Axial and Centrifugal Compressors and Expander-compressors

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Foreword

API 617 consists of the following parts, under the general topic “axial and centrifugal compressors and expander-compressors for special purpose applications handling gas or process air”:

— *Part 1—General Requirements,*

— *Part 2—Nonintegrally Geared Centrifugal and Axial Compressors,*

— *Part 3—Integrally Geared Centrifugal Compressors,*

— *Part 4—Expander-compressors.*

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Suggested revisions are invited and should be submitted to the Standards Department, API, 1220 L Street, NW, Washington, DC 20005, standards@api.org.

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Introduction

Users of this standard should be aware that further or differing requirements may be needed for individual applications. This standard is not intended to inhibit a supplier from offering, or the purchaser from accepting alternative equipment or engineering solutions for the individual application. This may be particularly appropriate where there is innovative or developing technology. Where an alternative is offered, the supplier should identify any variations from this standard and provide details.

A bullet (●) at the beginning of a section or subsection indicates that either a decision is required or further information is to be provided by the purchaser. This information should be indicated on datasheets or stated in the enquiry or purchase order (see examples in Annex A of Parts 2, 3, and 4).

In this standard, where practical, U.S. customary (USC) units are included in parentheses for information.

Axial and Centrifugal Compressors and Expander-compressors

Part 1—General Requirements

1 Scope

This standard specifies minimum requirements and gives recommendations for axial compressors, single-shaft and integrally geared process centrifugal compressors, and expander-compressors for special purpose applications that handle gas or process air in the petroleum, chemical, and gas industries. This part of API 617 specifies general requirements applicable to all such machines.

API 617 does not apply to fans (these are covered by API 673) or blowers that develop less than 34 kPa (5 psi) pressure rise above atmospheric pressure. API 617 also does not apply to packaged, integrally-geared centrifugal plant and instrument air compressors, which are covered by API 672. Hot gas expanders over 300 °C (570 °F) are not covered by API 617.

This part of API 617 contains information pertinent to all equipment covered by the other parts of this document. It shall be used in conjunction with the following parts, as applicable to the specific equipment covered:

— *Part 2—Nonintegrally Geared Centrifugal and Axial Compressors*,

— *Part 3—Integrally Geared Centrifugal Compressors*,

— *Part 4—Expander-compressors.*

2 Normative References

2.1 The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Standard 612, *Petroleum, Petrochemical and Natural Gas—Steam Turbines—Special Purpose Applications*, Sixth Edition

API Standard 613, *Special Purpose Gear Units for Petroleum, Chemical, and Gas Industry Services*, Fifth Edition

API Standard 614, *Lubrication, Shaft-sealing and Oil-control Systems and Auxiliaries*, Fifth Edition

API Standard 670*, Machinery Protection Systems,* Fourth Edition

API Standard 671, *Special Purpose Couplings for Petroleum, Chemical and Gas Industry Services,* Fourth Edition

AGMA 2015-1-A01 2001 [1], *Accuracy Classification System—Tangential Measurements for Cylindrical Gears*

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1 American Gear Manufacturers Association, 500 Montgomery Street, Suite 350, Alexandria, Virginia 22314, www.agma.org.

AGMA 2101-D04, *Fundamental Rating Factors and Calculation Methods for Involute Spur and Helical Gear Teeth 2004 (R 2010)*

ASME B1.1-2003 [2], *Unified Inch Screw Threads (UN and UNR Thread Form)*

ASME B1.20.1-2006, *Pipe Threads, General Purpose (Inch)*

ASME B16.1-2010, *Gray Iron Pipe Flanges and Flanged Fittings (Classes 25, 125, and 250)*

ASME B16.5-2011, *Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard*

ASME B16.11-2009*, Forged Fittings, Socket-Welding and Threaded*

ASME B16.42-2011, *Ductile Iron Pipe Flanges and Flanged Fittings Classes 150 and 300*

ASME B16.47-2011, *Large Diameter Steel Flanges NPS 26 Through NPS 60 Metric/Inch Standard*

ASME PTC 10-1997, *Performance Test Code on Compressors and Exhausters.*

ASTM A247 [3], *Standard Test Method for Evaluating the Microstructure of Graphite in Iron Castings*

ASTM A278, *Standard Specification for Gray Iron Castings for Pressure-containing Parts for Temperatures Up to 650 °F (350 °C)*

ASTM A395, *Standard Specification for Ferritic Ductile Iron Pressure-retaining Castings for Use at Elevated Temperatures*

ASTM A536, *Standard Specification for Ductile Iron Castings*

ASTM E125, *Standard Reference Photographs for Magnetic Particle Indications on Ferrous Castings*

ASTM E165, *Standard Practice for Liquid Penetrant Examination for General Industry*

ASTM E709, *Standard Guide for Magnetic Particle Testing*

AWS D1.1 [4], *Structural Welding Code*

EN 55011:2007 [5], *Industrial scientific and medical (ISM) radio-frequency equipment—Electromagnetic disturbance characteristics—Limits and methods of measurement*

EN 61000-6-2:2006, *Electromagnetic compatibility (EMC)—Part 6-2: Generic standards—Immunity for industrial environments*

IEC 60079-10-1[6], *Explosive atmospheres—Part 10-1: Classification of areas—Explosive gas atmospheres*

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2 ASME International, 3 Park Avenue, New York, New York 10016, www.asme.org.
3 ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org.
4 American Welding Society, 550 NW Le Jeune Road, Miami, Florida 33126, www.aws.org.
5 European Committee for Standardization (CEN), Rue de Stassart 36, BE-1050 Brussels, Belgium, www.cenorm.be.
6 International Electrotechnical Commission, 3, rue de Varembé, P.O. Box 131, CH-1211 Geneva 20, Switzerland, www.iec.ch.

ISO 261:1998 [7], *ISO general purpose metric threads, General plan*

ISO 1940:2003*, Mechanical vibration—Balance quality requirements for rotors in a constant (rigid) state—Part 1: Specification and verification of balance tolerances*

ISO 5389:2005*,Turbocompressors—Performance test code*

ISO 6708:1995, *Pipework components—Definition and selection of DN (nominal size)*

ISO 7005-1:1992, *Metallic flanges—Part 1: Steel flanges*

ISO 7005-2:1992, *Metallic flanges—Part 2: Cast iron flanges*

ISO 8068:2006, *Lubricants, industrial oils and related products (class L)—Family T (Turbines)—Specifications for lubricating oils for turbines*

ISO 8821:1989, *Mechanical vibration—Balancing—Shaft and fitment key convention*

ISO 14839-1:2002, *Mechanical vibration—Vibration of rotating machinery equipped with active magnetic bearings—Part 1: Vocabulary*

ISO 14839-3:2007, *Mechanical vibration—Vibration of rotating machinery equipped with active magnetic bearings—Part 3: Evaluation of stability margin*

NACE MR 0103-2007 [8], *Standard Material Requirements—Material Resistant to Sulfide Stress Cracking in Corrosive Petroleum Refining Environments*

NACE MR 0175-2008, *Petroleum and Natural Gas Industries—Materials for Use in H_2S Containing Environments in Oil and Gas Production—Part 3: Cracking Resistant CRAs (Corrosion Resistant Alloys) and Other Alloys* (Identical to ISO 15156-3)

NACE SP 0472-2008, *Methods and Controls to Prevent In-service Environmental Cracking of Carbon Steel Weldments in Corrosive Petroleum Refining Environments*

NFPA 70:2008 [9], *National Electrical Code*

SAE J518-1993 [10], *Hydraulic Flanged Tube, Pipe, and Hose Connections, Four-bolt Split Flange Type*

- **2.2** The hierarchy of documents shall be specified.

NOTE Typical documents submitted as a user inquiry or order are user specifications, industry specifications (such as API and ISO specifications), datasheets, meeting notes, and supplemental agreements.

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7 International Organization for Standardization, 1, ch. de la Voie-Creuse, Case postale 56, CH-1211 Geneva, Switzerland, www.iso.org.

8 NACE International (formerly the National Association of Corrosion Engineers), 1440 South Creek Drive, Houston, Texas 77218-8340, www.nace.org.

9 National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02169-7471, www.nfpa.org.

10 Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, Pennsylvania 15096-0001, www.sae.org.

3 Terms, Definitions, and Abbreviations

3.1 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1
anchor bolts
Bolts used to attach the mounting plates to the support structure (concrete foundation or steel structure); cf. **hold-down bolts** (3.1.13).

3.1.2
axially split joint
Joint split with the principal face parallel to the shaft centerline.

3.1.3
cartridge bundle assembly (centrifugal)
Assembly consisting of the complete compressor assembly minus the casing.

NOTE It includes the inner barrel assembly, end heads, seals, bearing housings, and bearings. It also includes the rotor assembly. It is designed to be shop assembled and ready for insertion into the casing to minimize installation work in the field.

3.1.4
certified point
Point to which the performance tolerances shall be applied.

NOTE This is usually the normal operating point, and suppliers will normally require that this point is within their preferred selection range.

3.1.5
complex stiffness
Notation for the total equivalent stiffness and damping expression, including the cross-coupled terms as required for the hydrodynamic bearing or squeeze damper oil film.

3.1.6
compliant seal
Seal design that allows rotor or rotor sleeve contact and possible stator element penetration without excessive loss of sealing performance.

3.1.7
compressor section
Series of one or more impellers with defined external process conditions (i.e. side streams, bypassing, or injection).

3.1.8
compressor rated point
Intersection on the 100 % speed curve corresponding to the highest capacity of any specified operating point.

NOTE This is generally a derived point rather than an actual operating point (see Figure 1 in Part 2 for a graphical representation).

3.1.9
critical speed
Shaft rotational speed at which the rotor-bearing support system is in a state of resonance.

3.1.10
design
Manufacturers' calculated parameter.

NOTE This is a term used by the equipment manufacturer to describe various parameters such as design power, design pressure, design temperature, or design speed. It is not intended for the purchaser to use this term.

3.1.11
gear wheel
bull gear
Lowest speed rotor in a gearbox; cf. **pinion(s)** (3.1.36).

3.1.12
gearing
The pinion(s) and gear wheel combination(s). A gear mesh is a pinion and gear wheel that operates together. A gear wheel may mesh with more than one pinion and therefore be part of more than one gear mesh.

3.1.13
hold-down bolts
Bolts holding the equipment to the mounting plate; cf. **anchor bolts** (3.1.1).

3.1.14
hydrodynamic bearings
Bearings that use the principles of hydrodynamic lubrication.

NOTE The bearing surfaces are oriented so that relative motion forms an oil wedge, or wedges, to support the load without shaft-to-bearing contact.

3.1.15
hysteresis damping (internal friction)
Causes a phase difference between the stress and strain in any material under cyclic loading. This phase difference produces the characteristic hysteric loop on a stress-strain diagram and thus a potentially destabilizing damping force.

3.1.16
informative
Information only; cf. **normative** (3.1.32).

NOTE An informative reference or annex provides advisory or explanatory information. It is intended to assist the understanding or use of the document. For example, Annex B—*Typical Shaft End Seals*, Annex C—*Requirements for Lateral Analysis Reports*, Annex D—*Requirements for Torsional Analysis Reports*, Annex E—*Magnetic Bearings*, Annex F—*Dry Gas Seal Testing at Manufacturer's Shop*, Annex G—*Guidelines for Anti-surge Systems*, and Annex H—*Typical Bid Tab Template*.

3.1.17
inlet volumetric flow
Flow rate expressed in volume flow units at the conditions of pressure, temperature, compressibility, and gas composition, including moisture content, at the machine inlet flange.

NOTE Inlet volumetric flow is a specific example of actual volumetric flow. Actual volumetric flow is the volume flow at any particular location such as interstage, impeller inlet or discharge, or machine inlet or discharge. Actual volumetric flow cannot be used interchangeably therefore with inlet volumetric flow.

3.1.18
inner barrel assembly (centrifugal)
Assembly consisting of the internal stationary parts that make up the removable portion of the flow path, including the inner barrel, the diaphragms, the impeller eye labyrinths, and the diaphragm labyrinths.

3.1.19
low temperature service
Service where the specified minimum design metal temperature is below −29 °C (−20 °F).

3.1.20
maximum allowable temperature
Maximum continuous temperature for which the manufacturer has designed the equipment (or any part to which the term is referred).

NOTE The maximum allowable temperature is usually set by material considerations.

3.1.21
maximum allowable working pressure
MAWP
Maximum continuous pressure for which the manufacturer has designed the equipment (or any part to which the term is referred).

NOTE Normally expected operating conditions can be based on settle-out pressure, maximum suction pressure plus the maximum developed differential pressure at the maximum speed (trip speed), or may be limited by relief valve set pressure or other means.

3.1.22
maximum continuous speed
MCS
Highest rotational speed (revolutions per minute) at which the machine, as-built and tested, is capable of continuous operation.

3.1.23
maximum inlet pressure
Highest specified inlet pressure the equipment shall be subject to.

3.1.24
maximum sealing pressure
Highest pressure the seals are required to seal during any specified static or operating conditions and during start-up and shutdown.

3.1.25
minimum allowable speed
Lowest speed (revolutions per minute) at which the manufacturer's design shall permit continuous operation.

3.1.26
minimum design metal temperature
Lowest mean metal temperature (through the thickness) expected, including operation upsets, auto refrigeration, and temperature of the surrounding environment.

3.1.27
modular rotor
Rotor that is built up using stub shafts or similar devices and held together by one or more through bolts.

3.1.28
moment simulator
Auxiliary device intended to simulate the moment of the mass of a half coupling.

NOTE A moment simulator can also be designated to serve as an idling adapter (solo plate).

3.1.29
mounting plate(s)
Device used to attach equipment to concrete foundations. This is either baseplate(s) or soleplate(s).

3.1.30
normal operating point
Point at which usual operation is expected and optimum efficiency is desired.

NOTE This point is usually the point at which the supplier certifies that performance is within the tolerances stated in this standard.

3.1.31
normal speed
Speed corresponding to the requirements of the normal operating condition.

3.1.32
normative
Required; cf. **informative** (3.1.16).

NOTE A normative reference or annex enumerates a requirement or mandate of the specification.

3.1.33
nominal pipe size
NPS
Dimensionless value approximately equal to the diameter in inches.

EXAMPLE NPS $^{3}/_{4}$.

NOTE 1 Adapted from ASME B 31.3-2002, Paragraph 300.2.

NOTE 2 The number following the letters NPS does not represent a measurable value.

NOTE 3 NPS is a designation of pipe size only. The pipe end may be threaded or prepared for a welded fitting.

3.1.34
observed (tests and inspections)
Inspection or test where the purchaser is notified of the timing of the inspection or test and the inspection or test is performed as scheduled even if the purchaser or his/her representative is not present; cf. **witnessed (tests and inspections)** (3.1.66).

3.1.35
overload
Highest flow point at which the predicted curve terminates on a speed line.

3.1.36
pinion(s)
High-speed rotor(s) in a gearbox; cf. **gear wheel** (3.1.11).

3.1.37
nominal pressure
PN
Numerical designation relating to pressure that is a convenient round number for reference purposes.

EXAMPLE PN 100 (ISO 7268:1983).

NOTE The permissible working pressure associated with a PN designation depends upon materials, design, and working temperature and has to be selected from the pressure/temperature rating tables in corresponding standards.

3.1.38
pressure casing
Composite of all stationary pressure-containing parts of the unit, including all nozzles and other attached parts that isolates process gas from the atmosphere.

3.1.39
purchaser
Agency that issues the order and specification to the supplier.

NOTE The purchaser may be the owner of the plant in which equipment is to be installed or the owner's appointed agent.

3.1.40
radially split
Split with the joint perpendicular to the shaft centerline.

3.1.41
rated speed
100 **%** speed
Highest rotational speed (revolutions per minute) required to meet any of the specified operating conditions.

3.1.42
relief valve set pressure
Pressure at which a relief valve starts to lift.

NOTE For information on relief valves, see API 520.

3.1.43
service factor (gear)
Factor that is applied to the tooth pitting index and the bending stress number, depending upon the characteristics of the driver and the driven equipment, to account for differences in potential overload, shock load, and/or continuous oscillatory torque characteristics.

3.1.44
settle-out pressure
Highest pressure that the compressor experiences when the compressor is not running and equilibrium has been reached.

NOTE Determination of settle-out pressure requires consideration of the trapped volume of gas throughout the compressor and its associated piping system. This includes all gas trapped between the downstream valve and the upstream valve after a compressor is shut down.

3.1.45
shaft end seal
Process gas seal on the shaft that restricts leakage of process gas to the atmosphere.

3.1.46
shall
Required in order to conform to the specification.

3.1.47
should
Recommended but not required in order to conform to the specification.

3.1.48
slow roll
Speed less than 5 % of the normal operating speed or the minimum speed permitted by the speed control.

3.1.49
soleplate
Plate attached to the foundation, with a mounting surface for equipment or for a baseplate.

3.1.50
special purpose application
Application for which the equipment is designed for uninterrupted, continuous operation in critical service, and for which there is usually no installed spare equipment.

3.1.51
special tool
Tool that is not a commercially available catalogue item.

3.1.52
stability analysis
Determination of the natural frequencies and the corresponding logarithmic decrements (log decs) of the damped rotor/support system using a complex value analysis.

3.1.53
standard volume flow
Flow rate expressed in volume flow units at standard conditions as follows.

ISO standard (normal) conditions
Flow: normal cubic meters per hour (Nm^3/h)
normal cubic meters per minute (Nm^3/min)
Pressure: 1.013 bar absolute
Temperature: 0 °C
Humidity: 0 %

U.S. customary standard conditions
Flow: standard cubic feet per minute (scfm)
million standard cubic feet per day (mmscfd)
Pressure: 14.7 psia
Temperature: 60 °F
Humidity: 0 %

NOTE 1 There are no universally accepted conditions for normal or standard cubic meters; therefore, their reference pressure and temperature are always spelled out, i.e. m^3/hr 0 °C, 1.013 barA.

NOTE 2 Due to the lack of uniformity on standard conditions, actual mass flow is typically provided in conjunction with standard flow rates to avoid confusion.

3.1.54
structure stiffness and damping
Bearing housing to ground equivalent complex stiffness.

3.1.55
surge
Instability that occurs in a centrifugal or axial compressor at low volumetric flow.

3.1.56
synchronous tilt pad coefficients
Complex frequency dependent coefficient with the frequency equal to the rotational speed of the shaft.

3.1.57
supplier
Manufacturer or manufacturer's agent that supplies the equipment.

3.1.58
support stiffness and damping
Equivalent oil film to ground complex stiffness characteristics. Pivot stiffness should be included in the oil film characteristics.

3.1. 59
tooth pitting index
Surface durability rating factor that is determined by the tangential load, pitch diameter, face width, and gear ratio.

3.1.60
total indicator runout
total indicator reading
TIR
Difference between the maximum and minimum readings of a dial indicator or similar device, monitoring a face or cylindrical surface during one complete revolution of the monitored surface.

NOTE For a cylindrical surface, the indicated runout implies an eccentricity equal to half the reading. For a flat face, indicated runout implies an out-of-squareness equal to the reading. If the diameter in question is not cylindrical or flat, the interpretation of the meaning of TIR is more complex and may represent ovality or surface irregularities.

3.1.61
trip speed
<electric motor driver>
Speed corresponding to the synchronous speed of the motor at maximum supply frequency at the motor terminals.

3.1.62
trip speed
<turbine, engine, expander, hydrostatic driver>
Speed at which the independent emergency overspeed device operates to shut down the driver.

3.1.63
turndown
Percentage of change in capacity (referred to rated capacity) between the rated capacity and the surge point capacity at the rated head when the unit is operating at rated suction temperature and gas composition.

3.1.64
ultimate load rating (hydrodynamic thrust bearing)
Load that shall produce the minimum acceptable oil film thickness without inducing failure during continuous service, or the load that shall not exceed the creep initiation or yield strength of the babbitt or bearing material at the location of maximum temperature on the pad, whichever load is less.

3.1.65
unit responsibility
Obligation for coordinating the documentation, delivery, and technical aspects of the equipment and all auxiliary systems included in the scope of the order.

3.1.66
witnessed (tests and inspections)
Inspection or test where the purchaser is notified of the timing of the inspection or test and a hold is placed on the inspection or test until the purchaser or the purchaser's representative is in attendance; cf. **observed (tests and inspections)** (3.1.34).

3.2 Abbreviations

For the purposes of this document, the following abbreviations apply.

A_{c1}	amplitude at N_{c1}, µm (mil)
AF	amplification factor (refer to API 684, Second Edition and Figure 2)
AF_1	amplification factor of the first critical speed defined as: $\mathrm{AF}_1 = N_{c1} / (N_2 - N_1)$
$A_{\max}$	maximum probe response amplitude (*p-p*) considering all vibration probes, over the range of N_{ma} to N_{mc}, for the unbalance amount/case being considered, µm (mil)
AMB	active magnetic bearing
ASME *Code*	American Society of Mechanical Engineers *Boiler and Pressure Vessel Code*
A_{vl}	mechanical test vibration limit defined in 4.8.2.10, µm (mil)
CCW	counterclockwise (rotation)
cf.	(Latin conferre) confer or compare—cross reference
CSR	critical speed ratio $= N_{\mathrm{mc}} / \mathrm{FCSR}$
CW	clockwise (rotation)
DN	nominal diameter
FCSR	first undamped critical speed on rigid supports, rpm

MAWP maximum allowable working pressure

MCS maximum continuous speed

N operating speed, rpm

N_{c1} rotor first critical speed, rpm

N_{cn} rotor n^{th} critical speed, rpm

N_{ma} minimum allowable speed, rpm

N_{mc} maximum continuous speed, rpm

N_1 initial (lesser) speed at 0.707 × peak amplitude, rpm

N_2 final (greater) speed at 0.707 × peak amplitude, rpm

OEM original equipment manufacturer

PPM proactive preventive maintenance

Q_A anticipated cross coupling for the rotor, kN/mm (klbf/in.)

defined as:

$$Q_A = \sum_{i=1}^{S} q_{Ai}$$

Q_0 minimum cross coupling needed to achieve a log decrement equal to zero for either minimum or maximum component clearance, kN/mm (klbf/in.)

q_a cross coupling defined in Equation (7) or Equation (8) for each stage or impeller, kN/mm (klbf/in.)

R_{out} combined mechanical and electrical runout, µm (mil)

S number of stages or impellers

S_{a1} actual separation for first critical speed, rpm

S_{an} actual separation for n^{th} critical speed, rpm

SM separation margin, see Figure 2

SM_1 separation margin for the first critical speed, %

$= 100 \times S_{a1} / N_{ma}$

SM_a forced response analysis actual separation margin, %

SM_{an} separation margin for n^{th} critical speed, %

SM_r the forced response analysis required separation margin, %

U_a input unbalance for the rotordynamic response analysis, g-mm (oz-in.)

$= 2 \times U_r$

U_r maximum allowable residual unbalance, g-mm (oz-in.)

VDDR Vendor (Supplier) Drawing and Data Requirements

VFD variable frequency drive (variable speed motor drive)

δ logarithmic decrement

δ_A minimum log decrement at the anticipated cross coupling for either minimum or maximum component clearance

δ_b basic log decrement of the rotor and support system only

δ_f log decrement of the complete rotor support system from the Level II analysis

ρ_{ave} average gas density across the rotor, kg/m^3 (lb/ft^3)

4 General

4.1 Dimensions and Units

Drawings and maintenance dimensions shall be in SI units or U.S. customary (USC) units. Use of an SI datasheet indicates that SI units shall be used. Use of an USC datasheet indicates that USC units shall be used.

NOTE Datasheets for SI and USC units are provided in Annex A in Parts 2, 3, and 4.

4.2 Statutory Requirements

The purchaser and the supplier shall determine the measures to be taken to comply with any governmental codes, regulations, ordinances, directives, or rules that are applicable to the equipment, its packaging, and any preservatives used.

4.3 Unit Responsibility

4.3.1 The supplier shall assume unit responsibility for all equipment and all auxiliary systems included in the scope of the order.

4.4 Basic Design

4.4.1 General

4.4.1.1 Performance

4.4.1.1.1 The equipment shall be capable of operating within the entire performance map, at all specified operating conditions as well as accommodating other conditions such as momentary surge, settle-out, trip, and start-up.

- **4.4.1.1.2** The purchaser shall specify all operating conditions for the equipment. Normal operating point shall be indicated.

NOTE Special operating conditions such as air dry-out, field commissioning test run, catalyst regeneration, etc. are specified in order to ensure that operation at off-design points can satisfactorily be met.

4.4.1.1.3 The compressor shall be designed to deliver normal head at the normal inlet volumetric flow. Performance tolerances given in the testing sections shall apply.

NOTE 1 The purchaser can furnish mass flow that will then be converted to volumetric flow by the supplier.

NOTE 2 If a factory test is not performed, additional measuring tolerances for site measurements are developed for performance testing in the field.

NOTE 3 See 6.3 of the applicable part for performance tolerances.

4.4.1.1.4 The overload condition shall be indicated on performance curves. Unless otherwise agreed, the sectional overload condition shall be at least 115 % of the rated condition.

NOTE See 3.1.35 for definition of overload.

4.4.1.1.5 The purchaser shall supply a gas analysis. Gas properties used shall be agreed.

- **4.4.1.2** The purchaser shall specify the period of uninterrupted continuous operation, during which time the equipment should not require shutdown to perform maintenance or inspection.

NOTE 1 It is realized that there are some services where this objective is easily attainable and others where it is difficult.

NOTE 2 Auxiliary system design and design of the process in which the equipment is installed are very important in meeting this objective.

NOTE 3 Section 4.4.1.2.1 requires the vendor to identify any component or maintenance requirement that would result in the need to shut down the equipment within the uninterrupted operational period.

4.4.1.2.1 Vendor shall advise in the proposal any component designed for finite life.

4.4.1.3 Unless otherwise specified, cooling water systems including those on process coolers shall be in accordance with API 614, Fifth Edition.

- **4.4.1.4** The purchaser shall advise the supplier in the inquiry of any specific requirements for liquid injection.

4.4.1.5 The arrangement of the equipment, including piping and auxiliaries, shall be developed jointly by the purchaser and the supplier at or before the coordination meeting. The arrangement shall provide adequate clearance areas and safe access for operation and maintenance.

- **4.4.1.6** The applicable electrical codes and area classification shall be specified.

NOTE Electrical codes vary widely depending upon the installed location. In the United States, one of the governing codes is the *National Electrical Code* document number NFPA 70, Articles 500, 501, 502, 504, and 505. In the European Union, the ATEX (from the French "Atmosphere Explosible") directives that are statutory law, govern. Other countries generally accept approval by an independent third party that states the equipment conforms to the governing standards. One of the third parties in the United States is Underwriter Lab (UL), and in Canada it is the Canadian Standards Association (CSA).

4.4.1.7 All equipment shall be designed to permit rapid and economical maintenance. Major parts such as casing components and bearing housings shall be designed and manufactured to ensure accurate alignment on reassembly.

NOTE This can be accomplished by the use of shouldering, cylindrical dowels, or keys.

4.4.1.8 All components, which are specific as to rotational direction, top or bottom casing half location, or axial location in the machine shall be designed to prevent incorrect installation.

- **4.4.1.9** The equipment including all auxiliaries shall be suitable for operation under the environmental conditions specified by the purchaser. These conditions shall include whether the installation is indoors (heated or unheated) or outdoors (with or without a roof), maximum and minimum temperatures, humidity, dusty or corrosive conditions, wind loads, and seismic zone.

- **4.4.1.10** Control of the sound pressure level (SPL) of all equipment furnished shall be a joint effort of the purchaser and the supplier having unit responsibility. The equipment furnished by the supplier shall conform to the maximum allowable sound pressure level specified. The supplier shall provide expected values for maximum sound pressure level per octave band for the equipment.

NOTE The installed SPL depends on the installation.

- **4.4.1.11** If specified, sound power levels based on calculation methods shall be supplied in addition to sound pressure level based on a free field analysis.

NOTE ASME PTC 36 or ISO 3740, ISO 3744, and ISO 3746 can be consulted for guidance. ISO 10494 can be consulted for gas turbine drive packages.

4.4.1.12 Unless otherwise specified, the design lubricant shall be hydrocarbon oil of viscosity Grade 32 in accordance with ISO 8068:2006, Type AR.

4.4.2 Speed Requirements

4.4.2.1 The equipment's maximum continuous speed (MCS) shall not be less than 105 % of the rated speed for variable speed machines [including variable frequency drive (VFD) controlled electric motors] and shall be equal to the synchronous speed for constant speed motor drives.

4.4.2.2 The equipment's trip speed shall not be less than the limiting speed of the emergency overspeed device furnished with the driver. Table 1 provides typical values for various drivers. Purchaser and supplier shall agree whether turbine trip speed based on loss of inertial load applies to the compressor.

4.4.2.3 Equipment shall be designed to operate simultaneously at the maximum allowable working pressure (MAWP) and trip speed without damage, regardless of driver power.

4.4.2.4 Equipment driven by induction motors shall be rated at the actual motor speed for the rated load condition.

Table 1—Driver Trip Speeds

Driver Type	Trip Speed (% of Maximum Continuous Speed)
Steam turbine	
NEMA Class A[a]	115 %
NEMA Class B, C, D[a]	110 %
Gas turbine	105 %
Variable speed motor	100 %
Variable speed gear	102 %
Constant speed motor	100 %
Reciprocating engine	110 %

[a] Indicates governor class as specified in NEMA SM 23.

4.4.3 The equipment (machine, driver, and ancillary equipment) shall perform on the test stand and on their permanent foundation within the specified acceptance criteria. After installation, the performance of the combined units shall be the joint responsibility of the purchaser and the supplier who has unit responsibility.

4.4.4 Many factors (such as piping loads, alignment at operating conditions, supporting structure, handling during shipment, and handling and assembly at the site) can adversely affect site performance. To minimize the influence of these factors, the supplier shall, when requested, review and comment on the purchaser's piping and foundation drawings. If specified, the supplier's representative shall witness:

a) a check of the piping alignment performed by unfastening the main process connections of the equipment,

b) the initial shaft alignment check at ambient conditions (cold alignment),

c) check shaft alignment at the operating temperature (hot alignment).

NOTE Refer to API 686 for basic guidelines for conducting piping alignments, shaft hot and cold alignments.

4.4.5 Motors, generators, instrumentation, electrical components, and electrical installations shall be suitable for the area classification (class, group, and division or zone) specified by the purchaser and shall meet the requirements of IEC 60079-10-1:2008 or NFPA 70:2008, Articles 500 through 505 as applicable, as well as local codes specified and furnished by the purchaser.

NOTE See 4.4.1.6.

4.4.6 Spare and replacement parts for the machine and all furnished auxiliaries shall meet all the criteria of this standard.

4.4.7 If specified, the machine or machines shall be suitable for field run on air. Performance parameters, including any required precautions, shall be agreed.

4.5 Materials

4.5.1 General

4.5.1.1 Materials of construction shall be the manufacturer's standard for the specified operating and site environmental conditions, except as required or prohibited by the datasheets or by this standard. Annex D of Parts 2, 3, and 4 lists material specifications that, when used with appropriate heat treatment or impact testing requirements, or both, are generally considered acceptable for major component parts. The metallurgy of all major components shall be clearly stated in the supplier's proposal. See 5.6 for requirements for auxiliary piping materials.

4.5.1.2 The materials of construction of all major components shall be clearly stated in the supplier's proposal. Materials shall be identified by reference to applicable international standards, including the material grade. When no such designation is available, the supplier's material specification, giving physical properties, chemical composition, and test requirements, shall be included in the proposal.

NOTE Where international standards are not available, internationally recognized national or other standards can be used.

- **4.5.1.3** The purchaser shall specify any corrosive agents (including trace quantities) present in the motive and process fluids in the site environment, including constituents that may cause corrosion.

NOTE 1 Typical agents of concern are hydrogen sulfide, amines, chlorides, cyanide, fluoride, naphthenic acid, and polythionic acid.

NOTE 2 Selection of materials is a joint effort between manufacturer and supplier. Nonrunning conditions are considered to ensure design acceptance for all combination of parameters.

4.5.1.4 The supplier shall specify the optional tests and inspection procedures that may be necessary to ensure that materials are satisfactory for the service. Such tests and inspections shall be listed in the proposal.

NOTE The purchaser can specify additional optional tests and inspections—especially for materials used for critical components or in critical services.

4.5.1.5 Low-carbon steels can be notch sensitive and susceptible to brittle fracture at ambient or lower temperatures. Therefore, only fully killed, normalized steels made to fine grain practice are acceptable for pressure-containing machine components. The use of steel made to a course austenitic grain size practice (e.g. ASTM A515) shall not be used.

4.5.1.6 Unless otherwise specified, if hydrogen sulfide has been identified in the gas composition, materials exposed to that gas shall be selected in accordance with the requirements of NACE MR 0103-2007 and where applicable, the referenced NACE SP 0472-2008.

NOTE 1 NACE MR 0103 requires restrictive hardness limits, more restrictive weld qualification procedures, and limits to the carbon equivalent levels of materials versus NACE MR 0175 (see 4.5.1.7).

NOTE 2 It is the responsibility of the purchaser to determine the amount of H_2S that may be present, considering normal operation, start-up, shutdown, idle standby, upsets, or unusual operating conditions such as catalyst regeneration.

- **4.5.1.7** If specified, NACE MR 0175-2008 shall be used in place of NACE MR 0103-2007.

NOTE 1 NACE MR 0175-2008 applies to material potentially subject to sulfide and chloride stress-corrosion cracking in oil and gas production facilities. These are upstream facilities; however, NACE MR 0175 earlier editions have been applied to compressors in downstream facilities since the Fifth Edition of API 617 (1988) prior to the introduction of NACE MR 0103-2007.

NOTE 2 A survey conducted of units built in accordance with NACE MR 0175 in previous API 617 editions has indicated no failures. The more restrictive requirements of NACE MR 0103 may therefore not be required to provide sufficient protection against corrosion.

NOTE 3 NACE MR 0175-2008 is identical to ISO 15156-3:2008.

4.5.1.8 Ferrous materials not covered by NACE MR 0103-2007 or NACE MR 0175-2008 shall have a maximum yield strength of 620 N/mm^2 (90,000 psi) and a maximum Rockwell hardness of HRC 22. Components fabricated by welding shall be postweld heat treated, if required, so that both the weld and the heat-affected zones meet the yield strength and hardness requirements.

NOTE NACE MR 0175-2008 is identical to ISO 15156-3:2008.

4.5.1.9 If austenitic stainless steel parts exposed to conditions that can promote intergranular corrosion are fabricated, hard faced, overlaid, or repaired by welding, they shall be made of low-carbon or stabilized grades.

NOTE Overlays or hard surfaces that contain more than 0.10 % carbon can sensitize both low-carbon and stabilized grades of austenitic stainless steel, unless a buffer layer that is not sensitive to intergranular corrosion is applied.

4.5.1.10 Austenitic steels shall not be used in services where stress-corrosion cracking is a possibility.

4.5.1.11 Materials that have a yield strength in excess of 827 MPa (120,000 psi) or hardness in excess of Rockwell C 34 are prohibited for use in hydrogen gas service where the partial pressure of hydrogen exceeds 689 kPa (100 psi gauge) or the hydrogen concentration exceeds 90 molar percent at any pressure.

4.5.1.12 External parts that are subject to rotary or sliding motions (such as control linkage joints and adjusting mechanisms) shall be of corrosion-resistant materials suitable for the site environment.

4.5.1.13 Minor parts such as nuts, springs, washers, gaskets, and keys shall have corrosion resistance at least equal to that of specified parts in the same environment.

4.5.1.14 Where mating parts such as studs and nuts of austenitic stainless steel or materials with similar galling tendencies are used, they shall be lubricated with an anti-seizure compound of the proper temperature specification and compatible with the specified process fluid(s).

NOTE Anti-seizure compounds can alter friction factors and are considered in specified torque loading in order to achieve the necessary preload.

4.5.1.15 O-ring materials shall be compatible with all specified services. Special consideration shall be given to the selection of O-rings for high-pressure services to ensure that they are not being damaged upon rapid depressurization (explosive decompression). For vertically split case designs, the supplier shall state the maximum allowable depressurizing rate of the compressor casing required to prevent explosive decompression of the O-ring material supplied.

NOTE Susceptibility to explosive decompression depends on the gas to which the O-ring is exposed, the compounding of the elastomer, temperature of exposure, the rate of decompression, and the number of cycles.

- **4.5.1.16** If specified, copper or copper alloys shall not be used for parts of machines or auxiliaries in contact with process fluids. Nickel-copper alloy (UNS N04400), bearing babbitt, and precipitation hardened stainless steels are excluded from this requirement.

NOTE Certain corrosive fluids in contact with copper alloys have been known to form explosive compounds.

- **4.5.1.17 Coatings**

If specified, mutually acceptable coatings shall be applied to the rotating and/or stationary components in the gas path. When coatings are applied to rotating components, the acceptance balance shall be after coatings have been applied. The sequence of procedures for balancing and coating of rotating components shall be agreed.

NOTE 1 It is advisable to prebalance in order to minimize balance corrections and subsequent repair to coating areas for the final acceptance balance. By minimizing the area repaired, a final check balance after repair may not be required.

NOTE 2 API 687, Chapter 1, Appendix L is an informative tutorial on coatings.

4.5.1.18 Positive Material Identification

- **4.5.1.18.1** The extent of positive material identification (PMI) testing shall be specified for materials, welds, fabrications, and piping. This shall be fully defined, including any sampling requirements.

4.5.1.18.2 When PMI is specified, techniques providing quantitative results shall be used.

4.5.1.18.3 Mill test reports, material composite certificates, visual stamps, or markings shall not be considered as substitutes for PMI testing.

4.5.1.18.4 PMI results shall be within governing standard limits with allowance for the accuracy of the PMI device as specified by the device manufacturer.

4.5.1.19 Low Temperature Service

NOTE See definition 3.1.19.

4.5.1.19.1 Pressure casings and rotating elements shall be designed with materials that comply with the paragraphs included in this section.

- **4.5.1.19.2** If specified, other components of the machinery train shall also be evaluated for the prevention of brittle fracture due to materials exhibiting change from ductile to brittle fracture as temperatures are reduced.

- **4.5.1.19.3** The purchaser shall specify the minimum design metal temperature and concurrent pressure used to establish impact test and other material requirements.

NOTE Normally, this will be the lower of the minimum surrounding ambient temperature or minimum fluid pumping temperature; however, the purchaser can specify a minimum design metal temperature based on properties of the pumped fluid, such as autorefrigeration at reduced pressures.

4.5.1.19.4 To avoid brittle failures, materials and construction for low temperature service shall be suitable for the minimum design metal temperature and concurrent pressure in accordance with the codes and other requirements specified. The purchaser and the supplier shall agree on any special precautions necessary with regard to conditions that may occur during operation, maintenance, transportation, erection, commissioning, and testing.

NOTE A good design practice will include the selection of fabrication methods, welding procedures, and materials for supplier furnished steel pressure retaining parts that may be subject to temperatures below the ductile-brittle transition temperature. The published design-allowable stresses for materials in internationally recognized standards such as the ASME *Code* and ANSI standards are based on minimum tensile properties.

4.5.1.19.5 All carbon and low alloy steel pressure-containing components for low temperature service including nozzles, flanges, and weldments shall be impact tested in accordance with the requirements of Section VIII, Division 1, Sections UCS-65 through 68 of the ASME *Code* or equivalent standard. High-alloy steels shall be tested in accordance with Section VIII, Division l, Section UHA-51 of the ASME *Code* or equivalent standard.

NOTE 1 In some situations, impact testing of a material will not be required depending on the minimum design metal temperature, thermal, mechanical and cyclic loading, and the governing thickness. Refer to requirements of Section VIII, Division l, Section UG-20F of the ASME *Code*, for example.

NOTE 2 Design codes other than ASME can require additional certification and material testing.

4.5.1.19.6 Governing thickness used to determine impact testing requirements shall be the greater of the following:

a) the nominal thickness of the largest butt-welded joint;

b) the largest nominal section for pressure containment, excluding:

   1) structural support sections such as feet or lugs,

   2) sections with increased thickness required for rigidity to mitigate shaft deflection,

   3) structural sections required for attachment or inclusion of mechanical features such as jackets or seal chambers;

c) one fourth of the nominal flange thickness, including parting flange thickness for axially split casings (in recognition that the predominant flange stress is not a membrane stress).

The results of the impact testing shall meet the minimum impact energy requirements of Section VIII, Division l, Section UG-84 of the ASME *Code* or equivalent standard.

4.5.1.19.7 For materials and thicknesses not covered by Section VIII, Division l of the ASME *Code* or equivalent standards, the purchaser shall specify requirements.

4.5.2 Castings

4.5.2.1 Castings shall comply with material specification requirements regarding porosity, hot tears, shrink holes, blow holes, cracks, scale, blisters, and similar injurious defects. Surfaces of castings shall be cleaned by sandblasting, shotblasting, chemical cleaning, or other standard methods. Mold-parting fins and the remains of gates and risers shall be chipped, filed, or ground flush.

4.5.2.2 The use of chaplets in pressure castings shall be held to a minimum. Where chaplets are necessary, they shall be clean and corrosion free (plating is permitted) and of a composition compatible with the casting.

4.5.2.3 Pressure-containing ferrous castings shall only be repaired as specified in 4.5.2.3.1 through 4.5.2.3.3.

4.5.2.3.1 Weldable grades of steel castings shall be repaired, using a qualified welding procedure based on the requirements of the appropriate pressure vessel code such as Section VIII, Division 1 and Section IX of the ASME *Code*. After major weld repairs and before hydrotest, the complete repaired casting shall be given a postweld heat treatment to ensure stress relief and continuity of mechanical properties of both weld and parent metal and dimensional stability during subsequent machining operations.

4.5.2.3.2 Cast gray iron may be repaired by plugging within the limits specified in ASTM A278, ASTM A395, or ASTM A536. The holes drilled for plugs shall be carefully examined, using liquid penetrant, to ensure that all defective material has been removed.

4.5.2.3.3 All repairs that are not covered by ASTM specifications shall be subject to the purchaser's approval.

4.5.2.4 Cored voids, which become fully enclosed by methods such as plugging, welding, or assembly, are prohibited.

4.5.2.5 All ductile (nodular) iron castings shall be produced in accordance with ASTM A395 or other equivalent internationally recognized standard as approved. The production of the castings shall conform to the conditions specified in 4.5.2.5.1 through 4.5.2.5.4.

4.5.2.5.1 The keel or Y block cast at the end of the pour shall have a thickness not less than the thickness of critical sections of the main casting. This test block shall be tested for tensile strength and hardness and shall be microscopically examined. Classification of graphite nodules under microscopic examination shall be in accordance with ASTM A247. There shall be no intercellular flake graphite.

NOTE Critical sections are typically heavy section changes, high-stress points such as flanges. Normally, bosses and similar sections are not considered critical sections of a casting. If critical sections of a casting have different thicknesses, average size keel or Y blocks may be selected in accordance with ASTM A395.

4.5.2.5.2 A minimum of one set (three samples) of Charpy V-notch impact specimens at one-third the thickness of the test block shall be made from the material adjacent to the tensile specimen on each keel or Y block. All three specimens shall have an impact value not less than 12 J (9 ft-lbf), and the mean of the three specimens shall not be less than 14 J (10 ft-lbf) at room temperature.

4.5.2.5.3 If approved, nonpressurized ductile (nodular) iron castings may be produced in accordance with ASTM A536 or other equivalent internationally recognized standard.

4.5.2.5.4 An "as-cast" sample from each ladle shall be chemically analyzed.

4.5.2.5.5 Brinell hardness tests shall be made on the actual casting at feasible critical sections such as section changes, flanges, and other accessible locations. Sufficient surface material shall be removed before hardness tests are made to eliminate any skin effect. Tests shall also be made at the extremities of the casting at locations that represent the sections poured first and last. These shall be made in addition to hardness test on keel or Y blocks in accordance with 4.5.2.5.1.

4.5.3 Forgings

4.5.3.1 The forging material should be selected from those listed in Annex D of Parts 2, 3, and 4 as applicable.

4.5.3.2 Pressure-containing ferrous forgings shall not be repaired except as specified in 4.5.3.2.1 and 4.5.3.2.2.

4.5.3.2.1 Weldable grades of steel forgings shall be repaired by welding. Using a qualified welding procedure based on the requirements of the appropriate pressure vessel code such as Section VIII, Division l and Section IX of the ASME *Code* or the equivalent specified standard. After major weld repairs, and before hydrotest, the complete forging shall be given a postweld heat treatment to ensure stress relief and continuity of mechanical properties of both weld and parent metal.

4.5.3.2.2 All repairs that are not covered by ASTM specifications shall be subject to the purchaser's approval.

4.5.4 Welding

4.5.4.1 Unless otherwise specified, nonpressurized component welding, such as welding on baseplates, nonpressure ducting, lagging, and control panels, shall be performed and inspected by operators and procedures qualified in accordance with AWS D1.1 or ASME Section IX or other purchaser approved standard.

4.5.4.2 Welding of piping, pressure-containing parts, rotating parts and other highly stressed parts, weld repairs and any dissimilar-metal welds shall be performed and inspected by operators and procedures qualified in accordance with Section VIII, Division l and Section IX of the ASME *Code* or purchaser approved standard such as EN 287 and EN 288 for weld qualifications or procedures or other purchaser approved standards.

4.6 Casings

4.6.1 Pressure-containing Casings

4.6.1.1 The pressure casing shall be designed in accordance with 4.6.1.1.1 or 4.6.1.1.2. The casing joint bolting shall be in accordance with 4.6.1.1.4.

4.6.1.1.1 The allowable tensile stress used in the design of the pressure casing (excluding bolting) for any material shall not exceed 0.25 times the minimum ultimate tensile strength for that material at the maximum specified operating temperature. For cast materials, the allowable tensile stress shall be multiplied by the appropriate casting factor as shown in Table 2.

Table 2—Casting Factors

Type of NDE	Casting Factor
Visual, magnetic particle and/or liquid penetrant	0.8
Spot radiography	0.9
Ultrasonic	0.9
Full radiography	1.0

4.6.1.1.2 Pressure-containing components may be designed with the aid of finite element analysis provided that the design limits comply with Section VIII, Division 2 of the ASME *Code* stress intensity as modified by Equation (1).

$$\text{MASI} = \text{CSI}\left(\frac{P_{\text{ch}}}{150}\right) \tag{1}$$

where

MASI is maximum allowable stress intensity, kPa (psi);

CSI is code stress intensity, kPa (psi);

P_{ch} is code hydrotest pressure, percent of MAWP.

The manufacturer shall state the source of the material properties, such as ASTM, as well as the casting factors applied in his/her proposal.

NOTE Refer to ASME *Code,* Section VIII, Division 2, Part AD-140(a) for definition of stress intensity.

4.6.1.1.3 A corrosion allowance of at least 3 mm (0.12 in.) shall be added to the casing thickness used in 4.6.1.1.1 or 4.6.1.1.2.

NOTE In general, deflection is the determining consideration in the design of casings. Ultimate tensile or yield strength is seldom the limiting factor.

4.6.1.1.4 For casing joint bolting, the allowable tensile stress (as determined in 4.6.1.1.1) shall be used to determine the total bolting area based on hydrostatic load and gasket preload as applicable. The preload stress shall not exceed 75 % of the bolting material minimum yield. During hydrotest, the bolting preload stress shall not exceed 90 % of the bolting material minimum yield, and a positive method for measuring bolting elongation shall be used. Preload during the assembled gas leakage test shall not exceed 75 % of the bolting material limited yield.

NOTE 1 Thread stress in the nut or case can be the limiting factor in the strength of the bolting.

NOTE 2 Torque wrenches are not an acceptable way to determine bolt elongation due to variations in friction factor.

4.6.1.2 For flammable or toxic gases, compressor casings shall be steel or purchaser approved alloy. Expander casings shall be made of material in Annex D of Part 4 or approved alloy.

4.6.1.3 For air or nonflammable gases, casings may be steel, ductile iron, or cast iron materials depending on the following ratings.

4.6.1.3.1 Ductile iron casings can be used up to the flange rating in accordance with ANSI B16.42, Class 300.

4.6.1.3.2 Cast iron casings can be used up to the flange rating in accordance with ASME B16.1, Class 250.

4.6.1.4 Jackscrews, guide rods, cylindrical casing-alignment dowels, and/or special tools shall be provided to facilitate disassembly and reassembly. Guide rods shall be of sufficient length to prevent damage to the internals or casing studs by the casing during disassembly and reassembly. Lifting lugs or eyebolts shall be provided for lifting only the top half of the casing of axially split casings. When jackscrews are used as a means of parting contacting faces, one of the faces shall be relieved (counterbored or recessed) to prevent a leaking joint or an improper fit caused by marring of the face.

NOTE "Special tools" could be extraction rigs for radially split equipment, or rollers on the bundles of these machines.

4.6.1.5 The use of threaded holes in pressure parts of cast iron casings is allowed but shall be minimized. To prevent leakage in pressure sections of casings, metal equal in thickness to at least 12 mm ($^1/_2$ in.), in addition to the allowance for corrosion, shall be left around and below the bottom of drilled and threaded holes. The depth of the threaded holes shall be at least 1.5 times the diameter of the threaded insert (stud, plug, etc.).

4.6.1.6 The sealing of stud clearance holes to prevent leakage is not permitted.

4.6.1.7 Bolting shall be furnished as specified in 4.6.1.7.1 through 4.6.1.7.6.

4.6.1.7.1 The details of threading shall conform to ASME B1.1 or ISO 261.

NOTE 1 ISO 261 covers general metric screw threads, and ASME B1.1 covers general inch series screw threads.

NOTE 2 Glossary of terms for screw threads can be found in ASME B18.12-2001.

4.6.1.7.2 Studs shall be supplied on the main joint of axially split casings and bolted end covers of radially split casings. Studs shall be used instead of cap screws, on all other external joints, except where hexagonal head cap screws are essential for assembly purposes and have been approved by the purchaser.

4.6.1.7.3 Adequate clearance shall be provided at bolting locations to permit the use of socket or box wrenches.

4.6.1.7.4 Supplier shall advise whether bolting that needs to be disassembled for maintenance is metric or imperial thread series.

● **4.6.1.7.5** If specified, the main casing joint studs and nuts shall be designed for the use of hydraulic bolt tensioning. Procedures and extent of special tooling provided by the supplier shall be agreed.

4.6.1.7.6 The minimum quality bolting material for pressure joints shall be carbon steel (such as ASTM A307, Grade B) for cast iron casings and high temperature alloy steel (such as ASTM A193, Grade B7) for steel casings. Carbon steel nuts (such as ASTM A194, Grade 2H) shall be used. Where space is limited, case hardened carbon steel nuts (such as ASTM A563, Grade A) shall be used.

NOTE For low temperature requirements, see 4.5.1.19.

4.6.1.8 Materials, casting factors, and the quality of any welding shall be equal to those required by Section VIII, Division 1 of the ASME *Code* or other purchaser approved standard. The manufacturer's data report forms, as specified in the *Code*, are not required unless required by regulation.

NOTE For low temperature requirements, see 4.5.1.19.

4.6.1.9 Welding of piping, pressure-containing parts, weld repairs and any dissimilar-metal welds shall be performed and inspected by operators and procedures qualified in accordance with Section VIII, Division l, and Section IX of the ASME *Code* or other purchaser approved standard.

4.6.2 Casing Repairs and Inspections

4.6.2.1 The supplier shall be responsible for the review of all repairs and repair welds to ensure that they are properly heat treated and nondestructively examined for soundness and compliance with the applicable qualified procedures (see 4.6.1.9). Repairs shall be nondestructively tested by the same method used to detect the original flaw; however, the minimum level of inspection after the repair shall be by the magnetic particle method in accordance with 6.2.2.4 for magnetic material and by the liquid penetrant method in accordance with 6.2.2.5 for nonmagnetic material.

Unless otherwise specified, procedures for major repairs shall be subject to review by the purchaser prior to any repair.

4.6.2.2 The purchaser shall be notified before making a major repair to a pressure-containing part. Major repair, for the purpose of purchaser notification only, is any defect that equals or exceeds any of the three criteria defined below:

a) the depth of the cavity prepared for repair welding exceeds 50 % of the component wall thickness,

b) the length of the cavity prepared for repair welding is longer than 150 mm (6 in.) in any direction,

c) the total area of all repairs to the part under repair exceeds 10 % of the surface area of the part.

4.6.2.3 Actual repairs shall be made as required by the following documents.

a) The repair of plates, prior to fabrication, shall be performed in accordance with the ASTM standard to which the plate was purchased.

b) The repair of castings or forgings shall be performed prior to final machining in accordance with the ASTM standard to which the casting or forging was purchased.

c) The repair of a fabricated casing or the defect in either a weld or the base metal of a cast or fabricated casing, uncovered during preliminary or final machining, shall be performed in accordance with Section VIII of the ASME *Code* or other purchaser approved standard.

4.6.2.4 Pressure-containing casings made of wrought materials or combinations of wrought and cast materials shall conform to the conditions specified in 4.6.2.4.1 through 4.6.2.4.6.

4.6.2.4.1 Plate edges shall be inspected by magnetic particle or liquid penetrant examination as required by Section VIII, Division 1, UG-93(d)(3) of the ASME *Code*. Alternative standards may be applied when approved by the purchaser.

4.6.2.4.2 Accessible surfaces of welds shall be inspected by magnetic particle or liquid penetrant examination after back chipping or gouging and again after postweld heat treatment.

● **4.6.2.4.3** If specified, the quality control of welds that will be inaccessible on completion of the fabrication shall be agreed on by the purchaser and supplier prior to fabrication.

4.6.2.4.4 Pressure-containing welds, including welds of the case to horizontal or vertical joint flanges, shall be full penetration (complete joint) welds unless otherwise approved by the purchaser prior to any fabrication.

NOTE This does not apply to auxiliary connections as described in 4.6.4.3.

4.6.2.4.5 Casings and fabrications that require machining to precise dimensions and tolerances to assure assembly shall be heat treated regardless of thickness.

NOTE The ASME code does not require all fabrications to be postweld heat treated.

4.6.2.4.6 All pressure-containing welds shall be examined as required by Section VIII, Division 1 of the ASME *Code*. Requirements for additional examination shall be agreed.

NOTE See 4.6.3 for required procedures and acceptance criteria.

4.6.3 Material Inspection of Pressure-containing Parts

NOTE Refer to 6.2.2 for inspection of non-pressure-containing parts.

4.6.3.1 Regardless of the generalized limits presented in this section, it shall be the supplier's responsibility to review the design limits of all materials and welds in the event that more stringent requirements are specified. Defects that exceed the limits imposed in 4.6.3 shall be removed to meet the quality standards cited, as determined by additional magnetic particle or liquid penetrant inspection as applicable prior to repair welding.

4.6.3.2 If radiographic, ultrasonic, magnetic particle, or liquid penetrant inspection of welds or materials is required or specified, the procedures and acceptance criteria in Table 3 shall apply, except as noted (see 6.2.2).

Table 3—ASME Materials Inspection Standards

Type of Inspection	Methods	Acceptance Criteria	
		For Fabrications	For Castings
Radiography	Section V, Articles 2 and 22 of the ASME *Code*	Section VIII , Division 1, UW-51 (for 100 % radiography) and UW-52 (for spot radiography) of the ASME *Code*	Section VIII, Division 1, Appendix 7 of the ASME *Code*
Ultrasonic inspection	Section V, Articles 4, 5, and 23 of the ASME *Code*	Section VIII, Division 1, UW-53 and Appendix 12 of the ASME *Code*	Section VIII, Division 1, Appendix 7 of the ASME *Code*
Magnetic particle inspection	Section V, Articles 7 and 25 of the ASME *Code*	Section VIII, Division 1, Appendix 6 of the ASME *Code*	See acceptance criteria in 4.6.3.3 and Table 2
Liquid penetrant inspection	Section V, Articles 6 and 24 of the ASME *Code*	Section VIII, Division 1, Appendix 8 of the ASME *Code*	Section VIII, Division 1, Appendix 7 of the ASME *Code*

4.6.3.2.1 Spot radiography shall consist of a minimum of one 150-mm (6-in.) spot radiograph for each 7.6 m (25 ft) of weld on each casing. As a minimum, one spot radiograph is required for each welding procedure and welder used for pressure-containing welds.

4.6.3.2.2 For magnetic particle inspections, linear indications shall be considered relevant only if the major dimension exceeds 1.6 mm ($^1/_{16}$ in.). Individual indications that are separated by less than 1.6 mm ($^1/_{16}$ in.) shall be considered continuous.

4.6.3.3 Cast steel casing parts shall be examined by magnetic particle methods. Acceptability of defects shall be based on a comparison with the photographs in ASTM E125. For each type of defect, the degree of severity shall not exceed the limits specified in Table 4.

Table 4—Maximum Severity of Defects in Castings

Type	Defect	Degree
I	Linear discontinuities	1
II	Shrinkage	2
III	Inclusions	2
IV	Chills and Chaplets	1
V	Porosity	1
VI	Welds	1

4.6.4 Pressure Casing Connections

4.6.4.1 General

4.6.4.1.1 All connections shall be flanged or machined and studded, except where threaded connections are permitted by 4.6.1.5 or 4.6.4.3. All process gas connections to the casing shall be suitable for the MAWP.

4.6.4.1.2 All of the purchaser's connections shall be accessible for disassembly without requiring the machine, or any major part of the machine, to be moved.

4.6.4.1.3 All openings or nozzles for piping connections on pressure casings shall be in accordance with ASME B1.20.1 (ISO 6708). Sizes DN (nominal diameter) 32, DN 65, DN 90, DN 125, DN 175, and DN 225 (NPS 1 1/4, NPS 2 1/2, NPS 3 1/2, NPS 5, NPS 7, and NPS 9) shall not be used.

NOTE NPS designates pipe per ASME B1.20.1.

4.6.4.1.4 Connections welded to the casing shall meet the material requirements of the casing, including impact values, rather than the requirements of the connected piping.

4.6.4.1.5 All welding of connections shall be completed before the casing is hydrostatically tested (see 6.3.2).

4.6.4.1.6 For axially split pressure casings, the supplier shall provide connections for complete drainage of all gas passages. For radially split pressure casings, the drains shall be located at the lowest point of each inlet section, the lowest point of the section between the inner and outer casings, and the lowest point of each discharge section. Number and size of drain connections shall be shown in the datasheet.

- **4.6.4.1.7** If specified, individual stage drains, including a drain for the balance piston cavity, shall be provided (see 4.6.4.1.6).

4.6.4.2 Main Process Connections

4.6.4.2.1 Main process connections shall be flanged or machined and studded and oriented as specified on the datasheets.

NOTE Main process connections include all process inlets and outlets including those for side loads and intermediate cooling.

4.6.4.2.2 Flanges shall conform to ASME B16.1, B16.5, B16.42, or ASME B16.47 Series B or ISO 7005-1: 1992 Series 1, including Annex D & E or ISO 7005-2:1988 Series 1, or other approved standard as applicable, except as specified in 4.6.4.2.3 through 4.6.4.2.4.

NOTE 1 ASME B16.47 includes both the former MSS SP-44 and API 605 flanges. Since these flange dimensions are not compatible, the MSS were designated as Series A and the API as Series B.

NOTE 2 ISO 7005-1:1992 (steel flanges) PN 20, PN 50, PN 110, PN 150, PN 260, and PN 420 are designed to be interchangeable with ASME B16.5 and MSS SP-44 flanges—ISO 7005-1:1992 flanges are not identical to ASME B16.5 and MSS SP-44 flanges but are deemed to comply with the dimensions specified in the ASME B16.5 and MSS SP-44.

NOTE 3 ISO 7005-2:1988 (cast iron) flanges PN 20 and PN 50 are designed to be interchangeable with ASME B16.1 (gray cast iron) and ASME B16.42 (ductile cast iron), but they are not identical. They are deemed to comply with dimensions specified in ASME B16.1 (gray cast iron) and ASME B16.42 (ductile cast iron).

NOTE 4 ISO PN 2.5, 6 do not have a corresponding ASME class, and ASME Class 75, Class 400, and Class 800 do not have a corresponding ISO PN designation. The use of these PN and class ratings are therefore not recommended.

4.6.4.2.3 If ISO 7005-1:1992 is used, materials shall be in accordance with ISO 1995-1:1992, Annex D-1 (DIN) or Annex D-2 (ASTM) as specified. The pressure temperature ratings in ISO 7005-1:1992, Annex E shall correspond to the materials specified.

- **4.6.4.2.4** If specified, ASME B16.47 Series A flanges may be supplied.

4.6.4.2.5 Supplier shall state the particular flange standard and provide details of the flanges that are being provided.

4.6.4.2.6 Cast iron flanges shall be flat faced and conform to the dimensional requirements of ASME B16.1 or ASME B16.42 (ISO 7005-2). Class 125 flanges shall have a minimum thickness equal to Class 250 for sizes DN 200 (NPS 8) and smaller. PN 20 (Class 125) flanges shall have a minimum thickness equal to PN 50 (Class 250) for sizes DN 200 (NPS 8) and smaller.

NOTE NPS designates pipe per ASME B1.20.1.

4.6.4.2.7 Flat face flanges with full raised face thickness are acceptable on casings of all materials.

4.6.4.2.8 Flanges in all materials that are thicker or have a larger outside diameter than required by ANSI/ASME (ISO) are acceptable. Nonstandard (oversized) flanges shall be completely dimensioned on the arrangement drawing. If oversized flanges require studs or bolts of nonstandard length, this requirement shall be identified on the arrangement drawing.

4.6.4.2.9 Flanges shall be full faced or spot faced on the back and shall be designed for through bolting.

4.6.4.2.10 Connections and flanges not in accordance with ASME B16.1, ASME B16.5, ASME B16.42, or ASME B16.47 Series A or Series B (ISO-7005-1 or ISO 7005-2) require purchaser's approval.

4.6.4.2.11 The supplier shall supply mating flanges, studs, and nuts for nonstandard connections.

4.6.4.2.12 The concentricity of the bolt circle and the bore of all casing flanges shall be such that the area of the machined gasket-seating surface is adequate to accommodate a complete standard gasket without protrusion of the gasket into the fluid flow.

4.6.4.2.13 For steel flanges imperfections in the flange gasket surface shall not exceed that permitted in ASME B16.5 or ASME B16.47 as applicable.

4.6.4.2.14 Machined and studded connections shall conform to the facing and drilling requirements of ASME B16.1, ASME B16.5, ASME B16.42, or ASME B16.47 (ISO 7005-1 or ISO 7005-2). Studs and nuts shall be furnished installed; the first 1.5 threads at both ends of each stud shall be removed.

NOTE Threads are removed at the end of the stud to allow the stud to bottom without damaging the end threads in the hole. Threads are removed from both ends of the stud to allow either end of the stud to be inserted into the threaded hole.

4.6.4.2.15 To minimize nozzle loads and facilitate installation of piping, machine flanges shall be parallel to the plane shown on the arrangement drawing to within 0.5°. Studs or bolt holes shall straddle centerlines parallel to the main axis of the equipment.

4.6.4.3 Auxiliary Connections

4.6.4.3.1 Auxiliary connections may include but are not limited to those for vents, liquid injection, drains (see 4.6.4.1.6), water cooling, lube and seal oil, flushing, seal and buffer gas, and balance piston cavity.

4.6.4.3.2 Flanges shall conform to ASME B16.1, ASME B16.5, or ASME B16.42 (ISO 7005-1 or ISO 7005-2), or SAE J518 as applicable.

4.6.4.3.3 Auxiliary connections other than oil or dry gas seal connections shall be socket-welded and flanged or machined and studded.

4.6.4.3.4 Auxiliary connections for lube oil, seal oil, or dry gas seal operation shall use weld-neck or slip-on flanges only.

NOTE Socket-weld is not allowed due to the possibility of a dirt trap.

4.6.4.3.5 Pipe nipples screwed or welded to the casing, preferably not more than 150 mm (6 in.) long, shall be a minimum of Schedule 160 seamless for sizes DN 25 (NPS 1) and smaller and a minimum of Schedule 80 for DN 40 (NPS 1 $^{1}/_{2}$).

4.6.4.3.6 Each pipe nipple shall be provided with a welding-neck, socket-weld, or slip-on flange, except as indicated below.

4.6.4.3.7 For socket-welded construction, a gap of 1.5 mm ($^{1}/_{16}$ in.), as measured prior to welding, shall be left between the pipe end and the bottom of the socket in the casing.

NOTE See 4.6.4.3.4 for connections where socket-weld is not allowed.

4.6.4.3.8 Requirements for Threaded Connections

- **4.6.4.3.8.1** Threaded openings for tapered pipe threads shall conform to ASME B1.20.1 or ISO 7-l:1994 as specified. If ISO 7-1:1994 has been specified, tapered or straight internal threads shall also be specified. Bosses for pipe threads shall conform to ASME B16.5.

NOTE ISO 7-1:1994 and ASME B1.20.1 are not equivalent for tapered threads; however, they are sufficiently close that stripped threads and/or sealing problems may result in installing incorrect parts (including later in the field). Caution is therefore taken in specifying a standard that agrees with the standard used within the plant.

- **4.6.4.3.8.2** Pipe threads shall be taper thread conforming to ASME B1.20.1 or ISO 7-1 as specified.

4.6.4.3.8.3 Threaded connections shall not be seal welded.

4.6.4.3.8.4 For threaded connections that are connected to pipe, a pipe nipple, preferably not more than 150 mm (6 in.) long, schedule 160 seamless minimum, shall be installed in the threaded opening. Each pipe nipple shall be provided with a welding-neck, socket-weld or slip-on flange. The nipple and flange materials shall meet the requirements of 4.6.4.1.4.

4.6.4.3.8.5 Threaded openings not required for piping connections shall be plugged with solid, round-head steel plugs in accordance with ASME B16.11. As a minimum, these plugs shall meet the material requirements of the pressure casing. Plugs that may later require removal shall be of a corrosion resistant material. Plastic plugs are not permitted. A process compatible thread lubricant of proper temperature specification shall be used on all threaded connections. Thread tape shall not be used.

4.6.5 Casing Support Structures

4.6.5.1 Machines requiring alignment shall meet the following criteria.

a) Mounting surfaces shall be machined to a finish of 6 µmm (250 µin.) arithmetic average roughness (Ra) or better.

b) Each mounting surface shall be machined within a flatness of 13 µm per 330 linear mm (0.0005 in. per linear ft) of mounting surface.

c) Different mounting planes shall be parallel to each other within 50 µm (0.002 in.) over the distance between mounting surfaces.

d) The upper machined or spot-faced surface shall be parallel to the mounting surface.

e) Hold-down bolt holes shall be drilled perpendicular to the mounting surfaces.

f) The mounting hole in the equipment feet shall be 12 mm ($^1/_2$ in.) larger in diameter than the hold-down bolt.

g) Mounting holes in equipment feet shall be machined or spot faced to a diameter suitable for a washer positioned eccentrically around the bolt to allow for equipment alignment. Holes shall not be slotted.

h) The equipment feet shall be provided with vertical jack-screws and shall be drilled with pilot holes that are accessible for use in final doweling.

NOTE 1 Mounting requirements for equipment mounting feet are covered in Parts 2, 3, and 4. Machinery requiring alignment (compressors, motors, gears, etc.) have holes in the equipment feet larger than the diameter of the hold-down bolts in order to allow for movement for alignment.

NOTE 2 Expander-compressors as covered in Part 4 do not require alignment since driver and compressor are on the same shaft.

NOTE 3 Refer to 5.4.1.2.1 for horizontal jackscrew requirements.

4.6.6 External Forces and Moments

External forces and moment information can be found in the applicable parts of this standard.

4.6.7 Guide Vanes, Stators, and Stationary Internals

Refer to subsequent parts of this standard for specific requirements.

4.7 Rotating Elements

4.7.1 Shaft ends for couplings shall conform to the requirements of API 671.

4.7.2 The rotor shaft sensing areas observed by radial-vibration probes shall be concentric with the bearing journals. All shaft sensing areas (both radial vibration and axial position) shall be free from stencil or scribe marks or any other surface discontinuity for a minimum of one probe tip diameter on each side of the probe. Only suppliers with proven experience or test data may metalize shafts to reduce electrical runout.

NOTE Shaft materials such as 17-4 PH frequently exhibit excessive electrical runout. Some suppliers have successfully reduced electrical runout to acceptable levels with treatments such as the application of 1 mm (0.04 in.) radial thickness of metalized aluminum.

4.7.3 The final surface finish of sensing areas observed by radial vibration probes shall be a maximum of 0.8 µm (32 µin.) Ra, preferably obtained by honing or burnishing. These areas shall be properly demagnetized to the levels specified in API 670 or otherwise treated so that the required combined total electrical and mechanical runout can be met. For areas observed by radial vibration probes the combined total electrical and mechanical runout shall not exceed the value from Equation (2) or 6.35 µm (0.25 mil), whichever is greater.

In SI units:

$$R = \frac{25.4}{4}\sqrt{\frac{12{,}000}{N}} \tag{2a}$$

In USC units:

$$R = \frac{1}{4}\sqrt{\frac{12{,}000}{N}} \tag{2b}$$

where

N is the maximum continuous operating speed (rpm);

R is the allowable runout (µm/mils).

For areas observed by axial vibration probes, the combined total electrical and mechanical runout shall not exceed 0.5 mil (12.7 µm).

NOTE 1 If all reasonable efforts fail to achieve the limits noted in 4.7.3, the supplier and the purchaser can agree on alternate acceptance criteria.

NOTE 2 Diamond burnishing of probe areas has been shown to be effective in reducing electrical runout.

NOTE 3 The use of magnetic holders or chucks in the probe areas during manufacture or handling will cause electrical runout.

4.7.4 To prevent the buildup of potential voltages in the shaft, residual magnetism of the rotating element free air gauss level shall not exceed 0.0005 Tesla (5 gauss) when measured with a calibrated indicator.

NOTE 1 The free air gauss level is measured while suspending the rotor from nonconductive straps with no influence from stray magnetic fields.

NOTE 2 A Hall effect probe is preferred.

4.7.5 The design of stressed parts shall include proper evaluation of the stress concentration factor (SCF) for the geometry. The design of stressed rotating parts shall include fillets that are limiting the SCF.

NOTE Areas of concern include the impeller vane-to-disk intersections, keyways, and shaft section changes.

4.7.6 Replaceable thrust collars shall be furnished only when they are required for removal of shaft end seals. When replaceable collars are furnished (for assembly and maintenance purposes), they shall be positively locked to the shaft to prevent fretting. When integral collars larger than 5 in. diameter are furnished, they shall be provided with at least $^{1}/_{8}$ in. (3 mm) of additional stock to enable refinishing if the collar is damaged.

4.7.7 Both faces of thrust collars shall have a surface finish of not more than 500 μm (20 mils) Ra, and the axial total indicator runout (TIR) of either face shall not exceed 12.7 μm (0.5 mils).

4.7.8 Stationary labyrinth seals shall have replaceable shaft sleeves or be designed so that major rotating parts need not be replaced. Labyrinth-type seals with the teeth on the rotating element shall have replaceable nonrotating element of an abradable material.

4.7.9 The design of the shaft-sleeve-impeller assemblies shall not create temporary nor permanent distortions of the rotor assembly. The method of attaching the impeller shall adequately maintain concentricity and balance under all specified operating conditions, including overspeed to trip speed.

4.7.10 Impellers

4.7.10.1 Impellers may be closed, consisting of a hub, blades, and a cover, or semi-open, consisting of a hub and blades. Impellers shall be of welded, brazed, milled, electro-eroded or cast construction. Other manufacturing methods may be permitted if approved by the purchaser. Each impeller shall be marked with a unique identification number.

4.7.10.2 Impellers may consist of forged and cast components. Welds in the gas passageway shall be smooth and free of weld spatter. Impellers shall be heat treated and stress relieved after welding. Impeller blade entrance and exit tips shall not have knife edges.

4.7.10.3 All accessible weld surfaces on welded impellers and finish machined surfaces of electro-eroded impellers shall be inspected by visual and magnetic particle or liquid penetrant examination. Impeller fabrications resulting in joints that are not visually accessible, such as brazed joints, shall be subjected to ultrasonic examination to verify joint integrity. Refer to 6.2.2 for material inspection methods and 6.2.2.1.1 for acceptance criteria.

4.7.10.4 Cast impellers hubs and covers shall be inspected by radiographic or ultrasonic means prior to finish machining. Details of inspection techniques and acceptance criteria shall be agreed. Refer to 6.2.2 for material inspection methods and 6.2.2.1.1 for acceptance criteria.

4.7.10.5 Upgrade or repair welding of impellers after overspeed testing may be permitted only with the purchaser's approval.

4.7.10.6 Welding as a means of balancing an impeller is not permitted.

4.7.10.7 After the overspeed test described in 6.3.3, each impeller shall be examined all over by means of magnetic particle or liquid penetrant methods. Refer to 6.2.2 for material inspection methods and 6.2.2.1.1 for acceptance criteria.

4.7.10.8 Metal plating of impeller bores is not permitted without purchaser's approval.

4.8 Dynamics

4.8.1 General

NOTE Refer to API 684 for more information on rotordynamics.

4.8.1.1 In the design of rotor-bearing systems, consideration shall be given to all potential sources of excitation that shall include, but are not limited to, the following:

a) unbalance in the rotor system;

b) fluid destabilizing forces from bearings, seals, and aerodynamics;

c) internal rubs;

d) blade, vane, nozzle, and diffuser passing frequencies;

e) Gear-tooth meshing and side bands.

f) Coupling misalignment.

g) Loose rotor-system components.

h) Internal friction within the rotor assembly.

i) Synchronous excitation from complimentary geared elements.

j) Control loop dynamics such as those involving active magnetic bearings (AMBs).

NOTE 1 The frequency of a potential source of excitation can be less than, equal to, or greater than the rotational speed of the rotor.

NOTE 2 When the frequency of a periodic forcing phenomenon (excitation) applied to a rotor-bearing support system coincides with a natural frequency of that system, the system will be in a state of resonance. A rotor-bearing support system in resonance can have the magnitude of its normal vibration amplified. The magnitude of amplification and, in the case of critical speeds, the rate of change of the phase-angle with respect to speed, is related to the amount of damping in the system.

4.8.1.2 Resonances of structural support systems that are within the supplier's scope of supply and that affect the rotor vibration amplitude shall not occur within the specified operating speed range or the required separation margins (SM_r) (see 4.8.2.9). The dynamic characteristics of the structural support shall be considered in the analysis of the rotor-support system [see 4.8.2.4 d)].

- **4.8.1.3** If specified, the supplier with unit responsibility shall communicate the existence of any undesirable running speeds in the range from zero to trip speed. This shall be illustrated by the use of a Campbell diagram, submitted to the purchaser for review, and included in the instruction manual [see Vendor (Supplier) Drawing and Data Requirements (VDDR) in Annex B of the applicable part].

NOTE 1 Examples of undesirable speeds are those associated with rotor lateral critical speeds with amplification factors (AFs) greater than or equal to 2.5, train torsionals, and vane and blading modes.

NOTE 2 See Annex D for examples of Campbell diagrams.

4.8.1.4 Analysis requirements specified in 4.8.2, 4.8.5, and 4.8.6 shall be reported per 4.8.1.4.1 through 4.8.1.4.3 and Annex C.

4.8.1.4.1 The basic rotordynamics report shall be provided.

- **4.8.1.4.2** If specified, the reporting requirements identified as required for independent audit of the results shall be provided.

- **4.8.1.4.3** If specified, provisions shall be made to provide the purchaser with access to drawings to develop independent models of the rotor, bearings, and seals. This data shall be made available in electronic format.

NOTE This can be requested at time of order as nondisclosure agreements may be required.

4.8.1.5 Torsional analysis requirements specified in 4.8.7 shall conform to 4.8.1.5.1 through 4.8.1.5.3 and Annex D.

4.8.1.5.1 Unless otherwise specified, the basic torsional report shall be provided for all covered machines.

- **4.8.1.5.2** If specified, the reporting requirements identified as required for independent audit of the results shall be provided.

- **4.8.1.5.3** If specified, provisions shall be made to provide the purchaser with access to drawings to develop independent models of the rotors. This data shall be made available in electronic format.

NOTE This can be requested at time of order as nondisclosure agreements may be required.

4.8.2 Lateral Analysis

4.8.2.1 Critical speeds and their associated AFs shall be determined by means of a damped unbalanced rotor response analysis.

4.8.2.2 If required, the location of all critical speeds below the trip speed shall be confirmed on the test stand during the mechanical running test (see 4.8.3.1). The accuracy of the analytical model shall be demonstrated (see 4.8.3).

4.8.2.3 The supplier shall conduct an undamped analysis to identify the undamped critical speeds and determine their mode shapes. The analysis shall identify the first four undamped critical speeds and cover as a minimum the stiffness range from 0.1X to 10X the expected support stiffness.

4.8.2.4 The rotordynamic analysis shall include but shall not be limited to the following:

NOTE The following is a list of items the analyst considers in a typical rotordynamic analysis. It does not address the details and product of the analysis that is covered in 4.8.1.4, 4.8.2.7, and 4.8.2.8.

a) rotor stiffness, mass and polar and transverse moments of inertia, including coupling halves, and rotor stiffness changes due to shrunk on components;

b) bearing lubricant-film stiffness and damping values including changes due to speed, load, preload, range of oil inlet temperature, maximum to minimum clearances resulting from accumulated assembly tolerances, and the effect of asymmetrical loading that may be caused by gear forces (including the changes over range of maximum to minimum torque), side streams, eccentric clearances, volutes, etc.;

c) for tilt-pad bearings, the pad pivot stiffness;

d) structure stiffness, mass, and damping characteristics, including effects of excitation frequency over the required analysis range. For machines whose dynamic structural stiffness values are less than or equal to 3.5 times the bearing stiffness values in the range from 0 to 150 % of N_{mc}, the structure characteristics shall be incorporated as an adequate dynamic system model, calculated frequency dependent structure stiffness and damping values (impedances), or structure stiffness and damping values (impedances) derived from modal or other testing. The supplier shall state the structure characteristic values used in the analysis and the basis for these values (for example, modal tests of similar rotor structure systems or calculated structure stiffness values);

e) rotational speed, including the various starting-speed detents, operating speed and load ranges (including agreed test conditions if different from those specified), trip speed, and coastdown conditions;

f) the influence, over the operating range of the casing shaft end oil seals. Minimum and maximum stiffness shall be considered taking into account the tolerance on the component clearance and the oil inlet temperature;

g) the location and orientation of the radial vibration probes that shall be the same in the analysis as in the machine;

h) squeeze film damper mass, stiffness and damping values considering the component clearance and centering tolerance, oil inlet temperature range, and operating eccentricity;

i) for machines equipped with rolling element bearings, the supplier shall state the bearing stiffness and damping values used for the analysis. The basis for these values or the assumptions made in calculating the values shall be presented;

j) dry gas seals shall be assumed to have no stiffness or damping.

- **4.8.2.5** If specified, the supplier with train responsibility shall provide a train lateral analysis**.**

4.8.2.6 The supplier with train responsibility shall provide a train lateral analysis for machinery trains with rigid couplings.

4.8.2.7 A separate damped unbalanced response analysis shall be conducted within the speed range of 0 to 150 % of N_{mc}. Unbalance shall analytically be placed at the locations defined in Figure 1. For the translatory (symmetric) modes, the unbalance shall be based on the sum of the journal static loads. For conical (asymmetric) modes, these unbalances shall be 180° out of phase and of a magnitude based on the static load on the adjacent bearing. For overhung modes, the unbalances shall be based on the overhung mass. Figure 1 shows the typical mode shapes and indicates the location and definition of U_a for each of the shapes. The magnitude of the unbalances shall be 2 times the value of U_r as calculated by Equation (3) or Equation (4).

In SI units:

$$U_r = 6350\frac{W}{N_{\text{mc}}} \quad (\text{for } N_{\text{mc}} < 25{,}000 \text{ rpm}) \tag{3a}$$

$$U_r = \frac{W}{3.937} \quad (\text{for } N_{\text{mc}} \geq 25{,}000 \text{ rpm}) \tag{4a}$$

In USC units:

$$U_r = 4\frac{W}{N_{\text{mc}}} \quad (\text{for } N_{\text{mc}} < 25{,}000 \text{ rpm}) \tag{3b}$$

$$U_r = \frac{W}{6250} \quad (\text{for } N_{\text{mc}} \geq 25{,}000 \text{ rpm}) \tag{4b}$$

where

U_a is the input unbalance for the unbalance response analysis in g-mm (oz-in.)

$= 2 \times U_r$;

U_r is the maximum allowable residual unbalance in g-mm (oz-in.);

N_{mc} is the maximum continuous operating speed, rpm;

W is the journal static load in kg (lbm), or for bending modes where the maximum deflection occurs at the shaft ends, the overhung mass (that is the mass of the rotor outboard of the bearing) in kg (lbm) (see Figure 1).

NOTE Above 25,000, the limit is based on 0.254 μm (10 μin.) mass displacement, which is in general agreement with the capabilities of conventional balance machines, and are necessary to invoke for small rotors running at high speeds.

4.8.2.8 As required by 4.8.3.1, additional analyses shall be made for use with the verification test specified in 4.8.3. The location of the unbalance shall be determined by the supplier. The unbalance shall not be less than 2 times or greater than 8 times the value from Equation (3) or Equation (4) or as specified in 4.8.2.8.1. Any test stand parameters that influence the results of the analysis shall be included.

4.8.2.8.1 For coupling unbalance placement (unbalance based on the coupling half weight), the unbalance shall be greater or equal to 16 times the value of Equation (3) or Equation (4).

NOTE For most machines, there will only be one plane readily accessible for the placement of an unbalance; for example, the coupling flange on a single ended drive machine, or the impeller hub or disk on an integrally geared machine, or expander-compressors. However, some compressor types (axial compressors, for example) may provide additional externally accessible balance planes. For these machines, when there exists the possibility of exciting other critical speeds, multiple runs will be required.

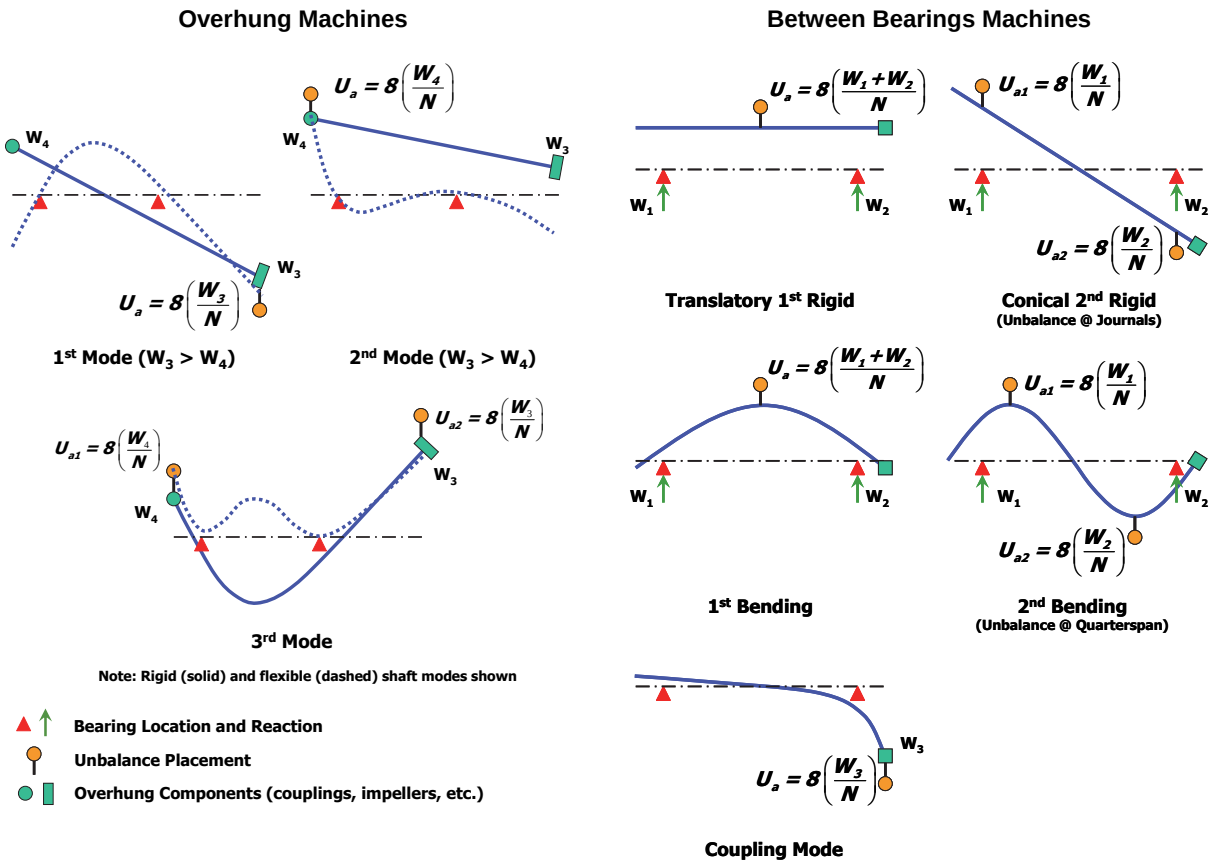


Figure 1—Typical Mode Shapes and Corresponding Unbalance

4.8.2.9 The damped unbalanced response analysis shall indicate that the machine meets the following requirement:

$$SM_a \geq SM_r \tag{5}$$

where

SM_r is the required separation margin, %;

SM_a is defined in Figure 2.

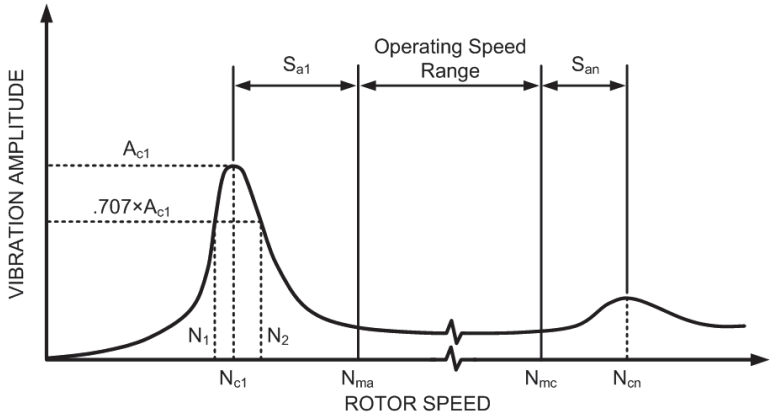
a) If the AF at a particular critical speed is less than 2.5, the response is considered critically damped and no separation margin is required ($SM_r = 0$).

b) If the AF at a particular critical speed is greater than or equal to 2.5 and that critical speed is below the minimum speed, the SM_r is given by Equation (6).

$$SM_r = 17\left(1 - \frac{1}{AF - 1.5}\right) \tag{6}$$

c) If the AF at a particular critical speed is greater than or equal to 2.5 and that critical speed is above the MCS, the SM_r is given by Equation (7).

$$SM_r = 10 + 17\left(1 - \frac{1}{AF - 1.5}\right) \quad (7)$$



N_{c1} = Rotor first critical speed
N_{cn} = n^{th} critical speed
N_{ma} = Minimum allowable speed
N_{mc} = Maximum continuous speed

A_{c1} = Amplitude at N_{c1}
N_1 = Initial (lesser) speed at 0.707 × A_{c1}
N_2 = Final (greater) speed at 0.707 × A_{c1}
AF_1 = Amplification factor of the first critical speed
= $N_{c1} / (N_2 - N_1)$

S_{a1} = Actual separation between N_{c1} and the operating speed range
S_{an} = Actual separation between N_{cn} and the operating speed range
SM_{a1} = Actual separation margin of first critical speed (%)
= 100 × S_{a1} / N_{ma}
SM_{an} = Actual separation margin of n^{th} critical speed (%)
= 100 × S_{an} / N_{mc}

NOTE The shape of the curve is for illustration only and does not necessarily represent any actual rotor response plot.

Figure 2—Typical Rotor Response Plot

4.8.2.10 The calculated unbalanced peak-to-peak response at each vibration probe, for each unbalance amount and case as specified in 4.8.2.7, shall not exceed the mechanical test vibration limit, A_{vl}, of [25.4 µm (1.0 mil) or Equation (8), whichever is less] over the range of N_{ma} to N_{mc} as shown in Figure 3.

In SI units:

$$A_{vl} = 25.4\sqrt{\frac{12{,}000}{N_{mc}}} \quad (8a)$$

In USC units:

$$A_{vl} = \sqrt{\frac{12{,}000}{N_{mc}}} \tag{8b}$$

where

A_{vl} is the mechanical test vibration limit, μm (mil);

N_{mc} is the maximum continuous speed (rpm).

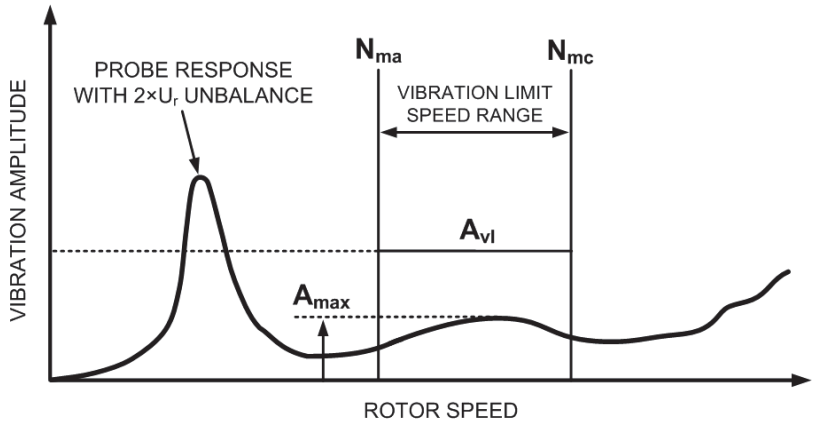


Figure 3—Plot of Applicable Speed Range of Vibration Limit

4.8.2.11 For each unbalance amount and case as specified in 4.8.2.7, the calculated major-axis, peak-to-peak response amplitudes at each close clearance location shall be multiplied by a scale factor defined by Equation (9).

$$S_{cc} = A_{vl} / A_{max} \quad \text{or 6, whichever is less} \tag{9}$$

where

S_{cc} is the scale factor for close clearance check;

A_{vl} is the mechanical test vibration limit defined in 4.8.2.10;

A_{max} is the maximum probe response amplitude (p-p) considering all vibration probes, over the range of N_{ma} to N_{mc}, for the unbalance amount/case being considered.

NOTE To meet the requirements of 4.8.2.10, the scale factor will be greater than or equal to one.

4.8.2.11.1 For each close clearance location, the scaled response shall be less than 75 % of the minimum design diametral running clearance over the range from zero to trip speed.

Running clearances can be different than the assembled clearances with the machine shutdown. Consideration should be given to:

a) centrifugal/thermal growth,

b) bearing lift,

c) rotor sag,

d) nonconcentricity (of stator to the bearings).

4.8.2.11.2 For this evaluation, floating-ring, abradable, and compliant seals are not considered close clearance locations. The response amplitude as compared to the running clearance at these locations shall be agreed.

4.8.2.12 If the analysis indicates that if either of the following requirements cannot be met:

a) the required separation margins or

b) the requirements of 4.8.2.10 or 4.8.2.11,

and the purchaser and supplier have agreed that all practical design efforts have been exhausted, then acceptable amplitudes, separation margins, and AFs shall be agreed by the purchaser and the supplier, subject to the requirements of 4.8.4.

4.8.3 Unbalanced Rotor Response Verification Test

4.8.3.1 If specified or when the first critical speed is less than 127 % of N_{mc}, an unbalanced rotor response test shall be performed as part of the mechanical running test (see 6.3.5 of Part 1, 6.3.1 of Parts 2 and 3, and 6.3.3 of Part 4, whichever is applicable), and the results shall be used to verify the analytical model. The actual response of the rotor on the test stand to the same arrangement of unbalance and bearing loads as was used in the analysis specified in 4.8.2.8 shall be used for determining the validity of the damped unbalanced response analysis. To accomplish this, the requirements of 4.8.3.1.1 through 4.8.3.1.6 shall be followed.

NOTE API 684 contains discussions related to verification testing performed in a balance bunker.

4.8.3.1.1 During the mechanical running test, the amplitudes and phase angle of the shaft vibration from trip to slow roll speed shall be recorded after the 4-hour run. The recording instrumentation resolution shall be at least 1.25 µm (0.05 mils).

NOTE This set of readings is normally taken during a coastdown, with convenient increments of speed such as 50 rpm. Since at this point the rotor is balanced, any vibration amplitude and phase detected may be the result of residual unbalance and mechanical and electrical runout.

4.8.3.1.2 The unbalance that was used in the analysis performed in 4.8.2.8 shall be added to the rotor in the location used in the analysis.

4.8.3.1.3 The machine shall then be brought up to trip speed after being held at maximum continuous speed for at least 15 minutes, and the indicated vibration amplitudes and phase shall be recorded during the coastdown using the same procedure as 4.8.3.1.1.

4.8.3.1.4 The location of critical speeds below the trip speed shall be established. If a clearly defined response peak is not observed during the test, then the critical speeds shall be identified as those in the lateral damped analysis report.

NOTE Slow roll run out is normally vectorially subtracted from the 1X Bode plots to accurately define the location of the critical speeds.

4.8.3.1.5 The corresponding indicated vibration data taken in accordance with 4.8.3.1.1 and 4.8.3.1.4 shall be vectorially subtracted.

NOTE Check slow roll run out prior to subtraction. The data is expected to be nearly identical for both runs.

4.8.3.1.6 The results of the mechanical run including the unbalance response verification test shall be compared with those from the analytical model specified at 4.8.2.8.

NOTE It is necessary for probe orientation to be the same for the analysis and the machine for the comparison to be valid.

4.8.3.2 Using the unbalance response test results, the supplier shall correct the model if it fails to meet either of the following criteria:

a) the actual critical speed(s) determined on test shall not deviate from the corresponding critical speed ranges predicted by analysis by more than ± 5 %,

b) the maximum probe responses from the results of 4.8.3.1.5 shall not exceed the predicted ranges.

4.8.3.3 The supplier shall determine whether the comparison made is for absolute or relative motion.

For absolute motion, bearing housing vibration will need to be vectorially added to relative probe readings. This is required for machinery with soft supports.

4.8.3.4 Unless otherwise specified, the verification test of the rotor unbalance shall be performed only on the first rotor tested, if multiple identical rotors are purchased.

4.8.3.5 After correcting the model, if required, the response amplitudes shall be checked against the limits specified in 4.8.2.10 and 4.8.2.11.

4.8.4 Additional Testing

4.8.4.1 Additional testing is required if from the shop verification test data (see 4.8.3) or from the damped, corrected unbalanced response analysis (see 4.8.3.2), if either of the following conditions exists:

a) any critical speed that fails to meet the SM_r requirements (see 4.8.2.9),

b) the requirements of 4.8.2.10 and 4.8.2.11 have not been met.

NOTE When the analysis or test data does not meet the requirements of the standard, additional more stringent testing is required. The purpose of this additional testing is to determine on the test stand that the machine will operate successfully.

4.8.4.2 Unbalance weights shall be placed as described in 4.8.2.7; this may require disassembly of the machine. Unbalance magnitudes shall be achieved by adjusting the indicated unbalance that exists in the rotor from the initial run to raise the displacement of the rotor at the probe locations to the vibration limit defined in 4.8.2.10 at the MCS; however, the unbalance used shall be no less than twice nor greater than 8 times the unbalance limit specified in 4.8.2.7, Equation (3) or Equation (4). The measurements from this test, taken in accordance with 4.8.3.1.1 through 4.8.3.1.3, shall meet the following criteria.

a) From zero to trip speed, the shaft deflections shall not exceed 90 % of the minimum design running clearances.

b) Within the operating speed range, including the SM_r, the shaft deflections shall not exceed 55 % of the minimum design running clearances or 150 % of the allowable vibration limit at the probes (see 4.8.2.10).

c) For this evaluation, floating-ring, abradable, and compliant seals are not considered close clearance locations. The response amplitude to the running clearance at these locations shall be agreed.

4.8.4.3 The internal deflection limits specified in 4.8.4.2 a) through 4.8.4.2 c) shall be based on the calculated displacement ratios between the probe locations and the areas of concern identified in 4.8.2.11 based on a corrected model, if required. Acceptance shall be based on these calculated displacements or inspection of the seals if the machine is opened.

