

DEP SPECIFICATION

ROTATING DISC CONTACTORS

DEP 31.22.01.31-Gen.

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(DEP Circulars 110/08 and 03/11 have been incorporated)

(DEP Circular 14/12 has been incorporated)

DESIGN AND ENGINEERING PRACTICE



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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.

Although there are worldwide several RDCs operating, mainly in refinery extraction processes, new applications are limited and often replaced by column tray technology. This DEP can be used for like-for-like replacements, repair and maintenance purposes.

This DEP is a revision of the, DEP with the same number, dated December 1995; a summary of the main changes is given in (1.5).

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorized by Shell GSI 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, where necessary, to Contractors and Manufacturers nominated by them.

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

When DEPs are applied, a Management of Change (MOC) process should be implemented; this is of particular importance when existing facilities are to be modified.

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

1.3 DEFINITIONS

1.3.1 General Definitions

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

The word **should** indicate 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 document 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).

1.5 CHANGES SINCE PREVIOUS ADDITION

The previous edition of this DEP was dated December 1995. Other than editorial changes, the following are the major changes to the previous edition.

- Update to reflect the latest practical experiences and lessons learnt.
- Seals details are updated and based on latest specifications.
- Testing requirements updated based on latest experiences.
- Interface management is added.
- Documentation requirements updated.

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be sent to the DEP Administrator at standards@shell.com. Shell staff may also post comments on this DEP on the Surface Global Network (SGN) under the Standards/DEP 31.22.01.31-Gen. folder. The DEP Administrator and DEP Author monitor these folders on a regular basis.

1.7 DUAL UNITS

**Amended per
Circular 14/12**

Dual units have been incorporated throughout this DEP.

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

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 tangentially or equipped with a tangential inlet deflector 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 drain 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 conditions, for which adequate safety precautions shall be made.

3. BASIC REQUIREMENTS

3.1 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.

Manufacturer's construction details based on proven experience shall be also acceptable.

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.

4. DESIGN AND ENGINEERING

4.1 VESSEL

The design of the vessel shall be in accordance with DEP 31.22.10.32-Gen., DEP 31.22.11.32-Gen. DEP 31.22.20.31-Gen., or DEP 31.22.31.31-Gen. as specified by the Principal.

4.1.1 Skirt

The RDC shall be provided with a full cylindrical/conical 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, DEP 31.22.10.32-Gen., DEP 31.22.11.32-Gen. or DEP 31.22.20.31-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. 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 4 mm (3/16 in) + 2 (1/16 in) x (corrosion allowance).

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

4.1.6 Shell Flanges

The inside diameter of the shell flanges shall be sufficient to allow proper installation/removal of the rotor assembly.

For economical/practical reasons a full vessel diameter shell flange is acceptable.

4.1.7 Top Head

The top cone / head construction as specified in Appendix 1 and Appendix 2 is for information only and deviations are acceptable if approved by the Principal.

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 not be used 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 bottom bearing and intermediate bearing, if applicable, shall be positioned in the centre of the vessel by means of adjustable tie rods (or suitable beam type supporting) 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 (to be specified by the Principal) 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 (optional, to be specified by the Principal)

4.4.1 Mechanical seals

All mechanical seals shall be in accordance with DEP 31.29.00.33-Gen

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 of the seals' auxiliary facilities such as circulation, injection, quenching and cooling, as required for the seal selected by the seal Manufacturer. These auxiliary facilities shall be supplied and installed by the (site) contractor.

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 (see also 12.2.1).

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. Uplift of the rotor assembly during operation shall be checked for and prevented.

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. See also 12.2.1.

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 drain 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.

The above lines/piping and auxiliaries shall be supplied by the Principal (or the site contractor).

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 (optional) 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.

Before working on an operating RDC an HSE risk analysis shall be performed. Refer also to 13.3.1 and 13.3.2.

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 (116-145 psi) 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 gearbox. 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 step-less variable type, equipped with a handwheel for manual speed control. A hydraulic variator is preferred; however, for capacities less than 7.5 kW (10 HP), 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 gearbox shall be applied. For the horizontal arrangement a flanged fitting bevel gear box is preferred; however, a flexible coupling between speed variator and gearbox is allowed.

The reduction gearbox 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 to V-belts (also known as conventional or 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 or BS 3790.

Wedge belts or V-belts shall only be used for duties up to 20 kW (27HP).

Integral multi-belts of the endless type shall be used for duties from 20 kW (27 HP) to 55 Kw (74 HP).