

TECHNICAL SPECIFICATION

ROTARY-TYPE POSITIVE DISPLACEMENT COMPRESSORS (AMENDMENTS/SUPPLEMENTS TO API 619)

DEP 31.29.40.32-Gen.

December 1999
(DEP Circular 27/04 has been incorporated)

DESIGN AND ENGINEERING PRACTICE



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PART I INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for dry and flooded helical lobe rotary compressors. This is a revision of the DEP of the same number dated September 1983.

This DEP is based on API 619, Third Edition, June 1997. Part III of this DEP amends, supplements and deletes various clauses and paragraphs of API 619.

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

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

If national and/or local regulations exist in which some of the requirements may be more stringent than in this DEP the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, 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

For the purposes of this DEP the following definitions shall apply:

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

The **Manufacturer/Supplier/Vendor** 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 the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets.

Other documents referenced by this DEP are listed in (Part IV).

PART II GENERAL INFORMATION

This DEP is written in four parts, of which Part III gives amendments and supplements to API 619, third edition, June 1997. Wherever reference is made to API 619, it shall be understood to mean API 619 as amended/supplemented by this specification.

For ease of reference, the clause numbering of API 619 has been used throughout Part III of this DEP. Clauses in API 619 which are not mentioned remain valid as written.

A bullet (•) in the margin against certain clauses in API 619 indicates that a decision by the Principal is required. This DEP addresses the decisions required by most of the API 619 bullet clauses. The remaining decisions shall be indicated directly on the relevant data/requisition sheet when provisions are made for them; otherwise they shall be indicated on the data/requisition sheet(s) under the heading 'Additional Requirements' or stated in the purchase order.

Note: The data/requisition sheets for rotary type positive displacement compressors have the number DEP 31.29.42.93-Gen.

PART III AMENDMENTS/SUPPLEMENTS TO API 619

1. SCOPE

Replace the first sentence of this clause by:

See Part I, section 1.1 of this DEP.

1.2 CONFLICTING REQUIREMENTS

Replace this clause by:

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

- upper level : purchase order and variations thereto
- second level : data/requisition sheets and drawings
- third level : this DEP.

Add new clause:

1.3 MANUFACTURER'S RESPONSIBILITIES

1.3.1 The Manufacturer shall be responsible for the design and engineering, the total mechanical/thermodynamic performance, and the guarantee of the entire compressor unit. This includes the compressor, driver, power transmission equipment and all auxiliary equipment furnished by sub-suppliers when purchased by the Manufacturer. This responsibility shall include determining critical speeds and performing the lateral rotor dynamic analysis for each major component of the unit and the torsional analysis for the entire unit, as well as any other analysis specified in the data/requisition sheets.

1.3.2 The Manufacturer shall have an implemented and effective quality system in accordance with ISO 9001 or an equivalent standard acceptable to the Principal.

In addition, the Manufacturer shall have an implemented and effective design release system, which will indicate and present any design changes for approval by the Principal.

1.3.3 The Principal reserves the right to review and check the design of any part of the equipment supplied. For this purpose the Manufacturer shall provide the necessary technical information of the subject part to the Principal to enable such verification or analysis. If required by the Manufacturer, the Principal shall agree not to divulge any of this information to any other party.

In the event of a conflict between the Manufacturer and the Principal regarding the interpretation of these design data, every effort shall be made to arrive at a mutually acceptable solution. If an agreement in this respect cannot be reached, the Principal shall have the right to insist that additional calculations and/or testing shall be made to ensure a design which is satisfactory to all parties involved.

However, it is recognised by the Principal that the Manufacturer's responsibilities, both contractually and in relation to the cost of any modifications and/or testing, shall be limited to the extent indicated in the Manufacturer's original design, unless it becomes evident that the Manufacturer's design was not adequate for the specified service.

1.3.4 The Manufacturer shall be responsible for co-ordination. This shall include at least:

- obtaining information required for fulfilling his obligations;
- communicating necessary data, specifications and other documents to sub-suppliers;
- negotiating interfaces with his sub-suppliers;
- standardising all components within the train, its auxiliaries and its utility requirements (such as oil type/grade etc.).

- 1.3.5** Factory representatives shall be provided to assist the Purchaser during initial installation (including piping checks specified in API 619, clause 4.1.11) and initial start-up. An outline of initial start-up procedures shall be prepared by the Manufacturer and shall be agreed upon by all parties involved before operations are commenced.
- 1.3.6** For reference purpose the physical properties of the process gas (C_p/C_v , molecular weight etc.) may be given on the data/requisition sheets in order to facilitate the compressor calculations. However, the Manufacturer shall base his performance calculations on the gas composition as stated in the data/requisition sheets.

The Manufacturer shall calculate the performance of all proposed compressors using his standard methods for computing the physical properties of the specified gases and shall take full responsibility for any design features affected. The Manufacturer shall state the values of all physical properties of the process gas used in his computations.

2. REFERENCES

2.1 *Add to this clause:*

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

4. BASIC DESIGN

4.1 GENERAL

4.1.1 *In this clause, replace the words "at least 3 years" by "at least 5 years".*

Add to this clause:

If the Vendor proposes to supply prototype equipment then the quotation shall state that the offered equipment is a prototype and it shall be accompanied by sufficient data for the Principal to thoroughly investigate its suitability for the intended duty.

NOTE: Equipment is not considered to be prototype if at least 3 units of similar type and size have each accumulated an uninterrupted operating time of at least 8000 hours in a duty similar to that pertaining to the enquiry in question.

4.1.2 *Replace by clause 1.3.1.*

4.1.3 *Add to this clause:*

The number of casings shall be as specified in the data/requisition sheet.

4.1.4 *Add to this clause:*

The Manufacturer shall state the operating limits of the compressor with respect to pressure and temperature.

4.1.5 *Replace this clause by:*

Cooling water systems shall be designed for the conditions specified in the data/requisition sheet and in no case shall they be designed for a working pressure of less than 6.9 bar (ga).

Provision shall be made for complete venting and draining of the system or systems.

4.1.7 *Add to this clause:*

- a) All left-handed threads shall be clearly marked.
- b) Any maintenance item with a mass greater than 20 kg shall be provided with lifting lugs or similar dedicated fixed lifting point(s). Screw-in eye-bolts may be used only for bearing housing covers and for internal components where other lifting arrangements are impractical. Holes for eye-bolts shall be permanently marked with the correct bolt size to be used. If this marking is impractical, bolt size information should be clearly indicated in the instruction manual.

4.1.8 *Add to this clause:*

Throughout the service life specified in (2.1.1), spare parts for all components of the unit shall be available for purchase and all manufacturing drawings shall be retained.

4.1.11 *In the last sentence of this clause, delete the words "When specified"*

4.1.12 *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 in the data/requisition sheets.