NOTE Internal displacements for these tests are calculated by multiplying these ratios by the peak readings from the probes.

4.8.4.4 Damage to any portion of the machine as a result of this testing shall constitute failure of the test. Internal seal rubs that do not cause changes outside the supplier's assembly clearance range do not constitute damage.

4.8.5 Level 1 Stability Analysis

4.8.5.1 A stability analysis shall be performed on all centrifugal, axial compressors, or radial flow rotors that meet the following:

a) those rotors whose MCS is greater than the first undamped critical speed on rigid supports (FCSR) in accordance with 4.8.2.3;

b) those rotors with fixed geometry bearings or oil film ring seals.

The stability analysis shall be calculated at the API defined MCS.

NOTE Level I analysis was developed to fulfill two purposes: first, it provides an initial screening to identify rotors that do not require a more detailed study. The approach as developed is conservative and not intended as an indication of an unstable rotor. Second, the Level I analysis specifies a standardized procedure applied to all manufacturers similar to that found in 4.8.2. (Refer to API 684 for a detailed explanation.)

4.8.5.2 The model used in the Level I analysis shall include the items listed in 4.8.2.4.

4.8.5.3 When tilt pad journal bearings are used, the analysis shall be performed with synchronous tilt pad coefficients.

4.8.5.4 For rotors that have quantifiable external radial loading (e.g. integrally geared compressors), the stability analysis shall also include the external loads associated with the operating conditions defined in 4.8.5.5. For some rotors, the unloaded (or minimal load condition) may represent the worst stability case and shall be considered.

4.8.5.5 The anticipated cross coupling, Q_A, present in the rotor is defined by the following procedures.

For centrifugal compressors:

The parameters in Equation (10) shall be determined based on the machine conditions at normal operating point unless the supplier and purchaser agree upon another operating point.

$$q_a = \frac{(\mathrm{HP})B_c C}{D_c H_c N_r}\left(\frac{\rho_d}{\rho_s}\right) \tag{10}$$

where

HP is the rated power per impeller, Nm/s (HP);

B_c is 3;

C is 9.55 (63);

ρ_d is the discharge gas density per impeller, kg/m^3 (lbm/ft^3);

ρ_s is the suction gas density per impeller, kg/m^3 (lbm/ft^3);

D_c is the impeller diameter, mm (in.);

H_c is the minimum of diffuser or impeller discharge width per impeller, mm (in.);

N_r is the normal operating speed for calculation of aerodynamic excitation (rpm);

q_a is the cross coupling for each individual impeller, kN/mm (klbf/in).

Equation (10) is calculated for each impeller of the rotor. Q_A is equal to the sum of q_a for all impellers.

For axial flow rotors:

$$q_a = \frac{(\mathrm{HP})B_t C}{D_t H_t N_r} \tag{11}$$

where

B_t is 1.5;

D_t is the blade pitch diameter, mm (in.);

H_t is the effective blade height, mm (in.).

Equation (11) is calculated for each blade row of the rotor. Q_A is equal to the sum of q_a for all stages.

4.8.5.6 An analysis shall be performed with a varying amount of cross coupling introduced at the rotor mid-span for between bearing rotors or at the center of gravity of the stage or impeller for single overhung rotors. For double overhung rotors, the cross coupling shall be placed at each stage or impeller concurrently and shall reflect the ratio of the anticipated cross coupling (q_a, calculated for each impeller or stage).

4.8.5.7 The applied cross coupling shall extend from zero to the minimum of:

a) a level equal to 10 times the anticipated cross coupling, Q_A;

b) the amount of the applied cross coupling required to produce a zero log decrement, $Q_{0.}$ This value can be reached by extrapolation or linear interpolation between two adjacent points on the curve shown in Figure C.2.

4.8.5.8 Level I Screening Criteria

a) For centrifugal compressors:

If any of the following criteria apply, a Level II stability analysis shall be performed:

1) $Q_0 / Q_A < 2.0$,

2) $\delta_A < 0.1$,

3) $Q_0 / Q_A < 10$ and the point defined by CSR and the average density at the normal operating point is located in Region B of Figure 4.

Otherwise, the stability is acceptable and no further analyses are required.

a) For axial flow rotors:

If $\delta_A < 0.1$, a Level II stability analysis shall be performed. Otherwise, the stability is acceptable and no further analyses are required.

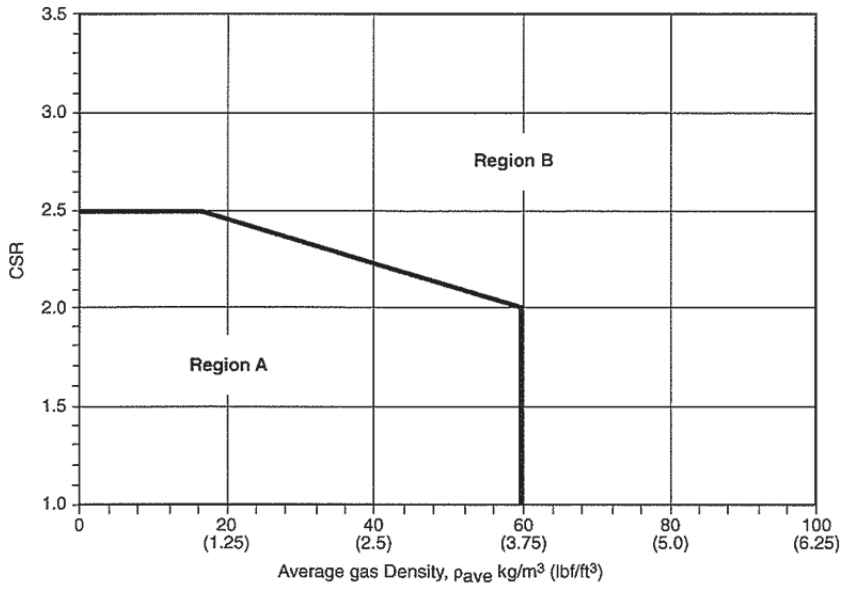


Figure 4—Stability Experience Plot

4.8.6 Level II Stability Analysis

4.8.6.1 A Level II analysis, which reflects the actual dynamic forces (both stabilizing and destabilizing) of the rotor, shall be performed as required by 4.8.5.8.

4.8.6.2 The Level II analysis shall include the dynamic effects from all sources that contribute to the overall stability of the rotating assembly. These dynamic effects shall replace the anticipated cross coupling, Q_A. The following sources shall be considered:

a) labyrinth seals,

b) damper seals,

c) impeller/blade flow aerodynamic effects,

d) internal friction.

4.8.6.2.1 The supplier shall state how the sources are handled in the analysis.

NOTE It is recognized that methods are not available at present to accurately model the destabilizing effects from all sources listed above.

4.8.6.3 The Level II analysis shall be calculated at N_{mc}.

4.8.6.4 The operating conditions defined for the normal operating point shall be extrapolated to N_{mc}.

NOTE Extrapolated conditions are expected to fall within the operating limits of the equipment train (the defined operating map).

4.8.6.5 The modeling requirements of Level I shall also apply.

4.8.6.6 The dynamic coefficients of the labyrinth seals shall be calculated at minimum seal running clearance.

4.8.6.7 When calculating the dynamic coefficients of damper seals, the running clearance profile range, which is determined by drawing dimensions, manufacturing tolerances, and deformations in the seal, seal support, and rotor, shall be included.

4.8.6.8 The frequency and log decrement of the first forward damped mode shall be calculated progressively for the following configurations (except for double overhung machines where the first two forward modes shall be considered):

a) rotor and support system only (basic log decrement, δ_b);

b) each source from 4.8.6.2 utilized in the analysis;

c) for damper seals, the dependence due to parameters defined in 4.8.6.7;

d) complete model including all sources (final log decrement, δ_f)**.**

4.8.6.9 Acceptance Criteria

The Level II stability analysis shall indicate that the machine, as calculated in 4.8.6.1 through 4.8.6.8, shall have a final log decrement, δ_f, greater than 0.1.

4.8.6.10 If after all practical design efforts have been exhausted to achieve the requirements of 4.8.6.9, acceptable levels of the log decrement, δ_f, shall be agreed.

NOTE It is recognized that other analysis methods and continuously updated acceptance criteria have been used successfully since the mid-1970s to evaluate stability. The historical data accumulated by machinery manufacturers for successfully operated machines can conflict with the acceptance criteria of this standard. If such a conflict exists and the suppliers can demonstrate that their stability analysis methods and acceptance criteria predict a stable rotor, then the suppliers' criteria can be the guiding principle in the determination of acceptability.

4.8.7 Torsional Analysis

4.8.7.1 For trains including motors, generators, positive displacement units, or gears, the supplier having unit responsibility shall ensure that a torsional vibration analysis of the complete coupled train is carried out and shall be responsible for directing any modifications necessary to meet the requirements of 4.8.7.3 through 4.8.7.7.

4.8.7.2 If specified, for direct driven turbine trains, the supplier shall perform a torsional vibration analysis of the complete coupled train and shall be responsible for directing any modifications necessary to meet the requirements of 4.8.7.3 through 4.8.7.7.

4.8.7.3 For trains in 4.8.7.2, a simplified torsional model (lumped rotor inertia and stiffness) is sufficient.

NOTE The intent of the simplified analysis is to calculate the primary (coupling) modes of the system. Primary modes are those influenced primarily by the coupling torsional stiffness.

4.8.7.4 Excitation of torsional natural frequencies may come from many sources and should be considered in the analysis. These sources shall include but are not limited to the following:

a) gear characteristics such as unbalance, pitch line runout, and cumulative pitch error;

b) torsional pulsations due to gear radial vibrations;

c) cyclic process impulses;

d) torsional excitation resulting from electric motors, and engines;

e) one and two times electrical line frequency;

f) one and two times operating speed(s).

4.8.7.5 Primary (coupling) modes shall be at least 10 % above or 10 % below any 1X excitation frequency (mechanical or electrical) within the specified operating speed range.

4.8.7.6 All other torsional natural frequencies shall preferably be at least 10 % above or 10 % below any possible excitation frequency within the specified operating speed range (from minimum to MCS).

4.8.7.6.1 Any interference resulting from 4.8.7.6 shall be shown to have no adverse effect using 4.8.7.7.

4.8.7.7 When torsional resonances are calculated to fall within the margin specified in 4.8.7.6 (and the purchaser and the supplier have agreed that all efforts to remove the critical from within the limiting frequency range have been exhausted), a steady state stress analysis shall be performed to demonstrate that the resonances have no adverse effect on the complete train.

4.8.7.7.1 The analysis shall show that all shaft sections, couplings, and gear mesh have infinite life using an agreed criteria.

4.8.7.8 In addition to the torsional analyses required in 4.8.7.3 through 4.8.7.7, the supplier shall perform a transient torsional vibration analysis for synchronous motor driven units, using a time-transient analysis. The requirements of 4.8.7.8.1 through 4.8.7.8.4 shall be followed.

4.8.7.8.1 In addition to the parameters used to perform the torsional analysis specified in 4.8.7.4, the following shall be included:

a) motor average torque, as well as pulsating torque (direct and quadrature axis) vs speed characteristics;

b) load torque vs speed characteristics;

c) electrical system characteristics affecting the motor terminal voltage or the assumptions made concerning the terminal voltage including the method of starting, such as across the line or some method of reduced voltage starting.

4.8.7.8.2 The analysis shall generate the maximum torque as well as a torque vs time history for each of the shafts in the compressor train.

The maximum torques shall be used to evaluate the peak torque capability of coupling components, gearing, and interference fits of components such as coupling hubs.

NOTE The torque vs time history is used to develop a cumulative damage fatigue analysis of shafting, keys, and coupling components.

4.8.7.8.3 Appropriate fatigue properties and stress concentrations shall be used.

4.8.7.8.4 An appropriate cumulative fatigue algorithm shall be used to develop a value for the safe number of starts. The safe number of starts shall be as agreed by the purchaser and supplier.

4.8.7.9 For VFD driven equipment trains, the supplier shall extend the analysis defined in 4.8.7.3 through 4.8.7.7 to include the following in 4.8.7.9.1 through 4.8.7.9.4.

4.8.7.9.1 In addition to the excitations of 4.8.7.4, the following shall also be considered but is not limited to:

a) integer orders of the drive output frequency,

b) sidebands of the pulse width modulation.

NOTE VFD produced broad band noise floor and feedback generated excitations can cause harmful torsional pulsations. Transient and/or mechanical/electrical coupled analyses can be required to understand the effects of these excitations.

4.8.7.9.2 A steady state response analysis shall be performed from 0 to MCS to quantify the effects of the VFD excitation of 4.8.7.9.1.

4.8.7.9.3 For interferences occurring below the minimum operating speed, an agreed criteria shall be used to establish acceptability of the train.

4.8.7.9.4 For interferences occurring within the operating speed range, the criteria set forth in 4.8.7.7.1 shall be used.

- **4.8.7.10** If specified, for motor-driven equipment and trains including an electrical generator, a transient short circuit fault analysis shall be performed in accordance with 4.8.7.10.1 through 4.8.7.10.2.

4.8.7.10.1 The following faults shall be considered but is not limited to:

a) short circuits:

   1) line-to-line,

2) two phase,

3) three phase,

4) line-to-ground,

5) line-to-line-to-ground;

b) synchronization (generators):

1) single phase,

2) three phase.

4.8.7.10.2 For these fault conditions, generated stresses in the shafting and couplings shall not exceed the low cycle fatigue limit.

NOTE The analysis for these fault conditions assumes a onetime event. It is possible that some components identified by the analysis will need to be replaced following the fault event.

● **4.8.7.11** If specified, alternating torques produced by breaker reclosure shall be shown to have no negative impact on the intended operating life of the equipment train.

4.8.8 Vibration and Balancing

4.8.8.1 Major parts of the rotating element, such as the shaft, balancing drum, and impellers, shall be individually dynamically balanced before assembly, to ISO 1940 Grade G0.67 or better. When a bare shaft with a single keyway is dynamically balanced, the keyway shall be filled with a fully crowned half key, in accordance with ISO 8821. Keyways 180° apart, but not in the same transverse plane, shall also be filled. The initial balance correction to the bare shaft shall be recorded. The components mounted on the shaft (impellers, balance drum, etc.) shall also be balanced in accordance with the "half-key-convention," as described in ISO 8821.

4.8.8.2 Unless otherwise specified, the rotating element shall be sequentially multiplane dynamically balanced during assembly. This shall be accomplished after the addition of no more than two major components. Balancing correction shall only be applied to the elements added. Minor correction of other components may be required during the final trim balancing of the completely assembled element. In the sequential balancing process, any half keys used in the balancing of the bare shaft (see 4.8.8.1) shall continue to be used until they are replaced with the final key and mating element. On rotors with single keyways, the keyway shall be filled with a fully crowned half-key. The weight of all half-keys used during final balancing of the assembled element shall be recorded on the Residual Unbalance Worksheet (see Annex A). The maximum allowable residual unbalance per plane (journal) shall be calculated as follows per Equation (3) or Equation (4) as applicable.

4.8.8.2.1 When the supplier's standard assembly procedures require the rotating element disassembled after final balance to allow compressor assembly (i.e. stacked rotors with solid diaphragms and compressor/expanders), the supplier shall, as a minimum, perform the following operations.

a) To ensure the rotor has been assembled concentrically, the supplier shall take axial and/or radial runout readings on the tip of each element (impeller or disc) and at the shaft adjacent to each element when possible. The runout on any element shall not exceed a value agreed between the purchaser and the supplier.

b) The supplier shall balance the rotor to the limits of 4.8.8.2, Equation (3), or Equation (4).

c) The supplier shall provide historic unbalance data readings of the change in balance due to disassembly and reassembly. This change in unbalance shall not exceed 4 times the sensitivity of the balance machine. For this purpose, balance machine sensitivity is 0.254 μm (10 μin.) maximum.

d) The supplier shall conduct an analysis in accordance with 4.8.2, to predict the vibration level during testing, using an unbalance equal to that in Item b), plus 2 times the average change in balance due to disassembly and reassembly as defined in Item c). The results of this analysis shall show that the predicted vibration at design speed on test shall be no greater than 2 times the requirements of 4.8.8.8.

NOTE Trim balancing in the compressor case can be done to achieve this level.

- **4.8.8.2.2** If specified, the supplier shall record the balance readings after initial balance for the contract rotor. The rotor shall then be disassembled and reassembled. The rotor shall be check balanced after reassembly to determine the change in balance due to disassembly and reassembly. This change in balance shall not exceed that defined in 4.8.8.2.1 c).

4.8.8.3 The following options are available concerning operating speed balancing.

- **4.8.8.3.1** If specified or with purchaser's approval, after low speed sequential balancing, the rotor shall be operating speed balanced in accordance with 4.8.8.4.

- **4.8.8.3.2** If specified or with purchaser's approval, completely assembled rotating elements shall be subject to operating speed balancing (in accordance with 4.8.8.4) in lieu of a sequential low speed balancing.

4.8.8.4 Operating Speed Balancing Procedure

4.8.8.4.1 The following information shall be provided, prior to operating speed balancing:

a) the contract rotordynamics analysis,

b) final low speed balance records when applicable,

c) mechanical radial and axial runout checks of the rotor,

d) job and balance stand bearing details.

4.8.8.4.2 The rotor shall be supported in bearings of the same type and with similar dynamic characteristics as those in which it shall be supported in service.

NOTE 1 Job bearings can be used when practical.

NOTE 2 Operating speed balance units run under a vacuum. Operation in a vacuum can require the need for temporary end seals.

4.8.8.4.3 The rotor shall be completely assembled including thrust collars with locking collars and any auxiliary equipment. Shaft end seals are not added.

4.8.8.4.4 The high speed drive assembly shall be shown to have an effect less than 25 % of the balance tolerance.

NOTE In some cases, the facility drive coupling and adapter may be adequate to simulate the job-coupling half moment. In some cases, the job-coupling hub with moment simulator will be required, especially for the outboard ends of drive-through machines.

4.8.8.4.5 If specified, two orthogonally mounted radial noncontacting vibration probes shall be mounted next to the bearings, at mid-shaft or at overhung locations as agreed by purchaser and supplier.

4.8.8.4.6 When noncontacting proximity vibration probes have been specified, structural resonance frequency of the probes and supports shall be determined after installation of the rotor and probe assemblies in the balance machine when nonstandard mounting is used (i.e. cantilevered probe holders).

4.8.8.4.7 The smallest pedestal available rated for the rotor weight shall be used without pedestal stiffening engaged.

NOTE Light rotors used with larger pedestals could require a reduction of the rotor balance criteria.

4.8.8.4.8 Prior to operating speed balance, the complete rotor shall be low speed balance checked in the operating speed facility. If the measured unbalance exceeds five times the maximum allowable residual unbalance for the rotor, then the cause of the unbalance shall be identified prior to operating speed balancing.

NOTE The purpose of identifying the unbalance is to increase the possibility of the rotor successfully traversing its critical speed(s) and to increase the likelihood of a successful balance.

4.8.8.4.9 Prior to balancing, the rotor residual unbalance shall be stabilized. This shall be accomplished by:

a) record low speed residual unbalance (amount and phase) before running up in speed;

b) run rotor to trip speed plus 4 % of MCS, hold for 3 minutes;

c) reduce to maximum continuous operating speed and record unbalance readings for each pedestal;

d) reduce speed and record low speed unbalance again;

e) repeat until readings taken in 4.8.8.4.9 c) and 4.8.8.4.9 d) are consistent.

4.8.8.4.10 Balance weights (if used) shall be compatible with disk material and suitable for the operating environment.

4.8.8.4.11 After the rotor is balanced within the tolerances of 4.8.8.5, repeat the final balance run with the pedestal stiffening engaged.

4.8.8.4.12 Upon completion of the balancing, Bode and polar plots for each pedestal velocity and proximity probe (when used) shall be provided for the initial run, stabilized rotor prior to balancing, and final balanced rotor with and without pedestal stiffening. Proximity probe data shall be compensated for slow roll mechanical and electrical runout.

4.8.8.5 The acceptance criteria shall be agreed between the purchaser and supplier.

NOTE The criteria are typically based on the operating speed balance provider's experience and can be expressed in pedestal vibration, pedestal force, or residual unbalance.

4.8.8.5.1 When noncontacting vibration probes have been specified in 4.8.8.4.5, the acceptance criteria for the readings shall be agreed.

4.8.8.6 A rotor that has been operating speed balanced shall have the residual unbalance recorded in a low speed balance machine. No corrections shall be made to the rotor. A permanent mark or part (such as a keyway) shall be used and recorded for the phase reference.

NOTE 1 This is for future reference if a low speed balance check is performed on the rotor before installation.

NOTE 2 The operating speed balanced rotor will generally not meet the low speed balance criteria.

4.8.8.7 For a rotor that has been low speed balanced, a low speed residual unbalance check shall be performed in a low speed balance machine and recorded in accordance with the Residual Unbalance Worksheet (see Annex A).

4.8.8.8 During the mechanical running test of the machine, assembled with the balanced rotor, operating at any speed within the specified operating speed range, the peak-to-peak amplitude of unfiltered vibration in any plane, measured on the shaft adjacent and relative to each radial bearing, shall not exceed the value from Equation (12) or 25.4 μm (1 mil), whichever is less.

In SI units:

$$A_{vl} = \left[25.4\sqrt{\frac{12{,}000}{N_{mc}}} \text{ or } 25.4 \right] \text{ whichever is less} \qquad (12a)$$

In USC units:

$$A_{vl} = \left[\sqrt{\frac{12{,}000}{N_{mc}}} \text{ or } 1.0 \right] \text{ whichever is less} \qquad (12b)$$

where

A_{vl} is the mechanical test vibration limit, μm (mil);

N_{mc} is the maximum continuous speed (rpm).

4.8.8.8.1 At any speed greater than the MCS, up to and including the trip speed of the driver, the vibration level shall not increase more than 12.7 μm (0.5 mil) above the value recorded at the MCS prior to accelerating to trip for each probe.

NOTE These limits are not to be confused with the limits specified in 4.8.3 for shop verification of unbalanced response.

4.8.8.9 Electrical and mechanical runout shall be determined by rotating the rotor through the full 360° supported in V blocks at the journal centers. The combined runout, measured with a noncontacting vibration probe, and the mechanical runout, measured with dial indicators at the centerline of each probe location, shall be continuously recorded during the rotation. Teflon shall not be used in the V blocks.

NOTE The rotor runout determined above generally will not be reproduced when the rotor is installed in a machine with hydrodynamic bearings. This is due to pad orientation on tilt pad bearings and effect of lubrication in all journal bearings.

4.8.8.10 Records of electrical and mechanical runout for the full 360° at each probe location shall be included in the mechanical test report (mechanical test section).

4.8.8.11 If the supplier can demonstrate that electrical or mechanical runout is present, a maximum of the level from Equation (12) or 6.35 μm (0.25 mil), whichever is greater, may be vectorially subtracted from the vibration signal measured during the factory test. Where shaft treatment such as metalized aluminum bands have been applied to reduce electrical runout, surface variations (noise) may cause a

high frequency noise component that does not have an applicable vector. The nature of the noise is always additive. In this case, the noise shall be mathematically subtracted.

In SI units:

$$R_{\text{out}} = \frac{25.4}{4}\sqrt{\frac{12,000}{N_{\text{mc}}}} \tag{13a}$$

In USC units:

$$R_{\text{out}} = \frac{1}{4}\sqrt{\frac{12,000}{N_{\text{mc}}}} \tag{13b}$$

4.9 Bearings and Bearing Housings

4.9.1 General

Radial and thrust bearings shall be as specified in the subsequent parts of this standard.

4.9.2 Hydrodynamic Radial Bearings

Hydrodynamic radial bearings shall be in accordance with the applicable parts of this standard.

4.9.3 Hydrodynamic Thrust Bearings

4.9.3.1 For gear couplings, the external thrust force shall be calculated from Equation (14).

In SI units:

$$F = \frac{(0.25)(9550)P_r}{N_r D} \tag{14a}$$

In USC units:

$$F = \frac{(0.25)(63{,}300)P_r}{N_r D} \tag{14b}$$

where

F is the external thrust force, in kilonewtons (lb);

P_r is the rated power, in Kw (HP);

N_r is the rated speed, in rpm;

D is the shaft diameter at the coupling, in mm (in.).

4.9.3.2 Thrust forces for flexible-element couplings shall be calculated on the basis of the maximum allowable deflection permitted by the coupling manufacturer.

4.9.3.3 If the thrust forces from two or more rotors are carried by one thrust bearing (such as from a gear box or motor), the resultant of the forces shall be used, provided the directions of the forces make them numerically additive; otherwise, the largest of the forces shall be used.

4.9.3.4 The basis for the sizing of thrust bearings shall be provided.

4.9.4 Bearing Housings

4.9.4.1 Bearing housings shall be equipped with replaceable labyrinth-type end seals and deflectors where the shaft passes through the housing. Lip-type seals shall not be used. The seals and deflectors shall be made of spark-resistant materials. Seals and deflectors shall be designed to retain oil in the housing and prevent entry of foreign material into the housing.

4.9.4.2 Bearing housings shall be arranged to minimize foaming. The drain system shall be adequate to maintain the oil and foam level below shaft seals.

4.9.4.3 Provisions for the installation of required instrumentation shall be provided.

4.9.4.4 Where practical, oil and instrument connections shall be in the lower half of the bearing housing to eliminate the need for their removal during bearing inspections. Instrument connections shall be above the oil level.

- **4.9.4.5** If specified, provisions for locally disconnecting bearing temperature sensors' wiring within the bearing housing shall be provided.

4.9.4.6 Oil flow control orifices used within the housing shall be replaceable and shall be identified on contractual drawings.

4.10 Shaft End Seals

4.10.1 General

4.10.1.1 Shaft seals and seal systems shall be provided to restrict or prevent process gas leaks to the atmosphere over the range of specified operating conditions, including start-up, shutdown, settle-out, or any other special conditions (air dry-out, etc.). The shaft seals and seal system shall be designed to permit safe machine pressurization with the seal system in operation prior to process start-up.

- **4.10.1.2** The purchaser shall provide the settle-out pressure.

NOTE If a value is not provided, the manufacturer will estimate a value that needs to be checked later against suction relief valve set pressure.

4.10.1.3 The maximum sealing pressure shall be at least equal to the settle-out pressure.

4.10.1.4 Typical cross sections of various types of shaft end seals are given in Annex B.

- **4.10.1.5** Shaft seals may be one or a combination of the types described in 4.10.2 through 4.10.4, as specified. The materials for component parts shall be suitable for the service.

4.10.1.6 Seal pressure equalizing lines and associated gas passages (including those for reference gas and axial thrust force balancing) shall be sized to maintain design shaft end seal performance at twice the maximum initial design clearances. The lines and passages shall also be sized to maintain minimal pressure drop through equalizing lines at all conditions.

4.10.1.7 Any reference pressure measurements for pressure control systems shall be drilled directly into the upper half of the cavity and should be taken from ports used only for that pressure measurement to eliminate exit and entrance losses. These ports should not be used for venting or supplying gas to the cavity.

NOTE This may not be practical on some smaller machines.

● **4.10.1.8** The purchaser shall specify composition and conditions (pressure, temperature) of buffer, seal, and separation gas.

4.10.1.9 The method of control (flow control or pressure control) and system configuration shall be mutually determined.

4.10.1.10 When buffer gas or seal gas is specified by the purchaser or required by the supplier, the supplier shall state the gas requirements, including pressures, flow rates, and filtration.

NOTE See API 614, Fifth Edition, Part 4, Annex D for definitions of buffer and seal gas.

4.10.1.11 Unless otherwise specified, the supplier shall furnish the complete seal control system including schematic and bill of material. Seal systems shall be in accordance with API 614, Fifth Edition, as applicable.

4.10.1.12 Unless otherwise specified, interconnecting piping (if required) shall be by purchaser.

4.10.1.13 Equipment supplier shall be responsible for the satisfactory function of the seal system and shall coordinate with the seal manufacturer and purchaser.

4.10.1.14 For compressors with subatmospheric pressure at the shaft end seals, provision shall be made to pressurize the seal(s) with gas at a pressure that is higher than atmospheric.

4.10.2 Clearance Seals

4.10.2.1 The labyrinth seal (see Figure B.1 in Annex B) may include carbon rings, in addition to the labyrinths, if approved by the purchaser. Labyrinths may be stationary or rotating.

4.10.2.2 The restrictive-ring seal (a typical seal is shown in Figure B.3) shall include rings of carbon or other suitable material mounted in retainers or in spacers. The seal may be operated dry, or with a sealing liquid, or with a buffer gas.

4.10.2.3 Eductors or injection systems shall be furnished complete with piping, regulating and control valves, pressure gauges, and strainers. Each item shall be piped and valved to permit its removal during operation of the compressor. Where gas from the compressor discharge is used for the motivating power of the eductor, provisions shall be made for sealing during start-up and shutdown. Instrumentation and controls shall be provided to ensure proper eductor performance under all potential motive fluid and compressor discharge pressure conditions.

NOTE Eductor performance can be sensitive to the motive and discharge pressure of the eductor.

4.10.3 Oil Seals

4.10.3.1 Shaft end oil seal(s) shall be provided with provision(s) to inject conditioned buffer gas between the seal and the process gas.

4.10.3.2 The leakage from each seal that contacts the process gas shall be piped to an independent drain pot.

4.10.3.3 Seal oil contaminated by the process gas that would damage components such as bearings, seal rings, O-rings, and couplings shall be piped away separately to allow disposal or reconditioning.

- **4.10.3.4** If specified, and when separate lube and seal oil is required, the uncontaminated oil drain shall be separate from the bearing housing oil drain with an internal seal with buffer provision provided to prevent oil cross contamination.

4.10.3.5 Mechanical Contact Seals

4.10.3.5.1 The mechanical contact seal (a typical seal is shown in Figure B.2) shall be provided with labyrinths and slingers.

4.10.3.5.2 Oil or other suitable liquid furnished under pressure to the rotating seal faces may be supplied from the lube-oil system or from an independent seal system. Mechanical seals shall be designed to minimize gas leaks while the compressor is pressurized and being shut down and after it is stopped in the event of seal-oil failure.

4.10.3.5.3 Unless otherwise specified, the seal shall be provided with a device to provide sealing while shutdown and when oil pressure is not applied.

4.10.3.6 Liquid Film Seal

4.10.3.6.1 The liquid-film seal (typical seals are shown in Figure B.4 and Figure B.5) shall be provided with sealing rings or bushings and labyrinths. Liquid-film seals may be cylindrical-bushing seal as shown in Figure B.4, or pumping seals as shown in Figure B.5.

4.10.3.6.2 Unless otherwise specified, an elevated tank shall be provided with the required static head to overcome system pressure losses (such as friction losses in internal passages and seal-oil piping) to maintain positive sealing pressure. The supplier shall state the height of the tank reference mark above the compressor centerline. Other means to maintain this differential pressure and positive seal may be used with the purchaser's approval.

4.10.4 Self-acting Dry Gas Seal

NOTE 1 Refer to API 614, Fifth Edition, Part 4, Annex D for dry gas seal nomenclature.

NOTE 2 See API 614, Fifth Edition, Part 4, Annex A for dry gas seal support system datasheets

4.10.4.1 The self-acting dry gas seal may be a single, tandem, tandem with intermediate labyrinth, or double configuration depending on the application. The self-acting dry gas seal requires external seal gas. Typical configurations are shown in Figure B.6, Figure B.7, Figure B.8, and Figure B.9. The seal gas shall be dry, filtered, and free of any contaminants that form residues. The seal gas source shall be taken from the compressor discharge or with purchaser's approval, an interstage point. An alternate seal gas source may be used and may be required during start-up or shutdown. The design of the gas seal support system is detailed in API 614, Fifth Edition, Part 4.

NOTE Caution is to be exercised when air is used as a separation or buffer gas. This is to ensure that explosive mixtures are not created when air is mixed with the seal outer leakage consisting of process gas.

4.10.4.2 Seal support systems for self-acting dry gas seals shall be in accordance with API 614, Fifth Edition, Part 4.

4.10.4.3 Each dry gas seal assembly, regardless of its arrangement, shall be cartridge mounted and positively located and attached to the compressor shaft. For unidirectional seals, cartridges shall be designed to prevent incorrect installation. The method and tolerances for locking the dry gas seal sleeve

to the rotor shall be mutually determined between the seal and compressor manufactures. The seal mounting method shall be defined in the proposal.

4.10.4.4 Seal vents and drains shall conform to the following.

a) Seal cavities shall be designed to keep liquid from the dry gas seals. Drains shall be located in the bottom of all seal cavities to fully drain the cavity.

b) The compressor supplier shall define the sizing criteria (pressure drop and maximum flow) for primary and secondary vents.

c) Drain sizing shall be such to prevent blockage of the line.

NOTE There can be insufficient space for small compressors to have dedicated drain lines.

4.10.4.5 The supplier shall provide the following speed limits to prevent damage to the dry gas seals:

a) lift-off speed for slow roll and coastdown operation,

b) acceptable speed range for turning gear,

c) maximum operating speed (for possible overspeed conditions),

d) minimum speed for continuous operation.

4.10.4.6 Seal gas supply shall be checked under all operating/static cases and lowest ambient combinations to ensure adequate superheat.

4.10.4.7 Seal cartridge shall be equipped with anti-rotation and drive devices that shall be visible or installed after seal installation. Blind pins or blind keys shall not be used. Pins or keys shall be replaceable without compressor disassembly other than seal cartridge removal.

4.11 Integral Gearing

For units with integral gears, see Part 3.

NOTE For separate gear units, see 5.1.7.

4.12 Nameplates and Rotation Arrows

Information regarding nameplates and rotational arrows may be found in Parts 2, 3, and 4 as applicable.

4.12.1 A nameplate shall be securely attached at a readily visible location on the equipment and on any major piece of auxiliary equipment.

4.12.2 Nameplates and rotation arrows (if attached) shall be of austenitic stainless steel or nickel-copper (UNS N04400) alloy. Attachment pins shall be of the same material. Welding to attach the nameplate to the casing is not permitted.

4.12.3 Where speed requires adjustment as a result of performance testing, the nameplate shall reflect these values.

NOTE Rated power on the nameplate can be the calculated value provided it is within allowable tolerances.

● **4.12.4** SI or USC units shall be specified for use on the nameplate.

4.12.5 Lateral critical speeds exhibited during the running tests shall be stamped on the nameplate followed by the word “test.” Lateral critical speeds predicted by calculation up to and including the critical speed above trip speed and not identifiable by test shall be stamped on the nameplate followed by the abbreviation “calc.”

5 Accessories

5.1 Drivers and Gearing

5.1.1 The driver shall be of the type specified, sized to meet the maximum specified operating conditions, including external gear or coupling losses, and shall be in accordance with applicable specifications. The driver(s) shall operate under the utility and site conditions specified.

5.1.2 The driver shall be sized to accept any specified process variations such as changes in the pressure, temperature, or properties of the fluids handled and plant start-up conditions.

5.1.3 The driver shall be capable of starting under the process and utility conditions specified. The starting method and worst case starting torque requirements shall be agreed. The driver’s starting-torque capabilities shall exceed the speed-torque requirements of the machine train.

5.1.4 Steam turbine drivers shall conform to API 612. Steam turbine drivers shall be sized to deliver continuously not less than 110 % of the maximum power required by the machine train, when operating at any of the specified operating conditions, and specified normal steam conditions.

NOTE The 110 % applies to the design phase of the project. After testing, this margin may not be available due to performance tolerances of the driven equipment.

5.1.5 Motor drives shall conform to internationally recognized standards such as API 541 or API 546, as applicable. (Motors that are below the power scope of API 541 or API 546 shall be in accordance with IEEE 841.) Electric motor drivers shall be rated with a 1.0 S.F. The motor power shall be at least 110 % of the greatest power required (including gear and coupling losses) for any of the specified operating conditions. Consideration shall be given to the starting conditions of both the driver and driven equipment and the possibility that these conditions may be different from the normal operating conditions.

NOTE 1 The 110 % applies to the design phase of a project. After testing, this margin might not be available due to performance tolerances of the driven equipment.

NOTE 2 Refer to Part 2: 6.3.3.1.5 and Part 3: 6.3.3.1.3 for allowable tolerances for fixed speed applications. The purchaser can specify additional motor power or removal of excess head.

5.1.6 Gas turbine drivers shall conform to API 616 and shall be sized as agreed taking account of site conditions, particularly variations in ambient air temperature.

5.1.7 Separate gear units shall conform to API 613.

NOTE For integral gears in compressors, see Part 3.

5.2 Couplings and Guards

5.2.1 Nonlubricated flexible couplings and guards between drivers and driven equipment shall be supplied by the manufacturer of the driven equipment.

5.2.2 Couplings, coupling to shaft junctures, and coupling guards shall conform to API 671. The make, type, and mounting arrangement of the coupling shall be agreed by the purchaser and the supplier with unit responsibility of the driver and driven equipment.

NOTE See API 614 for coupling requirements for auxiliary equipment.

5.2.3 The supplier shall coordinate the mounting of hubs.

NOTE Hubs can be mounted by equipment suppliers or by others in the field if required.

5.2.4 The purchaser of the coupling shall provide or include a moment simulator, as required for the mechanical running test.

5.2.5 If specified, the supplier shall provide ring and plug gauges in accordance with API 671:2010. The purchaser shall specify whether lapping tools are also required.

NOTE Refer to API 687 for procedures to repair shaft end tapers using lapping tools.

5.2.6 When hydraulically fitted couplings are provided, the supplier shall provide all necessary mounting tools to hydraulically remove and install each coupling. A common mounting fixture used for all couplings is preferred.

5.3 Lubrication and Sealing Systems

5.3.1 If required, a pressurized oil system or systems shall be furnished to supply oil at a suitable pressure or pressures, as applicable, to the following:

a) the bearings of the driver and of the driven equipment (including any gear),

b) the continuously lubricated couplings,

c) the governing and control-oil system,

d) the shaft seal-oil system,

e) the purchaser's control system (if hydraulic).

5.3.2 Housings that enclose moving lubricated parts (such as bearings and shaft seals), highly polished parts, instruments, and control elements shall be designed to minimize contamination by moisture, dust, and other foreign matter during periods of operation or idleness.

5.3.3 Unless otherwise specified, pressurized oil systems shall conform to the requirements of API 614, Fifth Edition, Parts 1 and 2.

NOTE Expander-compressors utilize pressurized bearing housings and reservoirs. These details are covered in Part 4.

5.4 Mounting Plates

5.4.1 General

5.4.1.1 The equipment shall be furnished with soleplates or a baseplate, as specified.

5.4.1.2 Mounting plates (baseplates and soleplates) shall comply to the requirements of 5.4.1.2.1 through 5.4.1.2.17.

5.4.1.2.1 Mounting plates shall be furnished with horizontal (axial and lateral) jackscrews. The lugs holding these jackscrews shall be attached to the mounting plates in such a manner that they do not interfere with the installation of the equipment, jackscrews or shims. Means for moving the equipment

vertically for removal or insertion of shims shall be provided. Precautions shall be taken to prevent vertical jackscrews (if provided) in the equipment feet from marring the shimming surfaces. Supports and alignment bolts shall be rigid enough to permit the machine to be moved by the use of lateral and axial jackscrews provided on the mounting plate. Alternative methods of lifting the equipment for the removal or insertion of shims or for moving the equipment horizontally, such as provision for the use of hydraulic jacks, may be proposed. Such arrangements should be proposed for equipment that is too heavy to be lifted or moved horizontally using jackscrews. Alignment jackscrews shall be plated for rust resistance.

5.4.1.2.2 The alignment shims shall be provided by the supplier in accordance with API 686 and shall straddle the hold-down bolts and vertical jackscrews and be at least 6 mm ($^1/_4$ in.) larger on all sides than the equipment feet.

5.4.1.2.3 All machinery mounting surfaces on the mounting plate shall be machined flat and parallel to the axial plane(s) of the machinery mounting feet after fabrication and shall extend at least 25 mm (1 in.) beyond the outer three sides of the equipment feet. These mounting surfaces shall meet the following requirements.

a) Each mounting surface shall be machined to a finish of 6 µm (250 µin.) Ra or better.

b) To prevent a soft foot, when the machine is installed on the mounting plate, all mounting surfaces in the same horizontal plane shall be within 25 µm (0.001 in.).

c) Each mounting surface shall be machined within a flatness of 40 µm per linear m (0.0005 in. per linear ft) of mounting surface.

d) Different mounting planes shall be parallel to each other within 50 µm (0.002 in.).

5.4.1.2.4 Machinery mounting plates and supports shall be designed to have sufficient strength and rigidity to limit coupling movement (caused by imposing allowable forces and moments) to 50 µm (0.002 in.).

NOTE Refer Parts 2, 3, or 4 as applicable for allowable piping loads.

5.4.1.2.5 Unless otherwise specified, anchor bolts shall be furnished by the purchaser.

5.4.1.2.6 Anchor bolts shall not be used to fasten machinery to the mounting plates.

5.4.1.2.7 Grouted mounting plates shall be adequately sized to limit the static loading to 690 Kn/m^2 (100 psi) on the grout.

5.4.1.2.8 Diametrical clearance between anchor bolts and the anchor bolt holes in the mounting plates shall be a minimum of 6 mm ($^1/_4$ in.).

5.4.1.2.9 Unless otherwise specified, mounting plates shall be supplied with vertical leveling screws for field leveling. A leveling screw shall be provided near each anchor bolt. If the equipment and mounting plates are too heavy to be lifted using leveling screws, alternate methods shall be provided by the equipment supplier. The design of the alternate method shall be included in the proposal.

5.4.1.2.10 Mounting plate surfaces that are embedded in grout shall have 50 mm (2 in.) radiused minimum outside corners (in the plan view). The embedded edges shall be chamfered or rounded. See Figure 5.

5.4.1.2.11 Machinery hold-down bolts and fasteners for attaching the equipment to the mounting shall be provided by the equipment supplier.

5.4.1.2.12 Adequate working clearance shall be provided at the hold-down and jack bolt locations to allow the use of standard socket or box wrenches to achieve the specified torque.

- **5.4.1.2.13** The purchaser shall specify the manufacturer and specific type of epoxy grout used for field installation.

NOTE Specific types of epoxy grouts have different recommended primers.

5.4.1.2.14 Unless otherwise specified, the equipment supplier shall prepare the mounting plates by commercially abrasive blasting all grout contacting surfaces in accordance with SSPC SP 6 (ISO 8501, Grade Sa2) and shall precoat these surfaces with a primer compatible with the specified epoxy grout.

NOTE Epoxy primers have a limited life after application.

5.4.1.2.15 The equipment supplier shall provide details of the actual epoxy primer used.

5.4.1.2.16 All mounting surfaces that are not grouted shall be coated with a rust preventive immediately after machining.

5.4.1.2.17 Unless otherwise specified, mounting plates shall not be drilled for components mounted by others.

5.4.2 Baseplates

- **5.4.2.1** When a baseplate is specified, the purchaser shall indicate the major equipment mounted on it. A baseplate shall be a single fabricated steel unit, unless the purchaser and the supplier agree that it may be fabricated in multiple sections. Unless otherwise specified, multiple-section baseplates shall have machined and doweled mating surfaces that shall be bolted together to ensure accurate field reassembly.

NOTE A baseplate with a nominal length of more than 12 m (40 ft) or a nominal width of more than 4 m (12 ft) can require fabrication in multiple sections because of shipping restrictions.

- **5.4.2.1.1** If specified, baseplates shall be equipped with a drip rim (see Figure 6). One minimum drain connection of at least 40 mm (NPS 1 $^{1}/_{2}$ in.) size shall be supplied to ensure proper drainage of possible leakage of the baseplate mounted equipment.

5.4.2.2 Unless otherwise specified, the underside mounting surfaces of the baseplate shall be in one plane to permit use of a single-level foundation.

5.4.2.3 All joints including deck plate and structural members shall be continuously seal welded to prevent crevice corrosion. Stitch welding, top or bottom is unacceptable.

- **5.4.2.4** If specified, nonskid decking or grating covering all walk and work areas shall be provided on the top of the baseplate. When grating is provided, it shall be removable.

NOTE If, after grouting, the purchaser plans to completely fill the baseplate with cement as a finished surface, decking or grating is not required.

- **5.4.2.4.1** If specified, horizontal solid decked surfaces shall be sloped to avoid collection of liquid.

- **5.4.2.5** If specified, the baseplate shall be designed for mounting on structural columns and shall be sufficiently rigid without continuous grouting. The purchaser and the supplier shall agree on the baseplate design.

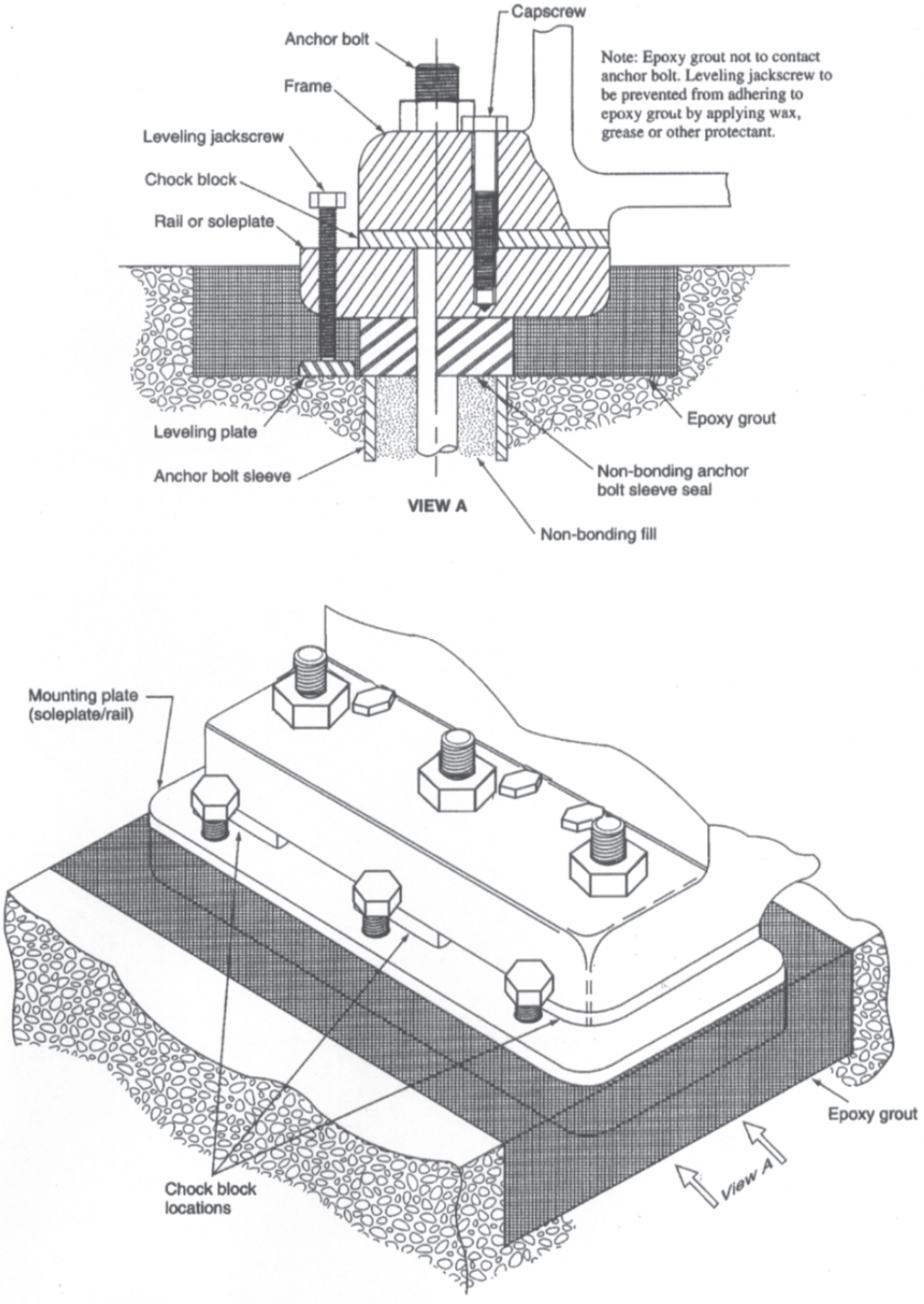
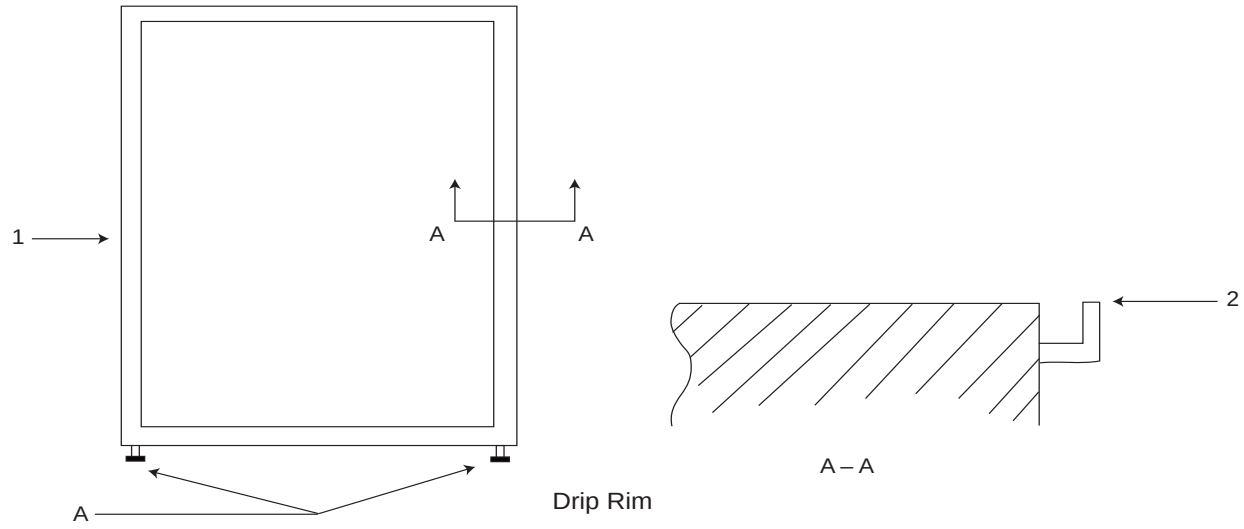


Figure 5—Typical Mounting Plate Arrangement



Key

A drains

NOTE 1 Slope to drain.
NOTE 2 Level with baseplate to avoid tripping hazard.

Figure 6—Drip Rim

5.4.2.6 If specified, the baseplate shall be designed to facilitate the use of optical, laser or other instruments for field leveling during installation. Design details are described in 5.4.2.6.1 through 5.4.2.6.2. The purchaser and the supplier shall agree on the final design.

5.4.2.6.1 When leveling pads or targets are provided, the pads or targets shall be located close to the machinery support points and be accessible for field leveling with the equipment mounted and the baseplate on the foundation. The leveling pads and targets shall have protective removable covers.

5.4.2.6.2 For baseplates longer than 6 m (20 ft), additional pads and targets shall be provided at intermediate points.

5.4.2.7 The baseplate shall be provided with lifting lugs for at least a four-point lift. Lifting lugs attached to the equipment shall be designed using a maximum stress of one third of the minimum yield strength of the material. Welding applied to lifting lugs shall be continuous welds and be in accordance with AWS D1.1, ISO 15614, or other agreed structural welding code. The welds shall be 100 % NDE tested in accordance with the applicable code. Lifting the baseplate complete with all equipment mounted shall not permanently distort or otherwise damage the baseplate or the equipment mounted on it.

5.4.2.8 When the baseplate is intended for grouting onto a concrete foundation, adequate access shall be provided into each compartment so all load carrying structural members can be properly grouted. It shall be provided with at least one grout hole having a clear area of at least 100 cm^2 (16 $in.^2$) and no less than 75 mm (3 in.) in each bulkhead section. These holes shall be located to permit grouting under all load carrying structural members. Where practical, the holes shall be accessible for grouting with the equipment installed. Vent holes at least 13 mm ($^1/_2$ in.) in size shall be provided at the highest point and located to vent the entire cavity of each bulkhead section of the baseplate.

5.4.2.9 Support for the equipment shall be located directly beneath the equipment feet and shall extend in line vertically to the bottom of the baseplate.

- **5.4.2.10** If specified, the bottom of the baseplate shall have machined mounting pads. These pads shall be machined in a single plane after the baseplate is fabricated.

NOTE These machined mounting pads are necessary when the baseplate is mounted on subsoleplates or structural steel members to facilitate field leveling.

- **5.4.2.11** If specified, subsole plates shall be provided by the supplier.

5.4.2.12 Unless otherwise specified, oil reservoirs shall be separate from the baseplate.

5.4.2.13 When the machine is properly aligned on the mounting plate in the shop, each hold-down bolt shall have a minimum clearance of 1.5 mm ($^1/_{16}$ in.) between the bolt and the bolt hole.

NOTE Hold-down bolts need adequate clearance within the bolt holes so the machinery can be moved laterally during final field alignment without becoming bolt bound.

5.4.3 Soleplates and Subsoleplates

- **5.4.3.1** If specified, soleplates shall meet the requirements of 5.4.3.1.1 through 5.4.3.1.5.

5.4.3.1.1 Soleplates shall be steel plates that are thick enough to transmit the expected loads from the equipment feet to the foundation, but in no case shall the plates be less than 40 mm ($1\ ^1/_2$ in.) thick.

5.4.3.1.2 Soleplates shall be large enough to extend beyond the feet of the equipment in all directions and shall be designed such that the anchor bolts are not covered by machine feet.

- **5.4.3.1.3** If specified, subsole plates shall be provided by the supplier.

5.4.3.1.4 When subsole plates are used, soleplates shall be fully machined top and bottom.

5.4.3.1.5 When subsole plates are specified, they shall be steel plates at least 25 mm (1 in.) thick. The finish of the subsole plates' mating surfaces shall match that of the soleplates.

5.5 Controls and Instrumentation

5.5.1 General

5.5.1.1 The supplier shall provide sufficient machine performance data (in accordance with Section 7) to enable the purchaser to properly design a control system for start-up, for all specified operating conditions, and for surge prevention.

- **5.5.1.2** If specified, the supplier shall review the purchaser's overall machine control system for compatibility. The scope of this review shall be agreed.

5.5.1.3 The supplier shall supply information relevant to the purchased equipment as needed by the purchaser to design a control system.

- **5.5.1.4** The purchaser shall specify that controls and instruments are designed for outdoor or indoor installation.

- **5.5.1.5** The purchaser shall specify required construction and installation standards for controls (see 5.5.1.6).

5.5.1.6 Controls that are installed outside shall have a minimum ingress protection level of IP 65 as detailed in IEC 60529 or a NEMA 4 minimum rating per NEMA Standard Publication 250. When IP 65 protection level is specified, the controls and instrumentation, equipment and wiring shall comply with the construction requirements of IEC 60079.

- **5.5.1.7** Terminal boxes shall have a minimum ingress protection level of IP 66 as detailed in IEC 60529 or a NEMA 4X minimum rating per NEMA Standard Publication 250, as specified.

5.5.1.8 All conduit, armored cable, and supports shall be designed and installed so that they can be easily removed without damage and shall be located so that they do not hamper removal of bearings, seals, or equipment internals.

5.5.2 Control Systems

- **5.5.2.1** The purchaser shall specify the method of control, the source of the control signal, its sensitivity and range, and the equipment furnished by the supplier.

NOTE Compressor control can be accomplished by suction throttling, variable inlet guide vanes, variable stator vanes, speed variation, a cooled bypass from discharge to suction, discharge blowoff, or discharge throttling.

- **5.5.2.2** If specified, an anti-surge system shall be provided. The scope of supply shall be agreed.

NOTE 1 See Annex G.

NOTE 2 Anti-surge systems are generally required to prevent operating in unstable regions that can cause damage to the compressor. The scope of supply for these systems is process dependent.

- **5.5.2.3** If specified, the supplier shall supply the anti-surge valve. The supplier shall identify the following information associated with the valve sizing.

a) The supplier shall identify the conditions upstream and downstream of the anti-surge valve.

b) The supplier shall identify the percent open valve position used during the sizing.

c) The supplier shall identify the time required to stroke the valve from full closed to full open.

The pressure drop between the valve and the compressor inlet and the valve and the compressor discharge shall be defined by the purchaser at maximum design recycle volume to properly size the valve.

- **5.5.2.4** If specified, the supplier shall supply the results of an anti-surge system transient response simulation.

The purchaser should supply information on the process components such as piping, coolers, vessels, etc., their volumes, and associated pressure drops to develop a simulation model.

5.5.3 Instrument and Control Panels

Refer to API 614, Fifth Edition for details on instrument and control panels.

5.5.4 Instrumentation

Refer to API 614, Fifth Edition for details on instrumentation, and API 670 for details on instrumentation and installation.

5.5.5 Alarms, Shutdowns, and Control Systems

Refer to API 614, Fifth Edition and API 670:2010 for details on alarms, shutdowns, and control systems.

5.5.6 Electrical Systems

Refer to API 615, Fifth Edition for details on electrical systems.

5.5.7 Vibration, Position, and Bearing Temperature Detectors

Vibration, position, and bearing temperature detectors shall be covered in 5.5 of Parts 2, 3, and 4 as applicable.

5.6 Piping and Appurtenances

5.6.1 General

5.6.1.1 Auxiliary piping shall be in accordance with API 614, Fifth Edition.

5.6.1.2 Auxiliary systems furnished shall be in accordance with API 614, Fifth Edition, Part 2 (*Special Purpose Oil Systems*) and API 614, Fifth Edition, Part 4 (*Self-acting Gas Seal Support Systems*).

5.6.1.3 Auxiliary systems are defined in API 614, Fifth Edition.

NOTE Casing connections are discussed in 4.6.4.

5.6.1.4 Auxiliary piping to the machine shall have breakout spools to allow for maintenance and for removal of the entire machine.

5.6.1.5 Provision shall be made for bypassing the bearings (and seals if applicable) of all equipment in the train during oil system flushing operations.

NOTE Generally this is accomplished by short spool pieces at the equipment.

5.6.1.6 Provision shall be made for bypassing the dry gas seals to allow blowing of the supply lines prior to operation.

5.6.2 Instrument Piping

Instrument piping, if furnished, shall be in accordance with API 614, Fifth Edition, Part 2.

5.6.3 Process Piping

Process piping, if furnished, shall be in accordance with API 614, Fifth Edition, Part 1.

5.7 Special Tools

5.7.1 When special tools or fixtures are required to disassemble, assemble, or maintain the equipment, they shall be included in the quotation and furnished as part of the initial supply of the equipment. For multiple-unit installations, the requirements for quantities of special tools and fixtures shall be agreed between purchaser and supplier. These special tools shall be used, and their use demonstrated, during shop assembly and post-test disassembly of the equipment.

5.7.2 When special tools are provided, they shall be packaged in a separate, rugged box(es) and shall be marked "special tools for (tag/item number)." Each tool shall be stamped or metal tagged to indicate its intended use.

- **5.7.2.1** If specified, the purchaser shall identify packaging requirements for special tools such as metal boxes, or other specific packaging.

5.7.2.2 Supplier shall supply a complete list of special tools and instructions for proper use.

6 Inspection, Testing, and Preparation for Shipment

6.1 General

6.1.1 After advance notification to the supplier, the purchaser's representative shall have entry to all supplier and subsupplier plants where manufacturing, testing, or inspection of the equipment is in progress.

6.1.2 The supplier shall notify subsuppliers of the purchaser's inspection and testing requirements.

- **6.1.3** The purchaser shall specify the amount of advance notification required for a witnessed or observed inspection or test.

- **6.1.4** The purchaser shall specify the extent of his/her participation in the inspection and testing.

6.1.4.1 When shop inspection and testing have been specified, the purchaser and the supplier shall coordinate manufacturing hold points and inspectors' visits.

6.1.5 Equipment materials and utilities required for the specified inspection and tests shall be provided by the supplier.

- **6.1.6** If specified, the purchaser's representative, the supplier's representative, or both shall indicate compliance in accordance with the Inspector's Checklist (Annex E of Parts 2, 3, or 4 as applicable) by initialing, dating, and submitting the completed form before shipment.

6.1.7 The purchaser's representative shall have access to the supplier's quality control program for review.

6.1.8 Unless otherwise agreed, witnessed mechanical running or performance tests require written confirmation of a successful preliminary test.

NOTE See 6.1.3. Notification need not wait until the successful preliminary test is completed.

6.2 Inspection

6.2.1 General

6.2.1.1 The supplier shall keep the following data available for at least 20 years:

a) necessary certification of materials, such as mill test reports, for pressure-containing parts and rotating elements;

b) test data and results to verify that the requirements of the specification have been met;

c) fully identified records of all heat treatment whether performed in the normal course of manufacture or as part of a repair procedure;

d) results of quality control tests and inspections;

e) details of all repairs;

f) as-built assembly and maintenance clearances;

g) other data specified by the purchaser or required by applicable codes and regulations (see 4.2 and 7.3.1.1);

h) purchase specifications for all major items on bills of materials.

6.2.1.2 Pressure-containing parts shall not be painted until hydrotest of the parts is completed. When a helium leak test after hydrotest is required (see 6.3.7.3), this requirement shall also apply.

6.2.1.3 In addition to the requirements of 4.5.1.4, and the materials specifications, the purchaser shall identify:

a) parts that shall be subject to surface and subsurface examination;

b) the type of examination required, such as magnetic particle, liquid penetrant, radiographic, or ultrasonic examination.

NOTE Material specifications contain mandated and may also contain supplemental inspections.

6.2.1.4 During assembly of the equipment, each component (including integrally cast in passages) and all piping and appurtenances shall be inspected to insure they have been cleaned and are free of foreign materials, corrosion products, and mill scale.

- **6.2.1.5** If specified, the equipment and all piping and appurtenances shall be inspected for cleanliness, before heads are welded onto vessels, openings in vessels or exchangers are closed, or piping is finally assembled.

- **6.2.1.6** If specified, the hardness of parts, welds, and heat-affected zones shall be verified as being within the allowable values by testing. The method, extent, documentation, and witnessing of the testing shall be agreed.

6.2.2 Material Inspection

6.2.2.1 General

6.2.2.1.1 When radiographic, ultrasonic, magnetic particle, or liquid penetrant inspection of welds or materials is required or specified, the recommended practices in 6.2.2.2 through 6.2.2.5 shall apply unless other corresponding procedures and acceptance criteria have been specified.

6.2.2.1.2 Cast iron may be inspected in accordance with 6.2.2.4 and/or 6.2.2.5.

6.2.2.1.3 Welds, cast steel, and wrought material may be inspected in accordance with 6.2.2.2 through 6.2.2.5.

NOTE 1 The material inspection of pressure-containing parts is covered in 4.6.3, and the material inspection of impellers is covered in 4.7.10.7.

NOTE 2 Since the specification for the actual component being inspected depends on metallurgy, component geometry, and method of manufacture, specific procedures and acceptance standards for the application are normally covered by written standards, developed by the manufacturer for the specific application.

6.2.2.1.4 Acceptance standards for 6.2.2.2 through 6.2.2.5 shall be agreed.

NOTE API 687:2001, Chapter 1, Section 3, Table of Generalized NDE Acceptance Criteria can be consulted and used as a guide.

6.2.2.2 Radiographic Inspections

Radiography shall be based upon the procedures of ASTM E94 or appropriate country codes and standards.

6.2.2.3 Ultrasonic Inspection

Ultrasonic inspection shall be based upon the procedures ASTM A609 (castings), ASTM A388 (forgings), or ASTM A578 (plate), or appropriate country codes and standards.

6.2.2.4 Magnetic Particle Inspection

Both wet and dry methods of magnetic particle inspection shall be based upon the procedures of ASTM E709 or appropriate country codes and standards.

6.2.2.5 Liquid Penetrant Inspection

Liquid penetrant inspection shall be based upon the procedures of ASTM E165 or appropriate country codes and standards

6.3 Testing

6.3.1 General

6.3.1.1 Equipment shall be tested in accordance with 6.3.2 through 6.3.6. Other tests that may be specified by the purchaser are described in 6.3.7.

6.3.1.2 Notification requirements are covered in 6.1.3; however, hydro and running test requirements shall not be less than 5 working days before the date the equipment shall be ready for testing. If the testing is rescheduled, the supplier shall contact the purchaser within 5 working days and the new date shall be agreed.

6.3.2 Hydrostatic Test

6.3.2.1 Pressure casings shall be tested hydrostatically with liquid at a minimum of 1.5 times the MAWP. The minimum hydrotest pressure shall not be less than 1.5 bar (20 psi).

6.3.2.2 Tests shall be maintained for a sufficient period of time to permit complete examination of parts under pressure. The hydrostatic test shall be considered satisfactory when neither leaks nor seepage through the casing or casing joint is observed for a minimum of 30 minutes. Large, heavy castings may require a longer testing period as agreed by the purchaser and the supplier. Seepage past internal closures required for testing of segmented cases and operation of a test pump to maintain pressure are acceptable.

6.3.2.3 The chloride content of liquids used to test austenitic stainless steel materials shall not exceed 50 mg/kg (50 parts per million). To prevent deposition of chlorides on austenitic stainless steel as a result of evaporative drying, all residual liquid shall be removed from tested parts at the conclusion of the test.

6.3.3 Overspeed Test

6.3.3.1 Impeller Overspeed Test

Each impeller shall be subjected to an overspeed test at not less than 115 % of MCS for a minimum duration of 1 minute. Impeller dimensions identified by the manufacturer as critical (such as bore, eye seal, and outside diameter) shall be measured before and after each overspeed test. All such measurements and the test speeds shall be recorded and submitted for the purchaser's review following the test. Any permanent deformation of the bore or other critical dimension outside drawing tolerances might be cause for rejection.

NOTE 1 The manufacturer can consider additional margin in the event that speed needs to be increased as a result of a performance test.

NOTE 2 Axial blading requirements are covered in Part 2.

6.3.4 Dry Gas Seals

Dry gas seals shall be tested at seal supplier's shop per the requirements of Annex F.

6.3.5 Mechanical Running Test

For additional specifics regarding mechanical running tests, see Parts 2, 3, or 4 as applicable.

6.3.5.1 All contract proximity probe and accelerometers shall be used during the test and their measurements shall be the basis for acceptance. Matched sets consisting of oscillator-demodulators and cables shall be either the contract equipment or shop equipment.

6.3.5.2 Shop test facilities shall include the capability of continuously monitoring, displaying, recording, and printing vibration displacement and phase, vibration spectra, Bode plots, and shaft orbits.

- **6.3.5.2.1** If specified, the user may furnish their own vibration equipment to record baseline readings.

6.3.5.2.2 The vibration characteristics determined using the instrumentation specified in 5.5 shall be the basis for acceptance or rejection of the machine (see 4.8.8.8).

6.3.5.3 At least 6 weeks prior to the first scheduled running test, the supplier shall submit to the purchaser detailed procedures for the mechanical running test and all specified running optional tests including acceptance criteria.

6.3.5.4 For units with oil seals, no individual shaft end seal shall have a leakage rate greater than 70 % of the total expected leakage from all shaft seals in a single machine.

6.3.5.5 All joints and connections shall be checked for tightness, and any leaks shall be corrected.

6.3.5.6 All warning, protective, and control devices used during the test shall be checked and adjusted as required.

6.3.5.7 All instrumentation used for the tests shall have valid calibration at the time of the test.

6.3.5.8 Entrance of oil into the machine(s) during the mechanical running test is prohibited.

NOTE Typically buffer gas or other facilities are provided to accomplish this.

6.3.5.9 During the mechanical running test, the requirements of 6.3.5.9.1 through 6.3.5.9.6 shall be met.

6.3.5.9.1 During the mechanical running test, the mechanical operation of all equipment being tested and the operation of the test instrumentation shall be satisfactory.

6.3.5.9.2 The measured unfiltered vibration shall not exceed the limits of 4.8.8.8 and shall be recorded throughout the operating speed range.

6.3.5.9.3 Synchronous vibration amplitude and phase angle versus speed during deceleration shall be plotted before and after the 4-hour run. Both the synchronous (one per revolution) and overall vibration levels shall be plotted. The speed range covered by these plots shall be from trip speed to 400 rpm.

- **6.3.5.9.3.1** If specified, these data shall also be furnished in polar form. The speed range covered by these plots shall be from trip speed to 400 rpm.

- **6.3.5.9.4** If specified, all real-time vibration data as agreed by the purchaser and supplier shall be recorded and a copy provided to the purchaser.

6.3.5.9.5 The following seal flow data shall be taken during the compressor mechanical running test.

a) For compressors with oil seals, inner oil leakage shall be measured at each seal.

b) For single dry gas seals, flow in the vent line from each seal shall be measured.

c) For tandem dry gas seals, flow in the primary and secondary vent line from each seal shall be measured.

d) For double dry gas seals, the total flow to each seal shall be measured.

NOTE 1 Dry gas seal performance at contract conditions is normally demonstrated in separate tests by the seal manufacturer (see Annex F for the requirements).

NOTE 2 Flow in the vents of single or tandem seals can include buffer or separation gas, in addition to seal leakage.

- **6.3.5.9.6** If specified, lube-oil and seal-oil inlet pressures and temperatures shall be varied through the range specified in the compressor operating manual. This shall be done during the 4-hour test. This option, when specified, does not constitute a waiver of the other specified test requirements.

6.3.5.9.7 When the lube oil specified on the datasheet is not available, the test may be conducted using shop lube oil conditioned to a viscosity equivalent to that of the specified oil at site operating conditions.

6.3.5.10 Unless otherwise specified, the requirements of 6.3.5.10.1 through 6.3.5.10.4 shall be met after the mechanical running test is completed.

6.3.5.10.1 All hydrodynamic bearings shall be removed, inspected, and reassembled after the mechanical running test is completed.

6.3.5.10.2 If replacement or modification of bearings or seals or dismantling of the case to replace or modify other parts is required to correct mechanical or performance deficiencies, the initial test shall not be acceptable, and the final shop tests shall be run after these replacements or corrections are made. A mechanical retest is not required when the compressor case is required to be dismantled to comply with the requirements of 6.3.5.10.1.

6.3.5.10.3 If minor scuffs and scratches occur on bearings, cosmetic repairs of these parts is not a cause for rerunning the test.

6.3.5.10.4 For liquid film seals, minor scratches due to dirt particles that do not dimensionally change nor affect functionality of the part are not a cause for rerunning the test.

- **6.3.5.11** If specified, shaft end seals shall be removed for inspection following a successful running test.

NOTE Inspection of cartridge seals can require that the seal be returned to the seal manufacturer's facility.

6.3.6 Assembled Machine Gas Leakage Test

For assembled gas leak testing, refer to Parts 2, 3, or 4 as applicable.

6.3.7 Optional Tests

Additional optional tests are covered in Parts 2, 3, or 4 as applicable.

- **6.3.7.1 Performance Test**

Performance testing requirements for specific equipment types are covered in Parts 2, 3, or 4 as applicable.

- **6.3.7.2 Field Performance Testing**

6.3.7.2.1 The purchaser shall advise the supplier of any plans to verify compressor performance by site testing of the installed compressor train. The testing shall be conducted with the compressor in as new condition and gas conditions conforming to specified as nearly as practical. Testing shall be in accordance with an agreed performance test code.

NOTE 1 As a guide, on-site testing can be conducted in accordance with ASME PTC-10 1997 or ISO 5389.

NOTE 2 There is no expander-compressor test code. Field performance testing of expander-compressors will be as agreed.

6.3.7.2.2 Testing tolerances shall be jointly determined and applied to test results.

- **6.3.7.3 Gas Test After Hydro**

The compressor casing shall be tested for gas leakage with helium at the MAWP. The test shall be conducted with the casing submerged in water. The MAWP shall be maintained for a minimum of 30 minutes, with no bubbles permitted. As an alternative, a nonsubmerged soap-bubble test may be performed if approved by the purchaser. This test is done immediately after hydrotest.

- **6.3.7.4 Sound-level Test**

The sound-level test shall be performed in accordance with purchaser requirements.

NOTE This test cannot reflect field sound levels due to shop test environment.

- **6.3.7.5 Auxiliary-equipment Test**

Auxiliary equipment such as oil systems and control systems shall be tested in the supplier's shop. Details of the auxiliary-equipment tests shall be developed jointly by the purchaser and the supplier.

6.3.7.6 Post-test Inspection of Compressor Internals

The compressor shall be dismantled, inspected, and reassembled after satisfactory completion of the mechanical running test. The gas test shall be performed after the post-test inspection.

NOTE The merits of post-test inspection of compressor internals can be evaluated against the benefits of shipping a unit with proven mechanical assembly.

6.3.7.7 Full-pressure/Full-load/Full-speed Test

The details of the full-pressure/full-load/full-speed test shall be developed jointly by the purchaser and the supplier. This test may be substituted for the mechanical running test. Typical compressor load tests are discussed in Annex I.

6.3.7.8 Post-test Inspection of the Hydraulic Coupling Fit

After the running tests, hydraulically mounted couplings shall be inspected by comparing hub/shaft match marks to ensure that the coupling hub has not moved on the shaft during the tests.

6.3.7.9 Spare-parts Test

Spare parts such as rotors, gears, diaphragms, bearings, and seals shall be tested as specified.

6.4 Preparation for Shipment

6.4.1 Equipment shall be prepared for the type of shipment specified, including blocking of the rotor when necessary. Blocked rotors shall be identified by means of corrosion-resistant tags attached with stainless steel wire. The preparation shall make the equipment suitable for 6 months of outdoor storage from the time of shipment, with no disassembly required before operation, except for inspection of bearings and seals. If storage for a longer period is contemplated, the purchaser shall consult with the supplier regarding the recommended procedures for the equipment.

6.4.2 The supplier shall provide the purchaser with the instructions necessary to preserve the integrity of the storage preparation after the equipment arrives at the job site and before start-up.

NOTE API 686, Second Edition, Chapter 3 defines the minimum requirements for protecting project machinery and related components from deterioration while in field storage, after installation, and during the period prior to commissioning.

6.4.3 The equipment shall be prepared for shipment after all testing and inspection have been completed and the equipment has been released by the purchaser. The preparation shall include that specified in 6.4.3.1 through 6.4.3.14 (see Annex B of Parts 2, 3, and 4).

6.4.3.1 Except for machined surfaces, all exterior surfaces that may corrode during shipment, storage or in service shall be given at least one coat of the manufacturer's standard paint. The paint shall not contain lead or chromates.

NOTE Austenitic stainless steels are typically not painted.

6.4.3.2 Exterior machined surfaces except for corrosion-resistant material shall be coated with a rust preventive.

6.4.3.3 The interior of the equipment shall be clean and free from scale, welding spatter, and foreign objects. The selection and application of preservatives or rust preventives shall be agreed.

6.4.3.4 Internal surfaces of bearing housings and carbon steel oil systems' components shall be coated with an oil-soluble rust preventive that is compatible with the lubricating oil.

6.4.3.5 Flanged openings shall be provided with metal closures at least 5 mm ($^3/_{16}$ in.) thick with elastomer gaskets and at least four full-diameter bolts. For studded openings, all nuts needed for the intended service shall be used to secure closures. Each opening shall be car sealed so that the protective cover cannot be removed without the seal being broken.

6.4.3.6 Threaded openings shall be provided with steel caps or round-head steel plugs. In no case shall nonmetallic (such as plastic) caps or plugs be used.

NOTE These are shipping plugs; permanent plugs are covered in 4.6.4.3.8.5.

6.4.3.7 Openings that have been beveled for welding shall be provided with closures designed to prevent entrance of foreign materials and damage to the bevel.

6.4.3.8 Lifting points and lifting lugs shall be clearly identified on the equipment or equipment package. The recommended lifting arrangement shall be described in the installation manual.

6.4.3.9 The equipment shall be identified with item and serial numbers. Material shipped separately shall be identified with securely affixed, corrosion-resistant metal tags indicating the item and serial number of the equipment for which it is intended. Crated equipment shall be shipped with duplicate packing lists, one inside and one on the outside of the shipping container.

6.4.3.10 A spare rotor, when purchased, shall be prepared for unheated indoor storage for a period of at least 3 years. It shall be treated with a rust preventive and shall be housed in a vapor-barrier envelope with a slow-release volatile-corrosion inhibitor. The rotor shall be crated for domestic or export shipment as specified.

- **6.4.3.10.1** If specified, spare rotors shall be shipped in a container capable of nitrogen pressurization and suitable for long term vertical or horizontal storage. Rotors shall have rust preventative coatings unless otherwise specified.

NOTE 1 Relying on nitrogen for long term storage protection requires that the owner provide PPM to insure that a nitrogen source is constantly available. This may also require outdoor storage due to hazards associated with leaking nitrogen in an enclosed area.

NOTE 2 Some process gases are not compatible with rust preventative coatings.

6.4.3.11 A suitable resilient material 3 mm ($^1/_8$ in.) thick [not tetrafluoroethylene (TFE) or polytetrafluoroethylene (PTFE)] shall be used between the rotor and the cradle at the support areas. The rotor shall not be supported on journals. The probe target areas shall be identified and protected.

NOTE TFE and PTFE are not recommended as cradle support liners since they cold flow and impregnate into the surface.

- **6.4.3.12** If specified, the rotor shall be prepared for vertical storage. It shall be supported from its coupling end with a fixture designed to support a minimum of 1.5 times the rotor's weight without damaging the shaft. Instructions on the use of the fixture shall be included in the installation, operation and maintenance manuals.

- **6.4.3.13** If specified, the fit-up and assembly of machine mounted piping and intercoolers shall be completed in the supplier's shop prior to shipment.

6.4.3.14 Exposed shafts and shaft couplings shall be wrapped with waterproof, moldable waxed cloth or volatile-corrosion inhibitor paper. The seams shall be sealed with oil-proof adhesive tape. The shaft end shall be protected against incidental mechanical damage.

6.4.4 Auxiliary piping connections furnished on the purchased equipment shall be impression stamped or permanently tagged to agree with the supplier's connection table or general arrangement drawing. Service and connection designations shall be indicated.

6.4.5 Connections on auxiliary piping removed for shipment shall be match marked for ease of reassembly.

6.4.6 One copy of the manufacturer's standard installation instructions shall be packed and shipped with the equipment.

6.4.7 Wood used in export shipping shall comply with the requirements of ISPM No. 15, FAO, Rome.

7 Supplier's Data

7.1 General

7.1.1 The information furnished by the supplier is specified in 7.2 and 7.3.

7.1.2 The data shall be identified on transmittal (cover) letters, title pages, and in title blocks, or other prominent position on the drawings, with the following information:

a) the purchaser/owner's corporate name;

b) the job/project number;

c) the equipment item number and service name;

d) the inquiry or purchase order number;

e) any other identification specified in the inquiry or purchase order;

f) the supplier's identifying proposal number, shop order number, serial number, or other reference required to completely identify return correspondence.

7.1.3 A coordination meeting shall be held, preferably at the supplier's plant, within an agreed time after the purchase commitment. The supplier shall prepare and distribute an agenda prior to this meeting, which as a minimum, shall include discussion of the following items:

a) the purchase order, scope of supply, unit responsibility, subsupplier items, and lines of communication;

b) the datasheets;

c) applicable specifications and previously agreed exceptions;

d) schedules for transmittal of data, production, and testing;

e) the quality assurance program and procedures;

f) inspection, expediting, and testing;

g) schematics and bills of material for auxiliary systems;

h) the general arrangement of equipment, piping, and auxiliary systems. Operating and maintenance access areas shall be reviewed. Access for any parts required for maintenance shall be detailed;

i) coupling selections and rating;

j) thrust- and journal-bearing sizing, estimated loading, and specific configurations;

k) seal operation and controls;

l) the rotordynamics analysis and data (lateral, torsional, and transient torsional, as required);

m) machine performance for normal and other specified conditions and other operating conditions, such as start-up, shutdown, and any operating limitations;

n) instrumentation and controls;

o) items for design reviews;

p) other technical items.

- **7.1.4** If specified, in addition to the coordination meeting, a design audit/review meeting shall be held at the supplier's plant sufficiently after the coordination meeting to allow for detailed technical information review. The purchaser shall prepare a list of items required for review and distribute the agenda prior to the meeting.

7.2 Proposals

7.2.1 General

The supplier shall forward the original proposal with the specified number of copies to the addressee specified in the inquiry documents. The proposal shall include, as a minimum, the data specified in 7.2.2 through 7.2.4 and a specific statement that the equipment and all its components are in strict accordance with this standard. If the equipment or any of its components or auxiliaries is not in strict accordance, the supplier shall include a list that details and explains each deviation. The supplier shall provide sufficient detail to enable the purchaser to evaluate any proposed alternative designs. All correspondence shall be clearly identified in accordance with 7.1.2.

7.2.2 Drawings

7.2.2.1 The drawings indicated on the agreed VDDR form (see Annex B in Parts 2, 3, or 4 as applicable for an example) shall be included in the proposal. As a minimum, the following shall be included:

a) a general arrangement or outline drawing for each machine train or skid-mounted package, showing overall dimensions, maintenance clearance dimensions, overall weights, erection weights, and the largest maintenance weight for each item. The direction of rotation and the size and location of major purchaser connections shall also be indicated;

b) cross-sectional drawings, of major equipment, showing the details of the proposed equipment;

c) representative schematics of all auxiliary systems, including lube oil, seal oil, or self-acting dry gas, control, and electrical systems. Bills of material shall be included;

d) sketches that show methods of lifting the assembled machine or machines, packages, and major components and auxiliaries. [This information may be included on the drawings specified in Item a) above.]

7.2.2.2 If typical drawings, schematics, and bills of material are used, major design deviations shall be clearly marked on the drawings. They shall also be marked up to show the expected weight and dimensions to reflect the actual equipment and scope proposed.

7.2.3 Technical Data

The following data shall be included in the proposal:

a) the purchaser's datasheets with complete supplier's information entered thereon and literature to fully describe details of the offering;

b) the predicted noise data (4.4.1.10);

c) the VDDR Form (see Annex B in Parts 2, 3, or 4 as applicable for an example) indicating the schedule according to which the supplier agrees to transmit all the data specified;

d) a schedule for shipment of the equipment, in weeks after receipt of an order;

e) a list of major wearing components, showing any interchangeability with the owner's existing machines;

f) a list of spare parts recommended for start-up and normal maintenance purposes;

g) a list of the special tools furnished for maintenance;

h) a description of any special weather protection and winterization required for start-up, operation, and periods of idleness, under the site conditions specified on the datasheets. This description shall clearly indicate the protection furnished by the purchaser as well as that included in the supplier's scope of supply;

i) a complete tabulation of utility requirements, e.g. steam, water, electricity, air, gas, lube oil (including the quantity and supply pressure of the oil required and the heat load removed by the oil), and the nameplate power rating and operating power requirements of auxiliary drivers. Approximate data shall be clearly indicated as such;

j) a description of any optional or additional tests and inspection procedures for materials as required;

k) a description of how special requirements are addressed, whether specified in the purchaser's inquiry or as mandated in this standard;

l) a list of machines, similar to the proposed machine(s), that have been installed and operating under conditions analogous to those specified in the inquiry;

m) any start-up, shutdown, or operating restrictions required to protect and operate the equipment;

n) list of any components that can be construed as being of alternative design to this standard, hence requiring purchaser's acceptance;

o) a summary of the materials of construction, including hardness for materials exposed to H_2S (see 4.5.1.6) and a detailed description of the impeller (type of construction, materials, and method of attachment to the shaft) or blade;

p) if oil seals are supplied, the maximum seal-gas rates and rated or expected inner seal-oil leakage rates, if applicable, shall be supplied. The inner seal-oil leakage shall be given on the basis of volume per day per machine at design gas or oil differential pressures and normal machine speed;

q) if self-acting dry gas seals are supplied, expected seal gas(s) requirements and vent flows shall be given for all specified operating conditions including start-up, shutdown, and settle-out;

r) if clearance seals are supplied, expected and guarantee buffer injection and eduction flows as applicable shall be supplied for all specified operating conditions including start-up, shutdown, and settle-out;

s) maximum and minimum allowable seal pressures for each compressor;

t) if interstage coolers or aftercoolers are furnished by the supplier, data for the purchaser's heat and material balances shall be supplied;

u) drawings, details, and descriptions of the operations of instrumentation and controls, as well as the makes, materials, and types of auxiliary equipment. The supplier shall also include a complete description of the alarm and shutdown facilities provided;

v) the minimum length of straight pipe required for proper flow characteristics at the inlet and at any side inlet connection;

w) a statement of the manufacturer's capability regarding testing (including performance testing) of the compressor and any other specified items on the train. Details of each optional test specified shall be included.

7.2.4 Curves

Performance curves shall be submitted for each process section of each casing as well as an overall curve for the train. These curves shall encompass the map of operations, with any limitations indicated thereon. All curves shall be marked "PREDICTED."

NOTE A process section is one or more impellers separated by an inlet or extraction connection to process or intercoolers.

7.2.4.1 Curves for variable-speed compressors shall include the following: discharge pressure; power; polytropic head; and polytropic efficiency versus inlet capacity (from predicted surge point to overload) at minimum operating speed and 80 %, 90 %, 100 %, and 105 % speed, indicating the effect of specified inlet pressures, temperatures, and molecular weights. Any specified operating points shall be noted within the envelope of the performance curve predicted.

7.2.4.2 Curves and data for fixed speed compressors shall include the following:

a) discharge pressure; power; polytropic head; and polytropic efficiency versus capacity (from surge point to overload) at normal speed, indicating the effect of specified molecular weights, suction pressures, and temperatures. Alternate operating conditions requiring throttling shall be shown;

b) speed versus torque required for acceleration of the train to operating speed. Moment of inertia (referenced to motor speed) and initial starting conditions assumed shall be recorded on the curve;

c) motor torque versus speed at rated voltage and at 80 % of rated voltage;

d) motor current versus speed at rated voltage and at 80 % of rated voltage;

e) estimated times for acceleration to rated speed for throttled suction and for open suction at 80 % of the nameplate motor voltage unless otherwise specified;

f) curves showing performance of AIGVs at variable vane settings covering the entire allowable map of operation (if supplied).

7.2.5 Optional Tests

The supplier shall furnish an outline of the procedures used for each of the special optional tests that have been specified by the purchaser or proposed by the supplier.

7.3 Contract Data

7.3.1 General

7.3.1.1 Contract data shall be furnished by the supplier in accordance with the agreed VDDR Form (see Annex B in Parts 2, 3, or 4 as applicable for an example).

7.3.1.2 Each drawing shall have a title block in the lower right-hand corner with the date of drawing certification, identification data specified in 7.1.2, revision number, and date and title. Similar information shall be provided on all other documents including subsupplier items.

7.3.1.3 The drawings and data furnished by the supplier shall contain sufficient information so that together with the manuals specified in 7.3.5, the purchaser can properly install, operate, and maintain the equipment covered by the purchase order. All contract drawings and data shall be clearly legible (8 point minimum font size, even if reduced from a larger size drawing), shall cover the scope of the agreed VDDR Form, and shall satisfy the applicable detailed descriptions in Annex D of the applicable chapter.

7.3.1.4 The purchaser shall review the supplier's data within the agreed time frame. This review shall not constitute permission to deviate from any requirements in the order unless specifically agreed in writing. After the data have been reviewed and accepted, the supplier shall furnish supplier certified copies.

7.3.1.5 A complete list of supplier data shall be included with the first issue of major drawings. This list shall contain titles, drawing numbers, and a schedule for transmittal of each item listed. This list shall cross-reference data with respect to the agreed VDDR form (see Annex B in Parts 2, 3, or 4 as applicable for an example).

7.3.2 Curves and Datasheets

7.3.2.1 Curves

7.3.2.1.1 The supplier shall provide complete performance curves to encompass the allowable map of operations, with any limitations indicated. The curves shall comply with the requirements of 7.3.2.1.2 through 7.3.2.1.6.

NOTE The allowable map of operations can include multiple operating speeds, variable stationary components such as stators or guide vanes, or other means to create a complete operating map.

7.3.2.1.2 All curves submitted prior to final performance testing shall be marked "PREDICTED."

7.3.2.1.3 If a performance test is specified, the supplier shall provide test data and curves when the test has been completed. The surge points shall be shown on the performance curves. These curves shall be marked "TESTED."

7.3.2.1.4 For compressors that have a back-to-back impeller arrangement, the supplier shall furnish a curve showing the expected loading on each side of the thrust bearing versus any combination of the differential pressures across the low-pressure and high-pressure sections of the casing.

- **7.3.2.1.5** If specified, the supplier shall supply curves of balance piston line differential pressure versus thrust load.

- **7.3.2.1.6** If specified, the supplier shall supply balance piston leakage based on design clearances and twice design clearances for the rated condition.

7.3.2.2 Datasheets

The supplier shall provide full information to enable completion of the datasheets for the train and auxiliary equipment, first for "as-purchased," and then for "as-built." This should be done by the supplier correcting and filling out the datasheets and submitting copies to the purchaser. Datasheets are available in Annex A in Parts 2, 3, or 4 as applicable.

7.3.3 Progress Reports

- **7.3.3.1** The supplier shall submit progress reports to the purchaser at the intervals specified. Planned and actual dates and the percentage completed shall be indicated for each milestone in the schedule.

- **7.3.3.2** If specified, 1 week prior to the start of assembly the supplier shall issue a "Tail End Schedule" bi-weekly including scheduled and actual completion dates of major activities.

NOTE The schedule can include major assemblies, subassemblies, test setup, testing, paint, packing, and shipment preparation.

7.3.4 Parts Lists and Recommended Spares

7.3.4.1 The supplier shall submit complete parts lists for all equipment and accessories supplied. These lists shall include part names, manufacturers' unique part numbers, and materials of construction (identified by applicable international standards). Each part shall be completely identified and shown on appropriate cross-sectional, assembly-type cutaway or exploded-view isometric drawings. Interchangeable parts shall be identified as such. Parts that have been modified from standard dimensions or finish to satisfy specific performance requirements shall be uniquely identified by part number. Standard purchased items shall be identified by the original manufacturer's name and part number.

7.3.4.2 The supplier shall indicate on each of these complete parts lists all those parts that are recommended as start-up or maintenance spares and the recommended stocking quantities of each. These should include spare parts recommendations of subsuppliers that were not available for inclusion in the supplier's original proposal.

7.3.5 Installation, Operation, Maintenance, and Technical Data Manuals

7.3.5.1 General

7.3.5.1.1 The supplier shall provide sufficient written instructions and all necessary drawings to enable the purchaser to install all of the equipment covered by the purchase order. This information shall be compiled in a manual or manuals with a cover sheet showing the information listed in 7.1.2, a table of contents, and an index sheet for each section, a complete list of the enclosed drawings by title, drawing number, and revision. The manual pages and drawings shall be numbered. The manual or manuals shall be prepared specifically for the equipment covered in the purchase order. "Typical" manuals are unacceptable.

7.3.5.1.2 If specified, a draft manual(s) shall be issued to purchaser 8 weeks prior to mechanical testing for review and comment.

7.3.5.1.3 Refer to the VDDR Form for number of copies. Hard copies as well as electronic copies shall be provided.

7.3.5.2 Installation Manual

All information required for the proper installation of the equipment shall be compiled in a manual. It may be separate from the operation and maintenance instructions. This manual shall contain information on alignment and grouting procedures (normal and maximum utility requirements), centers of mass, rigging procedures, and other installation data. All drawings and data specified in 7.2.2 and 7.2.3 that are pertinent to proper installation shall be included as part of this manual. One extra manual, over and above the specified quantity, shall be included with the first equipment shipment.

NOTE Refer to API 686 and the VDDR for installation requirements.

7.3.5.3 Operating and Maintenance Manual

A manual containing all required operating and maintenance instructions shall be supplied at shipment. In addition to covering operation at all specified process conditions, this manual shall also contain separate sections covering operation under any specified extreme environmental conditions.

7.3.5.4 Technical Data Manual

If specified, the supplier shall provide the purchaser with a technical data manual at shipment.

NOTE: See Annex B in Parts 2, 3, or 4 as applicable for additional information).

Annex A
(normative)

Procedure for the Determination of Residual Unbalance

A.1 General

This annex describes the procedure used to determine residual unbalance in machine rotors. Although some balancing machines may be set up to read out the exact amount of unbalance, the calibration can be in error. The only sure method of determining is to test the rotor with a known amount of unbalance.

A.2 Residual Unbalance

Residual unbalance is the amount of unbalance remaining in a rotor after balancing. Unless otherwise specified, residual unbalance shall be expressed in g-mm (g-in.).

A.3 Maximum Allowable Residual Unbalance

A.3.1 The maximum allowable residual unbalance, per plane, shall be calculated in accordance with 4.8.2.7.

A.3.2 The static weight on each journal shall be determined by physical measurement. (Calculation methods may introduce errors.) It should NOT simply be assumed that rotor weight is equally divided between the two journals. There can be great discrepancies in the journal weight to the point of being very low (even negative on overhung rotors). In the example problem, the left plane has a journal weight of 530.7 kg (1170 lb). The right plane has a journal weight of 571.5 kg (1260 lb).

A.4 Residual Unbalance Check

A.4.1 General

A.4.1.1 When the balancing machine readings indicate that the rotor has been balanced within the specified tolerance, a residual unbalance check shall be performed before the rotor is removed from the balancing machine.

A.4.1.2 To check the residual unbalance, a known trial weight is attached to the rotor sequentially in six equally spaced radial positions (60° apart), each at the same radius [i.e. same moment (g-mm or g-in.)]. The check is run at each balance machine readout plane, and the readings in each plane are tabulated and plotted on the polar graph using the procedure specified in A.4.2.

A.4.2 Procedure

A.4.2.1 Select a trial weight and radius that will be equivalent to between 1 and 2 times the maximum allowable residual unbalance [e.g. if $U_{\max}$ is 488.4 g-mm (19.2 g-in.), the trial weight should cause 488.4 g-mm to 976.8 g-mm (19.2 g-in. to 38.4 g-in.) of unbalance]. This trial weight and radius shall be sufficient so that the resulting plot in A.4.2.5 encompasses the origin of the polar plot.

A.4.2.2 Starting at a convenient reference plane (i.e. last heavy spot), mark off the specified six radial positions (60° increments) around the rotor. Add the trial weight near the last known heavy spot for that plane. Verify that the balance machine is responding and is within the range and graph selected for taking the residual unbalance check.

A.4.2.3 Verify that the balancing machine is responding reasonably (i.e. no faulty sensors or displays). For example, if the trial weight is added to the last known heavy spot, the first meter reading should be at least twice as much as the last reading taken before the trial weight was added. Little or no meter reading generally indicates that the rotor was not balanced to the correct tolerance, the balancing machine was not sensitive enough, or that a balancing machine fault exists (i.e. a faulty pickup). Proceed if this check behaves reasonably.

A.4.2.4 Remove the trial weight and rotate the trial weight to the next trial position (that is, 60°, 120°, 180°, 240°, 300°, and 360° from the initial trial weight position). Repeat the initial position as a check for repeatability on the Residual Unbalance Worksheet. All verification shall be performed using only one sensitivity range on the balance machine.

A.4.2.5 Plot the balancing machine amplitude readout versus angular location of trial weight (NOT balancing machine phase angle) on the Residual Unbalance Worksheet and calculate the amount of residual unbalance (refer to worksheets, Figure A.3 and Figure A.5).

NOTE 1 The maximum reading occurs when the trial weight is placed at the rotor's remaining heavy spot; the minimum reading occurs when the trial weight is placed opposite the rotor's heavy spot (light spot). The plotted readings are expected to form an approximate circle around the origin of the polar chart. The balance machine angular location readout will approximate the location of the trial weight. The maximum deviation (highest reading) is the heavy spot (represents the plane of the residual unbalance). Blank worksheets are Figure A.1 and Figure A.2.

NOTE 2 Figure A.4 and Figure A.6 are provided as sample filled-in worksheets.

A.4.2.6 Repeat the steps described in A.4.2.1 through A.4.2.5 for each balance machine readout plane. If the specified maximum allowable residual unbalance has been exceeded in any balance machine readout plane, the rotor shall be balanced more precisely and checked again. If a balance correction is made in any balance machine readout plane, then the residual unbalance check shall be repeated in all balance machine readout planes.

A.4.2.7 For stack component balanced rotors, a residual unbalance check shall be performed after the addition and balancing of the rotor after the addition of the first rotor component and at the completion of balancing of the entire rotor, as a minimum.

NOTE 1 This ensures that time is not wasted and rotor components are not subjected to unnecessary material removal in attempting to balance a multiple component rotor with a faulty balancing machine.

