



GS 134-9

**ROTARY TYPE POSITIVE
DISPLACEMENT COMPRESSORS
TO API 619**

November 1994

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BP GROUP RECOMMENDED PRACTICES AND SPECIFICATIONS FOR ENGINEERING											
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SCOPE AND PURPOSE This BP Group Guidance for Specification covers requirements for Rotary Positive Displacement Compressors and is for use with a data sheet to adapt it for specific application. It supplements the API standard, defining a number of the optional clauses and substituting, modifying and qualifying certain other clause in the light of BP experience.											
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FOREWORD

Introduction to BP Group Recommended Practices and Specifications for Engineering

The Introductory Volume contains a series of documents that provide an introduction to the BP Group Recommended Practices and Specifications for Engineering (RPSEs). In particular, the 'General Foreword' sets out the philosophy of the RPSEs. Other documents in the Introductory Volume provide general guidance on using the RPSEs and background information to Engineering Standards in BP. There are also recommendations for specific definitions and requirements.

Value of this Guidance for Specification

This Guidance for Specification defines a number of the optional API clauses and may substitute, add to or qualify other API clauses using BP's knowledge and experience worldwide.

Application

This Guidance for Specification is intended to guide the purchaser in the use or creation of a fit-for-purpose specification for enquiry or purchasing activity.

It is a transparent supplement to [API 619](#) Second Edition, dated May 1985, showing substitutions, qualifications and additions to the API text as necessary. As the titles and numbering of the BP text follow those of API, gaps in the numbering of the BP document may occur. Where clauses are added, the API text numbering has been extended accordingly.

Text in *italics* is Commentary. Commentary provides background information which supports the requirements of the Specification, and may discuss alternative options.

This document may refer to certain local, national or international regulations but the responsibility to ensure compliance with legislation and any other statutory requirements lies with the user. The user should adapt or supplement this document to ensure compliance for the specific application.

Specification Ready for Application

A Specification (BP Spec 134-9) is available which may be suitable for enquiry or purchasing without modification. It is derived from this BP Group Guidance for Specification by retaining the technical body unaltered but omitting all commentary, omitting the data page and inserting a modified Foreword.



Feedback and Further Information

Users are invited to feed back any comments and to detail experiences in the application of BP RPSE's, to assist in the process of their continuous improvement.

For feedback and further information, please contact Standards Group, BP International or the Custodian. See Quarterly Status List for contacts.



1. INTRODUCTION

1.1 Scope

This Specification specifies BP general requirements for rotary type positive displacement compressors conforming generally to [API 619](#).

[API 619](#), paragraph 1.1 is interpreted, for this Specification, as including oil injected screw compressors. Standard utility air compressors of 400 kW (540 HP) or less, with not more than 9 bar (130 psig) discharge pressure, are excluded. This latter group will generally be purchased as packaged units.

They shall meet the requirements of [API 619](#) Second Edition, May 1985 (adopted as ANSI/API Std 619-1992), as amplified and modified herein.

1.2 Alternative Designs

Designs alternative to those prescribed will be acceptable provided it can be shown to the satisfaction of the purchaser's professional engineer that the required performance and function are attained.

Referenced standards may be replaced by equivalent standards that are internationally or otherwise recognised provided that it can be shown to the satisfaction of the purchaser's professional engineer that they meet or exceed the requirements of the referenced standards.

(Substitution)

1.3 Conflicting Requirements

In case of conflict between various documents their order of precedence shall be:-

- (a) Local Authority or Statutory Regulations
- (b) The Equipment Requisition or Order
- (c) Data Sheets
- (d) This specification
- (e) Referenced industry standards

(Substitution)

1.6 Co-ordination

The compressor vendor shall be responsible for the co-ordination of the design and for the satisfactory functioning of the complete unit, i.e.



compressor, driver, transmission and ancillaries. In cases where the compressor vendor supplies equipment that has not been manufactured by them, they shall be responsible for ensuring that the designs of these items are compatible with each other and with their own equipment in all respects. The satisfactory functioning of the complete unit shall form part of the compressor vendor's contractual guarantee.

(Addition)

2. BASIC DESIGN

2.1 General

2.1.13 Noise limits will normally be specified in detail in an enquiry. However, in the absence of such requirements, noise levels at or beyond 1 m (3 ft) from the machine (compressor plus driver, transmission and auxiliaries) surfaces should not exceed 87 dB(A).

When 12 hour shifts and maintenance areas are considered, 83 dB(A) may be a more appropriate level.

The sound intensity method for measuring the noise level of equipment (which may be appropriate and should be considered) offers significant advantages over conventional sound pressure measurement techniques. These are:-

- (a) Measurement of sound radiated from each surface or area of the equipment. This enables the principal contributors to overall noise level to be identified and reduced by locally applied absorption materials.*
- (b) Improved compensation for background and reverberative effects.*

When a vendor cannot meet the limits without the addition of noise attenuation features, the levels with and without these features shall be stated in their proposal. Noise attenuation measures proposed by the vendor shall not conflict with the other requirements of this Standard.