4.1.13 *Replace this clause by:*

4.1.13.1 Noise Control

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.

4.1.13.2 Information to be submitted with the tender

The Manufacturer shall submit guaranteed sound power levels and sound pressure levels 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.

If noise enclosures are supplied, the full access to the equipment for maintenance purposes shall be ensured by means of an appropriate design.

4.1.14 *Delete the words "jointly by the purchaser and"*

4.1.15 *Add to this clause:*

If specified in the data/requisition sheets, for offshore installations, the total compression package shall be suitable for the worst ambient offshore conditions, as specified for that location. Compressor units, including auxiliaries, which are installed on floating stations or barges shall be capable of operating at the specified static vessel positions and also of accommodating any specified dynamic vessel movement while in operation.

4.1.16 *Insert new clause:*

The use of liquid injection into the gas stream to control the discharge temperature and/or to prevent fouling requires the explicit approval of the Principal.

4.1.17 *Insert new clause:*

For variable-speed drive, the Manufacturer shall state the minimum allowable speed of the compressor, and shall include in his proposals a suitable safeguarding system. If stated on the VSIDS Requisition the associated switchgear and transformer will be part of the supply.

4.1.18 *Insert new clause:*

The process gas discharge temperature at the normal operating point shall be at least 20 K below the maximum allowable temperature.

4.2 CASINGS

4.2.2.2 *Replace this clause by:*

For flooded screw compressors, relief valves on the oil separators shall be furnished by the Vendor and sized in accordance with DEP 80.45.10.10-Gen. (including the fire case).

4.2.3 *Replace this clause by:*

The casing material shall be steel if:

- rated discharge pressure > 10 bar; or
- discharge temperature > 250 °C; or
- service is flammable or toxic.

Nodular cast iron (only in accordance with ASTM A 395 or ASTM A 571) or steel may be offered for operating conditions other than those specified in 4.2.3. Other materials require the written approval of the Principal. Grey cast iron shall not be used.

4.2.5 *Add to this clause:*

Gasket materials shall be asbestos free and suitable for the gas handled. Soft metal gaskets are preferred.

4.2.7 *Add to this clause:*

The casing shall be supported from the base plate by vertical supports. Shim packs for vertical alignment shall be between surfaces that do not have relative movement. Shim packs shall have a total thickness of at least 5 mm and shall be made of stainless steel. The maximum number of shims per foot is 3. Provision shall be made to support the machine whilst shims are removed or replaced.

4.2.9 *Replace this clause by:*

Overlay, cladding or plating shall not be applied unless approved by the Principal.

4.3 CASING CONNECTIONS

4.3.1 *Add to this clause:*

All casing openings for pipe connections shall be not smaller than DN 20 (3/4 inch NPS) and shall be welded to the casing and flanged or, alternatively, machined and studded. All welded connections shall be full penetration butt welded. Openings smaller than DN 25 (1 inch NPS) may be self-reinforced branch fittings of the 'weldolet' type.

Threaded connections shall not be used. Socket welding shall not be used, except where other connection methods are not possible and then only with the approval of the Principal.

For wet gas duties, the suction shall be on the top and the discharge on the bottom.

4.3.5 *Replace this clause by:*

Auxiliary connections shall be in accordance with (4.3.1).

4.3.5.1 *Replace this clause by:*

A pipe nipple, preferably not more than 150 mm long, shall be used for all auxiliary connections which are welded to the compressor.

4.3.5.2 *Replace this clause by:*

Pipe nipples shall be at least Schedule 80.

4.3.5.3 *Replace this clause by:*

The pipe nipple will be provided with a welding-neck flange.

4.3.5.5 *Delete this clause*

4.3.7.1 *Replace the words "cast iron" by "nodular cast iron".*

4.3.7.2 *Replace this clause by:*

Flat-faced flanges may be used only on nodular cast iron casings and shall have full raised-face thickness.

4.3.9 *Replace this clause by:*

For casings containing process gas, openings that are not connected to piping shall be provided with a blind flange.

4.4 EXTERNAL FORCES AND MOMENTS

4.4.1 *Replace the last sentence of the first paragraph by:*

For each main process nozzle, the Manufacturer shall furnish in tabular format the following data:

- the maximum allowable forces and moments and combinations thereof for satisfactory continuous operation;
- the maximum allowable forces and moments and combinations thereof under transient conditions such as start-up and (emergency) shut-down;
- expected nozzle movements due to thermal expansion between the cold static and normal full load operating conditions;
- any expected movement in addition to the above as a result of transient conditions.

4.5 ROTATING ELEMENTS

4.5.1 Rotors

4.5.1.1 *Replace this clause by:*

Rotor stiffness shall be adequate to prevent contact between the rotor bodies and the casing and between gear-timed rotor bodies at the most unfavourable specified conditions including 110% of the relief valve set pressure. Rotors and shafts shall normally be manufactured from one piece.

For non-corrosive duties, rotors of built-up construction may be used. Rotor bodies not integral with the shaft shall be permanently attached to the shaft to prevent relative motion under any condition. Structural welds on rotors shall be full-penetration continuous welds and shall be stress relieved in accordance with the material specification.

4.5.1.6 *Add to this clause:*

The corners of keyways shall have radii of at least 1.5 mm.

4.5.1.7 *Insert new clause:*

Vendors shall demonstrate for screw compressors that the female rotor always absorbs enough power to avoid gear flutter.

4.5.1.8 *Insert new clause:*

Seal strips shall be integral with the rotor bodies unless otherwise approved by the Principal.

4.6 SHAFT SEALS

4.6.1.3 *Delete the word "preferably"*

4.6.1.4 *Add to this clause:*

The type of shaft seal shall be specified on the data/requisition sheets. Liquid Film type seals shall not be specified. For flooded compressors see (4.6.1.5).

Add new clause:

4.6.4 **Mechanical (contact) seals**

For mechanical contact seals, the Vendor shall state the normal and guaranteed internal and external oil leak rates.

4.6.6 *Replace this clause by:*

If self-acting gas seals are specified they shall be in accordance with DEP 31.29.00.34-Gen.

Each dry gas seal assembly, regardless of its arrangement, shall be cartridge mounted. For uni-directional seals, cartridges shall be designed so that incorrect installation of the cartridges is impossible.

In the event of a total seal failure the gas leakage rate to the flare and into atmosphere shall be limited to a maximum level, which shall be agreed between the Manufacturer and the Principal. An appropriate design of the combination of the restrictive labyrinth between dual or triple tandem seals, the labyrinth between the seals and the bearing compartment, and the venting facilities to flare and safe location shall provide maximum confidence that this maximum leakage rate will not be exceeded.

The venting lines to flare and safe location shall be adequately sized to avoid over-pressurising of the seal/bearing housing in case of a major seal failure.

Tandem seal arrangements without an intermediate labyrinth may only be used with the explicit approval of the Principal.

