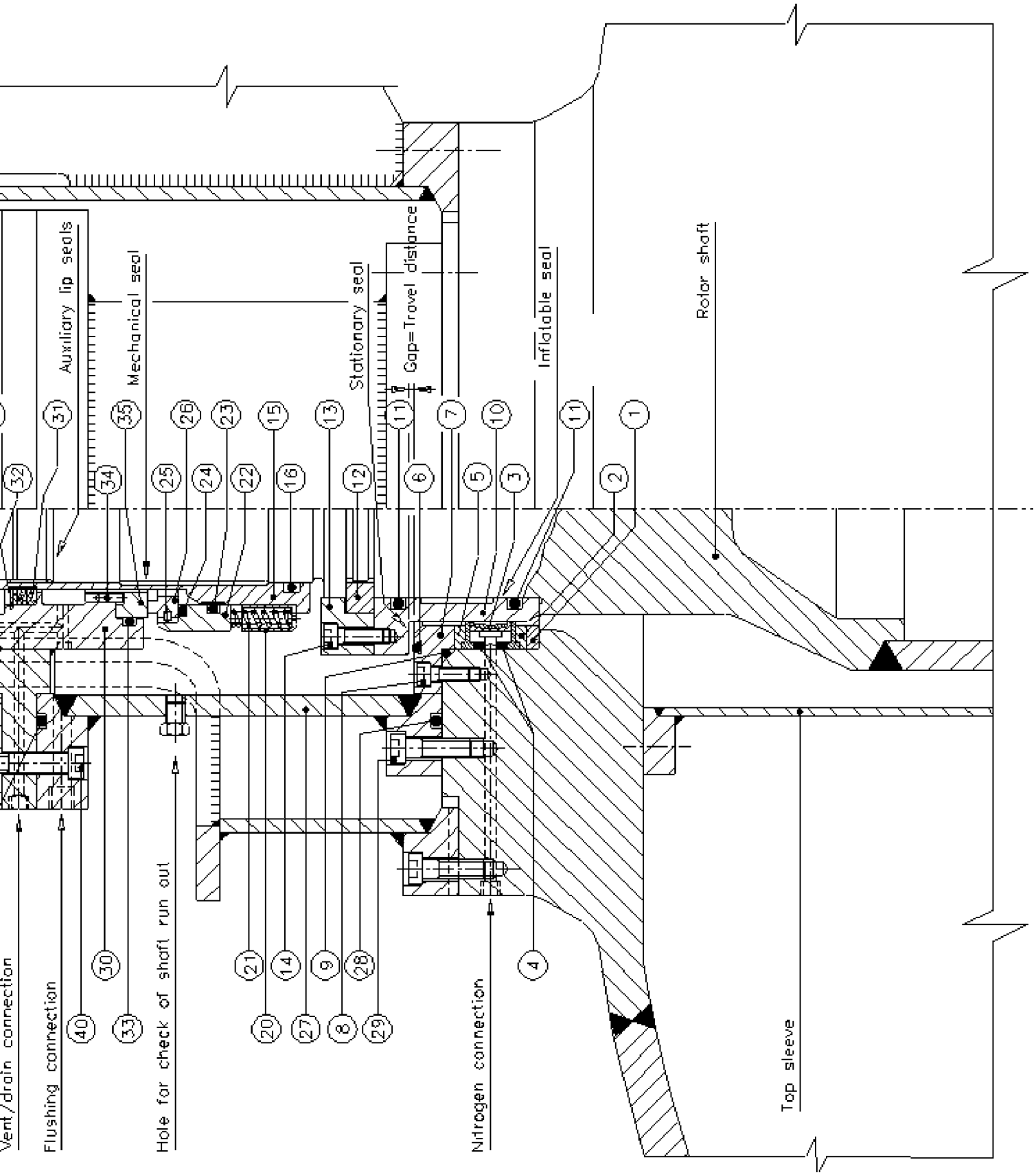


APPENDIX 3 SHAFT SEALING AND TOP BEARING

PARTS LIST FOR FIGURE OF APPENDIX 3

Item No.	
1	Bottom ring
2	Bottom header ring
3	Inflatable seal
4	O-ring (2x)
5	Top header ring
6	O-ring
7	Lower sealing flange
8	Bolt
9	O-ring
10	Upper sealing flange
11	O-ring (2x)
12	Split locating ring
13	Clamp ring
14	Bolt
15	Shaft sleeve
16	O-ring
17	O-ring
18	Drive collar
19	Grub screw
20	Spring retainer
21	Spring assembly
22	Seal face carrier
23	O-ring
24	O-ring
25	Drive pin
26	Rotary seal face
27	Seal housing
28	O-ring
29	Bolt
30	Clamp plate
31	Lip seal (2x) (incl. thrust ring)
32	Circlip
33	O-ring
34	Lock pin
35	Stationary seat
36	O-ring
37	Bearing housing
38	Oil seal ring (incl. thrust ring)
39	Circlip
40	Bolt
41	Bottom part of spherical roller bearing
42	Top part of spherical roller bearing
43	Bearing cover flange
44	Grub screw
45	Key
46	Coupling half
47	Lock plate
48	Lock screw


Driving shaft
Flexible coupling
47
48
45
46
44
43
42
Spherical roller thrust bearing
38
39
19
17
18
32
31
Auxiliary lip seals
Support to driving unit
Lubricant connection
37
41
Lubricant connection
36
Vent/drain connection
Flushing connection


Auxiliary lip seals
Mechanical seal
Stationary seal
Gap=Travel distance
Inflatable seal
Rotor shaft
Vent/drain connection
Flushing connection
Hole for check of shaft run out
Nitrogen connection
Top sleeve