The vendor shall provide details of the noise emission in octave bands from their equipment, obtained by the methods of test as specified in EEMUA Publication No. 140 or a method of test approved by BP. A vendor shall also provide details of any narrow-band noise emitted by their equipment which is noticeable to the ear, and the octave band or bands in which it occurs.

Noise attenuating enclosures will only be accepted when there is no alternative form of noise control. The design of these enclosures shall be such that normal operation and maintenance are not unduly compromised. All instrumentation and controls shall be either mounted externally to the enclosure or shall be clearly visible and controllable from outside the enclosure.

Enclosures shall be adequately purged and cooled. Instrumentation, sensors and cables installed inside enclosures shall not be subjected to



an environment which causes the component to be operated outside the vendor's specified ambient temperature limits.

Where the area classification would otherwise be Zone 2, equipment within an enclosure will normally need to be suitable for a Zone 1 area.

(Substitution)

2.2 Pressure Casings

2.2.2 *Because of the built in volume ratio it is possible for the pressure within the casing to be higher than delivery pressure. It is therefore necessary to take this pressure into account when determining whether the maximum allowable working pressure is adequate.*

2.2.4 *If a split level casing is proposed it is necessary to consider whether there is any possibility of pressurising the machine from an external source. If there is then the low pressure casing must be adequately protected.*

2.3 Casing Connections

2.3.1 Flanged connections are preferred.

(Qualification)

2.3.1 *Studded connections on casing nozzles hinder installation and maintenance since piping has to be sprung in order to remove casings or spool pieces.*

There is also the risk of broken studs being left in the casing.

2.3.3 Welded connections shall be attached prior to any heat treatment of the casing.

(Addition)

2.3.4 Casing drains are always required. They shall be provided with valves and flanged, but not manifolded.

(Addition)

2.3.7.4 When connections other than those covered by ANSI are supplied, all mating parts shall be supplied by the vendor and details shall be approved by the purchaser.

(Addition)

2.6 Seals

2.6.1 Application

2.6.1.1 Shaft seals and ancillary systems shall also be suitable for operation at pressures up to the maximum allowable working pressure as defined in API 2.2.2.

(Addition)



Although it is not intended to run machines up to relief valve pressure continuously, two transient situations may arise.

- (i) The machine runs up to relief valve pressure. Seals and ancillary systems must be suitable.*
- (ii) The machine is on standby but is pressurised from an external source. Again seals and ancillary systems must be suitable.*

2.6.4.3 Mechanical seals of compressors handling sour gases shall be suitable for operation with high quality straight mineral oils.

(Addition)

2.6.4.3 *Lubricating oil for turbo-machinery normally contains additives to minimise oxidation, foaming, emulsification and to enhance EP properties. These additives can react with non-hydrocarbon contaminants in seal oil systems resulting in deposits or plating on seals and high seal oil leakage.*

In particular, zinc based additives (commonly used to enhance EP Properties) should not be used in sour gas duties containing H₂S.

Similarly, phosphor based additives, also used to improve EP properties should not be used in applications where temperatures exceed 45°C. Straight mineral oils which contain no additives have been successfully used but must be restricted to seal systems, and the risk of oxidation of the oil minimised. The use of N₂ blanketing of seal oil reservoirs with reservoir and seal chamber vents manifolded has proved an effective barrier to oxidation.

Where these arrangements cannot be made then the use of an anti-oxidation additive may be necessary. These are stable with temperatures well in excess of those seen in bearings and seals. However, commercially available straight mineral oils do not include anti-oxidation additives, and a special formulation would be necessary.

2.7 Dynamics

2.7.2 **Vibration and Balance**

2.7.2.4 *This appears to be a cumbersome way of saying that if there is a response when attaching a weight of W/2 the balancing machine is probably sensitive enough. It is noted that this section on checking balancing machine sensitivity has been omitted from later editions of comparable API standards.*

Normally the degree of balance achieved will be verified when the machine is run on test. The requirement to check the sensitivity of the balancing machine is only relevant in the case of rotors being purchased as spares without being run.

2.7.2.4.2 *Note that the equations are not non-dimensional and will only give the correct answer when working in imperial units.*

The lesser value for allowable residual unbalance is given by the first equation at speeds above 14087 rpm.



2.7.2.5 *Note that the equation is not non-dimensional and will only give the correct answer when working in mils.*

2.8 Bearings and Bearing Housings

2.8.2.8 Radial and thrust bearings shall be capable of withstanding reverse rotation for a short period of time without damage.

(Addition)

2.8.2.8 *Reverse rotation can occur on tripping if the stored energy on the discharge side of the compressor is large compared to the kinetic energy of the rotor system. The maximum permissible stored energy to avoid reverse rotation will depend on the means by which it blows down on tripping. A limit of twice the kinetic energy should minimise the risk.*

A further risk remains from leakage through non-return valves. When practicable these should be backed-up by the automatic closure of block valves. Additionally it is desirable that compressors be designed to accept some reverse rotation.