The seal gas shall be filtered in order to remove all liquids and any contaminants that form residues. The seal gas may be taken from the compressor discharge or interstage point. An alternative seal-gas source may be required for dirty gas applications. This alternative source may also be used for start-up and/or shutdown only.

Sealing gas, buffer gas and separation gas shall be filtered to 5 µm absolute or less. Filters shall be double with a full flow transfer valve and valved and flanged drain and vent connections. Filters shall be sized to provide at least 4 000 hours of service before replacement and/or cleaning of elements is required.

Filters and all seal gas, buffer gas and separation gas piping after the filters shall be of austenitic stainless steel. If there is any possibility of condensation in these systems, both filters and piping shall be suitably heat traced. Alternatively, suitable coalescer separators may be applied.

4.7 DYNAMICS

4.7.1.5 *In this clause, delete the words "unless the resonances are critically damped"*

4.7.1.6 *Replace the final sentence by:*

The Vendor shall demonstrate that the machine has a stiff shaft construction with the first actual lateral critical speed at least 120 per cent of the maximum allowable speed.

4.7.2 Torsional analysis

4.7.2.1 *Replace items (c) and (d) by:*

- c. Torsional transients such as switch-on and terminal short circuits of all types of electric motors, as well as the start-up of variable speed motors and synchronous motors.
- d. Torsional excitation from variable speed drive systems (VSDS) including the worst case transient operation, and reciprocating engines.

4.7.2.3 *Replace this clause by:*

The following requirements shall apply:

- a. Torsional criticals at one and two times the electrical supply frequency shall be avoided for motor driven compressors.
- b. Torsional criticals at two or more times the running speeds of all shafts shall be avoided, except where corresponding excitation frequencies are unavoidable on VSDS driven compressors in which case they shall be shown to have no adverse effect.
- c. In addition to multiples of running speed, torsional excitations that are non-synchronous in nature shall be considered in the analysis.
- d. For the torsional analysis of a VSDS motor-driven compressor the Manufacturer shall identify together with the VSDS Supplier all excitation frequencies and their consequences on the train. These frequencies shall include but not be limited to:

- non-speed dependent excitations such as ripple;
- integer harmonics;
- non-integer harmonics;
- carrier frequency harmonics;
- switching harmonics between speed control windows.

4.7.2.4 *Add to this clause:*

The Manufacturer shall submit his procedures for carrying out stress analyses and the corresponding criteria to the Purchaser for approval by the Principal.

4.7.2.5 *Delete the words "when specified"*

4.7.2.6 *Replace the first sentence of this clause by:*

In addition to the torsional analyses required in (4.7.2.2 through 4.7.2.5), the Manufacturer shall perform a transient torsional analysis for all synchronous motor and VSDS driven units but only for those asynchronous electric motor driven units with a speed less than 750 r/min. This shall demonstrate that the transient occurrences in the motor have no adverse effect on the complete train.

The analysis shall consider but not be limited to the following transient load cases:

- a. switch-on and start up of electric motors;
- b. 2-phase and 3-phase terminal short circuits of motors;
- c. pulse operation of variable speed motors;
- d. asynchronous run-up on synchronous motors.

Refer to DEP 33.66.05.31-Gen. and DEP 33.65.11.31 Gen.

4.7.3 Vibration and balance

4.7.3.4 *Replace the last two sentences of this clause by:*

Acceptance limits shall be as follows:

		Hydrodynamic journal bearings	Antifriction bearings
Measurement on bearing housing	Vibration at any speed within the operating range:		
	Overall	$V_u < 5 \text{ mm/s RMS}$	$V_u < 8 \text{ mm/s RMS}$
	Discrete frequencies	$V_f < 2.8 \text{ mm/s RMS}$	$V_f < 4.5 \text{ mm/s RMS}$
	Increase in allowable vibration at speeds beyond operating speed but less than trip speed	20%	20%
Measurement on shaft adjacent to bearing	Maximum value of vibration at any speed within the operating range	$\sqrt{\frac{1.03 \times 10^7}{\text{rpm}}} \mu\text{m}$ or 63 μm , whichever is less	-
	1 x running speed component	30 μm	
	Increase in allowable vibration at speeds beyond operating speed but less than trip speed	20%	

Where :

V_u = unfiltered velocity.

V_f = filtered velocity at discrete frequencies.

A = unfiltered peak to peak vibration

rpm = maximum continuous speed in revolutions per minute

RMS = root mean square

4.8 BEARINGS

4.8.2 Antifriction Bearings

Add new clause:

4.8.2.4 Rolling element bearings shall have brass cages.

4.8.4.3 *Add to this clause:*

Thrust bearings shall be designed to allow for reverse rotation under the process conditions specified.

4.10 LUBE-OIL AND SEAL-OIL SYSTEMS

4.10.3 *Replace this clause by:*

For dry screw compressors, pressurised oil systems shall be in accordance with DEP 31.29.60.32-Gen.

4.10.4 *Add to this clause:*

Seal oil shall be the same as selected for the lube oil.

4.10.5.1 *Replace this clause by:*

Various components are required to be provided in stainless steel. In this respect stainless steel shall be either AISI 316 L or AISI 316 Ti stainless steel only or appropriate equivalents according to internationally accepted standards.

The use of any other stainless steel of the AISI 300 series is subject to the specific approval of the Principal.

Oil system components covered by this clause are :

- strainers;
- reservoirs;
- accumulators;
- overhead tanks;
- run-down tanks;
- degassing drums, collecting drums and separators;
- piping.
- flanges

4.10.5.4 *Add to the end of the first sentence:*

For non-spared duty, twin oil coolers shall be provided.

In the sixth sentence replace "15 millimetres (5/8)" " by "19 millimetres (3/4)"

4.10.5.5 *In the first sentence, replace "25 microns absolute" by "10 µm nominal":*

4.10.5.6 *Add to this clause:*

Electric immersion heaters should be installed in sealed tubes which allow the heaters to be removed during operation.

4.10.5.7 *Replace this clause by:*

See 4.10.3

4.10.5.8.2 *Replace this clause by:*

Separators shall be designed and constructed in accordance with the codes specified in the data/requisition sheet.

4.10.5.8.3 *Replace this clause by:*

Separators shall be constructed in either AISI 316 L or AISI 316 Ti stainless steel only or appropriate equivalents according to internationally accepted standards.

The use of any other stainless steel of the AISI 300 series is subject to the specific approval of the Principal.

4.10.5.8.4(a) *Replace second sentence by:*

A minimum four-minute retention time shall be provided.

4.11 MATERIALS

4.11.1 General

Add to this clause:

The Manufacturer shall furnish inspection certificates in accordance with ISO 10474 type 3.1.B for pressure containing parts and certificates of compliance in accordance with ISO 10474 type 2.1 for other parts.