NOTE 2 For large multistage rotors, the journal reactions can be considerably different from the case of a partially stacked to a completely stacked rotor.

Customer:
Job / Project Number:
OEM Equipment S / N:
Rotor Identification Number:
Repair Purchase Order Number:
Vendor Job Number:
Correction Plane (Left or Right) - use sketch (plane)

Balancing Speed (rpm)
Maximum Rotor Operating Speed (N) (rpm)
Static Journal Weight Closest to This Correction Plane (W) (kg) (lb)
Trial Weight Radius (R) - the radius at which the trial weight will be placed (mm) (in.)

Calculate Maximum Allowable Residual Unbalance (Umax):
Si Units:
Umax = (6350) X (W) / (N) = (6350) X ____ = (g-mm)
Customary Units:
Umax = (113.4) X (W) / (N) = (113.4) X ____ = (g-in.)

Calculate the trial unbalance (TU):
Trial Unbalance (TU) is between (1 X Umax) and (2 X Umax) (1 X) to (2 X) (Selected Multiplier is)
SI Units: to = (g-mm)
Customary units: to = (g-in.)

Calculate the trial weight (TW):
Trial Weight (TW) = Umax / R = g-mm / mm or g-in. / in. = (g)

Conversion Information:
1 kg = 2.2046 lb 1 ounce = 28.345 grams

Obtain the test data and complete the table:

Test Data

Position	Trial Weight	Balancing Mach Readout	
	Angular Location on Rotor (degrees)	Amplitude (grams)	Phase Angle (degrees)
1			
2			
3			
4			
5			
6			
Repeat 1			

Sketch the rotor configuration:

Rotor Sketch

PROCEDURE:

Step 1: Plot the balancing machine amplitude versus trial weight angular location on the polar chart (Figure A.2) such that the largest and smallest values will fit.

Step 2: The points located on the Polar Chart should closely approximate a circle. If it does not, then it is probabloy that the recorded data it is in error and the test should be repeated.

Step 3: Determine the maximum and minimum balancing machine amplitude readings.

Step 4: Using the worksheet (Figure A.2), determine the Y and Z values required for the residual unbalance calculation.

Step 5: Using the worksheet (Figure A.2), calculate the residual unbalance remaining in the rotor.

Step 6: Verify that the determined residual unbalance is equal to or less than the maximum allowable residual unbalance (Umax).

HALF KEYS USED FOR ROTOR BALANCING
(add sketch for clarification if necessary)

Location		Weight	

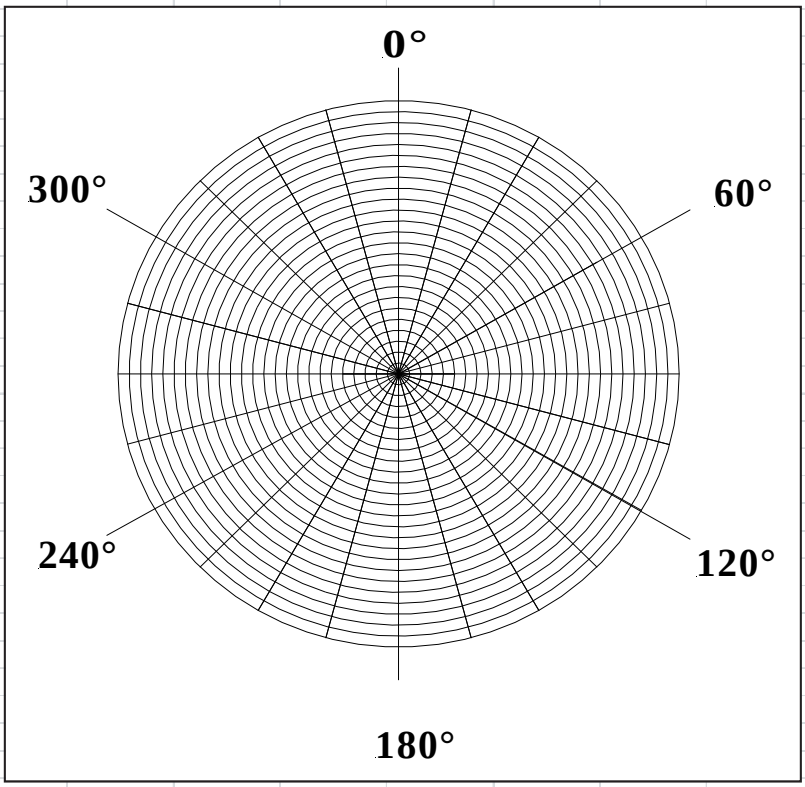
NOTES:
1) The trial weight angular location should be referenced to a keyway or some other permanent marking on the rotor. The preferred location is the location of the once-per-revolution mark (for the phase reference transducer).
2) The balancing machine amplitude readout for the Repeat of 1 should be the same as Position 1, indicating repeatability.
3) A primary source for error is not maintaining the same radius for each trial weight location.

Balanced By: Date:
Approved By: Date:

Figure A.1—(Blank) Residual Unbalance Worksheet

Customer:										
Job / Project Number:										
OEM Equipment S / N:										
Rotor Identification Number:										
Repair Purchase Order Number:										
Vendor Job Number:										
Correction Plane (Left or Right) - use sketch										**(plane)**

RESIDUAL UNBALANCE POLAR PLOT



Rotor Rotation:	☐	**CCW**	**Phase is layed out:**			☐	**CCW**			
	☐	**CW**				☐	**CW**			
Calculate Y and Z values:										
Maximum amplitude value is:			**grams**		**Minimum amplitude value is:**					**grams**
Y = (Maximum - Minimum) / 2 (			**-**		**) / 2**		**=**			
Z = (Maximum + Minimum) / 2 (			**+**		**) / 2**		**=**			
Residual Unbalance										
Left in Rotor =	**(TU)**	**X**	**(Y)**	**/**	**(Z)**					
SI Units:		**X**		**/**			**=**			**gm-mm**
Customary Units:		**X**		**/**			**=**			**gm-in.**
Allowable Unbalance Tolerance = Umax =				**gm-mm**			**gm-in.**			
RESULT:	**Residual unbalance left in the rotor is equal to or less than the allowable unbalance tolerance?**									
			☐	**PASS**	☐	**FAIL**				
☐	**As Received**	☐	**Final**	☐	**Other:**					
Balanced By:			**Date:**							
Approved By:			**Date:**							

Figure A.2—(Blank) Residual Unbalance Polar Plot Worksheet

Customer:						**Aramco**					
Job / Project Number:						**7662**					
OEM Equipment S / N:											
Rotor Identification Number:											
Repair Purchase Order Number:											
Vendor Job Number:											
Correction Plane (Left or Right) - use sketch						**Left**			**(plane)**		
Balancing Speed								**800**	**(rpm)**		
Maximum Rotor Operating Speed (N)								**9902**	**(rpm)**		
Static Journal Weight Closest to This Correction Plane (W)								**530.7**	**(kg)**	**315**	**(lb)**
Trial Weight Radius (R) - the radius at which the trial weight will be placed								**381**	**(mm)**	**7**	**(in.)**
Calculate Maximum Allowable Residual Unbalance (Umax):											
Si Units:											
Umax = (6350) X (W) = (6350) X 530.7 =					**340.3**	**(g-mm)**					
(N) 9902											
Customary Units:											
Umax = (113.4) X (W) = (113.4) X 315 =					**3.6**	**(g-in.)**					
(N) 9902											
Calculate the trial unbalance (TU):											
Trial Unbalance (TU) is between (1 X Umax) and (2 X Umax)					**(1 X)**	**to**	**(2 X)**	**(Selected Multiplier is)**			**1.6**
	SI Units:				**340.3**	**to**	**680.7**	**is**	**544.5**	**(g-mm)**	
	Customary units:				**3.6**	**to**	**7.2**	**is**	**5.8**	**(g-in.)**	
Calculate the trial weight (TW):											
Trial Weight (TW) = Umax = 545 g-mm				**or**	**6**	**g-in.**			**=**	**######**	**(g)**
R 381 mm					**7**	**in.**					

Conversion Information:

1 kg = 2.2046 lb **1 ounce = 28.345 grams**

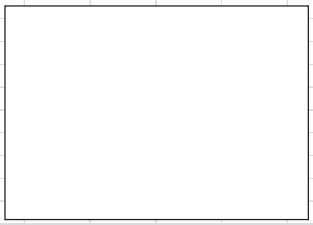
Obtain the test data and complete the table:

Sketch the rotor configuration:

Test Data

Position	Trial Weight Angular Location on Rotor (degrees)	Balancing Mach Readout Amplitude (grams)	Balancing Mach Readout Phase Angle (degrees)
1	0	3.17	354
2	60	3.40	54
3	120	3.48	114
4	180	3.49	177
5	240	3.56	240
6	300	3.23	290
Repeat 1	0	3.40	0

Rotor Sketch



PROCEDURE:

Step 1: Plot the balancing machine amplitude versus trial weight angular location on the polar chart (Figure A.2) such that the largest and smallest values will fit.

Step 2: The points located on the Polar Chart should closely approximate a circle. If it does not, then it is probabloy that the recorded data it is in error and the test should be repeated.

Step 3: Determine the maximum and minimum balancing machine amplitude readings.

Step 4: Using the worksheet (Figure A.2), determine the Y and Z values required for the residual unbalance calculation.

Step 5: Using the worksheet (Figure A.2), calculate the residual unbalance remaining in the rotor.

Step 6: Verify that the determined residual unbalance is equal to or less than the maximum allowable residual unbalance (Umax).

HALF KEYS USED FOR ROTOR BALANCING
(add sketch for clarification if necessary)

Location		Weight	

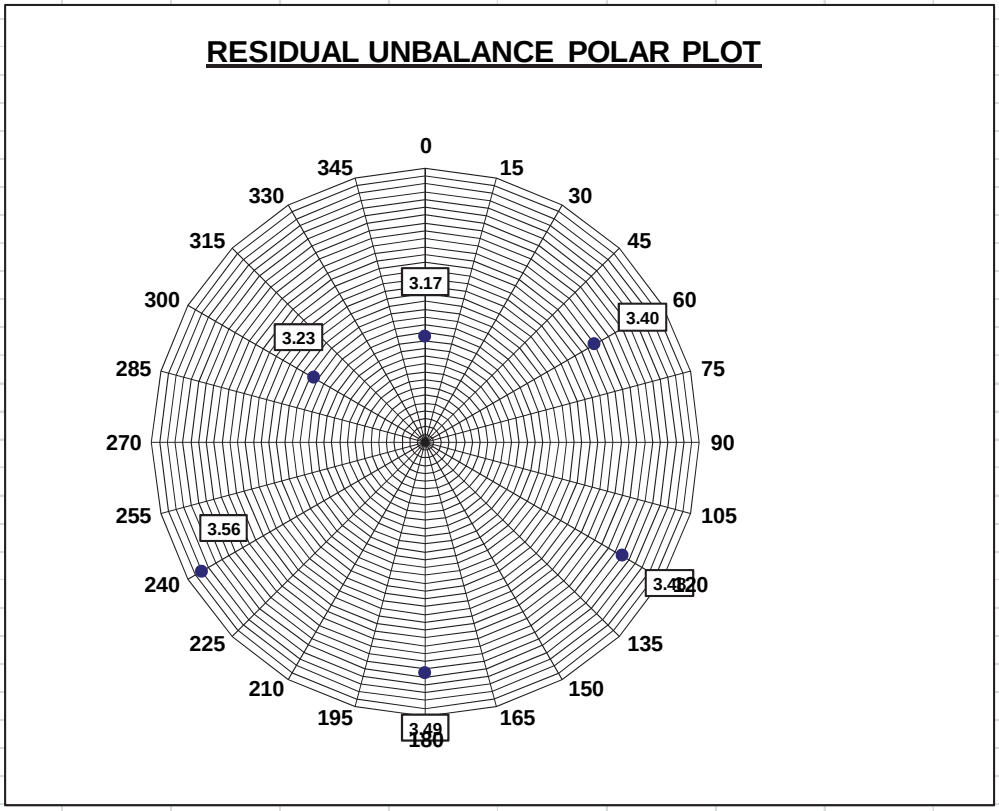
NOTES:

1) The trial weight angular location should be referenced to a keyway or some other permanent marking on the rotor. The preferred location is the location of the once-per-revolution mark (for the phase reference transducer).
2) The balancing machine amplitude readout for the Repeat of 1 should be the same as Position 1, indicating repeatability.
3) A primary source for error is not maintaining the same radius for each trial weight location.

Balanced By:	**CJ, TR, & RC**	**Date:**	**5/24/2000**
Approved By:	**CC**	**Date:**	**5/24/2000**

Figure A.3—Sample Residual Unbalance Worksheet for Left Plane

Customer:	Aramco
Job / Project Number:	7662
OEM Equipment S / N:	
Rotor Identification Number:	
Repair Purchase Order Number:	
Vendor Job Number:	
Correction Plane (Left or Right) - use sketch	Left (plane)



Rotor Rotation:	☑	CCW	Phase is layed out:	☐	CCW				
	☐	CW		☑	CW				
Calculate Y and Z values:									
Maximum amplitude value is:	3.56	grams		Minimum amplitude value is:			3.17	grams	
Y = (Maximum - Minimum) / 2 (	3.56	-	3.17	) / 2	=	0.2			
Z = (Maximum + Minimum) / 2 (	3.56	+	3.17	) / 2	=	3.4			
Residual Unbalance									
Left in Rotor =	(TU)	X	(Y)	/	(Z)				
SI Units:	545	X	0.20	/	3.37	=	31.6	g-mm	
Customary Units:	6	X	0.20	/	3.37	=	0.3	g-in.	
Allowable Unbalance Tolerance = Umax =			340.3	g-mm	3.6	g-in.			
RESULT:	Residual unbalance left in the rotor is equal to or less than the allowable unbalance tolerance?								PASS
☐ As Received		☐	Final	☑	Other: w/o trim hardware				
Balanced By:	CJ, TR & RC		Date:	5/24/2000					
Approved By:	CC		Date:	5/24/2000					

Figure A.4—Sample Residual Unbalance Polar Plot Worksheet for Left Plane

Customer:						**Aramco**					
Job / Project Number:						**7662**					
OEM Equipment S / N:											
Rotor Identification Number:											
Repair Purchase Order Number:											
Vendor Job Number:											
Correction Plane (Left or Right) - use sketch						**Right**			**(plane)**		
Balancing Speed								**800**	**(rpm)**		
Maximum Rotor Operating Speed (N)								**9902**	**(rpm)**		
Static Journal Weight Closest to This Correction Plane (W)								**571.5**	**(kg)**	**315**	**(lb)**
Trial Weight Radius (R) - the radius at which the trial weight will be placed								**203**	**(mm)**	**7**	**(in.)**
Calculate Maximum Allowable Residual Unbalance (Umax):											
Si Units:											
Umax = (6350) X (W) = (6350) X 571.5 =					**366.5**	**(g-mm)**					
(N) 9902											
Customary Units:											
Umax = (113.4) X (W) = (113.4) X 315 =					**3.6**	**(g-in.)**					
(N) 9902											
Calculate the trial unbalance (TU):											
Trial Unbalance (TU) is between (1 X Umax) and (2 X Umax)					**(1 X)**	**to**	**(2 X)**	**(Selected Multiplier is)**			**1.6**
	SI Units:				**366.5**	**to**	**733.0**	**is**	**586.4**	**(g-mm)**	
	Customary units:				**3.6**	**to**	**7.2**	**is**	**5.8**	**(g-in.)**	
Calculate the trial weight (TW):											
Trial Weight (TW) = Umax = R			**586**	**g-mm**	**or**	**6**	**g-in.**		**=**	**0.8**	**(g)**
			203	**mm**		**7**	**in.**				

Conversion Information:

1 kg = 2.2046 lb **1 ounce = 28.345 grams**

Obtain the test data and complete the table:

Test Data

Position	Trial Weight Angular Location on Rotor (degrees)	Balancing Mach Readout Amplitude (grams)	Balancing Mach Readout Phase Angle (degrees)
1	0	3.23	356
2	60	3.14	50
3	120	2.90	115
4	180		
5	240		
6	300		
Repeat 1	0		

Sketch the rotor configuration:

Rotor Sketch

PROCEDURE:

Step 1: Plot the balancing machine amplitude versus trial weight angular location on the polar chart (Figure A.2) such that the largest and smallest values will fit.

Step 2: The points located on the Polar Chart should closely approximate a circle. If it does not, then it is probabloy that the recorded data it is in error and the test should be repeated.

Step 3: Determine the maximum and minimum balancing machine amplitude readings.

Step 4: Using the worksheet (Figure A.2), determine the Y and Z values required for the residual unbalance calculation.

Step 5: Using the worksheet (Figure A.2), calculate the residual unbalance remaining in the rotor.

Step 6: Verify that the determined residual unbalance is equal to or less than the maximum allowable residual unbalance (Umax).

HALF KEYS USED FOR ROTOR BALANCING
(add sketch for clarification if necessary)

Location		Weight	

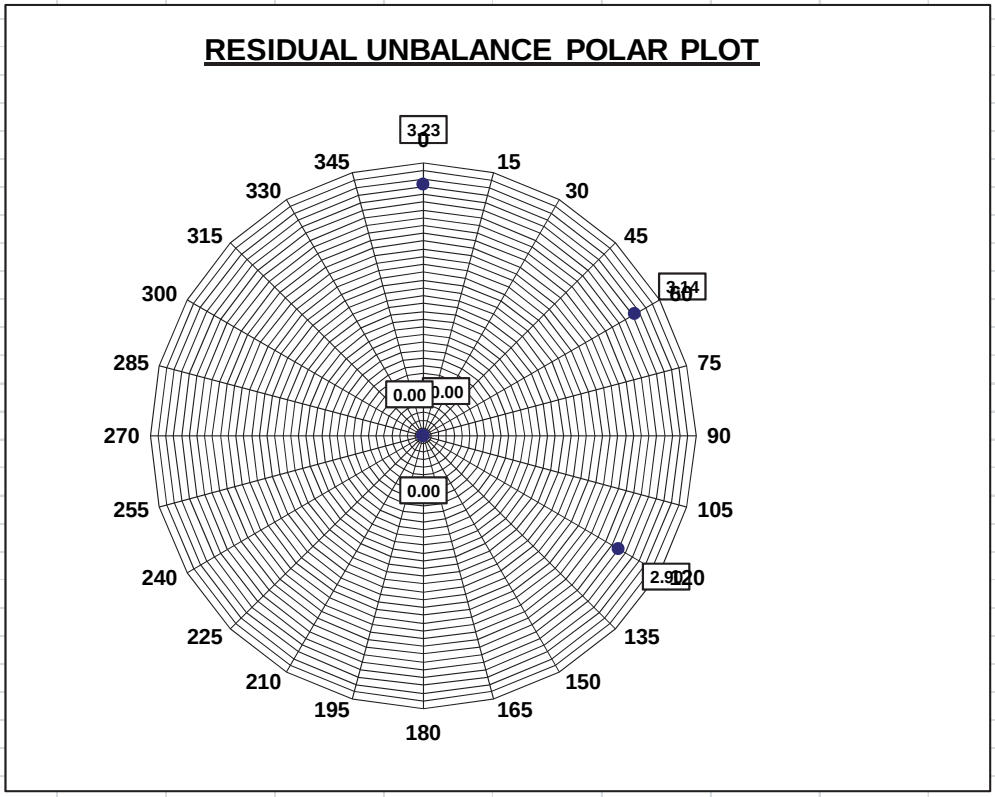
NOTES:

1) The trial weight angular location should be referenced to a keyway or some other permanent marking on the rotor. The preferred location is the location of the once-per-revolution mark (for the phase reference transducer).
2) The balancing machine amplitude readout for the Repeat of 1 should be the same as Position 1, indicating repeatability.
3) A primary source for error is not maintaining the same radius for each trial weight location.

Balanced By:	**CJ, TR, & RC**	**Date:**	**5/24/2000**
Approved By:	**CC**	**Date:**	**5/24/2000**

Figure A.5—Sample Residual Unbalance Worksheet for Right Plane

Customer:	ABC Refining Co.
Job / Project Number:	00 - 1234
OEM Equipment S / N:	C - 1234
Rotor Identification Number:	1234 - C - 4320
Repair Purchase Order Number:	PO 12345678
Vendor Job Number:	Shop - 00 - 1234
Correction Plane (Left or Right) - use sketch	Right (plane)



Rotor Rotation:	☑ CCW		Phase is layed out:	☐ CCW				
	☐ CW			☑ CW				
Calculate Y and Z values:								
Maximum amplitude value is:	3.23	grams		Minimum ampltude value is:			2.90	grams
Y = (Maximum - Minimum) / 2 (	3.23	-	2.90	) / 2	=		0.2	
Z = (Maximum + Minimum) / 2 (	3.23	+	2.90	) / 2	=		3.1	
Residual Unbalance								
Left in Rotor =	(TU)	X	(Y)	/	(Z)			
SI Units:	586	X	0.165	/	3.065	=	31.6	g-mm
Customary Units:	6	X	0.165	/	3.065	=	0.3	g-in.
Allowable Unbalance Tolerance = Umax =			366.5	g-mm	3.6	g-in.		
RESULT:	Residual unbalance left in the rotor is equal to or less than the allowable unbalance tolerance?							PASS
☐ As Received		☐ Final		☑ Other: w/o trim hardware				
Balanced By:	CJ, TR & RC		Date:	5/24/2000				
Approved By:	CC		Date:	5/24/2000				

Figure A.6—Sample Residual Unbalance Polar Plot Worksheet for Right Plane

Annex B
(informative)

Typical Shaft End Seals

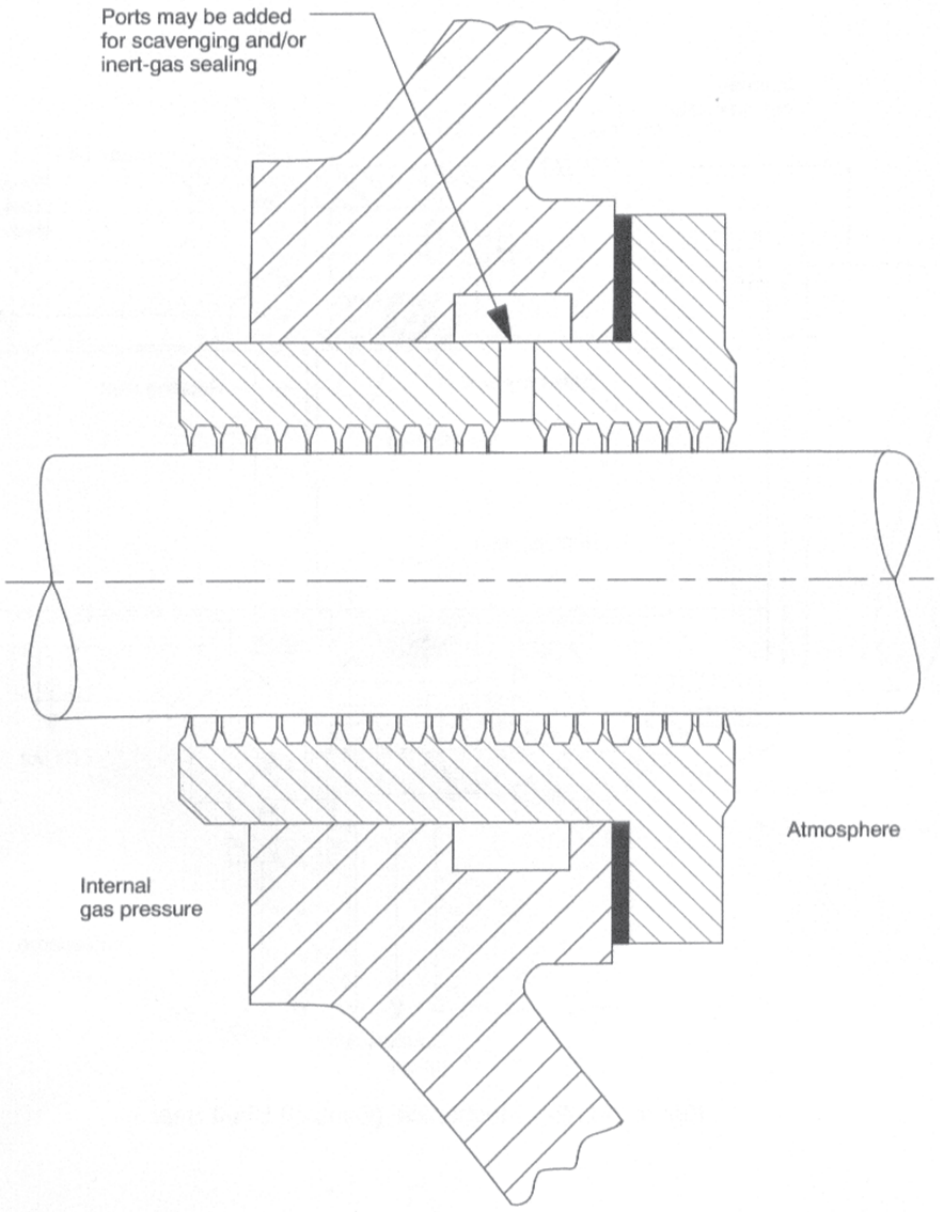


Figure B.1—Labyrinth Seal (Shown with Single Port)

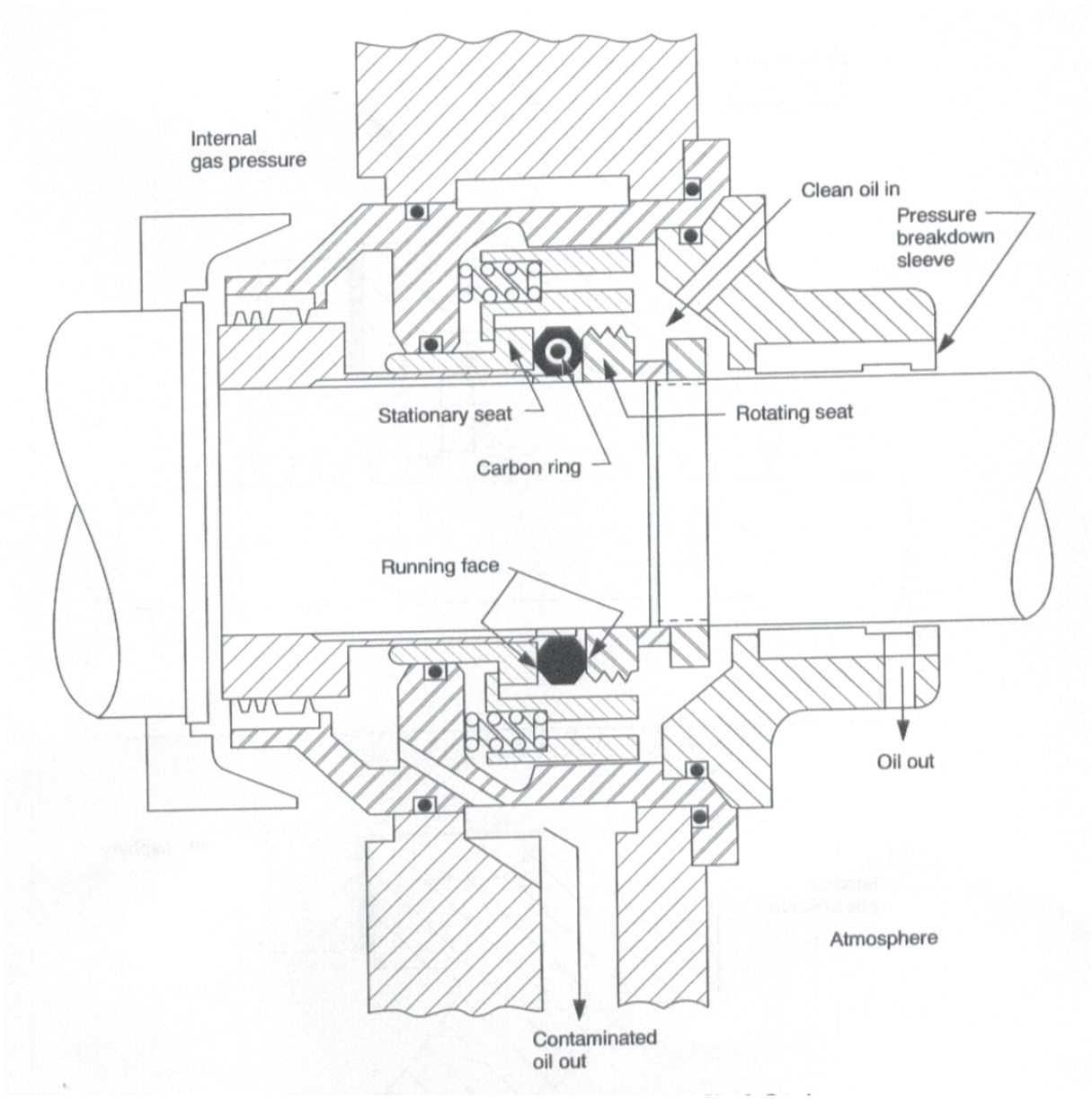


Figure B.2—Mechanical Contact Liquid Film Seal

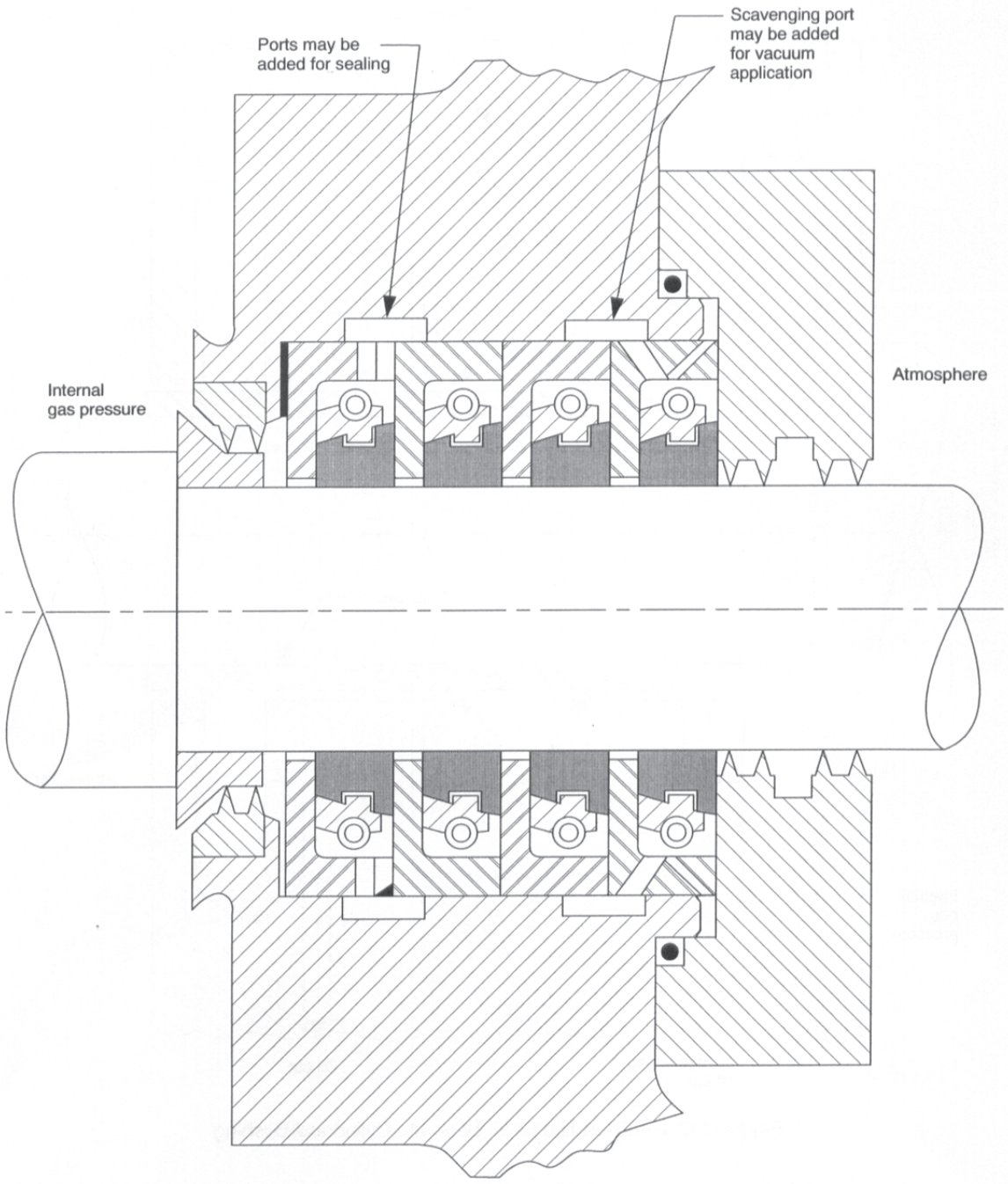


Figure B.3—Restrictive Ring Seal

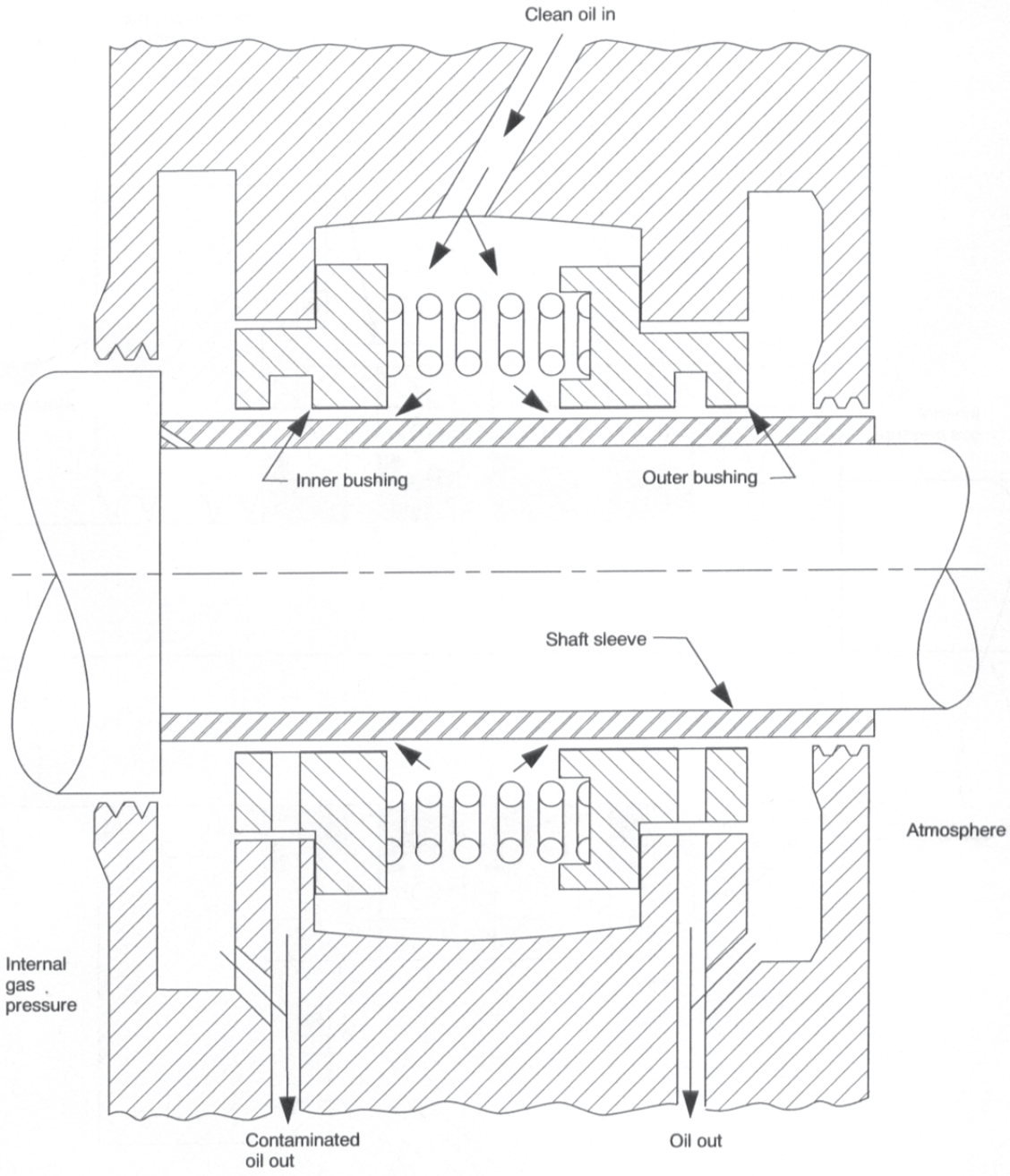


Figure B.4—Liquid-film (Bushing Seal)

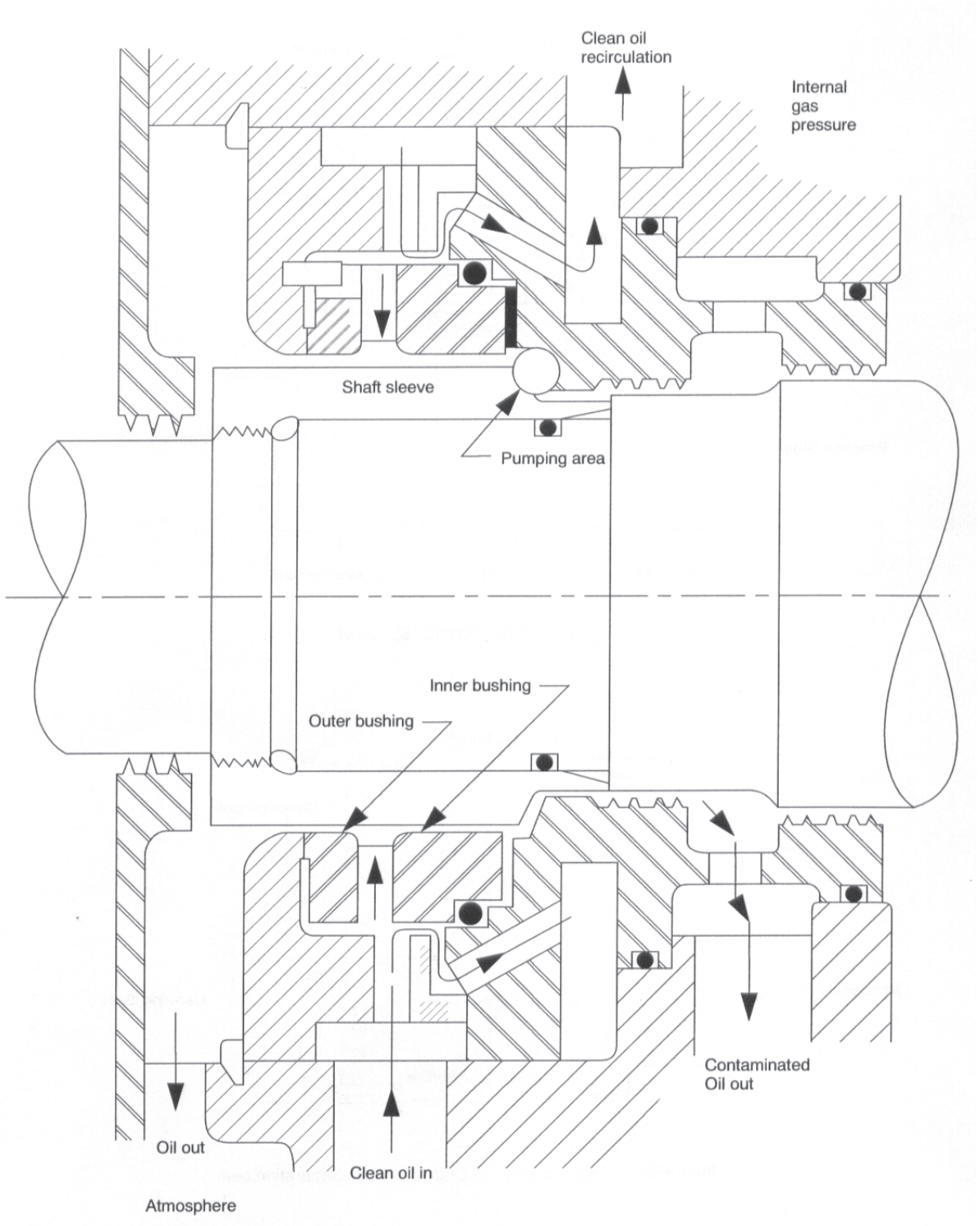


Figure B.5—Pumping Bushing Liquid Film Seal

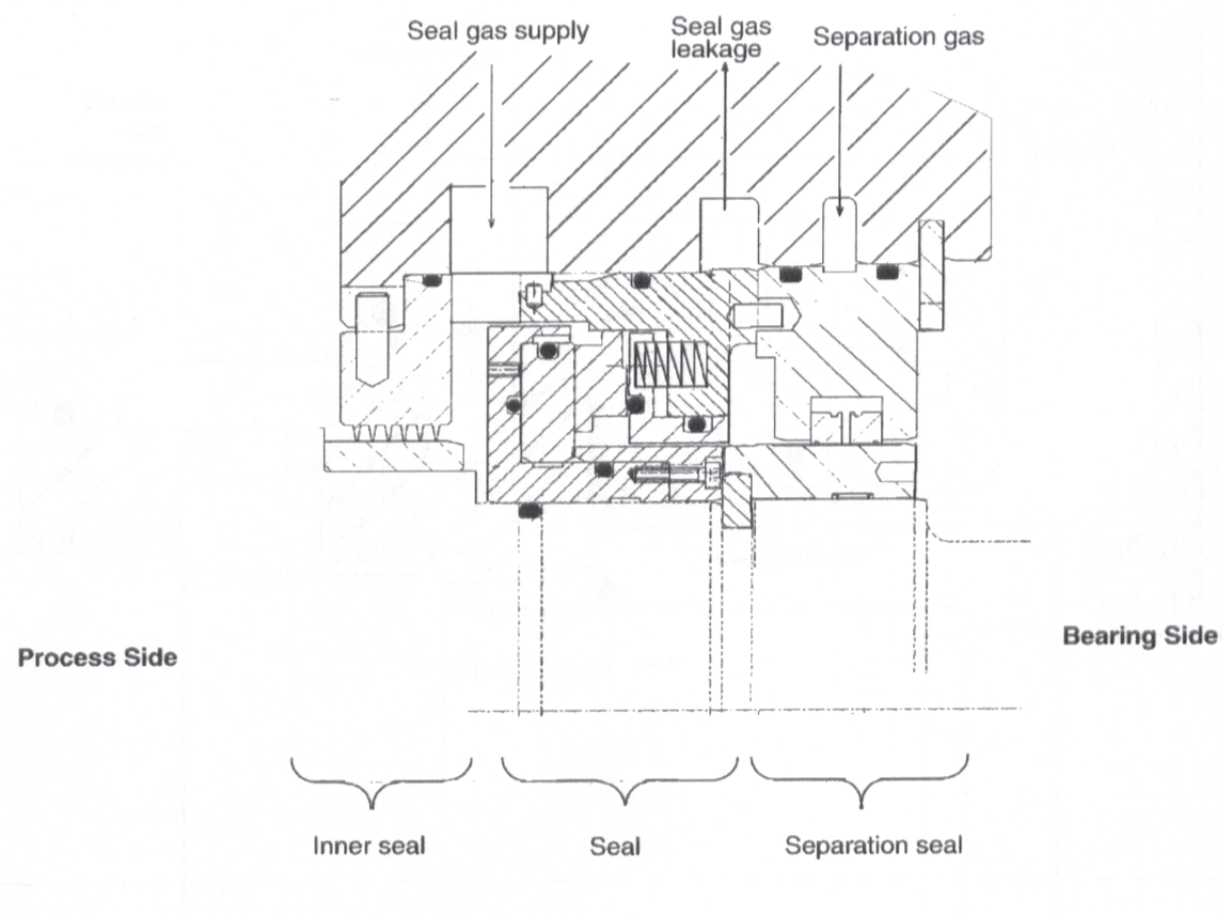


Figure B.6—Single Dry Gas Seal

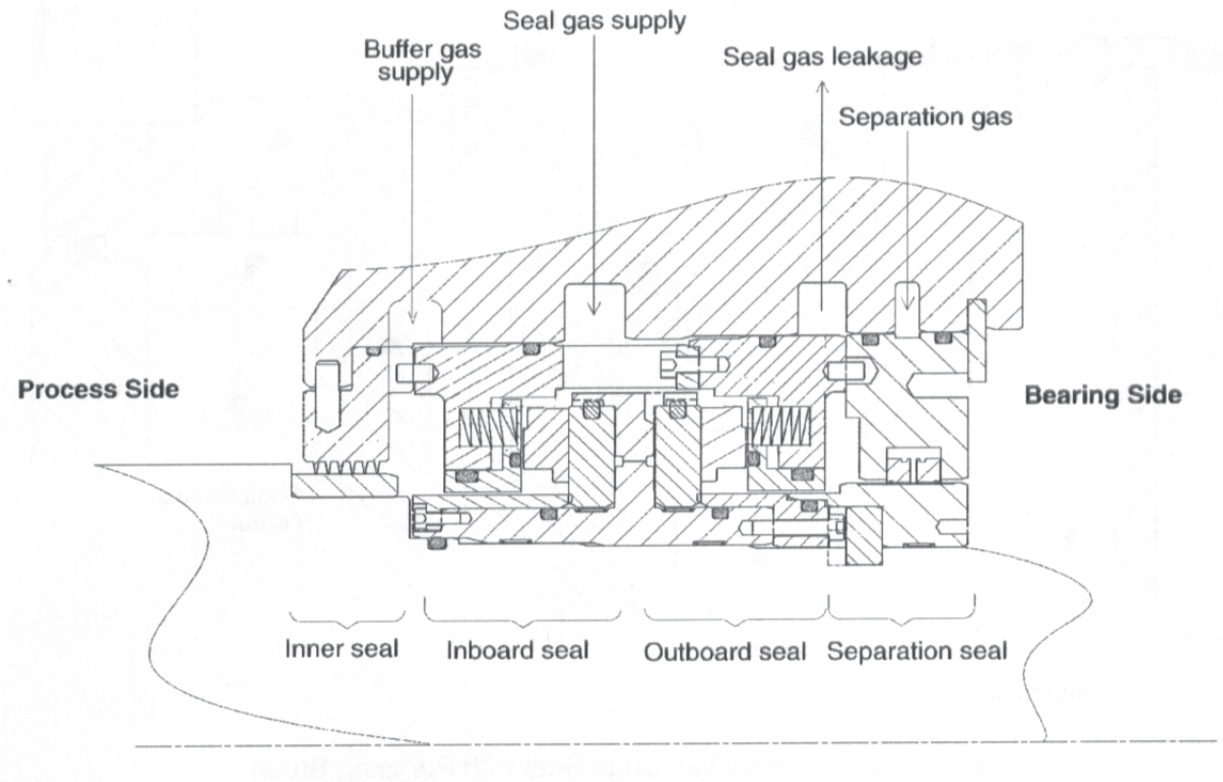


Figure B.7—Double Dry Gas Seal

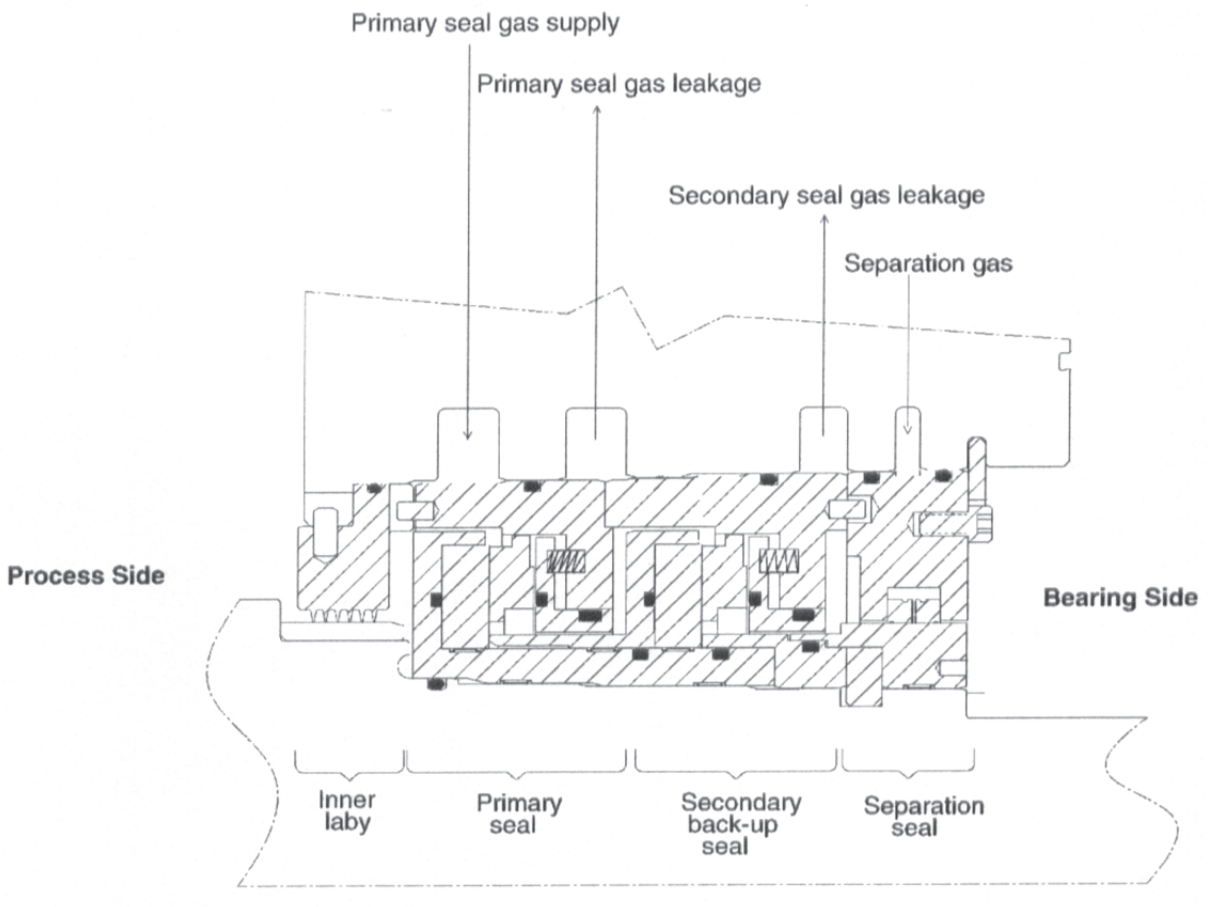


Figure B.8—Tandem Dry Gas Seal

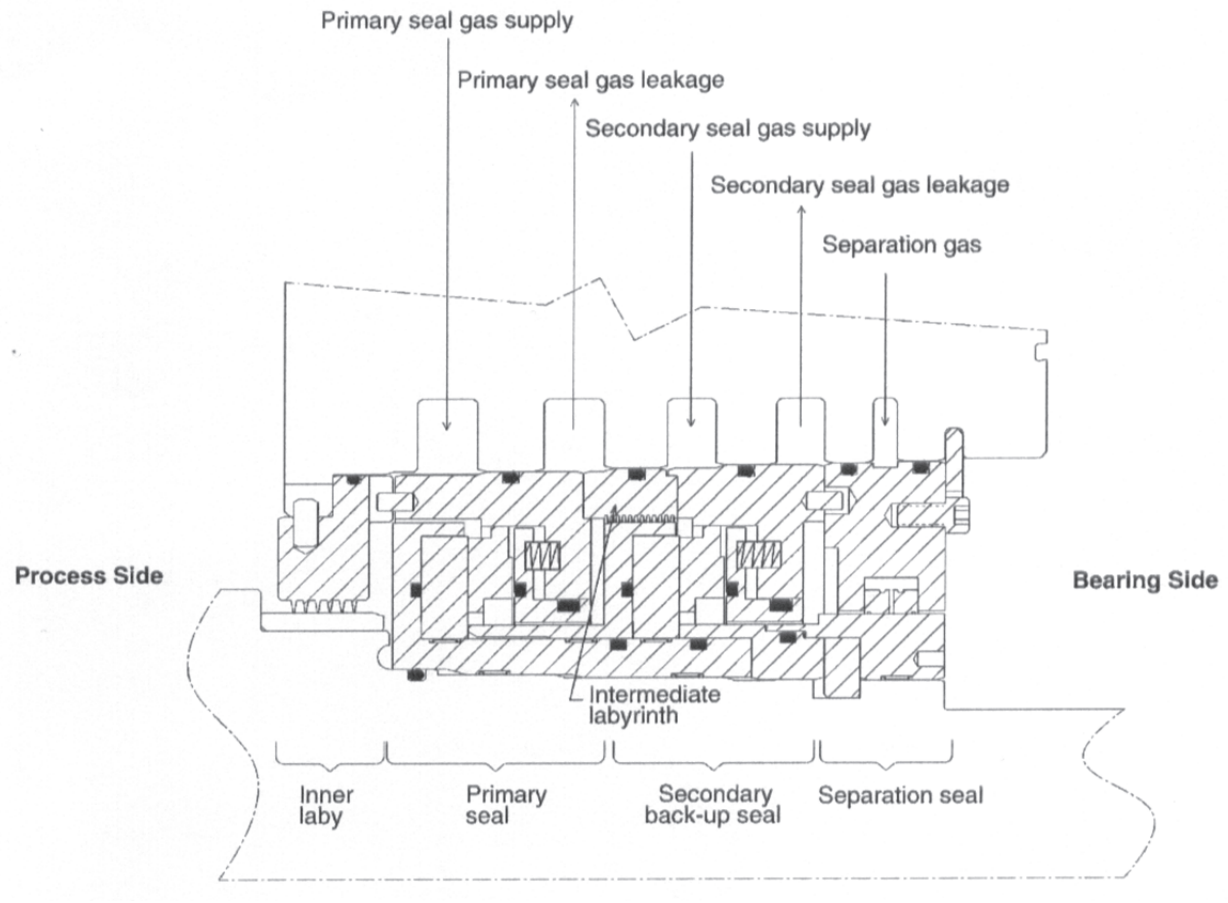


Figure B.9—Tandem Dry Gas Seal with Intermediate Seal Gas Labyrinth

Annex C
(normative)

Requirements for Lateral Analysis Reports—
Report Requirements for Lateral and Stability Analyses

C.1 Standard Lateral Analysis and Stability Report

a) Rotor model:

   i) sketch of rotor model;

   ii) clear identification of bearing, shaft end and internal seals, probe, coupling, and disc (impellers, wheels, etc.) locations.

b) Oil film bearings and liquid-film seals data (if present):

   i) dynamic coefficients (plot or table) for minimum and maximum stiffness cases vs speed and power;

   ii) in the Level II stability analysis, the synchronous and/or nonsynchronous coefficients when used by manufacturer;

   iii) identification of coordinate system including direction of rotation;

   iv) bearing type, length, pad arc length, diameter, minimum and maximum clearance, offset, number of pads, load geometry, preload and pivot type, and geometry;

   v) bearing load and direction vs speed and power;

   vi) oil film seal configuration, length, diameter, minimum and maximum clearance, load geometry, and seal geometry;

   vii) oil properties and operating conditions:

      — oil viscosity (two temperature data if a nonstandard ISO Grade),

      — oil flow rate and/or inlet pressure,

      — inlet operating temperature range,

      — oil specific gravity,

      — seal operating conditions.

c) Rolling element bearing data:

   i) type and model number,

   ii) dynamic coefficients vs frequency and speed,

iii) bearing loads and preload.

d) Bearing pedestal data:

i) identify parameters vs frequency (mass, stiffness, and damping).

e) Gas annular seal data:

i) coefficients (when a Level 2 analysis is required) for labyrinth seals, balance piston seal, and/or center bushing seal;

ii) seal type (labyrinth, honeycomb, hole pattern, etc.);

iii) teeth on rotor, teeth on stator, or interlocking;

iv) seal minimum and maximum operating clearance;

v) presence of shunt holes and/or swirl brakes.

f) Squeeze film dampers:

i) dynamic coefficients (plot or table) for clearance extremes vs frequency;

ii) state static position and whirl eccentricity assumptions or calculation;

iii) identification of coordinate system including direction of whirl;

iv) damper type, length, diameter, minimum and maximum clearance, centering device, and end seal type;

v) stiffness values for end seals and centering device (when used).

g) Other forces included in the analysis (machine dependent):

i) motor stator magnetic stiffness,

ii) volute fluid dynamic forces,

iii) gear mesh loads.

NOTE Supplier will typically state force magnitude and basis of calculation.

h) Analysis methods:

i) list computer codes used in the analysis with a brief description of the type of code, e.g. finite element, CFD, transfer matrix, etc.

i) Undamped critical speed map and mode shapes:

i) critical speed vs support stiffness;

ii) curves of the support stiffness (i.e. K_{xx} and K_{yy} for minimum and maximum stiffness) where K_{xx} is horizontal stiffness and K_{yy} is vertical stiffness;

iii) plot, as a minimum, the first four critical speeds with the stiffness axis extending to “rigid and soft support” regions;

iv) show the minimum allowable and MCSs;

v) the map shall be displayed as shown in Figure C.1;

vi) undamped mode shapes from the rigid, expected, and soft support regions;

vii) for machines that do not have similar support stiffness, the critical speed map shall indicate the specified reference bearing and its location. For each of the other bearing locations, the bearing stiffness ratio, relative to the specified reference bearing, shall be defined:

— the supplier can substitute mode shape plots for the undamped critical speed map and list the undamped critical speeds and the support stiffness for each of the identified modes.

j) Unbalance response predictions:

i) identification of the frequency of each critical speed in the range from 0 to 150 % of N_{mc};

ii) frequency, phase, and amplitude (Bode plots) at the vibration probe locations in the range 0 to 150 % of N_{mc} resulting from the unbalances specified in 4.8.2.7 and 4.8.2.8:

— if there are no vibration probes near a bearing centerline then the Bode plots shall be shown at the bearing centerline,

— minimum allowable and MCS shown;

iii) tabulation of critical speeds, AF, actual and required separation margin, and scale factor;

iv) axial location, amount, and phase of unbalance weights for each case;

v) plots of amplitude and phase angle vs speed at probe locations:

— for min and max bearing stiffness cases,

— pedestal vibration amplitudes for flexible pedestals as defined in 4.8.2.4 d);

vi) plots of deflected rotor shape at critical speeds and N_{mc}—for min and max bearing stiffness cases;

vii) a table of the close clearance magnitudes and locations and maximum vibration levels verifying that 4.8.2.11.1 has been met;

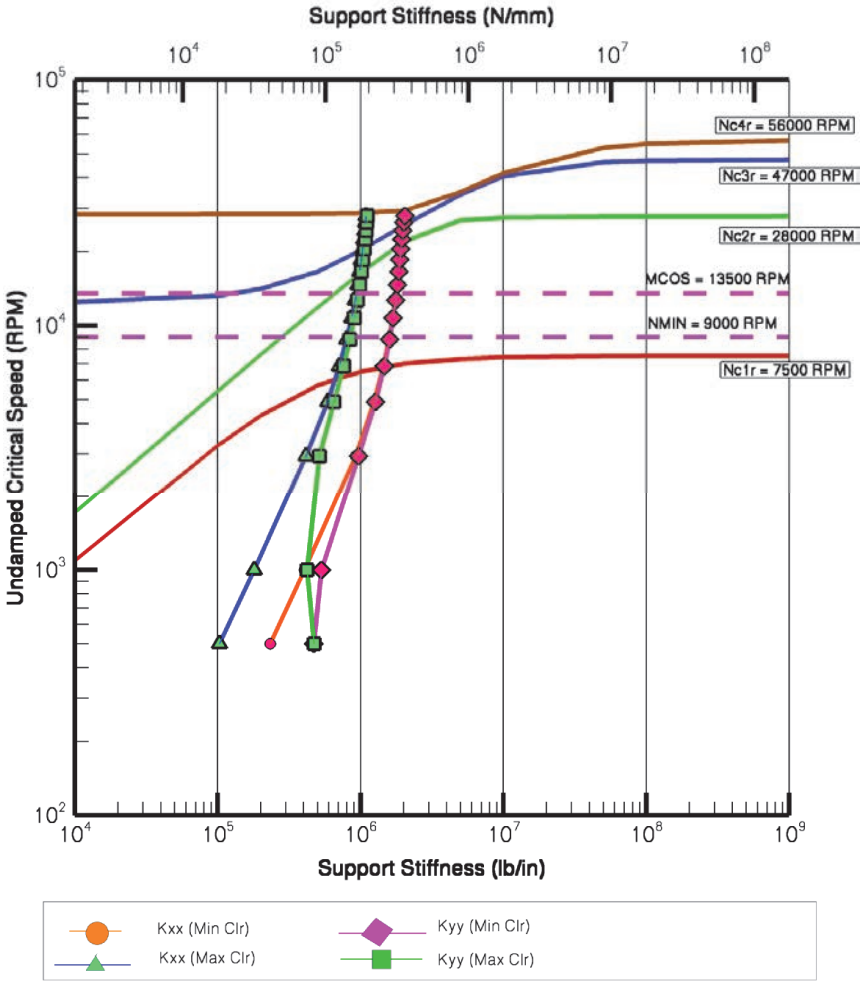


Figure C.1—Undamped Critical Speed Map

k) Stability level 1 analysis:

i) the calculated anticipated cross coupling, q_a (for each centrifugal impeller or axial stage), total anticipated cross coupling, Q_A, log dec and damped natural frequency at anticipated cross coupling, and Q_0 / Q_A;

ii) Figure C.2 plot of log dec vs cross coupled stiffness for min and max bearing stiffness;

iii) Figure C.3 plot of flexibility ratio vs average gas density with application point identified on plot.

l) Stability level II analysis:

i) description of all assumptions used in the analysis,

ii) description of all dynamic effects included in the analysis,

iii) value of log dec and frequency versus component addition for min and max bearing stiffness (defined in 4.8.6.8).

m) Summary sheet that identifies compliance with API requirements.

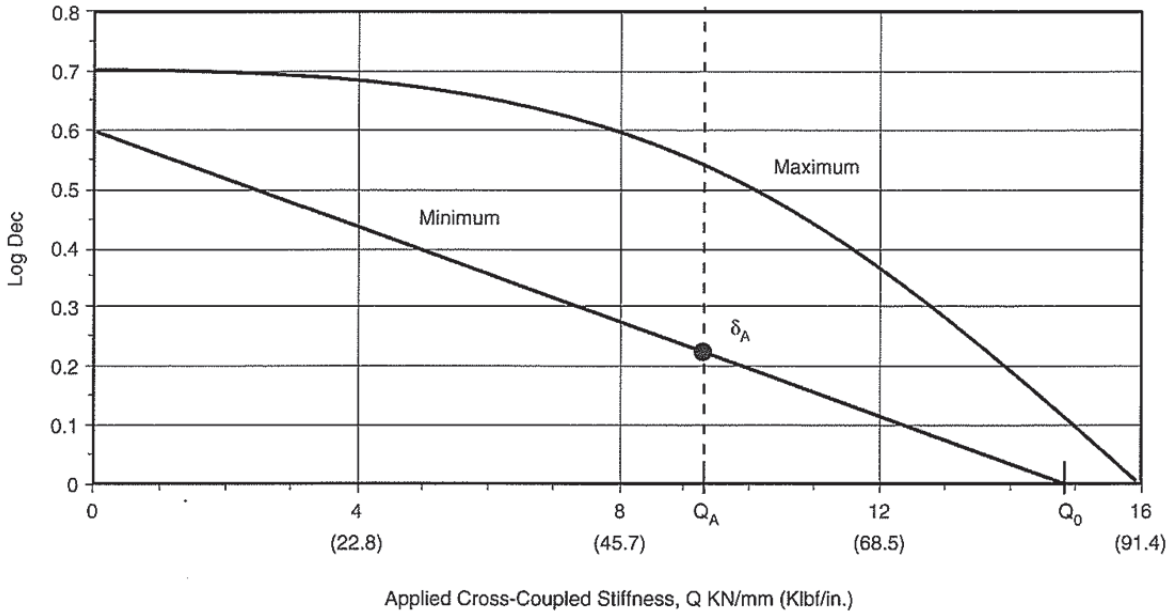


Figure C.2—Level I Stability Sensitivity Plot

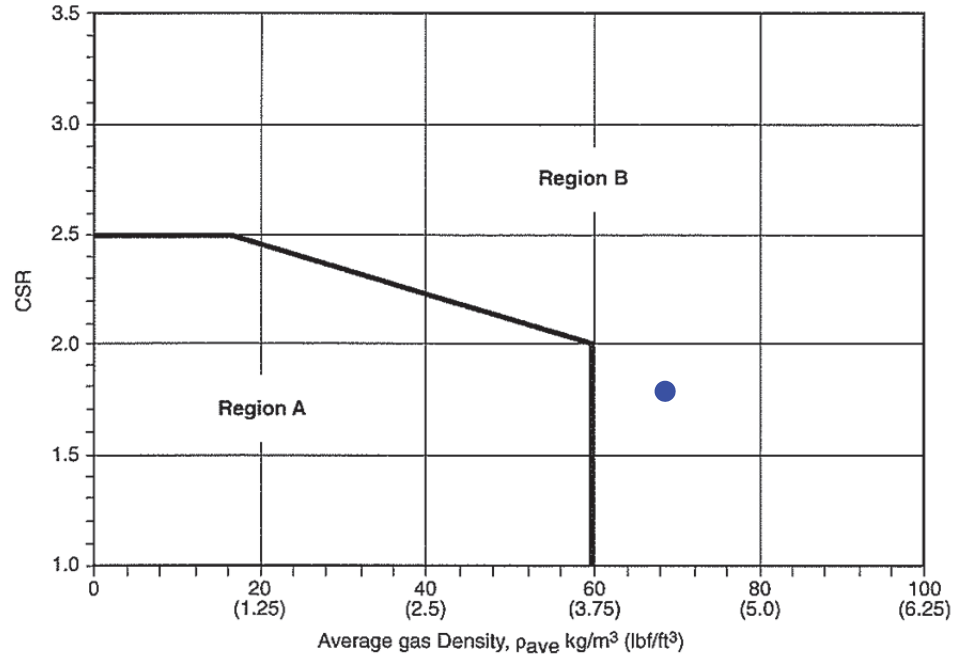


Figure C.3—Stability Experience Plot

C.2 Data Required to Perform Independent Audits of Lateral Analysis and Stability Reports

a) All of the requirements of C.1 shall be met. This requirement details additional data that shall be provided in conjunction with the Standard Report or as an addendum to it.

b) Rotor model:

   i) model tabulation to include rotor geometry (including delineation between stiffness and mass diameter) and external masses with weight, polar, and transverse moments of inertia;

   ii) the weight, polar and transverse moments of inertia, and center of gravity of the impellers, balance piston, shaft end seals, coupling(s), and any other rotating components;

   iii) shaft material properties (density and Young's Modulus with temperature dependence);

   iv) axial preloading due to tie bolts;

   v) the magnitude and direction of any additional side loads (gears forces, volutes, etc.) over the full operating range.

c) Bearing and liquid-film seal:

   i) data to permit independent calculation of bearing coefficients:

      — Table C.1, Figure C.4, and Figure C.5 indicate geometry required for tilt pad bearings;

      NOTE Similar dimensions are required for fixed pad bearings when used. API 684 can assist in the determination of the dimensions needed.

   i) tilt pad bearing and pivot material;

   ii) seal dimensional data.

d) Internal seals (labyrinth, balance piston seal, wear rings, and center bushing seal):

   i) data to permit independent calculation of seal coefficients:

      — dimensional data,

      — inlet swirl ratio,

      — swirl brake type,

      — clearance assumptions,

      — shunt hole location,

      — gas conditions and properties at operating speed.

Table C.1—Tilt Pad Bearing Dimensions and Tolerances

Dimension	Nominal	Tolerance (+)	Tolerance (−)
Shaft diameter at journal ($2 \times R_j$)			
Pad machined diameter ($2 \times R_p$)			
Set bore ($2 \times R_b$)			
Pivot location (α)			
Pad arc length (χ)			

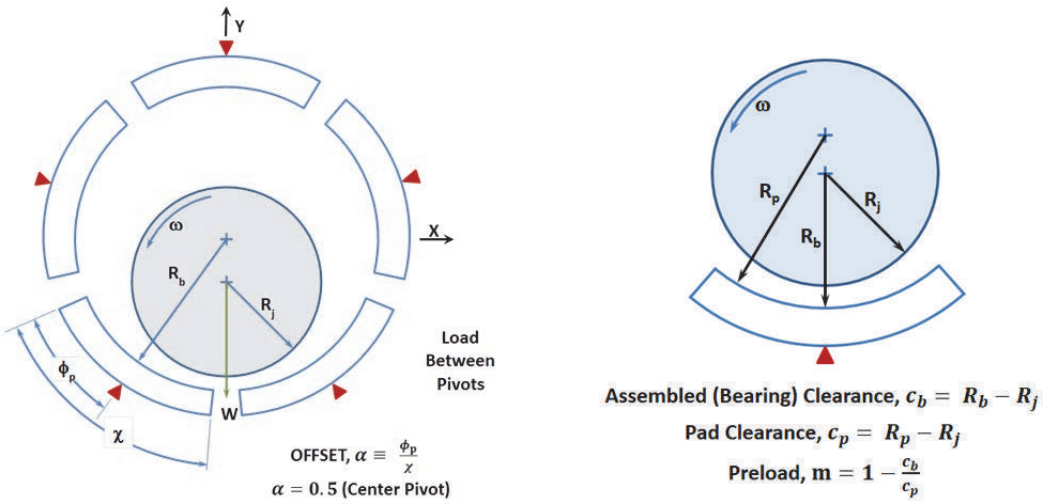


Figure C.4—Geometry Definitions for Tilt Pad Bearing

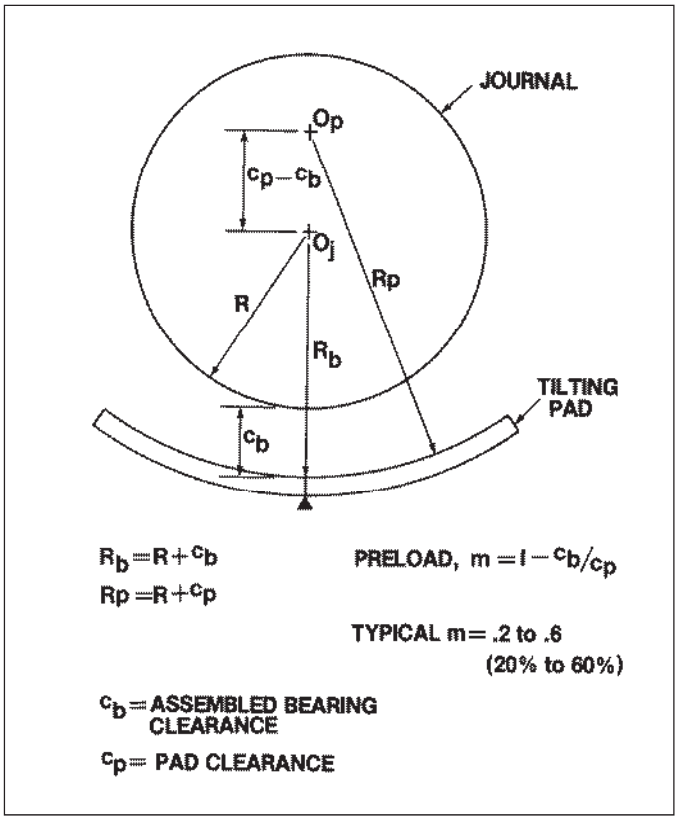


Figure C.5—Preloaded Pad

Annex D
(normative)

Requirements for Torsional Analysis Reports
(Report Requirements for Torsional Natural Frequency, Synchronous Torsional Response, and Transient Torsional Response Analyses)

D.1 Standard Torsional Natural Frequency Report (for Systems That Comply with Separation Margins)

a) System torsional sketch:

   1) sketch of torsional system,

   2) clear identification of individual rotors and their associated inertias and of coupling locations.

b) Shaft element data:

   1) shaft element length and diameters,

   2) shaft material properties (material density and shear modulus of elasticity).

c) Lumped inertia data:

   1) identify inertia magnitude and location,

   2) identify what each lumped inertia represents,

   3) identify inertia of each body and the total for the train.

NOTE Inertia and stiffness are expected to be actual values and not referenced to a particular shaft.

d) Coupling data:

   1) stiffness and inertia,

   2) description of shaft end model accounting for hub penetration.

e) Analysis methods:

   1) list computer codes used in the analysis with a brief description of the type of code, e.g. finite element, Holzer, etc.

f) Torsional natural frequencies:

   1) table of the torsional natural frequencies up to 2 times the highest rotor speed including separation margins.

g) Natural frequency mode shapes:

   1) plots for all torsional natural frequencies that are less than or equal to 2 times the highest rotor speed.

h) Campbell diagram:

1) identify torsional natural frequencies,

2) identify operating speed range(s) with 10 % separation margin for train components,

3) identify torsional excitation frequencies,

4) a typical diagram is shown in Figure D.1.

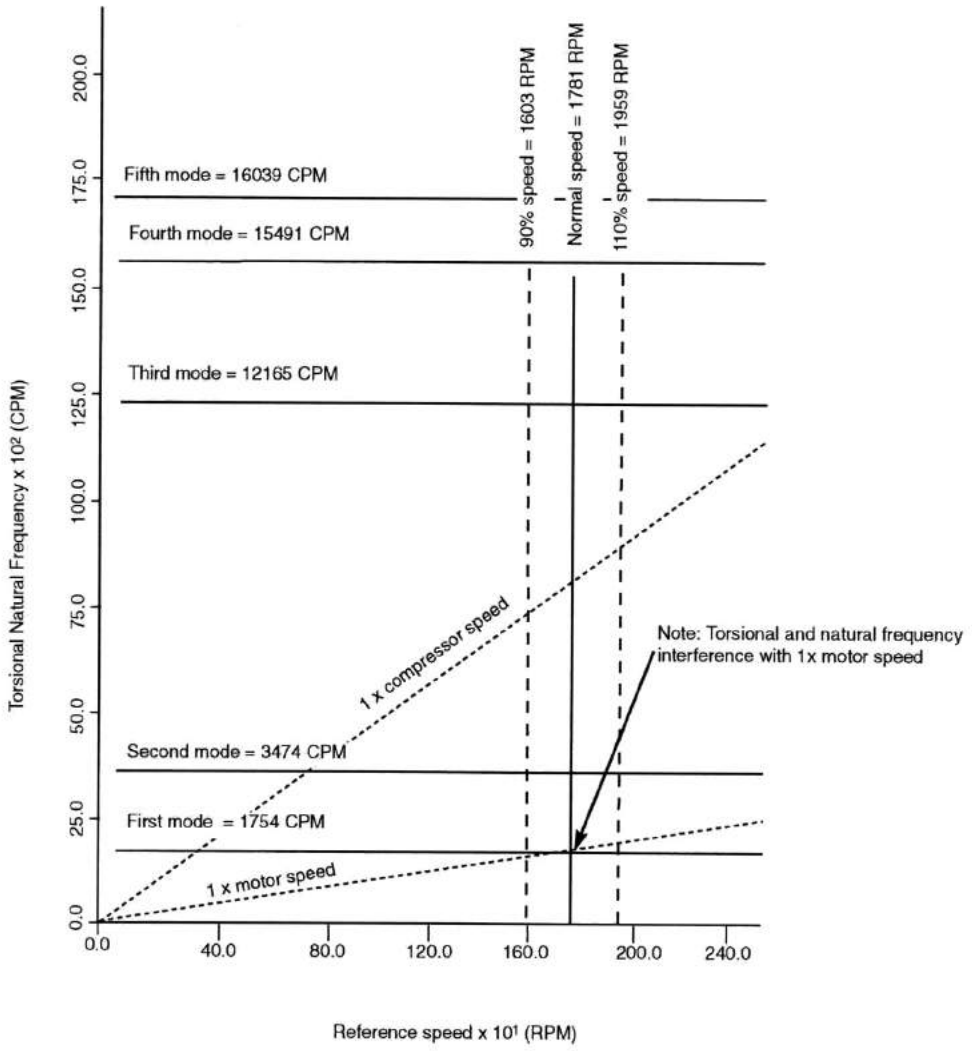


Figure D.1—Typical Campbell Diagram

D.2 Standard Torsional Natural Frequency Report [for Systems That Do Not Comply with Separation Margin(s)]

NOTE For variable speed motor drives, refer to D.3.

All of the items in D.1 above are required in addition to the following.

a) A statement of the potential torsional excitation mechanism(s), its location, magnitude, and frequency. For systems that operate at variable speeds, the excitation mechanism shall be evaluated throughout the operating speed range;

b) Damping levels used in the analysis shall be stated.

c) The peak torques for all couplings and gear mesh(s) shall be identified.

d) The calculated maximum shaft stress for each shaft shall be presented.

e) Shaft stress concentration factors applied shall be listed.

f) Statement of fatigue life acceptance criteria used and conformance.

D.3 Standard Torsional Natural Frequency Report for Variable Frequency Drives

All of the items in D.1 above are required [with the exception of identifying the VFD excitation on the Campbell diagram required in D.1 h)], and in addition, the following information shall be provided.

a) Train acceleration schedule.

b) The excitation associated with the VFD throughout the entire speed range shall be identified as a percentage of rated driver torque.

c) Damping levels and notch fatigue factors used shall be stated.

d) The peak torques for all couplings and gear mesh(s) shall be identified.

e) The calculated maximum shaft stress for each shaft shall be presented.

f) Shaft stress concentration factors applied shall be listed.

g) Statement of fatigue life acceptance criteria used and conformance.

D.4 Transient Analysis of Synchronous Motor Drives

The standard report associated with a conventional torsional natural frequency analysis shall be provided in accordance with D.1 or D.2 above as appropriate. In addition the following shall be provided.

a) The speed torque curve for the motor identifying the mean and alternating torque shall be plotted.

   NOTE For a realistic transient analysis, the motor speed torque will reflect the expected starting voltage drop and voltage recovery during starting.

b) A load speed torque curve of the driven equipment identifying the process conditions under which the equipment is required to start shall be included.

c) Damping levels and fatigue factors used shall be stated.

d) The transient torque vs speed for couplings, gear mesh(s) and selected shaft sections shall be plotted. Peak torques at the couplings and gear mesh shall be identified.

e) The transient stress vs speed for selected shaft sections with high cycle fatigue (HCF) (endurance limit) and the low cycle fatigue (LCF) limits shall be identified.

f) Results of the damage accumulation calculations as a function of one start.

g) Predicted number of starts to failure for each shaft, coupling(s), and gear mesh.

D.5 Transient Analysis of Electric Motor/Generator Short Circuit and Synchronization

The standard report associated with a conventional torsional natural frequency analysis shall be provided in accordance with D.1 or D.2 above as appropriate. In addition, the following shall be provided.

a) The torque magnitude and frequency associated with the short circuit fault condition shall be identified.

b) The analysis shall identify the peak torques in all rotors and couplings. The shaft stress at each of the peak torque locations shall be calculated and evaluated using criteria suitable for either high cycle or low cycle fatigue.

c) Damping levels and fatigue factors used shall be stated.

d) The transient torque vs time for couplings, gear mesh(s), and selected shaft sections shall be plotted. Peak torques at the couplings and gear mesh shall be identified.

e) The transient stress vs time for selected shaft sections with low cycle fatigue (LCF) identified.

f) A summary shall be included identifying that the shafting, coupling(s), and gear mesh have a finite number of fault cycles.

Annex E
(normative)

Magnetic Bearings

E.1 General

This annex covers the additional minimum requirements and modifications to the requirements presented in Part 1 for machines that have AMBs.

NOTE Magnetic bearings present unique requirements as opposed to hydrodynamic bearings. The paragraph numbers in this annex are aligned to paragraph numbers in Part 1 in order to facilitate ease of use. Additional requirements for magnetic bearings and superseding requirements applying to magnetic bearings from the hydrodynamic bearing requirements covered in this part of API 617 are as indicated.

E.2 Referenced Publications

For the purposes of this annex, the following normative references apply. The applicability of changes in standards, codes, and specifications that occur after the inquiry shall be mutually agreed by the purchaser and the supplier:

a) EN 55011, Group 1, Class A;

b) EN 61000-6-2;

c) ISO 14839-1;

d) ISO 14839- 3.

E.3 Terms, Definitions, and Abbreviations

For the purposes of this document, the following terms, definitions, and abbreviations apply.

E.3.1
active magnetic bearing
AMB
To support a rotor, without mechanical contact, using only attractive magnetic forces based upon servo feedback technology that normally consists of sensors, electromagnets, power amplifiers, power supplies, and controllers.

NOTE Adapted from ISO 14839-1.

E.3.2
actuator
Portion of the AMB system that applies a force to the rotor by converting a current into a magnetic force.

E.3.3
AMB control system
Device that detects and processes the sensor signal and transfers it to the power amplifier in order to regulate the magnetic attractive force to levitate the rotor.

NOTE Adapted from ISO 14839-1.

E.3.4
auxiliary bearing
Separate bearing system that supports the shaft when the shaft is not levitated by the AMB system or the AMB is overloaded. The auxiliary bearing is inactive under normal AMB operation. This bearing system may have a very limited life and be considered a consumable machine protection system.

Also known as a “touchdown,” “catcher,” “backup,” and/or “coastdown” bearing.

E.3.5
bearing axis
Location and specific direction in which the force acts or a rotor displacement is measured.

NOTE For horizontal axis machines, the radial bearing axes are typically at ± 45° from vertical.

E.3.6
close loop transfer function
Ratio of output response to input excitation signal for an actively controlled system, including the effects of the feedback loop.

NOTE Refer to ISO 14839-3:2006 for a more precise mathematical definition.

E.3.7
compensator
AMB controller, including any input and/or output transformations. The inputs to the compensator are the sensor outputs. The outputs of the compensator are the current or force commands.

E.3.8
delevitation
Loss of AMB control of rotor position.

E.3.9
free-free map
Plot of natural frequencies for the rotating assembly only (no bearings, no seals, etc.) as a function of operating speed.

E.3.10
landing surface or landing sleeve
Surface on the rotating assembly that is meant to contact the auxiliary bearing surface when the rotor comes into contact with it.

E.3.11
levitation
Activating the AMB system to provide currents to the bearing such that the rotor is suspended within the magnetic bearing. Can be used to refer to a single axis or the entire AMB system.

E.3.12
local electronics
Any electrical components required by the magnetic bearing system that are not included in the control system cabinet and are thus located on or near the machine skid.

E.3.13
noncollocation
Refers to the usual arrangement where the bearing actuator is not located in the same axial location as the corresponding sensor.

E.3.14
plant
Power amplifier(s), actuator(s), rotor/housing dynamics, and sensor(s). This term is used refer to a single axis, or multiple axes jointly.

E.3.15
sensitivity function
Ratio of the sum of output response plus excitation signal, to the excitation signal.

NOTE Refer to ISO 14839-3:2006 for a more precise mathematical definition.

E.3.16
transfer function
Mathematical relationship between the input and output of a linear system in terms of frequency.

E.3.17
unbalance force rejection control
Any control scheme that is phase and frequency locked to rotor rotation and has the objective of minimizing the synchronous (and/or integer harmonic) component of the bearing force.

E.4 General

E.4.1 Dimensions and Units

The dimensional and unit requirements of Part 1 shall apply.

E.4.2 Statutory Requirements

The statutory requirements of Part 1 shall apply**.**

E.4.3 No Specific Requirement

E.4.4 Basic Design

AMB systems shall be in accordance with 4.4 unless otherwise agreed and with the additional requirements as follows.

E.4.4.1 Supplier shall supply bearings suitable for the intended operating environment including any liquids that are expected to enter the bearing system during normal operation and shutdown periods.

E.4.4.2 All components shall be suitable for operation, both during shop tuning and testing and under field conditions.

E.4.4.3 All leads (power, sensor, speed, and temperature) shall be identified at both the stator end and the connector end. Identification shall be durable in the intended environment and shall be able to withstand handling associated with installation and removal.

E.4.4.4 For expander-compressors covered in Part 4 the design shall be such that the magnetic bearing stationary components can be removed and replaced as a single unit (cartridge design.) Part 4.

E.4.5 Materials

AMB systems shall be in accordance with 4.5 unless otherwise agreed and with the additional requirements as follows**.**

E.4.5.1 Electrical insulation of stator windings shall be Class H (180 °C) as a minimum. Overall bearing assembly shall be rated to Class F (155 °C) as a minimum.

E.4.6 Casings

AMB systems shall be in accordance with 4.6 as applicable, unless otherwise agreed**.**

E.4.7 Rotating Elements

AMB systems shall be in accordance with 4.7 as applicable, unless otherwise agreed, and with the additional requirements as follows**.**

E.4.7.1 The rotor shaft sensing areas observed by radial and axial shaft displacement sensors shall be as required to meet the requirements of the AMB sensor system. This requirement shall replace the relevant portions of 4.7.2, 4.7.3, and 4.7.4.

E.4.7.2 Sufficient area shall be provided on the AMB rotor segment to turn the assembled shaft assembly on a balancing machine. The total indicated runout between the surface used for balancing and the surface used by the sensors to determine rotor position shall not exceed 5 μm (0.0002 in.).

E.4.7.3 Rotor landing surfaces shall be either repairable or replaceable, without causing replacement of the entire rotor system.

E.4.8 Dynamics

AMB systems shall be in accordance with 4.8 as applicable and with the additional and modified requirements as follows.

E.4.8.1.1 In the design of rotor-bearing and AMB systems, consideration shall also be given to AMB sensor runout.

E.4.8.1.2 Analysis requirements specified in E.4.8.2.1 through E.4.8.7 shall be reported per E.4.8.1.2.1 and E.9.

- **E.4.8.1.2.1** If specified, the reporting requirements identified as required for independent audit of the results shall be provided**.**

E.4.8.2 Lateral Analysis

E.4.8.2.1 A free-free map shall be generated over the range of 0 to 150 % of N_{mc} and shall include, as a minimum, all modes below 300 % of N_{mc}.

E.4.8.2.2 The rotordynamics analysis shall also include:

a) any effects of sensor-actuator noncollocation,

b) the complete transfer functions from displacement to force,

c) any negative stiffness effects.

E.4.8.2.3 The rotordynamic analyses shall be conducted with unbalance force rejection control, when provided, not active.

E.4.8.2.4 The requirements specified in 4.8.2.10 shall be replaced with the following.

The calculated unbalanced peak-to-peak response at each vibration probe, for each unbalance amount and case as specified in 4.8.2.7, shall not exceed the smaller of Equation (E.1) or 0.3 times the minimum

diametral close clearance (typically the auxiliary bearing), over the range of N_{ma} to N_{mc} as shown in Figure 3.

In SI units:

$$A_{vl} = 3\left(25.4\sqrt{\frac{12{,}000}{N_{mc}}}\right) \quad \text{(E.1a)}$$

In USC units:

$$A_{vl} = 3\left(\sqrt{\frac{12{,}000}{N_{mc}}}\right) \quad \text{(E.1b)}$$

where

A_{vl} is the mechanical test vibration limit, μm (mil);

N_{mc} is the maximum continuous speed (rpm).

E.4.8.2.5 The predicted AMB dynamic forces resulting from for each analysis required in 4.8.2.7 and 4.8.2.11 shall be less than the AMB supplier specified allowable dynamic force capacity envelope versus frequency for the given machine. This force capacity envelope shall include an agreed factor of safety relative to the maximum rated dynamic force that shall be greater than or equal to 1.5.

E.4.8.2.6 If the analysis indicates that the force limit requirements cannot be met, and the purchaser and supplier have agreed that all practical design and retuning efforts have been exhausted, then acceptable dynamic force levels shall be agreed, subject to the requirements of 4.8.4.

E.4.8.3 Closed Loop Transfer Function Model Verification Test

- **E.4.8.3.1.1** If specified, the unbalance rotor response verification test specified in 4.8.3 shall be replaced with the transfer function based procedure described in E.4.8.3.2 through E.4.8.3.11 for the radial bearing axes.

  If the transfer function based approach is specified as replacing 4.8, the additional unbalance cases specified in 4.8.2.8 shall not be made.

- **E.4.8.3.1.2** If specified, both the unbalance rotor response verification test specified in 4.8.3 and the transfer function based procedure described in E.4.8.3.2 through E.4.8.3.11 shall be performed for the radial bearing axes.

  NOTE The unbalance based procedure specified in 4.8.3 can require disassembly of the machine for some AMB supported machinery.

E.4.8.3.1.3 The transfer function based procedure described in E.4.8.3.2 through E.4.8.3.11 shall be performed for the axial axis.

E.4.8.3.2 Analytical closed loop transfer functions shall be calculated on an axis by axis basis as (e.g. 4 lateral and/or 1 axial transfer functions for a 2 radial bearing configuration).

E.4.8.3.3 Transfer function measurements shall be performed as part of the mechanical running test and the results shall be used to verify the analytical model.

E.4.8.3.4 Closed loop transfer function measurements shall be made as described in E.4.8.3.6. These measurements shall be made at 0 rpm.

- **E.4.8.3.5** If specified, a second measurement as described in E.4.8.3.6 shall be made at an additional speed(s) that shall be agreed.

NOTE Measurements at higher speeds, in some cases, will not be suitable for validation purposes due to the presence of immeasurable forces from unbalance, aerodynamic forces, etc.

E.4.8.3.6 Closed loop transfer functions shall be measured on an axis by axis basis (e.g. 4 lateral and/or 1 axial transfer functions for a 2 radial bearing configuration). The excitation shall be added to the plant input as shown in Figure E1. The response shall be measured at the output of the compensator as shown in Figure E1. The closed loop transfer function shall be computed as Cmd/Exc. The required measurements and calculations may be performed externally or internally by the AMB control system using sine excitation.

- **E.4.8.3.7** If specified, the open loop transfer functions shall be measured on an axis by axis basis (e.g. 4 lateral and/or 1 axial transfer functions for a 2 radial bearing configuration). The excitation shall be applied to the plant input (Exc) as shown in Figure E1.

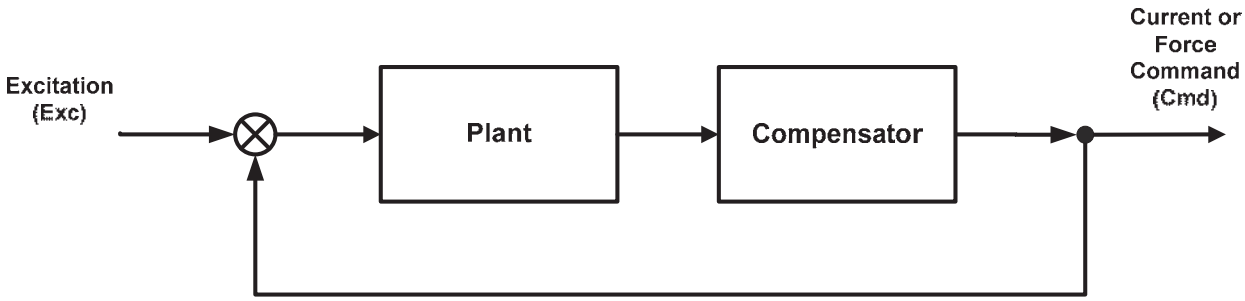


Figure E.1—Closed Loop Transfer Function Excitation and Measurement Locations

- **E.4.8.3.8** If specified, the lateral transfer function measurements required by E.4.8.3.6 and/or E.4.8.3.7 shall be made for all lateral transfer functions (e.g. each of 4 inputs to each of 4 outputs for a 2 radial bearing configuration).

E.4.8.3.9 The results of the transfer function measurements made in E.4.8.3.6 shall be compared with those from the analytical model specified in E.4.8.3.2 using the criteria specified in E.4.8.3.10.

E.4.8.3.10 The frequency of radial resonance peaks from the closed loop transfer function up to 125 % of N_{mc} shall not deviate from the corresponding frequency predicted by the analysis by more than ± 5 %, and the measured peak amplitudes shall not be greater than 1.0 times, nor less than 0.5 times the predicted amplitudes.

E.4.8.3.11 The frequency of axial resonance peaks from the closed loop transfer function up to 125 % of N_{mc} shall not deviate from the corresponding frequency predicted by the analysis by more than ± 10 %.

E.4.8.3.12 After correcting the model, if required, the response amplitudes shall be checked against the limits specified in 4.8.2.10 and 4.8.2.11, as well as E.4.8.2.5. The requirements of E.4.8.5.4 and/or E.4.8.6.5 and E.4.8.7.6 as applicable shall also be checked.

- **E.4.8.3.13** Unless otherwise specified, the verification test of the rotor unbalance shall be performed only on the first rotor tested, if multiple identical rotors are purchased.

E.4.8.4 Additional Testing

E.4.8.4.1 Additional testing as described in 4.8.4 is required if any of the requirements of E.4.8.3.10 and E.4.8.3.11 cannot be met and the purchaser and supplier have agreed that all practical design and AMB retuning efforts have been exhausted.

E.4.8.5 Level I Stability Analysis

E.4.8.5.1 A Level I stability analysis as described in 4.8.5 shall be performed on all AMB supported compressors and with the following additional requirements.

E.4.8.5.2 Level I Screening Criteria

a) All modes up to 200 % of N_{mc} shall be considered.

b) The requirements of 4.8.5.8 shall apply to all modes below N_{mc}.

c) For modes above 125 % of N_{mc}, a Level II analysis shall be performed if $\delta_A < 0.0$.

d) For modes between N_{mc} and 125 % of N_{mc}, a Level II analysis shall be performed if $\delta_A < \delta_{\text{min allowable}}$ given by Equation (E.2).

$$\delta_{\text{min allowable}} = 0.5 - 0.4\frac{N_{\text{mode}}}{N_{mc}} \tag{E.2}$$

E.4.8.5.3 The sensitive function analysis described in ISO 14839-3 shall be performed. The analysis shall be performed with 2 times the anticipated cross coupling, Q_A, as defined in Part 1.

E.4.8.5.4 If the peak values of the sensitivity functions computed in E.4.8.5.3 do not fall within zone A as defined in ISO 14839-3, a Level II analysis shall be performed.

E.4.8.6 Level II Stability Analysis

E.4.8.6.1 The calculations described in 4.8.6.8 shall be performed for all modes up to $2 \times N_{mc}$.

E.4.8.6.2 Acceptance Criteria

The Level II stability analysis shall indicate that the machine, as calculated in E.4.8.6.2:

a) has a final log decrement greater than 0.1 for all modes between 0 and N_{mc},

b) has a final log decrement greater than 0.0 for all modes greater than 125 % of N_{mc},

c) has a final log decrement greater than $\delta_{\text{min allowable}}$ given by Equation (E.3) for any mode between N_{mc} and 125 % of N_{mc}.

$$\delta_{\text{min allowable}} = 0.5 - 0.4\frac{N_{\text{mode}}}{N_{mc}} \tag{E.3}$$

E.4.8.6.3 If after all practical design and retuning efforts have been exhausted to achieve the requirements of E.4.8.6.2, acceptable levels of the log decrement, δ_f, shall be agreed.

E.4.8.6.4 The sensitive function analysis described in ISO 14839-3: shall be performed as part of the Level II analysis. The analysis shall be performed progressively, similar to the procedure described in 4.8.6.8.

E.4.8.6.5 The peak values of the sensitivity functions computed in E.4.8.6.4 shall fall within zone A as defined in ISO 14839-3.

E.4.8.6.6 If after all practical design and retuning efforts have been exhausted to achieve the requirements of E.4.8.6.5, acceptable levels of the peak value of the sensitivity function shall be mutually agreed.

E.4.8.7 Axial Analysis

NOTE Section E.4.8.7 presents additional axial analysis requirements that an AMB system shall meet. It does not replace the requirements of 4.8.7.

E.4.8.7.1 The supplier having train responsibility shall ensure that an axial analysis of the complete coupled train is carried out and shall be responsible for directing any modifications necessary to meet the requirements.

E.4.8.7.2 A simplified lumped mass model (lumped rotating component masses, stiffnesses, and damping) is sufficient for this analysis.

E.4.8.7.3 The axial analysis shall consider all major items that affect the axial dynamics including, but not limited to, the following:

a) rotating components masses, stiffnesses, and damping;

b) the axial AMB system;

c) coupling masses, stiffnesses, and damping;

d) nonrotating structural stiffness, mass, and damping characteristics as they relate to the axial actuator and sensor, including effects of excitation frequency over the required analysis range. The supplier shall state the structure characteristic values used in the analysis and the basis for these values (for example, modal tests of similar rotor structure systems, or calculated structure stiffness values);

e) disk flexibility;

f) seals;

g) magnetic and aerodynamic centering forces and associated dynamics;

h) eddy-current limitations on actuator bandwidth.