2.9 Bearing Housings

2.9.4 When separate seal and lubricating oil systems are to be used, positive separation of the seal and bearing housings shall be provided to ensure that cross flow of seal oil into the lubricating system cannot occur.

(Addition)

2.10 Lube-Oil and Seal-Oil Systems

2.10.3 A full [API 614](#) oil system is not always required. Where an oil system to [API 614](#) is specified, the requirements of BP Group [GS 134-3](#) shall also be met.

(Qualification)

2.10.3 *In the case of oil injected screw compressors the oil system has features to which API 614 is not relevant. For these machines such features as carbon steel reservoirs which are also oil separators and pressure vessels are normal. The requirement for eight minutes retention time is also irrelevant.*

2.10.4 Unless it is certain that seal oil contaminated with process gas will remain suitable for direct reuse, the seal inward (contaminated) flow shall not exceed 50 litres per seal day. This shall apply even if the seals are normally buffered by a clean non-contaminating gas.

(Addition)

2.10.5 (a) Seal oil systems of compressors handling toxic or corrosive gases or heavy hydrocarbons shall be separate from lube oil systems. This requirement shall apply even if seals are normally



buffered by a clean non-contaminating gas, or if the sour seal oil is normally degassed and decontaminated before being returned to the system.

(Addition)

Buffer gas supplies are commonly subject to interruption, and oil clean-up systems are commonly not completely effective. The objective of this requirement is to avoid contamination of lube oil systems without placing reliance on such sub-systems.

Process gas may render seal oil unfit for use as a lubricant in the following ways:

- (i) *The gas may react with additives to form deposits. For example Hydrogen Sulphide in sour gas can react with Zinc based additives to form sludge's.*

Phosphor base additives may be satisfactory if the use of additives is unavoidable. However the use of these oils should be avoided where surface temperatures exceed 95°C.

At higher temperature use additive free oil, if necessary in a separate seal oil system.

- (ii) *Components of the gas may be corrosive.*
- (iii) *Gas may reduce the viscosity and/or flashpoint of the oil below an acceptable level. For example LPG type gases are soluble in oil and reduce the viscosity and flashpoint.*
- (iv) *It is undesirable to have toxic gases in solution in the seal oil because of the risk of forming a toxic atmosphere around the reservoir or when equipment is opened.*

Oil containing EP additives, by design lays down deposits under conditions of high shear (sliding speed) or temperature. These lead to leakage of mechanical seals and to a lesser extent to problems with liquid film type seals. If an oil containing EP additives is specified by the compressor vendor, consideration should be given to separating seal and lube oil systems and using an additive free seal oil.

If the use of additives is unavoidable a grade of oil should be selected which minimises the concentration of additive.

- (b) *Seal oil systems of compressors handling flammable gases shall be separate from the lube oil system of HV motors of 3 kV and above unless of Ex d or Ex p construction.*

(Addition)

HV motors of 3 kV and above are currently considered as potentially sparking in service. The risk of gas accumulation via the oil system must therefore be minimised unless the motor is purged (Ex p) or is capable of containing an internal explosion (Ex d). The limiting 3 kV level is true



now but work is underway in order that this voltage level can be better defined.

- (c) When separate seal and lube oil systems are used, positive separation of the seal and bearing housings shall be provided to ensure that cross flow of seal oil into the lubricating system and visa-versa cannot occur. This shall be achieved without an external purge gas. Separation of the oil streams shall be demonstrated during the works test.

(Addition)

- (d) The vendor shall state in their proposal the method(s) to be used to de-gas and clean contaminated seal oil to restore flash point, viscosity and other properties.

Such systems shall include storage facilities for at least 3 days normal consumption.

(Addition)

A number of methods are available for the de-gassing of contaminated seal oil, these are:-

- (a) Simple atmospheric degassers
- (b) 'Vacuum' Degasser
- (c) Air Stripper
- (d) Steam Stripper.

Simple atmospheric degassers cannot remove components heavier than C5. Hence heavier gases will stay in solution and the seal oil viscosity and flash point will be reduced. Many existing heavy gas installations operate with these systems, which can, with careful operation, maintain flash points above 80°C. However, following a number of safety incidents, many offshore operators consider any reduction in flash point below 120°C as unacceptable and on existing installations are either dumping the contaminated seal oil or retrofitting more effective degassing devices.

Vacuum degassers have been applied on many installations in the North Sea. The equipment is complex and expensive and requires careful monitoring in operating.

The air stripping column was developed in an endeavour to overcome the shortcomings of the vacuum degasser. The principle is simple i.e. the oil cascades down a column in counterflow to air. The single pass operation proved very effective. However, the final design proved to be equally complex and expensive because of the need to monitor and control the gas levels in the exit air below the LEL and provide purging on loss of the normal air blower.