4.11.1.1 *Replace this clause by:*

Materials of construction shall be as specified in the data/requisition sheets. The Manufacturer may offer alternative materials if his experience indicates that these would be a better selection, but these proposed materials shall be suitable for the gas composition(s) given in the data/requisition sheets.

Application of alternative materials is subject to the approval of the Principal.

4.11.1.2 *Add to this clause:*

Equivalent materials in accordance with other internationally recognised standards are acceptable, but any deviation from the originally required ASTM standard is subject to the approval of the Principal.

4.11.1.5 *Replace this clause, including the footnote, by:*

**Amended per
Circular 27/04**

For compressors handling gas containing hydrogen sulphide, including trace quantities (25 ml/m³ or more), all components including associated systems and ancillaries in contact with the gas as well as the external bolting on the casing and seal glands shall comply with ISO 15156 or NACE MR0103, as applicable. Ferrous materials not covered by these standards shall have a maximum hardness of 248 HV10. This hardness limitation also applies to the heat affected zone of welds. Steel plate materials shall comply with the through-thickness tensile test of ASTM A 770 (S3) and shall have a minimum reduction of area of 35%.

- NOTES:
1. ISO 15156 shall apply to oil and gas production facilities and natural gas sweetening plants. NACE MR0175 is equivalent to ISO 15156.
 2. NACE MR0103 shall apply to other applications (e.g. oil refineries, LNG plants and chemical plants).

4.11.1.6 *Replace the first sentence of this clause by:*

The minimum quality bolting material for pressure joints shall be ASTM A 193 grade B7.

4.11.1.7 *Add to this clause:*

Overlays may be applied only if approved by the Principal.

4.11.1.8 *Add to this clause:*

For close-tolerance mating parts, such as shaft sleeves that are made from galling materials, the use of anti-seizure compound is not allowed. They shall be disassembled by hydraulic or thermal expansion techniques. These items shall have a suitable metallic coating to prevent galling.

4.11.1.14 *Add to this clause:*

The Manufacturer shall specify the Supplier, material, grade and shore hardness of all 'O' rings used and demonstrate that the selected materials are suitable for the specified operating conditions.

4.11.2 Castings

4.11.2.4 *Replace this clause by:*

Leaks and defects in pressure-containing castings shall not be repaired by peening or burning-in, or by impregnation with plastics or cement compounds. Repair by welding or plugging shall be undertaken only if permitted by the material specification, and then only in accordance with the procedures detailed in (4.11.2.4.1, 4.11.2.4.2 and 4.11.4.2).

4.11.2.4.1 *Replace this clause by:*

Repair by Welding

Weldable grades of castings may be repaired by welding subject to the following criteria:

Items 1 to 5 - as clause (4.11.4.2)

6. The repair welding procedures and the repair welder's qualifications shall be in accordance with ISO 9956/ ISO 9606, EN 287/ EN 288, ASTM A 488, ASME IX or equivalent standard approved by the Principal.
7. Weld repairs shall not be performed on nodular cast iron (ASTM A 395).

4.11.2.4.2 *Replace this clause by:*

Repair by plugging:

1. The need for repair by plugging shall be reported to the Principal before any repair is carried out.
2. Nodular iron may be repaired by plugging within the limits specified in ASTM A 395. The drilled holes for plugs shall be carefully examined by dye penetrant to ensure removal of all defective material.
3. All necessary repairs not covered by ASTM shall be subject to approval by the Principal.
4. Details of all repairs shall be recorded and included in the manufacturing report.

4.11.4 Welding

4.11.4.1 *Add to this clause:*

The Welding Procedure Specifications and Procedure Qualification Records shall be made available to the Purchaser for review and approval upon request.

4.11.4.2 *Add to this clause:*

Destructive mechanical tests, including impact tests if required, shall be carried out on test blocks after all heat treatments have been performed, including those for any repairs.

For weld repairs on fabricated pressure-containing parts the following shall apply:

1. Approval by the Principal shall be obtained before any major* weld repair (see definition below) is carried out.
2. All repairs shall meet the inspection requirements and acceptance standards of the original material.
3. Repair procedures for major* weld repairs are subject to the approval of the Principal.
4. Weld repairs shall be suitably heat-treated if this is specified in the relevant material specification. A major* weld repair shall be followed by a suitable heat treatment.
5. Details of all major* weld repairs and the heat treatment shall be recorded and reported to the Principal.

*NOTE: A weld repair is defined as "major" if one or more of the following is true:

- it entails the removal of more than 50% of the wall thickness;
- it extends over a length of more than 150 mm in one or more directions;
- the total surface area of all repairs exceeds 10% of the original surface area.

4.11.4.3 *Replace this clause by:*

All accessible areas of welds on built-up rotors shall be inspected by magnetic particle examination. Dye penetrant inspection shall be used only when magnetic particle inspection is not feasible. See 6.2.2.1.

4.11.4.4.1 *Add to this clause:*

Plates from which pressure-containing components are to be cut, forged, rolled or formed in any other manner shall be subject to systematic ultrasonic inspection for laminations in accordance with BS 5996 (Grade L4) or ASTM A 578 (level B).

4.11.4.5.1 *Replace this clause by:*

All welds in the casing, including those in piping attached to the casing, shall be examined by radiography or ultrasonic methods. See sub-section 6.2.2 for required procedures and acceptance criteria.

4.11.5 Impact test requirements

4.11.5.2 *Replace this clause by:*

For pressure-containing parts that may operate at a temperature of 0 °C or below, the selected material shall fulfil the minimum impact energy requirements specified in DEP 30.10.02.31-Gen.

4.12 NAMEPLATE AND ROTATION ARROWS

4.12.3 *Replace the final sentence of this clause by:*

Unless otherwise specified, the text on nameplates shall be in the English language and the data shall be in SI units.

The information on nameplates shall include the year of manufacture and the built-in compression ratio.

5. ACCESSORIES

5.1 DRIVERS

5.1.4 *Replace this clause by:*

See sub section 5.1.5.

5.1.5 *Replace this clause by:*

Electric motor drivers shall comply with DEP 33.66.05.31-Gen. for cage Induction machines and DEP 33.65.11.31-Gen. for synchronous machines. Variable Speed Drive Systems shall comply with DEP 33.66.05.33-Gen. The electric motor driver shall be capable of developing continuously at least 110% of the highest kW rating (including gear and coupling losses) required for any of the specified compressor operating conditions or 110 % of the highest kW required at the top of the power curve of the compressor at rated speed (including gear and coupling losses), whichever is the greater. Compressors driven by fixed speed motors shall be started at normal suction pressure, unless otherwise specified by the Principal.