E.4.8.7.4 The damped natural frequencies of all modes with an AF greater than or equal to 2.5 shall be calculated.

E.4.8.7.5 The sensitivity function analysis described in ISO 14839-3 shall be performed for the axial system from 0 to 1000 Hz.

E.4.8.7.6 The analytical sensitivity functions for rotor dominated modes computed in E.4.8.7.5 shall fall within zone B or better as defined in ISO 14839-3. Modes dominated by motion in a flexible coupling may be excluded from this requirement.

E.4.8.8 Vibration and Balancing

AMB systems shall be in accordance with 4.8.8 as applicable, unless otherwise agreed, and with the additional requirements as follows

E.4.8.8.1 During the mechanical running test of the machine, assembled with the balanced rotor, operating at any speed within the specified operating speed range, the peak-to-peak amplitude of unfiltered vibration in any plane, measured on the shaft adjacent and relative to each radial bearing, shall not exceed the smaller of Equation (E.4) or 0.3 times the minimum diametral close clearance (typically the auxiliary bearing), over the range of N_{ma} to N_{mc} as shown in Figure 3.

In SI units:

$$A_{vl} = 3\left(25.4\sqrt{\frac{12{,}000}{N_{mc}}}\right) \tag{E.4a}$$

In USC units:

$$A_{vl} = 3\left(\sqrt{\frac{12{,}000}{N_{mc}}}\right) \tag{E.4b}$$

where

A_{vl} is the mechanical test vibration limit, μm (mil);

N_{mc} is the maximum continuous speed (rpm).

This paragraph replaces the requirements of 4.8.8.8.

E.4.8.8.1.1 At any speed greater than the MCS, up to and including the trip speed of the driver, the vibration level shall not increase more than 38.1 μm (1.5 mil) above the value recorded for each probe at the MCS prior to accelerating to trip.

This paragraph replaces the requirements of 4.8.8.8.1.

E.4.9 Bearings and Housings

E.4.9.1 General

Radial and axial bearings shall be as specified in the subsequent parts of this standard. The design shall be such that the magnetic bearing stationary components can be removed and replaced as a single unit (cartridge design).

E.4.9.2 Radial Magnetic Bearing System

E.4.9.2.1 The load capacity of the radial bearings shall be designed with sufficient force capability to prevent contact between the rotor and any portion of the stator (including the auxiliary bearings) at all speeds from zero to trip at expected operating conditions.

E.4.9.2.2 Two (2) temperature sensors shall be installed in each radial bearing. One shall be used for over-temperature protection and the other as an installed spare.

E.4.9.3 Axial Magnetic Bearing System

E.4.9.3.1 The expected residual thrust load during normal operation shall be no more than 50 % of the axial magnetic bearing's rated load capacity.

For expander-compressors covered in Part 4 with automatic thrust balancing systems, the axial magnetic bearing's rated load capacity shall be no less than 2 times the largest residual thrust expected using the automatic thrust balancing system.

- **E.4.9.3.2** If specified, two (2) axial position sensors shall be provided and located such that they can be used to provide rotor to stator differential expansion information.

E.4.9.3.3 Two (2) temperature sensors shall be installed in each axial bearing. One shall be used for over-temperature protection and the other as an installed spare.

E.4.9.4 Auxiliary Bearing System

E.4.9.4.1 An auxiliary bearing system shall be provided for all machines that use AMBs.

NOTE Auxiliary bearings are considered to be a consumable machinery protective device.

E.4.9.4.2 The radial auxiliary bearing system shall include a damping mechanism.

E.4.9.4.3 Auxiliary bearing materials and lubricant(s) (if present) shall be compatible with the specified operating environment (both shop testing and in the field) and shall not adversely affect adjacent components.

E.4.9.4.4 The auxiliary bearing system shall be designed to support the rotor, without allowing any contact at close clearance locations between the rotor and stator, except at the auxiliary bearing, under all of the following conditions:

a) when the AMB system is not energized;

b) during specified transient operating events that exceed the load capacity of the AMB system;

c) during a rotor drop transient following a partial or full AMB failure;

d) during a coastdown from trip speed, under specified operating conditions, with the auxiliary bearing system providing the rotor support.

NOTE Rotor displacements with the full force capacity of one or more AMB actuators being applied may need to be considered.

E.4.9.4.5 For the purposes of E.4.9.4.4, floating ring, abradable, and compliant seals are not considered close clearance locations. The design requirements at these locations shall be agreed.

E.4.9.4.6 The supplier shall provide analytical predictions confirming that the requirements of E.4.9.4.4 are met.

E.4.9.4.7 The auxiliary bearing system shall be designed to accommodate an agreed number of momentary contacts due to specified transient operating events that exceed the load capacity of the AMB system without requiring replacement or refurbishment.

E.4.9.4.8 The auxiliary bearing system shall be designed to accommodate an agreed number of coastdowns from trip speed under specified operating conditions without requiring replacement or refurbishment. This number shall not be less than two (2).

E.4.9.4.9 The supplier shall describe the basis for expecting the auxiliary bearing system to meet the design requirements of E.4.9.4.7 and E.4.9.4.8. This basis may include analytical simulations, as well as field and/or test stand data.

E.4.9.4.10 The supplier shall provide a means for confirming operability of the auxiliary bearing system without requiring machine disassembly.

E.5 Other AMB Subsystems and Components

E.5.1 Monitoring and Control Systems

E.5.1.1 The AMB system shall include a control system.

E.5.1.2 The control system shall consist of an enclosure containing amplifiers, control electronics, and other equipment necessary for the operation and safety of all magnetic bearings. The control system shall provide alarm and shutdown protective logic for the magnetic bearings, auxiliary bearings, and control cabinet.

- **E.5.1.3** If specified, an electronic digital communications link(s) shall be provided for connection to purchaser's systems. The format(s) and data provided shall be agreed.

E.5.1.4 The magnetic bearing control system shall have the capability of moving the rotor both radially and axially in order to check auxiliary bearing clearances. This check shall be possible with the unit in service but not rotating (i.e. disassembly shall not be required to perform this check).

E.5.1.5 The magnetic bearing control system shall have the capability to record and display the number of large shaft excursions during machine operation. Consideration shall be given to both operating speed and magnitude of the excursion in determining if an excursion is counted.

E.5.1.5.1 The count specified in E.5.1.5 shall be provided as a total since installation and as a resettable count for the installed set of auxiliary bearings.

E.5.1.6 The control system shall not emit or be receptive to EMF signals, and shall comply with standards EN 55011, Group 1, Class A and EN 61000-6-2.

E.5.1.7 Unless otherwise specified, the control system enclosure shall be designed for bottom entry wiring and shall be suitable for the area classification and location specified.

E.5.1.8 A means shall be proved for cooling control system components as required.

E.5.1.8.1 If air cooling is used, the control cabinet shall be provided with multiple cooling fans. Failure of a single fan shall not cause over-temperature shutdown to occur.

E.5.1.8.2 If water cooling is used, provision shall be made to prevent problems from condensation.

E.5.1.9 Local electronics, if required, shall be provided. Local electronics shall be suitable for the specified area classification and for the specified ambient temperature and humidity range and vibration environment.

E.5.1.10 Supplier shall provide EMF filters on the control cabinet power supply, if required, to avoid contamination of input power by magnetic bearing power amplifiers.

E.5.1.11 Supplier's standard man-machine interface, if required, shall be provided. Unless otherwise specified, English language shall be used.

E.5.1.12 A system that shall provide power to the AMB system for a minimum required levitation time following loss of normal electric power supply shall be provided. The required levitation time shall be agreed**.**

E.5.1.13 The supplier's standard uninterruptable power supply/battery backup system shall be provided if a customer supplied system is not utilized.

E.5.2 Cabling

E.5.2.1 The supplier shall specify cabling requirements for the bearing power and sensor connections. Any electrical or electronic components required to adjust for the installed length shall be included in the supplier's scope of supply.

NOTE On systems where the cable distance between the machine and the control cabinet are long [100 m to 300 m (300 ft to 1000 ft)], special consideration is given to the electrical compensation and type of cable used to ensure proper operation. Electrical compensation can also be necessary for shop testing setups.

E.5.3 Rotor Position Sensors

E.5.3.1 Sensors shall be supplier's standard design with demonstrated operating experience.

E.5.3.2 Sensor components and assembly shall be compatible with the environment to which they are exposed.

E.5.3.3 The radial position sensors shall be located as close to the radial magnetic bearing as possible where practicable.

E.6 Inspection, Testing, and Preparation for Shipment

E.6.1 No Specific Requirement

E.6.2 No Specific Requirement

E.6.3 Testing

E.6.3.1 All electronic components shall have a 24-hour burn-in prior to shipment**.**

E.6.3.2 The dry insulation resistance of assembled bearing power coils shall be greater than 50 megohms when tested with a 500 Volt DC megohmmeter.

- **E.6.3.3** If specified, a "wet" bearing assembly insulation test shall be performed. Procedure and acceptance criteria shall be agreed.

E.6.3.4 The magnetic bearing control system shall be functionally tested prior to shipment. Functional test shall include, as a minimum, connection to a simulated load and demonstration of the system's monitoring functions.

- **E.6.3.5** If specified, static load capacity tests on all new bearing designs shall be performed. Bearing measured load capacity shall be equal to or greater than specified requirement.

E.6.3.6 Static and dynamic tests shall be performed using cables provided by the supplier. In general, these shall not be the same cables as that used in the field. The supplier shall allow for any special tuning adjustments in the design.

NOTE 1 Users will consider building up the actual machine skid for the mechanical test to reduce the likelihood of field retuning.

NOTE 2 A rotor ring test can also be advisable prior to machine assembly to improve the accuracy of higher rotor modes in the model.

E.6.3.7 The sensitive function measurement described in ISO 14839-3 (including the axial axis) shall be performed at 0 rpm prior to operating the machine for the mechanical test.

E.6.3.8 The peaks of the radial sensitivity functions measured in E.6.3.7 shall fall within zone A as defined in ISO 14839-3.

E.6.3.9 The peaks of the axial sensitivity functions measured in E.6.3.7 shall fall within zone B or better as defined in ISO 14839-3.

- **E.6.3.10** If specified, the sensitive function measurement described in ISO 14839-3 shall be performed at additional speed(s). The additional measured sensitivity function peaks shall also fall within the zones specified above.

E.6.3.11 While the equipment is operating at MCS, or other speed required by the test agenda, vibration data shall be acquired to determine amplitudes at frequencies other than synchronous. This data shall cover a frequency range from 0.25 to 8 times the MCS. If the amplitude of any discrete, nonsynchronous vibration exceeds 50 % of the allowable vibration as defined in 4.8.8.8, the purchaser and the supplier shall agree on requirements for any additional testing and on the equipment's acceptability.

This requirement replaces the requirements of Part 2: 6.3.1.2.2 and Part 4: 6.3.3.3.2.

- **E.6.3.12** If specified, short-term delevitations at specified operating conditions shall be performed during mechanical test and/or full-load test. The details of this test and the procedures followed, including any post-test auxiliary bearing inspection(s), shall be agreed.

NOTE The intent of this paragraph is to provide an option to use short (few seconds) delevitations at normal operating speed, followed by relevitation and normal AMB system operation, to confirm the basic operational characteristics of the auxiliary bearing system. It would be appropriate to stop the machine and perform lift checks and/or inspect the auxiliary bearings between multiple tests.

- **E.6.3.13** If specified, a coastdown from trip speed using the auxiliary bearing system, with the AMB system inactive, shall be performed during mechanical test and/or full-load test. The details of this test and the procedures followed, including any post-test auxiliary bearing inspection, shall be agreed.

NOTE If the mechanical test configuration coastdown time is significantly longer than the field coastdown time, this will not represent a valid test of the auxiliary bearing system's performance.

E.6.3.14 Damage to auxiliary bearing system components that did not compromise their ability to prevent contact at other close clearance locations, and did not cause secondary damage, does not constitute failure for the tests specified by either of E.6.3.12 or E.3.6.13.

NOTE Auxiliary bearings are considered to be a consumable machinery protective device. The AMB supplier can be consulted for guidance regarding auxiliary bearing reuse, refurbishment or replacement following these tests.

E.7 No Specific Requirement

E.8 Field, As-installed Analyses

NOTE Due to unmodeled structural dynamics and/or process condition effects, it can be necessary to fine-tune the AMB system based on actual machine field experience during commissioning. The intent of this section is to ensure that the final rotordynamics report reflects the installed tuning.

E.8.1 The final rotordynamics report shall include analyses performed with the AMB control system parameters used in the AMB system at the conclusion of initial commissioning.

E.8.2 The report shall indicate if the rotordynamic analyses with the as-tuned parameters meet the applicable requirements.

The analyses shall updated with the as-tuned parameters and reevaluated shall not include those related to the unbalance rotor response verification test described in 4.8.3 and/or the transfer function based procedure described in E.4.8.3.2 through E.4.8.3.11.

E.9 Reporting Requirements for Lateral and Stability Analysis

AMB systems shall have lateral analysis reports be in accordance with Annex C as applicable and with the additional requirements as follows.

E.9.1 Standard Lateral Analysis and Stability Report

E.9.1.1 AMB Data

a) General actuator and rotor component dimensions.

b) Auxiliary bearing gap(s) at 0 rpm and over the operating speed range.

c) Plot of allowable force versus frequency envelope, and identification of factor of safety assumed.

d) Identification of actuator coordinate system (generally ± 45° and axial).

e) Plots of AMB system displacement to force transfer functions that were used for the analytical rotordynamic predictions as amplitude and phase versus frequency (Bode plots). These shall be in physical (sensor-actuator) coordinates. Plots for cross coupling between the various axes shall be provided if there is significant coupling.

E.9.1.2 Undamped Results

a) Plot, as a minimum, a free-free map over the range of 0 to 150 % of N_{mc} and including all modes below 300 % of N_{mc}.

E.9.1.3 Unbalance Response Predictions

a) Plot predicted bearing forces relative to the allowable force envelope versus speed for each unbalance response case.

E.9.1.4 Level I Stability Analysis

a) Plots of predicted ISO 14839 sensitivity functions with twice Q_A applied.

b) The Level I stability plot specified in Figure C.2, augmented to show all modes required for analysis.

E.9.1.5 Level II Stability Analysis

a) Values of all log decrements for all modes required for analysis.

b) The peak values of the ISO 14839-3 sensitivity functions for each component, and the peak frequencies.

c) Plot(s) of the ISO 14839-3 sensitivity functions versus frequency with all components applied.

E.9.1.6 Axial Analysis

a) List of axial natural frequency and brief description or modeshape plot.

b) Plot of ISO 14839-3 sensitivity function for axial axis.

c) Peak value of sensitivity function plot.

E.9.1.7 Additional Plots

- Predicted closed loop transfer functions, with resonance peak frequencies and values annotated, if the optional closed loop verification test has been specified.

E.9.1.8 Auxiliary Bearings

Analytic results specified in E.4.9.4.4 and E.4.9.4.6 confirming no contact at close clearance locations.

E.9.2 Data Required to Perform Independent Audits of Lateral Analysis and Stability Reports

E.9.2.1 AMB Control/Actuator System Data to Permit Independent Analysis

a) Axial locations and angular orientations of sensors and actuators.

b) Coefficients for all required displacement to force transfer functions for lateral and axial analyses over a frequency range adequate to perform the required analyses. The force displacement functions includes the effects of all dynamic systems such as sensor, compensator, amplifier, sample rate, computational delays, eddy current effects, etc. These shall be provided for a coordinate system corresponding to the physical orientations of the sensors and actuators, not a transformed system (such as tilt-translate). If agreed, they may be supplied as first order system matrices.

c) Description of any significant variations in specific transfer function coefficients due to gain scheduling or other effects. A series of overall transfer functions for different speed ranges is also acceptable.

d) Actuator negative magnetic stiffness, and where applied, if required for model.

E.9.2.2 AMB Force Envelope

a) Force versus frequency operating envelope data in tabular format with brief explanation of what specific issues were considered.

b) Data to permit check on reasonableness of operating force envelope. This might include, for example:

   1) actuator nominal inductances,

2) nominal bias currents,

3) nominal power amplifier supply voltage,

4) nominal actuator force/current at 0 rpm for nominal radial load,

5) actuator/rotor materials and pole face area.

E.9.2.3 Auxiliary Bearings

a) Axial locations.

b) Type (i.e. angular contact, bushing), including dimensions, rotor/auxiliary bearing gap, coefficient of friction, geometry, and other pertinent information.

c) Force versus deflection curve, including the effects of hard stop if present.

d) Stiffness and damping provided by the auxiliary bearing and/or compliant mount system.

Annex F
(normative)

Dry Gas Seal Testing at Manufacturer's Shop

F.1 Test Procedure

This test procedure shall be followed on every purchased dry gas seal using the manufacturer's test rig to verify seal performance.

The test shall contain the following as a minimum.

The following data shall be recorded as required in F.2 or F.3:

a) time at which data is recorded;

b) seal gas temperature, seal gas pressure, and leakage flows (as read and as corrected to standard conditions);

c) static (breakaway) and test point torque;

d) process or test stand temperature and pressure;

e) seal gas leakage associated with the tandem seal primary and secondary outer leakage;

f) test speed in rpm;

g) power consumption (minus tare, if significant).

F.2 Static Test Procedure

a) Set the primary seal gas pressure to the maximum specified static seal gas pressure. Hold this pressure for a minimum of 10 minutes and record data. Reduce the pressure to 75 %, 50 %, and 25 % of the maximum specified static seal gas pressure. Hold at each pressure level and record static leakage at each step.

b) Set the secondary seal gas pressure to the maximum specified static seal gas pressure. Hold this pressure for a minimum of 10 minutes and record data. Reduce the pressure to 75 %, 50 %, and 25 % of the maximum specified static seal gas pressure. Hold at each pressure level and record static leakage at each step.

F.3 Dynamic Test Procedure

a) With the seal gas at the maximum specified pressure and temperature, and the primary vent at the minimum specified back pressure, increase the speed from stand still to MCS and run for at least 15 minutes, or until the primary seal leakage reaches steady state. Record data.

b) Increase the speed to trip speed (if higher than MCS) and run at least 15 minutes. Record data at 5-minute intervals.

c) Reduce the speed to MCS and run for at least 1 hour, recording data at 5-minute intervals. The average primary leakage shall be less than the maximum allowable leakage that was specified.

d) Increase the primary vent back pressure to the maximum value specified and run for at least 15 minutes. Record data.

e) Increase the primary vent back pressure (secondary seal gas pressure) to the maximum specified seal gas pressure.

This may require an increase in primary seal gas pressure to maintain a minimum ΔP on the primary seal.

Run for at least 15 minutes. Record data at 5-minute intervals.

NOTE The compressor manufacturer, based on his/her own standards and/or the user specification, can specify the seal gas temperature as the seal manufacturer's standard, if that has been proved acceptable, or the maximum seal gas temperature anticipated in the field. This can vary widely, and a judgment needs to be made by the purchaser of the seal as to whether the seal gas temperature in the field will be high enough that it should be simulated in the seal test.

f) Perform two consecutive shutdowns and restarts to MCS as fast as possible to trip speed and then reducing the speed to MCS. Hold the speed for 5 minutes or until the leakage reaches steady state. Record a complete set of data at rest and at speed. Maintain primary seal gas pressure and secondary seal gas pressure from Item e) above.

g) Shut down the rig and maintain specified seal gas conditions. Record two consecutive sets of data immediately following shutdown.

F.4 Visual Inspection

a) Following the test, disassemble the seal while insuring that all critical parts are match-marked with respect to circumferential orientation and examine components for wear, buildup, and general condition.

b) Tabulate condition on "prepared form" and make it part of the summary report.

F.5 Static Test Verification

a) Reassemble the seal paying particular attention to match marks and replace it in the test rig.

b) Repeat F.2.

F.6 Report

Supplier shall issue a detailed test report. This report shall document test run parameters including time, speed, and leakage rates.

Annex G
(informative)

Guidelines for Anti-surge Systems

Surge in Centrifugal or Axial Compressors

Surge is a characteristic behavior of an axial or centrifugal compressor that can occur when inlet flow is reduced such that the head developed by the compressor is insufficient to overcome the pressure at the discharge of the compressor. Once surge occurs, the output pressure of the compressor is drastically reduced, resulting in flow reversal within the compressor. This flow reversal may result in compressor or system damage resulting from the following:

a) A reversal of significant mass flow that can result in large dynamic forces on the impeller or blading within the compressor, on components of the compressor exposed to large changes in axial force on the rotor such as thrust bearings, bearing, housings or their attachment to the compressor casing and piping connected to the compressor. Left uncorrected, surge may result in fatigue damage to compressor or piping components.

b) A reversal of flow within the compressor results in hot compressed gas returning to the compressor inlet to be recompressed once flow is stabilized to a point to restore normal flow within the compressor. Left uncorrected, surge can result in ever increasing temperatures within the compressor leading to potential rubs created by differential expansion of components within the compressor.

c) A reversal of flow may lead to process related problems that could shut down a plant.

As a result of the potential for damage to critical compressors or associated piping systems, a multifaceted approach is required. The following items should be addressed when evaluating surge prevention.

a) A prediction of the compressor operating characteristics where surge shall occur is required at specified operating conditions.

b) Develop an algorithm that can use measured inputs for a control system to take corrective action to prevent surge.

c) Design a flow path other than the normal process piping that can blow off gas at the compressor discharge to atmosphere, or in cases where gas cannot be vented to the atmosphere, a recycle system to cool discharge gas and reroute it to the compressor inlet.

d) During the commissioning phase of the compressor, start-up tests should be conducted to identify either the actual surge point of the compressor or the point at which the anti-surge system responds to a reduction in the process inlet volume to the compressor. The ability of the anti-surge system to prevent surge as the process inlet volume is further reduced should also be verified. Whether or not to validate the actual surge point in the field might depend upon how surge might upset process operations or the potential for damage to piping systems especially if high gas densities are involved.

e) The user should consider whether the anti-surge system should be tied into the process alarm parameters. An alternate anti-surge response signal may be possible to provide warning to operators that process inlet volume is reducing and activation of the anti-surge control system is eminent.

f) In the event a surge system does not function as intended, a system needs shall designed to detect that surge has occurred to alert operators so that corrective action can be taken to get the machine out of surge or shut the machinery down.

For additional reference documents, see Item [21] in the bibliography.

Annex H
(informative)

Typical Bid Tab Template

A columnar bid tab in Microsoft Excel format is offered as a template for evaluating bids from suppliers. This form may be used or not or modified or not at the purchaser's discretion. This template is only available in electronic format.

H.1 Cover

		QUOTATION SUMMARY			
CENTRIFUGAL COMPRESSOR					
Service				Date	
Project name				Revision	
Project number				By	
Tag number					
Location					
	Guarantee	Rated			
Capacity			cfm		
Inlet pressure			psia		
Discharge pressure			psia		
Gas MW					
Inlet temperature			F		

H.2 Technical Compressor

		Specification			
1	Manufacturer		Manufacturer A	Manufacturer B	Manufacturer C
2	Point of Manufacture				
3	Compressor Model Number				
4	Number of Impellers				
5	Performance				
	Guarantee point				
a	Capacity (cfm)	0			
b	Inlet pressure	0			
c	Discharge pressure	0			
d	Gas MW	0			
e	Inlet temperature	0			
f	Outlet temperature				
g	Polytropic head				
h	Polytropic efficiency				
i	BHP				
	Rated point				
a	Capacity (cfm)	0			
b	Inlet pressure	0			
c	discharge pressure	0			
d	Gas MW	0			
e	Inlet temperature	0			
f	Outlet temperature				
g	Polytropic head				
h	Polytropic efficiency				
i	BHP				
6	Number of Casings				
7	Bearing/Seal Losses, HP				
8	Speeds				
a	Max. design limit speed				
b	Rated speed/max. continuous speed (rpm)				
c	Trip speed (rpm)				
d	1st and 2nd critical speeds (rpm)				
e	Amplification Factor—first critical				
9	Poly. Head/Stage @ Guaranteed Point (ft-lb/lb)				
10	Maximum Compressor Design Pressure				
11	Minimum Compressor Design Pressure Including				
	Minimum Suction Pressure at Which Seals				
	Can Properly Operate				
12	Discharge Temperature Guaranteed Point (°F)				
13	Max. Discharge Temperature at Surge				
	and at Max Continuous Speed (°F)				
14	Max. Allowable Discharge Temperature				
	for This Casing/Seal Arrangement				
15	Min. Allowable Inlet Temperature				
16	Percent Capacity @ Surge for Guarantee Case				
17	Percent Head Rise to Surge @ Guarantee Speed				
18	Casing Construction				
a	Casing split (H or V)				
b	Material of construction				
c	Thickness (in.)				
d	Corrosion allowance (in.)				
e	Max. allowable working pressure				
f	Max. design pressure				
g	Test pressure (hydro) (psig)				
h	Cast or fabricated				
i	First casting from new pattern (y/n)				
j	Max. operating temperature (°F)				
k	Max. casing design temperature (°F)				
l	Min. operating temperature (°F)				
m	Min. casing design temperature (°F)				
n	Max. number of impellers for casing				

o	Max. casing capacity (icfm)				
p	Casing split sealing (O-ring or no O-ring)				
19	Diaphragms				
a	Material of construction	steel			
20	Nozzles				
a	Suction nozzle				
1)	Size (in)				
2)	ANSI rating				
3)	Max gas velocity (fps) worse operating case				
4)	Orientation	down			
5)	Material				
b	Discharge nozzle				
1)	Size (in.)				
2)	ANSI rating				
3)	Max gas velocity (fps) worse operating case				
4)	Orientation	down			
5)	Material				
c	Side streams				
1)	Size (in.)				
2)	ANSI rating				
3)	Max gas velocity (fps) worse operating case				
4)	Orientation	down			
5)	Material				
6)	Pressure				
d	Number of casing drains				
1)	Size (in.)				
2)	ANSI rating				
21	Impellers (following data required for each impeller)				
a	Methods of fabrication				
b	Material of construction				
c	Type impeller (open, semi-open, closed)				
d	Number of impellers				
e	Impeller/diffusers (stages) that have				
	single stage test data				
f	Total number of impellers per section				
g	Number vanes each impeller				
h	Diameter quoted/max. diameter (in.)				
i	Tip width each stage/smallest tip internal width (in.)				
j	Max. inlet relative mach number cover side				
	impeller blade for worse operating case				
k	U2/Ao for process guarantee condition				
	Rated condition				
l	Impeller flow coefficient ($700Q/Nd^3$) for largest impeller				
m	inlet guide vane setting				
n	Maximum allowable impeller speed				
o	Impeller max. stress @ rated speed (psi)				
p	Impeller maximum allowable stress (psi)				
q	Impeller max. yield strength (psi)				
r	Max. speed of compressor				
	component setting speed limit				
s	Impeller Hardness (Rc)				
t	Percent backward lean				
u	Impeller lineup				
v	Inducers (yes/no)				
22	Diffusers				
a	Type (vaned/vaneless)	vaneless			
b	Material of construction				
23	Shaft				
a	Method of fastening wheels to shaft				
b	Material of construction				
c	Dia.@ impeller/dia.@ cplg/dia.@ brg. (in.)				
d	Shaft end configuration (tapered)				
e	Max. yield strength				
f	Shaft stress at cplg (allowable/actual)(psi)				
g	Bearing center line to center line distance (in.)				

24	Balance Piston				
a	Material of construction				
b	Actual diameter/max. diameter for casing (in.)				
c	Type labyrinths (straight, stepped)				
25	Shaft Seals				
a	Type (pumping type, fluid film, contact)	dry gas			
b	Seal system type				
c	Settling out pressure (psig)				
d	Seal design pressure (max./min.) (psig)				
e	Inner seal oil leakage guar. (gal/day/seal)				
f	Process gas/seal oil diff. pressure				
	corresponding to 'e' (psi)				
g	Min. speed for pumping seal (rpm)				
h	Buffer gas flow per seal (lb/min.) (psi)				
i	Process gas/buffer gas diff. pressure				
	corresponding to 'h' (psi)				
j	Supplier of buffer gas control system				
26	Shaft Sleeves				
a	End shaft sleeves and material				
b	Interstage shaft sleeves and material				
27	Labyrinths				
a	Interstage (type/material)				
b	Balance piston (type/material)				
c	Balance piston losses				
28	Radial Bearings				
a	Type	tilt-pad			
b	No. segments				
c	Load on pad/between pad				
d	Loading (allowable/actual) (psi)				
e	Pivot (center, offset/percent)				
f	Pad material				
g	Type babbitt				
h	Babbitt thickness				
i	Lube oil usage				
j	L/D				
29	Thrust Bearings				
a	Location				
b	Type	Kingsbury			
c	Manufacturer				
d	Area (in.^{2})/no. segments				
e	Loading (allowable/actual) (lb)				
f	G's loading (lb)				
g	Coupling slip load (lb)				
h	Coupling coefficient of friction				
i	Coupling gear pitch radius (in.)				
j	Balance piston compensating load (lb)				
k	Thrust collar mounting (hydraulic/shrink fit)				
l	Pivot (center, offset/percent)				
m	Pad material				
n	Type babbitt				
o	Babbitt thickness				
p	lube oil usage (gpm)				
30	Bearing Housing Construction				
a	Type/split				
b	Material of construction				
31	Couplings				
a	Driver-comp. or driver-gear				
1)	Manufacturer				
2)	Coupling type/spacer length				
3)	Coupling fit (hyd., taper, etc.)				
4)	Make				
5)	Model				
6)	Coupling rating (HP/100 rpm)				
b	Gear-compressor				
1)	Manufacturer				
2)	Coupling type/spacer length				
3)	Coupling fit (hyd., key, taper, etc.)				

4)	Make				
5)	Model				
6)	Coupling rating (HP/100 rpm)				
b	Gear-compressor				
1)	Manufacturer				
2)	Coupling type/spacer length				
3)	Coupling fit (hyd., key, taper, etc.)				
4)	Make				
5)	Model				
6)	Coupling rating (HP/100 rpm)				
32	Baseplate or Soleplates				
	Baseplate includes:				
a	Compressor(s)				
b	Gear				
c	Driver				
d	Junction boxes				
e	Gas seal panel				
f	Baseplate one-piece for string or multiple piece				
g	Ship complete or do some major items need to be removed				
33	Lube and Seal System (Separate/Combined)				
	(Combined With Booster)				
34	Overhead Seal Rundown Tank Capacity (gal)				
35	Lube Oil Overhead Rundown Tank Capacity (gal)				
a	Type (pressurized or nonpressurized)				
b	Material				
36	Lube Oil Clarifier				
37	Local Gauge Boards				
38	Vibration Monitoring Equip. Mfg.	BN			
39	Performance Curves				
40	Spare Parts List				
41	Winterization				
42	Noise Level Guarantee				
43	Recommended Straight Run of Pipe Diameters Before Suction				
44	Driver, BHP				
45	Gear, BHP				
46	Space Requirement (ft and in.)				
	Compressor L/W/H				
	Lube oil console L/W/H				
	Seal oil console L/W/H				
47	Weights				
a	Compressor/gear/driver/base				
b	Rotors for compressor/driver/gear				
c	Compressor upper case				
d	Max. wt. for maintenance (identify)				
e	Total shipping wt.				
48	Rotor Inertial WR^2 (lb-ft²) Referenced				
	to Low Speed Shaft for Motor Drives				

H.3 Technical—Aux Systems

	Specification				
Gear Increaser					
Manufacturer					
Model					
Unit rated power, kW					
Mechanical rating, kW					
Gear service factor					
Input speed					
Output speed					
Mech. efficiency, %					
Tooth pitting index, act./allow. %					
Pinion bending stress, act./allow. %					
Gear bending stress, act./allow. %					
Pitch line velocity, mps					
Gear to shaft fit					
Rim attachment					
Number of teeth pinion/gear					
Gear ratio					
Pinion tooth hardening method					
Gear tooth hardening method					
Tooth generation process					
Tooth finish process					
Lead modification					
Gear casing material					
Oil seal material					
Pinion bearing type					
Pinion bearing material					
L/D					
Gear bearing type					
Gear bearing material					
L/D					
Thrust bearing type					
Oil flow—pinion bearing					
Oil flow—gear bearing					
Oil flow—thrust					
Oil flow—gear mesh					
Oil flow—total					
Oil grade					
LS Coupling (motor to gear)					
Manufacturer					
Model					
SF					
Disk pack material					
Axial shim material					
Shaft separation					

HS Coupling (gear to comp)					
Manufacturer					
Model					
SF					
Disk pack material					
Axial shim material					
Shaft separation					
Lube Oil Console					
Manufacturer					
Total oil flow, m^3/h					
Total heat load, kW					
Oil type					
Dimensions L*W*H, m					
Piping material					
Tubing material					
Tubing fittings					
Reservoir working cap., min./liter					
Reservoir charge cap., liter					
Pump manufacturer					
Coupling manufacturer					
Filter manufacturer					
Filter rating , micron					
Filter material					
Exchanger manufacturer					
Exchanger type					
Exchanger duty, kW					
Tube length					
Tube OD/BWG					
Tube, tubesheet material					
Accumulators—number					
Accumulator volume, liter					
Accumulator shell material					
Accumulator bladder material					
Rundown tank—number					
Rundown tank volume, C-50 liter					
Rundown tank volume, C-150 liter					
Runown tank material					

H.4 Commerical

Currency conversion		1 Dollar =		Euro			
			purchased options		purchased options		purchased options
Manufacturer		**Manufacturer A**		**Manufacturer B**		**Manufacturer C**	
Frame descriptor		0		0		0	
Base bid							
Options							
Spares							
Shipping charges							
Total Purchase Price (dlrs)							
Total Purchase Price (Euro)							
Power evaluation							
Payment terms							
Total Evaluated price							
Delivery time							
Warantee							

H.5 Summary

H.6 Comments Manufacturer A

		Manufacturer A	
Status	Item. No.	Comment	Resolution

H.7 Comments Manufacturer B

		Manufacturer B	
Status	Item No.	Comment	Resolution

H.8 Comments Manufacturer C

		Manufacturer C	
Status	Item No.	Comment	Resolution

H.9 Instructions

Cover	
	Items with borders should be filled in.
Technical	
	The specified column alllows the user to pre-fill in specified items. Bordered items are typically pre-specified.
	Specified guarantee and rated conditions are linked from the cover page.
	Send the cover and technical tabs only to each supplier to fill out. You can then paste each of the supplier's comments
	from the technical tab and flag items to question by shading cells.
	A registry of comments from each supplier along with the resolution should be set up. Worksheets are furnished for
	each supplier to do this in this spreadsheet.
Commercial	
	Provided format is sketchy but covers the major items that need to be evaluated. A net present value analysis
	should be done on the basis of payment terms, and cost of energy can be included to evaluate power differences.
	If multiple currencies are quoted, convert to a common currency or show each bidder for both currencies.
	Columns E, G, and I should be used to tabulate options that will actually be purchased. The total price of these columns
	will then reflect the actual price of the PO and evaluated price of all offerings.

Annex I
(informative)

Full-load/Full-pressure/Full-speed Testing

This annex discusses the more typical optional load tests available for centrifugal compressors. These tests, due to their complexity and cost, should be fully discussed, with objectives defined, prior to equipment order.

I.1 ASME Class I Test (Type 1 per ASME PTC-10, 1997)

This test should not be confused with a full-load/full-pressure (FLFP) hydrocarbon test. This is a hydraulic performance test on the SPECIFIED gas at specified guarantee point inlet conditions and speed. Mechanical integrity under actual performance conditions is demonstrated. The Class I test may be performed using a shop driver or the contract driver. Typically, contract lube oil and seal systems are utilized. This is a very special test with specific requirements. It is recommended that all test requirements/objectives (such as number and location of test points, acceptance criteria, gas property equations of state, speeds etc.) be identified and agreed, in writing, between the client and supplier before a final cost is estimated and quoted.

The description of the test, given below, is typical of the supplier standard offering. If any additional data points are required, they should be identified and agreed.

Typically, the supplier performs a MODIFIED Class I test. Test capabilities (ambient conditions, cooling capabilities, etc.) may dictate operation at inlet temperatures other than those specified at the guarantee conditions. Secondly, the supplier cannot typically use the exact specified gas. Most often it is a gas blend of local pipeline gas with commercially available gases such as propane, carbon dioxide and nitrogen. The gas blend is typically designed to match the specified inlet density and k value at the test inlet temperature. Under these conditions the observed values of head, pressure ratio and horsepower will be the same as observed during operation in the field under specified conditions. This test also simulates any aerodynamic excitation imparted to the rotor/bearing system relative to field operation at the specified operating conditions.

The modified Class I test is conducted at the design speed of the guaranteed condition as identified during the Class III inert gas performance test (all units subject to a Class I test shall be tested under Class III). Five data points are read from overload to within 10 % of surge (inside the proposed surge control line), units will NOT be purposely surged during this test. Units having more than one section typically will be tested one section at a time, although if the same test gas blend may be utilized in each section the supplier may consider conducting both tests simultaneously (NOTE This is at supplier's discretion). The duration of the test is the time it takes to obtain the five data points.

If a contract driver is to be used review of the test site ambient conditions and/or facility restrictions need to be reviewed with the suppliers test department personnel. For example, a gas turbine may not be able to generate design power at the elevation and temperature of the supplier's test facility. The steam conditions required, for a contract steam turbine, may exceed test boiler capability or electrical facilities, for a contract motor, may not be adequate.

The contract lube and seal systems may be used (or be required to be used).

Typical acceptance criteria:

Supplier typically would guarantee test results to be within the following parameters.

Observed head will be ± 4 % of specified head at the specified speed established via the Class III test.

Observed Brake Horsepower will be ± 5 % of power established by Class III test. ***NOT ± 5 % of guarantee horsepower***. The horsepower guarantee is confirmed by the Class III test.

Typical questions:

Why is the horsepower ± 5 % of the established horsepower at specified conditions based on the Class III test and not ± 4 % of the guaranteed value?

Typically, the instrumentation used is not as accurate as the instrumentation used for the Class III test. For example, static pressure is measured during the Class I test v. total pressure during Class III testing. Thermowells are used instead of total temperature probes inserted directly in the gas stream. Gas property uncertainties of the specified test gas may contribute to errors. The gas properties of Class III test mediums are well known, whereas the properties of hydrocarbon mixtures are predicted.

What equations of state are used to predict the gas properties?

Supplier will evaluate various equations of state for the specified gas and select, with discussion and agreement with the client, the best equation for the particular application. Typically, BWRS (Benedict-Webb-Reuben-Starling), Lee-Kesler, SRK (Soave-Redlich-Kwong), or Peng Robinson are considered.

Will the compressor be run back into surge to establish the turndown/stability?

This is not done. To demonstrate that the unit has adequate stability a data point(s) is normally taken between the surge line and the surge control line to demonstrate stable operation.

I.2 FLFP Hydrocarbon Test

This is a mechanical integrity test and not a hydraulic performance test. This test is typically 4 hours in duration with the unit at design DISCHARGE pressure and design HORSEPOWER at MCOS (max continuous speed). Either a shop driver or the contract driver may be used. Design inlet temperature and pressure may not be the same as specified. Typically, the design molecular weight is matched by blending local pipeline gas with CO_2, However a lighter than design mixture may be used to facilitate operation. For example, a mole weight less than design (or heavier) may be used to achieve both design discharge pressure and horsepower simultaneously. In some cases matching discharge pressure and horsepower simultaneously is not possible. In these cases, the discharge pressure can usually be matched for 2 hours then the horsepower can be matched for the remaining 2 hours. Vibration acceptance levels are typically higher than those specified for the low pressure testing defined in the body of this standard.

The test is run at one operating condition throughout the test (unless discharge pressure and horsepower cannot be met simultaneously). This test also produces aerodynamic excitation imparted to the rotor/bearing system, however, the level may not be an exact match to field operation at the specified operating conditions.

If a contract driver is to be used a review of the test site ambient conditions and/or facility restrictions need to be made with the supplier. For example, a gas turbine may not be able to generate design power at the elevation and temperature of the supplier's test facility. The steam conditions required, for a contract steam turbine, may exceed test boiler capability or electrical facilities, for a contract motor, may not be adequate.

The contract lube and seal systems may be used (or required to be used).

All test objectives and acceptance criteria need to be documented before final quotation of such a test.

Typical questions:

Will the unit be surged during the test run?

No. The unit is operated at a single flow point on the compressor map.

Will the performance of the unit be guaranteed?

No. The unit is operated at a volume reduction ratio other than design. The performance is monitored relative to the predicted performance on the test blend but no tolerances or guarantees are typically placed on the observed parameters.

I.3 FLFP Inert Gas Test

This is a mechanical integrity test NOT a hydraulic performance test. This test is 4 hours in duration with the unit at design DISCHARGE pressure and design HORSEPOWER at MCOS (max continuous speed). Either a shop driver or the contract driver may be used. Design inlet temperature and pressure may not be the same as specified. Typically, the test molecular weight is lower than design to keep the final discharge temperature below maximum allowable levels as inert gases available have a higher K value than the design gas. In some cases matching discharge pressure and horsepower simultaneously is not possible. In these cases, the discharge pressure is matched for 2 hours then the horsepower is matched for the remaining 2 hours. Vibration acceptance levels are typically higher than those specified for the low pressure testing defined in the body of this standard.

Inert gases utilized are helium, nitrogen, helium-nitrogen mixtures, CO_2 and CO_2-nitrogen mixtures.

The test is run at one operating condition throughout the test. This test also produces aerodynamic excitation imparted to the rotor/bearing system; however, the level may not be an exact match to field operation at the specified operating conditions.

If a contract driver is to be used a review of the test site ambient conditions and/or facility restrictions need to be made with the supplier. For example, a gas turbine may not be able to generate design power at the elevation and temperature of the supplier test facility. The steam conditions required, for a contract steam turbine, may exceed test boiler capability or electrical facilities, for a contract motor, may not be adequate.

Contract lube and seal systems may be used (or required to be used).

All test objectives and acceptance criteria should be documented.

Typical questions:

Will the unit be surged during the test run?

No. The unit is operated at a single flow point on the compressor map.

Will the performance of the unit be guaranteed?

No. The unit is operated at a volume reduction ratio other than design. The performance is monitored relative to the predicted performance on the test blend but no tolerances or guarantees are to be placed on the observed parameters.

I.4 Magnetic Bearing Exciter Test Option with FLFP Inert or Hydrocarbon Gas Test

This test option provides a measure of the remaining damping in a rotor/bearing system while a compressor is operating at load under inert or hydrocarbon gas test conditions with the same limitations as noted above. Several of the above tests can indicate whether a rotor/bearing system is stable at the testing conditions. This test option demonstrates, through use of a magnetic bearing exciter, the log dec remaining (stability level) in the rotor/bearing system while operating under load. The specifics of the FLFP inert or hydrocarbon gas test with magnetic bearing exciter option need to be discussed with the supplier as the test conditions may be set up slightly different to better match the field predicted aero cross-coupling values

Bibliography

[1] API Recommended Practice 520, *Sizing, Selection, and Installation of Pressure-relieving Devices in Refineries Part 1—Sizing and Selection*, Eighth Edition

[2] API Standard 605, *Large-diameter Carbon Steel Flanges (Nominal Pipe Sizes 26 Through 60, Classes 75, 150, 300, 400, 600, and 900)*, Fourth Edition

[3] API Standard 671, *Special Purpose Couplings for Petroleum, Chemical and Gas Industry Services*

[4] API Standard 672, *Packaged, Integrally Geared Centrifugal Air Compressors for Petroleum, Chemical, and Gas Industry Services*

[5] API Standard 673, *Centrifugal Fans for Petroleum, Chemical and Gas Industry Services*

[6] API Recommended Practice 684, *API Standard Paragraphs Rotordynamic Tutorial: Lateral Critical Speeds, Unbalance Response, Stability, Train Torsionals, and Rotor Balancing*, Second Edition, August 2005

[7] API Recommended Practice 686, *Machinery Installation and Installation Design*, Second Edition, December 2009

[8] API Recommended Practice 687*, Rotor Repair,* First Edition, September 2001

[9] ASTM A193 [11], *Standard Specification for Alloy-steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications*

[10] ASTM A194, *Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both*

[11] ASTM A563, *Standard Specification for Carbons and Alloy Steel Nuts*

[12] ASTM A515, *Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher Temperature Service*

[13] ASME B1.20.1 [12], *Pipe Threads, General Purpose (Inch)*

[14] ASME B31.3, *Process Piping*

[15] ASME *Boiler and Pressure Vessel Code, Section VIII: Vessel Design and Fabrication*

[16] ASME PTC 36, *Measurement of Industrial Sound*

[17] ISO 3740 [13], *Acoustics—Determination of sound power levels of noise sources—Guidelines for the use of basic standards*

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11 ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org.

12 ASME International, 2 Park Avenue, New York, New York 10016, www.asme.org.

[18] ISO 3744, *Acoustics—Determination of sound power levels of noise sources using sound pressure—Engineering method in an essentially free field over a reflecting plane*

[19] ISO 3746, *Acoustics—Determination of sound power levels of noise sources using sound pressure—Survey method using an enveloping measurement surface over a reflecting plane*

[20] ISO 10494, *Gas turbine and gas turbine sets—Measurement of emitted airborne noise—Engineering/survey method*

[21] Gas Machinery Research Council/Southwest Research Institute/Release Version 4.3 April 2008, "GMRC Guideline–Release Version 4.3 Application Guideline for Centrifugal Compressor Surge Control Systems," pp. 1–75, http://www.gmrc.org/documents/GMRCSurgeGuideline.pdf

[13] International Organization for Standardization, 1, ch. de la Voie-Creuse, Case postale 56, CH-1211 Geneva, Switzerland, www.iso.org.

Axial and Centrifugal Compressors and Expander-compressors

Part 2—Nonintegrally Geared Centrifugal and Axial Compressors

1 Scope

This part of API 617 specifies minimum requirements and gives recommendations for axial compressors, single-shaft and integrally geared process centrifugal compressors, and expander-compressors for special purpose applications that handle gas or process air in the petroleum, chemical, and gas industries. This part of API 617 specifies requirements for nonintegrally geared centrifugal and axial compressors, in addition to the general requirements specified in API 617, Part 1. These machines do not have gears integral with their casing but can have external gears.

NOTE See Part 3 for integrally geared process compressors or API 672 for packaged plant instrument air compressors.

2 Normative References

Referenced documents indispensable for the application of this document are listed under Part 1, Section 2.

3 Terms, Definitions, and Abbreviations

For the purposes of this document, the terms, definitions, and abbreviations given in Part 1 apply.

NOTE Figure 1 is a typical operating map for a centrifugal compressor. Figure 2 and Figure 3 are typical operating maps for an axial compressor. Certain terms are depicted graphically in these figures.

4 General

4.1 Dimensions and Units

The dimensional and unit requirements of Part 1 shall apply.

4.2 Statutory Requirements

The statutory requirements of Part 1 shall apply.

4.3 Unit Responsibility

The unit responsibilities of Part 1 shall apply.

4.4 Basic Design

4.4.1 Performance

4.4.1.1 The sectional head-capacity characteristic curve shall rise continuously from the rated point to predicted surge. The compressor, without the use of a bypass, shall be suitable for continuous operation at any capacity at least 10 % greater than the predicted surge capacity shown in the proposal.

4.4.1.2 The supplier shall provide an overload limit for axial compressors to avoid damaging blade stresses.

4.5 Materials

Materials shall be in accordance with 4.5 of Part 1.

NOTE Refer to Annex D for typical materials.

4.6 Casings

Casings shall be in accordance with 4.6 of Part 1 and 4.6.1 through 4.6.6, as follows.

4.6.1 Pressure-containing Casings

4.6.1.1 The purchaser will specify the relief valve set pressure. The maximum allowable working pressure (MAWP) of the casing shall be at least equal to the specified relief valve set pressure.

4.6.1.1.1 When a relief valve set pressure is not specified, the MAWP shall be at least 125 % of the maximum specified discharge pressure (gauge). System protection shall be furnished by the purchaser.

4.6.1.2 Casings designed for more than one maximum allowable pressure level (split pressure-level casings) are permitted only in process air service with an atmospheric pressure inlet. Split pressure-level casings are not permitted in other services unless specifically approved by the purchaser. If approved, the supplier shall define the physical limits and the MAWP of each section of the casing.

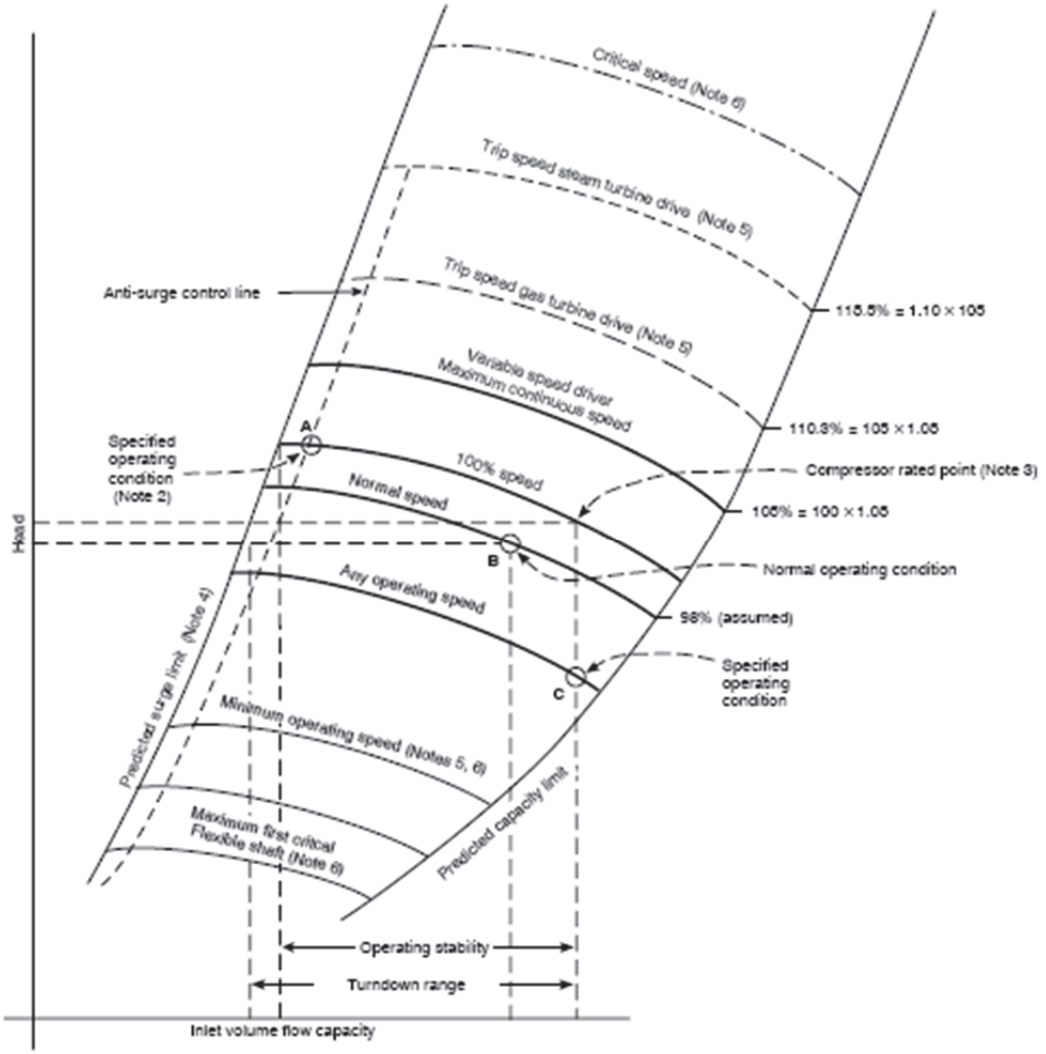
4.6.1.3 Unless otherwise specified, casings shall be radially split when the partial pressure of hydrogen (at MAWP) exceeds 1380 kPa gauge (200 psi gauge). The partial pressure of hydrogen shall be calculated by multiplying the highest specified mole (volume) percent of hydrogen by the MAWP.

4.6.1.4 Each axially split casing shall be sufficiently rigid to allow removal and replacement of its upper half without disturbing rotor-to-casing running clearances and bearing alignment.

4.6.1.5 Axially split casings shall use a metal-to-metal joint (with a suitable joint compound compatible with the process gas) that is tightly maintained by suitable bolting. Gaskets (including string type) shall not be used on the axial joint. O-rings retained in grooves machined into the flange facing of an axially split casing joint may be used with purchaser's approval.

4.6.1.6 Radially split casings normally use O-rings, gaskets, or other sealing devices between the end head(s) and cylinder. These devices shall be confined in machined grooves, and they shall be made of materials suitable for all specified service conditions.

4.6.1.7 Socket-head or spanner-type bolting shall not be used externally unless specifically approved by the purchaser.



NOTES:

1) Except where specific numerical relationships are stated, the relative values implied in this figure are assumed values for illustration only.
2) The 100 % speed curve is determined from the operating point requiring the highest head; point A in the illustration.
3) The compressor rated point (CRP) is the intersection on the 100% speed line corresponding to the highest flow of any operating point; point C in the illustration.
4) The head-capacity curve at 100 % speed should extend to at least 115 % of the capacity of the CRP.
5) These points define the “approximate capacity limit curve.
6) Refer to the applicable standard for the compressor driver such as API 612 or API 616 for trip speed and minimum operating speed limits.
7) Refer to 4.8.2.9, Figure 2 and 4.8.7 of Part 1 for allowable margins of critical speeds to operating speeds.

Figure 1—Centrifugal Compressor Performance Map—Illustration of Terms

4.6.2 Casing Repair

Casings repairs shall be in accordance with 4.6.2 of Part 1.

4.6.3 Material Inspection of Pressure-containing Parts

Casings material inspection of pressure-containing parts shall be in accordance with 4.6.3 of Part 1.

4.6.4 Pressure Casing Connections

Pressure casing connections shall be in accordance with 4.6.4 of Part 1 and the following paragraphs.

4.6.4.1 Main inlet and outlet connections for radially split machines shall be located in the outer casing, not in the end heads. On radially split overhung design machines, the process inlet connection may be in the end head.

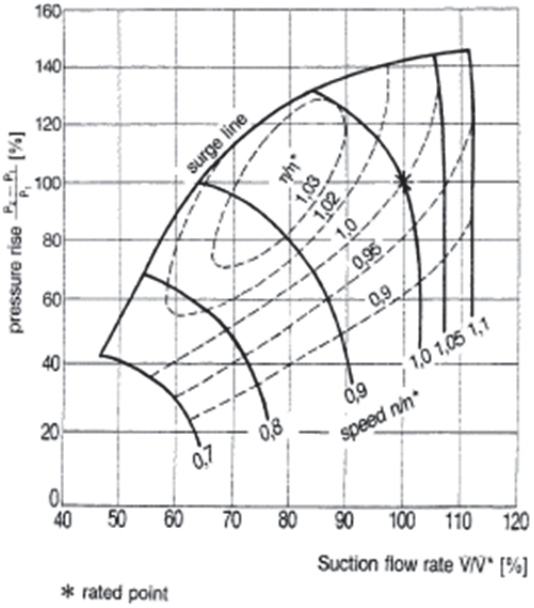


Figure 2—Axial Compressor Performance Map—Variable Speed

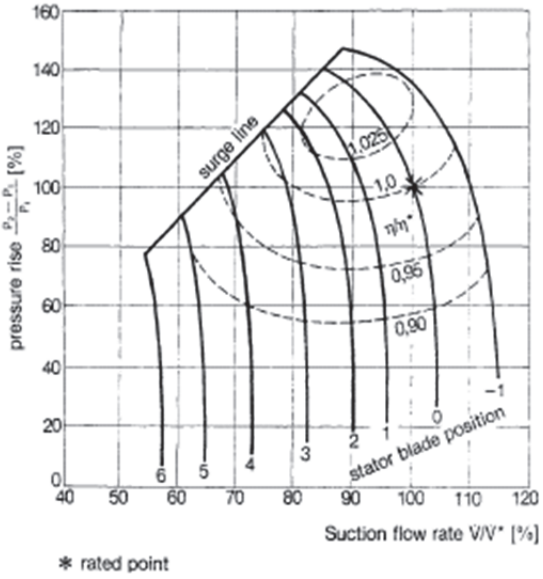


Figure 3—Axial Compressor Performance Map—Variable Stator Vanes

4.6.4.2 Auxiliary connections shall be at least DN 20 ($^3/_4$ in. nominal pipe size).

NOTE See 4.6.4.1.3 of Part 1 for allowable connection sizes.

4.6.4.3 Threaded connections for pipe sizes DN 20 (NPS $^3/_4$ in.) through DN 40 (NPS $1^1/_2$ in.) sizes are permissible with the approval of the purchaser.

NOTE See 4.6.4.1.3 of Part 1 for allowable connection sizes.

- **4.6.4.4** If specified, connections for borescopic examination shall be supplied in agreed locations.

4.6.5 Casing Support Structures

Refer to 4.6.5 of Part 1 for casing support structure requirements.

4.6.6 External Forces and Moments

4.6.6.1 The compressor shall be designed to withstand external forces and moments on each nozzle calculated per Annex F. The supplier shall furnish the allowable forces and moments for each nozzle in tabular form.

4.6.6.2 Casing and supports shall be designed to have sufficient strength and rigidity to limit coupling movement caused by imposing allowable forces and moments to 50 µm (0.002 in.).

4.6.7 Guide Vanes, Stators, and Stationary Internals

- **4.6.7.1** If specified or required to meet specified operating conditions, adjustable inlet guide vanes (AIGVs) on centrifugal compressors shall be supplied.

- **4.6.7.2** If specified or required to meet specified operating conditions, variable stators on axial compressors shall be supplied.

NOTE All or some of the stator blade rows can be adjustable.

4.6.7.3 The guide vane housing shall incorporate an external shell capable of providing an external purge of filtered air or inert gas.

4.6.7.4 A vane control system consisting of a positioner with direct driven local position indicator shall be provided that will be visible during operation of the machine.

4.6.7.5 Additional components to the vane control system in 4.6.7.4 shall be as specified.

4.6.7.6 Guide vanes shall be mounted in replaceable bushings. Vanes may be positioned in the housing by replaceable permanently sealed rolling element bearings if approved by the purchaser.

4.6.7.7 When inlet guide vanes or variable stators are used for toxic, flammable, or explosive process gas, the linkage passing through the casing or enclosure shall be sealed to prevent leakage.

4.6.7.8 The inlet guide vanes shall be located sufficiently close to the eye of the impeller to be effective.

4.6.7.9 The vanes shall open on loss of the control signal.

4.6.7.10 When intermediate main suction or discharge process connections are used, the purchaser shall specify the maximum differential pressure between the connections if intermediate check valves are used. The supplier shall design the intermediate diaphragm between the process connections for the expected maximum differential including a suitable safety factor as agreed.

4.6.8 Internal Joints

4.6.8.1 Internal joints shall be designed to minimize leakage and permit ease of disassembly.

4.6.9 Seal Components

4.6.9.1 Seal components shall be separate parts and be renewable or replaceable in order to restore design clearances.

4.6.10 Diaphragms

4.6.10.1 Diaphragms shall be axially split unless otherwise approved by the purchaser. The diaphragms shall be furnished with threaded holes for eyebolts or with another means to facilitate removal.

4.6.10.2 Upper half diaphragms shall be fastened to the upper half casing or to each other in such a manner that they are lifted as a unit.

● **4.6.10.3** If specified, the upper half diaphragms shall be attached to the lower half diaphragms.

NOTE For very large machines, this can have advantages in reducing the top half casing weight.

4.6.10.4 The internals of radially split multistage compressors shall be designed with an inner barrel assembly for withdrawal from the outer casing and disassembly for inspection or replacement of parts.

4.6.10.5 The supplier shall advise if a cartridge bundle assembly can be provided.

NOTE 1 This option can reduce maintenance time in the field.

NOTE 2 This feature is not available on all designs.

4.7 Rotating Elements

4.7.1 General

4.7.1.1 Each assembled rotor shall be clearly marked with a unique identification number. This number shall be on the nondrive end of the shaft or in another accessible area that is not prone to maintenance damage.

4.7.1.2 Unless other shaft protection is approved by the purchaser, renewable components shall be furnished at interstage close-clearance points. Sleeves, spacers, or bushings shall be made of materials that are corrosion-resistant in the specified service.

4.7.1.3 Shaft sleeves shall be provided under shaft end seals. Sleeves shall be treated to resist wear and sealed to prevent gas leakage between the shaft and sleeve.

4.7.1.4 Shaft sleeves shall be provided under interstage seals. Closed impeller eye seals, which are stationary, do not require replaceable sleeves on the impeller.

4.7.2 Shafts

4.7.2.1 Shafts for non-through-bolt rotors shall be made of one-piece, heat treated steel that is suitably machined. Shafts that have a finished diameter larger than 200 mm (8 in.) shall be forged steel. Shafts that have a finished diameter of 200 mm (8 in.) or less shall be forged steel or hot rolled barstock, providing such barstock meets all quality and heat treatment criteria established for shaft forgings.

4.7.2.2 When modular (through bolt) rotors are provided, the stub shafts shall meet all quality and heat treatment criteria for shaft forgings.

NOTE Refer to Annex C for rotor arrangements and nomenclature.

4.7.2.2.1 The studs or tie-bolts used to clamp a built-up rotor shall be made from bar or forgings. Threads shall be formed by rolling. Each tie-bolt shall be tested with a proof load corresponding to at least 110 % of maximum stretch that occurs during assembly or in operation.

4.7.2.2.2 Ferromagnetic material shall be DC wet magnetic particle inspected. Nonmagnetic material shall be fluorescent penetrant inspected. These inspections shall be performed subsequent to proof-load test and shall not reveal cracks, seams, or laps.

4.7.2.3 Proven methods of axial compressor rotor construction shall be offered. This includes solid (one-piece), disk-on-shaft, or stub shaft using through bolt, disk or drum construction, or other approved means.

4.7.3 Thrust Balancing

4.7.3.1 A balance piston, balance line, and porting shall be provided if required to reduce axial loads on the thrust bearings. A separate pressure-tap connection or connections shall be provided to indicate the pressure in the balancing chamber, not in the balance line.

4.7.3.2 The balance line, if required, shall be flanged and sized to handle balance piston gas leakage at twice the initial design balance piston seal clearance without exceeding the load rating of the thrust bearings (see 4.9.3.3). If the balance line involves a connection to purchaser's piping, then the connection size and locations shall be indicated on the datasheets.

- **4.7.3.3** If specified, a pressure tap connection shall be supplied in the downstream end of the balance line to allow measurement of differential pressure in the balance line.

NOTE This connection can be in the compressor supply or in the process piping.

- **4.7.3.3.1** If specified, a differential pressure gage or transmitter shall be supplied to monitor differential balance line pressure.

4.7.4 Impellers

Refer to 4.7.10 of Part 1 for impeller requirements.

4.7.5 Axial Compressor Rotor Blading

4.7.5.1 The blade natural frequencies shall not coincide with any source of excitation from 10 % below minimum allowable speed to 10 % above maximum continuous speed (MCS). If this is not feasible, blading shall be designed with stress levels low enough to allow unrestricted operation, at any specified operating speed for the minimum service life defined in 4.4.1.2 of Part 1. This shall be verified by

Goodman diagrams or their equivalent. The supplier shall identify unacceptable speeds. Goodman diagrams for all blades shall be submitted to the purchaser for review.

NOTE Excitation sources include fundamental and first and second harmonic passing frequencies of rotating and stationary blades upstream and downstream of each blade row, gas passage splitters, irregularities in vane and periodic impulses caused by nozzle segment design at horizontal casing flanges, and the first 10 rotor speed harmonics.

4.7.5.2 For each blade row, the supplier shall present bending and torsional blade natural frequencies under both operating and static conditions by Campbell diagrams or their equivalent.

NOTE Static frequencies can be used for comparison to "ring" testing on the blades installed in the rotor.

● **4.7.5.3** If specified, or if blade natural frequencies are based on theoretical predictions, at least one blade from each stage shall be verified by ring testing.

4.7.5.4 All blades shall be peened. Peening intensity and media depend upon base material, compressive layer depth desired and material thickness. The compressive layer induced shall be checked by using Alnen strip.

4.7.5.5 Axial compressor rotor blading may be attached via axial dovetail, tangential firtree, tangential, or T-slot. Other attachment methods are acceptable if approved by purchaser.

4.8 Dynamics

Refer to Part 1 for dynamics requirements.

4.9 Bearings and Bearing Housings

Refer to Part 1 and the following sections for bearing and bearing housing requirements.

4.9.1 General

4.9.1.1 Unless otherwise specified, hydrodynamic radial and thrust bearings shall be provided.

● **4.9.1.1.1** If specified, active magnetic bearings (AMBs) shall be provided.

NOTE Annex E of Part 1 gives application considerations for use of AMBs.

4.9.1.2 Thrust bearings and radial bearings shall be fitted with bearing-metal temperature sensors installed in accordance with API 670.

4.9.1.3 As a design criteria, bearing metal temperatures shall not exceed 100 °C (212 °F) at specified operating conditions with a maximum inlet oil temperature of 50 °C (120 °F). Suppliers shall provide bearing temperature alarm and shutdown limits.

4.9.1.3.1 In the event that the above design criteria cannot be met, purchaser and supplier shall agree on acceptable bearing metal temperatures.

4.9.2 Hydrodynamic Radial Bearings

4.9.2.1 Unless otherwise specified, hydrodynamic bearings shall have flood lubrication. Directed lube may be used if agreed.

NOTE Directed lube has advantages in power losses but has small passages with greater potential to plug. Radial bearings do not normally have significant power losses.

4.9.2.2 Sleeve or pad radial bearings shall be used and shall be split for ease of assembly. The use of nonsplit designs requires the purchaser's approval. The bearings shall be precision bored with steel or copper alloy backed babbitted replaceable liners, pads, or shells. The bearing design shall not require removal of the coupling hub to permit replacement of the bearing liners, pads, or shells unless approved by purchaser.

- **4.9.2.3** If specified, tilting pad bearings shoes shall be copper-alloy backed.

4.9.2.4 The removal of the top half of the casing of an axially split machine or the head of a radially split unit shall not be required for replacement of these elements.

NOTE This may not be possible for overhung designs.

4.9.3 Hydrodynamic Thrust Bearings

4.9.3.1 Thrust bearings shall be steel-backed, babbitted multiple segments designed for equal thrust capacity in both axial directions and arranged for continuous pressurized lubrication to each side. Both sides shall be tilting pads, incorporating a self-leveling feature, which ensures that each pad carries an equal share of the thrust load even with minor variation in pad thickness.

NOTE Some low inlet pressure overhung compressors or axials will not need to meet the equal thrust load bi-directional criteria.

4.9.3.2 Hydrodynamic thrust bearings shall be selected at no more than 50 % of the bearing manufacturer's ultimate load rating. In sizing thrust bearings, consider the following for each specified application:

a) the shaft speed;

b) the temperature of the bearing babbitt;

c) the deflection of the bearing pad;

d) the minimum oil film thickness;

e) the feed rate, viscosity, and supply conditions of the oil over the specified allowable oil supply condition range;

f) the design configuration of the bearing;

g) the babbitt or other bearing surface material alloy and pad material;

h) the turbulence of the oil film;

i) load changes due to process changes over the specified operating range.

NOTE See 3.1.64 of Part 1 for a definition of ultimate load rating for hydrodynamic thrust bearings.

4.9.3.3 Thrust bearings shall be sized for continuous operation under the most adverse specified operating conditions. Calculations of the thrust forces shall include but shall not be limited to the following factors:

a) seal maximum design internal clearances and twice the maximum design internal clearances;

b) pressurized rotor diameter step changes;

c) stage maximum differential pressures;

d) specified extreme variations in inlet, interstage, and discharge pressures;

e) the maximum thrust force that may be transmitted to the compressor thrust bearing by other equipment in the train (i.e. couplings, gears, or a motor without a thrust bearing);

f) the maximum thrust force from the sleeve bearing type drive if the motor or generator is directly connected.

4.9.3.4 The thrust bearing shall be arranged to allow both axial positioning of the rotor relative to the casing and setting the bearings' clearance.

4.9.3.5 Each pad within one side of the thrust bearing shall be designed and manufactured to tolerances to allow interchange or replacement of the individual pads.

NOTE Instrumented and offset pivot designs do not allow interchange side to side.

4.9.3.6 Unless otherwise specified, directed lube thrust bearings shall be used. Flooded lube may be used if agreed.

NOTE Directed lube has advantages in power losses, but has small passages with greater potential to plug.

● **4.9.3.7** If specified, thrust bearings pads shall be copper-alloy backed.

4.9.4 Bearing Housings

4.9.4.1 Rotor support system parts (bearings, bearing housings, bearing carriers, and bearing brackets) shall be separable from the casing, axially split, nonpressurized (vented to atmosphere), and furnished with plugged connections for dry air or inert gas purge to any atmospheric labyrinth seals.

4.9.4.2 Axially split-bearing housings shall have a metal-to-metal split joint whose halves are located by means of cylindrical dowels.

4.9.4.3 Shaft support structures bolted to casings shall be steel. Shaft support structures bolted to cast iron casings may be made from cast iron.

4.10 Shaft End Seals

4.10.1 Shaft end seals shall be in accordance with 4.10 of Part 1 and the following paragraphs.

NOTE 1 Typical cross sections of various shaft seals are given in Annex C of Part 1.

NOTE 2 Equipment covered in this part can be available with any of the shaft end seal types covered in Part 1, or additional hybrid types may be available.

- **4.10.2** Purchaser shall specify the type of shaft end seal(s) to be provided and all operating conditions including start-up, shutdown, and settle-out conditions.

NOTE Axial compressors in process air service will generally be supplied with labyrinth shaft end seals. Process compressors can have any type of shaft end seal specified.

4.10.3 Shaft end seals shall be accessible for inspection and replacement without removing the top half of the casing for an axially split compressor or the heads of a radially split unit. This requirement is not applicable for overhung designs.

- **4.10.4** If specified for non-cartridge-seal types, shaft sleeves under shaft end seals shall be accessible for inspection and replacement without removing the top half of the casing for an axially split compressor or the heads of a radially split unit. This requirement is not applicable for overhung designs.

NOTE This is of benefit for seal types where the wearing component is in close proximity to the sleeve. Example seal types are labyrinth and carbon ring.

4.11 Integral Gearing

Internal gearing is not applicable for equipment covered in this part. For external gearing, refer to API 613.

4.12 Nameplates and Rotation Arrows

4.12.1 Nameplates and rotation arrows shall be in accordance with 4.12 of Part 1 and this section.

4.12.2 The following data shall be clearly stamped or engraved on the nameplate:

— supplier’s name;

— serial number;

— size, type, and model;

— rated capacity;

— rated power;

— lateral critical speeds up to and including the next lateral above MCS;

— purchaser item number or other reference;

— MAWP;

— minimum and maximum allowable working temperature;

— minimum operating speed;

— MCS;

— trip speed;

— hydrostatic test pressure;

— maximum sealing pressure.

4.12.3 Rotation arrows shall be cast-in or attached to each major item of rotating equipment at a readily visible location.

5 Accessories

Accessories shall be in accordance with Section 5 of Part 1.

5.1 Drivers and Gearing

Drivers and external gearing shall be in conformance with 5.1 of Part 1.

5.2 Couplings and Guards

Couplings and guards shall be in conformance with 5.2 of Part 1.

5.3 Lubrication and Sealing Systems

Lubrication and sealing systems shall be in accordance with 5.3 of Part 1.

5.4 Mounting Plates

Mounting plates shall be in conformance with 5.4 of Part 1.

5.5 Controls and Instrumentation

5.5.1 Controls and instrumentation shall be in conformance with 5.5 of Part 1.

5.5.2 Control systems, when supplied, shall be in accordance with 5.5.2 of Part 1, with the additions as noted below.

5.5.2.1 Axial compressors shall be supplied with a map of allowable operating range to permit the design of control logic to prevent operation in the region of choke (overload) and therefore avoid potentially dangerous blade stresses.

NOTE Figure 2 and Figure 3 show typical performance maps for axial compressors.

5.5.2.2 When an anti-surge system as described in 5.5.2.2 of Part 1 is furnished for an axial compressor, the system shall also include overload protection.

● **5.5.2.3** For constant-speed centrifugal compressors, when AIGVs are required, the supplier shall also furnish a guide-vane positioner capable of supplying a compatible control signal as specified by the purchaser.

NOTE See 5.5.2.1 of Part 1.

5.5.2.4 For constant-speed axial compressors supplied with adjustable vanes, the supplier shall also furnish a vane positioner compatible with the type of control signal specified by the purchaser. A direct-driven local vane position indicator shall be provided that will be visible during operation of the machine.

5.5.3 Instrument and Control Panels

Instrument and control panels, when supplied, shall be in accordance with 5.5.3 of Part 1.

5.5.4 Instrumentation

Instrumentation, when supplied, shall be in accordance with 5.5.4 of Part 1.

5.5.5 Alarms, Shutdowns, and Control Systems

Alarms, shutdowns, and control systems, when supplied, shall be in accordance with 5.5.5 of Part 1.

5.5.6 Electrical Systems

Electrical systems, when supplied, shall be in accordance with 5.5.6 of Part 1.

5.5.7 Vibration, Position, and Bearing Temperature Detectors

5.5.7.1 Radial shaft vibration and axial-position transducers and bearing temperature sensors shall be supplied, installed, and calibrated in accordance with API 670.

- **5.5.7.2** If specified, radial shaft vibration and axial position monitors shall be supplied and calibrated in accordance with API 670.

- **5.5.7.3** Purchaser shall specify the type of temperature detector to be supplied. Installation shall be per API 670.

- **5.5.7.4** If specified, a bearing temperature monitor shall be supplied and calibrated in accordance with API 670.

- **5.5.7.5** If specified, casing vibration transducers shall be supplied, installed, and calibrated in accordance with API 670.

- **5.5.7.6** If specified, casing vibration monitors shall be supplied, installed and calibrated in accordance with API 670.

5.6 Piping and Appurtenances

5.6.1 General

Piping and appurtenances furnished shall be in accordance with 5.6 of Part 1, with additions as follows.

5.6.1.1 When a baseplate has been specified, the supplier shall furnish all piping systems, including mounted appurtenances, located within its confines. The piping shall terminate with flanged connections at the edge of the baseplate. When soleplates have been specified, the extent of the piping system supplied by the supplier shall be defined by the purchaser. The purchaser will furnish interconnecting piping between equipment groupings and off base facilities.

5.6.1.2 If specified, a liquid injection manifold shall be supplied. It shall include a throttle valve, an armored flow meter, a check valve, a pressure indicator, and a block valve for each injection point.

5.6.2 Process Piping

Process piping, if furnished, shall be in accordance with 2.4 of API 614, Fifth Edition.

5.7 Special Tools

Special tools shall be in accordance with 5.7 of Part 1.

6 Inspection, Testing, and Preparation for Shipment

6.1 General

General requirements for inspection, testing and preparation for shipment shall be in accordance with 6.1 of Part 1. Also refer to Annex E for the Inspector's Checklist.

6.2 Inspection

Requirements for inspection shall be in accordance with 6.2 of Part 1.

6.3 Testing

In addition to the requirements of 6.2 of Part 1, the compressor(s) shall be tested in accordance with 6.3.1 and 6.3.2. Optional tests that may be specified are described in 6.3.3. Immediately upon completion of each witnessed mechanical or performance test, copies of the data recorded during the test shall be given to the witnesses.

6.3.1 Mechanical Running Test

6.3.1.1 The requirements of 6.3.1.1.1 through 6.3.1.1.11 shall be met before the mechanical running test is performed.

6.3.1.1.1 The contract shaft seals and bearings shall be used in the machine for the mechanical running test, except that the atmospheric breakdown bushing(s) on oil seals may be replaced with a test bushing, if required.

NOTE Low-pressure mechanical testing can require increased clearance or fewer elements for proper heat removal.

6.3.1.1.2 Oil viscosity, pressures, and filtration shall be within the range of operating values recommended in the supplier's operating instructions for the unit being tested. Oil flow rates to each oil seal and bearing housing shall be measured.

NOTE Oil inlet temperature may be varied for the mechanical test to match the design oil viscosity.

6.3.1.1.3 If specified, oil temperatures and supply pressures shall be varied over the allowable operating range during test as agreed.

6.3.1.1.4 Oil system components downstream of the filters shall meet the cleanliness requirements of API 614, Fifth Edition, before any test is started.

6.3.1.1.5 All joints and connections shall be checked for tightness, and any leaks shall be corrected.

6.3.1.1.6 All warning, protective, and control devices used during the test shall be checked and adjusted as required.

6.3.1.1.7 Facilities shall be installed to prevent the entrance of oil into the process gas section of the compressor during the mechanical running test. These facilities shall be in operation throughout the test.

6.3.1.1.8 Testing with the contract coupling(s) is preferred. If this is not practical, the mechanical running test shall be performed with coupling(s) or simulators that have overhung moments within 10 % of the contract coupling(s).

6.3.1.1.9 The circumferential location of a hydraulically mounted coupling hub relative to the shaft shall be nonpermanently marked before starting the test.

NOTE It can be required to ramp through certain speed ranges to avoid resonant frequencies.

6.3.1.1.10 The equipment shall be operated at speed increments of approximately 10 % from zero to the MCS and run at the MCS until bearing metal temperatures and shaft vibrations have stabilized.

NOTE 1 Operating equipment at or near critical speeds is normally avoided. For axial compressors, other speeds at or near blade resonant frequencies are also avoided (see 4.7.6.1).

NOTE 2 Refer to Figure 4 for a graphical illustration of the complete mechanical running test including requirements of 6.3.1.1.10 through 6.3.1.1.12.

6.3.1.1.11 The speed shall be increased to trip speed and the equipment shall be run for a minimum of 15 minutes.

6.3.1.1.12 The speed shall be reduced to the MCS, and the equipment shall be run for 4 hours continuous operation.

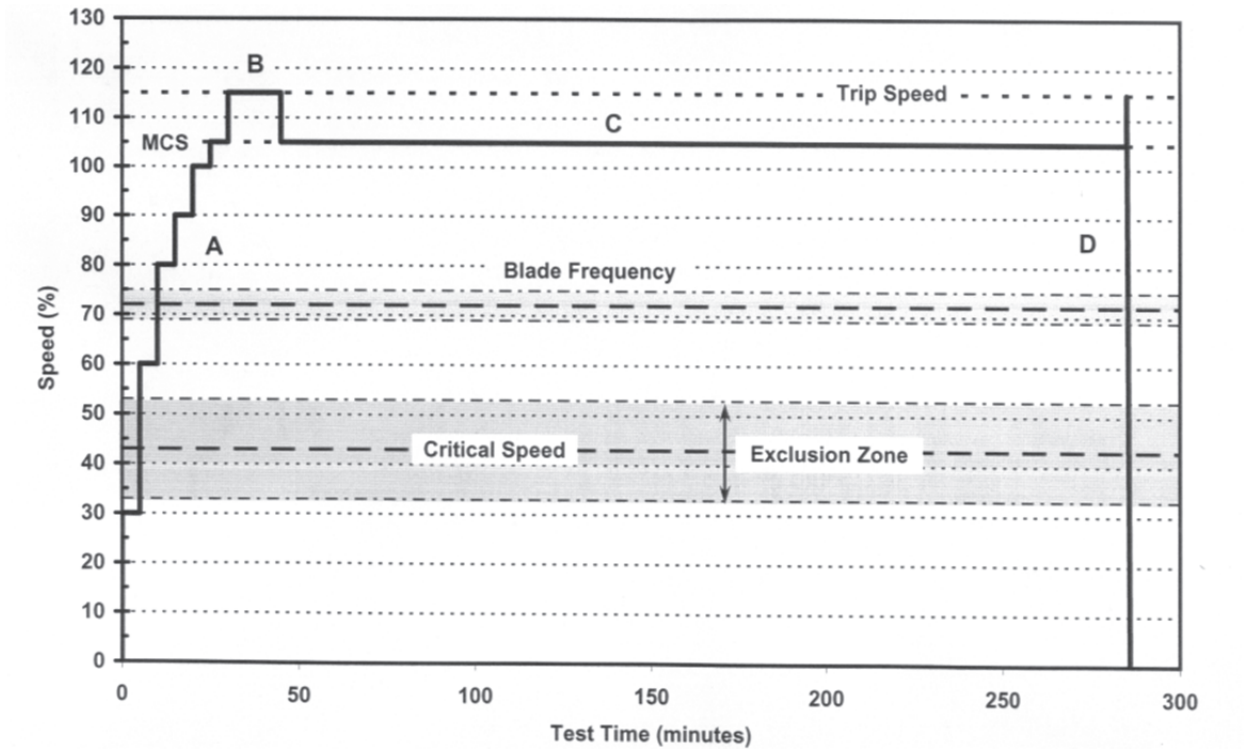
6.3.1.2 During the mechanical running test, the requirements of 6.3.1.2.1 through 6.3.1.2.9 shall be met.

6.3.1.2.1 During the mechanical running test, the mechanical operation of all equipment being tested and the operation of the test instrumentation shall be satisfactory. The measured unfiltered vibration shall not exceed the limits of 4.8.8.8 of Part 1 and shall be recorded throughout the operating speed range. Any other test acceptance criteria shall be agreed and stated in the test agenda.

6.3.1.2.2 While the equipment is operating at MCS, or other speed required by the test agenda, vibration data shall be acquired to determine amplitudes at frequencies other than synchronous. This data shall cover a frequency range from 0.25 to 8 times the MCS. If the amplitude of any discrete, nonsynchronous vibration exceeds 20 % of the allowable vibration as defined in 4.8.8.8 of Part 1, the purchaser and the supplier shall agree on requirements for any additional testing and on the equipment's acceptability.

6.3.1.2.3 The mechanical running test shall verify that lateral critical speeds conform to the requirements of 4.8.2 in Part 1 of this standard.

6.3.1.2.4 Shop verification of the unbalanced response analysis shall be performed in accordance with 4.8.3 in Part 1 of this standard.



Key

A warm-up phase
- speed increased multiple increments
- avoid critical speeds, blade frequencies, etc.

B trip speed operation
- 15 minutes

C maximum continuous speed 4-hour test
- oil supply variations performed
- operating conditions recorded

D Shutdown/ramp down
- momentary increase to trip speed
- transient operation recorded
- used as baseline for verification testing

Figure 4—Mechanical Test

6.3.1.2.5 When spare rotors are supplied to permit concurrent manufacture, each spare rotor shall also be given a mechanical running test in accordance with the requirements of this standard.

6.3.1.2.6 When spare inner barrel assemblies or cartridges bundle assemblies are supplied, the spare rotor shall be tested with the inner barrel assembly.

NOTE Spare cartridge bundle assemblies can result in reduced turnaround time.

NOTE See 3.1.3 and 3.1.15 of Part 1 for definitions of cartridge bundle assembly and inner barrel assembly.

6.3.1.2.7 When spare axial blade stator vane assemblies are supplied, the spare rotor shall be tested with the spare stator vanes.

6.3.1.2.8 The purchaser shall advise additional testing requirements for spare parts.

6.3.1.2.9 Axial compressors with variable stators shall be exercised throughout the entire range of movement using the contract linkage and linkage positioner during the mechanical test.

6.3.2 Assembled Compressor Gas Leakage Test

6.3.2.1 After the mechanical running test is completed, each completely assembled compressor casing intended for toxic, hazardous, or flammable service shall be tested as required in 6.3.2.2 and/or, when specified, 6.3.2.3.

NOTE These tests are intended to verify the integrity of the casing joint. Some shaft seal designs are not gas tight. Therefore, leakage from these seals is acceptable.

6.3.2.2 The assembled compressor (including end seals) shall be pressurized, with an inert gas to the maximum sealing pressure or the maximum seal design pressure, as agreed by the purchaser and the supplier; held at no less than this pressure for a minimum of 30 minutes, and subjected to a soap bubble test, or alternate method, to check for gas leaks. The test shall be considered satisfactory when no casing or casing joint leaks are observed.

NOTE Test gas mole weight will approximate or be less than contract gas mole weight. Helium for low mole weight contract gas and nitrogen or refrigerant gas for high mole weight can be considered.

- **6.3.2.3** If specified, the assembled compressor (with or without end seals installed) shall be pressurized with an inert gas to the maximum specified discharge pressure, held at this pressure for a minimum of 30 minutes, and subjected to a soap bubble test, or alternate method, to check for gas leaks. The test shall be considered satisfactory when no casing or casing joint leaks are observed.

NOTE The requirements of 6.3.2.2 and 6.3.2.3 can necessitate two separate tests.

- ### 6.3.3 Optional Tests

The purchaser will specify whether any of the following shop tests shall be performed. Test details shall be agreed prior to the test.

6.3.3.1 Factory Performance Test

6.3.3.1.1 The compressor shall be performance tested in accordance with ASME PTC 10-1997 or ISO 5389:2005 as specified. A minimum of five points, including surge and overload, shall be taken at the speed equivalent to normal speed.

NOTE Refer to the applicable test code for general instructions. ASME PTC 10-1997 cannot apply to some low pressure ratio compressors. Refer to the scope, 1.2.2, of PTC 10-1997 for the selection of the appropriate test code to be used.

- **6.3.3.1.2** If specified, surge line testing or additional speed lines may be tested for variable speed machines.

6.3.3.1.3 For variable speed machines, head and capacity shall have zero negative tolerance at the certified point, and the power at this point shall not exceed 104 % of the supplier predicted shaft power value. This tolerance shall be inclusive of all test tolerances. Surge shall comply with provisions of 4.4.1.1.

NOTE Both of the performance test codes referred to have provision for calculating inaccuracy based on instrumentation and procedures. These test inaccuracies are already included in the above tolerance and, therefore, are not to be further additive.

6.3.3.1.4 For variable-speed compressors, a speed other than the normal speed may be used, if necessary, to achieve the specified conditions, provided that this adjusted speed meets the criteria specified in Part 1: 4.8.

6.3.3.1.4.1 Variable speed compressors shall have MCS increased if necessary after performance testing to maintain a minimum 5 margin over adjusted rated speed based on test.

When a speed increase is necessary to achieve specified performance, all design margins such as separation margins, overspeed margins, maximum continuous margins, etc. shall be maintained,.

NOTE This maintains a 5 % speed margin for future process changes.

6.3.3.1.5 For constant-speed compressors, the capacity shall be as specified in 6.3.3.1.2. The head shall be within the range of 100 % to 105 % of the normal head. The horsepower, based on measured head at certified capacity, shall not exceed 107 % of the value at the specified certified point. If the power required at this point exceeds 107 %, or head exceeds 105 % of the normal head, excess head may be removed by trimming impellers at the purchaser's option.

6.3.3.1.6 If hardware modifications are required to meet performance, the performance test shall be repeated.

6.3.3.1.7 The performance test shall be conducted using only one contract rotor, unless otherwise specified.

- **6.3.3.1.8** If specified, purchaser shall state the intermediate pressures. Manufacturer shall state the pressure tolerance at each connection.

6.3.3.1.9 For trains with multiple compressors, intermediate pressures and individual power tolerances may be adjusted as agreed. Overall power tolerances shall be as stated above.

6.3.3.2 Complete Unit Test

The scope of this test shall be detailed by the purchaser. Such components as compressors, gears, drivers, and auxiliaries that make up a complete unit shall be tested together during the mechanical running test. A separate auxiliary test may be performed. The complete unit test may be performed in place of, or in addition to, separate tests of individual components.

- **6.3.3.2.1** If specified for the complete unit test, torsional vibration measurements shall be made to verify the supplier's analysis.

6.3.3.3 Tandem Test

Compressor bodies arranged for tandem drive shall be tested as a unit during the mechanical running test, using the shop driver and oil systems as specified.

6.3.3.4 Gear Test

For units with external gears, the contract gear shall be tested with the machine(s) during the mechanical running test.

6.4 Preparation for Shipment

Equipment shall be prepared for shipment in accordance with 4.4 of Part 1 and the following requirements.

- **6.4.1** If specified, dry gas seals shall be removed for shipment.

NOTE Seals will have to be reinstalled in the field or cover plates fabricated if the compressor is to be provided with a nitrogen blanket during construction.

7 Supplier's Data

Supplier's data shall be in accordance with Section 7 of Part 1.

7.1 General

7.1.1 The information to be furnished by the supplier is specified in Part 1 Section 7. The supplier shall complete and forward the agreed Vendor (supplier) Drawing and Data Requirements (VDDR) Form (See Annex B for an example) to the address or addresses noted on the inquiry or order. This form shall detail the schedule for transmission of drawings, curves, and data as agreed to at the time of the order, as well as the number and type of copies required by the purchaser.

7.2 Proposals

Proposal data shall be in accordance with 7.2 of Part 1.

7.3 Contract Data

Contract data shall be in accordance with 7.3 of Part 1.

Annex A
(normative)

Datasheets

A representation of the datasheets is enclosed in this annex; however, MS Excel format datasheets have been developed and are available, for purchase from API publications distributors, with this standard. The MS Excel electronic datasheets may have additional functionality over printed hard copies.

REVISION	0	1	2	3	4
DATE					
BY					
REV/APPR					

CENTRIFUGAL AND AXIAL COMPRESSOR DATASHEET (API 617-8th, Part 2)
SI UNITS (bar)

JOB NO. _____ ITEM NO. _____
PAGE 1 OF 7 REQ'N NO. _____

1 APPLICABLE TO: ○ PROPOSAL ○ PURCHASE ○ AS BUILT
2 FOR _____ UNIT _____
3 SITE _____ SERIAL NO. _____
4 SERVICE _____ NO. REQUIRED _____
5 MANUFACTURER _____ DRIVER TYPE _____
6 MODEL _____ DRIVER ITEM NO. _____
7 APPLICABLE STANDARD: ○ U.S. ○ ISO
8 INFORMATION TO BE COMPLETED: ○ BY PURCHASER ☐ BY MANUFACTURER △ MUTUAL AGREEMENT (PRIOR TO PURCHASE)

OPERATING CONDITIONS

(ALL DATA ON PER UNIT BASIS)

	NORMAL	OTHER CONDITIONS A	B	C	D	E
○ GAS HANDLED (ALSO SEE PAGE ____)						
△ GAS PROPERTIES						
○ M³/H (1013 barA & 0°C DRY)						
○ WEIGHT FLOW, (kg/h) (WET) (DRY)						
INLET CONDITIONS						
○ PRESSURE (barA)						
○ TEMPERATURE (°C)						
○ RELATIVE HUMIDITY %						
○ MOLECULAR WEIGHT						
☐ Cp/Cv (K_1) OR (K_{AVG}) (NOTE 1)						
☐ COMPRESSIBILITY (Z_1) OR (Z_{AVG}) (NOTE 1)						
☐ INLET VOLUME, (m³/h) (WET / DRY)						
DISCHARGE CONDITIONS						
○ PRESSURE (barA)						
☐ TEMPERATURE (°C)						
☐ Cp/Cv (K_2) OR (K_{AVG}) (NOTE 1)						
☐ COMPRESSIBILITY (Z_2) OR (Z_{AVG}) (NOTE 1)						
☐ GAS POWER REQUIRED (kW)						
☐ TRAIN POWER REQUIRED (kW)						
☐ POWER REQ'D AT DRIVER INCL. EXT. LOSSES (kW)						
☐ SPEED (rpm)						
☐ TURNDOWN (%)						
☐ POLYTROPIC HEAD (N-m/kg)						
☐ POLYTROPIC EFFICIENCY (%)						
○ CERTIFIED POINT						
☐ PERFORMANCE CURVE NUMBER						

PROCESS CONTROL

METHOD ○ SUCTION THROTTLING ○ VARIABLE INLET GUIDE VANES ○ SPEED VARIATION ○ DISCHARGE BLOWOFF ○ COOLED BYPASS
FROM _____ (barA) FROM _____ % FROM _____
TO _____ (barA) TO _____ % TO _____ TO _____
SIGNAL ○ SOURCE _____
TYPE ○ ELECTRONIC ○ PNEUMATIC ○ OTHER _____
RANGE _____ MA _____ (barG) _____
START-UP ○ FROM SETTLING OUT CONDITION ○ NORMAL SUCTION PRESSURE ○ OTHER: _____

REMARKS: NOTE 1: IF GAS ANALYSIS IS GIVEN, MANUFACTURER SHALL SUPPLY DATA, OTHERWISE DATA SHALL BE SUPPLIED BY USER

		0	1	2	3	4

CENTRIFUGAL AND AXIAL COMPRESSOR
DATASHEET (API 617-8th, Part 2)
SI UNITS (bar)

JOB NO. _____ ITEM NO.
PAGE 1b OF 7 REQ'N NO. _____

		NORMAL	OTHER CONDITIONS				
	(ALL DATA ON PER UNIT BASIS)		A	B	C	D	E
○	GAS HANDLED (ALSO SEE PAGE ___)						
△	GAS PROPERTIES						
○	M³/H (1013 barA & 0°C DRY)						
○	WEIGHT FLOW, (kg/h) (WET) (DRY)						
	INLET CONDITIONS						
○	PRESSURE (barA)						
○	TEMPERATURE (°C)						
○	RELATIVE HUMIDITY %						
○	MOLECULAR WEIGHT						
□	Cp/Cv (K_1) OR (K_{AVG}) (NOTE 1)						
□	COMPRESSIBILITY (Z_1) OR (Z_{AVG}) (NOTE 1)						
□	INLET VOLUME, (m³/h) (WET / DRY)						
	DISCHARGE CONDITIONS						
○	PRESSURE (barA)						
□	TEMPERATURE (°C)						
□	Cp/Cv (K_2) OR (K_{AVG}) (NOTE 1)						
□	COMPRESSIBILITY (Z_2) OR (Z_{AVG}) (NOTE 1)						
□	GAS POWER REQUIRED (kW)						
□	TRAIN POWER REQUIRED (kW)						
□	POWER REQ'D AT DRIVER INCL. EXT. LOSSES (kW)						
□	SPEED (rpm)						
□	TURNDOWN (%)						
□	POLYTROPIC HEAD (N-m/kg)						
□	POLYTROPIC EFFICIENCY (%)						
○	CERTIFIED POINT						
□	PERFORMANCE CURVE NUMBER						

REMARKS: NOTE 1 IF GAS ANALYSIS IS GIVEN, MANUFACTURER SHALL SUPPLY DATA, OTHERWISE DATA SHALL BE SUPPLIED BY USER

REVISION	0	1	2	3	4
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CENTRIFUGAL AND AXIAL COMPRESSOR
DATASHEET (API 617-8th, Part 2)
SI UNITS (bar)

JOB NO. ____ ITEM NO. ____
PAGE 1c OF 7 REQ'N NO. ____

OPERATING CONDITIONS

(ALL DATA ON PER UNIT BASIS)	NORMAL	OTHER CONDITIONS A	B	C	D	E
○ GAS HANDLED (ALSO SEE PAGE ___)						
△ GAS PROPERTIES						
○ M³/H (1013 barA & 0°C DRY)						
○ WEIGHT FLOW, (kg/h) (WET) (DRY)						
INLET CONDITIONS						
○ PRESSURE (barA)						
○ TEMPERATURE (°C)						
○ RELATIVE HUMIDITY %						
○ MOLECULAR WEIGHT						
□ Cp/Cv (K_1) OR (K_{AVG}) (NOTE 1) (NOTE 1)						
□ COMPRESSIBILITY (Z_1) OR (Z_{AVG}) (NOTE 1) (NOTE 1)						
□ INLET VOLUME, (m³/h) (WET / DRY)						
DISCHARGE CONDITIONS						
○ PRESSURE (barA)						
□ TEMPERATURE (°C)						
□ Cp/Cv (K_2) OR (K_{AVG}) (NOTE 1)						
□ COMPRESSIBILITY (Z_2) OR (Z_{AVG}) (NOTE 1)						
□ GAS POWER REQUIRED (kW)						
□ TRAIN POWER REQUIRED (kW)						
□ POWER REQ'D AT DRIVER INCL. EXT. LOSSES (kW)						
□ SPEED (rpm)						
□ TURNDOWN (%)						
□ POLYTROPIC HEAD (N-m/kg)						
□ POLYTROPIC EFFICIENCY (%)						
○ CERTIFIED POINT						
□ PERFORMANCE CURVE NUMBER						

REMARKS: NOTE 1: IF GAS ANALYSIS IS GIVEN, MANUFACTURER SHALL SUPPLY DATA, OTHERWISE DATA SHALL BE SUPPLIED BY USER

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CENTRIFUGAL AND AXIAL COMPRESSOR
DATASHEET (API 617-8th, Part 2)
SI UNITS (bar)

JOB NO. _____ ITEM NO. _____
PAGE 2 OF 7 REQ'N NO. _____

OPERATING CONDITIONS (Continued)

GAS ANALYSIS: ○ MOL %	MW	NORMAL	OTHER CONDITIONS A	B	C	D	E	REMARKS:
AIR	28.966							
OXYGEN	32.000							
NITROGEN	28.016							
WATER VAPOR	18.016							
CARBON MONOXIDE	28.010							
CARBON DIOXIDE	44.010							
HYDROGEN SULFIDE	34.076							
HYDROGEN	2.016							
METHANE	16.042							
ETHYLENE	28.052							
ETHANE	30.068							
PROPYLENE	42.078							
PROPANE	44.094							
I-BUTANE	58.120							
n-BUTANE	58.120							
I-PENTANE	72.146							
n-PENTANE	72.146							
HEXANE PLUS								
CORROSIVE AGENTS								
TOTAL								
AVG. MOL. WT.								