The steam stripper works on the same principle as the air stripper and because the steam is inert, the need to monitor the LEL is eliminated.



However, the unit requires a steam generator and potable water supply. The unit has proved very effective in trials.

The more severe degassers all to some degree strip additives from the oil. Where a separate seal oil system is installed this may not have any practical import, but with a combined lube and seal oil system it is essential that the correct additive levels are maintained, necessitating their regular monitoring and replenishment.

Sour gas can be removed by simple atmospheric degassing, and the recovered oil recycled to a separate seal oil reservoir. If the reservoir is purged by N₂ this will alleviate the possible accumulation of toxic H₂S levels.

- 2.10.6 Coolers, filters, overhead oil tanks, drainers, accumulators, silencers and other pressure vessels within the scope of [BS 5500](#) or Section VIII of the [ASME Boiler and Pressure Vessel Code](#) shall be built to either of these standards.

(Addition)

3. ACCESSORIES

3.1 Drivers

- 3.1.1 The driver shall also be capable of driving the compressor at relief valve set pressure (including accumulation) under the worst combination of specified utility, ambient and process conditions without margin.

(Addition)

- 3.1.4 Special purpose steam turbines shall be in accordance with BP Group [GS 134-7](#). Special purpose turbines shall be used for the main driver and general purpose for ancillary drives.

(Qualification)

- 3.1.5 Low voltage and high voltage induction motors shall comply with BP Group [GS 112-3](#) and [GS 112-4](#) respectively.

(Addition)

These documents make reference to EEMUA Publication No. 132.

3.2 Couplings and Guards

- 3.2.2 Spacers used in couplings that incorporate flexible membranes shall be positively constrained from flying out in the event of failure of the flexible membranes. All moving parts shall be guarded in accordance with national standards and national statutory regulations.



The material of guards shall be sheet steel unless conditions specifically require an alternative. Coupling guards shall be sufficiently robust to resist distortion under typical industrial maltreatment with consequent risk of sparking by contact with moving parts.

Gear couplings shall not be used without specific approval of the purchaser.

(Qualification)

3.2.2

Gear couplings suffer from a number of operational problems:-

- (a) *Wear caused by fretting resulting in vibration.*
- (b) *Relatively small radial misalignment capability which, if exceeded, may cause fretting, transmission of vibration and increased axial loading.*
- (c) *Transmission of axial loads due to inherent friction, which may become excessive if, as happens, the teeth become clogged by sludge centrifuged from the lubricating oil. This locking has resulted in thrust bearing failures.*

Gear couplings have advantages over flexible membrane types as they are lighter, which may be of value when rotordynamic design is difficult. Also they have greater axial movement capability.

When these couplings are used they should be of a design which permits the inspection of the teeth without disturbing hubs. They should also be of anti-sludging design and be lubricated via dedicated 2 x 100 micron filters in parallel; each filter to be capable of 100% duty and provided with continuous transfer valves to facilitate on-line maintenance.

Flexible membrane couplings avoid the shortcomings of gear types but they are normally of relatively large diameter necessitating careful design of the coupling housings to minimise windage heating and oil mist or oil vapour generation. These problems are more severe with diaphragm than metallic element couplings.

To minimise windage problems clearance between coupling flange and housing needs to be adequate and there must be a path for cooling air to sweep the interior of the housing without entraining oil mist or vapour remembering that the coupling flanges act like impellers drawing air in at the internal diameter and expelling it outwards. Additionally, couplings should be shrouded to minimise bolt windage.

The vendor should provide windage and heat balance calculations to demonstrate that air and guard surface temperatures are safe.

A method for predicting coupling and guard temperatures is given in "Design of Coupling Enclosures", M. M. Calistrat, R. E. Munyon, Texas A & M 14th Turbomachinery Symposium 1985.

Vendor experience and proposals should be carefully reviewed.

Personnel protection guards should be provided if (as is likely) the guard surface temperatures are greater than 60°C. (A perforated screen set 40-50 mm off the surface will suffice).



3.2.7 In order to allow adjustment of torsional critical speed by change of coupling spacer length, the effect of the coupling torsional flexibility on the torsional critical speeds shall be considered prior to finalising the general arrangement drawing.

(Addition)

3.2.8 All coupling hubs shall be capable of being removed on site without the application of heat and without moving driving or driven equipment, including any gearbox.

(Addition)

3.3 Mounting Plates

3.3.1 General

3.3.1.1 See 3.3.2.1 of this Specification

3.3.2 Baseplates

3.3.2.1 A single continuous base plate for compressor, gear unit, driver and control panel shall be provided, unless impracticable for shipping reasons.

(Addition)

3.3.2.7 Decking shall be provided on the top of the baseplate covering all walk and work areas.

(Qualification)

3.3.2.4 The vendor shall provide a four point lift and if necessary a spreader beam. Both shall be specifically designed for the baseplate being supplied and shall be certified for their safe working load to meet local and national requirements.