Associated equipment shall comply with the following standards:

DEP 33.65.40.31-Gen.	Power transformers
DEP 33.67.01.31-Gen.	Low voltage switchgear
DEP 70.10.90.11-Gen.	Spare parts

5.1.7 *Replace this clause by:*

Steam turbine drivers shall be selected, tested and installed in accordance with DEP 31.29.60.10-Gen. They shall be capable of continuously developing 110 % of the maximum power required for the Purchaser's specified conditions while operating at the corresponding speed under specified steam conditions (minimum inlet steam condition and maximum steam outlet condition unless specified otherwise).

5.1.8 *Replace this clause by:*

Speed increasers and reducers shall be in accordance with DEP 31.29.00.32-Gen. and shall be sized for the maximum power and speed of the driver under all specified operating and ambient conditions. For non-essential services, as defined in DEP 31.29.40.10-Gen., general purpose gears conforming to API 677 may be used with the approval of the Principal.

5.1.9 *Replace this clause by:*

The equipment feet of all drivers shall be provided with vertical jack screws.

5.1.10 *Add this clause:*

Gas turbine drivers shall comply with DEP 31.29.70.31-Gen. and shall be sized by agreement between the Principal and the Manufacturer.

All discrepancies between the above specification and the gas turbine proposed by the Manufacturer shall be itemised in a separate section of the proposal.

5.2 COUPLINGS AND GUARDS

5.2.2 *Add to this clause:*

Unless otherwise specified or approved by the Principal, non-lubricated spacer type couplings shall be used.

The coupling to shaft connection shall be rated for a minimum of 125% of the maximum driver power and be able to withstand without any slippage or permanent deformation all maximum transient torques that may occur in the complete unit.

The coupling design shall be such that the full rated torque of the coupling, including the API 671 service factor of 1.75, is transmitted by friction only and not by the coupling bolts' shear load.

Add new clause:

- 5.2.5** In the case of a totally enclosed coupling guard, temperatures measured on the outside surface shall not exceed 90°C. The use of oil spray to achieve this temperature is subject to the specific approval of the Principal. The cooling arrangement shall be designed to prevent areas of low-pressure at compressor or driver bearing housing seal locations.

Add new clause:

- 5.2.6** Guards shall be made of one of the following spark-resisting materials:

- 1) Aluminium or aluminium alloys with a maximum content of 2% magnesium or 0.2% copper.
- 2) Copper or copper based alloys (e.g. brass, bronze).

Add new clause:

- 5.2.7** Couplings with a maximum continuous speed higher than 5000 r/min shall receive a "residual unbalance verification" in accordance with API 671.

Add new clause:

- 5.2.8** The randomly assembled coupling shall receive an "assembly check balance" in accordance with API 671. The maximum allowed residual unbalance (U) shall not exceed:

$$U = 31750 \text{ W/N}$$

where U = residual unbalance (g.mm)

W = static mass (kg)

N = maximum continuous speed (r/min)

5.3 MOUNTING PLATES

5.3.1 General

5.3.1.1 *Replace this clause by:*

The equipment shall be furnished with a base plate.

5.3.1.2.7 *Delete the first sentence of this clause*

Add to this clause:

Mounting plates for offshore installations on steel structures shall be supplied with jacking arrangements to facilitate levelling of the mounting plate. For three-point mounting the jacking arrangement shall facilitate the removal, replacement and positioning of each mount. The type of jacking arrangement to be used is subject to the approval of the Principal.

5.3.2 Base plates

5.3.2.1 *Add to this clause:*

Base plates for units for offshore applications shall comply with the following minimum requirements:

1. The complete compressor unit, including gear and driver, shall be mounted on a single lift base plate of structural steel. There shall be no limits to the size of the base plate other than those derived from transportation, installation and/or plant lay-out considerations.
2. Where specified, the base plate shall include all auxiliary oil and shaft sealing systems and be designed for three-point mounting using gimbal mounts.
3. The base plate shall be designed to minimise weight. It shall be subject to a dynamic analysis to ensure that its flexibility will not have adverse effects on the rotor dynamic behaviour of the complete train.
4. The complete unit shall be shipped, mounted on its base plate.

5.3.2.3 *Add to this clause:*

For offshore installations, base plates shall be suitable for column mounting.

5.3.2.4 *Add to this clause:*

Deflection while lifting shall not exceed 1:1200.

5.3.2.7 *Add to this clause:*

For offshore installations, base plates shall have machined mounting pads.

5.4 CONTROLS AND INSTRUMENTATION

5.4.1 General

5.4.1.2 *Replace this clause by:*

For controls and instrumentation, DEP 32.31.09.31-Gen. shall apply. The applicable scope of supply option shall be as specified in the requisition.

Depending on the complexity of the package and whether there are elements of extended scope of supply, the Principal may require that certain instrumented protective functions are subject to an IPF classification exercise. IPF classification shall be based on DEP 32.80.10.10-Gen. The requisition should provide information on Vendor's involvement, timing aspects of any IPF classification and information on handling the resulting design impact.

5.4.1.3 *Delete this clause.*

5.4.1.4 *Delete this clause.*

5.4.2 Control systems

5.4.2.2 *In this clause, replace the words "70 % of the maximum continuous speed" by "75 % of rated speed"*

5.4.3 Instrumentation

5.4.3.1 to 5.4.3.4 *Delete these clauses.*

5.4.3.5.1 to 5.4.3.5.4 *Replace "API standard 670" by "API 670 and DEP 32.31.00.32-Gen."*

5.4.4 Alarms and shutdowns

5.4.4.1 General

5.4.4.1.1 *Replace this clause by:*

The Vendor shall recommend protective devices, in addition to those specified, which are deemed necessary to prevent damage to the equipment. The scope split between the Vendor and the Purchaser is defined by the purchaser.

Discrete, direct-mounted field switches for alarm and instrumented protective functions (IPFs) are not allowed. A combination of signal transmitter with switch and/or trip amplifier shall always be used.

The minimum alarm and shutdown requirements, as listed in Table 3, are to be considered as initial minimum requirements. The IPF classification will set the final requirements.

5.4.4.2 Alarm and Trip Devices

Delete this clause.

5.5 PIPING

5.5.1 General

5.5.1.1 *Replace "API 614" by "DEP 31.29.60.32-Gen." and delete the words "and Table 4."*

5.5.1.2 *Replace "Table 4" by "DEP 31.38.01.11-Gen."*

5.5.4 Process piping

5.5.4.2 *Replace "ANSI B 31.3" by "DEP 31.38.01.11-Gen. and DEP 31.38.01.31-Gen."*

5.5.3 Instrument piping

Replace this clause by:

Instrument piping connections shall comply with DEP 32.31.09.31-Gen. Scope limits shall be specified by the Purchaser.

5.6 INTERCOOLERS AND AFTERCOOLERS

5.6.3 *Replace this clause by:*

Water-cooled intercoolers and aftercoolers shall be designed and constructed in accordance with the codes specified in the data/requisition sheet.