LOCATION:
○ INDOOR ○ OUTDOOR ○ GRADE
○ HEATED ○ UNDER ROOF ○ MEZZANINE
○ UNHEATED ○ PARTIAL SIDES ○ _____

SITE DATA
○ ELEVATION _____ (m) BAROMETER _____ (barA)
○ RANGE OF AMBIENT TEMPS:

		DRY BULB	WET BULB
NORMAL	(°C)		
MAXIMUM	(°C)		
MINIMUM	(°C)		
_____	(°C)		

UNUSUAL CONDITIONS: ○ DUST ○ FUMES
○ OTHER _____
○ COPPER AND COPPER ALLOYS PROHIBITED

COATING:
○ ROTATING COMPONENTS _____
○ STATIONARY COMPONENTS _____

REMARKS: _____

NOISE SPECIFICATIONS:
○ APPLICABLE TO MACHINE:
SEE SPECIFICATION _____
○ APPLICABLE TO NEIGHBORHOOD:
SEE SPECIFICATION _____
ACOUSTIC HOUSING: ○ YES ○ NO

APPLICABLE SPECIFICATIONS:
API 617-7th, Part 2
○ VENDOR HAVING UNIT RESPONSIBILITY
_____
○ GOVERNING SPECIFICATION (IF DIFFERENT)
_____

○ ELEC. AREA CLASS. ○ NEC ○ IEC
EQUIPMENT
CLASS _____ GROUP _____ DIV. _____
ZONE _____ GROUP _____ TEMP CLASS _____
CONTROL PANNELS
CLASS _____ GROUP _____ DIV. _____
ZONE _____ GROUP _____ TEMP CLASS _____

INSTRUMENT AND CONTROLS
STANDARD ○ NEMA ○ IEC

	INDOOR	OUTDOOR
CONTROL ENCLOSURE		
TERMINAL BOX		

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CENTRIFUGAL AND AXIAL COMPRESSOR DATASHEET (API 617-8th, Part 2)

SI UNITS (bar)

JOB NO. _____ ITEM NO. _____

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CONSTRUCTION FEATURES

☐ **SPEEDS:**
MAX. CONT. _____ (rpm) TRIP _____ (rpm)
MAX. TIP SPEEDS: _____ (m/s) @ 100% SPEED
_____ (m/s) @ MAX. CONT. SPEED

☐ **LATERAL CRITICAL SPEEDS (DAMPED)**
FIRST CRITICAL _____ (rpm) _____ MODE
SECOND CRITICAL _____ (rpm) _____ MODE
THIRD CRITICAL _____ (rpm) _____ MODE
FOURTH CRITICAL _____ (rpm) _____ MODE

○ LATERAL ANALYSIS ADDITIONAL REQUIREMENTS
○ TRAIN LATERAL ANALYSIS REQUIRED
○ TRAIN TORSIONAL ANALYSIS REQUIRED

☐ **TORSIONAL CRITICAL SPEEDS:**
FIRST CRITICAL _____ (rpm)
SECOND CRITICAL _____ (rpm)
THIRD CRITICAL _____ (rpm)
FOURTH CRITICAL _____ (rpm)

○ LIST OF TRAIN UNDESIRABLE SPEEDS
○ STABILITY ANALYSIS

☐ **VIBRATION:**
ALLOWABLE TEST LEVEL _____ (μm)
(PEAK TO PEAK)

NAMEPLATE
○ US CUSTOMARY ○ METRIC

☐ **ROTATION, VIEWED FROM DRIVEN END** ○ CW ○ CCW

○ **MATERIALS INSPECTION REQUIREMENTS**
○ RADIOGRAPHY REQUIRED FOR _____
○ ULTRASONIC REQUIRED FOR _____
○ MAGNETIC PARTICLE REQUIRED FOR _____
○ LIQUID PENETRANT REQUIRED FOR _____
○ LOW TEMPERATURE _____
MIN.DESIGN METAL TEMPERATURE (℃) _____
AT CONCURRENT PRESSURE (barG) _____
○ OTHER TRAIN COMPONENTS

☐ **CASING:**
MODEL _____
CASING SPLIT _____
MATERIAL _____
THICKNESS (mm) _____ CORR. ALLOW. (mm) _____
MAX. ALLOWABLE PRESS _____ (barG)
TEST PRESS: (barG) HELIUM _____ HYDRO _____
MAX. ALLOWABLE TEMPERATURE _____ (℃)
MAX OPER. TEMP. _____ (℃) MIN. OPER. TEMP. _____ (℃)
MAX CASING CAPACITY _____ (m³/h)
○ SYSTEM RELIEF VALVE SET PT. _____ (barG)
○ Q.C. OF INACCESSIBLE WELDS

☐ **DIAPHRAGMS:**
MATERIAL _____
AXIALLY SPLIT ☐ YES ☐ NO
DIAPHRAGM MAX. Δ P (BAR)(kPa):

○ **INTERMEDIATE MAIN PROCESS CONNECTIONS**
DISCH. PRESSURE: (barG) MAX _____ MIN _____
INLET PRESSURE: (barG) MAX _____ MIN _____

☐ **GUIDE VANES**
○ IGV EXTERNAL PURGE _____
○ VANE CONTROL SYSTEM _____
NUMBER OF AXIAL BLADE ROWS _____
NUMBER OF ADJUSTIBLE ROWS _____
NO. VANES GUIDE VANE _____ MATERIAL _____

☐ **IMPELLERS:**
NO. _____ DIAMETERS _____
NO. VANES EA. IMPELLER _____
TYPE (OPEN, ENCLOSED, ETC.) _____
TYPE FABRICATION _____ MATERIAL _____
MIN. YIELD STRENGTH (MPa) _____
HARDNESS: (Rc) (BRINNEL) MAX _____ MIN _____
SMALLEST TIP INTERNAL WIDTH (mm) _____
MAX. MACH. NO. @ IMPELLER EYE _____
MAX. IMPELLER HEAD @ 100% SPD (N-m/kg) _____

☐ **SHAFT:**
○ ONE PIECE ○ BUILT UP
MATERIAL _____
DIA @ IMPELLERS (mm) _____ DIA @ COUPLING (mm) _____
SHAFT END: ○ TAPERED ○ CYLINDRICAL
○ SPLINED ○ INTEGRAL FLANGE
MIN. YIELD STRENGTH (MPa) _____
SHAFT HARDNESS (BNH)(Rc) _____
MAX TORQUE CAPABILITY (N-m) _____

☐ **BALANCE PISTON:**
MATERIAL _____ AREA _____ (mm²)
FIXATION METHOD _____
NORMAL CLEARANCE (mm) _____
FLOW WITH NORMAL CLEARANCE (kg/h) _____
FLOW WITH 2x NORMAL CLEARANCE (kg/h) _____

○ PRESS. CONN. BAL LINE DOWNSTREAM

☐ **SHAFT SLEEVES:**
AT INTERSTG. CLOSE MATL _____
CLEARANCE POINTS
AT SHAFT SEALS MATL _____

○ ACCESSIBLE

ROTOR
○ DISASSEMBLY AND REASSEMBLY
○ AT SPEED BALANCING
○ SEQUENTIAL LOW SPEED BAL. PREC. AT SPEED BAL.
○ RESIDUAL BALANCE CHECK

☐ **LABYRINTHS:**
INTERSTAGE
TYPE _____ MATERIAL _____
BALANCE PISTON
TYPE _____ MATERIAL _____

REMARKS: _____

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CENTRIFUGAL AND AXIAL COMPRESSOR
DATASHEET (API 617-8th, Part 2)
SI UNITS (bar)

JOB NO. _____ ITEM NO. _____
PAGE 4 OF 7 REQ'N NO. _____

LOW PRESSURE CASING CONSTRUCTION FEATURES (CONTINUED)

SHAFT SEALS:

- ○ SEAL TYPE _____
- ○ SETTLING OUT PRESSURE (barG) _____
- ○ MIN.SEALING PRESSURE (barG) _____
- ○ SUPPLEMENTAL DEVICE REQUIRED FOR CONTACT SEALS TYPE _____
- ○ BUFFER GAS SYSTEM REQUIRED
- ○ TYPE BUFFER GAS _____
  - ☐ PRESSURE _____ (barG)
  - ☐ FLOWRATE _____ (kg/h)
  - ☐ FILTRATION _____ (µm)
- ○ MANIFOLD
- ○ METHOD OF CONTROL
- ○ BUFFER GAS CONTROL SYSTEM SCHEMATIC BY VENDOR
- ○ PRESSURIZING GAS FOR SUBATMOSPHERIC SEALS
  - ○ EDUCTOR ○ INJECTION
- ☐ SEAL MANUFACTURER _____
- ☐ LEAKAGE TO PROCESS (l/day/seal) _____
- BUFFER GAS REQUIRED FOR:
  - ☐ AIR RUN-IN ☐ OTHER _____
- ☐ FLOW (PER SEAL):
  - NORM: _____ (kg/h) @ _____ (bar) ΔP _____
  - MAX. _____ (kg/h) @ _____ (bar) ΔP _____
- ☐ **BEARING HOUSING CONSTRUCTION:**
  - TYPE (SEPARATE, INTEGRAL) _____ SPLIT _____
  - MATERIAL _____

AXIAL COMPRESSOR

STAGE	1	2	3	4	5	6	7	8	9
ROTOR									
☐ BLADE MATERIAL									
☐ BLADE ROOT TYPE									
☐ CORD WIDTH (mm)									
☐ OUTER DIAMETER (mm)									
☐ BLADE HEIGHT (mm)									
☐ BLADE QUANTITY									
STATOR									
☐ BLADE MATERIAL									
☐ TYPE (MOVABLE, FIXED, ADJUSTABLE)									
☐ CORD WIDTH (mm)									
☐ BLADE QUANTITY									

STAGE	10	11	12	13	14	15	16	17	18
ROTOR									
☐ BLADE MATERIAL									
☐ BLADE ROOT TYPE									
☐ CORD WIDTH (mm)									
☐ OUTER DIAMETER (mm)									
☐ BLADE HEIGHT (mm)									
☐ BLADE QUANTITY									
STATOR									
☐ BLADE MATERIAL									
☐ TYPE (MOVABLE, FIXED, ADJUSTABLE)									
☐ CORD WIDTH (mm)									
☐ BLADE QUANTITY									

REMARKS: _____

REVISION	0	1	2	3	4
DATE					

CENTRIFUGAL AND AXIAL COMPRESSOR DATASHEET (API 617-8th, Part 2)
SI UNITS (bar)

JOB NO. _____ ITEM NO. _____
PAGE 5 OF 7 REQ'N NO. _____

CONSTRUCTION FEATURES (CONTINUED)

BEARINGS AND BEARING HOUSINGS

○ MAGNETIC BEARINGS

RADIAL	THRUST	NON-THRUST
☐ TYPE		
☐ MANUFACTURER		
☐ LENGTH (mm)		
☐ SHAFT DIA. (mm)		
☐ UNIT LOAD (ACT/ALLOW) (bar)		
☐ BASE MATERIAL		
☐ BABBIT THICKNESS (mm)		
☐ NO. PADS		
☐ LOAD: B'TWN/ON PAD		
☐ PIVOT: CTR/OFFSET, %		
PAD MATERIAL ○ ○		
☐ BEARING SPAN _____ (mm)		

THRUST	ACTIVE	INACTIVE
☐ TYPE		
☐ MANUFACTURER		
☐ UNIT LOADING - MAX (bar)		
☐ UNIT LOAD - ULT. (bar)		
☐ AREA (mm²)		
☐ NO. PADS		
☐ PIVOT: CENTER / OFFSET, %		
☐ PAD BASE MATL		

○ COPPER BACKED
LUBRICATION: ○ FLOODED ○ DIRECTED
THRUST COLLAR: ○ INTEGRAL ○ REPLACEABLE
MATERIAL _____
☐ SIZING CRITERIUM

BEARING TEMPERATURE DETECTORS

○ SEE ATTACHED API-670 DATASHEET
○ THERMOCOUPLES TYPE _____
○ RESISTANCE TEMP DETECTORS
○ RESISTANCE MAT'L _____ ○ _____ OHMS
☐ ALARM TEMPERATURE _____ (°C)
☐ SHUTDOWN TEMPERATURE _____ (°C)
○ PROVISION FOR LOCAL DISCONNECT
○ LOCATION-JOURNAL BRG
NO. ___ EA PAD _____ EVERY OTH PAD ___ PER BRG
OTHER _____
○ LOCATION-THRUST BRG
NO. ___ EA PAD _____ EVERY OTH PAD ___ PER BRG
OTHER _____
NO. (INACT) ___ EA PAD ___ EVERY OTH PAD ___ PER BRG
OTHER _____
○ LOCAL DISCONNECTION
○ MONITOR SUPPLIED BY _____
○ LOCATION _____ ENCLOSURE _____
○ MFR. _____ ☐ MODEL _____
☐ SCALE RGE _____ ○ ALARM ☐ SET @ _____ (°C)
○ SHTDWN ☐ SET @ _____ (°C) ○ TIME DELAY _____ SEC

KEY PHASOR REQUIRED

○ COMPRESSOR ○ GEAR H.S. ○ GEAR L.S.

VIBRATION DETECTORS: ○ SEE ATTACHED API 670 DATASHEET

○ TYPE _____ ☐ MODEL _____
○ MFR _____
○ NO. AT EA SHAFT BEARING _____ TOTAL NO. _____
○ OSCILLATOR-DETECTORS SUPPLIED BY _____
○ MFR _____ ☐ MODEL _____
MONITOR SUPPLIED BY _____
○ LOCATION _____ ENCLOSURE _____
○ MFR. _____ ☐ MODEL _____
☐ SCALE RGE ___ ○ ALARM ☐ SET @ _____ (μm)
○ SHTDWN: ☐ SET @ ___ (μm) ○ TIME DELAY ___ SEC
○ CASING VIBRATION TRANSDUCERS
○ CASING VIBRATION MONITORS

AXIAL POSITION DETECTOR: ○ SEE ATTACH. API-670 DATASHEET

○ TYPE _____ ☐ MODEL _____
● MFR _____ ○ NO. REQUIRED _____
○ OSCILLATOR-DEMODULATOR SUPPLIED BY _____
○ MFR _____ ☐ MODEL _____
○ MONITOR SUPPLIED BY _____
○ LOCATION _____ ENCLOSURE _____
○ MFR. _____ ☐ MODEL _____
☐ SCALE RGE _____ ○ ALARM ☐ SET @ _____ (μm)
○ SHTDWN: ☐ SET @ ___ (μm) ○ TIME DELAY ___ SEC

CASING CONNECTIONS

CONNECTION	☐ ANSI/ASME (B16.1; B16.5; B16.42; B16.47 series A, B; ISO 7005-1, -2; OTHER)	☐ FACING ☐ BORE	○ ORIENTATION	◎ FLANGED OR STUDDED	○ MATING FLG & GASKET BY VENDOR	☐ GAS VELOCITY (m/s)
INLET						
DISCHARGE						

○ BOROSCOPIC INSPECTION PORTS

REVISION	0	1	2	3	4
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CENTRIFUGAL AND AXIAL COMPRESSOR
DATASHEET (API 617-8th, Part 2)
SI UNITS (bar)

JOB NO. _____ ITEM NO. _____
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☐ **OTHER CONNECTIONS**

SERVICE:	NO.	SIZE	TYPE		NO.	SIZE	TYPE
LUBE-OIL INLET				PRESSURE			
LUBE OIL OUTLET				TEMPERATURE			
SEAL-OIL INLET				SOLVENT INJECTION			
SEAL-OIL OUTLET				PURGE FOR:			
SEAL GAS INLET				BRG. HOUSING			
SEAL GAS OUTLET				BTWN BRG & SEAL			
CASING DRAINS				BTWN SEAL & GAS			
STAGE DRAINS				_____			

○ INDIVIDUAL STAGE DRAINS REQUIRED
○ VALVED & BLINDED
○ VALVED & BLINDED & MANIFOLD

LUBRICATION AND SEALING SYSTEMS

○ SEE ATTACHED API 614 DATASHEET
○ SEPARATE ○ COMBINED
○ INTEGRAL OIL RESERVOIR
○ OIL TYPE

ACCESSORIES

COUPLING AND GUARDS

NOTE: SEE ROTATING ELEMENTS - SHAFT ENDS

○ SEE ATTACHED API 671 DATASHEET ○ KEYLESS HYDRAULIC ○ KEYED ○ FLANGED ○ OTHER _____
COUPLING FURNISHED BY _____ MOUNTED BY _____
MANUFACTURER _____ TYPE _____ MODEL _____
COUPLING GUARD FURNISHED BY: _____
TYPE: ○ FULLY ENCLOSED ○ SEMI-OPEN ○ OTHER

COUPLING DETAILS

☐ MAX O.D. _____ (mm)
☐ HUB WEIGHT _____ (kg)
☐ SPACER LENGTH _____ (mm)
☐ SPACER WEIGHT _____ (kg)

○ PLUG AND RING GAUGES ○ LAPPING TOOL
LUBRICATION REQUIREMENTS:
○ NON-LUBE ○ CONT. OIL LUBE ○ OTHER _____
QUANTITY PER HUB _____ (kg) or (L/min)

MOUNTING PLATES

○ BASEPLATES FURNISHED BY _____
○ COMPRESSOR ONLY ○ DRIVER ○ GEAR
○ OTHER _____
○ NONSKID DECKING ○ SLOPED DECK
△ LEVELING PADS OR TARGETS
△ COLUMN MOUNTING
○ SUB-SOLE PLATES REQUIRED
☐ STAINLESS STEEL SHIM THICKNESS _____ (mm)
○ MACHINED MOUNTING PADS REQUIRED

○ SOLEPLATES FURNISHED BY _____
☐ THICKNESS _____ (mm)
○ SUBSOLE PLATES REQUIRED
○ EXTENT OF PIPING _____
☐ STAINLESS STEEL SHIM THICKNESS _____ (mm)
○ COMPRESSOR _____
○ COUNTER BORE ANCHOR BOLT HOLES

ANTI-SURGE SYSTEM FURNISHED BY ○ PURCHASER ☐ SUPPLIER

○ ☐ ANTI-SURGE VALVE ○ SIZING ONLY
PRESSURE UPSTREAM: _____ (barG) DOWNSTREAM Δ P _____ (barG)
☐ Δ P VALVE _____ STROKE TIME OPEN - CLOSE _____ (sec)

○ ☐ RECIRCULATION VALVE ○ SIZING ONLY
○ ☐ BLOWOFF VALVE ○ SIZING ONLY
○ ☐ CONTROL SYSTEM
○ ☐ PIPING
○ ☐ FLOW ELEMENT
○ ☐ _____ ○ ☐ _____
○ ☐ _____ ○ ☐ _____
○ ☐ _____ ○ ☐ _____
○ ☐ _____ ○ ☐ _____
○ ☐ _____ ○ ☐ _____
○ ☐ _____ ○ ☐ _____

REMARKS: _____

REVISION	0	1	2	3	4
DATE					

CENTRIFUGAL AND AXIAL COMPRESSOR DATASHEET (API 617-8th, Part 2)

SI UNITS (bar)

JOB NO. _____ ITEM NO. _____

PAGE 7 OF 7 REQ'N NO. _____

UTILITIES

○ **UTILITY CONDITIONS:**

STEAM: **DRIVERS**

INLET MIN	(barG)	(℃)
NORM	(barG)	(℃)
MAX	(barG)	(℃)
EXHAUST. MIN	(barG)	(℃)
NORM	(barG)	(℃)
MAX	(barG)	(℃)

ELECTRICITY:

	DRIVERS	CONTROL	SHUTDOWN
VOLTAGE			
HERTZ			
PHASE			

○ REDUCED VOLTAGE START

△ NUMBER OF STARTS _____

INSTRUMENT AIR:

MAX PRESS _____ (barG) MIN PRESS _____ (barG)

SHOP INSPECTION AND TESTS

	REQ'D	WIT/OBV
○ (SEE INSPECTOR'S CHECKLIST)		
HYDROSTATIC	●	
IMPELLER OVERSPEED	●	
MECHANICAL RUN	●	
○ CONTRACT COUPLING ○ IDLING ADAPTOR(S)		
○ CONTRACT PROBES ○ SHOP PROBES		
○ PURCHASER VIB. EQUIPMENT		
VARY LUBE & SEAL OIL PRESSURES		
AND TEMPERATURES	○	
POLAR FORM VIB DATA	○	
TAPE RECORD VIB DATA	○	
SHAFT END SEAL INSP	○	
GAS LEAK TEST AT DISCH PRESS	○	
○ POST TEST INTERNAL INSP		
○ BEFORE GAS LEAKAGE TEST		
○ AFTER GAS LEAKAGE TEST		
INTERMEDIATE HEAD/PRESSURE TOL.	○	
PERFORMANCE TEST (GAS) (AIR)	○	
COMPLETE UNIT TEST	○	
TANDEM TEST	○	
GEAR TEST	○	
HELIUM LEAK TEST	○	
SOUND LEVEL TEST (SURVEY ONLY)	○	
AUX. EQUIPMENT TEST _____	○	
FULL LOAD / SPEED / PRESS TEST	○	
HYDRAULIC COUPLING INSP	○	
SPARE PARTS TEST _____	○	
INSPECTOR'S CHECKLIST COMPLIANCE	○	
GAS SEAL TEST VENDOR SHOP	○	
ADDITIONAL INSPECTION _____	○	

MANUALS

○ DRAFT MANUAL FOR REVIEW

○ TECHNICAL DATA MANUAL

MISCELLANEOUS:

☐ RECOMMENDED STRAIGHT RUN OF PIPE DIAMETERS BEFORE SUCTION _____

○ COMPRESSOR TO BE SUITABLE FOR FIELD RUN-IN ON AIR

○ PROVISION FOR LIQUID INJECTION _____

○ INJECTION MANIFOLD

○ VENDOR'S REVIEW & COMMENTS ON PURCHASER'S CONTROL SYSTEMS

○ SHOP FITUP OF VENDOR PROCESS PIPING

○ WELDING HARDNESS TESTING _____

○ INSPECT CLEANLINESS _____

○ DESIGN AUDIT

○ BALANCE PISTON ΔP

○ PROVIDE TAIL END SCHEDULES

VENDOR'S REPRESENTATIVE SHALL

○ OBSERVE FLANGE PARTING

○ CHECK ALIGNEMENT AT TEMPERATURE

○ BE PRESENT AT INITIAL ALIGNMENT

☐ **WEIGHTS:** (kg)

COMPR. _____ GEAR _____ DRIVER _____ BASE _____

ROTORS: COMPR. _____ DRIVER _____ GEAR _____

COMPRESSOR UPPER CASE _____

MAX. FOR MAINTENANCE (IDENTIFY) _____

TOTAL SHIPPING WEIGHT _____

☐ **SPACE REQUIREMENTS:** (mm)

COMPLETE UNIT: L _____ W _____ H _____

SPECIAL TOOL PACKAGING

○ METAL STORAGE CONTAINER

○ OTHER: _____

PAINTING:

○ MANUFACTURER'S STD.

○ OTHER _____

SHIPMENT:

○ DOMESTIC ○ EXPORT ○ EXPORT BOXING REQ'D.

○ OUTDOOR STORAGE MORE THAN 6 MONTHS _____ MONTH

SPARE ROTOR ASSEMBLY PACKAGE

○ HORIZONTAL STORAGE ○ VERTICAL STORAGE

○ METAL STORAGE CONTAINER

○ N2 PURGE ○ OTHER: _____

REMARKS: _____

REVISION	0	1	2	3	4
DATE					
BY					
REV/APPR					

CENTRIFUGAL AND AXIAL COMPRESSOR DATASHEET (API 617-8th, Part 2)
U.S. CUSTOMARY

JOB NO. _____ ITEM NO. _____
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APPLICABLE TO: ○ PROPOSAL ○ PURCHASE ○ AS BUILT

FOR		UNIT	
SITE		SERIAL NO.	
SERVICE		NO. REQUIRED	
MANUFACTURER		DRIVER TYPE	
MODEL		DRIVER ITEM NO.	

APPLICABLE STANDARD: ○ U.S. ○ ISO

INFORMATION TO BE COMPLETED: ○ BY PURCHASER ☐ BY MANUFACTURER △ MUTUAL AGREEMENT (PRIOR TO PURCHASE)

OPERATING CONDITIONS (SINGLE-COOLED CONFIGURATION)

(ALL DATA ON PER UNIT BASIS)	NORMAL		OTHER CONDITIONS			
	Section 1	Section 2	Section 1	Section 2	Section 1	Section 2
○ GAS HANDLED (ALSO SEE PAGE ____)						
△ GAS PROPERTIES						
○ MMSCFD/SCFM (14.7 psia & 60°F DRY)						
○ WEIGHT FLOW, (lb/hr) (WET) (DRY)						
INLET CONDITIONS						
○ PRESSURE (psia)						
○ TEMPERATURE (°F)						
○ RELATIVE HUMIDITY %						
○ MOLECULAR WEIGHT						
☐ Cp/Cv (K_1) OR (K_{AVG}) (NOTE 1)						
☐ COMPRESSIBILITY (Z_1) OR (Z_{AVG}) (NOTE 1)						
☐ INLET VOLUME, (cfm) (WET / DRY)						
DISCHARGE CONDITIONS						
○ PRESSURE (psia)						
☐ TEMPERATURE (°F)						
☐ Cp/Cv (K_2) OR (K_{AVG}) (NOTE 1)						
☐ COMPRESSIBILITY (Z_2) OR (Z_{AVG}) (NOTE 1)						
☐ GAS POWER REQUIRED (HP)						
☐ TRAIN POWER REQUIRED (HP)						
☐ POWER REQ'D AT DRIVER INCL. EXT. LOSSES (HP)						
☐ SPEED (rpm)						
☐ TURNDOWN (%)						
☐ POLYTROPIC HEAD (ft-lb/lb)						
☐ POLYTROPIC EFFICIENCY (%)						
○ CERTIFIED POINT						
☐ PERFORMANCE CURVE NUMBER						

PROCESS CONTROL

METHOD ○ SUCTION THROTTLING ○ VARIABLE INLET GUIDE VANES ○ SPEED VARIATION ○ DISCHARGE BLOWOFF ○ COOLED BYPASS

FROM	(psia)	FROM	%	FROM
TO	(psia)	TO	%	TO

SIGNAL ○ SOURCE _____
TYPE ○ ELECTRONIC ○ PNEUMATIC ○ OTHER _____
RANGE _____ MA _____ (psig) _____

START-UP ○ FROM SETTLING OUT CONDITION ○ NORMAL SUCTION PARTS ○ OTHER: _____

REMARKS: NOTE 1: IF GAS ANALYSIS IS GIVEN, MANUFACTURER SHALL SUPPLY DATA, OTHERWISE DATA SHALL BE SUPPLIED BY USER

CENTRIFUGAL AND AXIAL COMPRESSOR
DATASHEET (API 617-8th, Part 2)
U.S. CUSTOMARY

JOB NO. _____ ITEM NO.
PAGE 1b OF 7 REQ'N NO. _____

OPERATING CONDITIONS

	NORMAL	OTHER CONDITIONS				
(ALL DATA ON PER UNIT BASIS)		A	B	C	D	E
	0	1	2	3	4	
○ GAS HANDLED (ALSO SEE PAGE ___)						
△ GAS PROPERTIES						
○ MMSCFD/SCFM (14.7 psia & 60°F DRY)						
○ WEIGHT FLOW, (lb/hr) (WET) (DRY)						
INLET CONDITIONS						
○ PRESSURE (psia)						
○ TEMPERATURE (°F)						
○ RELATIVE HUMIDITY %						
○ MOLECULAR WEIGHT						
□ Cp/Cv (K_1) OR (K_{AVG}) (NOTE 1)						
□ COMPRESSIBILITY (Z_1) OR (Z_{AVG}) (NOTE 1)						
□ INLET VOLUME, (cfm) (WET / DRY)						
DISCHARGE CONDITIONS						
○ PRESSURE (psia)						
□ TEMPERATURE (°F)						
□ Cp/Cv (K_2) OR (K_{AVG}) (NOTE 1)						
□ COMPRESSIBILITY (Z_2) OR (Z_{AVG}) (NOTE 1)						
□ GAS POWER REQUIRED (HP)						
□ TRAIN POWER REQUIRED (HP)						
□ POWER REQ'D AT DRIVER INCL. EXT. LOSSES (HP)						
□ SPEED (rpm)						
□ TURNDOWN (%)						
□ POLYTROPIC HEAD (ft-lb/lb)						
□ POLYTROPIC EFFICIENCY (%)						
○ CERTIFIED POINT						
□ PERFORMANCE CURVE NUMBER						

REMARKS: NOTE 1: IF GAS ANALYSIS IS GIVEN, MANUFACTURER SHALL SUPPLY DATA, OTHERWISE DATA SHALL BE SUPPLIED BY USER

REVISION	0	1	2	3	4
DATE					

CENTRIFUGAL AND AXIAL COMPRESSOR
DATASHEET (API 617-8th, Part 2)
U.S. CUSTOMARY

JOB NO. _____ ITEM NO. _____
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OPERATING CONDITIONS

	NORMAL	OTHER CONDITIONS				
(ALL DATA ON PER UNIT BASIS)		A	B	C	D	E
○ GAS HANDLED (ALSO SEE PAGE ___)						
△ GAS PROPERTIES						
○ MMSCFD/SCFM (14.7 psia & 60°F DRY)						
○ WEIGHT FLOW, (lb/hr) (WET) (DRY)						
INLET CONDITIONS						
○ PRESSURE (psia)						
○ TEMPERATURE (°F)						
○ RELATIVE HUMIDITY %						
○ MOLECULAR WEIGHT						
□ Cp/Cv (K_1) OR (K_{AVG}) (NOTE 1) (NOTE 1)						
□ COMPRESSIBILITY (Z_1) OR (Z_{AVG}) (NOTE 1) (NOTE 1)						
□ INLET VOLUME, (cfm) (WET / DRY)						
DISCHARGE CONDITIONS						
○ PRESSURE (psia)						
□ TEMPERATURE (°F)						
□ Cp/Cv (K_2) OR (K_{AVG}) (NOTE 1)						
□ COMPRESSIBILITY (Z_2) OR (Z_{AVG}) (NOTE 1)						
□ GAS POWER REQUIRED (HP)						
□ TRAIN POWER REQUIRED (HP)						
□ POWER REQ'D AT DRIVER INCL. EXT. LOSSES (HP)						
□ SPEED (rpm)						
□ TURNDOWN (%)						
□ POLYTROPIC HEAD (ft-lb/lb)						
□ POLYTROPIC EFFICIENCY (%)						
○ CERTIFIED POINT						
□ PERFORMANCE CURVE NUMBER						

REMARKS: NOTE 1: IF GAS ANALYSIS IS GIVEN, MANUFACTURER SHALL SUPPLY DATA, OTHERWISE DATA SHALL BE SUPPLIED BY USER

REVISION	0	1	2	3	4
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CENTRIFUGAL AND AXIAL COMPRESSOR
DATASHEET (API 617-8th, Part 2)
U.S. CUSTOMARY

JOB NO. _____ ITEM NO. _____
PAGE 2 OF 7 REQ'N NO. _____

OPERATING CONDITIONS (Continued)

GAS ANALYSIS: ○ MOL %	MW	NORMAL	OTHER CONDITIONS A	B	C	D	E	REMARKS:
AIR	28.966							
OXYGEN	32.000							
NITROGEN	28.016							
WATER VAPOR	18.016							
CARBON MONOXIDE	28.010							
CARBON DIOXIDE	44.010							
HYDROGEN SULFIDE	34.076							
HYDROGEN	2.016							
METHANE	16.042							
ETHYLENE	28.052							
ETHANE	30.068							
PROPYLENE	42.078							
PROPANE	44.094							
I-BUTANE	58.120							
n-BUTANE	58.120							
I-PENTANE	72.146							
n-PENTANE	72.146							
HEXANE PLUS								
CORROSIVE AGENTS								
TOTAL								
AVG. MOL. WT.								

LOCATION:
○ INDOOR ○ OUTDOOR ○ GRADE
○ HEATED ○ UNDER ROOF ○ MEZZANINE
○ UNHEATED ○ PARTIAL SIDES ○ _____

SITE DATA
○ ELEVATION _____ (ft) BAROMETER _____ (psia)
○ RANGE OF AMBIENT TEMPS:

		DRY BULB	WET BULB
NORMAL	(°F)		
MAXIMUM	(°F)		
MINIMUM	(°F)		
_____	(°F)		

UNUSUAL CONDITIONS: ○ DUST ○ FUMES
○ OTHER _____
○ COPPER AND COPPER ALLOYS PROHIBITED

COATING:
○ ROTATING COMPONENTS _____
○ STATIONARY COMPONENTS _____

REMARKS: _____

NOISE SPECIFICATIONS:
○ APPLICABLE TO MACHINE:
SEE SPECIFICATION _____
○ APPLICABLE TO NEIGHBORHOOD:
SEE SPECIFICATION _____
ACOUSTIC HOUSING: ○ YES ○ NO

APPLICABLE SPECIFICATIONS:
API 617, 7TH CHAPTER 2
○ VENDOR HAVING UNIT RESPONSIBILITY
_____
○ GOVERNING SPECIFICATION (IF DIFFERENT)
_____

○ ELEC. AREA CLASS. ○ NEC ○ IEC
EQUIPMENT
CLASS _____ GROUP _____ DIV. _____
ZONE _____ GROUP _____ TEMP CLASS _____
CONTROL PANNELS
CLASS _____ GROUP _____ DIV. _____
ZONE _____ GROUP _____ TEMP CLASS _____

INSTRUMENT AND CONTROLS
STANDARD ○ NEMA ○ IEC

	INDOOR	OUTDOOR
CONTROL ENCLOSURE		
TERMINAL BOX		

REVISION	0	1	2	3	4
DATE					

CENTRIFUGAL AND AXIAL COMPRESSOR DATASHEET (API 617-8th, Part 2)
U.S. CUSTOMARY

JOB NO. _____ ITEM NO. _____
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CONSTRUCTION FEATURES

☐ **SPEEDS:**
MAX. CONT. _____ (rpm) TRIP _____ (rpm)
MAX. TIP SPEEDS: _____ (fps) @ 100% SPEED
_____ (fps) @ MAX. CONT. SPEED

☐ **LATERAL CRITICAL SPEEDS (DAMPED)**
FIRST CRITICAL _____ (rpm) _____ MODE
SECOND CRITICAL _____ (rpm) _____ MODE
THIRD CRITICAL _____ (rpm) _____ MODE
FOURTH CRITICAL _____ (rpm) _____ MODE

○ LATERAL ANALYSIS ADDITIONAL REQUIREMENTS
○ TRAIN LATERAL ANALYSIS REQUIRED
○ TRAIN TORSIONAL ANALYSIS REQUIRED

☐ **TORSIONAL CRITICAL SPEEDS:**
FIRST CRITICAL _____ (rpm)
SECOND CRITICAL _____ (rpm)
THIRD CRITICAL _____ (rpm)
FOURTH CRITICAL _____ (rpm)

○ LIST OF TRAIN UNDESIRABLE SPEEDS
○ STABILITY ANALYSIS

☐ **VIBRATION:**
ALLOWABLE TEST LEVEL _____ (mil)
(PEAK TO PEAK)

NAMEPLATE
○ US CUSTOMARY ○ METRIC

☐ **ROTATION, VIEWED FROM DRIVEN END** ○ CW ○ CCW

○ **MATERIALS INSPECTION REQUIREMENTS**
○ RADIOGRAPHY REQUIRED FOR _____
○ ULTRASONIC REQUIRED FOR _____
○ MAGNETIC PARTICLE REQUIRED FOR _____
○ LIQUID PENETRANT REQUIRED FOR _____
○ LOW TEMPERATURE _____
MIN. DESIGN METAL TEMPERATURE (°F) _____
AT CONCURRENT PRESSURE (psig) _____
○ OTHER TRAIN COMPONENTS

☐ **CASING:**
MODEL _____
CASING SPLIT _____
MATERIAL _____
THICKNESS (in.) _____ CORR. ALLOW. (in.) _____
MAX. ALLOWABLE PRESS _____ (psig)
TEST PRESS: (psig) HELIUM _____ HYDRO _____
MAX. ALLOWABLE TEMPERATURE _____ (°F)
MAX OPER. TEMP. _____ (°F) MIN. OPER. TEMP. _____ (°F)
MAX CASING CAPACITY _____ (icfm)
○ SYSTEM RELIEF VALVE SET PT. _____ (psig)
○ Q.C. OF INACCESSIBLE WELDS

☐ **DIAPHRAGMS:**
MATERIAL _____
AXIALLY SPLIT ☐ YES ☐ NO
DIAPHRAGM MAX. Δ P (BAR)(kPa):

○ **INTERMEDIATE MAIN PROCESS CONNECTIONS**
DISCH. PRESSURE: (psig) MAX _____ MIN _____
INLET PRESSURE: (psig) MAX _____ MIN _____

☐ **GUIDE VANES**
○ IGV EXTERNAL PURGE _____
○ VANE CONTROL SYSTEM _____
NUMBER OF AXIAL BLADE ROWS _____
NUMBER OF ADJUSTIBLE ROWS _____
NO. VANES GUIDE VANE _____ MATERIAL _____

☐ **IMPELLERS:**
NO. _____ DIAMETERS _____
NO. VANES EA. IMPELLER _____
TYPE (OPEN, ENCLOSED, ETC.) _____
TYPE FABRICATION _____ MATERIAL _____
MIN. YIELD STRENGTH (psi) _____
HARDNESS: (Rc) (BRINNEL) MAX _____ MIN _____
SMALLEST TIP INTERNAL WIDTH (in.) _____
MAX. MACH. NO. @ IMPELLER EYE _____
MAX. IMPELLER HEAD @ 100% SPD (ft-lb/lb) _____

☐ **SHAFT:**
○ ONE PIECE ○ BUILT UP
MATERIAL _____
DIA @ IMPELLERS (in.) _____ DIA @ COUPLING (in.) _____
SHAFT END: ○ TAPERED ○ CYLINDRICAL
○ SPLINED ○ INTEGRAL FLANGE
MIN. YIELD STRENGTH (psi) _____
SHAFT HARDNESS (BNH)(Rc) _____
MAX TORQUE CAPABILITY (ft-lb) _____

☐ **BALANCE PISTON:**
MATERIAL _____ AREA _____ (in.²)
FIXATION METHOD _____
NORMAL CLEARANCE (in.) _____
FLOW WITH NORMAL CLEARANCE (lb/min) _____
FLOW WITH 2x NORMAL CLEARANCE (lb/min) _____
○ PRESS. CONN. BAL LINE DOWNSTREAM

☐ **SHAFT SLEEVES:**
AT INTERSTG. CLOSE MATL _____
CLEARANCE POINTS
AT SHAFT SEALS MATL _____
○ ACCESSIBLE

ROTOR
○ DISASSEMBLY AND REASSEMBLY
○ AT SPEED BALANCING
○ SEQUENTIAL LOW SPEED BAL. PREC. AT SPEED BAL.
○ RESIDUAL BALANCE CHECK

☐ **LABYRINTHS:**
INTERSTAGE
TYPE _____ MATERIAL _____
BALANCE PISTON
TYPE _____ MATERIAL _____

REMARKS: _____

REVISION	0	1	2	3	4
DATE					

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LOW PRESSURE CASING CONSTRUCTION FEATURES (CONTINUED)

SHAFT SEALS:

- ○ SEAL TYPE _____
- ○ SETTLING OUT PRESSURE (psig) _____
- ○ MIN.SEALING PRESSURE (psig) _____
- ○ SUPPLEMENTAL DEVICE REQUIRED FOR CONTACT SEALS TYPE _____
- ○ BUFFER GAS SYSTEM REQUIRED
- ○ TYPE BUFFER GAS _____
  - ☐ PRESSURE _____ (psig)
  - ☐ FLOWRATE _____ (lb/min)
  - ☐ FILTRATION _____ (µm)
- ○ MANIFOLD
- ○ METHOD OF CONTROL
- ○ BUFFER GAS CONTROL SYSTEM SCHEMATIC BY VENDOR
- ○ PRESSURIZING GAS FOR SUBATMOSPHERIC SEALS
  - ○ EDUCTOR ○ INJECTION
- ☐ SEAL MANUFACTURER _____
- ☐ LEAKAGE TO PROCESS (gal/day/seal) _____
- BUFFER GAS REQUIRED FOR:
  - ☐ AIR RUN-IN ☐ OTHER _____
- ☐ FLOW (PER SEAL):
  - NORM: _____ (lb/min) @ _____ (psi) Δ P _____
  - MAX. _____ (lb/min) @ _____ (psi) Δ P _____
- ☐ **BEARING HOUSING CONSTRUCTION:**
  - TYPE (SEPARATE, INTEGRAL) _____ SPLIT _____
  - MATERIAL _____

AXIAL COMPRESSOR

STAGE	1	2	3	4	5	6	7	8	9
ROTOR									
☐ BLADE MATERIAL									
☐ BLADE ROOT TYPE									
☐ CORD WIDTH (in.)									
☐ OUTER DIAMETER (in.)									
☐ BLADE HEIGHT (in.)									
☐ BLADE QUANTITY									
STATOR									
☐ BLADE MATERIAL									
☐ TYPE (MOVABLE, FIXED, ADJUSTABLE)									
☐ CORD WIDTH (in.)									
☐ BLADE QUANTITY									

STAGE	10	11	12	13	14	15	16	17	18
ROTOR									
☐ BLADE MATERIAL									
☐ BLADE ROOT TYPE									
☐ CORD WIDTH (in.)									
☐ OUTER DIAMETER (in.)									
☐ BLADE HEIGHT (in.)									
☐ BLADE QUANTITY									
STATOR									
☐ BLADE MATERIAL									
☐ TYPE (MOVABLE, FIXED, ADJUSTABLE)									
☐ CORD WIDTH (in.)									
☐ BLADE QUANTITY									

REMARKS: _____

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CONSTRUCTION FEATURES (CONTINUED)

BEARINGS AND BEARING HOUSINGS

○ MAGNETIC BEARINGS

RADIAL	THRUST	NON-THRUST
☐ TYPE		
☐ MANUFACTURER		
☐ LENGTH (in.)		
☐ SHAFT DIA. (in.)		
☐ UNIT LOAD (ACT/ALLOW) (psi)		
☐ BASE MATERIAL		
☐ BABBIT THICKNESS (in.)		
☐ NO. PADS		
☐ LOAD: B'TWN/ON PAD		
☐ PIVOT: CTR/OFFSET, %		
PAD MATERIAL ○ ○		
☐ BEARING SPAN _____ (in.)		

THRUST	ACTIVE	INACTIVE
☐ TYPE		
☐ MANUFACTURER		
☐ UNIT LOADING - MAX (psi)		
☐ UNIT LOAD - ULT. (psi)		
☐ AREA (in.²)		
☐ NO. PADS		
☐ PIVOT: CENTER / OFFSET, %		
☐ PAD BASE MATL		

○ COPPER BACKED
LUBRICATION: ○ FLOODED ○ DIRECTED
THRUST COLLAR: ○ INTEGRAL ○ REPLACEABLE
MATERIAL _____
☐ SIZING CRITERIUM

BEARING TEMPERATURE DETECTORS

○ SEE ATTACHED API-670 DATASHEET
○ THERMOCOUPLES TYPE _____
○ RESISTANCE TEMP DETECTORS
○ RESISTANCE MAT'L _____ ○ _____ OHMS
☐ ALARM TEMPERATURE _____ (°F)
☐ SHUTDOWN TEMPERATURE _____ (°F)
○ PROVISION FOR LOCAL DISCONNECT
○ LOCATION-JOURNAL BRG
NO. ___ EA PAD _____ EVERY OTH PAD ___ PER BRG
OTHER _____
○ LOCATION-THRUST BRG
NO. ___ EA PAD _____ EVERY OTH PAD ___ PER BRG
OTHER _____
NO. (INACT) ___ EA PAD ___ EVERY OTH PAD ___ PER BRG
OTHER _____
○ LOCAL DISCONNECTION
○ MONITOR SUPPLIED BY _____
○ LOCATION _____ ENCLOSURE _____
○ MFR. _____ ☐ MODEL _____
☐ SCALE RGE _____ ○ ALARM ☐ SET @ _____ (°F)
○ SHTDWN ☐ SET @ _____ (°F) ○ TIME DELAY _____ SEC

VIBRATION DETECTORS: ○ SEE ATTACHED API 670 DATASHEET
○ TYPE _____ ☐ MODEL _____
○ MFR _____
○ NO. AT EA SHAFT BEARING _____ TOTAL NO. _____
○ OSCILLATOR-DETECTORS SUPPLIED BY _____
○ MFR _____ ☐ MODEL _____
MONITOR SUPPLIED BY _____
○ LOCATION _____ ENCLOSURE _____
○ MFR. _____ ☐ MODEL _____
☐ SCALE RGE ___ ○ ALARM ☐ SET @ _____ (mil)
○ SHTDWN: ☐ SET @ ___ (mil) ○ TIME DELAY ___ SEC
○ CASING VIBRATION TRANSDUCERS
○ CASING VIBRATION MONITORS

AXIAL POSITION DETECTOR: ○ SEE ATTACH. API-670 DATASHEET
○ TYPE _____ ☐ MODEL _____
● MFR _____ ○ NO. REQUIRED _____
○ OSCILLATOR-DEMODULATOR SUPPLIED BY _____
○ MFR _____ ☐ MODEL _____
○ MONITOR SUPPLIED BY _____
○ LOCATION _____ ENCLOSURE _____
○ MFR. _____ ☐ MODEL _____
☐ SCALE RGE ___ ○ ALARM ☐ SET @ _____ (mil)
○ SHTDWN: ☐ SET @ ___ (mil) ○ TIME DELAY ___ SEC

KEY PHASOR REQUIRED
○ COMPRESSOR ○ GEAR H.S. ○ GEAR L.S.

CASING CONNECTIONS

CONNECTION	☐ ANSI/ASME (B16.1; B16.5; B16.42; B16.47 series A, B; ISO 7005-1, -2; OTHER)	☐ FACING ☐ BORE	○ ORIENTATION	◯ FLANGED OR STUDDED	○ MATING FLG & GASKET BY VENDOR	☐ GAS VELOCITY (fps)
INLET						
DISCHARGE						

○ BOROSCOPIC INSPECTION PORTS

REVISION	0	1	2	3	4
DATE					

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☐ **OTHER CONNECTIONS**

SERVICE:	NO.	SIZE	TYPE		NO.	SIZE	TYPE
LUBE-OIL INLET				PRESSURE			
LUBE OIL OUTLET				TEMPERATURE			
SEAL-OIL INLET				SOLVENT INJECTION			
SEAL-OIL OUTLET				PURGE FOR:			
SEAL GAS INLET				BRG. HOUSING			
SEAL GAS OUTLET				BTWN BRG & SEAL			
CASING DRAINS				BTWN SEAL & GAS			
STAGE DRAINS							

○ INDIVIDUAL STAGE DRAINS REQUIRED
○ VALVED & BLINDED
○ VALVED & BLINDED & MANIFOLD

LUBRICATION AND SEALING SYSTEMS

○ SEE ATTACHED API 614 DATASHEET
○ SEPARATE ○ COMBINED
○ INTEGRAL OIL RESERVOIR
○ OIL TYPE

ACCESSORIES

COUPLING AND GUARDS

NOTE: SEE ROTATING ELEMENTS - SHAFT ENDS

○ SEE ATTACHED API 671 DATASHEET ○ KEYLESS HYDRAULIC ○ KEYED ○ FLANGED ○ OTHER _____
COUPLING FURNISHED BY _____ MOUNTED BY _____
MANUFACTURER _____ TYPE _____ MODEL _____
COUPLING GUARD FURNISHED BY: _____
TYPE: ○ FULLY ENCLOSED ○ SEMI-OPEN ○ OTHER

COUPLING DETAILS

☐ MAX O.D. _____ (in.)
☐ HUB WEIGHT _____ (lb)
☐ SPACER LENGTH _____ (in.)
☐ SPACER WEIGHT _____ (lb)

○ PLUG AND RING GAUGES ○ LAPPING TOOL
LUBRICATION REQUIREMENTS:
○ NON-LUBE ○ CONT. OIL LUBE ○ OTHER _____
QUANTITY PER HUB _____ (lb) or (gpm)

MOUNTING PLATES

○ BASEPLATES FURNISHED BY _____
○ COMPRESSOR ONLY ○ DRIVER ○ GEAR
○ OTHER _____
○ NONSKID DECKING ○ SLOPED DECK
△ LEVELING PADS OR TARGETS
△ COLUMN MOUNTING
○ SUB-SOLE PLATES REQUIRED
☐ STAINLESS STEEL SHIM THICKNESS _____ (in.)
○ MACHINED MOUNTING PADS REQUIRED

○ SOLEPLATES FURNISHED BY _____
☐ THICKNESS _____ (in.)
○ SUBSOLE PLATES REQUIRED
○ EXTENT OF PIPING _____
☐ STAINLESS STEEL SHIM THICKNESS _____ (in.)
○ COMPRESSOR _____
○ COUNTER BORE ANCHOR BOLT HOLES

ANTI-SURGE SYSTEM FURNISHED BY ○ PURCHASER ☐ SUPPLIER

○ ☐ ANTI-SURGE VALVE ○ SIZING ONLY
PRESSURE UPSTREAM: _____ (psig) DOWNSTREAM Δ P _____ (psig)
☐ Δ P VALVE _____ STROKE TIME OPEN - CLOSE _____ (sec)

○ ☐ RECIRCULATION VALVE ○ SIZING ONLY
○ ☐ BLOWOFF VALVE ○ SIZING ONLY
○ ☐ CONTROL SYSTEM
○ ☐ PIPING
○ ☐ FLOW ELEMENT
○ ☐ _____ ○ ☐ _____
○ ☐ _____ ○ ☐ _____
○ ☐ _____ ○ ☐ _____
○ ☐ _____ ○ ☐ _____
○ ☐ _____ ○ ☐ _____
○ ☐ _____ ○ ☐ _____

REMARKS: _____

REVISION	0	1	2	3	4
DATE	00-Jan-00				

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UTILITIES

○ **UTILITY CONDITIONS:**

STEAM: DRIVERS

INLET MIN		(psig)		(°F)
NORM		(psig)		(°F)
MAX		(psig)		(°F)
EXHAUST. MIN		(psig)		(°F)
NORM		(psig)		(°F)
MAX		(psig)		(°F)

ELECTRICITY:

	DRIVERS	CONTROL	SHUTDOWN
VOLTAGE			
HERTZ			
PHASE			

○ REDUCED VOLTAGE START

△ NUMBER OF STARTS _____

INSTRUMENT AIR:

MAX PRESS _____ (psig) MIN PRESS _____ (psig)

SHOP INSPECTION AND TESTS:

	REQ'D	WIT/OBV
○ (SEE INSPECTOR'S CHECKLIST)		
HYDROSTATIC	●	
IMPELLER OVERSPEED	●	
MECHANICAL RUN	●	
○ CONTRACT COUPLING ○ IDLING ADAPTOR(S)		
○ CONTRACT PROBES ○ SHOP PROBES		
○ PURCHASER VIB. EQUIPMENT		
VARY LUBE & SEAL OIL PRESSURES		
AND TEMPERATURES	○	
POLAR FORM VIB DATA	○	
TAPE RECORD VIB DATA	○	
SHAFT END SEAL INSP	○	
GAS LEAK TEST AT DISCH PRESS	○	
○ POST TEST INTERNAL INSP		
○ BEFORE GAS LEAKAGE TEST		
○ AFTER GAS LEAKAGE TEST		
INTERMEDIATE HEAD/PRESSURE TOL.	○	
PERFORMANCE TEST (GAS) (AIR)	○	
COMPLETE UNIT TEST	○	
TANDEM TEST	○	
GEAR TEST	○	
HELIUM LEAK TEST	○	
SOUND LEVEL TEST (SURVEY ONLY)	○	
AUX. EQUIPMENT TEST _____	○	
FULL LOAD / SPEED / PRESS TEST	○	
HYDRAULIC COUPLING INSP	○	
SPARE PARTS TEST _____	○	
INSPECTOR'S CHECKLIST COMPLIANCE	○	
GAS SEAL TEST VENDOR SHOP	○	
ADDITIONAL INSPECTION _____	○	

MANUALS

○ DRAFT MANUAL FOR REVIEW

○ TECHNICAL DATA MANUAL

MISCELLANEOUS:

☐ RECOMMENDED STRAIGHT RUN OF PIPE DIAMETERS BEFORE SUCTION _____

○ COMPRESSOR TO BE SUITABLE FOR FIELD RUN-IN ON AIR

○ PROVISION FOR LIQUID INJECTION _____

○ INJECTION MANIFOLD

○ VENDOR'S REVIEW & COMMENTS ON PURCHASER'S CONTROL SYSTEMS

○ SHOP FITUP OF VENDOR PROCESS PIPING

○ WELDING HARDNESS TESTING _____

○ INSPECT CLEANLINESS _____

○ DESIGN AUDIT

○ BALANCE PISTON ΔP

○ PROVIDE TAIL END SCHEDULES

VENDOR'S REPRESENTATIVE SHALL

○ OBSERVE FLANGE PARTING

○ CHECK ALIGNEMENT AT TEMPERATURE

○ BE PRESENT AT INITIAL ALIGNMENT

☐ **WEIGHTS:** (lb)

COMPR. _____ GEAR _____ DRIVER _____ BASE _____

ROTORS: COMPR. _____ DRIVER _____ GEAR _____

COMPRESSOR UPPER CASE _____

MAX. FOR MAINTENANCE (IDENTIFY) _____

TOTAL SHIPPING WEIGHT _____

☐ **SPACE REQUIREMENTS:** (in.)

COMPLETE UNIT: L _____ W _____ H _____

SPECIAL TOOL PACKAGING

○ METAL STORAGE CONTAINER

○ OTHER: _____

PAINTING:

○ MANUFACTURER'S STD.

○ OTHER _____

SHIPMENT:

○ DOMESTIC ○ EXPORT ○ EXPORT BOXING REQ'D.

○ OUTDOOR STORAGE MORE THAN 6 MONTHS _____ MONTH

SPARE ROTOR ASSEMBLY PACKAGE

○ HORIZONTAL STORAGE ○ VERTICAL STORAGE

○ METAL STORAGE CONTAINER

○ N2 PURGE ○ OTHER: _____

REMARKS: _____

Annex B
(informative)

Vendor (Supplier) Data and Drawing Requirements

B.1 VDDR for Centrifugal and Axial Compressors (See Text for Details of the Description)

CENTRIFUGAL AND AXIAL COMPRESSOR SUPPLIER DRAWING AND DATA REQUIREMENTS		
	Job No.	Item No. .....
	Purchase Order No.	Date .....
	Requisition No.	Date .....
	Inquiry No.	Date .....
	Revision ……. by	Manufacturer .....
	For	Unit .....
	Site	Service .....

Proposal [a]—Bidder shall furnish number of paper copies/number of electronic copies of data as indicated
Review—Supplier shall furnish number of paper copies/number of electronic copies of data as indicated
Final—Supplier shall furnish number of paper copies/number of electronic copies of data as indicated

			Description (see text)	**Distribution Record**				
				Review Due from Supplier [b c]	Review Received from Supplier	Review Returned to Supplier	Final Due from Supplier [c]	Final Received from Supplier
/	/	/	1. Certified dimensional outline drawing and list of connections					
/	/	/	2. Cross-sectional drawings and part numbers					
/	/	/	3. Rotor assembly drawings and part numbers					
/	/	/	4. Thrust-bearing assembly drawings and part numbers					
/	/	/	5. Journal-bearing assembly drawings and bill of materials					
/	/	/	6. Coupling assembly drawings and bill of materials					
/	/	/	7. Lube-oil schematic and bill of materials					
/	/	/	8. Lube-oil arrangement drawing and list of connections					
/	/	/	9. Lube-oil component drawings and data					
/	/	/	10. Seal system schematic and bill of material					

a Proposal drawings and data do not have to be certified. Typical data shall be clearly identified as such.
b Purchase may indicate in the column the desired time frame for submission of data.
c Bidder shall complete these two columns to reflect the actual distribution schedule and include this form with the proposal.

CENTRIFUGAL AND AXIAL COMPRESSOR SUPPLIER DRAWING AND DATA REQUIREMENTS		
	Job No.	Item No. .....
	Purchase Order No.	Date .....
	Requisition No.	Date .....
	Inquiry No.	Date .....
	Revision …….. by	Manufacturer .....
	For	Unit .....
	Site	Service .....

Proposal [a]—Bidder shall furnish number of paper copies/number of electronic copies of data as indicated
Review—Supplier shall furnish number of paper copies/number of electronic copies of data as indicated
Final—Supplier shall furnish number of paper copies/number of electronic copies of data as indicated

Description (see text)				**Distribution Record**				
▼	▼	▼		Review Due from Supplier [b c]	Review Received from Supplier	Review Returned to Supplier	Final Due from Supplier [c]	Final Received from Supplier
/	/	/	11. Seal system arrangement drawing and list of connections					
/	/	/	12. Seal system component drawings and data					
/	/	/	13. Seal assembly drawing and part numbers					
/	/	/	14. Electrical and instrumentation schematics and bill of materials					
/	/	/	15. Electrical and instrumentation arrangement of drawing and list of connections					
/	/	/	16. Buffer gas system schematic and bill of material					
/	/	/	17. Buffer gas system arrangement drawing and list of connections					
/	/	/	18. Buffer gas system component drawing and data					
/	/	/	19. Datasheets (proposal/as-built)					
/	/	/	20. Predicted noise sound level (proposal)					

[a] Proposal drawings and data do not have to be certified. Typical data shall be clearly identified as such.
[b] Purchase may indicate in the column the desired time frame for submission of data.
[c] Bidder shall complete these two columns to reflect the actual distribution schedule and include this form with the proposal.

CENTRIFUGAL AND AXIAL COMPRESSOR SUPPLIER DRAWING AND DATA REQUIREMENTS

Job No.	Item No. .....
Purchase Order No.	Date .....
Requisition No.	Date .....
Inquiry No.	Date .....
Revision ……. by	Manufacturer .....
For	Unit .....
Site	Service .....

Proposal [a]—Bidder shall furnish number of paper copies/number of electronic copies of data as indicated
Review—Supplier shall furnish number of paper copies/number of electronic copies of data as indicated
Final—Supplier shall furnish number of paper copies/number of electronic copies of data as indicated

			Description (see text)	**Distribution Record**				
				Review Due from Supplier [b c]	Review Received from Supplier	Review Returned to Supplier	Final Due from Supplier [c]	Final Received from Supplier
/	/	/	21. Metallurgy of major components (in proposal)					
/	/	/	22. Lateral analysis report and stability analysis (if required)					
/	/	/	23. Torsional analysis report					
/	/	/	24. Vibration analysis report					
/	/	/	25. Performance curves for each compressor section (proposal/as-built)					
/	/	/	26. Impeller overspeed test report					
/	/	/	27. Mechanical running test report					
/	/	/	28. Coupling selection and rating					
/	/	/	29. List of recommended spare parts					
/	/	/	30. List of special tools					
/	/	/	31. Preparation for storage at job site before installation					

a Proposal drawings and data do not have to be certified. Typical data shall be clearly identified as such.
b Purchase may indicate in the column the desired time frame for submission of data.
c Bidder shall complete these two columns to reflect the actual distribution schedule and include this form with the proposal.

CENTRIFUGAL AND AXIAL COMPRESSOR SUPPLIER DRAWING AND DATA REQUIREMENTS	Job No.	Item No. .....
	Purchase Order No.	Date .....
	Requisition No.	Date .....
	Inquiry No.	Date .....
	Revision ……. by	Manufacturer .....
	For	Unit .....
	Site	Service .....

Proposal [a]—Bidder shall furnish number of paper copies/number of electronic copies of data as indicated
Review—Supplier shall furnish number of paper copies/number of electronic copies of data as indicated
Final—Supplier shall furnish number of paper copies/number of electronic copies of data as indicated

			Description (see text)	**Distribution Record**				
				Review Due from Supplier [b c]	Review Received from Supplier	Review Returned to Supplier	Final Due from Supplier [c]	Final Received from Supplier
/	/	/	32. Weather protection and winterization required at job site					
/	/	/	33. Tabulation of all utilities					
/	/	/	34. List of similar machines					
/	/	/	35. Operating restrictions to protect equipment during start-up operation and shutdown					
/	/	/	36. List of components requiring purchaser's approval					
/	/	/	37. Summary of materials and hardness of materials exposed to H_2S					
/	/	/	38. Seal leakage rates					
/	/	/	39. Interstage cooler system data					
/	/	/	40. Drawings, details, and description of instrumentation and controls					
/	/	/	41. Minimum length of straight pipe required at machine inlet or side inlets					
/	/	/	42. Maximum and minimum allowable seal pressure for each compressor					

[a] Proposal drawings and data do not have to be certified. Typical data shall be clearly identified as such.
[b] Purchase may indicate in the column the desired time frame for submission of data.
[c] Bidder shall complete these two columns to reflect the actual distribution schedule and include this form with the proposal.

CENTRIFUGAL AND AXIAL COMPRESSOR SUPPLIER DRAWING AND DATA REQUIREMENTS		
	Job No.	Item No. .....
	Purchase Order No.	Date .....
	Requisition No.	Date .....
	Inquiry No.	Date .....
	Revision …….. by	Manufacturer .....
	For	Unit .....
	Site	Service .....

Proposal [a]—Bidder shall furnish number of paper copies/number of electronic copies of data as indicated
Review—Supplier shall furnish number of paper copies/number of electronic copies of data as indicated
Final—Supplier shall furnish number of paper copies/number of electronic copies of data as indicated

			Description (see text)	**Distribution Record**				
				Review Due from Supplier [b c]	Review Received from Supplier	Review Returned to Supplier	Final Due from Supplier [c]	Final Received from Supplier
/	/	/	43. Statement of manufacturer's testing capabilities					
/	/	/	44. Performance test data and curves					
/	/	/	45. Back-to-back impeller machine supplier to provide thrust bearing loads versus differential pressure curve					
/	/	/	46. Balance piston leakage rates					
/	/	/	47. When specified, supplier shall supply curves of balance piston line differential pressure versus thrust load					
/	/	/	48. Production/delivery schedule					
/	/	/	49. Testing procedures					
/	/	/	50. Progress reports					
/	/	/	51. Installation manual					
/	/	/	52. Operating and maintenance manual					
/	/	/	53. Technical data manual					

[a] Proposal drawings and data do not have to be certified. Typical data shall be clearly identified as such.
[b] Purchase may indicate in the column the desired time frame for submission of data.
[c] Bidder shall complete these two columns to reflect the actual distribution schedule and include this form with the proposal.

CENTRIFUGAL AND AXIAL COMPRESSOR SUPPLIER DRAWING AND DATA REQUIREMENTS	Job No.	Item No. .....
	Purchase Order No.	Date .....
	Requisition No.	Date .....
	Inquiry No.	Date .....
	Revision ……. by	Manufacturer .....
	For	Unit .....
	Site	Service .....

Notes:

1. Where necessary to meet the scheduled shipping date, the supplier shall proceed with manufacture upon receipt of the order and without awaiting the purchaser's approval of drawings.

2. The supplier shall send all drawings and data to the following:

_____

_____

_____

3. All drawings and data shall show project, purchase order, and item numbers as well as plant location and unit. One set of the drawings and instructions necessary for field installation, in addition to the copies specified above, shall be forwarded with shipment.

4. See the descriptions of required items that follow.

5. All of the information indicated on the distribution schedule shall be received before final payment is made.

6. If typical drawings, schematics, and bills of material are used for proposals, they shall be marked-up to show the expected weight and dimensions to reflect the actual equipment and scope proposed.

Nomenclature:

S number of weeks before shipment.

F number of weeks after firm order.

D number of weeks after receipt of approved drawings.

Supplier_____

Date_____ Supplier Reference _____

Signature_____

(Signature acknowledges receipt of all instructions)

B.2 Descriptions

1) Supplier certified dimensional outline drawing and list of connections, including the following:
   a) the size, rating, and location of all customer connections;
   b) approximate overall and handling weights;
   c) overall dimensions and maintenance and dismantling clearances;
   d) shaft centerline height;
   e) dimensions of baseplate (if furnished) for train or skid mounted package, complete with diameters, number, and locations of bolt holes and thicknesses of sections through which the bolts pass;
   f) grounding details;
   g) forces and moments allowed for suction and discharge nozzles;
   h) center of gravity and lifting points;
   i) shaft end separation and alignment data;
   j) direction of rotation;
   k) winterization, tropicalization, and/or noise attenuation details, when required;
   l) sketches to show lifting of assembled machine and major components and auxiliaries.
2) Cross-sectional drawings and part numbers of major equipment.
3) Rotor assembly drawings and part numbers.
4) Thrust-bearing assembly drawings and part numbers.
5) Journal-bearing assembly drawings and bill of materials.
6) Coupling assembly drawing and bill of materials.
7) Lube-oil schematic and bill of material including the following:
   a) oil flows, temperatures, and pressure at each point;
   b) control alarm shutdown settings for pressure and temperature;
   c) total heat loads;
   d) utility requirements including electrical, water, air, and steam;
   e) pipe, valve, and orifice sizes;
   f) instrumentation, safety devices, control schemes, wiring diagrams.
8) Lube-oil arrangement drawing and list of connections.

9) Lube-oil component drawings and data, including the following:
    a) pumps and drivers;
    b) coolers, filter, and reservoir;
    c) instrumentation.
10) Seal system schematic and bill of material, including the following:
    a) flows oil or gas, temperatures, and pressures at each point;
    b) control, alarm, and shutdown settings for pressure and temperatures;
    c) total heat load for coolers, if required;
    d) utility requirements including electrical, water, air, and steam;
    e) pipe, valve, and orifice sizes;
    f) instrumentation, safety devices, control schemes, and wiring diagrams;
    g) filtration requirements;
    h) height of overhead tank above centerline of machine.
11) Seal system arrangement drawing and list of connections.
12) Seal system components drawing and data, including the following:
    a) pumps and drivers;
    b) coolers, filter, and reservoirs;
    c) instrumentation.
13) Seal assembly drawing and part numbers.
14) Electrical and instrumentation arrangement drawing and list of connections.
    a) vibration warning and shutdown limits.
    b) bearing temperature warning and shutdown limits.
    c) lube-oil temperature warning and shutdown limits.
    d) lube-oil pressure warning and shutdown limits.
    e) lube-oil level warning and shutdown limits.
    f) machine discharge pressure and temperature warning and shutdown limits.
    g) seal, pressure, temperature, flow warning, and shutdown limits.
15) Electrical and instrumentation arrangement drawing and list of connections.
16) Buffer gas system schematic and bill of material.

17) Buffer gas system schematic and bill of material.

18) Buffer gas system component drawings and data, including the following:

    a) control devices,

    b) pressure and filtration requirements.

19) Datasheets provided with proposal as-built.

20) Predicted noise level, sound pressure, and sound power level.

21) Metallurgy of major components identified with ASTM, AISI, ASME, or SAE numbers stated in proposal.

22) Lateral analysis report when specified shall also include a stability analysis.

23) Torsional analysis report.

24) Vibration analysis conducted on machines that require disassembly after balancing to allow machine assembly. The supplier shall also provide historic unbalance data for the machine size and type.

25) Performance data and curves, sufficient performance data to enable the purchaser to properly design a control system, and surge prevention.

26) Dimensions taken from each impeller before and after overspeed testing shall be submitted for review.

27) Mechanical running test report to include the following:

    a) unfiltered vibration;

    b) plots showing synchronous vibration and phase angle, filtered and unfiltered;

    c) when specified, data shall be furnished in polar form;

    d) when specified, tape recordings shall be made of all real time vibration data;

    e) electrical and mechanical runout at each probe.

    Immediately upon completion of each witnessed mechanical or performance test, copies of the log and data recorded during the test shall be given to the witnesses.

28) Coupling selection and rating.

29) List of spare parts recommended for start-up and normal maintenance purposes.

30) List of the special tools furnished for maintenance.

31) The supplier shall provide the purchaser with instructions necessary to preserve the integrity of the storage preparation after the equipment arrives at the job site and before start-up.

32) A description of any special weather protection required for start-up, operation and period of idleness under the site conditions specified on the datasheets.

33) A complete list of utility requirements: quantity, filtration, and supply pressure of the following:

    a) steam,

    b) water,

    c) electricity,

    d) air,

    e) gas,

    f) lube oil and seal oil (quantity and supply pressure),

    g) heat loads,

    h) power ratings and operating power requirements for auxiliary drivers.

34) A list of machines similar to the proposed machines that have been installed and operating under conditions analogous to those specified in the inquiry.

35) Any start-up, shutdown, or operating restrictions required to protect the integrity of the equipment, including any unacceptable speeds due to natural frequencies.

36) A list of any components that can be construed as being of alternative design, requiring purchaser's acceptance.

37) A summary of the materials of construction for the compressor, including hardness for materials exposed to H_2S.

38) The maximum seal gas rates (injection or eduction) and rated or expected inner seal-oil leakage rates, if applicable. When self-acting dry gas seals are supplied, expected seal gas consumption, minimum seal gas supply flow, and primary vent flow should be given at maximum sealing pressure and at conditions over the operating envelope of the machine.

39) When interstage coolers are furnished, the supplier shall provide the following:

    a) drawing showing cooling system details,

    b) data for purchasers heat and material balances,

    c) details of provisions for separating and withdrawing condensate,

    d) supplier's recommendations regarding provision for support and piping expansion.

40) Drawings, details, and descriptions of the operations of instrumentation and controls as well as the makes, materials, and type of auxiliary equipment. The supplier shall also include a complete description of the alarm and shutdown facilities to be provided.

41) The minimum length of straight pipe required for proper flow characteristics at the inlet and at any side inlet connection.

42) Maximum and minimum allowable seal pressure for each compressor.

43) A statement of the manufacturers capability regarding testing (including performance testing) of the compressor and any other specified items on the train. Details of each optional test specified shall be included.

44) Performance curves shall be submitted for each section (between purchasers process nozzles) of each casing as well as an overall curve for the train. All curves submitted prior to complete performance testing shall be marked “predicted.”

    Any set of curves resulting from a test shall be marked “tested.”

    If a performance test is specified, the supplier shall provide test data and curves when the test has been completed. The surge points shall be shown on the performance curves.

45) For compressors that have a back-to-back impeller arrangement, the supplier shall furnish a curve showing the expected loading on the active or inactive side of the thrust bearing versus any combination of differential pressures across the low pressure and high pressure sections of the casing.

46) The supplier shall supply balance piston leakage based on design clearances and twice design clearances for the rated conditions.

47) If specified, the supplier shall supply curves of balance piston line differential pressure versus thrust load.

48) The supplier shall provide production and delivery schedules.

49) The supplier shall submit detailed procedures including acceptance criteria for the mechanical running test and all optional tests, at least 6 weeks prior to the first running test.

50) The supplier shall submit progress reports.

51) All information required for the proper installation of the equipment shall be compiled in a manual that shall be issued no later than the time of final certified drawings.

52) A manual containing all required operating and maintenance instructions shall be supplied not later than 2 weeks after all specified test shall have been successfully completed.

53) The supplier shall provide a “technical data manual within 30 days of completion” of shop testing including the following:

    a) necessary certification of materials,

    b) purchase specification for all items on the bill of materials,

    c) test data to verify requirements of specifications have been met,

    d) heat treat records,

    e) results of quality test and inspections,

    f) mechanical running test data log,

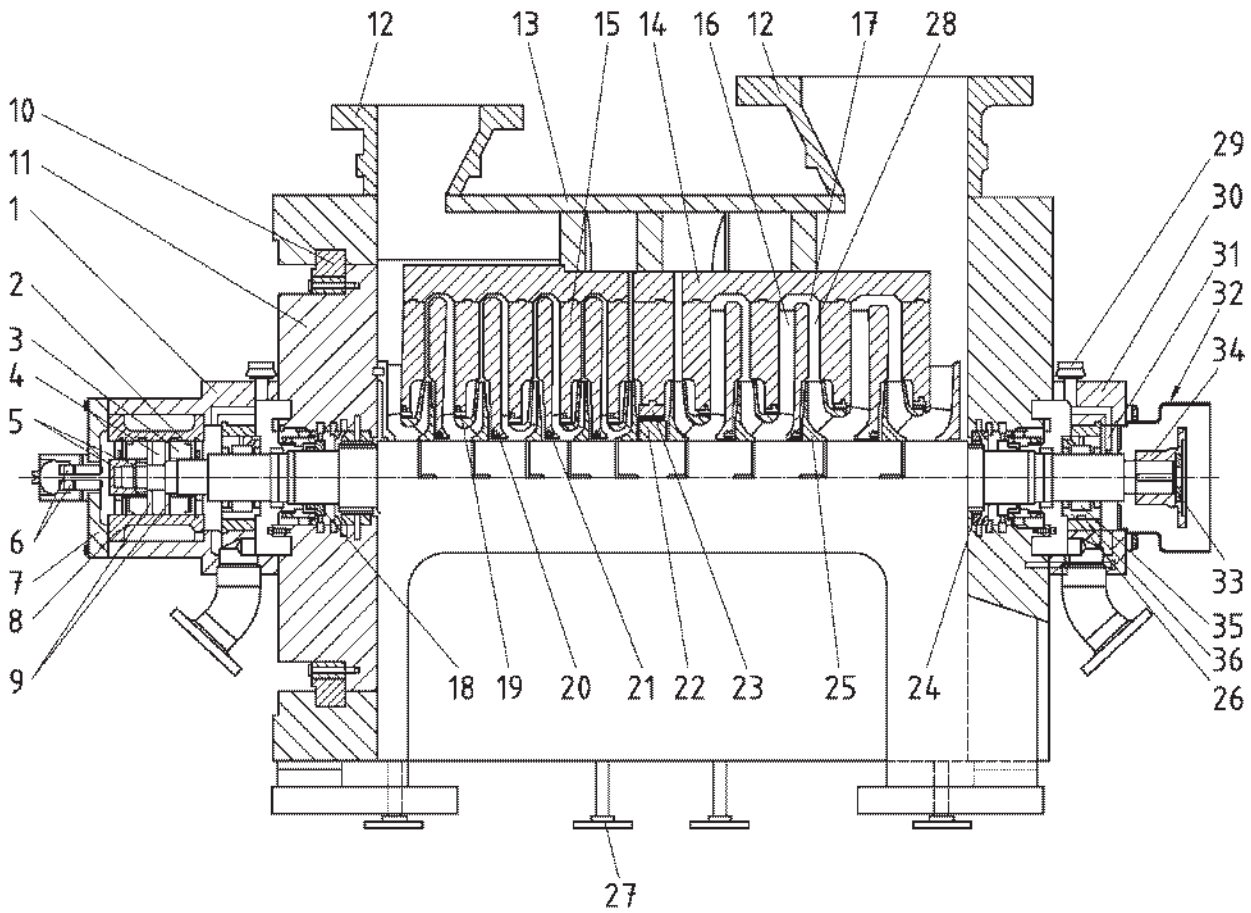
    g) final assembly maintenance and running clearances,

    The supplier is also required to keep this data available for examination by the purchaser upon request, for at least 5 years.

Annex C
(informative)

Centrifugal Compressor Nomenclature

Figure C.1 illustrates Nomenclature of key parts of a typical Nonintegrally geared centrifugal compressor.



NOTE Some compressors will use bolted-head construction.

Key

1	bearing housing	10	shear ring	19	impeller-eye labyrinth	28	diffuser passage
2	thrust shims	11	end head	20	shaft sleeve	29	breather/vent
3	thrust base ring	12	main process connections	21	diaphragm labyrinth	30	bearing house
4	thrust collar	13	casing	22	balance piston	31	radial-vibration probe
5	thrust collar locknuts	14	inner barrel	23	balance piston labyrinth	32	coupling guard
6	axial-position probes	15	diaphragm	24	labyrinth seal	33	coupling locknut
7	end cover	16	return channel	25	impeller	34	coupling hub
8	thrust-bearing carrier	17	crossover	26	journal-bearing housing	35	journal-bearing shoes
9	thrust-bearing shoes	18	end seal	27	case drains	36	journal-bearing carrier

Figure C.1—Centrifugal Compressor Nomenclature

Annex D
(informative)

Typical Materials for Components

The materials listed in this annex are considered equivalent as far as suitability for service. This does not imply that they are exactly equivalent. There may be significant differences in testing and other material requirements.

Component [g]	Materials [a]	Specification [b e]	Equivalent JIS Material	Equivalent EN Material		Form	Temperature Limits [c]	
							Minimum °C (°F)	Maximum °C (°F)
Casing, inlet casing, stator housing, discharge casing								
Cast	Cast iron	ASTM A278, Class 30	JIS G5501 FC200	EN 1561 EN-GJL-250	EN-JL1040	Cast	−45 (−50)	230 (450)
		ASTM A278, Class 40	JIS G5501 FC300	EN 1561 EN-GJL-300	EN-JL1050	Cast	−28 (−20)	260 (500)
	Austenitic cast iron	ASTM A436, Type 2	JIS G5510 FCA-NiCr202	NA		Cast	−45 (−50)	260 (500)
		ASTM A571, Type D-2M Class 1 & 2	JIS G5510 FCDA-Ni22	NA		Cast	−195 (−320)	260 (500)
	Ductile iron	ASTM A395	JIS G5502	EN 1563 EN-GJS-400-18U-RT	EN-JS1059	Cast	−28 (−20)	260 (500)
	Cast steel	ASTM A216, Grade WCB [d]	JIS G5102 SCW450	EN 10213 GP240GH ISO 4991 G240 similar reference DIN 1681 GS-38	1.0619 1.0420	Cast	−28 (−20)	400 (750)
		ASTM A352, Grade LCB	JIS G5152 SCPL1	GC24E	1.1156	Cast	−45 (−50)	345 (650)
		ASTM A352, Grade LC2	JIS G5152 SCPL21	EN 10213 G9Ni10	1.5636	Cast	−75 (−100)	345 (650)
		ASTM A352, Grade LC3	JIS G5152 SCPL31	EN 10213 G9Ni14	1.5638	Cast	−100 (−150)	345 (650)
		ASTM A352, Grade LC4	similar reference JIS G5152 SCPL31	similar reference EN 10213 G9Ni14	1.5638	Cast	−115 (−175)	345 (650)
		ASTM A352, Grade LC9	JIS G 5101 SC450 JIS G 5101 SC480			Cast	−195 (−320)	205 (400)
		ASTM A352, Grade LCC	similar reference JIS G5152 SCPL1	EN 10213 G17Mn5 EN 10213 G20Mn5 similar reference SEW 685 G26CrMo4	1.1131 1.6220 1.7221	Cast	−45 (−50)	345 (650)
		ASTM A217	JIS G5151	EN 10213		Cast	−28 (−20)	345 (650)
	Cast stainless steel	ASTM A743/744 or A351, Grade CF3, CF3M	CF3: JIS G5121 SCS19A CF3M: JIS G5121 SCS16A	CF3: EN 10213 GX2CrNi19-11 CF3M: EN 10213 GX2CrNiMo19-11-2	1.4309 1.4409	Cast	−195 (−320)	345 (650)
		ASTM A743/744 or A351CF8 or CF8M	CF8: JIS G5121 SCS13A CF8M: JIS G5121 SCS14A	CF8: EN 10213 GX5CrNi19-10 or SEW 685 GX6CrNi18-10 CF8M: EN 10213 GX5CrNiMo19-11-2	1.4308 1.6902 1.4408	Cast	−195 (−320)	345 (650)
		ASTM A351, Grade CF3MAor CF8MA	JIS G5121 SCS19A	CF3MA: EN 10213 GX2CrNiMo19-11-2 CF8MA: EN 10213 GX5CrNiMo19-11-2	1.4409 1.4408	Cast	−195 (−320)	345 (650)

Component [g]	Materials [a]	Specification [b e]	Equivalent JIS Material	Equivalent EN Material		Form	Temperature Limits [c]	
							Minimum °C (°F)	Maximum °C (°F)
		ASTM A487 Grade CA6NM Class Aand B	JIS G 5121 SCS6	EN 10213 GX4CrNi13-4	1.4317	Cast	−45 (−50)	345 (650)
		ASTM A757 Grade E3N	JIS G 5152 SCPL1	EN 10213 GX3CrNi13-4	1.6982	Cast	−75 (−100)	345 (650)
		ASTM A757 Grade D1Q1	JIS G 5152 SCPL11 (similar reference)	SEW 685 G15CrMo9-10	1.7377	Cast	−28 (−20)	345 (650)
	Cast aluminum	ASTM A356 or A357	JIS G5151	NA		Cast	−195 (−320)	150 (300)
	Cast titanium	ASTM B367, Grade C3 or C4	C3: JIS H4600 2 C4: NA	NA		Cast	−45 (−50)	150 (300)
Casing, inlet casing, stator housing, discharge casing								
Fabricated	Steel	ASTM A285, Grade C	JIS G3118 SGV450			Plate	−45 (−50)	345 (650)
		ASTM A516, Grade 55, 60, 65, 70	55: JIS G3118 SGV410 60: JIS G3118 SGV410 65: JIS G3118 SGV450 70: JIS G3118 SGV480	55: EN 10028-2 P235GH 60: EN 10028-2 P265GH 65: EN 10028-2 P355GH EN 10025 S355J2+N 70: EN 10028-2 P355GH	1.0345 1.0425 1.0473 1.0577 1.0473	Plate	−45 (−50)	345 (650)
		ASTM A203, Grade Aor B	A: JIS G3127 SL2N255 B: NA	12Ni9	1.5635	Plate	−60 (−75)	345 (650)
		ASTM A203, Grade D or E	D: JIS G3127 SL3N255 E: JIS G3127 SL3N275	EN 10028-4 12Ni14	1.5637	Plate	−105 (−160)	345 (650)
		ASTM A537, Class 1 or 2	1: JIS G3115 SPV355 2: JIS G3115 SPV450	EN 10028-6 P355QH EN 10028-6 P460QH	1.8867 1.8871	Plate	−60 (−75)	345 (650)
		ASTM A353	JIS G3127 SL9N520	EN 10028-3 X8Ni9	1.5662	Plate	−195 (−320)	345 (650)
		ASTM A553, Type I	JIS G3127 SL9N590	EN 10028-3 X8Ni9	1.5662	Plate	−195 (−320)	345 (650)
		ASTM A553, Type II	JIS G3127 SL9N590	EN 10028-3 X8Ni9	1.5662	Plate	−170 (−275)	345 (650)
		ASTM A266, Class 1 or 4	JIS G3202 SFVC1	EN 10222-4 P355NH	1.0565	Forged	−28 (−20)	345 (650)
		ASTM A336, Class F1	JIS G3202 SFVA F1	EN 10222-2 16Mo3	1.5415	Forged	−28 (−20)	345 (650)
		ASTM A414	JIS G3116	EN 10120		Sheet	−28 (−20)	345 (650)

Component [g]	Materials [a]	Specification [b e]	Equivalent JIS Material	Equivalent EN Material		Form	Temperature Limits [c]	
							Minimum °C (°F)	Maximum °C (°F)
		ASTM A508, Class 5a [now: Grade 5 Class 2]	JIS G3204 SFVQ3	20NiCrMo14-6	1.6742	Forged	−28 (−20)	345 (650)
		ASTM A350, Grade LF2	JIS G3205 SFL2	EN 10222-3 12Ni14	1.5637	Forged	−45 (−50)	345 (650)
		ASTM A350, Grade LF3	JIS G3205 SFL3	EN 10222-3 12Ni14	1.5637	Forged	−100 (−150)	345 (650)
		ASTM A266 CL.1	JIS G3202 SFVC1			Forged	−28 (−20)	345 (650)
		ASTM A662 Grade B	JIS G3205 SFL1	EN 10028-4 P355N EN 10028-4 P355NL2	1.0562 1.1106	Plate	−45 (−50)	345 (650)
		ASTM A765 Grade IV	JIS G3201 SF490A	EN 10222-4 P355QH1	1.0571	Forged	−30 (−20)	345 (650)
		ASTM A350 Grade LF6 Class 1	JIS G3201 SF340A	DIN 17103 TStE 355	1.0566	Forged	−50 (−60)	345 (650)
	Stainless steel	ASTM A240, Type 304, 304L, 316, 316L	304: JIS G4304 SUS304, JIS G4305 SUS304 304L: JIS G4304 SUS304L, JIS G4305 SUS304L 316: JIS G4304 SUS316, JIS G4305 SUS316 316L: JIS G4304 SUS316L, JIS G4305 SUS316L 321:JIS G4304 SUS321, JIS G4305 SUS321	304: EN 10028-7 X5CrNi18-10 304L: EN 10028-7 X2CrNi18-9 316: EN 10028-7 X5CrNiMo17-12-2 316L: EN 10028-7 X2CrNiMo17-12-2 or EN 10028-7 X5CrNiMoTi17-12-2 321: EN 10028-7 X5CrNiTi18-10	1.4301 1.4307 1.4401 1.4404 1.4571 1.4541	Plate	−195 (−320)	345 (650)
		ASTM A240, Type 321				Plate	−195 (−320)	345 (650)
		ASTM A182, Grade F304, F304L, F316	F304: JIS G3214 SUS F304 F304L: JIS G3214 SUS F304L F316: JIS G3214 SUS F316	F304: EN 10222-5 X5CrNi18-10 F304L: EN 10222-5 X2CrNi18-9 F316: EN 10222-5 X5CrNiMo17-12-2 or EN 10222-5 X5CrNiMoTi17-12-2	1.4301 1.4307 1.4401 1.4571 1.4541	Forged	−195 (−320)	345 (650)
		ASTM A182, Grade F321	F321: JIS G3214 SUS F321	F321: EN 10222-5 X5CrNiTi18-10		Forged	−195 (−320)	345 (650)
		ASTM A182, Grade F 6NM	JIS G3214 SUS F6 NM	EN 10222-5 X3CrNiMo13-4	1.4313	Forged	−45 (−50)	345 (650)
		AISI Type 304L	JIS G4304 SUS 304L, JIS G4305 SUS 304L			Plate	−195 (−320)	345 (650)

Component [g]	Materials [a]	Specification [b e]	Equivalent JIS Material	Equivalent EN Material		Form	Temperature Limits [c]	
							Minimum °C (°F)	Maximum °C (°F)
	Aluminum	ASTM B209, Alloy 6061 or 7075	6061: JIS H4000 6061 7075: JIS H4000 7075			Plate	−195 (−320)	150 (300)
		ASTM B211, Alloy 6061 or 7075	6061: JIS H4040 6061 7075: JIS H4040 7075			Bar	−195 (−320)	150 (300)
		ASTM B247, Alloy 6061 or 7075	6061: JIS H4140 6061 7075: JIS H4140 7050			Forged	−195 (−320)	150 (300)
		AMS 4108, Alloy 7050	JIS H4140 7050			Forged	−195 (−320)	150 (300)
Diaphragms, guide vanes, and inner casings								
	Cast iron	ASTM A48 or A278, Class 30	JIS G5501 FC250	EN 1561 EN-GJL-250	EN-JL1040	Cast	−195 (−320)	345 (650)
	Ductile iron	ASTM A536	JIS G5502	EN 1563 EN-GJS-400-15U	EN-JS1072	Cast	−195 (−320)	345 (650)
	Cast steel	ASTM A216, Grade WCB	JIS G5102 SCW450	EN 10213 GP240GH ISO 4991 G240 similar reference DIN 1681 GS-38	1.0619 1.0420	Cast	−195 (−320)	345 (650)
	Steel	ASTM A283, A284, A285, A516 or	JIS G3101 SS400	EN 10025 S235JR EN 10025 S355J2+N	1.0038 1.0577	Plate	−195 (−320)	345 (650)
		A543				Plate	−195 (−320)	345 (650)
		ASTM A36	JIS G3101 SS400	EN 10025 S235JR	1.0038	Plate	−195 (−320)	345 (650)
	Stainless steel	ASTM A743/744 or A351, Grade CA15,	JIS G5121 SCS13A, JIS G5121 SCS19A	CF8: EN 10213 GX5CrNi19-10 or SEW 685 GX6CrNi18-10 CF8M: EN 10213 GX5CrNiMo19-11-2	1.4308 1.6902 1.4408	Cast	−195 (−320)	345 (650)
		CF3, CF3M, CF8 or CF8M				Cast	−195 (−320)	345 (650)
		ASTM A240, Type 410	JIS G4304 SUS410, JIS G4305 SUS410	EN 10088-2 X12Cr13	1.4006	Plate	−195 (−320)	345 (650)
		ASTM A276, Type 410	JIS G4303 SUS410	EN 10088-3 X12Cr13	1.4006	Bar	−195 (−320)	345 (650)
		AISI Type 304	JIS G4304 SUS304, JIS G4305 SUS 304			Plate	−195 (−320)	345 (650)
		AISI Type 304L	JIS G4304 SUS 304L, JIS G4305 SUS 304L	similar reference EN 10250 X6CrNiTi18-10	1.4541	Plate	−195 (−320)	345 (650)
		ASTM A182, Grade F321, F316Ti	F321: JIS G 3214 SUS F 321 F316Ti:	F316 Ti: EN 10250 X6CrNiMoTi17-12-2 F321: EN 10250 X6CrNiTi18-10	1.4571 1.4541	Forged	−195 (−320)	345 (650)

Component [g]	Materials [a]	Specification [b e]	Equivalent JIS Material	Equivalent EN Material		Form	Temperature Limits [c]	
							Minimum °C (°F)	Maximum °C (°F)
		ASTM A662 Grade B	JIS G3205 SFL1	EN 10028-4 P355N EN 10028-4 P355NL2	1.0562 1.1106	Plate	−195 (−320)	345 (650)
		ASTM A350 Grade LF6 Class 1	JIS G3201 SF340A	DIN 17103 TStE 355	1.0566	Forged	−195 (−320)	345 (650)
		ASTM A182, Grade F 6NM	JIS G3214 SUS F6 NM	EN 10250 X3CrNiMo13-4	1.4313	Forged	−195 (−320)	345 (650)
		ASTM A487 Grade CA6NM Class Aand B	JIS G 5121 SCS6	EN 10213 GX4CrNi13-4	1.4317	Cast	−195 (−320)	345 (650)
		ASTM A757 Grade E3N	JIS G5152 1991 SCPL1	EN 10213 GX3CrNi13-4	1.6982	Cast	−195 (−320)	345 (650)
	Aluminum	ASTM B26, Alloy 355 or C355	JIS H5202 AC4D	NA		Cast	−195 (−320)	345 (650)
Fixed, pre-whirl, de-whirl, and variable stator vanes								
	Stainless steel	ASTM A478 Type 347				Bar	−195 (−320)	345 (650)
		ASTM A240 Type 304 or 304L				Plate	−195 (−320)	345 (650)
		ASTM A276 Type 316/316L				Bar	−195 (−320)	345 (650)
Shaft, stub shafts, shaft drums								
	Steel	ASTM A470, Class 1	similar reference JIS G3201 SF540A			Forged	−28 (−20)	345 (650)
		ASTM A470, Class 7	similar reference JIS G3204 SFVQ3	SEW 555 26NiCrMoV11-5 SEW 555 26NiCrMoV14-5	1.6948 1.6957	Forged	−115 (−175)	400 (750)
		AISI Type 4340	JIS G4053 SNCM439	EN 10083-3 30CrNiMo8	1.6580	Forged	−115 (−175)	345 (650)
		AISI Type 4140	JIS G4053 SCM440	EN 10083-3 42CrMo4	1.7225	Forged	−28 (−20)	400 (750)
		AISI Types 1040-1050 [c]	JIS G4051 S40C	EN 10083-2 C45E	1.1191	Bar or Forged	−28 (−20)	345 (650)
		AISI Types 4140-4150 [c]	JIS G4053 SCM440	EN 10083-3 42CrMo4	1.7225	Bar or Forged	−28 (−20)	400 (750)

Component [g]	Materials [a]	Specification [b e]	Equivalent JIS Material	Equivalent EN Material		Form	Temperature Limits [c]	
							Minimum °C (°F)	Maximum °C (°F)
		AISI Type 2320 [c]	NA			Bar or Forged	−110 (−170)	345 (650)
		AISI Type 2330	NA			Bar or Forged	−110 (−170)	345 (650)
		ASTM A522, Type 1	JIS G3127 SL9N520	EN 10222-3 X8Ni9	1.5662	Forged	−195 (−320)	345 (650)
		ASTM 4340-4345	ASTM maybe replaced to AISI. JIS G4053 SNCM439	EN 10083-3 30CrNiMo8 ISO 4957 55NiCrMoV7	1.6580 1.2714	Forged	−115 (−175)	345 (650)
	Stainless steel	ASTM A336, Grade F6	G3214 SUS F410-C	EN 10088-3 X12Cr13	1.4006	Forged	−60 (−75)	345 (650)
		ASTM A473, Type 410	JIS G3214 SUS F410	EN 10088-3 X12Cr13	1.4006	Forged	−60 (−75)	345 (650)
		ASTM A1021, Grade D, Class 2 (422)	NA			Forged	−60 (−75)	345 (650)
		ASTM A182, Grade F 6NM	JIS G3214 SUS F6 NM	EN 10250 X3CrNiMo13-4	1.4313	Forged	−60 (−75)	345 (650)
	Precipitation hardening stainless steel	ASTM A705, Types 630 or XM-12	JIS G3214 SUS F630	EN 10250 X5CrNiCuNb16-4	1.4542	Forged	−75 (−100)	345 (650)
		ASTM A564, Type 630 or XM-12	JIS G4303 SUS630	EN 10250 X5CrNiCuNb16-4	1.4542	Bar	−270 (−454)	345 (650)
Through bolts (axial rotor)								
	Stainless steel	UNS S45000	NA			Bar	−60 (−75)	345 (650)
		UNS S42200	JIS G4303 SUS410 (similar reference)			Bar	−60 (−75)	345 (650)
Impellers								
Cast	Aluminum	ASTM B26, Alloy C355	JIS H5202 AC4C			Cast	−195 (−320)	150 (300)
	Precipitation hardening stainless steel	ASTM A747, Type CB7CU-1 or CB7CU-2	G5121 SCS 24			Cast	−75 (−100)	345 (650)
	Steel	ASTM A148	JIS G5111			Cast	−28 (−20)	345 (650)
		ASTM A487 Gs 4Q	JIS G5111 SCMnCrM2			Cast	−45 (−50)	345 (650)
	Stainless steel	ASTM A743/744 or A351, Grade CA15	JIS G5121 SCS1			Cast	−45 (−50)	345 (650)