(Qualification)

3.4 Controls and Instrumentation

3.4.1 General

3.4.1.1 In all cases the compressor vendor shall review the proposed control systems to confirm their suitability for start-up, shutdown and all specified operating conditions.

(Addition)

3.4.1.2 Instrumentation equipment shall conform to BP Group. [GS 130-2](#).

(Addition)



3.4.3 Instrumentation and Control Panels

- 3.4.3.1 The instrument panel, if provided, shall contain indication of all individual alarms, all individual trips, and all important instruments and controls for the compressor, driver, transmission and auxiliaries such as to facilitate rapid fault finding and safe control with the minimum of personnel.

(Addition)

- 3.4.3.3 The following instrumentation shall be regarded as the minimum required for mounting on the local panel. Particular installations may require additions.

- (1) Suction and discharge temperature indication for each compressor stage.
- (2) Suction and discharge pressure indication for each compressor stage.
- (3) Annunciation of utilities' standby equipment having been automatically brought into operation.
- (4) By-pass flow indication (if applicable).
- (5) Instrumentation for lubricating and seal oil systems. Refer to BP Group [GS 134-3](#).
- (6) Instrumentation for the driver and transmission which is to be co-ordinated by the compressor vendor.
- (7) Vibration monitors (if applicable).

(Addition)

When no local panel is specified, indication of process and utilities' pressures and temperatures shall be provided by pressure and temperature gauges mounted locally on the machinery. Where it would be beneficial for operational reasons, pressure gauges shall be grouped on a baseplate supported gauge panel.

3.4.4 Alarms and Shutdowns

- 3.4.4.1 The following alarms shall be regarded as the minimum required, including the requirements of API 3.4.4.1. Particular installations may require additions.

- (1) Gas discharge, high temperature (for each stage).



- (2) Compressor suction drum, high level. (Provision on panel, and also for independent indication on plant control room annunciator).
- (3) Buffer gas differential pressure, low (if applicable).
- (4) All alarms specified in BP Group [GS 134-4](#) for lubrication, shaft sealing and control oil systems.
- (5) High lubricating oil temperature.
- (6) All alarms for the driver and transmission.
- (7) Vibration (if applicable).

The following trips shall be regarded as the minimum required, including the requirements of API 3.4.4.1. Particular installations may require additions:-

- (a) Manual local - on machine.
- (b) Compressor suction drum, extra high level. (Provision on panel).
- (c) All trips specified in BP Group [GS 134-3](#) for lubrication, shaft sealing and control oil systems.
- (d) All trips for the driver and transmission.
- (e) Gas discharge, high temperature (for each stage).

(Qualification)

- 3.4.4.3 Electric switches installed to initiate both alarm and shutdown (trip) functions shall be closed (energised) during normal machine operating conditions and open (de-energised) to initiate the alarm or trip action.

(Substitution)

- 3.4.4.6 For the purpose of testing alarm and shutdown initiating pressure switches, an orifice shall be installed immediately before the drain/vent facility.

(Addition)

- 3.4.4.6 *The design of temperature elements and associated thermowells for temperature trip applications where fast response is required, such as compressor discharge, requires special attention. The use of low mass thin wall tip thermowells should be considered. Alternative arrangements may also be considered provided the*



mechanical integrity is such as to ensure pressure containment during the life of the installation. The influence of any chosen design with regard to vibration effects and possible failures must also be addressed.

- 3.4.4.7 All instruments and controls shall be installed with suitable isolation to permit removal while the system is in operation. Pressure sensing instruments shall be provided with safe draining/vent facilities.

(Substitution)

3.4.5 Vibration and Position detectors

- 3.4.5.1 If proximity probes are being provided, in order to allow calibration of each transducer circuit, the compressor vendor shall supply "calibration" test pieces, made from each shaft material used in the machinery train, i.e. driver, gearbox and compressor.

(Addition)

- 3.4.5.1 *The calibration of proximity probes depends upon the properties of the shaft material. Hence the requirement for test pieces made from the relevant materials.*

It is not usual to fit proximity probes to screw compressors. The design of the machines makes fitting such probes difficult and expensive. This is particularly so in the case of oil injected machines.

Where such probes have been fitted to screw compressors the vibrations were found to be higher than expected and led to unnecessary concern about machines which were operating satisfactorily.

- 3.4.5.2 Where external seismic vibration transducers are used, a machined flat surface for the mounting of these transducers shall be provided at each bearing housing.

(Addition)

- 3.4.5.2 *Accelerometers could be fitted to the bearing housing. This is unlikely to be effective in the case of oil injected machines because the bearings are right inside the machine and the casing is likely to mask shaft induced vibrations. In addition, the vibrations induced by the periodic opening of the suction and discharge ports is likely to be large enough to mask shaft vibrations.*

- 3.4.5.4 Vibration monitoring equipment, if provided, shall be standardised for the complete set (driver, transmission and compressor). Details shall be included in the proposal.