5.6.5 *Replace the second sentence of this clause by:*

Rupture discs on the shell side to protect the shell in the case of tube failures are not allowed.

5.6.6 *Replace this clause by:*

Aircoolers, when specified, shall conform to DEP 31.21.70.31-Gen.

5.6.7 *Delete this clause.*

5.6.9 *Replace this clause by:*

Coolers shall not be installed on top of the compressor.

5.7 INTAKE AIR FILTERS

Replace this entire section by:

Air intake air filters shall comply with DEP 31.29.40.10-Gen.

5.8 PULSATION SUPPRESSORS/SILENCERS FOR DRY SCREW COMPRESSORS

5.8.5 *Add to this clause:*

In all cases the Manufacturer shall use a proven design, supply references for similar duties and be approved by the Principal. Stainless steel shall be used in air and corrosive service.

5.8.8 *Replace this clause by:*

Pulsation damping equipment shall be designed and constructed in accordance with the codes specified in the data/requisition sheet.

5.8.10 *Replace this clause by:*

Inlet and outlet nozzles of suction pulsation suppressing equipment shall be flush with the inner wall and arranged so that no liquid can accumulate inside the vessel, thus preventing liquid slugs entering the compressor.

6. INSPECTION, TESTING, AND PREPARATION FOR SHIPMENT

6.1.2 *In this clause, delete the words "When specified,"*

Add new clause:

6.1.8 **Inspection by the Purchaser**

The Purchaser shall indicate if, and to what extent, he will witness the Manufacturer's inspection and testing. This may include, but need not be limited to, the following:

- a check (against outline drawings which have been approved by the Purchaser) of all main dimensions, base plate dimensions, location of foundation bolt holes, size/position/rating of flanges and coupling guard arrangement;
- an inspection of flange face finish, in accordance with (2.4.2.6);
- a verification that the Manufacturer has performed the specified inspections and tests with satisfactory results;
- a verification of the required material certificates and (to the extent specified) their traceability to the respective components;
- a check of casing wall thickness;
- measurement of the running clearances;
- a visual check for good workmanship and finish of internals;
- verification of taper fits with matched plug and ring set;
- verification of machinery alignment and operability of contract special tools;
- performance and mechanical run testing.

6.2 INSPECTION

6.2.1.1 *Add to the end of the first sentence:*

and shall be offered to the Principal thereafter.

In item (d), delete the words "When specified"

6.2.2 **Material Inspection**

Replace this section by:

6.2.2.1 The material inspection requirements are summarised in the following table; the procedures and acceptance criteria are given in sections 6.2.2.2 to 6.2.2.5.

COMPONENT	REQUIRED MATERIAL INSPECTION
Compressor casing – cast	RT, and MT or PT
Compressor casing – fabricated	UT, and MT or PT
Compressor fabrication - full penetration welds - fillet welds	RT or UT, and MT or PT MT or PT
Timing gears	MT or PT, and VI
Labyrinths	VI
Shafts, rotors	MT or PT
Shaft sleeves	MT or PT
Bearing housings, bearings	VI
Shaft seals	VI
Auxiliary piping	see DEP 31.38.01.31-Gen.

NOTES: 1) VI = Visual Inspection (6.2.2.6)
MT = Magnetic Particle Examination (6.2.2.4)
PT = Liquid Penetrant Examination (6.2.2.5)

RT = Radiographic Examination (6.2.2.2)
UT = Ultrasonic Examination (6.2.2.3)

- 2) "Casing" includes all items of the pressure boundary of the finished compressor casing (e.g. the casing itself and other parts such as nozzles, flanges, end head, closure plates, shear rings etc.). RT shall be applied to cast casings where the UT does not provide conclusive results.
- 3) Timing of inspection
 - VI/MT/PT shall be performed after final heat treatment in the final machined condition.
 - RT/UT of castings may be performed before or after final heat treatment if it is followed by MT/PT after the heat treatment. Otherwise, RT/UT of castings shall be performed after final heat treatment but they need not be in the final machined condition provided that the thickness is not more than 110 % of the final thickness. In any case the radiographic sensitivity indicator (e.g. penetrameter) shall be selected according to the actual thickness.
 - RT of welds and UT of fabricated material and welds shall be performed after final heat treatment.
 - UT of wrought material shall be performed prior to any machining operations (e.g. for keyways, drilled holes etc.) which may interfere with the UT examination.
- 4) PT examination shall only be used where MT is not feasible.

6.2.2.2 Radiographic examination (RT)

6.2.2.2.1 RT of castings shall be performed in accordance with ASME VIII, Division 1, Appendix 7. Critical sections of each casting shall be fully radiographed; where such sections cannot be radiographed and/or for wall thickness above 50 mm, UT shall be used (also in accordance with ASME VIII, Division 1, Appendix 7). The Manufacturer shall submit details of the critical sections proposed to undergo RT/UT, for the Purchaser's approval.

6.2.2.2.2 RT of welds shall be in accordance with ASME VIII, Division 1, UW-51. Coverage shall be 100 %.

6.2.2.3 Ultrasonic examination (UT)

6.2.2.3.1 UT of welds shall be in accordance with ASME VIII, Division 1, Appendix 12. Coverage shall be 100 %. UT of welds shall be performed for weld thicknesses over 30 mm.

6.2.2.3.2 UT of fabricated material shall be in accordance with ASME V, Article 5. The acceptance criteria shall be as follows:

a) Austenitic forgings

Referring to ASTM A 745:

- QL-1 for straight beam with thickness $t = 0$ to 75 mm
- QL-2 for straight beam with thickness $t = 76$ to 200 mm or
- QA-2 for angle beam, all thicknesses.

b) Non-austenitic forgings

Referring to ASTM A 388:

- For straight beam examination, back reflection method, no areas shall have a loss of 95 % or more of the reference back reflection.
- For straight beam examination, reference block method, there shall be no indications equal to or larger than the indication received from the reference block constructed with the following flat bottomed holes:
 - 1.5 mm for $t = 0$ to 37 mm;
 - 3 mm for $t = 38$ to 150 mm;
 - 6 mm for $t = 151$ mm and greater.
- For angle beam examination, there shall be no indications equal to or larger than the indication received from the reference notch or amplitude reference line.

c) Plate material

For material inspection during fabrication see (2.11.2.9.1).

After fabrication UT inspection shall be in accordance with ASTM A 577.

d) Tubular material

Acceptance criteria in accordance with ASTM E 213, in which the calibration notch shall take the following form:

- shape shall be rectangular;
- depth shall be maximum 5 percent of the nominal wall thickness;
- length shall be 25 ± 5 mm;
- width shall be no greater than twice the depth.

6.2.2.4 Magnetic particle examination (MT)

All surfaces shall be examined.

