

TECHNICAL SPECIFICATION

LIQUID RING VACUUM PUMPS AND COMPRESSORS (AMENDMENTS/SUPPLEMENTS TO API STD 681)

DEP 31.29.42.30-Gen.

July 1997

DESIGN AND ENGINEERING PRACTICE

USED BY
COMPANIES OF THE ROYAL DUTCH/SHELL GROUP



This document is confidential. Neither the whole nor any part of this document may be disclosed to any third party without the prior written consent of Shell International Oil Products B.V. and Shell International Exploration and Production B.V., The Hague, The Netherlands. The copyright of this document is vested in these companies. All rights reserved. Neither the whole nor any part of this document may be reproduced, stored in any retrieval system or transmitted in any form or by any means (electronic, mechanical, reprographic, recording or otherwise) without the prior written consent of the copyright owners.

PREFACE

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

Shell International Oil Products B.V. (SIOP)
and
Shell International Exploration and Production B.V. (SIEP)
and
Shell International Chemicals B.V. (SIC)
The Hague, The Netherlands,
and other Service Companies.

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

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

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

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

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

- 1) Operating companies having a Service Agreement with SIOP, SIEP, SIC or other Service Company. The use of DEPs by these Operating companies is subject in all respects to the terms and conditions of the relevant Service Agreement.
- 2) Other parties who are authorized to use DEPs subject to appropriate contractual arrangements.
- 3) Contractors/subcontractors and Manufacturers/Suppliers under a contract with users referred to under 1) or 2) which requires that tenders for projects, materials supplied or - generally - work performed on behalf of the said users comply with the relevant standards.

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

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

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

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

TABLE OF CONTENTS

PART I	INTRODUCTION.....	4
1.1	SCOPE.....	4
1.2	DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS	4
1.3	DEFINITIONS.....	4
1.4	CROSS-REFERENCES.....	4
1.5	GUIDANCE FOR USE.....	5
PART II	AMENDMENTS/SUPPLEMENTS TO API STD 681	6
SECTION 1	GENERAL.....	6
1.3	CONFLICTING REQUIREMENTS.....	6
1.4	DEFINITION OF TERMS.....	6
1.5	REFERENCED PUBLICATIONS	6
SECTION 2	BASIC DESIGN.....	6
2.1	GENERAL.....	6
2.3	CASING CONNECTIONS	7
2.4	EXTERNAL FORCES AND MOMENTS.....	7
2.5	ROTATING ELEMENTS.....	7
2.6	MECHANICAL SHAFT SEALS.....	7
2.7	DYNAMICS.....	8
2.8	BEARINGS, BEARING HOUSINGS AND LUBRICATION.....	8
2.9	MATERIALS	8
SECTION 3	ACCESSORIES.....	8
3.1	RING LIQUID SYSTEM.....	8
3.2	CONTROLS AND INSTRUMENTATION	9
3.3	DRIVERS AND TRANSMISSIONS	9
3.4	COUPLINGS AND GUARDS	10
3.7	PIPING.....	10
SECTION 4	INSPECTION, TESTING, AND PREPARATION FOR SHIPMENT	10
4.1	GENERAL.....	10
4.2	INSPECTION.....	11
4.3	TESTING.....	12
PART III	REFERENCES.....	13

PART I INTRODUCTION

1.1 SCOPE

This new DEP specifies requirements and gives recommendations for liquid ring vacuum pumps and compressors. Part II of this DEP gives amendments and supplements to API Std 681, on which this DEP is based.

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, gas handling installations, chemical 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, commissioning or management of a project, or operation or maintenance of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** 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 **Purchaser** is the party which buys the liquid ring compressor or pump for its own use or as an agent for the owner. The Purchaser may be either the Principal or the Contractor.

The term **Vendor** used in API Std 681 is synonymous with the term Manufacturer/Supplier as defined above.

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets. Referenced section numbers in the API document are not shown in brackets. Other documents referenced in this DEP are listed in (Part III).

1.5 GUIDANCE FOR USE

The amendments and supplements given in Part II refer directly to specific sections in API

Std 681. Where clauses in API Std 681 are referenced within this DEP, those clauses as amended by this DEP shall be meant. Clauses in API Std 681 that are not amended by this DEP shall remain valid as written.