(Addition)

- 3.4.5.5 *Lube Oil Condition Monitoring*

This method consists of taking regular samples of the lube oil and analysing it for oil properties and contamination whether by process fluids or wear debris. By identifying the need for an oil change, wear problems may be prevented.



Two prime objectives:-

(a) *Check of Oil Properties*

Viscosity, flash point, TAN etc., to ascertain its ability to fulfill its required functions.

(b) *Ferrography*

The analysis of wear debris to ascertain the conditions of rotors and bearings. Provided the materials of construction of the oil wetted parts of the machine are known, the source of wear debris can usually be identified and an opinion formed as to the condition of the wearing components and the need for maintenance.

A similar procedure can be applied to the seal oil system if present.

This approach is probably the most effective in relation to screw compressors.

3.5 Piping and Appurtenances

3.5.1 General

3.5.1.5 Piping for lubricating and seal oil systems shall be grouped for convenient connection to their remotely located units.

The requirement for normal accessibility for operation, maintenance and thorough cleaning shall be met by the provision of sufficient flanged connections. Components requiring removal for maintenance shall also be flanged, e.g. control valves.

(Addition)

3.5.2 Oil Piping

3.5.2.1 The piping specifications of BP Group [134-3](#) shall apply to all piping mounted on either the compressor unit or the baseplate, or on both.

On an oil injected compressor, process gas will become entrained in the lubricating oil. All components exposed to the lubricating oil must, therefore, be of suitable materials and designed for service exposed to both the lubricating oil and the process gas.

(Addition)

3.5.5 Intercoolers and Aftercoolers

3.5.5.5 Tubes in hydrogen service (as defined in Appendix A of this Standard) and in other services where specified, shall be seal welded. Tubes shall be welded in accordance with BP Group [GS 118-8](#).

(Addition)



3.5.7 Silencers

3.5.7.3 *Note that the equation is not non-dimensional. P must be in psia to give the correct result.*

The equation gives the smaller allowable pulsation limit at pressures above 428 psia (29.1 Bar a).

3.5.7.4 *Much of the noise emitted by rotary compressor installations is emitted from the pipework as a result of the pressure pulsation's therein. For this reason silencers have most effect if placed as close as possible to the compressor. If silencers cannot be mounted on compressor flanges it will probably be necessary to lag suction and/or delivery pipes to reduce sound emission.*

4. INSPECTION , TESTING AND PREPARATION FOR SHIPMENT

4.1 General

4.1.1 The vendor shall table his internal inspection and test plan as the basis of discussion to agree the extent of purchaser participation in the inspection and testing.
(Substitution)

Verification of the vendor's quality system is normally part of the pre-qualification procedure, and is therefore not specified in the core text of this specification. If this is not the case, clauses should be inserted to require the vendor to operate and be prepared to demonstrate the quality system to the purchaser.

Further suggestions may be found in the BP Group RPSEs Introductory volume.

Purchaser participation will need to be agreed on an individual job basis recognising factors such as:

- (a) *The maturity of the design.*
- (b) *The criticality of the machine with respect to operation and safety.*
- (c) *Experience in the production and test facility where the machine will be built and tested.*
- (d) *Previous experience with the vendor.*

Any requirement for inspection by an Independent Authority such as might arise for statutory or insurance reasons should be taken into account.

Typical inspection activities pertinent to rotary compressors are listed below together with guidance on their importance. It is assumed that the competence of the vendor has been established as satisfactory by previous experience or by audit.

- (a) *Material certification: certificates for major items such as casing, impellers and shafts should normally be examined. They should be readily available being a requirement of API 4.2.1.*



Additionally, it should be established that satisfactory systems exist for material traceability.

- (b) *Repairs: those justifying purchaser involvement would normally be limited to through-thickness weld repairs, repairs of cracks in casings (to establish the cause) and repairs to rotating elements.*
- (c) *Balancing: witnessing will not normally be justified as the state of balance will be demonstrated during the mechanical test.*
- (d) *Pressure tests: witnessing of main casing tests is necessary as a check of functionality. Witnessing of tests on ancillary systems is not normally justified.*
- (e) *Dimensions and layout: checking of dimensions will not normally be necessary but layout of customised (non-standard) packages should be examined to ensure adequate access for operation and maintenance.*
- (f) *Mechanical and performance: all tests should be witnessed. They demonstrate the essential functionality of the machine.*
- (g) *Packaging: this may justify attention if shipment is offshore or otherwise onerous or if long term storage is required.*

4.3 Testing

4.3.1 General

4.3.1.1 The following tests are required:-

- (a) Hydrostatic test in accordance with 4.3.2.1 of [API 619](#)
- (b) Mechanical running test in accordance with 4.3.3, Post Test Inspection shall be carried out after each Mechanical Running Test, in accordance with 4.3.4.8 of [API 619](#)
- (c) Performance test in accordance with 4.3.4.1 of [API 619](#) for the first off each type.
- (d) Complete-unit test in accordance with 4.3.4.2 of [API 619](#) for all offshore machines.
- (e) In addition to the requirements of 4.3.2.2 of [API 619](#) helium tests will be required if the compressor is on hydrogen service as defined in Appendix A of this Guidance for Specification.
- (f) Sound level test in accordance with 4.3.4.6 of [API 619](#) for the first off each type.