MT of castings shall be performed by the wet method in accordance with ASME VIII, Division 1, Appendix 7.

MT of welds and wrought material shall be performed by the wet method in accordance with ASME VIII, Division 1, Appendix 6.

6.2.2.5 Liquid penetrant examination (PT)

All surfaces shall be examined.

PT of castings shall be performed in accordance with ASME VIII, Division 1, Appendix 7.

PT of welds and wrought material shall be performed in accordance with ASME VIII, Division 1, Appendix 8.

6.2.2.6 Visual inspection (VI)

All surfaces shall be inspected.

VI shall be performed in accordance with ASME V, Article 9.

Acceptance criteria for pressure-containing steel castings shall be in accordance with MSS SP-55. Acceptance criteria for other parts shall be in accordance with the material specification and the Manufacturer's documented procedures.

6.3 TESTING

6.3.1 General

Add new clause:

6.3.1.4 Instruments and associated systems shall be function tested as in DEP 32.31.09.31-Gen.

6.3.2 Hydrostatic tests

6.3.2.1 *Add to this clause:*

For jackets, the minimum test pressure shall be 1.5 times the maximum working pressure of the cooling medium but not less than 8 bar (ga). Hydrostatic testing shall only be done after final machining.

6.3.3 Mechanical running test

6.3.3.1.10 *Add to this clause:*

Real time display of vibration and frequency analysis shall be available during the test.

6.3.3.2.1 *Add to this clause:*

Fixed speed electric motor driven compressors may be brought up to speed at once.

6.3.3.3.5 *Replace this clause by:*

During the mechanical running test, the lubricating oil and seal oil temperatures shall be held for a minimum period of 30 minutes at the temperature corresponding to the minimum allowable viscosity, and for 30 minutes at the temperature corresponding to the maximum allowable viscosity. Variable speed compressors shall be checked for correct rotor dynamic behaviour through their full speed range during this temperature variation. Oil pressures and temperatures and bearing temperatures shall be measured throughout the test.

6.3.3.3.2 *Replace the third sentence of this clause by:*

Sub-synchronous vibration should not be present. There shall **NOT** be any load-dependent sub-synchronous vibration at a frequency corresponding with a rotor resonance. The source of other sub-synchronous vibration shall be known, proven by the Principal to be steady and shall not exceed an amplitude of 3 μm peak-to peak.

Resonances from timing gear mesh and lobe passing frequencies shall not exceed 10% of allowable shown in 4.7.3.4.

6.3.3.3.4 *In this clause, delete the words "when specified"*

6.3.3.4.1 *Replace the second sentence of this clause by:*

Oil film type shaft seals shall be removed for inspection following a successful running test; but not mechanical contact type nor dry gas seals.

6.3.3.4.3 *Add to this clause:*

Subject to the approval of the Principal, spare rotors for compressors may be exempted from the mechanical running test, provided the main rotor has successfully completed the mechanical running test.

6.3.4 Optional tests

6.3.4.1 Performance Test

Replace this clause by:

When specified, the compressor shall be performance-tested in accordance with ISO 1217.

6.3.4.2 Complete-unit test

Replace the first sentence by:

When specified, such components as gears, the driver and all auxiliaries that make up the complete compressor unit shall be tested together with the compressor during the mechanical running test. This will include, but not necessarily be limited to, coolers, vessels, piping, all instrumentation and all electrical equipment in the scope of supply of the Vendor.

Details of the extent and the procedure of the test shall be included in the proposal. The final version of the test procedure shall be subject to the Principal's approval.

Add to this clause:

For electric motors with variable speed drive system (VSDD) control, provisions shall be made for torsional vibration measurements during testing to check for torsional resonances and to verify the Manufacturer's torsional analysis; this may be done, for example, with strain gauges on the coupling.

For each component in the train the requirements of 6.3.3 will apply during the complete unit test.

Unless otherwise specified and approved by the Principal, all compressors intended for use in Exploration and Production facilities shall be subject to a complete unit test. Even if the test is not specified, the whole unit shall be completely assembled in the Manufacturer's works, including all auxiliary equipment and instrumentation in the Manufacturer's scope of supply. Unless otherwise specified, all control and safeguarding systems for these compressor units, including start-up and shut-down logic systems, either mounted on the machine or in a separate panel, shall be subject to a full functional test. This is irrespective of whether these systems are supplied by the Manufacturer, or free-issued to him. The scope of the testing and the applicable procedures shall be agreed between the Principal and the Manufacturer.

6.3.4.6 Sound-Level Test

Replace this clause by:

When specified, a sound level test shall be performed on the equipment in accordance with EEMUA 140 (see 4.1.13). The acceptance limits shall be as specified by the Contractor, in accordance with DEP 31.10.00.31-Gen., on the data sheet DEP 31.10.00.94-Gen. which forms part of the requisition.

6.4 PREPARATION FOR SHIPMENT

6.4.1 *In this clause, replace the words "6 months" by the words "18 months".*

Add to this clause:

The equipment shall be shipped in the fewest possible number of base plate sections.

6.4.3.12 *Add to this clause:*

Exposed shaft ends shall be protected against physical damage.

Add new clause:

6.4.3.13 Where vapour-phase inhibitor (VPI) or silica gel crystals in bags are installed in large cavities, either for inhibiting corrosion or absorbing moisture respectively, they shall be placed so that they can be removed easily. The bags shall be attached with stainless steel wire and their locations indicated with corrosion resistant tags also fixed with stainless steel wire.

6.4.8 *In this clause, delete the words "When specified"*

7. VENDOR'S DATA

7.3 CONTRACT DATA

7.3.1.1 *Add to this clause:*

The information shall include the documents for controls and instrumentation as specified in DEP 32.31.09.31-Gen.

Add new clause:

7.3.5.3 Parts list and recommended spares

Quotations for compressors shall be accompanied by a recommended spare parts listing which should be itemised and priced separately.

7.3.6 Installation, operation, maintenance, and technical manuals

7.3.6.1 *Add to this clause:*

The installation, operating and maintenance manuals shall be issued for Purchaser's review and comment.

The final manuals shall be forwarded to the Purchaser within one week after shipment.

Add new section:

8. WEIGHT CONTROL FOR OFFSHORE INSTALLATIONS

8.1 GENERAL

For equipment to be installed on an offshore facility, the Manufacturer shall comply with the following requirements when specified.

8.2 INFORMATION WITH THE PROPOSAL

The Manufacturer shall provide in his proposal estimates of the total installed mass of each compressor unit to be supplied. This mass shall include all auxiliaries and appurtenances, regardless of whether they are being supplied separately or installed on the unit. The estimate shall have an upper tolerance of 10% or 10 kg, whichever is the greater. If an order is placed, the Manufacturer may be required to guarantee his mass estimates prior to the order date.