A bullet (•) in the margin against certain clauses in API Std 681 indicates that a decision by the Principal is required. These decisions shall be indicated directly on the requisition sheet where provided for; otherwise they shall be indicated on the requisition sheet under the heading 'Additional Requirements' or stated in the purchase order.

PART II AMENDMENTS/SUPPLEMENTS TO API STD 681

SECTION 1 GENERAL

1.3 CONFLICTING REQUIREMENTS

Replace this clause by:

In the 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 : requisition;
- third level : this DEP.

1.4 DEFINITION OF TERMS

Add new clause:

1.4.27 "Hazardous service" is defined as a service in which the process stream contains:

- hydrogen sulphide above 600 mg/kg;
- hydrogen plus hydrocarbons when the partial pressure of hydrogen exceeds 0.7 MPa (7 bar abs);
- hydrocarbons at an operating temperature above the auto-ignition temperature;
- toxic substances (as indicated on the data/requisition sheet);
- hydrocarbon services butane and lighter;
- hydrocarbon services with a seal chamber vapour pressure greater than 0.5 MPa (5 bar abs).

1.5 REFERENCED PUBLICATIONS

Add to this clause:

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

SECTION 2 BASIC DESIGN

2.1 GENERAL

2.1.1 Add to this clause:

The equipment shall not exceed the limits of the Vendor's design and shall be within the Vendor's actual experience. Equipment shall have proven reliability.

2.1.3 Add to this clause:

Data/requisition sheets for Rotary Type Compressors and Fans (ref. DEP 31.29.42.93-Gen.) may be used. The Purchaser shall specify the equipment's normal operating duty and any alternative duties on the data sheets.

2.1.4 Replace this clause by:

- Noise Control:

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

The Vendor shall submit guaranteed sound power levels and sound pressure levels of the equipment, together with any other relevant information requested in the data sheet, DEP 31.10.00.94-Gen. The Vendor shall indicate which special measures, if any, are proposed in order to meet the specified levels.

2.1.8 Replace this clause by:

- All electrical components and installations shall be suitable for the area classification, gas grouping and temperature classes specified by the Principal on the data/requisition sheet.

2.1.14 Replace the first sentence of this clause by:

All equipment shall be additionally suitable for running on air during testing and commissioning.

2.3 CASING CONNECTIONS

2.3.3 Delete the words "or threaded and seal welded" from the first sentence.

2.3.4 Replace this clause by:

Threaded connections shall not be used for equipment in hazardous service. Where threaded joints are supplied they shall not be seal welded.

2.3.6 Add to this clause:

NOTE: The excluded opening sizes may be accepted if the cost impact of changing the Vendor's standard design exceeds the cost of non-standard piping design.

2.3.8.5 Add new clause:

In hazardous service applications or when specified the gasket contact surface finish shall be in accordance with API Std 610 clause 2.3.2.6.

2.4 EXTERNAL FORCES AND MOMENTS

Add to this clause:

Alternatively the nozzle loadings outlined in API Std 610 should be used.

2.5 ROTATING ELEMENTS

2.5.3 Add to the end of the second sentence:

... and with the approval of the Principal.

NOTE: Filling the void with metal may lead to unacceptable vibration levels. Consideration shall be given to the method of venting, particularly in hazardous service.

2.6 MECHANICAL SHAFT SEALS

2.6.6 Add to this clause:

NOTE: Mechanical seals shall normally have silicon carbide face material and carbon seat material unless incompatible with the seal liquid.

2.6.9 Add to this clause:

Alternatively, the mechanical seal piping may be in accordance with the appropriate plan shown in API Std 682.

2.7 DYNAMICS

2.7.2.3 Replace this clause by:

- If specified, the level quoted in 2.7.2.2 shall be demonstrated for all operating conditions specified in the data sheets.

2.8 BEARINGS, BEARING HOUSINGS AND LUBRICATION

2.8.1.1 Add to this clause:

Cages of antifriction bearings shall be metal.