The use of sound intensity may be the better means of carrying out these tests.



- (g) Assembled compressor gas-leakage tests in accordance with 4.3.4.10 of [API 619](#) are required in all cases for toxic or flammable gas service.

(Qualification)

4.3.3 Mechanical Running Test

- 4.3.3.2.2 Lube-oil and seal-oil temperatures shall be held for at least half an hour at the values corresponding to the minimum allowable viscosity and half an hour at the values corresponding to the maximum allowable viscosity. Under both conditions shaft vibrations shall be measured in accordance with 4.3.3.4.

(Qualification)

- 4.3.3.4 Prior to the works mechanical running test, the shaft runout shall be measured at the location of each proximity probe if fitted.

(Addition)

4.3.4 Optional Tests

Requirements for Optional Tests should be specified on the data sheets or agreed prior to order placement. In the absence of agreed alternatives the requirements of 4.3.1.1 apply.

- 4.3.4.1 When capacity control is by means of a built in slide valve, a full performance test is required with the slide valve set for maximum capacity. In addition, operation of the slide valve through the full range of travel shall be demonstrated. Sufficient measurements shall be taken at reduced capacity to assess the degree of turndown and control achievable.

- 4.3.4.1 As the [ASME Power Test Code PTC. 9](#) gives no guidance on the method of calculating the performance on contract gas from the results of a performance test on any other gas, the method of performing this conversion must be agreed.

Dry Screw Compressors

Vendors have theory for estimating the volumetric efficiency of a dry screw compressor. The equation includes a term for the internal clearance screw tip/bore of the machine. When predicting the machine performance the nominal value of the clearance is used.

When evaluating test results the equation is rearranged to allow the calculation of the clearance. The value found is then used in the original equation to predict the performance under contract conditions.

In order to test a dry screw compressor the following conditions should be met. It is assumed that the test will be performed on air and that the results will have to be corrected to contract conditions.



- 1) *The Contract Equivalent Pressure Ratio (CEPR) should be calculated. This is the pressure ratio on air which gives the same discharge temperature as calculated for the contract gas and conditions.*

Single stage machines should be tested at least to the CEPR. In many cases it would be prudent to test them to slightly above the CEPR so that the highest temperature to be experienced in service is seen on test.

- 2) *If the contract gas has a low gamma value then the CEPR will be less than the contract pressure ratio. In this case the pressure ratio or differential pressure must be increased to test the mechanical integrity of the machine. The discharge temperature can be reduced by injecting water into the suction.*

Oil Injected Screw Compressors

Since the compression process in oil injected compressors is approximately isothermal and internal leakage is greatly reduced by the sealing effect of the oil, the test gas is not of great significance.

It is usual to test these machines on air. The maximum test differential pressure should at least equal the contract differential pressure. Flow, differential pressure and power should be equal to contract conditions along the performance curve.

There is no satisfactory theoretical basis for correcting air performance to that on process gas. In the case of refrigeration machines it may be possible to base the correction on tests by SRM, the original licensee of most designs. In a number of cases SRM have tested machines on air and refrigerant gas. The capacity of the machine on test is then scaled by the ratio of performance on gas to that on air at the same pressure ratio.

If the machine incorporates a slide valve for capacity control then its functioning should be witnessed.

4.3.4.8

Note that dismantling the compressor after the mechanical running test to some extent invalidates the test because of disturbing the screw timing. Consideration should be given to modifying the strip down in accordance with API 4.3.3.6 or giving the compressor a final check run. The Complete Unit Test can serve as the check run.

4.3.4.2 and 4.3.4.9

Complete Unit Test and Full-Pressure/Full-Load/Full-Speed Test.

Complete unit tests will normally be at limited load.

There is an increasing trend towards full-pressure/full-load/full-speed testing of compressor trains where the location is isolated e.g. Off-shore and remote on-shore areas. The cost and delivery extension for these tests may be justified by forestalling site problems and hence expediting commissioning. Areas verified by full-pressure/full-load/full-speed test not covered by no load tests are:

- (a) *Complete rotordynamic behaviour.*



- (b) *Compressor Thrust Bearing Loads*
- (c) *Gear box: Bearing temperatures, noise, and tooth contact.*
- (d) *Hot alignment.*
- (e) *Transient behaviour of seal oil systems during starting, tripping, pump change-over etc.*

For multiple unit orders full-pressure/full-load/full-speed testing is unlikely to be justifiable for more than one train.