Component [g]	Materials [a]	Specification [b e]	Equivalent JIS Material	Equivalent EN Material		Form	Temperature Limits [c]	
							Minimum °C (°F)	Maximum °C (°F)
		or CA6NM				Cast	−45 (−50)	345 (650)
		ASTM A743/744 or A351, Grade CF3, CF3M,	CF3: JIS G5121 SCS19A CF3M: JIS G5121 SCS16A			Cast	−195 (−320)	345 (650)
		CF8 or CF8M	CF8: JIS G5121 SCS13A CF8M: JIS G5121 SCS14A			Cast	−195 (−320)	345 (650)
	Aluminum	ASTM A356 or A357	JIS G5151			Cast	−195 (−320)	150 (300)
	Titanium	ASTM B367, Grade C3 or C4	C3: JIS H4600 2 C4: NA			Cast	−45 (−50)	345 (650)
		ASTM B367, Grade C5	JIS H4600 Class 3			Cast	−195 (−320)	345 (650)
Fabricated (covers, hubs, blades)	Aluminum	ASTM B209, Alloy 6061 or 7075	6061: JIS H4000 6061 7075: JIS H4000 7075			Plate	−195 (−320)	150 (300)
		ASTM B211, Alloy 6061 or 7075	6061: JIS H4040 6061 7075: JIS H4040 7075			Bar	−195 (−320)	150 (300)
		ASTM B221, Alloy 6061 or 7075	6061: JIS H4040 6061 7075: JIS H4040 7075			Extruded	−195 (−320)	150 (300)
		ASTM B247, Alloy 2618,	2618: JIS H4140 2618 6061: JIS H4140 6061 7075: JIS H4140 7050			Forged	−195 (−320)	150 (300)
		6061 or 7075				Forged	−195 (−320)	150 (300)
		AMS 4108, Alloy 7050	JIS H4140 7050			Forged	−195 (−320)	150 (300)
Impellers	Steel	AISI Types 4130-4140 [c]	JIS G4053 SCM430	EN 10083-3 42CrMo4	1.7225	Plate or Forged	−28 (−20)	400 (750)
Fabricated								
		AISI Types 4320-4345 [c]	JIS G4053 SNCM431	EN 10083-3 30CrNiMo8	1.6580	Plate or Forged	−115 (−175)	400 (750)
		ASTM A470, Class 8	JIS G3221 SFCM 740S (similar reference)	14CrMoV6-9	1.7735	Forged	−45 (−50)	400 (750)
		AISI Type 3140 [c]	similar reference JIS G4102 SNC236			Forged	−45 (−50)	400 (750)
		ASTM A543	JIS G3101 SS400			Plate	−115 (−175)	400 (750)

Component [g]	Materials [a]	Specification [b e]	Equivalent JIS Material	Equivalent EN Material		Form	Temperature Limits [c]	
							Minimum °C (°F)	Maximum °C (°F)
		ASTM A522, Type I	JIS G3127 SL9N520	EN 10222-3 X8Ni9	1.5662	Forged	−145 (−230)	345 (650)
		ASTM A522, Type II	JIS G3127 SL9N520	EN 10222-3 X8Ni9	1.5662	Forged	−170 (−275)	345 (650)
		ASTM A353	JIS G3127 SL9N520	EN 10222-3 X8Ni9	1.5662	Plate	−195 (−320)	345 (650)
		AISI Type 403 [c]	JIS G3214 SUS F403	EN 10088-3 X6Cr13	1.4000	Forged	−60 (−75)	345 (650)
		ASTM A473, Type 410	JIS G3214 SUS F410	EN 10088-3 X12Cr13	1.4006	Forged	−60 (−75)	345 (650)
		ASTM A240, Type 304, 304L, 316	304: JIS G4304 SUS304, JIS G4305 SUS304 304L: JIS G4304 SUS304L, JIS G4305 SUS304L 316: JIS G4304 SUS316, JIS G4305 SUS316 316L: JIS G4304 SUS316L, JIS G4305 SUS316L	304: EN 10028-7 X5CrNi18-10 304L: EN 10028-7 X2CrNi18-9 316: EN 10028-7 X5CrNiMo17-12-2 316L: EN 10028-7 X2CrNiMo17-12-2	1.4301 1.4307 1.4401 1.4404	Plate	−195 (−320)	345 (650)
		ASTM A473, Type 304, 304L, 316, or 316L	304: JIS G3214 SUS F304 304L: JIS G3214 SUS F304L 316: JIS G3214 SUS F316 316L: JIS G3214 SUS F316L	F304: EN 10222-5 X5CrNi18-10 F304L: EN 10222-5 X2CrNi18-9 F316: EN 10222-5 X5CrNiMo17-12-2 F316L: EN 10222-5 X2CrNiMo17-12-2	1.4301 1.4307 1.4401 1.4404	Forged	−195 (−320)	345 (650)
		UNS S42400	NA	EN 10250 X3CrNiMo13-4	1.4313	Forged	−101 (−150)	345 (650)
		AISI Type 410	JIS G4303 SUS410	NA		Forged	−60 (−75)	345 (650)
		ASTM A638 Grade 660 Type 2 (A286)	JIS G4311 SUH660	EN 10302 X6NiCrTiMoVB25-15-2	1.4980			345 (650)
	Precipitation hardening stainless steel	ASTM A705, Type 630 or XM-12	JIS G3214 SUS F630	EN 10250 X5CrNiCuNb16-4	1.4542	Forged	−75 (−100)	345 (650)
		AISI S17400	JIS G4303 SUS630				−75 (−100)	345 (650)

Component [g]	Materials [a]	Specification [b e]	Equivalent JIS Material	Equivalent EN Material		Form	Temperature Limits [c]	
							Minimum °C (°F)	Maximum °C (°F)
		ASTM A693, Type 630 or XM-12	JIS G4304 SUS630, JIS G4305 SUS630	EN 10088-2 X5CrNiCuNb16-4	1.4542	Plate	−75 (−100)	345 (650)
	Ni-based	AMS 5662 Alloy 718	JIS G 4902 NCF718			Forged	−110 (−170)	345 (650)
	Ni-Cu	SAE AMS 4646	NA	?		Forged	−115 (−175)	345 (650)
		ASTM B127	JIS H4551			Plate	−115 (−175)	345 (650)
		QQ-N-286	JIS H4551 NW5500			Plate	−115 (−175)	345 (650)
		ASTM B865 UNS N05500	JIS H4551 NW5500	DIN 17743 NiCu30Al ISO 9725 NiCu30Al3Ti	2.4375 NW5500	Forging	−115 (−175)	345 (650)
	Titanium	ASTM B381 Grade F5	JIS H4657 TAF6400	DIN 17864 TiAl6V4	3.7165	Forging	−195 (−320)	345 (650)
Rotor blades								
	Stainless steel	UNS S45000				Forged or Bar	−60 (−75)	345 (650)
		UNS S42200	JIS G4303 SUS410 (similar reference)			Forged or Bar	−60 (−75)	345 (650)
	Titanium	AMS 4928 Ti-6Al-4V	JIS H4600 TAP6400H			Forged or Bar	−60 (−75)	345 (650)
Labyrinths, impeller interstage, shaft seal, balance piston, thrust seal, inlet, and discharge shaft seals								
	Aluminum	ASTM B26, Alloy 443, 335, 850,	JIS H5202	EN 586		Cast	−195 (−320)	315 (600)
		AA-A850 or B850				Cast	−195 (−320)	315 (600)
		6061-T6 or 1100	6061: JIS H4000 6061 1100: JIS H4000 1100			Plate	−195 (−320)	315 (600)
		ASTM B209 Grade 5083	JIS H4000 A 5083 P	EN 586 EN-AW-5083 [Al Mg4.5Mn0.7]	AW5083	Plate	−195 (−320)	315 (600)
	Babbit	ASTM B23	JIS H5401			Cast	−195 (−320)	175 (350)
	Brass	ASTM B16 or B21	JIS H3250	EN 12420		Rod, Bar	−195 (−320)	150 (300)
		ASTM B36	JIS H3100	EN 1652		Plate, Bar	−195 (−320)	150 (300)

Component [g]	Materials [a]	Specification [b e]	Equivalent JIS Material	Equivalent EN Material		Form	Temperature Limits [c]	
							Minimum °C (°F)	Maximum °C (°F)
		ASTM B171	JIS H3100	EN 1652		Plate	−195 (−320)	150 (300)
		ASTM B564 UNS N04400	JIS H4551 NW4400	DIN 17743 NiCu30Fe ISO 9725 NiCu30	2.4360 NW4400		−195 (−320)	150 (300)
	Stainless steel	AISI Types 403, 410, 416,	403: JIS G3214 SUS F403 410: JIS G3214 SUS F410 416: JIS G3214 SUS F416	EN 10088-3 X6Cr13 EN 10088-3 X12Cr13 additional: X19CrMo12-1	1.4000 1.4006 1.4921	Wrought	−195 (−320)	345 (650)
		420	420: JIS G4304 SUS 420J2 , JIS G4305 SUS 420J2	EN 10088-3 X20Cr13	1.4021	Wrought	−195 (−320)	345 (650)
		303, 304, or 316	403: JIS G3214 SUS F303 410: JIS G3214 SUS F304 416: JIS G3214 SUS F316	EN 10088-3 X6CrNiTi18-10 EN 10088-3 X6CrNiMoTi17-12-2	1.4541 1.4571	Wrought	−195 (−320)	345 (650)
	Cr-Ni-Fe-Mo-Cu-Cb	ASTM B462	JIS H4551 NW6007	EN 10088-3 X1NiCrMoCuN25-20-7	1.4529	Wrought	−195 (−320)	345 (650)
	Stainless steel honeycomb	ASTM A240, Type 304, 304L, 316 or 316L	304: JIS G4304 SUS304, JIS G4305 SUS304 304L: JIS G4304 SUS304L, JIS G4305 SUS304L 316: JIS G4304 SUS316, JIS G4305 SUS316 316L: JIS G4304 SUS316L, JIS G4305 SUS316L	304: EN 10028-7 X5CrNi18-10 304L: EN 10028-7 X2CrNi18-9 316: EN 10028-7 X5CrNiMo17-12-2 316L: EN 10028-7 X2CrNiMo17-12-2	1.4301 1.4307 1.4401 1.4404	Fabricated	−195 (−320)	345 (650)
	Ni-Cu alloy	ASTM B164	JIS H4553	DIN 17743 NiCu30Fe ISO 9725 NiCu30	2.4360 NW4400	Wrought	−115 (−175)	345 (650)
	Nonmetallic TFE [f]					Molded	−195 (−320)	260 (500)
	Nonmetallic TFE [f]					Molded	−28 (−20)	260 (500)
	carbon-filled							

Component [g]	Materials [a]	Specification [b e]	Equivalent JIS Material	Equivalent EN Material		Form	Temperature Limits [c]	
							Minimum °C (°F)	Maximum °C (°F)
	Nonmetallic TFE [f]					Molded	−54 (−65)	260 (500)
	mica-filled							
	Polyamide-Imide (PAI)					Molded	−100 (−150)	300 (570)
	Polyetheretherketone (PEEK)					Molded	−100 (−150)	160 (320)
	Polyaryletherketone (PEK)					Molded	−100 (−150)	195 (380)
	Lead	ASTM B29	H2105	NA		Cast	−101 (−150)	205 (400)
	Nickel-graphite					Coating	−101 (−150)	482 (900)
	Phenolic resin	Micarta, NEMA, Grade LE	NA			Sheet	−195 (−320)	65 (130)
	impregnated materials							
		Micarta, NEMA, Grade G10 or G9	NA			Sheet	−195 (−320)	110 (230)
Balance piston	Steel (new)	ASTM A470, Class 1	similar reference JIS G3201 SF540A			Forged	−28 (−20)	345 (600)
		ASTM A470, Class 7	similar reference JIS G3204 SFVQ3	SEW 555 26NiCrMoV11-5 SEW 555 26NiCrMoV14-5	1.6948 1.6957	Forged	−115 (−175)	400 (750)
		AISI Types, 1040-1050 [c]	JIS G4051 S40C	EN 10083-2 C45E	1.1191	Forged	−28 (−20)	345 (650)
		AISI Types, 4130-4145 [c]	JIS G4053 SCM440	EN 10083-3 42CrMo4	1.7225	Forged	−28 (−20)	400 (750)
		AISI Types, 4330, 4340, 4345 [c]	JIS G4053 SNCM431	EN 10083-3 30CrNiMo8	1.6580	Forged	−115 (−175)	455 (850)
		AISI Type 2320 [c]	NA			Forged	−112 (−170)	345 (650)
		ASTM A522, Type I	JIS G3127 SL9N520	EN 10222-3 X8Ni9	1.5662	Forged	−195 (−320)	345 (650)
	Stainless steel (new)	ASTM A336, Grade F6	G3214 SUS F410-C			Forged	−60 (−75)	345 (650)
		ASTM A473, Type 410	JIS G3214 SUS F410	EN 10088-3 X12Cr13	1.4006	Forged	−60 (−75)	345 (650)

Component [g]	Materials [a]	Specification [b e]	Equivalent JIS Material	Equivalent EN Material		Form	Temperature Limits [c]	
							Minimum °C (°F)	Maximum °C (°F)
		AISI Type 403 or 410 [c]	403: JIS G3214 SUS F403 410: JIS G3214 SUS F410	EN 10088-3 X6Cr13 EN 10088-3 X12Cr13	1.4000 1.4006	Forged	−28 (−20)	345 (650)
	Precipitation harden-ing stainless steel	ASTM A705, Type 630 or XM-12	JIS G3214 SUS F630	EN 10250 X5CrNiCuNb16-4	1.4542	Forged	−75 (−100)	345 (650)
		ASTM A470, Class 8	JIS G 3221 SFCM 740S (similar reference)	14CrMoV6-9	1.7735	Forged	−45 (−50)	400 (750)
		UNS S42400	NA	EN 10250 X3CrNiMo13-4	1.4313	Forged	−101 (−150)	345 (650)
		ASTM A638 Grade 660 Type 2 (A286)	JIS G4311 SUH660	EN 10302 X6NiCrTiMoVB25-15-2	1.4980			
	Ni-Cu alloy	ASTM B865 UNS N05500	JIS H4551 NW5500	DIN 17743 NiCu30Al ISO 9725 NiCu30Al3Ti	2.4375 NW5500	Forging	−115 (−175)	345 (650)
		SAE AMS 4676	NA			Forged	−115 (−175)	345 (650)
Shaft sleeves	Steel	AISI Types, 4130-4150 [c]	JIS G4053 SCM440	EN 10083-3 42CrMo4	1.7225	Forged	−45 (−50)	345 (650)
		AISI Types, 4320, 4345 [c]	JIS G4053 SNCM431	EN 10083-3 30CrNiMo8	1.6580	Forged	−115 (−175)	400 (750)
		AISI Type 4330 [c]	JIS G4053 SNCM431			Forged	−115 (−175)	400 (750)
		ASTM A470, Class 7	similar reference JIS G3201 SF540A	SEW 555 26NiCrMoV11-5 SEW 555 26NiCrMoV14-5	1.6948 1.6957	Forged	−115 (−175)	400 (750)
		ASTM A522, Type I	JIS G3127 SL9N520	EN 10222-3 X8Ni9	1.5662	Forged	−195 (−320)	345 (650)
		ASTM A106	JIS G3456	EN 10216		Pipe	−28 (−20)	345 (650)
		ASTM A350	JIS G3205	EN 10250		Forged	−45 (−50)	345 (650)
		ASTM A350, Grade LF-3	JIS G3205 SFL3	EN 10250 12Ni14	1.5637	Forged	−100 (−150)	345 (650)
	Stainless steel	AISI Types 403 or 410 [c]	403: JIS G3214 SUS F403 410: JIS G3214 SUS F410	EN 10088-3 X6Cr13 EN 10088-3 X12Cr13	1.4000 1.4006	Forged	−75 (−100)	400 (750)
	Ni-Cu alloy	ASTM B164 or SAE AMS 4676	JIS H4553			Forged	−115 (−175)	345 (650)
	Ni-Mo-Cr alloy	ASTM B574, Alloy N10276	JIS H4551 NW0276	DIN 17744 NiMo16Cr15W ISO 9725 NiMo16Cr15Fe6W4	2.4819 NW0276	Wrought	−115 (−175)	345 (600)

Component [g]	Materials [a]	Specification [b e]	Equivalent JIS Material	Equivalent EN Material		Form	Temperature Limits [c]	
							Minimum °C (°F)	Maximum °C (°F)
		ASTM A494, Grade CW-12M-1	similar reference JIS H5701 NMCrC			Cast	−115 (−175)	345 (650)
	Precipitation hardening stainless steel	A 705 Type 630 or XM-12	JIS G3214 SUS F630	EN 10250 X5CrNiCuNb16-4	1.4542	Forged	−75 (−100)	345 (650)

[a] The materials shown in this table are those commonly used by compressor manufacturers, but the list is not all inclusive. Other suitable materials may exist and may be used as indicated by specific design considerations.

[b] Descriptions of AISI Types (cross-referenced to UNS) can be found in SAE HS1086. Descriptions of UNS Types can can also be found in ASTM DS 56J.

[c] The temperature limits shown in this table are those commonly observed by compressor manufacturers and are not necessarily the same as any temperature limits specified in the applicable material specifications.

[d] Normalized or normalized and tempered.

[e] AISI and UNS designations are only a description of chemical analyses of types of steels; they are not procurement specifications. All materials should be purchased to a specification that adequately defines the required properties and controls.

[f] TFE = tetrafluoroethylene.

[g] See nomenclature in cross sections of either the centrifugal or axial compressor for part names in Annex C.

Annex E
(informative)

Inspector’s Checklist

Item	API 617		Date Inspected	Inspected By	Status
	Section	Part			
4.5 MATERIALS					
Coating applied prior to acceptance balance	4.5.1.15	1			
PMI	4.5.1.16.1	1			
Impact testing	4.5.1.17.5	1			
Castings—material specification compliance	4.5.2.1	1			
Castings—purchaser approval of repairs	4.5.2.3.3	1			
Castings—ductile (nodular) iron	4.5.2.5	1			
Forgings—repairs	4.5.3.2	1			
Welding—nonpressure components	4.5.4.1	1			
Welding—pressure-containing and rotating parts	4.5.4.2	1			
4.6 CASINGS					
Jackscrews, dowels and special tools	4.6.1.4	1			
Depth of threaded holes	4.6.1.5	1			
Studs instead of cap screws	4.6.1.7.2	1			
Adequate clearance at bolts	4.6.1.7.3	1			
Bolting materials	4.6.1.7.6	1			
Welding	4.6.1.8	1			
Casing repair—minimum level of inspection and purchaser review	4.6.2.1	1			
Casing repair—major repairs	4.6.2.2	1			
Casing repair—material standards	4.6.2.3	1			
Pressure casings—plate edges	4.6.2.4.1	1			
Pressure casings—MPT or LPT	4.6.2.4.2	1			
Pressure casings—weld QC	4.6.2.4.3	1			
Pressure casings—full penetration welds	4.6.2.4.4	1			
Casings—heat treatment	4.6.2.4.5	1			
Pressure-containing weld inspection	4.6.2.4.6	1			
Materials inspection standards	4.6.3.2	1			
Cast steel casings—acceptability of defects	4.6.3.3	1			
Pressure casing connection size	4.6.4.1.3	1			
Casing connections—welding before hydrotest	4.6.4.1.5	1			
Main process connection orientation	4.6.4.2.1	1			
Flanges	4.6.4.2.2	1			
Cast iron flanges	4.6.4.2.6	1			
Concentricity of bolt circle and bore	4.6.4.2.12	1			
Steel flange facing finish	4.6.4.2.13	1			
Machined and studded connections	4.6.4.2.14	1			
Flanges parallel within 0.5 degrees	4.6.4.2.15	1			
Auxiliary connections—flanges	4.6.4.3.2	1			
Auxiliary connections—allowable types	4.6.4.3.3	1			

Auxiliary connections—pipe nipples	4.6.4.3.4	1			
Auxiliary connections—socket weld gap	4.6.4.3.6	1			
Auxiliary connections—lube or seal service	4.6.4.3.7	1			
Threaded openings for tapered pipe threads	4.6.4.3.8.1	1			
Tapered pipe threads	4.6.4.3.8.2	1			
Seal welding tapered pipe threads	4.6.4.3.8.3	1			
Pipe nipples for threaded openings	4.6.4.3.8.4	1			
Plugs for threaded openings	4.6.4.3.8.5	1			
Machine mounting surfaces	4.6.5.1	1			
4.7 ROTATING ELEMENTS					
Shaft ends for couplings	4.7.1	1			
Assembled rotor marking	4.7.1	2			
Shaft sensing areas for probes	4.7.2	1			
Shaft sensing areas—final surface finish	4.7.3	1			
Stud or tie-bolt proof load testing	4.7.3.2.1	2			
Modular rotor wet MPT or flourescent LPT	4.7.3.2.2	2			
Thrust collar surface finish and TIR	4.7.6	1			
Axial compressor blade peening	4.7.6.4	2			
Fabricated impeller inspection	4.7.10.3	1			
Cast impeller inspection	4.7.10.4	1			
Cast impeller repair	4.7.10.5	1			
Welding not permitted for impeller balancing	4.7.10.6	1			
MPT or LPT of impellers after overspeed	4.7.10.7	1			
4.8 DYNAMICS					
Confirmation of critical speeds	4.8.2.2	1			
Unbalanced rotor response verification test	4.8.3	1			
Additional testing	4.8.4.1	1			
Rotating element—component balance	4.8.8.1	1			
Rotating element—sequential multiplane balance	4.8.8.2	1			
Rotating element—if disassembled after balance	4.8.8.2.1	1			
Rotating element—reassembly check balance	4.8.8.2.2	1			
Operating speed balance	4.8.8.3	1			
Operating speed balance procedure	4.8.8.4	1			
4.12 NAMEPLATES AND ROTATION ARROWS					
Nameplate at readily visible location	4.12.1	1			
Nameplate material	4.12.2	1			
Nameplate contents	4.12.2	2			
Rotation arrows	4.12.3	2			
Lateral critical speeds on nameplate	4.12.5	1			

5.4 MOUNTING PLATES					
Jackscrews	5.4.1.2.1	1			
Alignment shims	5.4.1.2.2	1			
Machinery mounting surfaces	5.4.1.2.3	1			
Anchor bolt clearance	5.4.1.2.8	1			
Vertical leveling screws	5.4.1.2.9	1			
Radiused corners for grout	5.4.1.2.10	1			
Hold-down bolt clearance	5.4.1.2.12	1			
Wrench clearance	5.4.1.2.13	1			
Grout contacting surface preparation	5.4.1.2.15	1			
Mounting surface preservation	5.4.1.2.17	1			
Seal welded joints	5.4.2.3	1			
Leveling pads or targets	5.4.2.6.1	1			
Additional pads or targets	5.4.2.6.2	1			
Lifting lugs	5.4.2.7	1			
Grout fill and vent holes	5.4.2.8	1			
Soleplate thickness	5.4.3.1.1	1			
Soleplate size	5.4.3.1.2	1			
Soleplates fully machined	5.4.3.1.4	1			
Sub-soleplates	5.4.3.1.5	1			
5.5 CONTROLS AND INSTRUMENTATION					
Controls ingress protection level	5.5.1.6	1			
Terminal box ingress protection level	5.5.1.7	1			
Conduit and cable location and installation	5.5.1.8	1			
Transducers and sensors per API 670	5.5.7.1	2			
Monitors per API 670	5.5.7.2	2			
Bearing temp monitor per API 670	5.5.7.4	2			
Casing vibration transducers per API 670	5.5.7.5	2			
Casing vibration monitors per API 670	5.5.7.6	2			
5.6 PIPING AND APPURTENANCES					
Breakout spools	5.6.1.4	1			
Provisions to bypass bearings	5.6.1.5	1			
Provisions to bypass dry gas seals	5.6.1.6	1			
Instrument piping	5.6.2	1			
Process piping	5.6.3	1			
5.7 SPECIAL TOOLS					
Use of tools	5.7.1	1			
Tool packing and marking	5.7.2	1			

6.1 INSPECTION, TESTING AND PREPARATION FOR SHIPMENT—GENERAL					
Access to vendor's quality control program	6.1.7	1			
6.2 INSPECTION					
Painting before hydrotest	6.2.1.1	1			
Cleanliness	6.2.1.3	1			
Hardness of parts, welds, and heat affected zones	6.2.1.5	1			
Radiographic inspection	6.2.2.2	1			
Ultrasonic inspection	6.2.2.3	1			
Magnetic particle inspection	6.2.2.4	1			
Liquid penetrant inspection	6.2.2.5	1			
6.3 TESTING					
Contract probes and accelerometers used	6.3.2.1	1			
Contract shaft seals and bearings used	6.3.1.1.1	2			
Oil system cleanliness before testing	6.3.1.1.3	2			
Joint and connection tightness	6.3.2.5 6.3.1.1.4	1 2			
Warning, protective and control devices	6.3.2.6 6.3.1.1.5	1 2			
Contract coupling	6.3.1.1.7	2			
Coupling hub location marked	6.3.1.1.8	2			
Instrument calibration	6.3.2.7	1			
Hydrostatic test—pressure	6.3.3.1	1			
Hydrostatic test—duration	6.3.3.2	1			
Hydrostatic test—chloride content	6.3.3.3	1			
Impeller overspeed test	6.3.4.1	1			
Residual magnetism	6.3.5	1			
Dry gas seals	6.3.6	1			
Mechanical running test—operation of equipment and test instrumentation	6.3.7.1.1	1			
Mechanical running test—unfiltered vibration	6.3.7.1.2	1			
Mechanical running test—vibration plots	6.3.7.1.3	1			
Mechanical running test—real time vibration data recorded	6.3.7.1.4	1			
Mechanical running test—seal flow data	6.3.7.1.5	1			
Mechanical running test—lube oil and seal oil variations	6.3.7.1.6	1			
Mechanical running test—hydrodynamic bearing inspection	6.3.7.2.1	1			
Mechanical running test—shaft end seal inspection	6.3.7.3	1			

Gas test after hydro	6.3.9.3	1			
assembled compressor gas leak test	6.3.2	2			
Sound-level test	6.3.9.4	1			
Auxiliary equipment test	6.3.9.5	1			
Post-test inspection of internals	6.3.9.6	1			
Full-pressure/full-load/full-speed test	6.3.9.7	1			
Post-test inspection of coupling fit	6.3.9.8	1			
Spare parts test	6.3.9.9	1			
6.4 PREPARATION FOR SHIPMENT					
Preparation for shipment	6.4.1	1			
Dry gas seals removed for shipment	6.4.1	2			
Testing completed and equipment released	6.4.3	1			
Coating on exterior surfaces	6.4.3.1	1			
Exterior machined surfaces coating	6.4.3.2	1			
Interior of equipment	6.4.3.3	1			
Internal surfaces of bearing housings	6.4.3.4	1			
Flange covers	6.4.3.5	1			
Threaded openings	6.4.3.6	1			
Beveled welding openings	6.4.3.7	1			
Lifting point identification	6.4.3.8	1			
Equipment tagging and packing lists	6.4.3.9	1			
Spare rotor storage preparation	6.4.3.10	1			
Spare rotor container	6.4.3.10.1	1			
Cradle support liner	6.4.3.11	1			
Rotor preparation for vertical storage	6.4.3.12	1			
Fit-up and assembly of piping and intercoolers	6.4.3.13	1			
Shaft and coupling protection	6.4.3.14	1			
Auxiliary connection marking	6.4.4	1			
Auxiliary piping match marks	6.4.5	1			
IOM shipped with equipment	6.4.6	1			
Wood used in export shipping	6.4.7	1			

5.7 SPECIAL TOOLS					
Use of tools	5.7.1	1			
Tool packing and marking	5.7.2	1			
6.1 INSPECTION, TESTING AND PREPARATION FOR SHIPMENT - GENERAL					
Access to vendor's quality control program	6.1.7	1			
6.2 INSPECTION					
Painting before hydrotest	6.2.1.1	1			
Cleanliness	6.2.1.3	1			
Hardness of parts, welds and heat affected zones	6.2.1.5	1			
Radiographic inspection	6.2.2.2	1			
Ultrasonic inspection	6.2.2.3	1			
Magnetic particle inspection	6.2.2.4	1			
Liquid penetrant inspection	6.2.2.5	1			
6.3 TESTING					
Contract probes and accelerometers used	6.3.2.1	1			
Contract shaft seals and bearings used	6.3.1.1.1	2			
Oil system cleanliness before testing	6.3.1.1.3	2			
Joint and connection tightness	6.3.2.5 6.3.1.1.4	1 2			
Warning, protective and control devices	6.3.2.6 6.3.1.1.5	1 2			
Contract coupling	6.3.1.1.7	2			
Coupling hub location marked	6.3.1.1.8	2			
Instrument calibration	6.3.2.7	1			
Hydrostatic test - pressure	6.3.3.1	1			
Hydrostatic test - duration	6.3.3.2	1			
Hydrostatic test - chloride content	6.3.3.3	1			
Impeller Overspeed test	6.3.4.1	1			
Residual magnetism	6.3.5	1			
Dry gas seals	6.3.6	1			
Mechanical running test - operation of equipment and test instrumentation	6.3.7.1.1	1			
Mechanical running test - unfiltered vibration	6.3.7.1.2	1			
Mechanical running test - vibration plots	6.3.7.1.3	1			
Mechanical running test - real time vibration data recorded	6.3.7.1.4	1			
Mechanical running test - seal flow data	6.3.7.1.5	1			
Mechanical running test - lube oil and seal oil variations	6.3.7.1.6	1			
Mechanical running test - hydrodynamic bearing inspection	6.3.7.2.1	1			
Mechanical running test - shaft end seal inspection	6.3.7.3	1			
Gas test after hydro	6.3.9.3	1			
assembled compressor gas leak test	6.3.2	2			
Sound-level test	6.3.9.4	1			
Auxiliary equipment test	6.3.9.5	1			
Post-test inspection of internals	6.3.9.6	1			
Full-pressure/full-load/full-speed test	6.3.9.7	1			
Post-test inspection of coupling fit	6.3.9.8	1			
Spare parts test	6.3.9.9	1			
6.4 PREPARATION FOR SHIPMENT					
Preparation for shipment	6.4.1	1			
Dry gas seals removed for shipment	6.4.1	2			

Annex F
(informative)

Nozzle Forces and Moments

F.1 General

F.1.1 The April 1988, November 1979, and October 1973 issues of API 617 referred nozzle forces and moments calculations to appropriate NEMA documents with the stipulation that the constants in the equations be multiplied by 1.85. Experience has shown that there has not been a uniform interpretation of "1.85 times NEMA." Therefore, the equations have been adapted to compressors by identifying all the constants and clarifying that the equivalent of the exhaust nozzle in the NEMA calculation is the largest compressor nozzle. This is usually, but not necessarily, the inlet nozzle.

F.1.2 For machinery primarily designed for low pressures (such as axial compressors, low-pressure overhung compressors or compressors or machinery designed with open impellers that rely upon close radial and axial clearances of the impeller to the casing), the supplier shall identify the maximum allowable forces and moments.

F.2 Equations

The design of each compressor body shall allow for limited piping loads on the various casing nozzles. For maximum system reliability, nozzle loads imposed by piping should be as low as possible regardless of the compressor's (machines') load-carrying capability. As a standard, for cast axially split centrifugal compressors, radially split centrifugal compressors and higher pressure, over 50 psig inlet pressure, overhung single-stage compressors the forces and moments acting on compressors due to the inlet, side stream, and discharge connections should be limited by the following:

The total resultant force and total resultant moment imposed on the compressor at any connection should not exceed the values shown in Equation (F.1).

In SI units**:**

$$F_r + 1.09\, M_r \leq 54.1\, D_e \qquad \text{(F.1a)}$$

In U.S. customary (USC) units:

$$3\, F_r + M_r \leq 927\, D_e \qquad \text{(F.1b)}$$

where

F_r is the resultant force, Newtons (lb) (see Figure F.1);

$$F_r = \sqrt{F_x^2 + F_y^2 + F_z^2} \qquad \text{(F.2)}$$

M_r resultant moment, in Newton-meters (ft-lb) from Figure F.1;

$$M_r = \sqrt{M_x^2 + M_y^2 + M_z^2} \ . \tag{F.3}$$

For sizes up to 200 mm (8 in.) in diameter:

D_e is the nominal pipe diameter of the connection, mm (in.).

For sizes greater than 200 mm (8 in.), use the following values.

In SI units:

$$D_e = \frac{\left(400 + D_{\text{nom}}\right)}{3} \ (\text{mm}) \tag{F.4a}$$

In USC units:

$$D_e = \frac{\left(16 + D_{\text{nom}}\right)}{3} \ (\text{in.}) \tag{F.4b}$$

where

D_e is the equivalent pipe diameter of the connection, mm (in.);

D_{nom} is the nominal pipe diameter, mm (in.).

The combined resultants of the forces and moments of the inlet, sidestream, and discharge connections resolved at the centerlines of the largest connection should not exceed the following.

The resultants shall not exceed the following.

In SI units:

$$F_c + 1.64M_c \le 40.4D_c \tag{F.5a}$$

In USC units**:**

$$2F_c + M_c \le 462D_c \tag{F.5b}$$

where

F_c is the combined resultant of inlet, sidestream, and discharge forces, Newtons (lb);

M_c is the combined resultant of inlet, sidestream, and discharge moments, and moments resulting from forces, Newton-meters (ft-lb);

D_c is the diameter [mm (in.)] of one circular opening equal to the total areas of the inlet, sidestream, and discharge openings. If the equivalent nozzle diameter is greater than 230 mm (9 in.), use a value of D_c equal to the following.

In SI units:

$$D_c \frac{(460 + \text{Equivalent Diameter})}{3} \quad \text{(mm)} \tag{F.6a}$$

In USC units:

$$D_c \frac{(18 + \text{Equivalent Diameter})}{3} \quad \text{(in.)} \tag{F.6b}$$

The absolute value of the individual components (Figure F.1) of these resultants should not exceed the following.

In SI units:

$F_x = 16.1D_c$ $M_x = 24.6D_c$

$F_y = 40.5D_c$ $M_y = 12.3D_c$

$F_z = 32.4D_c$ $M_z = 12.3D_c$

In USC units:

$F_x = 92D_c$ $M_x = 462D_c$

$F_y = 231D_c$ $M_y = 231D_c$

$F_z = 185D_c$ $M_z = 231D_c$

where

F_x is the horizontal component of F_c, parallel to the compressor shaft, Newtons (lb);

F_y is the vertical component of F_c, Newtons (lb);

F_z is the horizontal component of F_c at right angles to be compressor shaft, Newtons (lb);

M_x is the component of M_c, around the horizontal axis, Newton-meters (ft-lb);

M_y is the component of M_c, around the vertical axis, Newton-meters (ft-lb);

M_z is the component of M_c around the horizontal axis at right angles to the compressor shaft, Newton-meters (ft-lb).

These values of allowable forces and moments pertain to the compressor structure only. They do not pertain to the forces and moments in the connecting pipes, flanges, and flange bolting, which should not exceed the allowable stress as defined by applicable codes and regulatory bodies.

It is recommended that calculated operating loads be minimized by appropriate piping system design. If the forces and moments limits of this annex can not be achieved, after all efforts have been made to modify the piping design system, the final calculated forces and moments shall be identified to the supplier. The final magnitude of the forces and moments shall be agreed.

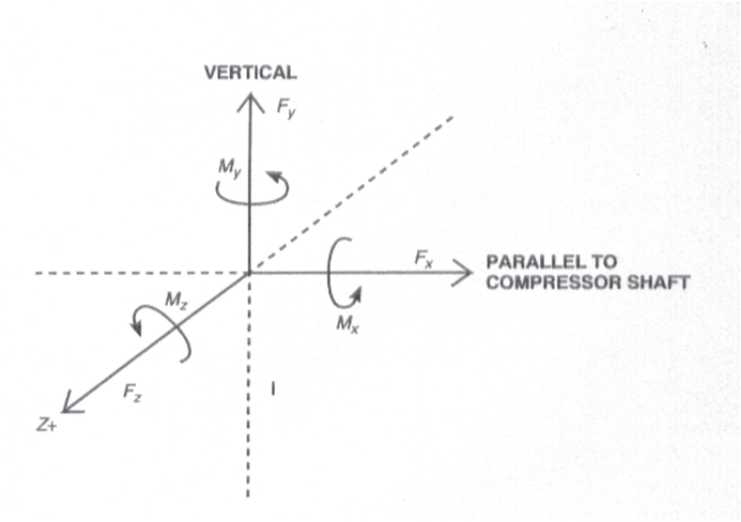


Figure F.1—Combined Resultants of the Forces and Moments of Corrections

Axial and Centrifugal Compressors and Expander-compressors

Part 3—Integrally Geared Centrifugal Compressors

1 Scope

This standard specifies minimum requirements and gives recommendations for axial compressors, single-shaft and integrally geared process centrifugal compressors, and expander-compressors for special purpose applications that handle gas or process air in the petroleum, chemical, and gas industries. This part of API 617 specifies integrally geared centrifugal compressors in conjunction with API 617, Part 1.

NOTE 1 See API 672 for packaged plant instrument air compressors.

NOTE 2 Expander stages are sometimes provided on these machines.

2 Normative References

Referenced documents indispensable for the application of this document are listed under Part 1: Section 2.

3 Terms, Definitions, and Abbreviations

For the purposes of this document, the terms, definitions, and abbreviations given in Part 1 apply.

NOTE A cross-section showing nomenclature of an integrally geared centrifugal compressor may be found in Annex C.

4 General

4.1 Dimensions and Units

The dimensional and unit requirements of Part 1 shall apply.

4.2 Statutory Requirements

The statutory requirements of Part 1 shall apply.

4.3 Unit Responsibility

The unit responsibilities of Part 1 shall apply.

4.4 Basic Design

4.4.1 Performance

4.4.1.1 The sectional head-capacity characteristic curve of each compressor section shall rise continuously from the rated point to predicted surge. The compressor, without the use of a bypass, shall

be suitable for continuous operation at any capacity at least 10 % greater than the predicted surge capacity shown in the proposal.

4.4.1.2 Unless otherwise specified, the design lubricant shall be hydrocarbon oil of viscosity Grade 32 with an FZG load stage of 5, in accordance with ISO 8068. Viscosity Grade 46 with an FZG load stage of 5 may be used as a design lubricant, with purchaser's approval. Oils with extreme pressure (EP) additives shall not be used.

NOTE Typical oil used in refineries and chemical plants has an FZG of 5 or higher. Requiring a higher FZG by design can require the need for special oil for this equipment.

4.5 Materials

Materials shall be in accordance with 4.5 of Part 1.

NOTE Refer to Annex D for typical materials.

4.6 Casings

Casings shall be in accordance with 4.6 of Part 1 and 4.6.1 through 4.6.6, as follows.

4.6.1 Pressure-containing Casings

4.6.1.1 The maximum allowable working pressure (MAWP) of each pressure casing shall be at least equal to the specified relief valve set pressure for that casing. The purchaser will specify the relief valve set pressure(s) for final discharge pressure and intermediate casing pressures, if applicable.

NOTE If only one relief valve pressure is specified, its set pressure will not usually apply to the intermediate pressure.

4.6.1.1.1 When a relief valve set pressure is not specified, each pressure casing shall be rated for at least 125 % of the maximum specified discharge pressure (gauge) of that pressure casing as determined by the supplier. System protection shall be furnished by the purchaser.

4.6.1.2 Socket-head or spanner-type bolting shall not be used externally unless specifically approved by the purchaser. For limited space locations, integrally flanged fasteners may be required.

4.6.2 Casing Repair

Casings repairs shall be in accordance with 4.6.2 of Part 1.

4.6.3 Material Inspection of Pressure-containing Parts

Casing material inspection of pressure-containing parts shall be in accordance with 4.6.3 of Part 1.

4.6.4 Pressure Casing Connections

Pressure Casing Connections shall be in accordance with 4.6.4 of Part 1 and the following paragraphs.

4.6.4.1 Main Process Connections

Main process connections shall be in accordance with 4.6.4.2 of Part 1.

4.6.4.2 Auxiliary Connections

4.6.4.2.1 If flanged or machined and studded openings are impractical, threaded connections may be used where they do not come in contact with flammable or toxic gas, with purchaser's approval as follows:

a) on nonweldable materials, such as cast iron;

b) Where essential for maintenance (disassembly and assembly).

These threaded openings shall be as specified in 4.6.4.3.8 of Part 1.

4.6.4.2.2 Auxiliary connections shall be at least DN 20 (NPS $^{3}/_{4}$ in.). See 4.11.1.7 through 4.11.1.9 and Table 1 for auxiliary gearbox connections.

NOTE See 4.6.4.1.3 of Part 1 for allowable connection sizes.

4.6.4.2.3 Threaded connections for pipe sizes DN 20 (NPS $^{3}/_{4}$ in.) through DN 40 (NPS 1 $^{1}/_{2}$ in.) size are permissible with the approval of the purchaser.

NOTE See 4.6.4.1.3 of Part 1 for allowable connection sizes.

4.6.5 Casing Support Structure

The mounting of the pressure casing (volute) to the gearbox shall be per 4.4.1.7 of Part 1. Bolting used to mount pressure casings shall be per 4.6.1.7 of Part 1.

4.6.6 External Forces and Moments

4.6.6.1 The supplier shall furnish the allowable forces and moments for each main process nozzle which has a customer connection in tabular form with the proposal. If nozzle loadings are not furnished, they shall be no less than NEMA SM-23.

NOTE 1 Forces and moments allowed on integrally geared compressors are generally less than allowed on API 617, Part 2 compressors. (See Annex F.)

NOTE 2 Piping system design will need to be rigorous in order to avoid piping expansion joints.

4.6.6.2 Pressure casing and supports shall be designed to have sufficient strength and rigidity to avoid adversely affecting impeller running clearances, gear contact pattern, seals, bearings, and coupling alignment.

4.6.7 Variable Inlet and/or Diffuser Guide Vanes

- **4.6.7.1** Adjustable guide vanes shall be provided when specified or required by the supplier to meet specified operating conditions.

4.6.7.2 When provided, adjustable inlet guide vanes and operating mechanisms shall be suitable for all specified operating conditions, as well as start-up, shutdown, trip-out, settle-out, and momentary surge.

4.6.7.2.1 Guide vanes shall be mounted in replaceable bushings. Vanes may be positioned in the housing by replaceable permanently sealed rolling element bearings, if approved by the purchaser.

4.6.7.2.2 When adjustable guide vanes are used for toxic, flammable, or explosive process gas, then the linkage passing through the casing or enclosure shall be sealed to prevent leakage.

4.6.7.2.3 The inlet guide vanes shall be located sufficiently close to the eye of the impeller to be effective.

4.6.7.2.4 The vane foils shall have an aerodynamically smooth surface, especially where the shank enters the gas stream through the housing. A cantilevered design in lieu of a center supported vane design is preferred.

4.6.7.2.5 The vanes shall be designed such that the vanes will tend to open on loss of the control signal.

4.6.7.2.6 A vane control system consisting of a valve positioner with direct driven local position indicator shall be provided that will be visible during operation of the machine.

- **4.6.7.2.7** Additional components to the vane control system in 4.6.7.2.6 shall be as specified.

- **4.6.7.3** If specified, the actuation shaft seal shall be buffered using a barrier gas.

4.7 Rotating Elements

4.7.1 Each impeller and shaft shall be clearly marked with a unique identification number. This number shall be on an accessible area that is not prone to maintenance damage.

4.7.2 Unless other shaft protection is approved by the purchaser, renewable components shall be furnished at close clearance points. Sleeves, spacers, or bushings shall be made of materials that are corrosion-resistant in the specified service (see 4.5.1.6 of Part 1 for limitations).

4.7.2.1 Shaft sleeves shall be provided under shaft end seals. Sleeves shall be treated to resist wear and sealed to prevent gas leakage between the shaft and sleeve.

4.7.3 Thrust Balancing

Thrust loads from impellers and gears shall be absorbed by individual thrust bearings on pinions or transmitted to the bull gear thrust bearing by means of thrust rider rings fixed to the pinions and bull gear. All specified operating conditions and start-up conditions shall be evaluated for residual thrust loads.

NOTE Balance pistons are normally not used. Thrust balancing can be achieved by helix thrust force direction of the gearing and offsetting impeller aerodynamic thrust forces.

4.7.4 Impellers

Refer to 4.7.10 of Part 1 for impeller requirements.

4.8 Dynamics

Refer to Part 1 for dynamics requirements.

4.8.1 For equipment covered in this part, a lateral analysis shall be carried out for each shaft. For the bull gear, this shall consist only of an undamped critical speed map.

4.9 Bearings and Bearing Housings

Refer to Part 1 and the following sections for bearing and bearing housing requirements.

4.9.1 General

4.9.1.1 Unless otherwise specified, radial and thrust bearings shall be of the hydrodynamic fluid film type.

4.9.1.2 Unless otherwise specified, thrust bearings and radial bearings shall be fitted with bearing-metal temperature sensors installed in accordance with API 670.

4.9.1.2.1 As a design criteria, bearing metal temperatures shall not exceed 100 °C (212 °F) at specified operating conditions with a maximum oil inlet temperature of 50 °C (120 °F).

4.9.1.2.2 In the event the above design criteria cannot be met, purchaser and supplier shall agree on acceptable bearing metal temperatures.

4.9.2 Hydrodynamic Radial Bearings

4.9.2.1 Sleeve or pad radial bearings shall be used and shall be split for ease of assembly. The use of nonsplit designs requires the purchaser's approval. The bearings shall be precision bored with steel, copper, cupro-nickel or bronze backed babbitted liners, pads, or shells. The bearings shall be equipped with anti-rotation pins and shall be positively secured in the axial direction.

- **4.9.2.2** If specified, tilting pad bearing pads shall be copper-alloy backed.

4.9.2.3 Unless otherwise specified, the liners, pads, or shells shall be in axially split housings. The bearing design shall not require removal of the coupling hub to permit replacement of the bearing liners, pads, or shells unless approved by purchaser.

4.9.3 Hydrodynamic Thrust Bearings

4.9.3.1 Thrust bearings may be fixed geometry (e.g. tapered-land) or tilting-pad type, steel-backed and babbitted, arranged for continuous pressurized lubrication to each side.

NOTE See 4.7.3 for thrust rider rings.

- **4.9.3.2** If specified, bearings shall be tilting pad on one or both sides.

4.9.3.3 Hydrodynamic thrust bearings shall be selected at no more than 50 % of the bearing manufacturer's ultimate load rating. In sizing thrust bearings, consider the following for each specified application:

a) the shaft speed;

b) the temperature of the bearing babbitt;

c) the deflection of the bearing pad;

d) the minimum oil film thickness;

e) the feed rate, viscosity, and supply conditions of the oil over the specified allowable oil supply condition range;

f) the design configuration of the bearing;

g) the babbitt or other bearing surface material alloy and pad material;

h) the turbulence of the oil film;

i) load changes due to process changes over the specified operating range.

NOTE See 3.1.64 of Part 1 for a definition of ultimate load rating for hydrodynamic thrust bearings.

4.9.3.4 Thrust bearings shall be sized for continuous operation under the most adverse specified operating conditions. Calculations of the thrust forces shall include but shall not be limited to the following factors:

a) seal maximum design internal clearances and twice the maximum design internal clearances;

b) pressurized rotor diameter step changes;

c) stage maximum differential pressures;

d) specified extreme variations in inlet, interstage, and discharge pressures;

e) the maximum thrust force that may be transmitted to the compressor thrust bearing by other equipment in the train (i.e. couplings, gears, or a motor without a thrust bearing);

f) the maximum thrust force from the sleeve bearing type drive if the motor or generator is directly connected.

4.9.4 Bearing Housings

4.9.4.1 The term bearing housing refers to all bearing enclosures including the gearbox.

4.9.4.2 Bearing housings for pressure-lubricated hydrodynamic bearings shall be arranged to minimize foaming. The drain system shall be adequate to maintain the oil and foam level below shaft seals.

4.9.4.3 Oil reservoirs and housings that enclose moving lubricated parts (such as bearings and shaft seals), highly polished parts, instruments, and control elements shall be designed to minimize contamination by moisture, dust, and other foreign matter during periods of operation and idleness.

4.9.4.4 Provision shall be made in the bearing housings for the probes specified in 5.5.7.1.

4.10 Shaft End Seals

4.10.1 Process seals and seal systems shall be in accordance with 4.10 of Part 1.

NOTE 1 Typical cross sections of various seal systems are given in Part 1: Annex B.

NOTE 2 Equipment covered in this part can be available with any of the shaft end seal types covered in Part 1, or additional hybrid types are available.

4.10.2 Purchaser shall specify the type of shaft end seal(s) to be provided and all operating conditions including start-up, shutdown, and settle-out conditions.

4.11 Integral Gearing

4.11.1 The supplier shall dowel or key the gearbox to the mounting plate to maintain alignment.

NOTE Integrally geared compressors are fixed to the mounting plate and are not to be moved for alignment (to avoid distortion of the gearbox).

4.11.1.1 To the maximum extent practical, gearboxes shall be designed with internal oil passages to minimize external piping. External piping connections shall conform to the requirements of 4.6.4.3 of Part 1.

4.11.1.2 The design of internal piping and tubing shall achieve proper support and protection to prevent damage from vibration or from shipment, operation, and maintenance. Cantilevered piping in excess of 10 pipe diameters shall include reinforcing gussets in two planes at all pipe-to-flange connections.

4.11.1.3 The gearbox shall be designed to permit rapid drainage of lube oil and to minimize oil foaming (which could lead to excessive heating of the oil). For gears with pitch line velocities of more than 125 m/sec (25,000 ft/min), consideration should be given to design features such as windage baffles, false bottoms, adequate sump depth, and an additional full-size drain connection.

4.11.1.4 A removable and gasketed inspection cover or covers shall be provided in the gearbox to permit direct visual inspection of the full-face width of the pinion(s) and gear. The inspection opening or openings shall be at least one-half the width of the gear face.

4.11.1.5 Permanent coatings or paint shall not be applied to the interior of the casing, unless the purchaser approves in advance the material and method of application.

4.11.1.6 A single lube-oil supply connection is preferred.

4.11.1.7 A single lube-oil drain connection from the gear casing is preferred. The minimum drainpipe size shall be sized to be no more than half full and shall be based on the total inlet flow to the gear casing, as shown in Table 1 below.

Table 1—Drain Pipe Sizes

Inlet Flow Rate		Minimum Drain Size [a]	
L/min	U.S. gal/min	mm	in.
74	19	50	2
176	46	75	3
370	97	100	4
1146	302	150	6

[a] Nominal pipe size.

4.11.1.8 Gearboxes shall be provided with a plugged or flanged-and-blinded purge gas connection.

4.11.1.9 Gearbox casing vents shall be designed to permit adequate draining, inhibit intrusion of dirt and moisture, and prevent the escape of oil mist to the atmosphere.

4.11.2 Gearbox Split Lines

Gearbox split lines shall use a metal-to-metal joint. Adequate sealing shall be provided with a suitable joint compound or groove type seals. Gaskets (including string type) shall not be used on the gearbox split lines.

4.11.3 Gear Rating

4.11.3.1 When a gearbox has a gear mesh with a ratio of 7:1 or greater, all of the gearing in that gearbox shall be rated in accordance with Annex G. All other gear sets shall be rated per API 613.

4.11.3.2 The rated power of the gearing shall not be less than the driver nameplate rating multiplied by the driver service factor. When there are multiple pinions, the power rating of the gear sets shall not be less than:

a) 110 % of the maximum power transmitted by the gear set;

b) the maximum power of the driver (including service factor) prorated between all the gear sets, based on normal power demands. If the maximum transmitted torque occurs at a continuous operating speed other than the maximum continuous speed (MCS), this torque and its corresponding speed shall be the basis for sizing the gear set.

4.11.3.3 The power rating based upon both pitting resistance and bending strength shall be calculated for each member of each gear set in the unit. The pinion and bull gear teeth may have different ratings due to differences in material properties, geometry factors, and number of cycles under load. The lowest of the four ratings (pinion bending, pinion pitting, bull gear bending, bull gear pitting) shall be used as the gear rating (see Annex G). Wherever possible, gear sets shall be designed such that failure will occur due to pitting rather than bending (i.e. wear out before breaking).

NOTE Higher gear ratios require a large number of teeth, therefore, it may not be possible to provide tooth design (which will fail in pitting rather than bending) without compromising other aspects of the gear design (i.e. higher pitchline velocities).

4.11.3.4 Gearing shall be designed and manufactured to meet the requirements of ANSI/AGMA 2015-1-A01, accuracy grade 4.

NOTE For equivalent loading conditions, gearing produced to higher quality levels will always result in longer service life and reduced bearing loads.

4.11.3.5 The manufacturer shall provide documentation showing that the required quality levels in 4.11.3.4 have been met.

4.11.3.6 The pinion face width to working pitch diameter ratio (L/d ratio) shall be limited based on pinion tooth hardness, as follows.

4.11.3.6.1 For pinion hardness equal to or less than 38 Rc (BHN 354), L/d shall be limited to 2.0 maximum.

4.11.3.6.2 For pinion hardness equal to or greater than 58 Rc (BHN 615), L/d shall be limited to 1.6 maximum.

4.11.3.6.3 For pinion hardness between 38 and 58 Rc (BHN 354 and BHN 615), L/d shall be limited to $L/d = 2.76 – 0.02*H$ (see Figure 1).

NOTE H is the hardness in Rockwell C.

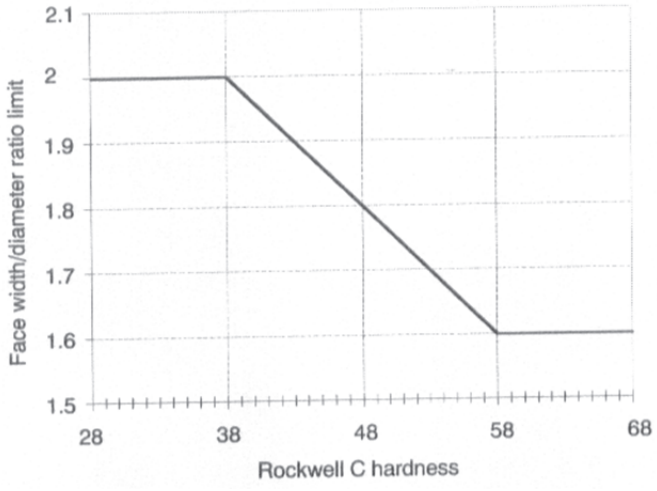


Figure 1—Face Width Limit

4.11.3.7 The material used for gearing shall meet the specifications for AGMA 2101 Grade 2 material, as a minimum. If a superior grade of material is used, credit for the better material shall not be taken in the gear rating.

4.11.3.8 The tooth portion of pinions shall be integral with their shafts.

4.11.3.9 The bull gear may be integral with or separate from its shaft. Separate shafts shall be assembled into the bull gear with an interference fit suitable for all torque requirements including pulsations.

4.11.3.10 Shafts shall be made of one-piece, heat-treated steel that is suitably machined. Shafts that have a finished diameter larger than 200 mm (8 in.) shall be forged steel. Shafts that have a finished diameter of 200 mm (8 in.) or less shall be forged steel or, hot rolled barstock, providing such barstock meets all quality and heat treatment criteria established for shaft forgings.

4.11.3.11 Gearboxes shall not require a break-in period.

4.11.3.12 The gearing shall be designed to withstand all internal and external loads inherent to geared, rotating machinery systems to the limit of the installed driver.

4.11.3.13 The unplated tooth surface on loaded faces of completed gears shall have a finish, as measured along the pitch line, of 0.8 μm (32 μin.) Ra or better.

4.11.3.14 Hunting tooth combinations are preferred. To achieve this, it may be necessary for the manufacturer to adjust the exact gear ratio. If such adjustment is impractical, the purchaser and the supplier shall negotiate a solution. At least one mesh shall be hunting tooth.

NOTE A hunting tooth combination is preferred because the intent is for every tooth on a pinion to mesh with as many teeth as possible on the mating gear before the same teeth mesh again or repeat. However, with multiple pinion units a hunting tooth combination is not as critical because the gear wheel meshes with multiple pinions and is, therefore, not as susceptible to the problems of nonhunting tooth designs.

4.11.3.15 Each gear and each pinion shall be supported between two bearings. Overhung designs are not permitted.

4.12 Nameplates and Rotation Arrows

4.12.1 Nameplates and rotation arrows shall be in accordance with 4.12 of Part 1, and this section.

4.12.2 The following data shall be clearly stamped or engraved on the nameplate(s):

— supplier's name;

— serial number;

— size, type, and model;

— rated capacity;

— rated power;

— gear ratio;

— rated input speed or speed range for variable speed driver;

— purchaser item number;

— MAWP of each pressure-containing casing;

— maximum and minimum allowable working temperature of each pressure-containing casing;

— hydrostatic test pressure for each pressure-containing casing;

— maximum sealing pressure of each pressure-containing casing.

NOTE Normally, multiple nameplates are provided.

4.12.3 Rotation arrows shall be cast-in or attached for the bull gear rotation at a readily visible location.

NOTE See 4.12 of Part 1.

5 Accessories

Accessories shall conform with Section 5 of Part 1.

5.1 Drivers

Drivers shall conform with 5.1 of Part 1.

5.2 Couplings and Guards

Couplings and guards shall conform with 5.2 of Part 1.

5.3 Lubrication and Sealing Systems

5.3.1 Lubrication and sealing systems shall conform with 5.3 of Part 1.

5.4 Mounting Plates

Mounting plates shall conform with 5.4 of Part 1.

- **5.4.1** If specified or approved by the purchaser the oil reservoir shall be integral with the baseplate.

- **5.4.2** If specified, the baseplate shall have a series of machined mounting pads suitable for mating to field installed soleplates to facilitate installation.

  NOTE See API 686, Second Edition, Figure C.1.

- **5.4.3** If specified, when machined mounting pads as indicated in 5.4.2 have been specified, the supplier shall also supply the soleplates needed for field installation.

5.5 Controls and Instrumentation

5.5.1 Controls and instrumentation shall be in conformance with 5.5 of Part 1.

5.5.2 Control Systems

- **5.5.2.1** For a constant-speed centrifugal compressor, the control signal shall actuate either a purchaser-furnished control valve in the compressor inlet piping or the adjustable inlet guide vanes or variable diffuser vanes furnished by the supplier as an integral part of the compressor, as specified.

5.5.2.2 If adjustable inlet guide vanes or variable diffuser vanes are specified, the supplier shall also furnish a guide-vane positioner compatible with the type of control signal specified by the purchaser.

- **5.5.2.3** If specified, the guide vane positioner shall include a local manual override. A direct-driven vane position indicator shall be provided that will be visible during operation of the machine.

5.5.3 Instrument and Control Panels

Instrument and control panels, when supplied, shall be in accordance with 5.5.3 of Part 1.

5.5.4 Instrumentation

Instrumentation, when supplied, shall be in accordance with 5.5.4 of Part 1.

5.5.5 Alarms and Shutdowns

Alarms and shutdowns, when supplied, shall be in accordance with 5.5.5 of Part 1.

5.5.6 Electrical Systems

Electrical systems, when supplied, shall be in accordance with 5.5.6 of Part 1.

5.5.7 Vibration, Position, and Bearing Temperature

5.5.7.1 Unless otherwise specified, the following transducers shall be provided: two radial-vibration probes adjacent to each radial bearing, two axial-position probes for each shaft equipped with a thrust bearing, and a one-event-per-revolution probe for each shaft.

5.5.7.2 Vibration and axial position transducers shall be supplied, installed, and calibrated in accordance with API 670.

- **5.5.7.3** If specified, radial shaft vibration and axial position monitors shall be supplied and calibrated in accordance with API 670.

5.5.7.4 Two bearing temperature sensors shall be supplied, installed, and calibrated for each radial and thrust bearing in accordance with API 670.

NOTE The second sensor can be used as a spare.

- **5.5.7.5** Purchaser shall specify the type of temperature sensors required per API 670.

- **5.5.7.6** If specified, a bearing temperature monitor shall be supplied and calibrated in accordance with API 670.

- **5.5.7.7** If specified, an accelerometer shall be supplied, installed at the shaft on the gearbox, and calibrated in accordance with API 670.

NOTE Commercially available accelerometers that have hazardous area certifications have difficulty reaching high gear mesh frequencies.

- **5.5.7.8** If specified, an accelerometer monitor shall be supplied, installed and calibrated in accordance with API 670.

5.6 Piping and Appurtenances

5.6.1 General

Piping and appurtenances furnished shall be in accordance with 5.6 of Part 1, with additions as follows.

5.6.1.1 When a baseplate has been specified, the supplier shall furnish all piping systems, including mounted appurtenances, located within its confines. The piping shall terminate with flanged connections at the edge of the baseplate. The purchaser will furnish only interconnecting piping between equipment groupings and off base facilities.

NOTE The oil reservoir and oil system can be combined in the baseplate. See 5.4.1.

- **5.6.1.2** If specified, a liquid injection manifold shall be supplied. It shall include a throttle valve, an armored flow meter, a check valve, a pressure indicator, and a block valve for each injection point.

5.6.2 Process Piping and Accessories

5.6.2.1 Unless otherwise specified, process piping, if furnished, shall be in accordance with API 614, Fifth Edition, Parts 1, 2, and 4 as applicable.

- **5.6.2.2** If specified, the purchaser shall furnish piping specifications for supplier furnished process piping.

- **5.6.2.3** If specified, the supplier shall provide process gas heat exchangers in accordance with purchaser provided specifications.

NOTE Refer to API 614, Fifth Edition, Part 1 for process heat exchanger requirements.

5.7 Special Tools

Special tools shall be in accordance with 5.7 of Part 1.

6 Inspection, Testing, and Preparation for Shipment

6.1 General

General requirements for inspection, testing and preparation for shipment shall be in accordance with 6.1 of Part 1. Also refer to Annex E for the Inspector's Checklist.

6.2 Inspection

Requirements for inspection shall be in accordance with 6.2 of Part 1 and the following.

6.2.1 Gear Contact Checks

6.2.1.1 Each set of installed gears shall be checked for contact in the job gearbox at the supplier's shop.

6.2.1.2 A thin coating of color transfer material (such as Prussian blue) shall be applied at three locations, 120 degrees apart, to four or more teeth of the dry degreased gear. (Layout dye shall not be used for the assembly contact check.) With the gear held firmly, the coated teeth shall be rotated through the mesh with a moderate drag torque applied in a direction that will cause the teeth to contact on the normally loaded faces. The color transfer shall show evidence of contact distributed across each helix, as prescribed by the supplier. Prior to the contact tests, the supplier shall make available to the purchaser a contact drawing or supplier engineering specification that defines the acceptable contact. The results of the contact check shall be preserved by lifting the contrasting colors from a tooth by applying and peeling off a strip of clear, adhesive tape and then applying the tape to a notated sheet of white paper. The drawing or specification and the results of the contact checks shall be preserved for at least 20 years and shall be available to the purchaser on request.

NOTE Unmodified leads generally show about 80 % contact across the tooth length.

6.3 Testing

In addition to the requirements of 6.3 of Part 1, the compressor shall be tested in accordance with 6.3.1 and 6.3.2. Other tests that may be specified are described in 6.3.3.

6.3.1 Mechanical Running Test

6.3.1.1 The requirements of 6.3.1.1.1 through 6.3.1.1.5 shall be met before the mechanical running test is performed.

6.3.1.1.1 The contract shaft seals and bearings shall be used in the machine for the mechanical running test.

6.3.1.1.2 Compressors covered in this part generally do not use oil-injected seals or seal-oil systems. When these are specified, testing shall be as agreed between user and supplier.

NOTE For guidance see 6.3.2 of Part 1.

6.3.1.1.3 Oil viscosity, pressures, temperatures, and filtration shall be within the range of operating values recommended in the supplier's operating instructions for the specific unit being tested. Overall oil flow rates for each oil supply line shall be measured.

6.3.1.1.4 Oil system components downstream of the filters shall meet the cleanliness requirements of API 614 before any test is started.

6.3.1.1.5 Facilities shall be installed to prevent the entrance of oil into the compressor during the mechanical running test. These facilities shall be in operation throughout the test.

6.3.1.2 The mechanical running test of the equipment shall be conducted as specified in 6.3.1.2.1 through 6.3.1.2.4.

NOTE Testing with the contract coupling(s) is preferred.

6.3.1.2.1 The equipment shall be accelerated to the maximum continuous speed and run until bearings, lube-oil temperatures, and shaft vibrations have stabilized.

NOTE Operating equipment at or near critical speeds is normally avoided.

6.3.1.2.2 For variable speed machines, the speed shall be increased to trip speed and the equipment shall be run for a minimum of 15 minutes.

6.3.1.2.3 The speed shall be reduced to the MCS, and the equipment shall be run for 4 hours continuous operation.

6.3.1.2.4 The following seal flow data shall be taken during the mechanical running test to assure that the seals are installed and operating properly.

a) For single dry gas seals, flow in the vent line from each seal shall be measured.

b) For tandem dry gas seals, flow in the primary and secondary vent line from each seal shall be measured.

c) For double dry gas seals, the total seal gas flow to each seal shall be measured.

NOTE 1 Seal performance at contract conditions is normally determined in separate tests by the seal manufacturer (see 4.10 of Part 1 for the requirements).

NOTE 2 Flow in the vents of single or tandem seals can include buffer or separation gas in addition to process gas leakage through the seal.

6.3.1.3 During the mechanical running test, the requirements of 6.3.1.3.1 through 6.3.1.3.7 shall be met.

6.3.1.3.1 During the mechanical running test, the mechanical operation of all equipment being tested and the operation of the test instrumentation shall be satisfactory. The equipment measured unfiltered vibration shall not exceed the limits of 4.8.8.8 of Part 1 and shall be recorded at the operating speed. Any other test acceptance criteria shall be agreed and stated in the test agenda.

6.3.1.3.2 Casing vibration shall not exceed an overall level of 4 Gs peak at gear mesh frequency.

6.3.1.3.3 While the equipment is operating at MCS or other speeds, vibration data shall be acquired to determine amplitudes at frequencies other than synchronous. This data shall cover a frequency range from 0.25 to 8 times the MCS. If the amplitude of any discrete, nonsynchronous vibration exceeds 20 % of the allowable vibration as defined in 4.8.8.8 of Part 1, the purchaser and the supplier shall agree on requirements for any additional testing and on the equipment acceptability.

6.3.1.3.4 The mechanical running test shall verify that lateral critical speeds below running speed conform to the requirements of 4.8.2 of Part 1.

- **6.3.1.3.5** If specified, shop verification of the unbalanced response analysis shall be performed in accordance with 4.8.3 of Part 1.

- **6.3.1.3.6** If specified, all real-time vibration data as agreed by the purchaser and the supplier shall be recorded and a copy provided to the purchaser.

- **6.3.1.3.7** If specified, the user may bring in vibration equipment to record baseline readings.

6.3.1.4 Following the mechanical running test, the requirements of 6.3.5.10 of Part 1 shall be met, as well as the requirements of 6.3.1.4.1 and 6.3.1.4.2 below.

6.3.1.4.1 The tooth mesh shall be inspected for proper contact and for surface damage resulting from the test.

6.3.1.4.2 Spare rotor sets ordered to permit concurrent manufacture shall also be given a mechanical running test in accordance with the requirements of this standard. Complete spare set shall be run as a unit.

6.3.2 Assembled Compressor Gas Leakage Test

6.3.2.1 After the mechanical running test is completed, each completely assembled compressor casing intended for toxic, hazardous, or flammable service shall be tested as required in 6.3.2.2 and/or, if specified, 6.3.2.3.

NOTE These tests are intended to verify the integrity of the casing joint. Some shaft seal designs are not gas tight. Therefore, leakage from these seals during this test is acceptable.

6.3.2.2 The assembled compressor (including end seals) shall be pressurized, with an inert gas, to the maximum sealing pressure or the maximum seal design pressure, as agreed by the purchaser and the supplier; held at no less than this pressure for a minimum of 30 minutes; and subjected to a soap bubble test, or alternate method, to check for gas leaks. The test shall be considered satisfactory when no casing or casing joint leaks are observed. If design mole weight is less than 12, the test gas shall be helium.

NOTE Test gas mole weight will approximate or be less than contract gas mole weight.

- **6.3.2.3** If specified, the assembled compressor (with or without end seals installed) shall be pressurized with an inert gas to the maximum specified discharge pressure, held at this pressure for a minimum of 30 minutes, and subjected to a soap bubble test, or alternate method, to check for gas leaks. The test shall be considered satisfactory when no casing or casing joint leaks are observed.

NOTE The requirements of 6.3.2.2 and 6.3.2.3 can necessitate two separate tests.

6.3.3 Optional Tests

The purchaser will specify whether any of the following shop tests shall be performed. The purchaser and the supplier shall agree upon test details prior to the test.

6.3.3.1 Performance Test

6.3.3.1.1 The compressor shall be performance tested in accordance with ASME PTC 10-1997 or ISO 5389, as specified. A minimum of five points, including surge and overload, shall be taken at normal speed and vane setting. For variable speed or variable vane machines, additional points may be specified.

NOTE Refer to the applicable test code for general instructions. ASME PTC 10-1997 will not apply to some low-pressure ratio compressors. Refer to the scope 1.2.2 of PTC 10-1997 for the selection of the appropriate test code to be used.

6.3.3.1.2 For variable speed or variable vane machines, head and capacity shall have zero negative tolerance at the normal operating point (or other point as specified), and the power at this point shall not exceed 104 % of the supplier predicted shaft power value. This tolerance shall be inclusive of all test tolerances. Surge shall comply with provisions of 4.4.1.1.

NOTE Both of the performance test codes referred to have provision for calculating inaccuracy based on instrumentation and procedures. These test inaccuracies are already included in the above tolerance and, therefore, are not to be further additive.

6.3.3.1.3 For constant speed compressors, the capacity shall be as specified in 6.3.3.1.2. The head shall be within the range of 100 % to 105 % of the normal head. The horsepower, based on measured head at normal capacity, shall not exceed 107 % of the value at the specified normal operating point. If the power required at this point exceeds 107 %, excess head may be removed by trimming impellers at the purchaser's option.

6.3.3.1.4 The performance test shall be conducted using only one contract rotor set, unless additional performance testing is specified.

6.3.3.1.5 Compressors with intermediate specified process pressures shall have individual sectional head (pressure) tolerances as agreed.

6.3.3.2 Complete Unit Test

Such components as compressors, gears, drivers, and auxiliaries that make up a complete unit shall be tested together during the mechanical running test. A separate auxiliary test may be performed with the purchaser's approval. The complete unit test may be performed in place of or in addition to separate tests of individual components specified by the purchaser. If specified, torsional vibration measurements shall be made to verify the supplier's analysis.

6.4 Preparation for Shipment

6.4.1 Preparation for shipment shall be in accordance with Part 1: 6.4 and the following.

6.4.1.1 If specified, the fit-up and assembly of machine-mounted piping, intercoolers, etc. shall be completed in the supplier's shop prior to shipment.

7 Supplier's Data

Supplier's data shall be in accordance with Section 7 of Part 1.

7.1 General

7.1.1 The information to be furnished by the supplier is specified in Part 1 Section 7. The supplier shall complete and forward the agreed Vendor (supplier) Drawing and Data Requirements (VDDR) Form (See annex B for an example) to the address or addresses noted on the inquiry or order. This form shall detail the schedule for transmission of drawings, curves, and data as agreed to at the time of the order, as well as the number and type of copies required by the purchaser

7.1.2 On the datasheets and in drawings and tables, the shaft rotational direction shall be designated by the abbreviations CW (clockwise) or CCW (counterclockwise) (see 4.12.3).

7.1.3 Suppliers shall provide bearing temperature alarm and shutdown limits.

7.2 Proposals

Proposals shall be in accordance with 7.2 of Part 1.

7.3 Contract Data

Contract data shall be in accordance with 7.3 of Part 1.

Annex A
(informative)

Typical Datasheets

A representation of the datasheets is enclosed in this annex; however, MS Excel format datasheets have been developed and are available, for purchase from API publications distributors, with this standard. The MS Excel electronic datasheets may have additional functionality over printed hard copies.

	REVISION	0	1	2	3	4
	DATE					
	BY					
INTEGRALLY GEARED COMPRESSOR DATASHEET (API 617-8th, Part 3) SI UNITS (bar)	REV/APPR					
	JOB NO.		ITEM NO.			
	PAGE 1 OF 12		REQ'N NO.			

APPLICABLE TO: ○ PROPOSAL ○ PURCHASE ○ AS BUILT

FOR _____ UNIT _____

SITE _____ SERIAL NO. _____

SERVICE _____ NO. REQUIRED _____

MANUFACTURER _____ DRIVER TYPE _____

MODEL _____ DRIVER ITEM NO. _____

APPLICABLE STANDARD: ○ U.S. ○ ISO

NOTE: INFORMATION TO BE COMPLETED BY: ○ PURCHASER □ MANUFACTURER △ PURCHASER OR MANUFACTURER

OPERATING CONDITIONS

(ALL DATA ON PER UNIT BASIS)	NORMAL	OTHER CONDITIONS				
		RATED	B	C	D	E
	(NOTE 1)					
○ GAS HANDLED (ALSO SEE PAGE ___)						
△ GAS PROPERTIES						
□ N(m³/h) (1013 barA & 0°C DRY)						
○ WEIGHT FLOW (lb/min) ○ WET ○ DRY						
INLET CONDITIONS						
○ PRESSURE (barA)						
○ TEMPERATURE (°C)						
○ RELATIVE HUMIDITY %						
○ MOLECULAR WEIGHT						
□ Cp/Cv (K_1) OR (K_{AVG})						
□ COMPRESSIBILITY (Z_1) OR (Z_{AVG})						
□ INLET VOLUME (m³/h) ○ WET ○ DRY						
DISCHARGE CONDITIONS						
○ PRESSURE (barA)						
□ TEMPERATURE (°C) **(ESTIMATED)**						
□ Cp/Cv (K_2) OR (K_{AVG})						
□ COMPRESSIBILITY (Z_2) OR (Z_{AVG})						
□ GHP REQUIRED (kW)						
□ TRAIN (BkW) REQUIRED						
□ (BkW) REQUIRED AT DRIVER INCL. EXT. LOSSES (GEAR, ETC.)						
□ SPEED of driver (rpm)						
□ TURNDOWN (%)						
□ POLYTROPIC HEAD (N-m/kg)						
□ POLYTROPIC EFFICIENCY (%)						
○ CERTIFIED POINT						
□ PERFORMANCE CURVE NUMBER						

PROCESS CONTROL

○ METHOD ○ SUCTION THROTTLING FROM ___ (barA) TO ___ (barA) ○ VARIABLE INLET GUIDE VANES ○ SPEED VARIATION FROM ___ % TO ___ % ○ DISCHARGE BLOWOFF OR RECIRCULATION ○ VARIABLE DIFFUSER GUIDE VANES

SIGNAL ○ SOURCE _____

TYPE ○ ELECTRONIC ○ PNEUMATIC ○ OTHER _____

RANGE _____ MA _____ (barG)

REMARKS: NOTE 1 IF GAS ANALYSIS IS GIVEN, MANUFACTURER SHALL SUPPLY GAS PROPERTIES, OTHERWISE DATA SHALL BE SUPPLIED BY USER

REVISION	0	1	2	3	4
DATE					

INTEGRALLY GEARED COMPRESSOR
DATASHEET (API 617-8th, Part 3)
SI UNITS (bar)

JOB NO. _____ ITEM NO _____
PAGE 2 OF 12 REQ'N NO. _____

OPERATING CONDITIONS (Continued)

GAS ANALYSIS: ○ MOL %	MW	NORMAL	OTHER CONDITIONS RATED	B	C	D	E	REMARKS:
AIR	28.966							
OXYGEN	32.000							
NITROGEN	28.016							
WATER VAPOR	18.016							
CARBON MONOXIDE	28.010							
CARBON DIOXIDE	44.010							
HYDROGEN SULFIDE	34.076							
HYDROGEN	2.016							
METHANE	16.042							
ETHYLENE	28.052							
ETHANE	30.068							
PROPYLENE	42.078							
PROPANE	44.094							
I-BUTANE	58.120							
n-BUTANE	58.120							
I-PENTANE	72.146							
n-PENTANE	72.146							
HEXANE PLUS								
CORROSIVE AGENTS								
TOTAL								
AVG. MOL. WT.								

LOCATION:
○ INDOOR ○ OUTDOOR ○ GRADE
○ HEATED ○ UNDER ROOF ○ MEZZANINE
○ UNHEATED ○ PARTIAL SIDES ○ _____

SITE DATA
○ ELEVATION _____ (m) BAROMETER _____ (barA)
○ RANGE OF AMBIENT TEMPS:

		DRY BULB	WET BULB
NORMAL	(°C)		
MAXIMUM	(°C)		
MINIMUM	(°C)		
_____	(°C)		

UNUSUAL CONDITIONS: ○ DUST ○ FUMES
○ OTHER _____
○ COPPER AND COPPER ALLOYS PROHIBITED

COATING:
○ ROTATING COMPONENTS _____
○ STATIONARY COMPONENTS _____

REMARKS: _____

NOISE SPECIFICATIONS:
○ APPLICABLE TO MACHINE:
SEE SPECIFICATION _____
○ APPLICABLE TO NEIGHBORHOOD:
SEE SPECIFICATION _____
ACOUSTIC HOUSING: ○ YES ○ NO

APPLICABLE SPECIFICATIONS:
API 617-7th Parts 1& 3
○ VENDOR HAVING UNIT RESPONSIBILITY
_____
○ GOVERNING SPECIFICATION (IF DIFFERENT)
_____
○ ELEC. AREA CLASS. ○ NEC ○ IEC
EQUIPMENT
CLASS _____ GROUP _____ DIV. _____
ZONE _____ GROUP _____ TEMP CLASS _____
CONTROL PANNELS
CLASS _____ GROUP _____ DIV. _____
ZONE _____ GROUP _____ TEMP CLASS _____
INSTRUMENT AND CONTROLS
STANDARD ○ NEMA ○ IEC

	INDOOR	OUTDOOR
CONTROL ENCLOSURE		
TERMINAL BOX		

REVISION	0	1	2	3	4
DATE					

INTEGRALLY GEARED COMPRESSOR
DATASHEET (API 617-8th, Part 3)
SI UNITS (bar)

JOB NO. _____ ITEM NO _____
PAGE 3 OF 12 REQ'N NO. _____

CONSTRUCTION FEATURES (1 COLUMN PER STAGE, USE ADDITIONAL SHEETS IF NEEDED)

Rotor	Rotor 1					
Stage	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6
☐ **CASING:**						
MODEL						
CASING SPLIT						
MATERIAL						
THICKNESS (mm)						
CORROSION ALLOWANCE (mm)						
MAX. ALLOWABLE PRESS (barG)						
TEST PRESS (barG)						
MAX. ALLOWABLE TEMP. (°C)						
MAX. OPERATING TEMP (°C)						
MIN. OPERATING TEMPERATUF (°C)						
MAX CASING CAPACITY (m³/h)						
☐ **INLET CONNECTIONS**						
TYPE						
ORIENTATION						
FLANGED OR STUDDED?						
MATING FLG & GASKET BY VENDOR?						
GAS VELOCITY (m/s)						
☐ **DISCHARGE CONNECTIONS**						
TYPE						
ORIENTATION						
FLANGED OR STUDDED?						
MATING FLG & GASKET BY VENDOR?						
GAS VELOCITY (m/s)						
○ **INTERMEDIATE MAIN PROCESS CONNECTIONS**						
DISCH. PRESSURE (barG)						
INLET PRESSURE (barG)						
☐ **ADJUSTABLE INLET GUIDE VANES**						
MATERIAL _____						
NO. INLET GUIDE VANES						
☐ **IMPELLER:**						
DIAMETER						
Number of VANES						
TYPE (OPEN, ENCLOSED, ETC.)						
TYPE FABRICATION						
MATERIAL						
MIN. YIELD STRENGTH (MPa)						
HARDNESS: (Rc) (BRINNEL)						
SMALLEST TIP INTERNAL WIDTH (mm)						
MAX. MACH. NO. @ IMPELLER EYE						
MAX. IMPELLER HEAD @ 100% SPEED (m)						
MAX. IMPELLER TIP SPEED (m/s)						
☐ **DIFFUSER GUIDE VANES**						
ADJUSTABLE?						
MATERIAL						
NO. GUIDE VANES						

REMARKS: _____

REVISION	0	1	2	3	4
DATE					

INTEGRALLY GEARED COMPRESSOR DATASHEET (API 617-8th, Part 3)
SI UNITS (bar)

JOB NO. _____ ITEM NO _____
PAGE 4 OF 12 REQ'N NO. _____

CONSTRUCTION FEATURES, continued (1 COLUMN PER STAGE, USE ADDITIONAL SHEETS IF NEEDED)

☐ SHAFT SLEEVES:	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6
MATERIAL						
AT SHAFT SEALS?						
OTHER LOCATIONS?						
SHAFT SEALS:						
○ SEAL TYPE						
○ SETTLING OUT PRESSURE (barG)						
○ MINIMUM SEALING PRESSURE (barG)						
○ TYPE BUFFER GAS, PRIMARY						
☐ PRESSURE (barG)						
☐ FLOWRATE (kg/h)						
☐ FILTRATION						
○ TYPE BUFFER GAS, SECONDARY						
☐ PRESSURE (barG)						
☐ FLOWRATE (kg/h)						
☐ FILTRATION						
☐ FLOWRATE TO PROCESS						

○ BUFFER GAS SYSTEM REQUIRED
○ MANIFOLD
○ METHOD OF CONTROL _____
○ BUFFER GAS CONTROL SYSTEM SCHEMATIC BY VENDOR
○ PRESSURIZING GAS FOR SUBATMOSPHERIC SEALS ○ EDUCTOR ○ INJECTION
☐ SEAL MANUFACTURER _____ ○ SYSTEM RELIEF VALVE SET PT. _____

BEARING TEMPERATURE DETECTORS
○ SEE ATTACHED API-670 DATASHEET
○ THERMOCOUPLES TYPE _____
○ RESISTANCE TEMP DETECTORS
○ RESISTANCE MATERIAL _____ ○ _____ (ohm)
☐ ALARM TEMPERATURE (°C) _____
☐ SHUTDOWN TEMPERATURE (°C) _____
○ PROVISION FOR LOCAL DISCONNECT
○ LOCATION-JOURNAL BEARING
NO. ____ EA PAD _____ EVERY OTHER PAD ____ PER BEARING
OTHER _____
○ LOCATION-THRUST BEARING
NO. ____ EA PAD _____ EVERY OTHER PAD ____ PER BEARING
OTHER _____
NO. (INACT) ____ EA PAD ____ EVERY OTHER PAD ____ PER BEARING
OTHER _____
○ LOCAL DISCONNECTION
○ MONITOR SUPPLIED BY _____
○ LOCATION _____ ENCLOSURE _____
○ MFR. _____ ☐ MODEL _____
☐ SCALE RANGE _____ ALARM ☐ SET @ _____ (°C)
○ SHUTDOWN: ☐ SET @ ____ (°C) ○ TIME DELAY _____ (sec)

KEY PHASOR REQUIRED
○ COMPRESSOR ○ GEAR H.S. ○ GEAR L.S.

VIBRATION DETECTORS: ○ SEE ATTACHED API-670 DATASHEET
○ TYPE _____ ☐ MODEL _____
○ MFR _____
○ NO. AT EA SHAFT BEARING _____ TOTAL NO. _____
○ OSCILLATOR-DETECTORS SUPPLIED BY _____
○ MFR _____ ☐ MODEL _____
○ MONITOR SUPPLIED BY _____
○ LOCATION _____ ENCLOSURE _____
○ MFR. _____ ☐ MODEL _____
☐ SCALE RANGE ____ ALARM ☐ SET @ _____ (μm)
○ SHUTDOWN: ☐ SET @ _____ (μm) ○ TIME DELAY _____ (sec)
○ CASING VIBRATION TRANSDUCERS
○ CASING VIBRATION MONITORS

AXIAL POSITION DETECTOR:
○ SEE ATTACH. API-670 DATASHEET
○ TYPE _____ ☐ MODEL _____
○ MFR _____ ○ NO. REQUIRED _____
○ OSCILLATOR-DEMODULATOR SUPPLIED BY _____
○ MFR _____ ☐ MODEL _____
○ MONITOR SUPPLIED BY _____
○ LOCATION _____ ENCLOSURE _____
○ MFR. _____ ☐ MODEL _____
☐ SCALE RANGE _____ ALARM ☐ SET @ _____ (μm)
○ SHUTDOWN: ☐ SET @ _____ (μm) ○ TIME DELAY _____ (sec)

REMARKS: _____

REVISION	0	1	2	3	4
DATE					

INTEGRALLY GEARED COMPRESSOR
DATASHEET (API 617-8th, Part 3)
SI UNITS (bar)

JOB NO. _____ ITEM NO _____
PAGE 5 OF 12 REQ'N NO. _____

CONSTRUCTION FEATURES, ROTORS (1COLUMN PER ROTOR, USE ADDITIONAL SHEETS IF NEEDED)

☐ **DRIVER SPEEDS:** PITCH LINE VELOCITY (m/s) _____
MAX. CONT. _____ NORMAL DIAMETRAL PITCH _____
TRIP SPEED _____ HELIX ANGLE _____ PRESSURE ANGLE _____

☐ ROTOR NUMBER	BULL GEAR	ROTOR 1	ROTOR 2	ROTOR 3	ROTOR 4
SPEED (rpm)					
SERVICE POWER (kW)					
SERVICE FACTOR					
NUMBER OF TEETH					
FACE WIDTH (mm)					
AGMA GEOMETRY FACTOR "J"					
AGMA GEOMETRY FACTOR "I"					
MINIMUM HARDNESS (Rc)					
ROTOR WEIGHT (INC WHEELS) (kg)					
BACKLASH (mm)					

GEARBOX FULL LOAD POWER LOSS _____

☐ LATERAL CRITICAL SPEEDS (DAMPED)					
FIRST CRITICAL					
SECOND CRITICAL					
THIRD CRITICAL					
FOURTH CRITICAL					

○ LATERAL ANALYSIS ADDITIONAL REQUIREMENTS
○ TRAIN LATERAL ANALYSIS REQUIRED
○ TRAIN TORSIONAL ANALYSIS REQUIRED

☐ TORSIONAL CRITICAL SPEEDS:	
FIRST CRITICAL	
SECOND CRITICAL	
THIRD CRITICAL	
FOURTH CRITICAL	

○ LIST OF TRAIN UNDESIRABLE SPEEDS
○ STABILITY ANALYSIS

☐ VIBRATION:					
ALLOWABLE TEST LEVEL (PK-PK)					

☐ BALANCE PISTON:				
MATERIAL				
FIXATION METHOD				
NORMAL CLEARANCE (mm)				
AREA (mm²)				
FLOW, NORMAL CLEARANCE (kg/h)				
FLOW, 2x NORMAL CLEAR (kg/h)				
○ PRESS. CONN. BAL LINE				

REMARKS: _____

	REVISION	0	1	2	3	4
	DATE					

INTEGRALLY GEARED COMPRESSOR
DATASHEET (API 617-8th, Part 3)
SI UNITS (bar)

JOB NO. _____ ITEM NO _____
PAGE 6 OF 12 REQ'N NO. _____

	CONSTRUCTION FEATURES, ROTOR BEARINGS (1 COLUMN PER ROTOR, USE ADDITIONAL SHEETS IF NEEDED)					
	RADIAL BEARINGS, DRIVE END	BULL GEAR	ROTOR 1	ROTOR 2	ROTOR 3	ROTOR 4
	☐ TYPE					
	☐ MANUFACTURER					
	☐ LENGTH (mm)					
	☐ SHAFT DIAMETER (mm)					
	☐ UNIT LOAD (ACT/ALLOW)					
	☐ BASE MATERIAL					
	☐ BABBIT THICKNESS (mm)					
	☐ NUMBER OF PADS					
	☐ LOAD: BETWEEN/ON PAD					
	☐ PIVOT: CENTER/OFFSET, %					
	☐ RADIAL BEARING SPAN					
	RADIAL BRG, OPPOSITE DRIVE END					
	☐ TYPE					
	☐ MANUFACTURER					
	☐ LENGTH (mm)					
	☐ SHAFT DIAMETER (mm)					
	☐ UNIT LOAD (ACT/ALLOW)					
	☐ BASE MATERIAL					
	☐ BABBIT THICKNESS (mm)					
	☐ NUMBER OF PADS					
	☐ LOAD: BETWEEN/ON PAD					
	☐ PIVOT: CENTER/OFFSET, %					
	THRUST BEARINGS, ACTIVE					
	☐ TYPE					
	☐ MANUFACTURER					
	☐ UNIT LOADING (max) (MPa)					
	☐ UNIT LOAD (ULT.) (MPa)					
	☐ AREA (mm^2)					
	☐ NUMBER OF PADS					
	☐ PIVOT: CENTER / OFFSET, %					
	☐ PAD BASE MATERIAL					
	☐ COPPER BACKED?					
	☐ COLLAR MATERIAL					
	☐ INTEGRAL OR REPLACEABLE COLLAR?					
	☐ SIZING CRITERIA					
	☐ FLOODED OR DIRECTED LUBRICATION?					
	THRUST BEARINGS, INACTIVE					
	☐ TYPE					
	☐ MANUFACTURER					
	☐ UNIT LOADING (max) (MPa)					
	☐ UNIT LOAD (ULT.) (MPa)					
	☐ AREA (mm^2)					
	☐ NUMBER OF PADS					
	☐ PIVOT: CENTER / OFFSET, %					
	☐ PAD BASE MATERIAL					
	☐ COPPER BACKED?					
	☐ COLLAR MATERIAL					
	☐ INTEGRAL OR REPLACEABLE COLLAR?					
	☐ SIZING CRITERIA					
	☐ FLOODED OR DIRECTED LUBRICATION?					