8.3 ENGINEERING INFORMATION

Within four weeks (or any other period, as specified) after the receipt of an order the Manufacturer shall supply the following information to the Purchaser for review and approval:

1. The mass and location of the centre of mass of the compressor and its main driver in the following situations:
 - as intended to be shipped, included packing, shipping constraints, lifting equipment etc.;
 - as installed, including all auxiliaries and appurtenances;
 - in operation, i.e. including the normal contents of process fluid and lubricants.
2. The mass of any auxiliary component or system to be shipped separately.
3. The mass of any component or item included in the scope of supply which has a mass greater than 200 kg.

8.4 WEIGHT CONTROL DURING MANUFACTURE

The Manufacturer shall have an implemented and effective weight control program. The Purchaser shall be notified of any deviation of more than 5% or 5 kg, whichever is the greater, from the original mass estimate of (8.2) above.

The Manufacturer shall be responsible for verifying the correct mass of all components and auxiliaries, as they are completed in his workshop or as they are received from sub-suppliers.

When all masses of significant components have been verified, the Manufacturer shall review his initial mass estimate and confirm or modify the data by re-issuing the information as required by (8.2) above. This shall be done not later than one month prior to the agreed shipping date of the compressor unit.

Upon completion of the complete compressor unit the Manufacturer shall reverify the mass and issue a certificate for the final mass and centre of mass of the unit.

PART IV 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.
Metallic materials - prevention of brittle fracture	DEP 30.10.02.31-Gen.
Noise control	DEP 31.10.00.31-Gen.
Data/requisition sheet for equipment noise limitation	DEP 31.10.00.94-Gen.
Air-cooled heat exchangers	DEP 31.21.70.31-Gen.
Special purpose gear units for petroleum, chemical and gas industry service	DEP 31.29.00.32-Gen.
Compressor selection, testing and installation	DEP 31.29.40.10-Gen.
Dry gas seal systems for centrifugal compressors	DEP 31.29.00.34-Gen.
Data/requisition sheet for rotary type compressors and fans	DEP 31.29.42.93-Gen.
Steam turbines - selection, testing and installation	DEP 31.29.60.10-Gen.
Lubrication, shaft-sealing and control oil systems for special-purpose application (amendments/supplements to API 614)	DEP 31.29.60.32-Gen.
Combustion gas turbines (amendments/supplements to API 616)	DEP 31.29.70.31-Gen.
Piping - general requirements	DEP 31.38.01.11-Gen
Shop and field fabrication of piping	DEP 31.38.01.31-Gen
Instruments for measurement and control	DEP 32.31.00.32-Gen.
Instrumentation for equipment packages	DEP 32.31.09.31-Gen.
Classification and implementation of instrumented protective functions	DEP 32.80.10.10-Gen.
Synchronous AC machines (amendments/supplements to IEC 34-1)	DEP 33.65.11.31-Gen.
Power transformers (amendments/supplements to IEC 76 and IEC 726)	DEP 33.65.40.31-Gen.
Electric machines - cage-induction types (amendments/supplements to IEC 60034-1)	DEP 33.66.05.31-Gen.
Electrical variable speed drive systems	DEP 33.66.05.33-Gen
Low-voltage switchgear and controlgear assemblies (amendments/supplements to IEC 439-1)	DEP 33.67.01.31-Gen.
Spare parts	DEP 70.10.90.11-Gen.
Pressure relief, emergency depressurising, flare and vent systems	DEP 80.45.10.10-Gen.

AMERICAN STANDARDS

Special purpose steam turbines for petroleum, chemical and gas industry services	API 612
Rotary type positive displacement compressors for petroleum, chemical and gas industry services	API 619, 3rd edition, June 1997
Vibration, axial-position, and bearing-temperature monitoring systems	API 670
Special purpose couplings for petroleum, chemical and gas industry services	API 671
General purpose gear units for petroleum, chemical and gas industry services	API 677

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USA

ASME boiler and pressure vessel code:

Section V, Non-destructive examination	ASME V
Section VIII, Pressure vessels	ASME VIII
Section IX, Welding and brazing qualifications	ASME IX

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American Society of Mechanical Engineers
345 East 47th Street
New York NY 10017
USA

Standard specification for alloy-steel and stainless steel bolting materials for high-temperature service	ASTM A 193
Standard practice for ultrasonic examination of heavy steel forgings	ASTM A 388
Standard specification for ferritic ductile iron pressure-retaining castings for use at elevated temperatures	ASTM A 395
Standard practice for steel castings, welding, qualifications of procedures and personnel	ASTM A 488
Standard specification for austenitic ductile iron castings for pressure-containing parts suitable for low temperature service	ASTM A 571
Standard specification for ultrasonic angle-beam examination of steel plates	ASTM A 577
Standard specification for straight-beam ultrasonic examination of plain and clad steel plates for special applications	ASTM A 578
Standard practice for ultrasonic examination of austenitic steel forgings	ASTM A 745
Standard specification for through-thickness tension testing of steel plates for special applications	ASTM A 770
Standard practice for ultrasonic examination of metal pipe and tubing	ASTM E 213

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

Quality standard for steel castings - visual method

MSS SP-55

Issued by:
Manufacturers Standardisation Society
of the Valve and Fittings Industry
5203 Leesburg Pike, Suite 502
Falls Church
Virginia 22041
USA

**Amended per
Circular 27/04**

Materials resistant to sulfide stress cracking in corrosive
petroleum refining environments

NACE MR0103

Petroleum and natural gas industries — Materials for
use in H₂S-containing environments in oil and gas
production

NACE MR0175

Issued by:
NACE International
1440 South Creek Drive
Houston, Texas 77084
USA

BRITISH STANDARD

Acceptance levels for internal imperfections in steel
plate, strip and wide flats, based on ultrasonic
testing

BS 5996

Issued by:
British Standards Institution
389 Chiswick High Road
London W4 4AL
UK

Noise procedure specification

EEMUA 140

Issued by:
EEMUA,
45 Beech Street,
London EC2Y 8AD,
UK

EUROPEAN STANDARDS

Approval testing of welders - fusion welding

EN 287

Specification and qualification of welding procedures
for metallic materials

EN 288

Issued by:
CEN Secrétariat Central
Rue de Stassart 36
B-1050 Brussels
Belgium.

Copies can also be obtained from national standards organizations

INTERNATIONAL STANDARDS

Displacement compressors - acceptance tests

ISO 1217

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

ISO 9001

servicing

Approval testing of welders – fusion welding ISO 9606

Specification and approval of welding procedures for
metallic materials ISO 9956

Steel and steel products - inspection documents ISO 10474

**Amended per
Circular 27/04**

Petroleum and natural gas industries — Materials for use in
H₂S-containing environments in oil and gas production ISO 15156

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

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NOTE: Most referenced external standards are available for Shell users on the Shell Wide Web at address
<http://sww.shell.com/standards>