4.4 Preparation for Shipment

- 4.4.3.1 Special requirements for a particular situation may be required, or a review of the vendors procedures carried out.

(Substitution)

5. VENDORS DATA

5.1 Proposals

- 5.1.1 In addition to the requirements of API 619 Clause 5.1 the following information is to be included:-
 - (1) Details of air purging, if this is proposed, in order to meet area classification requirements. See 2.1.12 of [API 619](#)
 - (2) Sufficient detail of the design of acoustic enclosures to permit assessment of ease of operation and maintenance. See 2.1.13 of this Specification.
 - (3) Built in Volume Ratio. See 2.2.2 of this Specification.
 - (4) Maximum pressure as defined in the first paragraph of 2.2.2 of this Specification.
 - (5) Full details of any metal bellows and their installation (see API 2.4.2).
 - (6) Details of proposed methods for de-gassing and cleaning contaminated seal oil. See 2.10.5 of this Specification.
 - (7) Details of proposed vibration monitoring equipment. See 3.4.5.4 of this Specification.



- (8) The ability of radial and thrust bearings to operate at full speed in reverse rotation under full differential pressure. See 2.8.2.8 of this Specification.
- (9) When flexible couplings of the single membrane type are to be used, full supporting information shall be provided to demonstrate that the flexible elements have an infinite life under all conditions of torque, speed, axial movement, lateral and angular misalignment that can be encountered in normal service and at start-up. This information shall include Goodman diagrams showing steady and alternating stresses for each situation and the assumptions used in the calculations.

(Addition)

5.2 Contract Data

5.2.1 General

- 5.2.1.1 Data necessary for the prediction of performance on contract gas from test results shall be included in the schedule of data to be transmitted. The data is to be provided before any performance test.

(Addition)

5.2.5 Instruction Manuals

Instruction manuals shall also include records of all design and as built fits and clearances required for assembly, maintenance and repair.

(Addition)



DEFINITIONS AND ABBREVIATIONS**Definitions**

Standardised definitions may be found in the BP Group RPSEs Introductory Volume.

Reference in this Specification to hydrogen service shall be taken to mean that the gas contains hydrogen at a partial pressure of 5 bar (72.5 lb/in) abs or higher at any point within the machine.

Abbreviations

ANSI	American National Standards Institute
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
bar	barometric
EEMUA	Engineering Equipment and Materials Users Association
EP	Extreme Pressure
H ₂ S	Hydrogen Sulphide
HP	Horse Power
HV	High Voltage
kW	Kilowatt
LEL	Lower Explosive Limit
LPG	Liquefied Petroleum Gas
N ₂	Nitrogen
OCMA	Oil Companies Materials Association (subsumed into EEMUA)
psig	pounds per square inch, gauge
SRM	Swedish Licensee of Screw Compressors



LIST OF REFERENCED DOCUMENTS

A reference invokes the latest published issue or amendment unless stated otherwise.

Referenced standards may be replaced by equivalent standards that are internationally or otherwise recognised provided that it can be shown to the satisfaction of the purchaser's professional engineer that they meet or exceed the requirements of the referenced standards.

American

API 614	Lubrication, Shaft Sealing and Control Oil Systems for Special Purpose Applications (to be replaced by ISO 10438)
API 619	Rotary-Type Positive Displacement Compressors for General Refinery Services (to be replaced by ISO 10440)
ASME	Boiler and Pressure Vessel Code, Section VIII, Division 1
ASME PCT. 9	<i>Displacement Compressors, Vacuum Pumps and Blowers</i>

British Standards

BS 5500	Unfired Fusion Welded Pressure Vessels
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BP Group Documents

BP Group GS 112-3	Low Voltage Induction Motors (replaces BP Std 221)
BP Group GS 112-4	High Voltage Induction Motors (replaces BP Std 220)
BP Group GS 118-8	End Welding of Heat Exchanger Tubes (replaces BP Std 191)
BP Group GS 130-2	Instrumentation for Rotating Machinery (replaces BP Std 128)
BP Group GS 134-3	Lubrication, Shaft Sealing and Control Oil Systems for Special Purpose Applications to API 614 (replaces BP Std 190)



BP Group [GS 134-4](#)

Centrifugal Pumps to API 610
(replaces BP Std 195)

BP Group [GS 134-7](#)

Special Purpose Steam Turbines to API 612
(replaces BP Std 198)

EEMUA and other Documents

[EEMUA Publication No. 132](#)

Three Phase Cage Induction Motors
(replaces OCMA Specification ELEC1)

[EEMUA Publication No. 140](#)

Noise Procedure Specification
(replaces OCMA specification NWG-1).

Design of Coupling Enclosures, M.M. Calistrat, R.E. Munyon, Texas A&M 14th Turbomachinery Symposium 1985