REMARKS: _____

REVISION	0	1	2	3	4
DATE					

INTEGRALLY GEARED COMPRESSOR DATASHEET (API 617-8th, Part 3)

SI UNITS (bar)

JOB NO. _____ ITEM NO _____

PAGE 7 OF 12 REQ'N NO. _____

☐ **OTHER CONNECTIONS**

SERVICE:	NO.	SIZE	TYPE		NO.	SIZE	TYPE
☐ LUBE-OIL INLET				☐ PRESSURE			
☐ LUBE OIL OUTLET				☐ TEMPERATURE			
☐ SEAL-OIL INLET				☐ SOLVENT INJECTION			
☐ SEAL-OIL OUTLET				☐ PURGE FOR:			
☐ SEAL GAS INLET				☐ BRG. HOUSING			
☐ SEAL GAS OUTLET				☐ BTWN BRG & SEAL			
☐ CASING DRAINS				☐ BTWN SEAL & GAS			
☐ STAGE DRAINS				_____			

○ INDIVIDUAL STAGE DRAINS REQUIRED
○ VALVED & BLINDED
○ VALVED & BLINDED & MANIFOLD

LUBRICATION AND SEALING SYSTEMS

○ SEE ATTACHED API 614 DATASHEET
○ SEPARATE ○ COMBINED
○ INTEGRAL OIL RESERVOIR
○ OIL TYPE

ACCESSORIES

COUPLING AND GUARDS

NOTE: SEE ROTATING ELEMENTS - SHAFT ENDS

○ SEE ATTACHED API-671 DATASHEET ○ KEYLESS HYDRAULIC ○ KEYED ○ FLANGED ○ OTHER _____

COUPLING FURNISHED BY _____ MOUNTED BY _____

MANUFACTURER _____ TYPE _____ MODEL _____

COUPLING GUARD FURNISHED BY: _____

TYPE: ○ FULLY ENCLOSED ○ SEMI-OPEN ○ OTHER _____

COUPLING DETAILS

☐ MAX O.D. _____ (mm)
☐ HUB WEIGHT _____ (kg)
☐ SPACER LENGTH _____ (mm)
☐ SPACER WEIGHT _____ (kg)

○ PLUG AND RING GAUGES ○ LAPPING TOOL

LUBRICATION REQUIREMENTS:

○ NON-LUBE ○ CONT. OIL LUBE ○ OTHER _____

☐ QUANTITY PER HUB _____ (L/min)

MOUNTING PLATES

○ BASEPLATES FURNISHED BY _____
○ COMPRESSOR ONLY ○ DRIVER ○ GEAR
○ OTHER _____
○ NONSKID DECKING ○ SLOPED DECK
△ LEVELING PADS OR TARGETS
△ COLUMN MOUNTING
○ SUB-SOLE PLATES REQUIRED
☐ STAINLESS STEEL SHIM THICKNESS _____ (mm)
○ MACHINED MOUNTING PADS REQUIRED

○ SOLEPLATES FURNISHED BY _____
☐ THICKNESS _____ (mm)
○ SUBSOLE PLATES REQUIRED

☐ STAINLESS STEEL SHIM THICKNESS _____ (mm)
○ COMPRESSOR _____

○ COUNTER BORE ANCHOR BOLT HOLES

ANTI-SURGE SYSTEM FURNISHED BY ○ PURCHASER ☐ SUPPLIER

○ ☐ ANTI-SURGE VALVE ○ SIZING ONLY
PRESSURE UPSTREAM: _____ (barG) DOWNSTREAM Δ P _____ (barG)
☐ Δ P VALVE _____ STROKE TIME OPEN - CLOSE _____ (sec)

○ ☐ RECIRCULATION VALVE ○ SIZING ONLY
○ ☐ BLOWOFF VALVE ○ SIZING ONLY
○ ☐ CONTROL SYSTEM
○ ☐ PIPING
○ ☐ FLOW ELEMENT
○ ☐ _____ ○ ☐ _____
○ ☐ _____ ○ ☐ _____
○ ☐ _____ ○ ☐ _____
○ ☐ _____ ○ ☐ _____
○ ☐ _____ ○ ☐ _____

REMARKS: _____

REVISION	0	1	2	3	4
DATE					

INTEGRALLY GEARED COMPRESSOR DATASHEET (API 617-8th, Part 3)
SI UNITS (bar)

JOB NO. _____ ITEM NO _____
PAGE 8 OF 12 REQ'N NO. _____

UTILITIES

○ **UTILITY CONDITIONS:**

STEAM: (DRIVERS)

INLET MIN	(barG)	(℃)
NORM	(barG)	(℃)
MAX	(barG)	(℃)
EXHAUST. MIN	(barG)	(℃)
NORM	(barG)	(℃)
MAX	(barG)	(℃)

ELECTRICITY:

	DRIVERS	CONTROL	SHUTDOWN
VOLTAGE			
HERTZ			
PHASE			

○ REDUCED VOLTAGE START
NUMBER OF STARTS _____
○ **INSTRUMENT AIR:**
MAX PRESS _____ (psig) MIN PRESS _____ (barG)
☐ **ROTATION, VIEWED OPP. DRIVE END** ○ **CW** ○ **CCW**

MANUALS
○ DRAFT MANUAL FOR REVIEW
○ TECHNICAL DATA MANUAL

MISCELLANEOUS:
☐ RECOMMENDED STRAIGHT RUN OF PIPE DIAMETERS BEFORE SUCTION _____
○ COMPRESSOR TO BE SUITABLE FOR FIELD RUN-IN ON AIR
○ PROVISION FOR LIQUID INJECTION _____
○ INJECTION MANIFOLD
○ VENDOR'S REVIEW & COMMENTS ON PURCHASER'S
○ CONTROL SYSTEMS
○ SHOP FITUP OF VENDOR PROCESS PIPING
○ WELDING HARDNESS TESTING _____
○ DESIGN AUDIT
○ BALANCE PISTON ΔP
○ PROVIDE TAIL END SCHEDULES
○ BOROSCOPIC INSPECTION PORTS

SHOP INSPECTION AND TESTS:

	REQ'D	WIT/OBV
○ (SEE INSPECTOR'S CHECKLIST)		
HYDROSTATIC	●	
IMPELLER OVERSPEED	●	
MECHANICAL RUN	●	
○ CONTRACT COUPLING ○ IDLING ADAPTOR(S)		
○ CONTRACT PROBES ○ SHOP PROBES		
○ PURCHASER VIB. EQUIPMENT		
VARY LUBE & SEAL OIL PRESSURES	○	
AND TEMPERATURES	○	
POLAR FORM VIB DATA	○	
TAPE RECORD VIB DATA	○	
SHAFT END SEAL INSP	○	
GAS LEAK TEST AT DISCH PRESS	○	
○ POST TEST INTERNAL INSP		
○ BEFORE GAS LEAKAGE TEST		
○ AFTER GAS LEAKAGE TEST	○	
PERFORMANCE TEST (GAS) (AIR)	○	
COMPLETE UNIT TEST	○	
TANDEM TEST	○	
GEAR TEST	○	
HELIUM LEAK TEST	○	
SOUND LEVEL TEST	○	
AUX. EQUIPMENT TEST _____	○	
FULL LOAD / SPEED / PRESS TEST	○	
HYDRAULIC COUPLING INSP	○	
SPARE PARTS TEST _____	○	
INSPECTOR'S CHECKLIST COMPLIANCE	○	
GAS SEAL TEST VENDOR SHOP	○	

VENDOR'S REPRESENTATIVE SHALL
○ OBSERVE FLANGE PARTING
○ CHECK ALIGNEMENT AT TEMPERATURE
○ BE PRESENT AT INITIAL ALIGNMENT

☐ **WEIGHTS:** (kg)
COMPR. _____ GEAR _____ DRIVER _____ BASE _____
ROTORS: COMPR. _____ DRIVER _____ GEAR _____
COMPRESSOR UPPER CASE _____
MAX. FOR MAINTENANCE (IDENTIFY) _____
TOTAL SHIPPING WEIGHT _____

☐ **SPACE REQUIREMENTS:** (mm)
COMPLETE UNIT: L _____ W _____ H _____

SPECIAL TOOL PACKAGING
○ METAL STORAGE CONTAINER
○ OTHER: _____

PAINTING:
○ MANUFACTURER'S STD.
○ OTHER _____

NAMEPLATE ○ U.S. CU.S.TOMARY ○ METRIC

SHIPMENT:
○ DOMESTIC ○ EXPORT ○ EXPORT BOXING REQ'D.
○ OUTDOOR STORAGE MORE THAN 6 MONTHS _____ MO
SPARE ROTOR ASSEMBLY PACKAGE
○ HORIZONTAL STORAGE ○ VERTICAL STORAGE
○ METAL STORAGE CONTAINER
○ N2 PURGE ○ OTHER: _____

MATERIALS INSPECTION REQUIREMENTS

○ RADIOGRAPHY REQUIRED FOR _____
○ ULTRASONIC REQUIRED FOR _____
○ MAGNETIC PARTICLE REQUIRED FOR _____
○ LIQUID PENETRANT REQUIRED FOR _____

○ LOW TEMPERATURE _____
MIN.DESIGN METAL TEMPERATURE _____ (℃)
AT CONCURRANT PRESSURE _____ (barG)
○ OTHER TRAIN COMPONENTS
○ Q.C. OF INACCESSIBLE WELDS

REMARKS: _____

REVISION	0	1	2	3	4
DATE					

INTEGRALLY GEARED COMPRESSOR
DATASHEET (API 617-8th, Part 3)
SI UNITS (bar)

JOB NO. _____ ITEM NO _____
PAGE 9 OF 12 REQ'N NO. _____

INTER COOLER(S) - BETWEEN 1st and 2nd STAGE

SERVICE OF UNIT: _____ ITEM NO _____
SIZE: _____ TYPE: _____ ☐ HORIZ ☐ VERT CONNECTED IN ☐ PARALLEL ☐ SERIES
SURF/UNIT: (GROSS/EFF) _____ (m²) SHELLS/UNIT: _____ SURF/SHELL: (GROSS/EFF) _____

PERFORMANCE OF ONE UNIT

	SHELL SIDE		TUBE SIDE	
○ FLUID NAME				
☐ FLUID QUANTITY, TOTAL (kg/h)				
VAPOR--IN/OUT				
LIQUID--IN/OUT				
☐ TEMPERATURE--IN/OUT (°C)				
☐ SPECIFIC GRAVITY				
☐ VISCOSITY, LIQUID (mPa-s)				
☐ SPECIFIC HEAT, (kJ/kg °C)				
☐ THERMAL CONDUCTIVITY, (kJ/m h °C)				
☐ LATENT HEAT, (kJ/kg °C)				
☐ INLET PRESSURE, (barG)				
◎ VELOCITY, (m/s)				
◎ PRESSURE DROP--ALLOW/CALC, (bar)				
◎ FOULING RESISTANCE--MINIMUM (hr m² °C/kJ)				

☐ HEAT EXCHANGED _____ (kJ/hr) MTD CORRECTED _____ (°C)
☐ TRANSFER RATE, (kJ/hr m² °C) SERVICE _____ CLEAN _____

☐ **CONSTRUCTION OF ONE SHELL**

SKETCH: BUNDLE NOZZLE ORIENTATIONS

	SHELL SIDE	TUBE SIDE
DESIGN/TEST PRESSURE, (barG)		
DESIGN TEMPERATURE, (°C)		
NO. PASSES PER SHELL		
CORROSION ALLOWANCE, (mm)		
NOZZLES: INLET		
SIZE & OUTLET		
RATING VENT-DRAIN		

TUBE NO. _____ O.D. _____ (mm) THK (MIN) (AVG) _____ (mm) LENGTH _____ (m) PITCH _____ (mm) ◁ 30 △ 60 □ 90 ◇ 45
TUBE TYPE _____ MATERIAL _____
SHELL MATL _____ I.D. _____ (mm) O.D. _____ (mm) SHELL COVER MATL _____ (INTEG)(REMOV)
CHANNEL OR BONNET MATL _____ CHANNEL COVER MATL _____
TUBESHEET--STATIONARY MATL _____ TUBESHEET--FLOATING MATL _____
FLOATING HEAD COVER MATL _____ IMPINGEMENT PROTECTION _____
BAFFLES--CROSS MATL _____ TYPE _____ %CUT (DIA) (AREA) _____ SPACING: C/C _____ INLET _____ (mm)
BAFFLES--LONG MATL _____ SEAL TYPE _____
SUPPORTS--TUBE _____ U-BEND _____ TYPE _____
BYPASS SEAL ARRANGEMENT _____ TUBE--TUBESHEET JOINT _____
GASKETS--SHELL SIDE _____ -- TUBE SIDE _____
--FLOATING HEAD _____
ASME SECTION VIII CODE REQUIREMENTS: ☐ DESIGN & TEST ☐ STAMP ☐ NOT APPLICABLE ○ TEMA CLASS _____
WEIGHT/SHELL _____ (kg) FILLED WITH WATER _____ (kg) BUNDLE _____ (kg)

REMARKS: _____

REVISION	0	1	2	3	4
DATE					

INTEGRALLY GEARED COMPRESSOR
DATASHEET (API 617-8th, Part 3)
SI UNITS (bar)

JOB NO. _____ ITEM NO _____
PAGE 10 OF 12 REQ'N NO. _____

INTER COOLER(S) - BETWEEN 2nd and 3rd STAGE

SERVICE OF UNIT: _____ ITEM NO _____
SIZE: _____ TYPE: _____ ☐ HORIZ ☐ VERT CONNECTED IN ☐ PARALLEL ☐ SERIES
SURF/UNIT: (GROSS/EFF) _____ (m²) SHELLS/UNIT: _____ SURF/SHELL: (GROSS/EFF) _____

PERFORMANCE OF ONE UNIT

	SHELL SIDE		TUBE SIDE	
○ FLUID NAME				
☐ FLUID QUANTITY, TOTAL (kg/h)				
VAPOR--IN/OUT				
LIQUID--IN/OUT				
☐ TEMPERATURE--IN/OUT (°C)				
☐ SPECIFIC GRAVITY				
☐ VISCOSITY, LIQUID (mPa-s)				
☐ SPECIFIC HEAT, (kJ/kg °C)				
☐ THERMAL CONDUCTIVITY, (kJ/m h °C)				
☐ LATENT HEAT, (kJ/kg °C)				
☐ INLET PRESSURE, (barG)				
◎ VELOCITY, (m/s)				
◎ PRESSURE DROP--ALLOW/CALC, (bar)				
◎ FOULING RESISTANCE--MINIMUM (hr m² °C/kJ)				

☐ HEAT EXCHANGED _____ (kJ/hr) MTD CORRECTED _____ (°C)
☐ TRANSFER RATE, (kJ/hr m² °C) SERVICE _____ CLEAN _____

☐ **CONSTRUCTION OF ONE SHELL**

	SHELL SIDE	TUBE SIDE
DESIGN/TEST PRESSURE, (barG)		
DESIGN TEMPERATURE, (°C)		
NO. PASSES PER SHELL		
CORROSION ALLOWANCE, (mm)		
NOZZLES: INLET		
SIZE & OUTLET		
RATING VENT-DRAIN		

SKETCH: BUNDLE NOZZLE ORIENTATIONS

TUBE NO. _____ O.D. _____ (mm) THK (MIN) (AVG) _____ (mm) LENGTH _____ (m) PITCH _____ (mm) ◁ 30 △ 60 □ 90 ◇ 45
TUBE TYPE _____ MATERIAL _____
SHELL MATL _____ I.D. _____ (mm) O.D. _____ (mm) SHELL COVER MATL _____ (INTEG)(REMOV)
CHANNEL OR BONNET MATL _____ CHANNEL COVER MATL _____
TUBESHEET--STATIONARY MATL _____ TUBESHEET--FLOATING MATL _____
FLOATING HEAD COVER MATL _____ IMPINGEMENT PROTECTION _____
BAFFLES--CROSS MATL _____ TYPE _____ %CUT (DIA) (AREA) _____ SPACING: C/C _____ INLET _____ (mm)
BAFFLES--LONG MATL _____ SEAL TYPE _____
SUPPORTS--TUBE _____ U-BEND _____ TYPE _____
BYPASS SEAL ARRANGEMENT _____ TUBE--TUBESHEET JOINT _____
GASKETS--SHELL SIDE _____ -- TUBE SIDE _____
--FLOATING HEAD _____
ASME SECTION VIII CODE REQUIREMENTS: ☐ DESIGN & TEST ☐ STAMP ☐ NOT APPLICABLE ○ TEMA CLASS _____
WEIGHT/SHELL _____ (kg) FILLED WITH WATER _____ (kg) BUNDLE _____ (kg)

REMARKS: _____

REVISION	0	1	2	3	4
DATE					

INTEGRALLY GEARED COMPRESSOR
DATASHEET (API 617-8th, Part 3)
SI UNITS (bar)

JOB NO. _____ ITEM NO _____
PAGE 11 OF 12 REQ'N NO. _____

INTER COOLER(S) - BETWEEN 3rd and 4th STAGE

SERVICE OF UNIT: _____ ITEM NO _____
SIZE: _____ TYPE: _____ ☐ HORIZ ☐ VERT CONNECTED IN ☐ PARALLEL ☐ SERIES
SURF/UNIT: (GROSS/EFF) _____ (m²) SHELLS/UNIT: _____ SURF/SHELL: (GROSS/EFF) _____

PERFORMANCE OF ONE UNIT

	SHELL SIDE		TUBE SIDE	
○ FLUID NAME				
☐ FLUID QUANTITY, TOTAL (kg/h)				
VAPOR--IN/OUT				
LIQUID--IN/OUT				
☐ TEMPERATURE--IN/OUT (°C)				
☐ SPECIFIC GRAVITY				
☐ VISCOSITY, LIQUID (mPa-s)				
☐ SPECIFIC HEAT, (kJ/kg °C)				
☐ THERMAL CONDUCTIVITY, (kJ/m h °C)				
☐ LATENT HEAT, (kJ/kg °C)				
☐ INLET PRESSURE, (barG)				
◎ VELOCITY, (m/s)				
◎ PRESSURE DROP--ALLOW/CALC, (bar)				
◎ FOULING RESISTANCE--MINIMUM (hr m² °C/kJ)				

☐ HEAT EXCHANGED _____ (kJ/hr) MTD CORRECTED _____ (°C)
☐ TRANSFER RATE, (kJ/hr m² °C) SERVICE _____ CLEAN _____

☐ **CONSTRUCTION OF ONE SHELL**

	SHELL SIDE	TUBE SIDE
DESIGN/TEST PRESSURE, (barG)		
DESIGN TEMPERATURE, (°C)		
NO. PASSES PER SHELL		
CORROSION ALLOWANCE, (mm)		
NOZZLES: INLET		
SIZE & OUTLET		
RATING VENT-DRAIN		

SKETCH: BUNDLE NOZZLE ORIENTATIONS

TUBE NO. _____ O.D. _____ (mm) THK (MIN) (AVG) _____ (mm) LENGTH _____ (m) PITCH _____ (mm) ◁ 30 △ 60 □ 90 ◇ 45
TUBE TYPE _____ MATERIAL _____
SHELL MATL _____ I.D. _____ (mm) O.D. _____ (mm) SHELL COVER MATL _____ (INTEG)(REMOV)
CHANNEL OR BONNET MATL _____ CHANNEL COVER MATL _____
TUBESHEET--STATIONARY MATL _____ TUBESHEET--FLOATING MATL _____
FLOATING HEAD COVER MATL _____ IMPINGEMENT PROTECTION _____
BAFFLES--CROSS MATL _____ TYPE _____ %CUT (DIA) (AREA) _____ SPACING: C/C _____ INLET _____ (mm)
BAFFLES--LONG MATL _____ SEAL TYPE _____
SUPPORTS--TUBE _____ U-BEND _____ TYPE _____
BYPASS SEAL ARRANGEMENT _____ TUBE--TUBESHEET JOINT _____
GASKETS--SHELL SIDE _____ -- TUBE SIDE _____
--FLOATING HEAD _____
ASME SECTION VIII CODE REQUIREMENTS: ☐ DESIGN & TEST ☐ STAMP ☐ NOT APPLICABLE ○ TEMA CLASS _____
WEIGHT/SHELL _____ (kg) FILLED WITH WATER _____ (kg) BUNDLE _____ (kg)

REMARKS: _____

REVISION	0	1	2	3	4
DATE					

INTEGRALLY GEARED COMPRESSOR
DATASHEET (API 617-8th, Part 3)
SI UNITS (bar)

JOB NO. _____ ITEM NO _____
PAGE 12 OF 12 REQ'N NO. _____

INTER COOLER(S) - BETWEEN 4th and 5th STAGE

SERVICE OF UNIT: _____ ITEM NO _____
SIZE: _____ TYPE: _____ ☐ HORIZ ☐ VERT CONNECTED IN ☐ PARALLEL ☐ SERIES
SURF/UNIT: (GROSS/EFF) _____ (m²) SHELLS/UNIT: _____ SURF/SHELL: (GROSS/EFF) _____

PERFORMANCE OF ONE UNIT

	SHELL SIDE		TUBE SIDE	
○ FLUID NAME				
☐ FLUID QUANTITY, TOTAL (kg/h)				
VAPOR--IN/OUT				
LIQUID--IN/OUT				
☐ TEMPERATURE--IN/OUT (°C)				
☐ SPECIFIC GRAVITY				
☐ VISCOSITY, LIQUID (mPa-s)				
☐ SPECIFIC HEAT, (kJ/kg °C)				
☐ THERMAL CONDUCTIVITY, (kJ/m h °C)				
☐ LATENT HEAT, (kJ/kg °C)				
☐ INLET PRESSURE, (barG)				
◎ VELOCITY, (m/s)				
◎ PRESSURE DROP--ALLOW/CALC, (bar)				
◎ FOULING RESISTANCE--MINIMUM (hr m² °C/kJ)				

☐ HEAT EXCHANGED _____ (kJ/hr) MTD CORRECTED _____ (°C)
☐ TRANSFER RATE, (kJ/hr m² °C) SERVICE _____ CLEAN _____

☐ **CONSTRUCTION OF ONE SHELL**

SKETCH: BUNDLE NOZZLE ORIENTATIONS

	SHELL SIDE	TUBE SIDE
DESIGN/TEST PRESSURE, (barG)		
DESIGN TEMPERATURE, (°C)		
NO. PASSES PER SHELL		
CORROSION ALLOWANCE, (mm)		
NOZZLES: INLET		
SIZE & OUTLET		
RATING VENT-DRAIN		

TUBE NO. _____ O.D. _____ (mm THK (MIN) (AVG) _____ (mm) LENGTH _____ (m) PITCH _____ (mm) ◁ 30 △ 60 □ 90 ◇ 45
TUBE TYPE _____ MATERIAL _____
SHELL MATL _____ I.D. _____ (mm) O.D. _____ (mm) SHELL COVER MATL _____ (INTEG)(REMOV)
CHANNEL OR BONNET MATL _____ CHANNEL COVER MATL _____
TUBESHEET--STATIONARY MATL _____ TUBESHEET--FLOATING MATL _____
FLOATING HEAD COVER MATL _____ IMPINGEMENT PROTECTION _____
BAFFLES--CROSS MATL _____ TYPE _____ %CUT (DIA) (AREA) _____ SPACING: C/C _____ INLET _____ (mm)
BAFFLES--LONG MATL _____ SEAL TYPE _____
SUPPORTS--TUBE _____ U-BEND _____ TYPE _____
BYPASS SEAL ARRANGEMENT _____ TUBE--TUBESHEET JOINT _____
GASKETS--SHELL SIDE _____ -- TUBE SIDE _____
--FLOATING HEAD _____
ASME SECTION VIII CODE REQUIREMENTS: ☐ DESIGN & TEST ☐ STAMP ☐ NOT APPLICABLE ○ TEMA CLASS _____
WEIGHT/SHELL _____ (kg) FILLED WITH WATER _____ (kg) BUNDLE _____ (kg)

REMARKS: _____

REVISION	0	1	2	3	4
DATE					
BY					
REV/APPR					

INTEGRALLY GEARED COMPRESSOR DATASHEET (API 617-8th, Part 3)

U.S. CUSTOMARY UNITS

JOB NO. _____ ITEM NO. _____

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APPLICABLE TO: ○ PROPOSAL ○ PURCHASE ○ AS BUILT

FOR _____ UNIT _____

SITE _____ SERIAL NO. _____

SERVICE _____ NO. REQUIRED _____

MANUFACTURER _____ DRIVER TYPE _____

MODEL _____ DRIVER ITEM NO. _____

APPLICABLE STANDARD: ○ US ○ ISO

NOTE: INFORMATION TO BE COMPLETED BY: ○ PURCHASER □ MANUFACTURER △ PURCHASER OR MANUFACTURER

OPERATING CONDITIONS

(ALL DATA ON PER UNIT BASIS)

	NORMAL	OTHER CONDITIONS				
		RATED	B	C	D	E
	(NOTE 1)					
○ GAS HANDLED (ALSO SEE PAGE ___)						
△ GAS PROPERTIES						
□ SCFM (14.7 psia & 60°F DRY)						
○ WEIGHT FLOW (lb/min) ○ WET ○ DRY						
INLET CONDITIONS						
○ PRESSURE (psia)						
○ TEMPERATURE (°F)						
○ RELATIVE HUMIDITY %						
○ MOLECULAR WEIGHT						
□ Cp/Cv (K_1) OR (K_{AVG})						
□ COMPRESSIBILITY (Z_1) OR (Z_{AVG})						
□ INLET VOLUME (cfm) ○ WET ○ DRY						
DISCHARGE CONDITIONS						
○ PRESSURE (psia)						
□ TEMPERATURE (°F) **(ESTIMATED)**						
□ Cp/Cv (K_2) OR (K_{AVG})						
□ COMPRESSIBILITY (Z_2) OR (Z_{AVG})						
□ GHP REQUIRED (HP)						
□ TRAIN (BHP) REQUIRED						
□ (BHP) REQUIRED AT DRIVER INCL. EXT. LOSSES (GEAR, ETC.)						
□ SPEED of driver (rpm)						
□ TURNDOWN (%)						
□ POLYTROPIC HEAD (ft-lb/lb)						
□ POLYTROPIC EFFICIENCY (%)						
○ CERTIFIED POINT						
□ PERFORMANCE CURVE NUMBER						

PROCESS CONTROL

○ METHOD ○ SUCTION THROTTLING FROM ___ (psia) TO ___ (psia) ○ VARIABLE INLET GUIDE VANES ○ SPEED VARIATION FROM ___ % TO ___ % ○ DISCHARGE BLOWOFF OR RECIRCULATION ○ VARIABLE DIFFUSER GUIDE VANES

SIGNAL ○ SOURCE _____

TYPE ○ ELECTRONIC ○ PNEUMATIC ○ OTHER _____

RANGE _____ MA _____ (psig)

REMARKS: NOTE 1 IF GAS ANALYSIS IS GIVEN, MANUFACTURER SHALL SUPPLY GAS PROPERTIES, OTHERWISE DATA SHALL BE SUPPLIED BY USER

REVISION	0	1	2	3	4
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INTEGRALLY GEARED COMPRESSOR
DATASHEET (API 617-8th, Part 3)
U.S. CUSTOMARY UNITS

JOB NO. _____ ITEM NO _____
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OPERATING CONDITIONS (Continued)

GAS ANALYSIS: ○ MOL %	MW	NORMAL	OTHER CONDITIONS RATED	B	C	D	E	REMARKS:
AIR	28.966							
OXYGEN	32.000							
NITROGEN	28.016							
WATER VAPOR	18.016							
CARBON MONOXIDE	28.010							
CARBON DIOXIDE	44.010							
HYDROGEN SULFIDE	34.076							
HYDROGEN	2.016							
METHANE	16.042							
ETHYLENE	28.052							
ETHANE	30.068							
PROPYLENE	42.078							
PROPANE	44.094							
I-BUTANE	58.120							
n-BUTANE	58.120							
I-PENTANE	72.146							
n-PENTANE	72.146							
HEXANE PLUS								
CORROSIVE AGENTS								
TOTAL								
AVG. MOL. WT.								

LOCATION:
○ INDOOR ○ OUTDOOR ○ GRADE
○ HEATED ○ UNDER ROOF ○ MEZZANINE
○ UNHEATED ○ PARTIAL SIDES ○ _____

SITE DATA
○ ELEVATION _____ (ft) BAROMETER _____ (psia)
○ RANGE OF AMBIENT TEMPS:

		DRY BULB	WET BULB
NORMAL	(°F)		
MAXIMUM	(°F)		
MINIMUM	(°F)		
	(°F)		

UNUSUAL CONDITIONS: ○ DUST ○ FUMES
○ OTHER _____
○ COPPER AND COPPER ALLOYS PROHIBITED

COATING:
○ ROTATING COMPONENTS _____
○ STATIONARY COMPONENTS _____

REMARKS: _____

NOISE SPECIFICATIONS:
○ APPLICABLE TO MACHINE:
SEE SPECIFICATION _____
○ APPLICABLE TO NEIGHBORHOOD:
SEE SPECIFICATION _____
ACOUSTIC HOUSING: ○ YES ○ NO

APPLICABLE SPECIFICATIONS:
API 617-7th, Parts 1&3
○ VENDOR HAVING UNIT RESPONSIBILITY
_____
○ GOVERNING SPECIFICATION (IF DIFFERENT)
_____
○ ELEC. AREA CLASS. ○ NEC ○ IEC
EQUIPMENT
CLASS _____ GROUP _____ DIV. _____
ZONE _____ GROUP _____ TEMP CLASS _____
CONTROL PANNELS
CLASS _____ GROUP _____ DIV. _____
ZONE _____ GROUP _____ TEMP CLASS _____
INSTRUMENT AND CONTROLS
STANDARD ○ NEMA ○ IEC

	INDOOR	OUTDOOR
CONTROL ENCLOSURE		
TERMINAL BOX		

REVISION	0	1	2	3	4
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INTEGRALLY GEARED COMPRESSOR
DATASHEET (API 617-8th, Part 3)
U.S. CUSTOMARY UNITS

JOB NO. _____ ITEM NO _____
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CONSTRUCTION FEATURES (1 COLUMN PER STAGE, USE ADDITIONAL SHEETS IF NEEDED)

	Rotor 1					
Stage	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6
☐ **CASING:**						
MODEL						
CASING SPLIT						
MATERIAL						
THICKNESS (in.)						
CORROSION ALLOWANCE (in.)						
MAX. ALLOWABLE PRESS (psig)						
TEST PRESS (psig)						
MAX. ALLOWABLE TEMP. (°F)						
MAX. OPERATING TEMP (°F)						
MIN. OPERATING TEMPERATUF (°F)						
MAX CASING CAPACITY (icfm)						
☐ **INLET CONNECTIONS**						
TYPE						
ORIENTATION						
FLANGED OR STUDDED?						
MATING FLG & GASKET BY VENDOR?						
GAS VELOCITY (fps)						
☐ **DISCHARGE CONNECTIONS**						
TYPE						
ORIENTATION						
FLANGED OR STUDDED?						
MATING FLG & GASKET BY VENDOR?						
GAS VELOCITY (fps)						
○ **INTERMEDIATE MAIN PROCESS CONNECTIONS**						
DISCH. PRESSURE (psig)						
INLET PRESSURE (psig)						
☐ **ADJUSTABLE INLET GUIDE VANES**						
MATERIAL _____						
NO. INLET GUIDE VANES						
☐ **IMPELLER:**						
DIAMETER						
Number of VANES						
TYPE (OPEN, ENCLOSED, ETC.)						
TYPE FABRICATION						
MATERIAL						
MIN. YIELD STRENGTH (psi)						
HARDNESS: (Rc) (BRINNEL)						
SMALLEST TIP INTERNAL WIDTH (in.)						
MAX. MACH. NO. @ IMPELLER EYE						
MAX. IMPELLER HEAD @ 100% SPEED (ft)						
MAX. IMPELLER TIP SPEED (ft/min)						
☐ **DIFFUSER GUIDE VANES**						
ADJUSTABLE?						
MATERIAL						
NO. GUIDE VANES						

REMARKS: _____

REVISION	0	1	2	3	4
DATE					

INTEGRALLY GEARED COMPRESSOR DATASHEET (API 617-8th, Part 3)
U.S. CUSTOMARY UNITS

JOB NO. _____ ITEM NO _____
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CONSTRUCTION FEATURES, continued (1 COLUMN PER STAGE, USE ADDITIONAL SHEETS IF NEEDED)

☐ SHAFT SLEEVES:	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6
MATERIAL						
AT SHAFT SEALS?						
OTHER LOCATIONS?						
SHAFT SEALS:						
○ SEAL TYPE						
○ SETTLING OUT PRESSURE (psig)						
○ MINIMUM SEALING PRESSURE (psig)						
○ TYPE BUFFER GAS, PRIMARY						
☐ PRESSURE (psig)						
☐ FLOWRATE (lb/min)						
☐ FILTRATION						
○ TYPE BUFFER GAS, SECONDARY						
☐ PRESSURE (psig)						
☐ FLOWRATE (lb/min)						
☐ FILTRATION						
☐ FLOWRATE TO PROCESS						

○ BUFFER GAS SYSTEM REQUIRED
○ MANIFOLD
○ METHOD OF CONTROL _____
○ BUFFER GAS CONTROL SYSTEM SCHEMATIC BY VENDOR
○ PRESSURIZING GAS FOR SUBATMOSPHERIC SEALS ○ EDUCTOR ○ INJECTION
☐ SEAL MANUFACTURER _____ ○ SYSTEM RELIEF VALVE SET PT. _____

BEARING TEMPERATURE DETECTORS

○ SEE ATTACHED API 670 DATASHEET
○ THERMOCOUPLES TYPE _____
○ RESISTANCE TEMP DETECTORS
○ RESISTANCE MATERIAL _____ ○ _____ (ohm)
☐ ALARM TEMPERATURE (°F) _____
☐ SHUTDOWN TEMPERATURE (°F) _____
○ PROVISION FOR LOCAL DISCONNECT
○ LOCATION-JOURNAL BEARING
NO. ____ EA PAD _____ EVERY OTHER PAD _____ PER BEARING
OTHER _____
○ LOCATION-THRUST BEARING
NO. ____ EA PAD _____ EVERY OTHER PAD ____ PER BEARING
OTHER _____
NO. (INACT) ____ EA PAD ____ EVERY OTHER PAD ____ PER BEARING
OTHER _____
○ LOCAL DISCONNECTION
○ MONITOR SUPPLIED BY _____
○ LOCATION _____ ENCLOSURE _____
○ MFR. _____ ☐ MODEL _____
☐ SCALE RANGE _____ ALARM ☐ SET @ _____ (°F)
○ SHUTDOWN: ☐ SET @ ____ (°F) ○ TIME DELAY _____ (sec)

KEY PHASOR REQUIRED

○ COMPRESSOR ○ GEAR H.S. ○ GEAR L.S.

VIBRATION DETECTORS: ○ SEE ATTACHED API 670 DATASHEET

○ TYPE _____ ☐ MODEL _____
○ MFR _____
○ NO. AT EA SHAFT BEARING _____ TOTAL NO. _____
○ OSCILLATOR-DETECTORS SUPPLIED BY _____
○ MFR _____ ☐ MODEL _____
○ MONITOR SUPPLIED BY _____
○ LOCATION _____ ENCLOSURE _____
○ MFR. _____ ☐ MODEL _____
☐ SCALE RANGE ____ ALARM ☐ SET @ _____ (mil)
○ SHUTDOWN: ☐ SET @ _____ (mil) ○ TIME DELAY _____ (sec)
○ CASING VIBRATION TRANSDUCERS
○ CASING VIBRATION MONITORS

AXIAL POSITION DETECTOR:

○ SEE ATTACH. API 670 DATASHEET
○ TYPE _____ ☐ MODEL _____
○ MFR _____ ○ NO. REQUIRED _____
○ OSCILLATOR-DEMODULATOR SUPPLIED BY _____
○ MFR _____ ☐ MODEL _____
○ MONITOR SUPPLIED BY _____
○ LOCATION _____ ENCLOSURE _____
○ MFR. _____ ☐ MODEL _____
☐ SCALE RANGE _____ ALARM ☐ SET @ _____ (mil)
○ SHUTDOWN: ☐ SET @ _____ (mil) ○ TIME DELAY _____ (sec)

REMARKS: _____

REVISION	0	1	2	3	4
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INTEGRALLY GEARED COMPRESSOR
DATASHEET (API 617-8th, Part 3)
U.S. CUSTOMARY UNITS

JOB NO. _____ ITEM NO _____
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CONSTRUCTION FEATURES, ROTORS (1 COLUMN PER ROTOR, USE ADDITIONAL SHEETS IF NEEDED)

☐ **DRIVER SPEEDS:**
MAX. CONT. _____
TRIP SPEED _____

PITCH LINE VELOCITY (fps) _____
NORMAL DIAMETRAL PITCH _____
HELIX ANGLE _____ PRESSURE ANGLE _____

☐ ROTOR NUMBER	BULL GEAR	ROTOR 1	ROTOR 2	ROTOR 3	ROTOR 4
SPEED (rpm)					
SERVICE POWER (HP)					
SERVICE FACTOR					
NUMBER OF TEETH					
FACE WIDTH (in.)					
AGMA GEOMETRY FACTOR "J"					
AGMA GEOMETRY FACTOR "I"					
MINIMUM HARDNESS (Rc)					
ROTOR WEIGHT (INC WHEELS) (lb)					
BACKLASH (in.)					

GEARBOX FULL LOAD POWER LOSS _____

☐ LATERAL CRITICAL SPEEDS (DAMPED)					
FIRST CRITICAL					
SECOND CRITICAL					
THIRD CRITICAL					
FOURTH CRITICAL					

○ LATERAL ANALYSIS ADDITIONAL REQUIREMENTS
○ TRAIN LATERAL ANALYSIS REQUIRED
○ TRAIN TORSIONAL ANALYSIS REQUIRED

☐ TORSIONAL CRITICAL SPEEDS:	
FIRST CRITICAL	
SECOND CRITICAL	
THIRD CRITICAL	
FOURTH CRITICAL	

○ LIST OF TRAIN UNDESIRABLE SPEEDS
○ STABILITY ANALYSIS

☐ VIBRATION:					
ALLOWABLE TEST LEVEL (PK-PK)					

☐ BALANCE PISTON:				
MATERIAL				
FIXATION METHOD				
NORMAL CLEARANCE (in.)				
AREA ($in.^2$)				
FLOW, NORMAL CLEARANCE (lb/min)				
FLOW, 2x NORMAL CLEAR (lb/min)				
○ PRESS. CONN. BAL LINE				

REMARKS: _____

REVISION	0	1	2	3	4
DATE					

INTEGRALLY GEARED COMPRESSOR
DATASHEET (API 617-8th, Part 3)
U.S. CUSTOMARY UNITS

JOB NO. _____ ITEM NO _____
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CONSTRUCTION FEATURES, ROTOR BEARINGS (1 COLUMN PER ROTOR, USE ADDITIONAL SHEETS IF NEEDED)

RADIAL BEARINGS, DRIVE END	BULL GEAR	ROTOR 1	ROTOR 2	ROTOR 3	ROTOR 4
☐ TYPE					
☐ MANUFACTURER					
☐ LENGTH (in.)					
☐ SHAFT DIAMETER (in.)					
☐ UNIT LOAD (ACT/ALLOW)					
☐ BASE MATERIAL					
☐ BABBIT THICKNESS (in.)					
☐ NUMBER OF PADS					
☐ LOAD: BETWEEN/ON PAD					
☐ PIVOT: CENTER/OFFSET, %					
☐ RADIAL BEARING SPAN					
RADIAL BRG, OPPOSITE DRIVE END					
☐ TYPE					
☐ MANUFACTURER					
☐ LENGTH (in.)					
☐ SHAFT DIAMETER (in.)					
☐ UNIT LOAD (ACT/ALLOW)					
☐ BASE MATERIAL					
☐ BABBIT THICKNESS (in.)					
☐ NUMBER OF PADS					
☐ LOAD: BETWEEN/ON PAD					
☐ PIVOT: CENTER/OFFSET, %					
THRUST BEARINGS, ACTIVE					
☐ TYPE					
☐ MANUFACTURER					
☐ UNIT LOADING (max) (psi)					
☐ UNIT LOAD (ULT.) (psi)					
☐ AREA ($in.^2$)					
☐ NUMBER OF PADS					
☐ PIVOT: CENTER / OFFSET, %					
☐ PAD BASE MATERIAL					
☐ COPPER BACKED?					
☐ COLLAR MATERIAL					
☐ INTEGRAL OR REPLACEABLE COLLAR?					
☐ SIZING CRITERIA					
☐ FLOODED OR DIRECTED LUBRICATION?					
THRUST BEARINGS, INACTIVE					
☐ TYPE					
☐ MANUFACTURER					
☐ UNIT LOADING (max) (psi)					
☐ UNIT LOAD (ULT.) (psi)					
☐ AREA ($in.^2$)					
☐ NUMBER OF PADS					
☐ PIVOT: CENTER / OFFSET, %					
☐ PAD BASE MATERIAL					
☐ COPPER BACKED?					
☐ COLLAR MATERIAL					
☐ INTEGRAL OR REPLACEABLE COLLAR?					
☐ SIZING CRITERIA					
☐ FLOODED OR DIRECTED LUBRICATION?					

REMARKS: _____

REVISION	0	1	2	3	4
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INTEGRALLY GEARED COMPRESSOR DATASHEET (API 617-8th, Part 3)

U.S. CUSTOMARY UNITS

JOB NO. _____ ITEM NO _____

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☐ **OTHER CONNECTIONS**

SERVICE:	NO.	SIZE	TYPE		NO.	SIZE	TYPE
☐ LUBE-OIL INLET				☐ PRESSURE			
☐ LUBE OIL OUTLET				☐ TEMPERATURE			
☐ SEAL-OIL INLET				☐ SOLVENT INJECTION			
☐ SEAL-OIL OUTLET				☐ PURGE FOR:			
☐ SEAL GAS INLET				☐ BRG. HOUSING			
☐ SEAL GAS OUTLET				☐ BTWN BRG & SEAL			
☐ CASING DRAINS				☐ BTWN SEAL & GAS			
☐ STAGE DRAINS				_____			

○ INDIVIDUAL STAGE DRAINS REQUIRED
○ VALVED & BLINDED
○ VALVED & BLINDED & MANIFOLD

LUBRICATION AND SEALING SYSTEMS

○ SEE ATTACHED API 614 DATASHEET
○ SEPARATE ○ COMBINED
○ INTEGRAL OIL RESERVOIR
○ OIL TYPE

ACCESSORIES

COUPLING AND GUARDS

NOTE: SEE ROTATING ELEMENTS - SHAFT ENDS

○ SEE ATTACHED API 671 DATASHEET ○ KEYLESS HYDRAULIC ○ KEYED ○ FLANGED ○ OTHER _____

COUPLING FURNISHED BY _____ MOUNTED BY _____

MANUFACTURER _____ TYPE _____ MODEL _____

COUPLING GUARD FURNISHED BY: _____

TYPE: ○ FULLY ENCLOSED ○ SEMI-OPEN ○ OTHER _____

COUPLING DETAILS

☐ MAX O.D. _____ (in.)
☐ HUB WEIGHT _____ (lb)
☐ SPACER LENGTH _____ (in.)
☐ SPACER WEIGHT _____ (lb)

○ PLUG AND RING GAUGES ○ LAPPING TOOL

LUBRICATION REQUIREMENTS:
○ NON-LUBE ○ CONT. OIL LUBE ○ OTHER _____
☐ QUANTITY PER HUB _____ (gpm)

MOUNTING PLATES

○ BASEPLATES FURNISHED BY _____
○ COMPRESSOR ONLY ○ DRIVER ○ GEAR
○ OTHER _____
○ NONSKID DECKING ○ SLOPED DECK
△ LEVELING PADS OR TARGETS
△ COLUMN MOUNTING
○ SUB-SOLE PLATES REQUIRED
☐ STAINLESS STEEL SHIM THICKNESS _____ (in.)
○ MACHINED MOUNTING PADS REQUIRED

○ SOLEPLATES FURNISHED BY _____
☐ THICKNESS _____ (in.)
○ SUBSOLE PLATES REQUIRED
☐ STAINLESS STEEL SHIM THICKNESS _____ (in.)
○ COMPRESSOR _____
○ COUNTER BORE ANCHOR BOLT HOLES

ANTI-SURGE SYSTEM FURNISHED BY ○ PURCHASER ☐ SUPPLIER

○ ☐ ANTI-SURGE VALVE ○ SIZING ONLY
PRESSURE UPSTREAM: _____ (psig) DOWNSTREAM Δ P _____ (psig)
☐ Δ P VALVE _____ STROKE TIME OPEN - CLOSE _____ (sec)

○ ☐ RECIRCULATION VALVE ○ SIZING ONLY
○ ☐ BLOWOFF VALVE ○ SIZING ONLY
○ ☐ CONTROL SYSTEM
○ ☐ PIPING
○ ☐ FLOW ELEMENT
○ ☐ _____ ○ ☐ _____
○ ☐ _____ ○ ☐ _____
○ ☐ _____ ○ ☐ _____
○ ☐ _____ ○ ☐ _____
○ ☐ _____ ○ ☐ _____

REMARKS: _____

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INTEGRALLY GEARED COMPRESSOR DATASHEET (API 617-8th, Part 3)

U.S. CUSTOMARY UNITS

JOB NO. _____ ITEM NO _____

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UTILITIES

○ **UTILITY CONDITIONS:**

STEAM: — **DRIVERS**

INLET MIN	(psig)	(°F)
NORM	(psig)	(°F)
MAX	(psig)	(°F)
EXHAUST. MIN	(psig)	(°F)
NORM	(psig)	(°F)
MAX	(psig)	(°F)

ELECTRICITY:

	DRIVERS	CONTROL	SHUTDOWN
VOLTAGE			
HERTZ			
PHASE			

○ REDUCED VOLTAGE START

NUMBER OF STARTS _____

○ **INSTRUMENT AIR:**

MAX PRESS _____ (psig) MIN PRESS _____ (psig)

☐ **ROTATION, VIEWED OPP. DRIVE END** ○ **CW** ○ **CCW**

MANUALS

○ DRAFT MANUAL FOR REVIEW

○ TECHNICAL DATA MANUAL

MISCELLANEOUS:

☐ RECOMMENDED STRAIGHT RUN OF PIPE DIAMETERS BEFORE SUCTION _____

○ COMPRESSOR TO BE SUITABLE FOR FIELD RUN-IN ON AIR

○ PROVISION FOR LIQUID INJECTION _____

○ INJECTION MANIFOLD

○ VENDOR'S REVIEW & COMMENTS ON PURCHASER'S

○ CONTROL SYSTEMS

○ SHOP FITUP OF VENDOR PROCESS PIPING

○ WELDING HARDNESS TESTING _____

○ DESIGN AUDIT

○ BALANCE PISTON ΔP

○ PROVIDE TAIL END SCHEDULES

○ BOROSCOPIC INSPECTION PORTS

SHOP INSPECTION AND TESTS:

○ (SEE INSPECTOR'S CHECKLIST)	REQ'D	WIT/OBV
HYDROSTATIC	●	
IMPELLER OVERSPEED	●	
MECHANICAL RUN	●	
○ CONTRACT COUPLING ○ IDLING ADAPTOR(S)		
○ CONTRACT PROBES ○ SHOP PROBES		
○ PURCHASER VIB. EQUIPMENT		
VARY LUBE & SEAL OIL PRESSURES	○	
AND TEMPERATURES	○	
POLAR FORM VIB DATA	○	
TAPE RECORD VIB DATA	○	
SHAFT END SEAL INSP	○	
GAS LEAK TEST AT DISCH PRESS	○	
○ POST TEST INTERNAL INSP		
○ BEFORE GAS LEAKAGE TEST		
○ AFTER GAS LEAKAGE TEST	○	
PERFORMANCE TEST (GAS) (AIR)	○	
COMPLETE UNIT TEST	○	
TANDEM TEST	○	
GEAR TEST	○	
HELIUM LEAK TEST	○	
SOUND LEVEL TEST	○	
AUX. EQUIPMENT TEST _____	○	
FULL LOAD / SPEED / PRESS TEST	○	
HYDRAULIC COUPLING INSP	○	
SPARE PARTS TEST _____	○	
INSPECTOR'S CHECKLIST COMPLIANCE	○	
GAS SEAL TEST VENDOR SHOP	○	

VENDOR'S REPRESENTATIVE SHALL

○ OBSERVE FLANGE PARTING

○ CHECK ALIGNEMENT AT TEMPERATURE

○ BE PRESENT AT INITIAL ALIGNMENT

☐ **WEIGHTS:** (lb)

COMPR. _____ GEAR _____ DRIVER _____ BASE _____

ROTORS: COMPR. _____ DRIVER _____ GEAR _____

COMPRESSOR UPPER CASE _____

MAX. FOR MAINTENANCE (IDENTIFY) _____

TOTAL SHIPPING WEIGHT _____

☐ **SPACE REQUIREMENTS:** (in.)

COMPLETE UNIT: L _____ W _____ H _____

SPECIAL TOOL PACKAGING

○ METAL STORAGE CONTAINER

○ OTHER: _____

PAINTING:

○ MANUFACTURER'S STD.

○ OTHER _____

NAMEPLATE ○ U.S. CUSTOMARY ○ METRIC

SHIPMENT:

○ DOMESTIC ○ EXPORT ○ EXPORT BOXING REQ'D.

○ OUTDOOR STORAGE MORE THAN 6 MONTHS _____ MO

SPARE ROTOR ASSEMBLY PACKAGE

○ HORIZONTAL STORAGE ○ VERTICAL STORAGE

○ METAL STORAGE CONTAINER

○ N2 PURGE ○ OTHER: _____

MATERIALS INSPECTION REQUIREMENTS

○ RADIOGRAPHY REQUIRED FOR _____

○ ULTRASONIC REQUIRED FOR _____

○ MAGNETIC PARTICLE REQUIRED FOR _____

○ LIQUID PENETRANT REQUIRED FOR _____

○ LOW TEMPERATURE _____

MIN.DESIGN METAL TEMPERATURE _____ (°F)

AT CONCURRANT PRESSURE _____ (psig)

○ OTHER TRAIN COMPONENTS

○ Q.C. OF INACCESSIBLE WELDS

REMARKS: _____

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INTEGRALLY GEARED COMPRESSOR DATASHEET (API 617-8th, Part 3)

U.S. CUSTOMARY UNITS

JOB NO. _____ ITEM NO _____

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INTER COOLER(S) - BETWEEN 1st and 2nd STAGE

SERVICE OF UNIT: _____ ITEM NO _____

SIZE: _____ TYPE: _____ ☐ HORIZ ☐ VERT CONNECTED IN ☐ PARALLEL ☐ SERIES

SURF/UNIT: (GROSS/EFF) _____ (ft²) SHELLS/UNIT: _____ SURF/SHELL: (GROSS/EFF) _____

PERFORMANCE OF ONE UNIT

	SHELL SIDE		TUBE SIDE	
○ FLUID NAME				
☐ FLUID QUANTITY, TOTAL (lb/hr)				
VAPOR--IN/OUT				
LIQUID--IN/OUT				
☐ TEMPERATURE--IN/OUT (°F)				
☐ SPECIFIC GRAVITY				
☐ VISCOSITY, LIQUID (cP)				
☐ SPECIFIC HEAT, (BTU/lb °F)				
☐ THERMAL CONDUCTIVITY, (Btu/ft h °F)				
☐ LATENT HEAT, (BTU/lb °F)				
☐ INLET PRESSURE, (psig)				
◎ VELOCITY, (fps)				
◎ PRESSURE DROP--ALLOW/CALC, (psi)				
◎ FOULING RESISTANCE--MINIMUM (hr ft²°F/BTU)				

☐ HEAT EXCHANGED _____ (BTU/hr) MTD CORRECTED _____ (°F)

☐ TRANSFER RATE, (BTU/hr ft² °F) SERVICE _____ CLEAN _____

☐ **CONSTRUCTION OF ONE SHELL**

	SHELL SIDE	TUBE SIDE
DESIGN/TEST PRESSURE, (psig)		
DESIGN TEMPERATURE, (°F)		
NO. PASSES PER SHELL		
CORROSION ALLOWANCE, (in.)		
NOZZLES: INLET		
SIZE & OUTLET		
RATING VENT-DRAIN		

SKETCH: BUNDLE NOZZLE ORIENTATIONS

TUBE NO. _____ O.D. _____ (in.) THK (MIN) (AVG) _____ (in.) LENGTH _____ (ft) PITCH _____ (in.) ◁ 30 △ 60 ☐ 90 ◇ 45

TUBE TYPE _____ MATERIAL _____

SHELL MATL _____ I.D. _____ (in.) O.D. _____ (in.) SHELL COVER MATL _____ (INTEG)(REMOV)

CHANNEL OR BONNET MATL _____ CHANNEL COVER MATL _____

TUBESHEET--STATIONARY MATL _____ TUBESHEET--FLOATING MATL _____

FLOATING HEAD COVER MATL _____ IMPINGEMENT PROTECTION _____

BAFFLES--CROSS MATL _____ TYPE _____ %CUT (DIA) (AREA) _____ SPACING: C/C _____ INLET _____ (in.)

BAFFLES--LONG MATL _____ SEAL TYPE _____

SUPPORTS--TUBE _____ U-BEND _____ TYPE _____

BYPASS SEAL ARRANGEMENT _____ TUBE--TUBESHEET JOINT _____

GASKETS--SHELL SIDE _____ -- TUBE SIDE _____

--FLOATING HEAD _____

ASME SECTION VIII CODE REQUIREMENTS: ☐ DESIGN & TEST ☐ STAMP ☐ NOT APPLICABLE ○ TEMA CLASS _____

WEIGHT/SHELL _____ (lb) FILLED WITH WATER _____ (lb) BUNDLE _____ (lb)

REMARKS: _____

REVISION	0	1	2	3	4
DATE					

INTEGRALLY GEARED COMPRESSOR DATASHEET (API 617-8th, Part 3)

U.S. CUSTOMARY UNITS

JOB NO. _____ ITEM NO _____

PAGE 10 OF 12 REQ'N NO. _____

INTER COOLER(S) - BETWEEN 2nd and 3rd STAGE

SERVICE OF UNIT: _____ ITEM NO _____

SIZE: _____ TYPE: _____ ☐ HORIZ ☐ VERT CONNECTED IN ☐ PARALLEL ☐ SERIES

SURF/UNIT: (GROSS/EFF) _____ (ft²) SHELLS/UNIT: _____ SURF/SHELL: (GROSS/EFF) _____

PERFORMANCE OF ONE UNIT

	SHELL SIDE		TUBE SIDE	
○ FLUID NAME				
☐ FLUID QUANTITY, TOTAL (lb/hr)				
VAPOR--IN/OUT				
LIQUID--IN/OUT				
☐ TEMPERATURE--IN/OUT (°F)				
☐ SPECIFIC GRAVITY				
☐ VISCOSITY, LIQUID (cP)				
☐ SPECIFIC HEAT, (BTU/lb °F)				
☐ THERMAL CONDUCTIVITY, (Btu/ft h °F)				
☐ LATENT HEAT, (BTU/lb °F)				
☐ INLET PRESSURE, (psig)				
◎ VELOCITY, (fps)				
◎ PRESSURE DROP--ALLOW/CALC, (psi)				
◎ FOULING RESISTANCE--MINIMUM (hr ft²°F/BTU)				

☐ HEAT EXCHANGED _____ (BTU/hr) MTD CORRECTED _____ (°F)

☐ TRANSFER RATE, (BTU/hr ft² °F) SERVICE _____ CLEAN _____

☐ **CONSTRUCTION OF ONE SHELL**

	SHELL SIDE	TUBE SIDE
DESIGN/TEST PRESSURE, (psig)		
DESIGN TEMPERATURE, (°F)		
NO. PASSES PER SHELL		
CORROSION ALLOWANCE, (in.)		
NOZZLES: INLET		
SIZE & OUTLET		
RATING VENT-DRAIN		

SKETCH: BUNDLE NOZZLE ORIENTATIONS

TUBE NO. _____ O.D. _____ (in.) THK (MIN) (AVG) _____ (in.) LENGTH _____ (ft) PITCH _____ (in.) ◁ 30 △ 60 ☐ 90 ◇ 45

TUBE TYPE _____ MATERIAL _____

SHELL MATL _____ I.D. _____ (in.) O.D. _____ (in.) SHELL COVER MATL _____ (INTEG)(REMOV)

CHANNEL OR BONNET MATL _____ CHANNEL COVER MATL _____

TUBESHEET--STATIONARY MATL _____ TUBESHEET--FLOATING MATL _____

FLOATING HEAD COVER MATL _____ IMPINGEMENT PROTECTION _____

BAFFLES--CROSS MATL _____ TYPE _____ %CUT (DIA) (AREA) _____ SPACING: C/C _____ INLET _____ (in.)

BAFFLES--LONG MATL _____ SEAL TYPE _____

SUPPORTS--TUBE _____ U-BEND _____ TYPE _____

BYPASS SEAL ARRANGEMENT _____ TUBE--TUBESHEET JOINT _____

GASKETS--SHELL SIDE _____ -- TUBE SIDE _____

--FLOATING HEAD _____

ASME SECTION VIII CODE REQUIREMENTS: ☐ DESIGN & TEST ☐ STAMP ☐ NOT APPLICABLE ○ TEMA CLASS _____

WEIGHT/SHELL _____ (lb) FILLED WITH WATER _____ (lb) BUNDLE _____ (lb)

REMARKS: _____

REVISION	0	1	2	3	4
DATE					

INTEGRALLY GEARED COMPRESSOR
DATASHEET (API 617-8th, Part 3)
U.S. CUSTOMARY UNITS

JOB NO. _____ ITEM NO _____
PAGE 11 OF 12 REQ'N NO. _____

INTER COOLER(S) - BETWEEN 3rd and 4th STAGE

SERVICE OF UNIT: _____ ITEM NO _____
SIZE: _____ TYPE: _____ ☐ HORIZ ☐ VERT CONNECTED IN ☐ PARALLEL ☐ SERIES
SURF/UNIT: (GROSS/EFF) _____ (ft²) SHELLS/UNIT: _____ SURF/SHELL: (GROSS/EFF) _____

PERFORMANCE OF ONE UNIT

	SHELL SIDE		TUBE SIDE	
○ FLUID NAME				
☐ FLUID QUANTITY, TOTAL (lb/hr)				
VAPOR--IN/OUT				
LIQUID--IN/OUT				
☐ TEMPERATURE--IN/OUT (°F)				
☐ SPECIFIC GRAVITY				
☐ VISCOSITY, LIQUID (cP)				
☐ SPECIFIC HEAT, (BTU/lb °F)				
☐ THERMAL CONDUCTIVITY, (Btu/ft h °F)				
☐ LATENT HEAT, (BTU/lb °F)				
☐ INLET PRESSURE, (psig)				
◎ VELOCITY, (fps)				
◎ PRESSURE DROP--ALLOW/CALC, (psi)				
◎ FOULING RESISTANCE--MINIMUM (hr ft²°F/BTU)				

☐ HEAT EXCHANGED _____ (BTU/hr) MTD CORRECTED _____ (°F)
☐ TRANSFER RATE, (BTU/hr ft² °F) SERVICE _____ CLEAN _____

☐ **CONSTRUCTION OF ONE SHELL**

	SHELL SIDE	TUBE SIDE
DESIGN/TEST PRESSURE, (psig)		
DESIGN TEMPERATURE, (°F)		
NO. PASSES PER SHELL		
CORROSION ALLOWANCE, (in.)		
NOZZLES: INLET		
SIZE & OUTLET		
RATING VENT-DRAIN		

SKETCH: BUNDLE NOZZLE ORIENTATIONS

TUBE NO. _____ O.D. _____ (in.) THK (MIN) (AVG) _____ (in.) LENGTH _____ (ft) PITCH _____ (in.) ◁ 30 △ 60 ☐ 90 ◇ 45
TUBE TYPE _____ MATERIAL _____
SHELL MATL _____ I.D. _____ (in.) O.D. _____ (in.) SHELL COVER MATL _____ (INTEG)(REMOV)
CHANNEL OR BONNET MATL _____ CHANNEL COVER MATL _____
TUBESHEET--STATIONARY MATL _____ TUBESHEET--FLOATING MATL _____
FLOATING HEAD COVER MATL _____ IMPINGEMENT PROTECTION _____
BAFFLES--CROSS MATL _____ TYPE _____ %CUT (DIA) (AREA) _____ SPACING: C/C _____ INLET _____ (in.)
BAFFLES--LONG MATL _____ SEAL TYPE _____
SUPPORTS--TUBE _____ U-BEND _____ TYPE _____
BYPASS SEAL ARRANGEMENT _____ TUBE--TUBESHEET JOINT _____
GASKETS--SHELL SIDE _____ -- TUBE SIDE _____
--FLOATING HEAD _____
ASME SECTION VIII CODE REQUIREMENTS: ☐ DESIGN & TEST ☐ STAMP ☐ NOT APPLICABLE ○ TEMA CLASS _____
WEIGHT/SHELL _____ (lb) FILLED WITH WATER _____ (lb) BUNDLE _____ (lb)

REMARKS: _____

REVISION	0	1	2	3	4
DATE					

INTEGRALLY GEARED COMPRESSOR DATASHEET (API 617-8th, Part 3)

U.S. CUSTOMARY UNITS

JOB NO. _____ ITEM NO _____

PAGE 12 OF 12 REQ'N NO. _____

INTER COOLER(S) - BETWEEN 4th and 5th STAGE

SERVICE OF UNIT: _____ ITEM NO _____

SIZE: _____ TYPE: _____ ☐ HORIZ ☐ VERT CONNECTED IN ☐ PARALLEL ☐ SERIES

SURF/UNIT: (GROSS/EFF) _____ (ft²) SHELLS/UNIT: _____ SURF/SHELL: (GROSS/EFF) _____

PERFORMANCE OF ONE UNIT

	SHELL SIDE		TUBE SIDE	
○ FLUID NAME				
☐ FLUID QUANTITY, TOTAL (lb/hr)				
VAPOR--IN/OUT				
LIQUID--IN/OUT				
☐ TEMPERATURE--IN/OUT (°F)				
☐ SPECIFIC GRAVITY				
☐ VISCOSITY, LIQUID (cP)				
☐ SPECIFIC HEAT, (BTU/lb °F)				
☐ THERMAL CONDUCTIVITY, (Btu/ft h °F)				
☐ LATENT HEAT, (BTU/lb °F)				
☐ INLET PRESSURE, (psig)				
◎ VELOCITY, (fps)				
◎ PRESSURE DROP--ALLOW/CALC, (psi)				
◎ FOULING RESISTANCE--MINIMUM (hr ft²°F/BTU)				

☐ HEAT EXCHANGED _____ (BTU/hr) MTD CORRECTED _____ (°F)

☐ TRANSFER RATE, (BTU/hr ft² °F) SERVICE _____ CLEAN _____

☐ **CONSTRUCTION OF ONE SHELL**

	SHELL SIDE	TUBE SIDE
DESIGN/TEST PRESSURE, (psig)		
DESIGN TEMPERATURE, (°F)		
NO. PASSES PER SHELL		
CORROSION ALLOWANCE, (in.)		
NOZZLES: INLET		
SIZE & OUTLET		
RATING VENT-DRAIN		

SKETCH: BUNDLE NOZZLE ORIENTATIONS

TUBE NO. _____ O.D. _____ (in.) THK (MIN) (AVG) _____ (in.) LENGTH _____ (ft) PITCH _____ (in.) ◁ 30 △ 60 ☐ 90 ◇ 45

TUBE TYPE _____ MATERIAL _____

SHELL MATL _____ I.D. _____ (in.) O.D. _____ (in.) SHELL COVER MATL _____ (INTEG)(REMOV)

CHANNEL OR BONNET MATL _____ CHANNEL COVER MATL _____

TUBESHEET--STATIONARY MATL _____ TUBESHEET--FLOATING MATL _____

FLOATING HEAD COVER MATL _____ IMPINGEMENT PROTECTION _____

BAFFLES--CROSS MATL _____ TYPE _____ %CUT (DIA) (AREA) _____ SPACING: C/C _____ INLET _____ (in.)

BAFFLES--LONG MATL _____ SEAL TYPE _____

SUPPORTS--TUBE _____ U-BEND _____ TYPE _____

BYPASS SEAL ARRANGEMENT _____ TUBE--TUBESHEET JOINT _____

GASKETS--SHELL SIDE _____ -- TUBE SIDE _____

--FLOATING HEAD _____

ASME SECTION VIII CODE REQUIREMENTS: ☐ DESIGN & TEST ☐ STAMP ☐ NOT APPLICABLE ○ TEMA CLASS _____

WEIGHT/SHELL _____ (lb) FILLED WITH WATER _____ (lb) BUNDLE _____ (lb)

REMARKS: _____

Annex B
(informative)

Vendor (Supplier) Data and Drawing Requirements

B.1 VDDR for Integrally Geared Compressors (See Text for Details of the Description)

INTEGRALLY GEARED COMPRESSOR SUPPLIER DRAWING AND DATA REQUIREMENTS	Job No.....	Item No.....
	Purchase Order No.	Date.....
	Requisition No.....	Date.....
	Inquiry No.....	Date.....
	Revision …….. by.....	Manufacturer .....
	For.....	Unit.....
	Site.....	Service .....

Proposal [a]— Bidder shall furnish number of paper copies/number of electronic copies of data as indicated
Review—Supplier shall furnish number of paper copies/number of electronic copies of data as indicated
Final—Supplier shall furnish number of paper copies/number of electronic copies of data as indicated

			Description (see text)	**Distribution Record**				
				Review Due from Supplier [b c]	Review Received from Supplier	Review Returned to Supplier	Final due From Supplier [c]	Final Received from Supplier
/	/	/	1. Certified dimensional outline drawing and list of connections					
/	/	/	2. Cross-sectional drawings and part numbers					
/	/	/	3. Rotor assembly drawings and part numbers					
/	/	/	4. Thrust-bearing assembly drawings and part numbers					
/	/	/	5. Journal-bearing assembly drawings and bill of materials					
/	/	/	6. Coupling assembly drawings and bill of materials					
/	/	/	7. Lube-oil schematic and bill of materials					
/	/	/	8. Lube-oil arrangement drawing and list of connections					
/	/	/	9. Lube-oil component drawings and data					
/	/	/	10. Seal system schematic and bill of material					

[a] Proposal drawings and data do not have to be certified. Typical data shall be clearly identified as such.
[b] Purchase may indicate in the column the desired time frame for submission of data.
[c] Bidder shall complete these two columns to reflect the actual distribution schedule and include this form with the proposal.

INTEGRALLY GEARED COMPRESSOR SUPPLIER DRAWING AND DATA REQUIREMENTS		
	Job No.	Item No. .....
	Purchase Order No.	Date .....
	Requisition No.	Date .....
	Inquiry No.	Date .....
	Revision ……. by	Manufacturer .....
	For	Unit .....
	Site	Service .....

Proposal [a]— Bidder shall furnish number of paper copies/number of electronic copies of data as indicated
Review—Supplier shall furnish number of paper copies/number of electronic copies of data as indicated
Final—Supplier shall furnish number of paper copies/number of electronic copies of data as indicated

			Description (see text)	**Distribution Record**				
				Review Due from Supplier [b c]	Review Received from Supplier	Review Returned to Supplier	Final due From Supplier [c]	Final Received from Supplier
/	/	/	11. Seal system arrangement drawing and list of connections					
/	/	/	12. Seal system component drawings and data					
/	/	/	13. Seal assembly drawing and part numbers					
/	/	/	14. Electrical and instrumentation schematics and bill of materials					
/	/	/	15. Electrical and instrumentation arrangement of drawing and list of connections					
/	/	/	16. Buffer gas system schematic and bill of material					
/	/	/	17. Buffer gas system arrangement drawing and list of connections					
/	/	/	18. Buffer gas system component drawing and data					
/	/	/	19. Datasheets (proposal/as-built)					
/	/	/	20. Allowable external forces and moments for each nozzle in tabular form (with proposal)					
/	/	/	21. Gear quality documentations					

[a] Proposal drawings and data do not have to be certified. Typical data shall be clearly identified as such.
[b] Purchase may indicate in the column the desired time frame for submission of data.
[c] Bidder shall complete these two columns to reflect the actual distribution schedule and include this form with the proposal.

INTEGRALLY GEARED COMPRESSOR SUPPLIER DRAWING AND DATA REQUIREMENTS		
	Job No.	Item No.
	Purchase Order No.	Date
	Requisition No.	Date
	Inquiry No.	Date
	Revision …….. by	Manufacturer
	For	Unit
	Site	Service

Proposal [a]—Bidder shall furnish number of paper copies/number of electronic copies of data as indicated
Review—Supplier shall furnish number of paper copies/number of electronic copies of data as indicated
Final—Supplier shall furnish number of paper copies/number of electronic copies of data as indicated

Description (see text)				**Distribution Record**				
				Review Due from Supplier [b c]	Review Received from Supplier	Review Returned to Supplier	Final Due from Supplier [c]	Final Received from Supplier
/	/	/	22. Gear tooth contact check results					
/	/	/	23. Certificates for gear materials					
/	/	/	24. Predicted noise sound level (proposal)					
/	/	/	25. Metallurgy of major components (in proposal)					
/	/	/	26. Lateral analysis report and stability analysis (if required)					
/	/	/	27. Torsional analysis report					
/	/	/	28. Vibration analysis report					
/	/	/	29. Performance curves for each compressor section (proposal/as-built)					
/	/	/	30. Impeller overspeed test report					
/	/	/	31. Mechanical running test report					
/	/	/	32. Coupling selection and rating					

[a] Proposal drawings and data do not have to be certified. Typical data shall be clearly identified as such.
[b] Purchase may indicate in the column the desired time frame for submission of data.
[c] Bidder shall complete these two columns to reflect the actual distribution schedule and include this form with the proposal.

INTEGRALLY GEARED COMPRESSOR SUPPLIER DRAWING AND DATA REQUIREMENTS		
	Job No.	Item No. .....
	Purchase Order No.	Date .....
	Requisition No.	Date .....
	Inquiry No.	Date .....
	Revision ……. by	Manufacturer .....
	For	Unit .....
	Site	Service .....

Proposal [a]—Bidder shall furnish number of paper copies/number of electronic copies of data as indicated
Review—Supplier shall furnish number of paper copies/number of electronic copies of data as indicated
Final—Supplier shall furnish number of paper copies/number of electronic copies of data as indicated

			Description (see text)	**Distribution Record**				
				Review Due from Supplier [b c]	Review Received from Supplier	Review Returned to Supplier	Final Due from Supplier [c]	Final Received from Supplier
/	/	/	33. List of recommended spare parts					
/	/	/	34. List of special tools					
/	/	/	35. Preparation for storage at job site before installation					
/	/	/	36. Weather protection and winterization required at job site					
/	/	/	37. Tabulation of all utilities					
/	/	/	38. List of similar machines					
/	/	/	39. Operating restrictions to protect equipment during start-up operation and shutdown					
/	/	/	40. List of components requiring purchaser's approval					
/	/	/	41. Summary of materials and hardness of materials exposed to H_2S					
/	/	/	42. Seal leakage rates					
/	/	/	43. Interstage cooler system data					

[a] Proposal drawings and data do not have to be certified. Typical data shall be clearly identified as such.
[b] Purchase may indicate in the column the desired time frame for submission of data.
[c] Bidder shall complete these two columns to reflect the actual distribution schedule and include this form with the proposal.

INTEGRALLY GEARED COMPRESSOR SUPPLIER DRAWING AND DATA REQUIREMENTS		
	Job No.	Item No. .....
	Purchase Order No.	Date .....
	Requisition No.	Date .....
	Inquiry No.	Date .....
	Revision …….. by	Manufacturer .....
	For	Unit .....
	Site	Service .....

Proposal [a]—Bidder shall furnish number of paper copies/number of electronic copies of data as indicated
Review—Supplier shall furnish number of paper copies/number of electronic copies of data as indicated
Final—Supplier shall furnish number of paper copies/number of electronic copies of data as indicated

			Description (see text)	**Distribution Record**				
				Review Due from Supplier [b c]	Review Received from Supplier	Review Returned to Supplier	Final Due from Supplier [c]	Final Received from Supplier
/	/	/	44. Drawings, details and description of instrumentation and controls					
/	/	/	45. Minimum length of straight pipe required at machine inlet or side inlets					
/	/	/	46. Maximum and minimum allowable seal pressure for each compressor					
/	/	/	47. Statement of manufacturer's testing capabilities					
/	/	/	48. Performance test data and curves					
/	/	/	49. Back-to-back impeller machine supplier to provide thrust-bearing loads versus differential pressure curve					
/	/	/	50. Production delivery schedule					
/	/	/	51. Testing procedures					
/	/	/	52. Progress reports					
/	/	/	53. Installation manual					
/	/	/	54. Operating and maintenance manual					
/	/	/	55. Technical data manual					

a Proposal drawings and data do not have to be certified. Typical data shall be clearly identified as such.
b Purchase may indicate in the column the desired time frame for submission of data.
c Bidder shall complete these two columns to reflect the actual distribution schedule and include this form with the proposal.

INTEGRALLY GEARED COMPRESSOR SUPPLIER DRAWING AND DATA REQUIREMENTS		
	Job No.	Item No.
	Purchase Order No.	Date
	Requisition No.	Date
	Inquiry No.	Date
	Revision ……. by	Manufacturer
	For	Unit
	Site	Service

Notes:

1. Where necessary to meet the scheduled shipping date, the supplier shall proceed with manufacture upon receipt of the order and without awaiting the purchaser's approval of drawings.

2. The supplier shall send all drawings and data to the following:

_____

_____

_____

3. All drawings and data shall show project, purchase order, and item numbers as well as plant location and unit. One set of the drawings and instructions necessary for field installation, in addition to the copies specified above, shall be forwarded with shipment.

4. See the descriptions of required items that follow.

5. All of the information indicated on the distribution schedule shall be received before final payment is made.

6. If typical drawings, schematics, and bills of material are used for proposals, they shall be marked-up to show the expected weight and dimensions to reflect the actual equipment and scope proposed.

Nomenclature:

S number of weeks before shipment.

F number of weeks after firm order.

D number of weeks after receipt of approved drawings.

Supplier_____

Date_____ Supplier Reference _____

Signature_____

(Signature acknowledges receipt of all instructions)

B.2 Descriptions

1) Certified dimensional outline drawing and list of connections, including the following:

   a) the size, rating, and location of all customer connections;

   b) approximate overall and handling weights;

   c) overall dimensions and maintenance and dismantling clearances;

   d) shaft centering height;

   e) dimensions of baseplate (if furnished) for train or skid mounted package, complete with diameters, number and locations of bolt holes, and thicknesses of sections through which the bolts pass;

   f) grounding details;

   g) forces and moments allowed for suction and discharge nozzles;

   h) center of gravity and lifting points;

   i) shaft end separation and alignment data;

   j) direction of rotation;

   k) winterization, tropicalization, and/or noise attenuation details, when required;

   l) sketches to show lifting of assembled machine and major components and auxiliaries.

2) Cross-sectional drawings and part numbers of major equipment.

3) Rotor assembly drawings and part numbers.

4) Thrust-bearing assembly drawings and part numbers.

5) Journal-bearing assembly drawings and bill of materials.

6) Coupling assembly drawing and bill of materials.

7) Lube-oil schematic and bill of material including the following:

   a) oil flows, temperatures, and pressure at each point;

   b) control alarm shutdown settings for pressure and temperature;

   c) total heat loads;

   d) utility requirements including electrical, water, air and steam;

   e) pipe, valve and orifice sizes;

   f) instrumentation, safety devices, control schemes, and wiring diagrams.

8) Lube-oil arrangement drawing and list of connections.

9) Lube-oil component drawings and data, including the following:

   a) pumps and drivers;

   b) coolers, filter and reservoir;

   c) instrumentation.

10) Seal system schematic and bill of material, including the following:

   a) flows oil or gas, temperatures, and pressures at each point;

   b) control, alarm, and shutdown settings for pressure and temperatures;

   c) total heat load for coolers, if required;

   d) utility requirements including electrical, water, air, and steam;

   e) pipe, valve, and orifice sizes;

   f) instrumentation, safety devices, control schemes, and wiring diagrams;

   g) filtration requirements;

   h) height of overhead tank above centerline of machine.

11) Seal system arrangement drawing and list of connections.

12) Seal system components drawing and data, including the following:

   a) pumps and drivers;

   b) coolers, filter, and reservoirs;

   c) instrumentation.

13) Seal assembly drawing and part numbers.

14) Electrical and instrumentation arrangement drawing and list of connections.

   a) vibration warning and shutdown limits;

   b) bearing temperature warning and shutdown limits;

   c) lube-oil temperature warning and shutdown limits;

   d) lube-oil pressure warning and shutdown limits;

   e) lube-oil level warning and shutdown limits;

   f) machine discharge pressure and temperature warning and shutdown limits;

   g) seal, pressure, temperature, flow warning, and shutdown limits.

15) Electrical and instrumentation arrangement drawing and list of connections.

16) Buffer gas system schematic and bill of material.

17) Buffer gas system arrangement drawing and list of connections.

18) Buffer gas system component drawings and data, including the following:

    a) control devices,

    b) pressure and filtration requirements.

19) Datasheets provided with proposal as-built.

20) Supplier shall furnish the allowable forces and moments for each nozzle in tabular form with the proposal.

21) The supplier shall provide documentation showing the gear has met the quality levels of ANSI/AGMA 2015-1-A01, Grade 4.

22) The supplier shall make available to the purchaser the results of the gear tooth contact check for each gear set installed in the job gear box.

23) Certificates for gearing materials:

    a) mill test reports for all gear element components;

    b) UT of all gear element components after rough machining;

    c) record of all heat treatment and resulting hardness, versus case depth of all welds on rotating elements;

    d) MP of gear and pinion teeth;

    e) results of quality control checks;

    f) gear tooth surface finish;

    g) plating of teeth;

    h) tooth profile, helix deviation pitch error, and cumulative pitch error;

    i) contact checks in job casing;

    j) records of all radiographs and UT;

    k) hardness versus case depth.

24) Predicted noise level, sound pressure, and sound power level.

25) Metallurgy of major components identified with ASTM, AISI, ASME, or SAE numbers stated in proposal.

26) Lateral analysis report when specified shall also include a stability analysis.

27) Torsional analysis report.

28) Vibration analysis conducted on machines that require disassembly after balancing to allow machine assembly. The supplier shall also provide historic unbalance data for the machine size and type.

29) Performance data and curves, sufficient performance data to enable the purchaser to properly design a control system, and surge prevention.

30) Dimensions taken from each impeller before and after overspeed testing shall be submitted for review.

31) Mechanical running test report to include the following:

    a) unfiltered vibration;

    b) plots showing synchronous vibration and phone angle, filtered and unfiltered;

    c) when specified, data shall be furnished in polar form;

    d) when specified, tape recordings shall be made of all real time vibration data;

    e) electrical and mechanical runout at each probe;

    f) immediately upon completion of each witnessed mechanical or performance test, copies of the log and data recorded during the test shall be given to the witnesses.

32) Coupling selection and rating.

33) List of spare parts recommended for start-up and normal maintenance purposes.

34) List of the special tools furnished for maintenance

35) The supplier shall provide the purchaser with instructions necessary to preserve the integrity of the storage preparation after the equipment arrives at the job site and before start-up.

36) A description of any special weather protection required for start-up, operation and period of idleness under the site conditions specified on the datasheets.

37) A complete list of utility requirements: quantity, filtration and supply pressure of the following:

    a) steam,

    b) water,

    c) electricity,

    d) air,

    e) gas,

    f) lube oil and seal oil (quantity and supply pressure),

    g) heat loads,

    h) power ratings and operating power requirements for auxiliary drivers.

38) A list of machines similar to the proposed machines that have been installed and operating under conditions analogous to those specified in the inquiry.

39) Any start-up, shutdown, or operating restrictions required to protect the integrity of the equipment, including any unacceptable speeds due to natural frequencies.

40) A list of any components that can be construed as being of alternative design, requiring purchaser's acceptance.

41) A summary of the materials of construction for the compressor, including hardness for materials exposed to H_2S.

42) The maximum seal gas rates (injection or eduction) and rated or expected inner seal-oil leakage rates, if applicable.

    a) When self-acting dry gas seals are supplied, expected seal gas consumption, minimum seal gas supply flow and primary vent flow should be given at maximum sealing pressure and at conditions over the operating envelope of the machine.

43) When interstage coolers are furnished, the supplier shall provide the following:

    a) drawing showing cooling system details,

    b) data for purchasers heat and material balances,

    c) details of provisions for separating and withdrawing condensate,

    d) supplier's recommendations regarding provision for support and piping expansion.

44) Drawings, details and descriptions of the operations of instrumentation and controls as well as the makes, materials, and type of auxiliary equipment. The supplier shall also include a complete description of the alarm and shutdown facilities to be provided.

45) The minimum length of straight pipe required for proper flow characteristics at the inlet and at any side inlet connection.

46) Maximum and minimum allowable seal pressure for each compressor.

47) A statement of the manufacturer's capability regarding testing (including performance testing) of the compressor and any other specified items on the train. Details of each optional test specified shall be included.

48) Performance curves shall be submitted for each section (between purchaser's process nozzles) of each casing as well as an overall curve for the train. All curves submitted prior to complete performance testing shall be marked "predicted."

    a) Any set of curves resulting from a test shall be marked "tested."

    b) If a performance test is specified, the supplier shall provide test data and curves when the test has been completed. The surge points shall be shown on the performance curves.

49) For compressors that have a back-to-back impeller arrangement, the supplier shall furnish a curve showing the expected loading on the active or inactive side of the thrust bearing versus any combination of differential pressures across the low pressure and high pressure sections of the casing.

50) The supplier shall provide production and delivery schedules.

51) The supplier shall submit detailed procedures, including acceptance criteria for the mechanical running test and all optional test, at least 6 weeks before the first running test.

52) The supplier shall submit progress reports.

53) All information required for the proper installation of the equipment shall be compiled in a manual that shall be issued no later than the time of final certified drawings.

54) A manual containing all required operating and maintenance instructions shall be supplied not later than 2 weeks after all specified test shall have been successfully completed.

55) The supplier shall provide a “technical data manual within 30 days of completion” of shop testing including the following:

    a) necessary certification of materials;

    b) purchase specification for all items on the bill of materials;

    c) test data to verify requirements of specifications have been met;

    d) heat treat records;

    e) results of quality test and inspections;

    f) mechanical running test data log;

    g) final assembly maintenance and running clearances;

    h) the supplier is also required to keep this data available for examination by the purchaser upon request, for at least 5 years.

Annex C
(informative)

Nomenclature

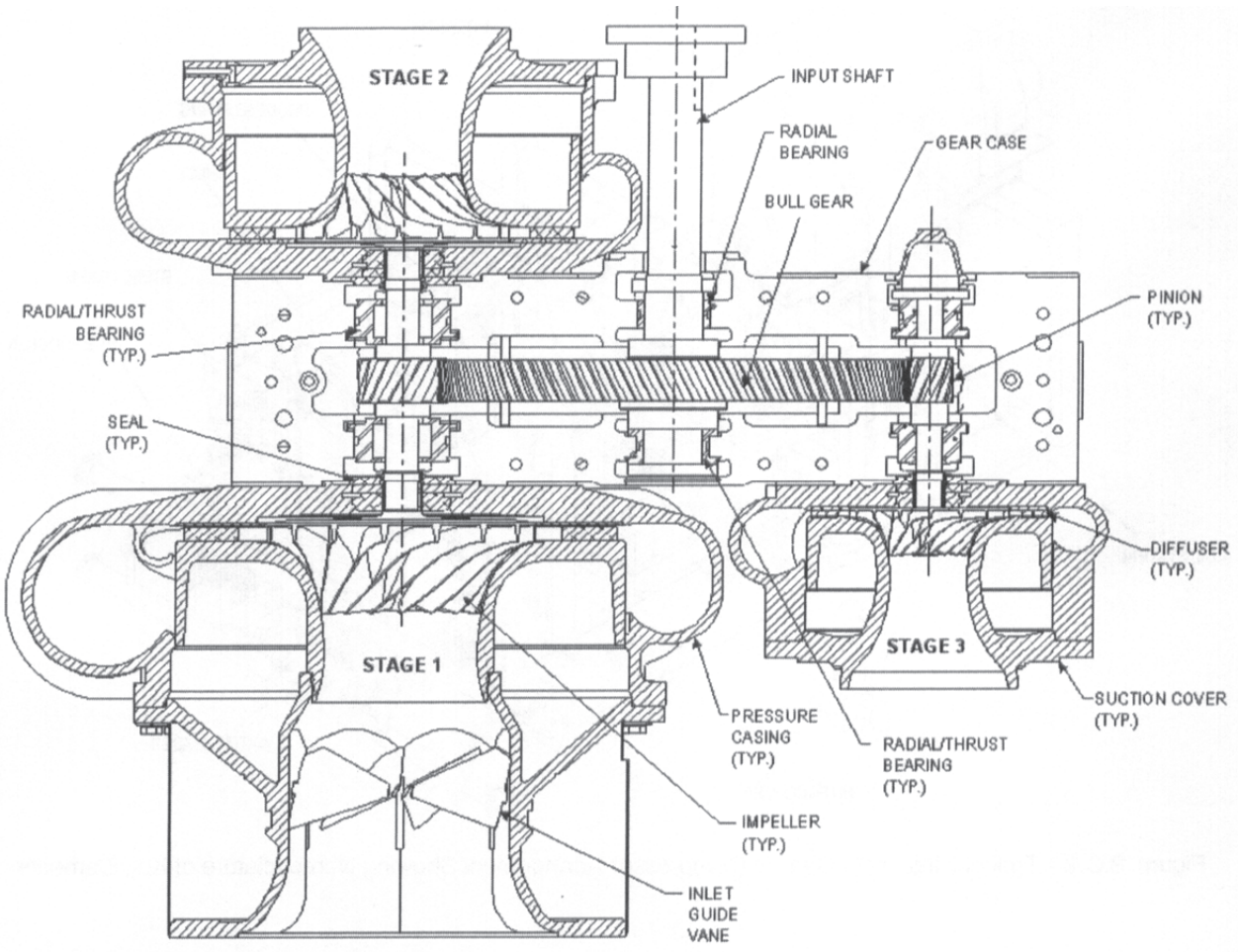

Figure C.1—Cross-sectional View 3 Stage, 2 Pinion Compressor

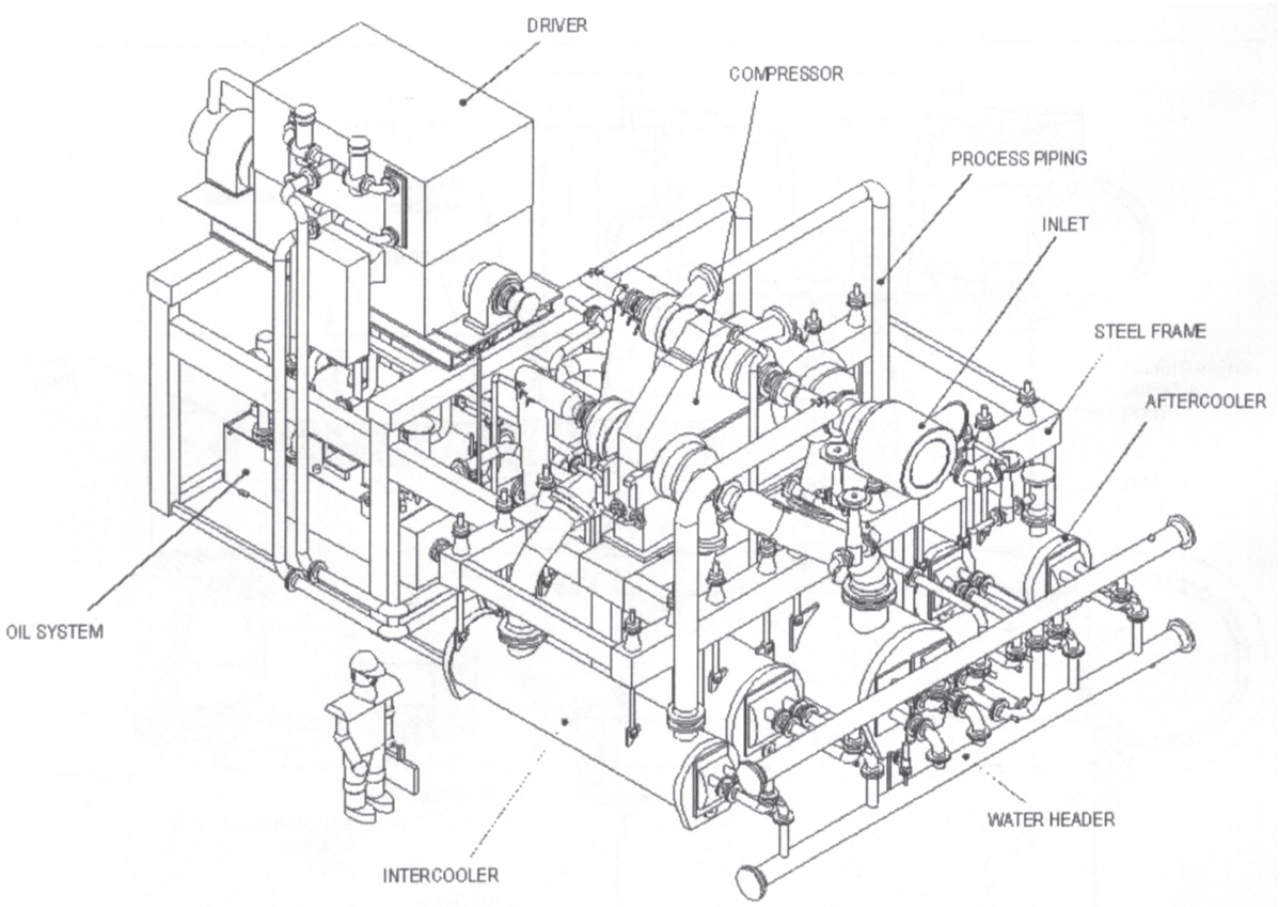

Figure C.2—Typical Integrally Geared Compressor Package

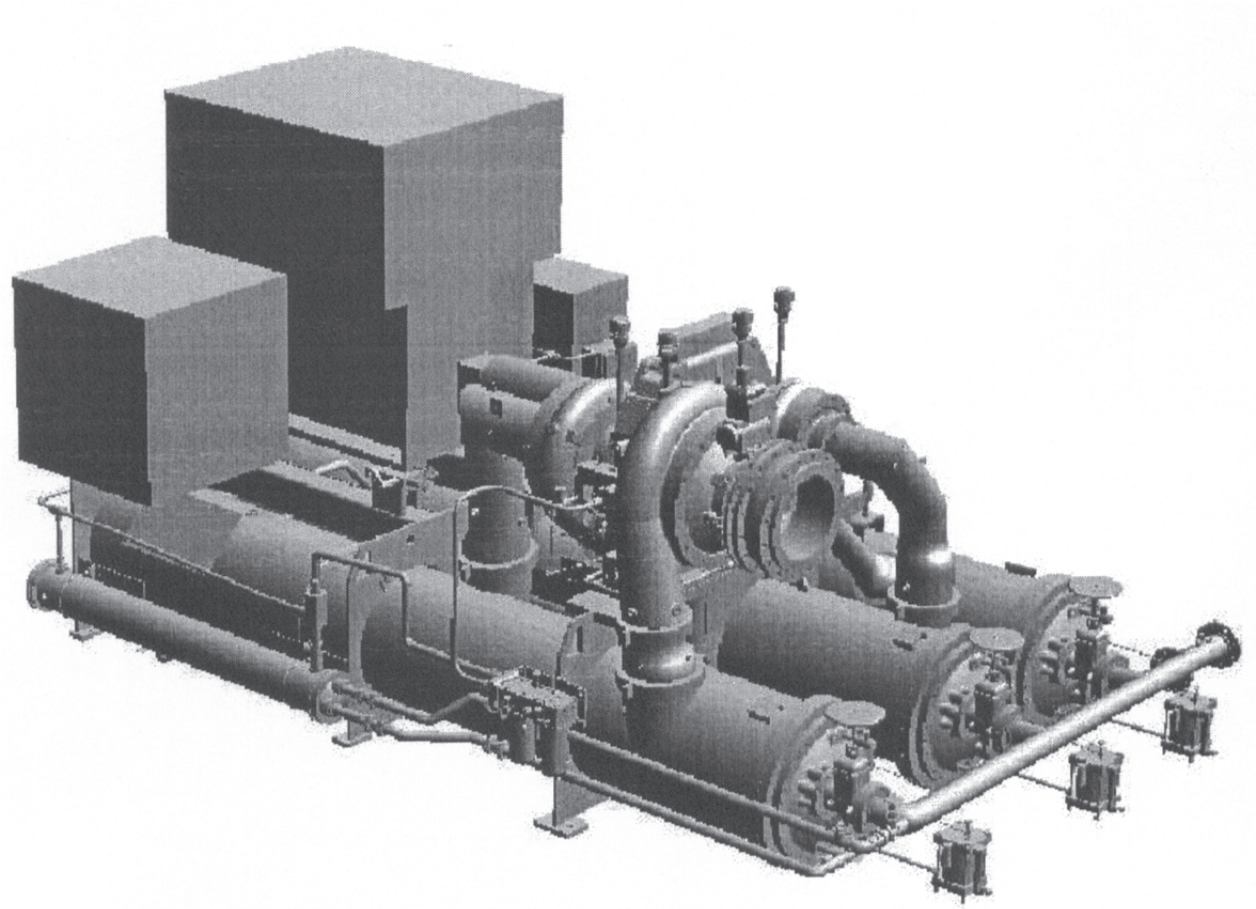

Figure C.3—Typical Integrally Geared Compressor Arrangement

Annex D
(informative)

Typical Materials for Integrally Geared Compressors

Component	Materials [a]	Material Code [b e]	Equivalent JIS Material	Equivalent EN Material		Form	Temperature Limits	
							Minimum Temperature °C (°F)	Maximum Temperature °C (°F)
Casing, inlet casing, discharge casing	Cast iron	ASTM A278, Class 30	JIS G5501 FC200	EN 1561 EN-GJL-250	EN-JL1040	Cast	−45 (−50)	230 (450)
		ASTM A278, Class 40	JIS G5501 FC300	EN 1561 EN-GJL-300	EN-JL1050	Cast	−28 (−20)	260 (500)
	Austenitic cast iron	ASTM A436, Type 2	JIS G5510 FCA-NiCr202			Cast	−45 (−50)	260 (500)
		ASTM A571, Type D-2M, Class 1 & 2	JIS G5510 FCDA-Ni22			Cast	−195 (−320)	260 (500)
	Ductile iron	ASTM A395	JIS G5502	EN 1563 EN-GJS-400-18U-RT	EN-JS1059	Cast	−28 (−20)	260 (500)
	Cast steel	ASTM A216, Grade WCB [d]	JIS G5102 SCW450	EN 10213 GP240GH ISO 4991 G240 similar reference DIN 1681 GS-38	1.0619 1.0420	Cast	−28 (−20)	400 (750)
		ASTM A352, Grade LCB	JIS G5152 SCPL1	GC24E	1.1156	Cast	−45 (−50)	345 (650)
		ASTM A352, Grade LC2	JIS G5152 SCPL21	EN 10213 G9Ni10	1.5636	Cast	−75 (−100)	345 (650)
		ASTM A352, Grade LC3	JIS G5152 SCPL31	EN 10213 G9Ni14	1.5638	Cast	−100 (−150)	345 (650)
		ASTM A352, Grade LC4	similar reference JIS G5152 SCPL31	similar reference EN 10213 G9Ni14	1.5638	Cast	−115 (−175)	345 (650)
		ASTM A352, Grade LC9	JIS G 5101 SC450 JIS G 5101 SC480			Cast	−195 (−320)	205 (400)
		ASTM A352, Grade LCC	similar reference JIS G5152 SCPL1	EN 10213 G17Mn5 EN 10213 G20Mn5 similar reference SEW 685 G26CrMo4	1.1131 1.6220 1.7221	Cast	−45 (−50)	345 (650)

Component	Materials [a]	Material Code [b e]	Equivalent JIS Material	Equivalent EN Material		Form	Temperature Limits	
							Minimum Temperature °C (°F)	Maximum Temperature °C (°F)
		ASTM A217	JIS G5151	EN 10213		Cast	−28 (−20)	345 (650)
	Cast stainless steel	ASTM A743/744 or ASTM A351, Grade CF3, CF3M	CF3: JIS G5121 SCS19A CF3M: JIS G5121 SCS16A CF8: JIS G5121 SCS13A CF8M: JIS G5121 SCS14A	CF3: EN 10213 GX2CrNi19-11 CF3M: EN 10213 GX2CrNiMo19-11-2	1.4309 1.4409	Cast	−195 (−320)	345 (650)
		ASTM A743/744 or ASTM A351CF8 or CF8M		CF8: EN 10213 GX5CrNi19-10 or SEW 685 GX6CrNi18-10 CF8M: EN 10213 GX5CrNiMo19-11-2	1.4308 1.6902 1.4408	Cast	−195 (−320)	345 (650)
		ASTM A351, Grade CF3MA or CF8MA	JIS G5121 SCS19A	CF3MA: EN 10213 GX2CrNiMo19-11-2 CF8MA: EN 10213 GX5CrNiMo19-11-2	1.4409 1.4408	Cast	−195 (−320)	345 (650)
		ASTM A487, Grade CA6NM, Class A and B	JIS G 5121 SCS6	EN 10213 GX4CrNi13-4	1.4317	Cast	−45 (−50)	345 (650)
		ASTM A757, Grade E3N	JIS G 5152 SCPL1	EN 10213 GX3CrNi13-4	1.6982	Cast	−75 (−100)	345 (650)
		ASTM A757, Grade D1Q1	JIS G 5152 SCPL11 (similar reference)	SEW 685 G15CrMo9-10	1.7377	Cast	−28 (−20)	345 (650)
		ASTM A747, Grade CB7Cu-1	JIS G5121 SCS 24			Cast		
	Cast aluminum	ASTM A356 or ASTM A357	JIS G5151	NA		Cast	−195 (−320)	150 (300)
	Cast Hastelloy	ASTM A494, Grade CW2M	JIS H5701 NMCrC (Similar Reference)			Cast		
		ASTM A494, Grade N-7M	JIS H4551 NW0665			Cast		
	Cast titanium	ASTM B367, Grade C3 or C4	C3: JIS H4600 Class 2 C4: NA	NA		Cast	−45 (−50)	150 (300)

Component	Materials [a]	Material Code [b e]	Equivalent JIS Material	Equivalent EN Material		Form	Temperature Limits	
							Minimum Temperature °C (°F)	Maximum Temperature °C (°F)
		ASTM B367, Grade C5	JIS H4600 Class 3			Cast		
Casing, inlet casing, discharge casing								
Fabricated	Steel	ASTM A285, Grade C	JIS G3118 SGV450			Plate	−45 (−50)	345 (650)
		ASTM A516, Grade 55, 60, 65, 70	55: JIS G3118 SGV410 60: JIS G3118 SGV410 65: JIS G3118 SGV450 70: JIS G3118 SGV480	55: EN 10028-2 P235GH 60: EN 10028-2 P265GH 65: EN 10028-2 P355GH EN 10025 S355J2+N 70: EN 10028-2 P355GH	1.0345 1.0425 1.0473 1.0577 1.0473	Plate	−45 (−50)	345 (650)
		ASTM A203, Grade A or B	A: JIS G3127 SL2N255 B: NA	12Ni9	1.5635	Plate	−60 (−75)	345 (650)
		ASTM A203, Grade D or E	D: JIS G3127 SL3N255 E: JIS G3127 SL3N275	EN 10028-4 12Ni14	1.5637	Plate	−105 (−160)	345 (650)
		ASTM A537, Class 1 or 2	1: JIS G3115 SPV355 2: JIS G3115 SPV450	EN 10028-6 P355QH EN 10028-6 P460QH	1.8867 1.8871	Plate	−60 (−75)	345 (650)
		ASTM A353	JIS G3127 SL9N520	EN 10028-3 X8Ni9	1.5662	Plate	−195 (−320)	345 (650)
		ASTM A553, Type I	JIS G3127 SL9N590	EN 10028-3 X8Ni9	1.5662	Plate	−195 (−320)	345 (650)
		ASTM A553, Type II	JIS G3127 SL9N590	EN 10028-3 X8Ni9	1.5662	Plate	−170 (−275)	345 (650)
		ASTM A266, Class 1 or 4	JIS G3202 SFVC1	EN 10222-4 P355NH	1.0565	Forged	−28 (−20)	345 (650)
		ASTM A336, Class F1	JIS G3202 SFVA F1	EN 10222-2 16Mo3	1.5415	Forged	−28 (−20)	345 (650)
		ASTM A414	JIS G3116	EN 10120		Sheet	−28 (−20)	345 (650)
		ASTM A508, Class 5a (now: Grade 5 Class 2)	JIS G3204 SFVQ3	20NiCrMo14-6	1.6742	Forged	−28 (−20)	345 (650)
		ASTM A350, Grade LF2	JIS G3205 SFL2	EN 10222-3 12Ni14	1.5637	Forged	−45 (−50)	345 (650)

Component	Materials [a]	Material Code [b e]	Equivalent JIS Material	Equivalent EN Material		Form	Temperature Limits	
							Minimum Temperature °C (°F)	Maximum Temperature °C (°F)
		ASTM A350, Grade LF3	JIS G3205 SFL3	EN 10222-3 12Ni14	1.5637	Forged	−100 (−150)	345 (650)
		ASTM A266, CL.1	JIS G3202 SFVC1			Forged	−28 (−20)	345 (650)
		ASTM A662, Grade B	JIS G3205 SFL1	EN 10028-4 P355N EN 10028-4 P355NL2	1.0562 1.1106	Plate	−45 (−50)	345 (650)
		ASTM A765, Grade IV	JIS G3201 SF490A	EN 10222-4 P355QH1	1.0571	Forged	−30 (−20)	345 (650)
		ASTM A350, Grade LF6, Class 1	JIS G3201 SF340A	DIN 17103 TStE 355	1.0566	Forged	−50 (−60)	345 (650)
	Stainless steel	ASTM A240, Type 304, 304L, 316, 316L	304: JIS G4304 SUS304, JIS G4305 SUS304 304L: JIS G4304 SUS304L, JIS G4305 SUS304L 316: JIS G4304 SUS316, JIS G4305 SUS316 316L: JIS G4304 SUS316L, JIS G4305 SUS316L 321:JIS G4304 SUS321, JIS G4305 SUS321	304: EN 10028-7 X5CrNi18-10 304L: EN 10028-7 X2CrNi18-9 316: EN 10028-7 X5CrNiMo17-12-2 316L: EN 10028-7 X2CrNiMo17-12-2 or EN 10028-7 X5CrNiMoTi17-12-2 321: EN 10028-7 X5CrNiTi18-10	1.4301 1.4307 1.4401 1.4404 1.4571 1.4541			
		ASTM A240, Type 321						
		ASTM A182, Grade F304, F304L, F316	F304: JIS G3214 SUS F304 F304L: JIS G3214 SUS F304L F316: JIS G3214 SUS F316 F321: JIS G3214 SUS F321	F304: EN 10222-5 X5CrNi18-10 F304L: EN 10222-5 X2CrNi18-9 F316: EN 10222-5 X5CrNiMo17-12-2 or EN 10222-5 X5CrNiMoTi17-12-2 F321: EN 10222-5 X5CrNiTi18-10	1.4301 1.4307 1.4401 1.4571 1.4541	Forged	−195 (−320)	345 (650)
		ASTM A182, Grade F321				Forged	−195 (−320)	345 (650)