2.8.2.3 Replace the word "toxic" with "hazardous".

2.8.2.6 Add to this clause:

For small units, it may not be practical for the location of the vibration transducer to be in accordance with API Std 670. In such cases the location of the transducer shall be in accordance with the Vendor's standard.

2.9 MATERIALS

2.9.1.9 Replace this clause by:

- All materials for components exposed to hydrogen sulphide in concentrations exceeding the limits prescribed by NACE MR0175 shall conform to the requirements of NACE MR0175. All external bolting on the casing and seal glands shall also conform to the above requirements even where NACE MR0175 restricts the requirement to enclosed bolting. The Purchaser shall specify on the data sheets the level of hydrogen sulphide in the process gas.

2.9.4 Replace this clause by:

The minimum temperature for which the pump shall be suitable shall be specified on the data/requisition sheet. If this temperature is 0 °C or below, the materials of the pressure-containing parts shall be in accordance with DEP 30.10.02.31-Gen.

SECTION 3 ACCESSORIES

3.1 RING LIQUID SYSTEM

3.1.1.2 Add to item a):

In some instances it may be preferable to have two separators, one for gas/vapour-liquid separation and one for liquid-liquid separation. The preferred arrangement should be agreed between Purchaser and Vendor.

3.1.1.7 Add to this clause:

The Purchaser shall specify whether the vessels shall also be in accordance with DEP 31.22.10.32-Gen. or DEP 31.22.20.31-Gen.

3.1.2.1 Add to this clause:

The Vendor shall provide the basis of the separator design in its technical proposal.

3.1.3.1 Replace this clause by:

- The cooler shall be either a shell-and-tube heat exchanger or an air-cooled heat exchanger. The Purchaser shall specify the preferred type of cooler and the range of physical properties of the cooling medium.

3.1.3.5 Add to this clause:

The Purchaser shall specify whether the cooler design shall also be in accordance with DEP 31.21.01.30-Gen.

3.1.3.6 Add new clause:

- If air coolers are specified, they shall be in accordance with API Std 661 and shall have automatic temperature control. In addition, the Purchaser shall specify whether the air cooler design shall also be in accordance with DEP 31.21.70.31-Gen.

3.1.5.2 Add to this clause:

The Purchaser shall specify whether the pumps shall also be in accordance with DEP 31.29.02.30-Gen.

3.2 CONTROLS AND INSTRUMENTATION

3.2.1.1 Add new clause:

Instrumentation supplied as part of the package by the Vendor shall conform to DEP 32.31.09.31-Gen. Unless otherwise stated the scope of supply shall be in accordance with Option A.

3.2.4.2.1 Replace the second sentence of this clause by:

They shall be at least 125 mm in diameter and of the bimetallic type. Liquid or mercury filled systems shall not be used.

3.2.4.4 Add to this clause:

Only thermocouple detectors shall be used.

3.2.4.5 Replace the third sentence by:

Oil-filled gauges should not be used and consideration should be given to providing vibration-resistant gauges.

3.2.5.3.2 Replace this clause by:

Switches shall be normally energised and give an alarm and/or trip signal when de-energised, i.e. a fail-safe configuration.

3.2.5.3.3 Add to this clause:

The Vendor shall provide voltage-free contacts for the Purchaser to connect a remote alarm to the plant control/monitoring system to announce when trips are overridden.

3.3 DRIVERS AND TRANSMISSIONS

3.3.5 Replace this clause by:

- Electric motor drives shall be as specified in data/requisition sheet DEP 33.66.05.93-Gen. and shall comply with DEP 33.66.05.31-Gen.

3.4 COUPLINGS AND GUARDS

3.4.1 Add to this clause:

- The Purchaser shall specify whether the couplings shall conform to API Std 671.

3.7 PIPING

3.7.1.2 Add to this clause:

Carbon steel piping components that are welded shall have a maximum carbon content of 0.23%. The carbon equivalent (CE) shall be 0.45 maximum determined by the following formula:

$$CE = \%C + \%Mn/6 + (\%Cr + \%Mo + \%V)/5 + (\%Ni + \%Cu)/15$$

Seamless pipe manufactured in accordance with API Spec 5L Gr B is acceptable in lieu of ASTM A 106 Gr B and ASTM A 53 Gr B.

If "sour service" or NACE MR0175 is specified, carbon steel piping shall have a maximum sulphur content of 0.01%.

Delete the sentence which makes reference to Table 4.

3.7.1.16 Add new clause:

Threaded connections shall not be used for piping in hazardous services. Where threaded connections are supplied they shall not be seal welded.

SECTION 4 INSPECTION, TESTING, AND PREPARATION FOR SHIPMENT

4.1 GENERAL

Add new clause:

4.1.7 **Quality system**

The Vendor shall have an implemented quality system in accordance with ISO 9001 or equivalent standard.

Add new clause:

4.1.8 Material certificates

The Vendor shall furnish material certificates in accordance with ISO 10474 as specified below:

COMPONENT	TYPE OF CERTIFICATE
Pressure-containing parts	3.1.B
Rotor	3.1.B
Bolting	3.1.B
All other process and auxiliary piping, flanges and connections	3.1.B

NOTES: 1. The above certification requirements assume that the quality system of the material manufacturer complies with (4.1.7) of this DEP.

2. The Purchaser shall specify whether the certification requirements are to be type 2.1 or 3.1.C for a particular application.

Add new clause:

4.1.9 Marking

Marking is required for all pressure casings.

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

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

The stamping/markings shall include:

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

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

4.2 INSPECTION

4.2.1.1 Replace the first sentence of this clause by:

The Vendor shall keep the data listed below available for examination by the Purchaser or his representative upon request. The data shall be kept for at least 10 years or shall be offered to the Purchaser after 5 years.

Add new clause:

4.2.1.4 Shop inspection

The scope of Purchaser's shop inspection shall be confirmed prior to manufacture.

4.2.2 Material inspection

Replace this clause by:

Material inspection shall be in accordance with DEP 31.29.02.30-Gen.

4.3 TESTING

4.3.2.4 Modify this clause as follows:

Replace "50 parts per million" by "20 mg/kg".

PART III REFERENCES

In this DEP reference is made to the following publications:

NOTE: Unless specifically designated by 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.
Requisitioning (binder)	DEP 30.10.01.10-Gen.
Noise control	DEP 31.10.00.31-Gen.
Metallic materials - prevention of brittle fracture	DEP 30.10.02.31-Gen.
Data/requisition sheet for equipment noise limitation	DEP 31.10.00.94-Gen.
Shell-and-tube heat exchangers (amendments/supplements to TEMA Standards)	DEP 31.21.01.30-Gen.
Pressure vessels (amendments/supplements to BS 5500)	DEP 31.22.10.32-Gen.
Air-cooled heat exchange equipment (amendments/supplements to API Std 661)	DEP 31.21.70.31-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.
Data/requisition sheet for rotary-type compressors and fans*	DEP 31.29.42.93-Gen.
Instrumentation for equipment packages	DEP 32.31.09.31-Gen.
Electric motors - Cage-induction and synchronous type	DEP 33.66.05.31-Gen.
Data/requisition sheet for electric motors*	DEP 33.66.05.93-Gen.

* Data/requisition sheets are contained in DEP binder 30.10.01.10-Gen.

AMERICAN STANDARDS

Specification for line pipe	API Spec 5L
Centrifugal pumps for petroleum heavy duty chemical and gas industry services	API Std 610 Eighth Edition, 1995
Air-cooled heat exchangers for general refinery service	API Std 661
Vibration, axial-position, and bearing-temperature monitoring systems	API Std 670
Special-purpose couplings for refinery service	API Std 671
Liquid ring vacuum pumps and compressors for petroleum, chemical and gas industry services	API Std 681 First Edition, 1996
Shaft sealing systems for centrifugal and rotary pumps	API Std 682

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

Pipe, steel, back and hot-dipped, zinc-coated, welded and seamless ASTM A 53

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

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

*Issued by:
National Association of Corrosion Engineers
P.O. Box 218340
Houston, Texas 77218
USA.*

INTERNATIONAL STANDARDS

Quality systems - Model for quality assurance in design, development, production, installation and servicing

Steel and steel products - Inspection documents ISO 10474

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

Copies can also be obtained from National Standards Organizations.