Component	Materials [a]	Material Code [b e]	Equivalent JIS Material	Equivalent EN Material		Form	Temperature Limits	
							Minimum Temperature °C (°F)	Maximum Temperature °C (°F)
		ASTM A182, Grade F 6NM	JIS G3214 SUS F6 NM	EN 10222-5 X3CrNiMo13-4	1.4313	Forged	−45 (−50)	345 (650)
		AISI Type 304L	JIS G3214 SUS 304L			Plate	−195 (−320)	345 (650)
	Aluminum	ASTM B209, Alloy 6061 or 7075	6061: JIS H4000 6061 7075: JIS H4000 7075			Plate	−195 (−320)	150 (300)
		ASTM B211, Alloy 6061 or 7075	6061: JIS H4040 6061 7075: JIS H4040 7075			Bar	−195 (−320)	150 (300)
		ASTM B247, Alloy 6061 or 7075	6061: JIS H4140 6061 7075: JIS H4140 7050			Forged	−195 (−320)	150 (300)
		AMS 4108, Alloy 7050	JIS H4140 7050			Forged	−195 (−320)	150 (300)
Diffuser, shroud, guide vanes								
	Cast iron	ASTM A48 or ASTM A278, Class 30	JIS G5501 FC250	EN 1561 EN-GJL-250	EN-JL1040	Cast	−195 (−320)	345 (650)
	Ductile iron	ASTM A536	JIS G5502	EN 1563 EN-GJS-400-15U	EN-JS1072	Cast	−195 (−320)	345 (650)
	Cast steel	ASTM A216, Grade WCB	JIS G5102 SCW450	EN 10213 GP240GH ISO 4991 G240 similar reference DIN 1681 GS-38	1.0619 1.0420	Cast	−195 (−320)	345 (650)
		ASTM A352, Grade LCB	JIS G5152 SCPL1	GC24E	1.1156	Cast	−45 (−50)	345 (650)
	Steel	ASTM A283, ASTM A284, ASTM A285, ASTM A516 or	JIS G3101 SS400	EN 10025 S235JR EN 10025 S355J2+N	1.0038 1.0577	Plate	−195 (−320)	345 (650)
		A543				Plate	−195 (−320)	345 (650)
		ASTM A36	JIS G3101 SS400	EN 10025 S235JR	1.0038	Plate	−195 (−320)	345 (650)

Component	Materials [a]	Material Code [b e]	Equivalent JIS Material	Equivalent EN Material		Form	Temperature Limits	
							Minimum Temperature °C (°F)	Maximum Temperature °C (°F)
	Stainless steel	ASTM A743/744 or ASTM A351, Grade CA15,	JIS G5121 SCS13A, JIS G5121 SCS19A	CF8: EN 10213 GX5CrNi19-10 or SEW 685 GX6CrNi18-10 CF8M: EN 10213 GX5CrNiMo19-11-2	1.4308 1.6902 1.4408	Cast	−195 (−320)	345 (650)
		CF3, CF3M, CF8, or CF8M				Cast	−195 (−320)	345 (650)
		ASTM A240, Type 410	JIS G4304 SUS410, JIS G4305 SUS410	EN 10088-2 X12Cr13	1.4006	Plate	−195 (−320)	345 (650)
		ASTM A276, Type 410	JIS G4303 SUS410	EN 10088-3 X12Cr13	1.4006	Bar	−195 (−320)	345 (650)
		AISI Type 304	JIS G4304 SUS304			Plate	−195 (−320)	345 (650)
		AISI Type 304L	JIS G3214 SUSF304L	similar reference EN 10250 X6CrNiTi18-10	1.4541	Plate	−195 (−320)	345 (650)
		ASTM A182, Grade F321, F316Ti	F321: JIS G 3214 SUS F 321 F316Ti:	F316 Ti: EN 10250 X6CrNiMoTi17-12-2 F321: EN 10250 X6CrNiTi18-10	1.4571 1.4541	Forged	−195 (−320)	345 (650)
		ASTM A662, Grade B	JIS G3205 SFL1	EN 10028-4 P355N EN 10028-4 P355NL2	1.0562 1.1106	Plate	−195 (−320)	345 (650)
		ASTM A350, Grade LF6, Class 1	JIS G3201 SF340A	DIN 17103 TStE 355	1.0566	Forged	−195 (−320)	345 (650)
		ASTM A182, Grade F 6NM	JIS G3214 SUS F6 NM	EN 10250 X3CrNiMo13-4	1.4313	Forged	−195 (−320)	345 (650)
		ASTM A487, Grade CA6NM, Class A and B	JIS G5151 SCPH 32 （Similar reference）	EN 10213 GX4CrNi13-4	1.4317	Cast	−195 (−320)	345 (650)
		ASTM A757, Grade E3N	JIS G5152 1991 SCPL1	EN 10213 GX3CrNi13-4	1.6982	Cast	−195 (−320)	345 (650)
	Titanium	ASTM B367, Grade C5	JIS H4600 Class 3			Cast		
	Aluminum	ASTM B26, Alloy 355 or C355	JIS H5202 AC4D	.		Cast	−195 (−320)	345 (650)

Component	Materials [a]	Material Code [b e]	Equivalent JIS Material	Equivalent EN Material		Form	Temperature Limits	
							Minimum Temperature °C (°F)	Maximum Temperature °C (°F)
Fixed, pre-whirl, de-whirl, and variable stator vanes								
	Stainless steel	ASTM A478, Type 347	JIS G4309 SUS347			Bar	−195 (−320)	345 (650)
		ASTM A240, Type 304 or 304L	304: JIS G4304 SUS304, JIS G4305 SUS304 304L: JIS G4304 SUS304L, JIS G4305 SUS304L			Plate	−195 (−320)	345 (650)
		ASTM A276, Type 316/316L	316: JIS G4303 SUS316 316L: JIS G4303 SUS316L			Bar	−195 (−320)	345 (650)
Shaft								
	Steel	ASTM A470, Class 1	similar reference JIS G3201 SF540A			Forged	−28 (−20)	345 (650)
		ASTM A470, Class 7	similar reference JIS G3204 SFVQ3	SEW 555 26NiCrMoV11-5 SEW 555 26NiCrMoV14-5	1.6948 1.6957	Forged	−115 (−175)	400 (750)
		AISI Type 4340	JIS G4053 SNCM439	EN 10083-3 30CrNiMo8	1.6580	Forged	−115 (−175)	345 (650)
		AISI Type 4140	JIS G4053 SCM440	EN 10083-3 42CrMo4	1.7225	Forged	−28 (−20)	400 (750)
		AISI Types 1040-1050 [c]	JIS G4051 S40C	EN 10083-2 C45E	1.1191	Bar or Forged	−28 (−20)	345 (650)
		AISI Types 4140-4150 [c]	JIS G4053 SCM440	EN 10083-3 42CrMo4	1.7225	Bar or Forged	−28 (−20)	400 (750)
		AISI Type 2320 [C]	NA			Bar or Forged	−110 (−170)	345 (650)

Component	Materials [a]	Material Code [b e]	Equivalent JIS Material	Equivalent EN Material		Form	Temperature Limits	
							Minimum Temperature °C (°F)	Maximum Temperature °C (°F)
		AISI Type 2330	NA			Bar or Forged	−110 (−170)	345 (650)
		AISI Type 9310	JIS G4053 SNCM 625			Bar or Forged		
		ASTM A522, Type 1	JIS G3127 SL9N520	EN 10222-3 X8Ni9	1.5662	Forged	−195 (−320)	345 (650)
		ASTM 4340-4345	ASTM maybe replaced to AISI. JIS G4053 SNCM439	EN 10083-3 30CrNiMo8 ISO 4957 55NiCrMoV7	1.6580 1.2714	Forged	−115 (−175)	345 (650)
	Stainless steel	ASTM A336, Grade F6	G3214 SUS F410-C	EN 10088-3 X12Cr13	1.4006	Forged	−60 (−75)	345 (650)
		ASTM A473, Type 410	JIS G3214 SUS F410	EN 10088-3 X12Cr13	1.4006	Forged	−60 (−75)	345 (650)
		ASTM A1021, Grade D, Class 2 (422)	NA			Forged	−60 (−75)	345 (650)
		ASTM A182, Grade F 6NM	JIS G3214 SUS F6 NM	EN 10250 X3CrNiMo13-4	1.4313	Forged	−60 (−75)	345 (650)
	Precipitation hardening stainless steel	ASTM A705, Type 630 or XM-12	JIS G3214 SUS F630	EN 10250 X5CrNiCuNb16-4	1.4542	Forged	−75 (−100)	345 (650)
	Nickel alloys	ASTM A564, Type 630 or XM-12	JIS G4303 SUS630	EN 10250 X5CrNiCuNb16-4	1.4542	Bar	−270 (−454)	345 (650)
		AMS 4676	JIS H4553			Bar		
Impellers								
Cast and forged	Aluminum	ASTM B26, Alloy C355	JIS H5202 AC4C			Cast	−195 (−320)	150 (300)
	Precipitation hardening stainless steel	ASTM A747, Type CB7CU-1 or CB7CU-2	JIS G5121 SCS 24			Cast	−75 (−100)	345 (650)
	Steel	ASTM A148	JIS G5111			Cast	−28 (−20)	345 (650)
		ASTM A487, Gs 4Q	JIS G5111 SCMnCrM2			Cast	−45 (−50)	345 (650)

Component	Materials [a]	Material Code [b e]	Equivalent JIS Material	Equivalent EN Material		Form	Temperature Limits	
							Minimum Temperature °C (°F)	Maximum Temperature °C (°F)
	Stainless steel	ASTM A743/744 or ASTM A351, Grade CA15	JIS G5121 SCS1			Cast	−45 (−50)	345 (650)
		or CA6NM				Cast	−45 (−50)	345 (650)
		ASTM A743/744 or ASTM A351, Grade CF3, CF3M,	CF3: JIS G5121 SCS19A CF3M: JIS G5121 SCS16A CF8: JIS G5121 SCS13A CF8M: JIS G5121 SCS14A			Cast	−195 (−320)	345 (650)
		CF8, or CF8M				Cast	−195 (−320)	345 (650)
	Aluminum	ASTM A356 or ASTM A357	JIS G5151			Cast	−195 (−320)	150 (300)
	Titanium	ASTM B367, Grade C3 or C4	C3: JIS H4600 Class 2 C4: NA			Cast	−45 (−50)	345 (650)
		ASTM B367, Grade C5	JIS H4600 Class 3			Cast	−195 (−320)	345 (650)
		ASTM B348, Grade 5	JIS H4650 Class 60			Cast		
		ASTM B348, Grade 19	NA			Cast		
		ASTM B381, Grade F-19	NA			Forged		
	Inconel	ASTM B637, Alloy N07718	JIS G4902 NCF718			Bar or Forged		
Fabricated (covers, hubs, blades)	Aluminum	ASTM B209, Alloy 6061 or 7075	6061: JIS H4000 6061 7075: JIS H4000 7075			Plate	−195 (−320)	150 (300)
		ASTM B211, Alloy 6061 or 7075	6061: JIS H4040 6061 7075: JIS H4040 7075			Bar	−195 (−320)	150 (300)

Component	Materials [a]	Material Code [b e]	Equivalent JIS Material	Equivalent EN Material		Form	Temperature Limits	
							Minimum Temperature °C (°F)	Maximum Temperature °C (°F)
		ASTM B221, Alloy 6061 or 7075	6061: JIS H4040 6061 7075: JIS H4040 7075			Extruded	−195 (−320)	150 (300)
		ASTM B247, Alloy 2618,	2618: JIS H4140 2618 6061: JIS H4140 6061 7075: JIS H4140 7050			Forged	−195 (−320)	150 (300)
		6061, or 7075				Forged	−195 (−320)	150 (300)
		AMS 4108, Alloy 7050	JIS H4140 7050			Forged	−195 (−320)	150 (300)
Impellers, fabricated	Steel	AISI Types 4130–4140 [c]	JIS G4053 SCM430	EN 10083-3 42CrMo4	1.7225	Plate or Forged	−28 (−20)	400 (750)
		AISI Types 4320–4345 [c]	JIS G4053 SNCM431	EN 10083-3 30CrNiMo8	1.6580	Plate or Forged	−115 (−175)	400 (750)
		ASTM A470, Class 8	JIS G3221 SFCM 740S (similar reference)	14CrMoV6-9	1.7735	Forged	−45 (−50)	400 (750)
		AISI Type 3140 [c]	similar reference JIS G4102 SNC236			Forged	−45 (−50)	400 (750)
		ASTM A543	JIS G3101 SS400			Plate	−115 (−175)	400 (750)
		ASTM A522, Type I	JIS G3127 SL9N520	EN 10222-3 X8Ni9	1.5662	Forged	−145 (−230)	345 (650)
		ASTM A522, Type II	JIS G3127 SL9N520	EN 10222-3 X8Ni9	1.5662	Forged	−170 (−275)	345 (650)
		ASTM A353	JIS G3127 SL9N520	EN 10222-3 X8Ni9	1.5662	Plate	−195 (−320)	345 (650)
		AISI Type 403 [c]	JIS G3214 SUS F403	EN 10088-3 X6Cr13	1.4000	Forged	−60 (−75)	345 (650)
		ASTM A473, Type 410	JIS G3214 SUS F410	EN 10088-3 X12Cr13	1.4006	Forged	−60 (−75)	345 (650)

Component	Materials [a]	Material Code [b e]	Equivalent JIS Material	Equivalent EN Material		Form	Temperature Limits	
							Minimum Temperature °C (°F)	Maximum Temperature °C (°F)
		ASTM A240, Type 304, 304L, 316	304: JIS G4304 SUS304, JIS G4305 SUS304 304L: JIS G4304 SUS304L, JIS G4305 SUS304L 316: JIS G4304 SUS316, JIS G4305 SUS316 316L: JIS G4304 SUS316L, JIS G4305 SUS316L	304: EN 10028-7 X5CrNi18-10 304L: EN 10028-7 X2CrNi18-9 316: EN 10028-7 X5CrNiMo17-12-2 316L: EN 10028-7 X2CrNiMo17-12-2	1.4301 1.4307 1.4401 1.4404	Plate	−195 (−320)	345 (650)
		ASTM A473, Type 304, 304L, 316, or 316L	304: JIS G3214 SUS F304 304L: JIS G3214 SUS F304L 316: JIS G3214 SUS F316 316L: JIS G3214 SUS F316L	F304: EN 10222-5 X5CrNi18-10 F304L: EN 10222-5 X2CrNi18-9 F316: EN 10222-5 X5CrNiMo17-12-2 F316L: EN 10222-5 X2CrNiMo17-12-2	1.4301 1.4307 1.4401 1.4404	Forged	−195 (−320)	345 (650)
		UNS S42400	NA	EN 10250 X3CrNiMo13-4	1.4313	Forged	−101 (−150)	345 (650)
		AISI Type 410	JIS G4303 SUS410	NA		Forged	−60 (−75)	345 (650)
		ASTM A638, Grade 660, Type 2 (A286)	JIS G4311 SUH660	EN 10302 X6NiCrTiMoVB25-15-2	1.4980			345 (650)
		AISI Types 4130–4140 [c]	JIS G4053 SCM430	EN 10083-3 42CrMo4	1.7225	Plate or Forged	−28 (−20)	400 (750)
	Precipitation hardening stainless steel	ASTM A705, Type 630 or XM-12	JIS G3214 SUS F630	EN 10250 X5CrNiCuNb16-4	1.4542	Forged	−75 (−100)	345 (650)
		AISI S17400	JIS G4303 SUS630				−75 (−100)	345 (650)
		ASTM A693, Type 630 or XM-12	JIS G4304 SUS630, JIS G4305 SUS630	EN 10088-2 X5CrNiCuNb16-4	1.4542	Plate	−75 (−100)	345 (650)
	Ni-based	AMS 5662 Alloy 718	JIS G 4902 NCF718			Forged	−110 (−170)	345 (650)
	Ni-Cu	SAE AMS 4646	NA	?		Forged	−115 (−175)	345 (650)

Component	Materials [a]	Material Code [b e]	Equivalent JIS Material	Equivalent EN Material		Form	Temperature Limits	
							Minimum Temperature °C (°F)	Maximum Temperature °C (°F)
		ASTM B127	JIS H4551			Plate	−115 (−175)	345 (650)
		QQ-N-286	JIS H4551 NW5500			Plate	−115 (−175)	345 (650)
		ASTM B865, UNS N05500	JIS H4551 NW5500	DIN 17743 NiCu30Al ISO 9725 NiCu30Al3Ti	2.4375 NW5500	Forging	−115 (−175)	345 (650)
	Titanium	ASTM B381, Grade F5	JIS H4657 TAF6400	DIN 17864 TiAl6V4	3.7165	Forging	−195 (−320)	345 (650)
Rotor blades								
	Stainless steel	UNS S45000	NA			Forged or Bar	−60 (−75)	345 (650)
		UNS S42200	JIS G4311 SUH616			Forged or Bar	−60 (−75)	345 (650)
	Titanium	AMS 4928 Ti-6Al-4V	JIS H4650 Class 60			Forged or Bar	−60 (−75)	345 (650)
Shaft sleeves	Steel	AISI Types 4130–4150 [c]	JIS G4053 SCM440	EN 10083-3 42CrMo4	1.7225	Forged	−45 (−50)	345 (650)
		AISI Types 4320, 4345 [c]	JIS G4053 SNCM431	EN 10083-3 30CrNiMo8	1.6580	Forged	−115 (−175)	400 (750)
		AISI Type 4330 [c]	JIS G4053 SNCM431			Forged	−115 (−175)	400 (750)
		ASTM A470, Class 7	similar reference JIS G3201 SF540A	SEW 555 26NiCrMoV11-5 SEW 555 26NiCrMoV14-5	1.6948 1.6957	Forged	−115 (−175)	400 (750)
		ASTM A522, Type I	JIS G3127 SL9N520	EN 10222-3 X8Ni9	1.5662	Forged	−195 (−320)	345 (650)
		ASTM A106	JIS G3456	EN 10216		Pipe	−28 (−20)	345 (650)
		ASTM A350	JIS G3205	EN 10250		Forged	−45 (−50)	345 (650)
		ASTM A350, Grade LF-3	JIS G3205 SFL3	EN 10250 12Ni14	1.5637	Forged	−100 (−150)	345 (650)

Component	Materials [a]	Material Code [b e]	Equivalent JIS Material	Equivalent EN Material		Form	Temperature Limits	
							Minimum Temperature °C (°F)	Maximum Temperature °C (°F)
	Stainless steel	AISI Types 403 or 410 [c]	403: JIS G3214 SUS F403 410: JIS G3214 SUS F410	EN 10088-3 X6Cr13 EN 10088-3 X12Cr13	1.4000 1.4006	Forged	−75 (−100)	400 (750)
	Ni-Cu alloy	ASTM B164 or SAE AMS 4676	JIS H4553			Forged	−115 (−175)	345 (650)
	Ni-Mo-Cr alloy	ASTM B574, Alloy N10276	JIS H4551 NW0276	DIN 17744 NiMo16Cr15W ISO 9725 NiMo16Cr15Fe6W4	2.4819 NW0276	Wrought	−115 (−175)	345 (600)
		ASTM A494, Grade CW-12M-1	similar reference JIS H5701 NMCrC			Cast	−115 (−175)	345 (650)
	Precipitation hardening stainless steel	ASTM A705, Type 630 or XM-12	JIS G3214 SUS F630	EN 10250 X5CrNiCuNb16-4	1.4542	Forged	−75 (−100)	345 (650)

[a] The materials shown in this table are those commonly used by compressor manufacturers, but the list is not all inclusive. Other suitable materials may exist and may be used as indicated by specific design considerations.

[b] Descriptions of AISI Types (cross-referenced to UNS) can be found in SAE HS1086. Descriptions of UNS Types can also be found in ASTM DS 56J.

[c] The temperature limits shown in this table are those commonly observed by compressor manufacturers and are not necessarily the same as any temperature limits specified in the applicable material specifications.

[d] Normalized or normalized and tempered.

[e] AISI and UNS designations are only a description of chemical analyses of types of steels; they are not procurement specifications. All materials should be purchased to a specification that adequately defines the required properties and controls.

Annex E
(informative)

Inspector’s Checklist

Item	Standard 617		Date Inspected	Inspected By	Status
	Section	Part			
4.5 MATERIALS					
Coating applied prior to acceptance balance	4.5.1.15	1			
PMI	4.5.1.16.1	1			
Impact testing	4.5.1.17.5	1			
Castings—material specification compliance	4.5.2.1	1			
Castings—purchaser approval of repairs	4.5.2.3.3	1			
Castings—ductile (nodular) iron	4.5.2.5	1			
Forgings—repairs	4.5.3.2	1			
Welding—nonpressure components	4.5.4.1	1			
Welding—pressure-containing and rotating parts	4.5.4.2	1			
4.6 CASINGS					
Jackscrews, dowels, and special tools	4.6.1.4	1			
Depth of threaded holes	4.6.1.5	1			
Studs instead of cap screws	4.6.1.7.2	1			
Socket-head or spanner-type bolting	4.6.1.2	3			
Adequate clearance at bolts	4.6.1.7.3	1			
Bolting materials	4.6.1.7.6	1			
Welding	4.6.1.8	1			
Casing repair—minimum level of inspection and purchaser review	4.6.2.1	1			
Casing repair—major repairs	4.6.2.2	1			
Casing repair—material standards	4.6.2.3	1			
Pressure casings—plate edges	4.6.2.4.1	1			
Pressure casings—MPT or LPT	4.6.2.4.2	1			
Pressure casings—weld QC	4.6.2.4.3	1			
Pressure casings—full penetration welds	4.6.2.4.4	1			
Casings—heat treatment	4.6.2.4.5	1			
Pressure-containing weld inspection	4.6.2.4.6	1			
Materials inspection standards	4.6.3.2	1			
Cast steel casings—acceptability of defects	4.6.3.3	1			
Pressure casing connection size	4.6.4.1.3	1			
Casing connections—welding before hydrotest	4.6.4.1.5	1			
Main process connection orientation	4.6.4.2.1	1			
Flanges	4.6.4.2.2	1			
Cast iron flanges	4.6.4.2.6	1			
Concentricity of bolt circle and bore	4.6.4.2.12	1			
Steel flange facing finish	4.6.4.2.13	1			
Machined and studded connections	4.6.4.2.14	1			
Flanges parallel within 0.5 degrees	4.6.4.2.15	1			
Auxiliary connections—minimum size	4.6.4.2.2	3			
Auxiliary connections—threaded	4.6.4.2.3	3			

Auxiliary connections—flanges	4.6.4.3.2	1			
Auxiliary connections—allowable types	4.6.4.3.3	1			
Auxiliary connections—pipe nipples	4.6.4.3.4	1			
Auxiliary connections—socket weld gap	4.6.4.3.6	1			
Auxiliary connections—lube or seal service	4.6.4.3.7	1			
Threaded openings for tapered pipe threads	4.6.4.3.8.1	1			
Tapered pipe threads	4.6.4.3.8.2	1			
Seal welding tapered pipe threads	4.6.4.3.8.3	1			
Pipe nipples for threaded openings	4.6.4.3.8.4	1			
Plugs for threaded openings	4.6.4.3.8.5	1			
Machine mounting surfaces	4.6.5.1	1			
4.7 ROTATING ELEMENTS					
Shaft ends for couplings	4.7.1	1			
Impeller and shaft marking	4.7.1	3			
Shaft sensing areas for probes	4.7.2	1			
Shaft sensing areas—final surface finish	4.7.3	1			
Thrust collar surface finish and TIR	4.7.6	1			
Fabricated impeller inspection	4.7.10.3	1			
Cast impeller inspection	4.7.10.4	1			
Cast impeller repair	4.7.10.5	1			
Welding not permitted for impeller balancing	4.7.10.6	1			
MPT or LPT of impellers after overspeed	4.7.10.7	1			
4.8 DYNAMICS					
Confirmation of critical speeds	4.8.2.2	1			
Unbalanced rotor response verification test	4.8.3	1			
Additional testing	4.8.4.1	1			
Rotating element—component balance	4.8.8.1	1			
Rotating element—sequential multiplane balance	4.8.8.2	1			
Rotating element—if disassembled after balance	4.8.8.2.1	1			
Rotating element—reassembly check balance	4.8.8.2.2	1			
Operating speed balance	4.8.8.3	1			
Operating speed balance procedure	4.8.8.4	1			
4.11 INTEGRAL GEARING (Part 3)					
Doweled or keyed gearbox	4.11.1	3			
Inspection cover	4.11.1.4	3			
Documentation for gearing quality level	4.11.3.5	3			
Tooth surface finish	4.11.3.13	3			

4.12 NAMEPLATES AND ROTATION ARROWS					
Nameplate at readily visible location	4.12.1	1			
Nameplate material	4.12.2	1			
Nameplate contents	4.12.2	3			
Rotation arrows	4.12.3	3			
Lateral critical speeds on nameplate	4.12.5	1			
5.4 MOUNTING PLATES					
Jackscrews	5.4.1.2.1	1			
Alignment shims	5.4.1.2.2	1			
Machinery mounting surfaces	5.4.1.2.3	1			
Anchor bolt clearance	5.4.1.2.8	1			
Vertical leveling screws	5.4.1.2.9	1			
Radiused corners for grout	5.4.1.2.10	1			
Hold down bolt clearance	5.4.1.2.12	1			
Wrench clearance	5.4.1.2.13	1			
Grout contacting surface preparation	5.4.1.2.15	1			
Mounting surface preservation	5.4.1.2.17	1			
Seal welded joints	5.4.2.3	1			
Leveling pads or targets	5.4.2.6.1	1			
Additional pads or targets	5.4.2.6.2	1			
Lifting lugs	5.4.2.7	1			
Grout fill and vent holes	5.4.2.8	1			
Soleplates supplied	5.4.3	3			
Soleplate thickness	5.4.3.1.1	1			
Soleplate size	5.4.3.1.2	1			
Soleplates fully machined	5.4.3.1.4	1			
Sub-soleplates	5.4.3.1.5	1			
5.5 CONTROLS AND INSTRUMENTATION					
Controls ingress protection level	5.5.1.6	1			
Terminal box ingress protection level	5.5.1.7	1			
Conduit and cable location and installation	5.5.1.8	1			
Transducers per API 670	5.5.7.2	3			
Monitors per API 670	5.5.7.3	3			
Bearing temperature sensors per API 670	5.5.7.4	3			
Bearing temperature monitor per API 670	5.5.7.6	3			
Accelerometer per API 670	5.5.7.7	3			
Accelerometer monitor per API 670	5.5.7.8	3			

5.6 PIPING AND APPURTENANCES					
Breakout spools	5.6.1.4	1			
Provisions to bypass bearings	5.6.1.5	1			
Provisions to bypass dry gas seals	5.6.1.6	1			
Instrument piping	5.6.2	1			
Process piping	5.6.3	1			
5.7 SPECIAL TOOLS					
Use of tools	5.7.1	1			
Tool packing and marking	5.7.2	1			
6.1 INSPECTION, TESTING, AND PREPARATION FOR SHIPMENT—GENERAL					
Access to vendor's quality control program	6.1.7	1			
6.2 INSPECTION					
Painting before hydrotest	6.2.1.1	1			
Cleanliness	6.2.1.3	1			
Hardness of parts, welds, and heat affected zones	6.2.1.5	1			
Radiographic inspection	6.2.2.2	1			
Ultrasonic inspection	6.2.2.3	1			
Magnetic particle inspection	6.2.2.4	1			
Liquid penetrant inspection	6.2.2.5	1			
Gear contact checks	6.2.1.1	3			
6.3 TESTING					
Contract shaft seals and bearings used	6.3.1.1.1	3			
Oil system cleanliness before testing	6.3.1.1.4	3			
Joint and connection tightness	6.3.2.5 6.3.1.1.5	1 3			
Warning, protective, and control devices	6.3.2.6 6.3.1.1.6	1 3			
Hydrostatic test—pressure	6.3.3.1	1			
Hydrostatic test—duration	6.3.3.2	1			
Hydrostatic test—chloride content	6.3.3.3	1			
Impeller overspeed test	6.3.4.1	1			
Residual magnetism	6.3.5	1			
Dry gas seals	6.3.6	1			
Mechanical running test—operation of equipment and test instrumentation	6.3.7.1.1 6.3.1.3.1	1 3			
Mechanical running test—unfiltered vibration	6.3.7.1.2	1			
Mechanical running test—casing vibration	6.3.1.3.2	3			
Mechanical running test—vibration plots	6.3.7.1.3	1			
Mechanical running test—real time vibration data recorded	6.3.7.1.4 6.3.1.3.6	1 3			
Mechanical running test—seal flow data	6.3.7.1.5 6.3.1.2.4	1 3			
Mechanical running test—lube oil and seal oil variations	6.3.7.1.6	1			

Mechanical running test—hydrodynamic bearing inspection	6.3.7.2.1	1			
Mechanical running test—shaft end seal inspection	6.3.7.3	1			
Mechanical running test—tooth mesh inspection	6.3.1.4.1	3			
Mechanical running test—spare rotor	6.3.1.4.2	3			
Gas test after hydro	6.3.9.3	1			
Assembled compressor gas leak test—seal pressure	6.3.2.2	3			
Assembled compressor gas leak test—max discharge pressure	6.3.2.3	3			
Sound-level test	6.3.9.4	1			
Auxiliary equipment test	6.3.9.5	1			
Post-test inspection of internals	6.3.9.6	1			
Full-pressure/full-load/full-speed test	6.3.9.7	1			
Post-test inspection of coupling fit	6.3.9.8	1			
Spare parts test	6.3.9.9	1			
6.4 PREPARATION FOR SHIPMENT					
Preparation for shipment	6.4.1	1			
Testing completed and equipment released	6.4.3	1			
Coating on exterior surfaces	6.4.3.1	1			
Exterior machined surfaces coating	6.4.3.2	1			
Interior of equipment	6.4.3.3	1			
Internal surfaces of bearing housings	6.4.3.4	1			
Flange covers	6.4.3.5	1			
Threaded openings	6.4.3.6	1			
Beveled welding openings	6.4.3.7	1			
Lifting point identification	6.4.3.8	1			
Equipment tagging and packing lists	6.4.3.9	1			
Spare rotor storage preparation	6.4.3.10	1			
Spare rotor container	6.4.3.10.1	1			
Cradle support liner	6.4.3.11	1			
Rotor preparation for vertical storage	6.4.3.12	1			
Fit-up and assembly of piping and intercoolers	6.4.3.13	1			
Shaft and coupling protection	6.4.3.14	1			
Auxiliary connection marking	6.4.4	1			
Auxiliary piping match marks	6.4.5	1			
IOM shipped with equipment	6.4.6	1			
Wood used in export shipping	6.4.7	1			

Annex F
(informative)

External Forces and Moments

External Forces and Moments

For integrally geared compressors, it is not possible to give a formula to calculate the maximum allowable piping forces and moments on each casing flange. The limiting criteria are the gear contact pattern and the impeller/stator gap. The maximum value of the external forces and moments, which leads to acceptable deformations and therefore acceptable changes of the gear contact pattern and the impeller/stator gap, depends on various parameters. These parameters include:

a) volute geometry,

b) volute wall thickness,

c) length of overhang,

d) gear case geometry,

e) gear case wall thickness.

The possible combinations are nearly endless and unique for each manufacturer's design. Each manufacturer has limits based on his/her experience for each volute size and gear case combination for a given specific machine. The values are available from the manufacturer with the quotation. Allowable nozzle loads on integrally geared compressors are much less than beam or overhung compressors covered in Part 2. It is a common practice on integrally geared compressors to require expansion joints in order to minimize the piping loads on the machine flanges and to insure that piping loads are within the allowable limits for the particular unit. If expansion joints are not to be allowed or if they are very preferably to be avoided if at all possible, it is necessary to obtain values for allowable nozzle loading very early; preferably in the quotation stage. This facilitates the piping discipline to allow for a carefully designed piping system which will meet the manufacturer's allowable nozzle loading criteria.

See 4.6.6.1 of Part 3. Allowable nozzle loading on main process nozzles that are customer connections should be supplied with the quotation. In the event these values are not furnished, they should be a minimum of the values in NEMA SM-23. Where not supplied, NEMA SM-23 values can therefore be used to develop the piping design.

NOTE Where a supplier has furnished nozzle loadings, they can be less than allowed by NEMA SM-23.

Annex G
(normative)

Rating Formulae for Integral Gearing

G.1 Rating Formulas for Integrally Geared Compressor

The rating formula's given below are based on the methods from AGMA 2101-D04. The constant of 0.8 at the beginning of the formulas below is to provide increased reliability.

G.2 Pitting Resistance Power Rating

The pitting resistance allowable transmitted power (kw), P_{az}, for a gear set is:

$$P_{az} = 0.8\left(\frac{\omega_1 b}{1.91\times10^7}\right)\left(\frac{Z_1}{K_v K_H C_{\mathrm{SF}}}\right)\left(\frac{d_{w1}\sigma_{\mathrm{HP}} Z_N}{Z_E}\right)^2 \quad \text{(G.1)}$$

where

ω_1 is the pinion speed (rpm);

σ_{HP} is the allowable contact stress number (see G.7) (N/mm^2);

b is the face width (mm);

d_{w1} is the operating pitch diameter of pinion (mm) = $2a/(u+1)$;

a is the operating center distance (mm);

u is the gear tooth ratio (never less than 1.0);

C_{SF} is the API 617 service factor;

K_v is the dynamic factor (see G.5);

K_h is the load distribution factor (see G.4);

Z_E is the elastic coefficient = 190 [N/mm^2]$^{0.5}$ for steel pinion and gear;

Z_I is the geometry factor (reference AGMA 908);

Z_N is the stress cycle factor for pitting resistance (see G.6).

G.3 Bending Strength Power Rating

The bending strength allowable transmitted power (kw), P_{ay}, for a gear pair is:

$$P_{ay} = 0.8\left(\frac{\omega_1 d_{w1}}{1.91\times10^7}\right)\left(\frac{bm_t Y_J \sigma_{\mathrm{FP}} Y_N}{K_V K_H K_{\mathrm{SF}}}\right) \tag{G.2}$$

where

m_t is the transverse module (equal to normal module divided by the cosine of the helix angle at the standard pitch diameter);

Y_J is the geometry factor (reference AGMA 908);

K_{SF} is the API 617 SF;

σ_{FP} is the allowable bending stress number (see G.7) (N/mm^2);

Y_N is the stress cycle factor for bending (see G.6).

G.4 Load Distribution Factor, K_H

If the value of K_H calculated below is less than 1.1, then 1.1 shall be used as the value of K_H. Gear designs shall not result in a calculated value of K_H over 1.50 without approval from the purchaser.

$$K_H = 1.0 + 0.8\left(K_{Hpf} + 0.054 + 0.4032\times10^{-3} b - 1.152\times10^{-7} b^2\right) \tag{G.3}$$

where

b is the face width of narrower member of gear set (mm);

K_{Hpf} = bod – 0.025 when $b \le 25$ mm,

= bod – 0.0375 + 0.000492b when $25 < b \le 432$,

= bod – 0.1109 + 0.000815b – 3.53 $\times10^{-7} b^2$ when $432 < b \le 1020$;

bod = the greater of 0.05 or $b/(10 d_{w1})$.

NOTE The distance from the center of the gear mesh to the center of the bearing span divided by the bearing span should be less than 0.175. Leads should be properly modified by crowning or lead correction. The tooth contact should be checked at assembly, with contact adjustments as required. If these conditions are not met, or for wide face gears, an analytical approach may be used to determine a more conservative load distribution factor, with prior approval by the purchaser.

G.5 Dynamic Factor, K_v

ISO 1328 Grade 5 = > K_v = 1.135

ISO 1328 Grade 4 = > K_v = 1.120

ISO 1328 Grade 3 = > K_v = 1.105

ISO 1328 Grade 2 = > K_v = 1.090

The dynamic factor, K_v, does not account for dynamic tooth loads that may occur due to torsional or lateral natural frequencies. System designs should avoid having such natural frequencies close to an excitation frequency associated with an operating speed since the resulting gear tooth dynamic loads may be very high.

G.6 Stress Cycle Factors, Z_N and Y_N

Z_N = $2.466N^{-0.056}$, pitting resistance stress cycle (life) factor;

Y_N = $1.6831N^{-0.0323}$, bending strength stress cycle (life) factor;

N is the number of stress cycles;

N = pinion rpm $\times$ 1.052 $\times$ 10^7 for the pinion;

N = gear rpm $\times$ 1.052 $\times$ 10^7 $\times$ number of pinions in mesh for the bull gear.

NOTE These factors are based on the lower line in Figure 17 and Figure 18 of ANSI/AGMA 2101-D04 with 175,316 hours (20 years $\times$ 365.242 days/year $\times$ 24 hours/day) of continuous service at rated operating speed.

G.7 Allowable Stress Numbers, σ_{HP} and σ_{FP}

The values of σ_{HP} and σ_{FP} shall be for Grade 2 materials per ANSI/AGMA 2101-C95, Section 16.

G.8 Reverse Loading

For idler gears and other gears where the teeth are completely reverse loaded on every cycle, use 70 % of the allowable bending stress number, σ_{FP}, in ANSI/AGMA 2101-D04.

G.9 Service Factor, C_{SF} and K_{SF}

The service factor used for integrally geared centrifugal compressors shall be 1.4 when driven by an induction motor, 1.6 when driven by a gas or steam turbine, and 1.7 when driven by a synchronous motor or internal combustion engine.

Axial and Centrifugal Compressors and Expander-compressors

Part 4—Expander-compressors

1 Scope

This standard specifies minimum requirements and gives recommendations for axial compressors, single-shaft and integrally geared process centrifugal compressors, and expander-compressors for special purpose applications that handle gas or process air in the petroleum, chemical, and gas industries. This part of API 617 specifies requirements for expander-compressors, in addition to the general requirements specified in Part 1.

This scope covers only expanders and compressors on a common shaft (expander-compressor). This scope does not apply to expanders with separate output shafts (e.g. generator drives). Hot gas expanders over 300 °C (570 °F) are not covered in this standard.

2 Normative References

Referenced documents indispensable for the application of this document are listed under Part 1: Section 2.

3 Terms, Definitions, and Abbreviations

For the purposes of this document, the terms, definitions, and abbreviations given in Part 1 apply.

NOTE A cross section showing nomenclature of an expander-compressor may be found in Annex C.

4 General

4.1 Dimensions and Units

The dimensional and unit requirements of Part 1 shall apply.

4.2 Statutory Requirements

The statutory requirements of Part 1 shall apply.

4.3 Unit Responsibility

The unit responsibilities of Part 1 shall apply.

4.4 Basic Design

4.4.1 The expander shall meet at least 98 % of the predicted efficiency at the certified point (see 6.3.5.1.1). The compressor shall deliver at least 98 % of the normal head at the normal capacity. The compressor power at the normal condition shall not be more than 106 % of that available from the expander, nor shall it be less than 96 % of that available from the expander.

NOTE Compressor-loaded expanders achieve a power balance that determines the speed of the machine. There is generally no speed control governor to control the speed the way other turbine driven compressors are controlled. If the expander power is more than expected, then the speed of the machine will be higher than predicted. If the compressor power is more than expected, then the speed of the machine will be lower than predicted. The above tolerances are needed to set limits beyond which hardware changes will be required to achieve a reasonable normal speed.

4.4.2 The compressor head-capacity characteristic curve at the rated speed shall rise continuously from the rated point to surge. The compressor shall be suitable for continuous operation at any capacity on the predicted performance curve(s) at least 10 % greater than the predicted surge capacity shown in the proposal.

NOTE It is common for flow to be bypassed around the compressor during normal operation.

4.5 Materials

Materials shall be in accordance with 4.5 of Part 1. Refer to Annex D for a table of typical materials.

4.5.1 If traces of mercury have been specified, aluminum impellers shall be treated by anodizing or other approved methods.

4.6 Casings

Casings shall be in accordance with 4.6 of Part 1 and the additional requirements as follows.

4.6.1 Pressure-containing Casings

- **4.6.1.1** The maximum allowable working pressure (MAWP) of the casing(s) shall be at least equal to the relief valve set pressure(s) specified by the purchaser.

4.6.1.1.1 If a relief valve set pressure is not specified, the MAWP of an expander casing shall be at least 1.1 times the maximum specified inlet pressure (gauge). System pressure protection shall be furnished by the purchaser.

4.6.1.1.2 If a relief valve set pressure is not specified, the MAWP of the compressor casing of an expander-compressor shall be at least 1.25 times the maximum specified discharge pressure (gauge). System pressure protection shall be furnished by the purchaser.

4.6.1.1.3 When the purchaser has not supplied a relief valve setting, he shall be responsible for insuring that furnished relief valves are compatible with casing ratings as set by 4.6.1.1.1 and 4.6.1.1.2.

4.6.1.2 O-rings, gaskets or other sealing devices which may be used on radially spilt casings shall be confined in machined grooves and shall be made of materials suitable for all specified service conditions.

4.6.1.3 Provisions for lifting the casings and removing the center section shall be provided.

4.6.1.4 The expander-compressor casing shall be designed with sufficient strength to contain parts which might separate in the event of uncontrolled overspeed.

4.6.2 Casing Repairs

Casing repairs shall be in accordance with Part 1.

4.6.3 Material Inspection of Pressure-containing Parts

Material inspection of pressure-containing parts shall be in accordance with Part 1.

4.6.4 Pressure Casing Connections

In addition to the requirements of Part 1, the following sections in 4.6.4 shall apply:

4.6.4.1 Main Process Connections

Main process connections shall be in accordance with Part 1.

4.6.4.2 Auxiliary Connections

Auxiliary connections shall be in accordance with Part 1 and as follows.

4.6.4.2.1 Auxiliary connections shall be at least DN 15 (NPS $^1/_2$).

4.6.5 Casing Support Structures

NOTE 1 Expander-compressors have no coupling, therefore, there are no special requirements for casing support structures.

NOTE 2 Expander-compressor units do not require highly finished mounting surfaces.

4.6.6 External Forces and Moments

4.6.6.1 Expander-compressor packages shall be designed to withstand external forces and moments on each nozzle calculated in accordance with Equation (F.1) and Equation (F.2) of Annex F.

NOTE Expander-compressor shaft alignment is not affected by piping forces since they do not have a coupling.

4.6.6.2 The supplier shall furnish the allowable forces and moments for each nozzle in tabular form.

4.6.7 Variable Nozzles and Heat Shields

4.6.7.1 Each expander shall be equipped with variable nozzles (variable inlet guide vanes).

NOTE Variable nozzles permit the efficient conversion of head into velocity throughout the design range of the unit.

4.6.7.2 Variable nozzles shall be sized capable of flowing at least 110 % of the mass flow at any specified operating condition.

4.6.7.3 Actuating devices shall be capable of operation at all specified operating conditions, including maximum inlet pressure, maximum flow, and minimum discharge pressure.

NOTE Variable nozzles are used for flow and pressure control. Precise control of the nozzles is necessary for smooth process operation.

4.6.7.4 Variable nozzles and actuators shall be capable of closing with maximum inlet pressure at all flow conditions.

NOTE Adjustable nozzles are often required to control expander discharge pressure under conditions of restricted flow on the discharge. It is necessary for nozzles to close rapidly with minimal leakage; however, variable nozzles are not tight shutoff devices.

4.6.7.4.1 Actuators shall be equipped with an agreed force limiting device to ensure no overforcing in closing or opening the inlet guide vanes.

4.6.7.5 Variable nozzles shall be designed to minimize friction.

4.6.7.6 If variable nozzles are used for toxic, flammable or explosive process gas, the linkage passing through the casing or enclosure shall be sealed.

4.6.7.7 If required, an insulating heat shield shall be provided between the cold expander process fluids and the bearing cavity. Heat shields shall be constructed of materials with good insulation properties.

NOTE See Annex D for typical heat shield materials.

4.7 Rotating Elements

4.7.1 General

4.7.1.1 Rotating elements shall be in accordance with 4.7 of Part 1 and this section.

4.7.1.2 Each impeller and shaft shall be clearly marked with a unique identification number. This number shall be in an accessible area that is not prone to maintenance damage.

4.7.2 Shaft Sleeve

4.7.2.1 Unless other shaft protection is approved by the purchaser, replaceable components shall be furnished at labyrinth shaft seal locations. Sleeves, spacers, or bushings shall be made of materials that are corrosion-resistant in the specified service.

4.7.3 Shafts

4.7.3.1 Shafts shall be of one piece or permanently joined multiple piece construction and may be hollow.

NOTE 1 Expanders can have multi piece construction hollow shafts that are joined by methods such as friction welding per ANSI/AWS C6.1.

NOTE 2 Because these parts are permanently joined, trapped process gas is not a problem.

4.7.3.2 All welds on the shaft shall be inspected by ultrasonic or radiographic examination. After finish machining, the welds shall be inspected by magnetic particle or liquid penetrant examination. Refer to 6.2.2 of Part 1 for material inspection methods and 6.2.2.1.1 of Part 1 for acceptance criteria.

4.7.3.3 For precipitation-hardened stainless steel shafts with maximum journal velocities (trip speed) above 95 m/s (315 ft/s), the supplier shall provide a coating or overlay on the journals to prevent wire wooling.

NOTE Chrome plating, weld overlay, high velocity oxygen fuel (HVOF), high velocity liquid fuel (HVLF) and graphite impregnation are some of the methods which have been used successfully to prevent wire wooling.

4.7.4 Impellers

For impeller requirements see 4.7.10 of Part 1.

4.7.4.1 Thrust Balancing

4.7.4.1.1 A balance cavity, line, and porting shall be provided if required to limit axial loads on the thrust bearings.

4.7.4.1.2 When an automatic or fixed thrust equalizing valve is provided as per 4.9.3.4, this valve shall be flanged and sized to handle balance drum gas leakage at twice the initial design labyrinth clearance without exceeding the load rating of the thrust bearings. If the balance line involves a purchaser's connection to his/her piping, then the connection sizes shall be indicated on the datasheets.

4.7.4.1.3 An automatic thrust equalizing valve shall be provided. This valve shall react to changes in thrust load as measured by thrust pressure (magnetic bearing current, etc.) to actively maintain a low thrust load on the thrust bearings by injecting to or venting from balancing chambers inside the machine. See Figure 1 for typical automatic thrust equalizing valve schematic.

4.8 Dynamics

Dynamics shall be in accordance with 4.8 of Part 1.

4.8.1 Vibration Balancing

4.8.1.1 The balancing method described in 4.8.1.2 through 4.8.1.5 shall apply only to single-shaft expander-compressors which require rotor disassembly and reassembly to install. All other expander-compressors shall comply with 4.8.8 in Part 1.

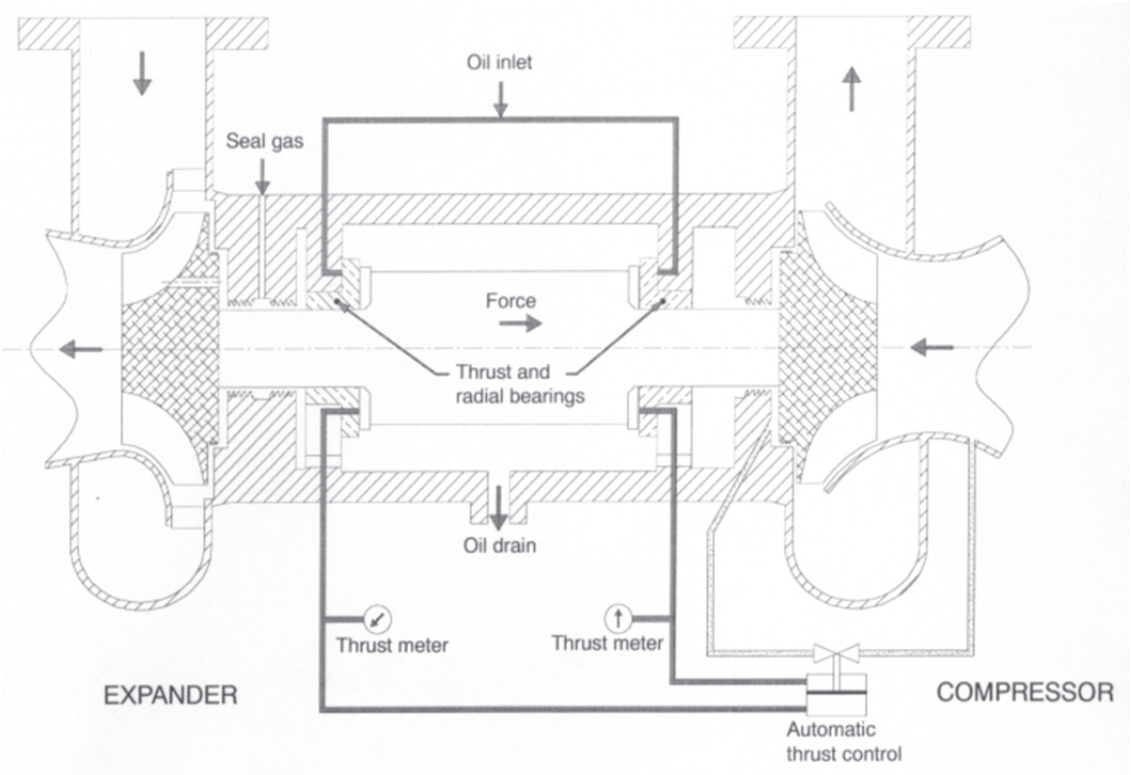

Figure 1—Automatic Thrust Balancing System

NOTE Expander-compressors in cryogenic service are typically single-shaft rotors that require disassembly and reassembly of the rotor to install in the machine casing. By requiring index balancing, either the compressor or expander component can be replaced individually without requiring the complete rotor to be rebalanced.

4.8.1.2 The expander wheel, compressor wheel, and the shaft shall be balanced using an index balancing procedure. All machining of components shall be completed before balancing. The wheels shall be supported by a concentric arbor during the balancing procedure. Two-plane balancing is preferred, but single-plane balancing may be used for components with a length to diameter (L/D) ratio of 0.2 or less. Each component shall be balanced so that the level of residual unbalance for each balance plane does not exceed the greatest value determined by Equation (3) or Equation (4) as applicable from Part 1.

NOTE For information on the index balance procedure refer to API 684.

4.8.1.3 Prior to starting the index balancing procedure for the compressor and expander wheels, the following steps shall be performed to check the integrity of the fits between the wheels and arbor.

a) Mount the wheel at an arbitrary 0° location on the arbor. Record the unbalance reading of the assembly.

b) Dismount and remount the wheel on the arbor in the original 0° position. Record the unbalance.

c) The vector reading from Item b) shall be within 20 % of the vector reading from Item a). If not, the arbor fit shall be checked for poor contact, dirt, or other items affecting the fit integrity.

4.8.1.4 Index balance both wheels, using an arbor, to the tolerance specified in 4.8.1.2. After this step, the wheels should be in balance and no further corrections should be required.

4.8.1.5 The shaft index balance procedure shall be performed using both wheels mounted in the following manner:

a) Mount the expander and compressor wheels on the shaft. Both wheels should be marked to an arbitrary 0° location on the shaft.

b) Identify appropriate balance planes on the shaft. Perform index balancing of the shaft using the wheels to the tolerance specified in 4.8.1.2.

c) Both wheels shall be treated as one part and turned together during the index balancing procedure.

- **4.8.1.6** If specified, rotors shall be assembled and the balance verified. The residual unbalance for the randomly assembled components shall not exceed 10 times the maximum allowable residual unbalance as determined by Equation (3) or Equation (4) as applicable in Part 1.

Assembled rotors that fail to meet these criteria shall be balance corrected by repeating the component index balance, not by trim balancing the assembly.

- **4.8.1.7 Residual Unbalance Procedure**

If specified, a residual unbalance check shall be performed on assembled rotors. The residual unbalance check shall be performed after assembly balancing or assembly check-balancing is complete and before the assembled rotor is removed from the balancing machine.

NOTE Refer to Annex A of Part 1 for a description of the procedure for residual unbalance determination.

4.9 Bearings and Bearing Housings

4.9.1 General

4.9.1.1 Unless otherwise specified, hydrodynamic radial and thrust bearings shall be provided.

NOTE The typical expander-compressor has both the radial and thrust bearing built into a single assembly.

4.9.1.2 If specified, magnetic bearings shall be supplied in accordance with Annex E of Part 1.

4.9.1.3 Bearing material selection criteria shall include compatibility with the process gas.

NOTE Bearings are generally in contact with the process gas.

4.9.2 Hydrodynamic Radial Bearings

4.9.2.1 Sleeve or pad type bearings shall be used. The bearings shall be precision machined. Materials used shall be steel, brass, bronze, aluminum, copper alloy, or other suitable material.

4.9.2.2 Unless otherwise specified, hydrodynamic radial bearings shall be fitted with bearing metal temperature sensors installed in accordance with API 670.

4.9.3 Hydrodynamic Thrust Bearings

Hydrodynamic thrust bearings shall comply with the requirements of 4.9.3 of Part 1 and the following requirements in this section:

4.9.3.1 Hydrodynamic thrust bearings shall be precision machined, continuous or segmented face design. Continuous face designs shall have grooving, such as spiral grooving, to allow oil distribution. Segmented face designs may be either fixed or tilting pad configuration. Materials used shall be steel, bronze, aluminum, copper alloy, or other materials suitable for the application. Hydrodynamic thrust bearings shall be arranged for continuous pressurized lubrication to each side.

NOTE A typical expander-compressor thrust bearing can be made of brass or bronze, have a tapered land or spiral groove face design, and be unbabbited.

4.9.3.2 Unless otherwise specified, thrust bearings shall be designed for equal thrust capacity in both axial directions.

4.9.3.3 Loads on hydrodynamic thrust bearings shall be limited to no more than 50 % of the bearing manufacturer’s ultimate load rating at specified operating conditions

4.9.3.4 When calculated loads on hydrodynamic thrust bearings exceed 50 % of the ultimate capacity of the bearings, expander-compressors shall be equipped with automatic or fixed position thrust equalizing valves to reduce the bearing loads for the specified conditions to a minimum, reducing expected loads to no more than 50 % of the ultimate capacity of the bearing (see Annex C).

Bearings shall also be capable of meeting start-up and upset conditions.

NOTE 1 This device can be a direct operated valve, using fluid pressures taken from the thrust bearing oil film for actuation.

NOTE 2 Loading of 50 % of the ultimate load can be exceeded during start-up or upset conditions.

4.9.4 Bearing Housings

4.9.4.1 Bearing housings shall be in accordance with 4.9.4 of Part 1 and the following requirements in this section.

4.9.4.2 Rotor support system parts (bearings, bearing housings, bearing shells, and bearing brackets) shall be separable from the mating casings.

NOTE Expander bearing housings are pressurized.

4.10 Expander-compressor Shaft Seals

4.10.1 General

Shaft seals shall comply with the requirement of 4.10 of Part 1 and the following in this section.

NOTE Expander-compressors do not have shaft end seals, but the same types of seals are used for internal sealing between the process gas and the bearing housing.

4.10.2 Shaft seals shall be provided to restrict the leakage of process gas into the bearing housing over the range of specified operating conditions, including start-up and shutdown. Seals shall be suitable for specified variations in seal operating conditions that may prevail during start-up, shutdown, or settle out and during any other special operation specified.

4.10.3 Shaft seals used in expanders may be either clearance seals or self-acting dry gas seals.

NOTE See 4.10 of Part 1 for information on shaft end seals.

4.11 Integral Gearing

Integral gears are not applicable to expander-compressors.

4.12 Nameplates and Rotation Arrows

4.12.1 Nameplates and rotation arrows shall be in accordance with 4.12 of Part 1.

NOTE Rotation arrows are generally not provided for expander-compressors.

4.12.2 The following data shall be clearly stamped or engraved on the nameplate:

— supplier’s name;

— serial number;

— size, type, and model number;

— design power;

— rated speed (rpm);

— trip speed (rpm);

— purchaser’s item number or other reference;

— MAWP of each casing;

— maximum and minimum working temperature of each casing;

— hydrostatic test pressure of each casing;

— maximum continuous speed (MCS);

— lateral critical speeds up to and including the next critical above MCS.

5 Accessories

5.1 Drivers

NOTE Expander-compressor units do not have separate drivers.

5.2 Couplings and Guards

NOTE Expander-compressors do not have couplings and guards.

5.3 Lubrication and Sealing Systems

5.3.1 When required, a pressurized oil system shall be furnished to supply oil at suitable pressure(s) to the machine. Such systems shall be in accordance with API 614, Fifth Edition, as modified by Annex G.

5.4 Mounting Plates

5.4.1 Mounting plates shall be in accordance with the requirements of 5.4 of Part 1 and the following in this section.

NOTE Soleplates are not used with expanders.

5.4.1.1 Unless an externally connected piece of rotating equipment such as a generator is supplied, jackscrews and other leveling devices are not required.

5.4.2 General

The expander-compressor shall be furnished with a baseplate in accordance with 5.4.2 of Part 1.

NOTE Expander-compressor units do not have couplings; therefore, sections of Part 1 that invoke requirements for alignment shims, machined surfaces, etc. are not applicable to expanders.

5.5 Controls and Instrumentation

Controls and instrumentation shall be in accordance with 5.5 of Part 1 and the following in this section.

5.5.1 Vibration and Position Monitoring

5.5.1.1 Unless otherwise specified, vibration transducers shall be supplied, installed, and calibrated in accordance with API 670.

- **5.5.1.2** If specified, axial position probes shall be provided in accordance with API 670.

NOTE Expander-compressors normally use pressure from active thrust compensation system rather than axial position probes for alarm/shutdown functions.

- **5.5.1.3** If specified, vibration monitors shall be supplied and calibrated in accordance with API 670.

5.5.2 Hydrodynamic Bearings

- **5.5.2.1** Unless otherwise specified, hydrodynamic radial bearings shall be fitted with bearing-metal temperature sensors installed in accordance with API 670. The purchaser will specify the type of detector.

- **5.5.2.2** If specified, hydrodynamic thrust bearings shall be fitted with bearing-metal temperature sensors installed in accordance with API 670. The purchaser will specify the type of detector required.

- **5.5.2.3** If specified, a bearing temperature monitor shall be supplied and calibrated in accordance with API 670.

5.5.3 Magnetic Bearings

If magnetic thrust and radial bearings have been specified, they shall be fitted with bearing temperature sensors installed in accordance with Annex E of Part 1.

5.5.4 Overspeed Shutdown System

5.5.4.1 General

5.5.4.1.1 Unless otherwise specified, an overspeed shutdown system based on a single circuit shall be provided.

NOTE The design of an expander-compressor provides an inherent degree of overspeed protection. Overspeed primarily results from an interruption of flow to the compressor or operation, primarily during start-up, with a very low compressor suction pressure. The design of the piping system, including all valves and associated controls, should ensure that compressor flow interruption or very low suction pressure do not occur. Since the system is unlikely to produce an overspeed condition, single circuit overspeed detection and trip systems are the standard.

- **5.5.4.1.2** If specified, an overspeed shutdown system based on two-out-of-three voting logic shall be furnished.

5.5.4.1.3 The supplier shall design an overspeed shutdown system consisting of:

a) electronic overspeed circuit [speed sensor(s) and logic device],

b) expander inlet trip valve,

c) electric solenoid valves.

NOTE Due to the wide variation in process services using expanders, it is not unusual for the expander inlet trip valve to be furnished by the purchaser.

5.5.4.2 Electronic Overspeed Detection Circuit

5.5.4.2.1 Unless otherwise specified, an electronic overspeed detection circuit, consisting of a speed sensor(s) and logic device, shall be furnished. The design of the circuit shall include the following.

a) Failure of either the sensor(s) or logic device shall initiate a shutdown;

b) All settings incorporated in the overspeed circuit shall be protected through control access;

c) It shall accept inputs from a frequency generator for verifying the trip speed setting;

d) It shall provide an output for a speed indicator.

5.5.4.2.2 Unless otherwise specified, magnetic pickups shall be supplied for speed sensing.

5.5.4.2.3 A hole or grooved surface integral with the shaft shall be provided for speed sensing. The hole or grooved surface may be used by both the overspeed system and the tachometer sensors.

5.5.4.3 Expander Trip Valve

5.5.4.3.1 Unless otherwise specified, the supplier will provide an expander inlet trip valve that will close when the supplier's shutdown system senses overspeed.

NOTE 1 Due to the wide variation in process services using expanders, it is not unusual for the expander inlet trip valve and solenoids to be furnished by the purchaser. The expander inlet trip valve is not the control mechanism for the expander. The trip valve is either full open or full closed (tripped). Capacity and speed control are provided by expander variable inlet nozzles, compressor minimum flow valve, or other means. The inclusion of a unit isolation valve upstream of the trip valve is typical of most installations, with provisions to depressurize the piping volume between the isolation and trip valves so that the trip valve does not have to be opened against full line pressure. The isolation valve is meant to close when the trip valve closes.

NOTE 2 See 4.6.1.4.

5.5.4.3.2 The design of expander inlet trip valves shall include, but not be limited to, the following:

a) the ability to close rapidly as possible within a time as agreed;

b) actuation from a fail-safe spring loaded actuator, a gas operated actuator, or an air-operated actuator. If the design of the gas or air supply system could permit loss of gas or air pressure, then connections to provide volume bottles with capacity for two full stroke closures of the trip valve. The torque capability of the actuator shall be sufficient to permit the valve to close with ice buildup on it. Consideration shall be given to additional sealing devices such as flexible pressure-assisted seal rings to overcome the friction of ice build-up;

c) an extended bonnet to maintain the stem packing at a noncryogenic temperature;

d) special features to prevent ice, hydrates, and other solids from stopping valve closure.

5.5.4.3.3 If the expander inlet trip valve is furnished by the purchaser, the supplier shall review the selection and shall provide recommendations concerning the sizing, location, and closing time requirements.

5.5.4.3.4 Electric Solenoid Valves

An electric solenoid-operated valve shall be provided to initiate operation of the trip valve. Unless otherwise specified, the solenoid valve shall be de-energized to trip.

NOTE 1 Solenoids can draw significantly high currents.

NOTE 2 The purchaser can ensure that the electronic overspeed shutdown system is supplied from an uninterruptable power source.

5.5.4.3.5 When solenoids draw high currents that exceed the current rating of the relay in the overspeed shutdown system, interposing relays or other provisions shall be supplied.

5.5.5 Permanent Strainer

- **5.5.5.1** If specified, a permanent strainer located upstream of the trip valve in a removable spool piece, with an effective free flow area at least twice the cross-sectional area of the expander inlet trip valves shall be furnished by the supplier.

NOTE The spool piece is normally provided by the user. Differential pressure indication with a high pressure alarm switch can be provided for the strainer.

- **5.5.5.2** If specified, the spool piece and differential pressure instrumentation for the permanent strainer shall be provided.

5.5.5.3 The supplier's design shall include provision for a local manual trip mechanism located near the expander inlet trip valve. Actuation of the manual trip mechanism shall close the trip valve and the variable inlet nozzles.

- **5.5.5.4** If specified, the supplier shall furnish the local manual trip mechanism.

5.6 Piping and Appurtenances

Piping and appurtenances furnished shall be in accordance with 5.6 of Part 1 and the following in this section.

5.6.1 The supplier shall furnish all piping systems, including mounted appurtenances, located within the confines of the baseplate. The piping shall terminate with flanged connections at the edge of the baseplate. The purchaser will furnish only interconnection piping between equipment groupings and offbase facilities.

5.7 Special Tools

Special tools shall be furnished in accordance with 5.7 of Part 1.

6 Inspection, Testing, and Preparation for Shipment

Inspection, testing, and preparation for shipment shall be in accordance with Section 6 of Part 1 except as modified below.

6.1 General

General requirements for inspection, testing and preparation for shipment shall be in accordance with 6.1 of Part 1. Also refer to Annex E for The Inspector's Checklist.

6.2 Inspection

Requirements for inspection shall be in accordance with Part 1.

6.3 Testing

6.3.1 General

6.3.1.1 In addition to the requirements of Part 1, 6.3, the expander-compressor(s) shall be tested in accordance with 6.3.3 and 6.3.4. Other optional tests that may be specified are described in 6.3.5.

6.3.1.2 Immediately upon completion of each witnessed mechanical or performance test, copies of the log data recorded during the test shall be given to the witnesses.

6.3.2 Wheel Shaker Test

6.3.2.1 For any new design which has not been previously built and tested, a shaker test shall be performed. The purpose of this test is to verify that the fundamental natural frequency of the blades and disk are in agreement with the range of predicted values calculated during the design phase. The measured frequency shall be within ± 5 % of the calculated frequency under wheel shaker test conditions.

6.3.2.2 If this test does not validate the calculated values, the actual natural frequency shall be assessed against the operating speed range and expected stresses and the need for corrective action mutually agreed between the supplier and the purchaser.

6.3.2.3 If it is necessary to modify the wheel to adjust this natural frequency, the modified wheel shall be retested to confirm that the modification was successful.

6.3.3 Mechanical Running Test

6.3.3.1 The requirements of 6.3.3.1.1 through 6.3.3.1.5 shall be met before the mechanical running test is performed.

6.3.3.1.1 Unless otherwise agreed, the contract shaft seals and bearings shall be used in the machine for the mechanical running test.

NOTE Test expander wheel seals may be required due to the temperature differences between operating conditions and test conditions.

6.3.3.1.2 A test compressor wheel that closely matches the weight, center of gravity, and moment of inertia of the actual wheel can be used.

NOTE A test wheel is typically used when the mechanical test would result in temperatures in the compressor that could cause damage to the actual wheel, or the expander cannot produce sufficient power on the test stand to achieve the desired speeds. The test wheel generates less heat and absorbs less power, thereby, eliminating this problem

6.3.3.1.3 When oil lubricated bearings and/or seals are supplied, all oil pressures, viscosities and temperatures shall be within the range of operating values recommended in the supplier’s operating instructions for the specific unit being tested. Oil flow rates shall be measured.

6.3.3.1.4 Oil system components downstream of the filters shall meet the cleanliness requirements of API 614, Fifth Edition, before any test is started.

6.3.3.1.5 If magnetic bearings are used, the cooling air to the bearing cavity shall be established, levitation and turning of the magnetic bearings shall be checked per the manufacturer’s instructions, and the magnetic bearing control package shall be exercised.

6.3.3.2 The mechanical running test of the equipment shall be conducted as specified in 6.3.3.2.1 through 6.3.3.2.4.

6.3.3.2.1 The equipment shall be operated at speed increments from zero to the MCS until bearing temperatures, lube-oil temperatures (if applicable), and shaft vibrations have stabilized.

NOTE The supplier will decide on the need for no dwell zones for blade resonances, critical speeds, and other natural frequencies

6.3.3.2.2 The equipment shall be run for 4 hours continuous operation at MCS.

6.3.3.2.3 The speed shall be increased to trip speed and the equipment shall be run for a minimum of 15 minutes.

6.3.3.2.4 The unit shall be tripped and allowed to coast to a stop.

6.3.3.3 During the mechanical running test, the requirements of 6.3.3.3.1 through 6.3.3.3.6 shall be met.

6.3.3.3.1 During the mechanical running test, the mechanical operation of all equipment being tested and the operation of the test instrumentation shall be satisfactory. The measured unfiltered vibration shall not exceed the limits of 4.8.8.8 of Part 1 and shall be recorded throughout the operating speed range. Any other test acceptance criteria shall be mutually agreed and stated in the test agenda.

6.3.3.3.2 While the equipment is operating at MCS, or other speed and/or load that may have been specified in the test agenda, vibration data shall be acquired to determine amplitudes at frequencies other than synchronous. As a minimum, this data shall cover a frequency range from 0.25 to 8 times the MCS. If the amplitude of any discrete, nonsynchronous vibration exceeds 20 % of the allowable vibration as defined in 4.8.8.8 of Part 1 or 6.5 µm (0.25 mil), whichever is greater, the purchaser and the supplier shall mutually agree on requirements for any additional testing and on the equipment's acceptability.

6.3.3.3.3 The mechanical running test shall verify that lateral critical speeds conform to the requirements of 4.8.2.9 of Part 1. Any noncritically damped critical speed below the trip speed shall be determined during the mechanical running test and stamped on the nameplate followed by the word "test."

6.3.3.3.4 Shop verification of the unbalanced response analysis is not required.

- **6.3.3.3.5** If specified, all real-time vibration data as agreed by the purchaser and supplier shall be recorded and a copy provided to the purchaser.

6.3.3.3.6 When spare mechanical center sections including bearing housings are ordered to permit concurrent manufacture, each spare mechanical center section shall also be given a mechanical running test in accordance with the requirements of this standard.

- **6.3.3.4** For spare rotors and, if specified for main rotors, the requirements of 6.3.3.4.1 through 6.3.3.4.4 shall be met after the mechanical running test is completed.

NOTE Removal of bearings and seals can require disassembly of the machine. The merits of bearing and seal inspection of expander-compressor by dismantling, inspecting, and reassembling the machine are typically evaluated against the benefits of shipping a unit with proven mechanical assembly and casing joint integrity.

6.3.3.4.1 Hydrodynamic bearings shall be removed, inspected, and reassembled after the mechanical running test is completed.

- **6.3.3.4.2** If specified, shaft seals shall be removed for inspection following a successful running test.

NOTE Removal and inspection of some seal types (such as cartridges) can require that the seal be returned to the seal manufacturer's facility.

6.3.3.4.3 If replacement or modification of bearings or seals or dismantling of the machine to replace or modify other parts is required to correct mechanical or performance deficiencies, the initial test will not be acceptable, and the final shop tests shall be run after these replacements or corrections are made.

6.3.3.4.4 If minor scuffs and scratches occur on bearings or process gas seal surfaces, minor cosmetic repairs of these parts is not a cause for rerunning the test.

6.3.4 Assembled Machine Gas Leakage Test

6.3.4.1 After the mechanical running test is completed, each completely assembled machine casing intended for toxic or flammable gas service shall be tested for gas leakage. The assembled casing shall be pressurized to the lowest of the expander or compressor casing MAWP, held at this pressure for a minimum of 30 minutes and subjected to a soap bubble test to check for gas leaks. The test shall be considered satisfactory when no casing or casing joint leaks are observed.

NOTE These tests are intended to verify the integrity of the casing joints.

6.3.4.2 If a post-test inspection of machine internals is required (see 6.3.3.4), these tests shall be performed after machine reassembly following a satisfactory inspection.

6.3.5 Optional Tests

Refer to 6.3.9 of Part 1 for optional tests.

6.3.5.1 Performance Test

6.3.5.1.1 The expander shall be performance tested at the U/C ratio corresponding to the certified point,

where

U is the expander wheel tip speed;

C is the velocity equivalent to the enthalpy drop across the machine.

Sufficient points shall be taken to either side of the peak to establish the expander efficiency parabolic curve. The measured efficiency shall be at least 98 % of the predicted value.

NOTE 1 The expander U/C ratio is the single most important parameter affecting the machine performance. The typical expander is designed to peak at a U/C ratio (a dimensionless number) of 0.7.

NOTE 2 There is no applicable industry standard test code for expanders. It can be necessary to perform corrections to the data such as when certified point Q/N and U/C cannot be met simultaneously during the test.

6.3.5.1.2 The compressor shall be performance tested at the Q/N ratio corresponding to the certified point,

where

Q is the compressor inlet volume flow;

N is the normal speed of the machine.

A minimum of five points shall be taken to either side to establish a curve of the compressor head and efficiency vs flow. The surge point shall be established and the observed surge point indicated on the performance test head curve. Other than this, the performance test shall be in accordance with ASME PTC10-1997or ISO 5389. The compressor shall deliver at least 98 % of the normal head at the normal capacity at the speed derived through power balance from the measured expander efficiency. The compressor power at the normal condition shall not be more than 106 % of that available from the expander, nor shall it be less than 96 % of that available from the expander.

NOTE Refer to the applicable test code for general instructions. ASME PTC 10-1997 will not apply to some low-pressure ratio compressors. Refer to 1.2.2 of PTC 10-1997 for the selection of the appropriate test code to be used.

6.3.5.1.3 These tolerances shall be inclusive of all test tolerances.

NOTE Both of the performance test codes referred to have provision for calculating inaccuracy based on instrumentation and procedures. These test inaccuracies are already included in the above tolerance and, therefore, are not to be further additive.

6.3.5.1.4 The performance test shall be conducted using only one contract mechanical center section.

6.4 Preparation for Shipment

Preparation for shipment shall be in accordance with 6.4 of Part 1 and the following in this section.

6.4.1 When a spare mechanical center section is purchased, it shall be prepared for unheated indoor storage for a period of at least 5 years.

NOTE This can require inspection or other activities by the purchaser.

7 Supplier's Data

Supplier data shall be provided in accordance with Section 7 of Part 1 and the following in this section.

7.1 General

The information to be furnished by the supplier is specified in Part 1 Section 7. The supplier shall complete and forward the agreed Vendor (supplier) Drawing and Data Requirements (VDDR) Form (See Annex B for an example) to the address or addresses noted in the inquiry or order. This form shall detail the schedule for transmission of drawings and data as agreed at the time of the order as well as the number and type of copies required by the purchaser.

7.2 Proposals

7.2.1 Technical Data

Technical data shall be in accordance with 7.2.3 of Part 1 and the following in this section.

7.2.1.1 Curves

7.2.1.1.1 Performance curves shall be submitted for each compressor and expander. These curves shall encompass the map of operations, with any limitations indicated thereon. All curves shall be marked "PREDICTED."

7.2.1.1.2 Predicted curves provided for expander-compressors shall include the following:

a) expander power vs flow,

b) compressor power vs flow,

c) compressor head and pressure ratio vs flow for at least four speed lines from 70 % to 110 % of normal speed,

d) compressor surge line,

e) expander U/C vs efficiency.

7.3 Contract Data

Contract data shall be in accordance with 7.3 of Part 1 with the following additions in this section.

7.3.1 General

7.3.2 Curves and Datasheets

7.3.2.1 Curves

Curves shall be provided in accordance with 7.3.2.1 of Part 1 and 7.3.2.2 below.

7.3.2.2 If a performance test is specified, the supplier shall provide test data and curves when the test has been completed. Curves for the as-tested performance shall include the data shown in 7.3.2.2.1. All curves shall be marked “AS TESTED.”

Annex A
(informative)

Datasheets

A representation of the datasheets is enclosed in this annex; however, MS Excel format datasheets have been developed and are available, for purchase from API publications distributors, with this standard. The MS Excel electronic datasheets may have additional functionality over printed hard copies.

REVISION	0	1	2	3	4
DATE					
BY					
REV/APPR					

TURBOEXPANDER / COMPRESSOR DATASHEET (API 617-7th, Part 4)
SI UNITS (bar)

JOB NO. _____ ITEM NO. _____
PAGE 1 OF 5 REQ'N NO. _____

APPLICABLE TO: ○ PROPOSAL ○ PURCHASE ○ AS BUILT
FOR _____ UNIT _____
SITE _____
SERVICE _____ MODEL:
MANUFACTURER _____ SERIAL NO. _____
APPLICABLE STANDARD: ○ U.S. ○ ISO
NOTE: INFORMATION TO BE COMPLETED BY: ○ PURCHASER ☐ MANUFACTURER ▽ PURCHASER OR MANUFACTURER

OPERATING CONDITIONS

(ALL DATA ON PER UNIT BASIS)

	NORMAL CASE		CASE A		CASE B	
	EXP	COMP	EXP	COMP	EXP	COMP
INLET CONDITIONS:						
○ (m^3/h) (1013 barA & 0°C DRY)						
○ WEIGHT FLOW, (kg/h) (EXP: WET / DRY; COMP: WET / DRY)						
○ PRESSURE (barA)						
○ TEMPERATURE (°C)						
○ MOLECULAR WEIGHT						
○ _____						
○ _____						
DISCHARGE CONDITIONS:						
☐ PRESSURE (barA)						
☐ TEMPERATURE (°C)						
☐ WEIGHT PERCENT LIQUID (%)						
☐ GAS HORSEPOWER (kW)						
☐ SPEED (rpm)						
☐ ADIABATIC / POLYTROPIC EFFICIENCY (Exp / Comp, %)						
○ _____						
○ _____						
○ GUARANTEE CASE (check one case)						

VARIABLE INLET GUIDE VANE PROCESS CONTROL SIGNAL SOURCE:
TYPE: ○ ELECTRONIC RANGE: _____ mA
○ PNEUMATIC _____ (barG)

GAS ANALYSIS: ○ MOL % ○ WT %	MW	NORMAL EXP	NORMAL COMP	CASE A EXP	CASE A COMP	CASE B EXP	CASE B COMP	SEAL GAS	REMARKS:
HELIUM	4.000								
HYDROGEN	2.016								
NITROGEN	28.016								
WATER VAPOR	18.016								
CARBON DIOXIDE	44.010								
HYDROGEN SULFIDE	34.076								
METHANE	16.042								
ETHYLENE	28.052								
ETHANE	30.068								
PROPYLENE	42.078								
PROPANE	44.094								
I-BUTANE	58.120								
n-BUTANE	58.120								
I-PENTANE	72.146								
n-PENTANE	72.146								
HEXANE PLUS									
TOTAL									
AVG. MOL. WT.									

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TURBOEXPANDER / COMPRESSOR DATASHEET (API 617-7th, Part 4)
SI UNITS (bar)

JOB NO. _____ ITEM NO _____
PAGE 2 OF 5 REQ'N NO _____

CONSTRUCTION FEATURES

☐ **SPEEDS:**
MAX. CONT. _____ RPM TRIP _____ RPM
TIP SPEEDS: EXPANDER _____ (m/s) @ MCS
COMPRESSOR _____ (m/s) @ MCS

LATERAL CRITICAL SPEEDS (DAMPED)
☐ FIRST CRITICAL _____ RPM BENDING MODE
○ UNDAMPED CRITICAL SPEED MAP
○ COMPLETE ROTORDYNAMIC ANALYSIS (API 617 TYPE)

CASINGS:
☐ MODEL _____

	EXP	BRG HSG	COMP
☐ CASING SPLIT			
☐ MATERIAL			
☐ ASTM A-351 CF8			
☐ ASTM A-352 LC3			
☐ ASTM A-352 LCC			
☐ ASTM A-216 WCB			
☐ _____			
○ DESIGN PRES (barG)			
○ MAX DESIGN TEMP, (℃)			
○ MIN. DESIGN TEMP (℃)			
○ VISUAL INSPECTION			
○ CHARPY TESTING			
○ MAGNETIC PARTICLE			
○ LIQUID PENETRANT			
○ CRITICAL AREA X-RAY			
_____			
_____			

☐ HYDROTEST PRESS ☐ 1.5 X DESIGN ☐ _____
○ CASING LEAK TEST ☐ 1.1X DESIGN ☐ _____
○ 100% NITROGEN
○ NITROGEN / HELIUM MIX (90 / 10)
○ 100% HELIUM
NOTE: LEAK TEST PERFORMED FOLLOWING HYDROTEST USING SOAP BUBBLE METHOD

IMPELLERS:

	EXP	COMP
☐ DIAMETER (IN.)		
☐ TYPE (OPEN, ENCLOSED)		
☐ TYPE FABRICATION		
☐ EXPANDER WHEEL MATERIAL		
☐ YIELD STRENGTH (bar) MAX _____ MIN _____ (TYP)		
☐ HARDNESS: _____ BNH / R_C (TYP)		
☐ COMPRESSOR WHEEL MATERIAL		
☐ YIELD STRENGTH (bar) MAX _____ MIN _____ (TYP)		
☐ HARDNESS: _____ BNH / R_C (TYP)		

SHAFT:
☐ MATERIAL _____
SHAFT END: ☐ TAPERED ☐ CYLINDRICAL
☐ YIELD STRENGTH (bar)
☐ SHAFT HARDNESS (BNH)(Rc)

☐ **SHAFT SEALS:**
☐ SINGLE PORT BUFFERED LABYRINTH
☐ DOUBLE PORT BUFFERED LABYRINTH
☐ TRIPLE PORT BUFFERED LABYRINTH
BLEED PRESSURE: _____ (barG)
☐ DRY GAS SEAL: _____
○ TYPE BUFFER GAS
○ BUFFER GAS SUPPLY PRESSURE _____ (barG)
☐ OTHER _____

SEAL GAS REQUIREMENTS :
☐ TYPE: _____
☐ MIN. SUPPLY PRESS. _____ (barG)
☐ MAX SUPPLY PRESS. _____ (℃)
☐ MIN SUPPLY TEMP. _____ (℃)
☐ MAX SUPPLY TEMP. _____ (℃)
☐ NORMAL FLOW _____ (m^3/h) _____ (bar) Δ P
☐ MAX FLOW _____ (m^3/h) _____ (bar) Δ P
NOTE: PURCHASER TO SUPPLY SEAL GAS COMPOSITION ON SHEET 1

CASING CONNECTIONS:

CONNECTION	☐ SIZE NPS / RATING	☐ FACING	☐ POSITION	☐ FLANGED OR STUDDED	○ MATING FLG & GASKET BY VENDOR	☐ GAS VELOCITY (m/s)
EXPANDER INLET						
EXPANDER DISCHARGE						
COMPRESSOR INLET						
COMPRESSOR DISCHARGE						

☐ OTHER CONNECTIONS

SERVICE:	NO.	SIZE	TYPE
LUBE-OIL INLET			
LUBE OIL OUTLET			
SEAL GAS INLET			
SEAL GAS OUTLET			
CASING DRAINS, EXP / COMP			
INTERMEDIATE BLEED			

SERVICE:	NO.	SIZE	TYPE
THRUST PRESSURES			
WHEEL PRESSURES, EX / COM			
BEARING HOUSING PRESS			

CASING DRAINS:
○ PLUGGED ○ FLANGED AND VALVED
○ FLANGED ○ FLANGED, VALVED, AND MANIFOLDED

○ **ALLOWABLE PIPING FORCES AND MOMENTS:**
○ 1.85 X NEMA SM 23
○ 3 X NEMA SM 23
○ OTHER: _____

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DATE					

TURBOEXPANDER / COMPRESSOR DATASHEET (API 617-7th, Part 4)
SI UNITS (bar)

JOB NO. _____ ITEM NO _____
PAGE 3 OF 5 REQ'N N _____

CONSTRUCTION FEATURES (CONTINUED)

BEARINGS:

RADIAL:

☐ TYPE:
- ☐ SLEEVE BEARING
- ☐ TILTING PAD BEARING
- ☐ ACTIVE MAGNETIC BEARING
- ☐ OTHER _____

☐ MATERIAL:
- ☐ ALUMINUM (BABBITTED)
- ☐ BRASS / BRONZE(BABBITTED)
- ☐ CARBON STEEL (BABBITTED)
- ☐ OTHER _____

☐ SHAFT DIA. (mm) _____
☐ MANUFACTURER _____

BEARING TEMPERATURE DEVICES:

○ **TYPE**
- ○ THERMOCOUPLES TYPE: _____
- ○ RESISTANCE TEMP DETECTORS
  - ○ RESISTANCE MAT'L _____ ○ _____ OHMS

○ **LOCATION / QTY**
- ☐ SINGLE DUAL ELEMENT (MAIN & SPARE) ____ PER BRG

○ **TEMPERATURE PROTECTION LOGIC DEVICE:**
- ○ TEMPERATURE MONITOR ○ DCS
- ○ PLC ○ OTHER _____
- ○ LOGIC DEVICE SUPPLIED BY: ○ VENDOR PURCH
- ○ LOCATION OF TEMPERATURE PROTECTION LOGIC DEVICE:
- ○ LOCAL CONTROL PANEL ○ REMOTE CONTROL PANEL
- ○ MAIN CONTROL ROOM ○ OTHER _____

○ **BEARING TEMPERATURE DISPLAY TYPE:**
- ○ TEMPERATURE MONITOR ☐ MODEL _____
- ○ ALPHANUMERIC DISPLAY
- ○ MMI / VDU
- ○ PURCHASER
- ○ OTHER _____

○ DISPLAY DEVICE PROVIDED BY: ○ VENDOR ○ PURCH
- ○ LOCATION OF TEMPERATURE DISPLAY DEVICE:
- ○ LOCAL CONTROL PANEL ○ REMOTE CONTROL PANEL
- ○ MAIN CONTROL ROOM ○ OTHER _____

SPEED PROBES:

○ **TYPE:** ○ ELECTROMAGNETIC ○ EDDY CURRENT
○ **QUANTITY** _____
○ **MACHINE PROTECTION LOGIC DEVICE:**
- ○ SWITCH ○ SPEED MONITOR ○ _____

○ **LOCATION OF SPEED DISPLAY:**
- ○ LOCAL PANEL ○ REMOTE DISPLAY

THRUST:

☐ TYPE:
- ☐ TAPERED LAND THRUST BEARING
- ☐ TILTING PAD THRUST BEARING
- ☐ ACTIVE MAGNETIC THRUST BEARING
- ☐ OTHER _____

☐ MANUFACTURER _____
LUBRICATION: ☐ FLOODED ☐ DIRECTED ☐ N/A
THRUST COLLAR / DISK: ☐ INTEGRAL ☐ SEPARATE

VIBRATION DETECTORS:

TYPE: ☐ EDDY CURRENT ☐ INDUCTIVE ☐ _____
- ○ MFR _____
- ☐ MODEL _____

○ **LOCATION AND QUANTITY:**
- ○ NO. PER JOURNAL BEARING _____ TOTAL NO. _____
- ○ IF REQ'D, OSCILLATOR-DEMODULATORS SUPPLIED BY:
  - ○ VENDOR ○ MODEL _____
  - ○ PURCHASER ○ MODEL _____

○ **MACHINE VIBRATION PROTECTION LOGIC DEVICE:**
- ○ VIBRATION MONITOR ○ DCS
- ○ PLC ○ OTHER _____
- ○ LOGIC DEVICE PROVIDED BY: ○ VENDOR ○ PURCH
- ○ LOCATION OF VIBRATION PROTECTION LOGIC DEVICE:
- ○ LOCAL CONTROL PANEL ○ REMOTE CONTROL PANEL
- ○ MAIN CONTROL ROOM ○ _____

○ **VIBRATION AMPLITUDE DISPLAY**
- ○ VIBRATION MONITOR ☐ MODEL _____
- ○ ALPHANUMERIC DISPLAY
- ○ MMI / VDU
- ○ OTHER _____
- ○ DISPLAY DEVICE PROVIDED BY: ○ VENDOR ○ PURCH
- ○ LOCATION OF DISPLAY DEVICE:
- ○ LOCAL CONTROL PANEL ○ REMOTE CONTROL PANEL
- ○ MAIN CONTROL ROOM ○ _____

○ KEY PHASOR ○ YES ○ NO

MAGNETIC BEARING CONTROL CABINET, IF REQUIRED

○ UPS SUPPLIED BY: ○ VENDOR ○ PURCHASER
○ **LOCATION OF CONTROL CABINET:**
- ○ LOCAL PANEL ○ REMOTE PANEL
- ○ MAIN CONTROL ROOM ○ _____

○ CABLE LENGTH FROM MACHINE SKID TO CONTROL CABINET: _____ (m)
○ **POWER AND SIGNAL CABLES:**
- ○ SUPPLIED BY PURCHASER ○ SUPPLIED BY VENDOR

○ **COMUNICATION PROTOCOL**
- ○ MODBUS ○ OTHER: _____

☐ POWER CONSUMPTION: (kW)

REMARKS: _____

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TURBOEXPANDER / COMPRESSOR DATASHEET (API 617-7th, Part 4)
SI UNITS (bar)

JOB NO. _____ ITEM NO _____
PAGE 4 OF 5 REQ'N NO _____

ACCESSORIES

○ **EXPANDER INLET TRIP VALVE:**

○ TYPE:
○ BUTTERFLY VALVE ○ SIZE: _____ ○ RATING: _____ ○ ALLOWABLE PRESSURE DROP: _____ (bar)
○ OTHER: _____
○ DESIGN PRESSURE: _____ (barG) ○ DESIGN TEMPERATURE (MIN / MAX) _____ / _____ (°C)
○ MATERIAL:
○ STAINLESS STEEL ○ LOW TEMP CARBON STEEL ○ CARBON STEEL ○ _____
○ TRIP VALVE SUPPLIED BY: ○ VENDOR ○ PURCHASER

○ **INLET SCREENS AND PIPE SPOOLS:**

INLET SCREENS:	EXP	COMP
TYPE: (CONE, BASKET, OTHER)		
SIZE (DIA.) (mm)		
MESH SIZE		
PRESSURE DROP (bar)		
MATERIAL:		
STAINLESS STEEL	○	○
OTHER _____	○	○

INLET SCREENS SUPPLIED BY: ○ VENDOR ○ PURCHASER

INLET SPOOLS FOR INLET SCREENS:	EXP	COMP
SIZE		
RATING		
FACING		
DESIGN PRESSURE: (barG)		
DESIGN TEMPERATURE (MIN/MAX) (°C)		
DESIGN TEMPERATURE (MIN/MAX) (°C)		
MATERIAL:		
STAINLESS STEEL	○	○
LOW TEMP CARBON STEEL	○	○
CARBON STEEL	○	○
OTHER:		
SPOOL CONSTRUCTION:		
SLIP-ON / SOCKETWELD	○	○
SOCKETWELD	○	○
WELDNECK / BUTTWELD	○	○

PIPE SPECIFICATION: _____

○ **COMPRESSOR ANTI-SURGE SYSTEM** FURNISHED BY ○ PURCHASER ○ SUPPLIER

○ CONTROLLER: ○ PID CONTROLLER ○ OTHER: _____
○ RECYCLE VALVE ○ BY SUPPLIER ○ SIZING ONLY
TYPE: _____ MTL: _____ NOISE LIMIT: ○ VENDOR STD ○ SPECIAL: _____
○ DESIGN PRESSURE: _____ (barG) ○ DESIGN TEMPERATURE (MIN/MAX) _____ / _____ (°C)
PRESSURE UPSTREAM: _____ (barG) DOWNSTREAM Δ P _____ (barG)
☐ Δ P VALVE _____ STROKE TIME OPEN - CLOSE _____ (sec) _____
○ INLET FLOW DEVICE TYPE: _____ ○ BY: _____
○ COMP. INLET FLOW TRANSMITTER ○ COMP. DIFF. PRESSURE TRANSMITTER
○ PIPING: ○ BY PURCHASER ○ BY SUPPLIER

REMARKS: _____

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TURBOEXPANDER / COMPRESSOR DATASHEET (API 617-7th, Part 4)

SI UNITS (bar)

JOB NO. _____ ITEM NO _____

PAGE 5 OF 5 REQ'N NO _____

SITE DATA

○ ELEVATION _____ (m) BAROMETER _____ (barA)

○ RANGE OF AMBIENT TEMPS:

NORMAL _____ (°C)

MAXIMUM _____ (°C)

MINIMUM _____ (°C)

LOCATION:

○ INDOOR ○ OUTDOOR ○ GRADE

○ HEATED ○ UNDER ROOF ○ MEZZANINE

○ UNHEATED ○ PARTIAL SIDES ○ _____

UNUSUAL CONDITIONS: ○ DUST ○ FUMES

○ WINTERIZATION REQ'D. ○ TROPICALIZATION REQ'D.

○ OTHER _____

INSTRUMENT AND CONTROLS

STANDARD ○ NEMA ○ IEC

	INDOOR	OUTDOOR
CONTROL ENCLOSURE		
TERMINAL BOX		

SHOP INSPECTION AND TESTS:

	REQ'D	OBSRV	WTNS
CLEANLINESS	○	○	○
HYDROSTATIC	○	○	○
LOW SPEED BALANCE (ISO 1940 G2.5)	○	○	○
IMPELLER OVERSPEED (115% OF MCS)	○	○	○
IMPELLER RESONANCE TEST	○	○	○
MECHANICAL RUN	○	○	○
○ MAIN ○ SPARE			
○ CONTRACT PROBES ○ SHOP PROBES			
VARY LUBE & SEAL OIL PRESSURES AND TEMPERATURES	○	○	○
POLAR FORM VIB DATA	○	○	○
TAPE RECORD VIB DATA	○	○	○
TAPE DATA TO PURCHASER	○	○	○
PERFORMANCE TEST (AIR)	○	○	○
COMPLETE UNIT TEST	○	○	○
HE/N2 CASING LEAK TEST	○	○	○
SOUND LEVEL TEST	○	○	○
FULL POWER TEST	○	○	○
	○	○	○
	○	○	○

PAINTING:

○ VENDOR STANDARD

○ OTHER _____

SHIPPING PREPARATION:

○ DOMESTIC PACKING

○ EXPORT PACKING (MIL-P 116J METHOD II)

○ SPECIAL: _____

SPARE ROTATING ASSEMBLY:

○ WOODEN SHIPPING CONTAINER

○ METAL STORAGE CONTAINER

○ N2 PURGE ○ OTHER:

APPLICABLE SPECIFICATIONS:

○ VENDOR STANDARD

○ API 617, 7TH EDITION

○ OTHER: _____

NOISE SPECIFICATIONS:

○ VENDOR STANDARD

○ PURCHASER SPECIFICATION

○ SEE SPECIFICATION _____

ACOUSTIC COVERING: ○ YES ○ NO

○ ELEC. AREA CLASS. ○ NEC ○ IEC

EQUIPMENT

CLASS _____ GROUP _____ DIV. _____

ZONE _____ GROUP _____ TEMP CLASS _____

CONTROL PANNELS

CLASS _____ GROUP _____ DIV. _____

ZONE _____ GROUP _____ TEMP CLASS _____

○ **UTILITY CONDITIONS:**

INSTRUMENT AIR FOR GUIDE VANE ACTUATOR:

MAX PRESS _____ (barG) MIN PRESS _____ (barG)

MISCELLANEOUS:

☐ RECOMMENDED STRAIGHT RUN OF PIPE DIAMETERS

AT EXPANDER DISCHARGE: _____

AT COMPRESSOR INLET: _____

○ VENDOR TO REVIEW & COMMENT ON PURCHASER'S PIPING & FOUNDATION

○ VENDOR TO REVIEW & COMMENT ON PURCHASER'S CONTROL SYSTEMS

○ _____

○ _____

○ _____

☐ **WEIGHTS** (kg)

EXP / COMP UNIT _____ (kg)

MAINTENANCE (SPARE ROTATING ASSY) _____ (kg)

TOTAL MACHINERY SKID WEIGHT: _____ (kg)

TOTAL SUPPORT SYSTEM SKID WT. (IF SEPARATE): _____ (kg)

☐ **SPACE REQUIREMENTS** (m)

MACHINERY SKID: L _____ W _____ H _____

SUPPORT SYSTEM SKID: L _____ W _____ H _____

SPECIAL TOOL PACKAGING

○ METAL STORAGE CONTAINER

○ OTHER: _____

DELIVERY:

○ FCA FACTORY

○ FOB SITE (DOMESTIC ONLY)

○ OTHER: _____

REMARKS: _____

REVISION	0	1	2	3	4
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BY					
REV/APPR					

TURBOEXPANDER / COMPRESSOR DATASHEET (API 617-7th, Part 4)
U.S. CUSTOMARY

JOB NO. _____ ITEM NO. _____
PAGE 1 OF 5 REQ'N NO. _____

APPLICABLE TO: ○ PROPOSAL ○ PURCHASE ○ AS BUILT
FOR _____ UNIT _____
SITE _____
SERVICE _____ MODEL:
MANUFACTURER _____ SERIAL NO. _____
APPLICABLE STANDARD: ○ U.S. ○ ISO
NOTE: INFORMATION TO BE COMPLETED BY: ○ PURCHASER ☐ MANUFACTURER ▽ PURCHASER OR MANUFACTURER

OPERATING CONDITIONS

(ALL DATA ON PER UNIT BASIS)	NORMAL CASE		CASE A		CASE B	
	EXP	COMP	EXP	COMP	EXP	COMP
INLET CONDITIONS:						
○ (scfm) (14.7 psia & 60°F DRY)						
○ WEIGHT FLOW, (lb/hr) (EXP: WET / DRY; COMP: WET / DRY)						
○ PRESSURE (psia)						
○ TEMPERATURE (°F)						
○ MOLECULAR WEIGHT						
○ _____						
○ _____						
DISCHARGE CONDITIONS:						
☐ PRESSURE (psia)						
☐ TEMPERATURE (°F)						
☐ WEIGHT PERCENT LIQUID (%)						
☐ GAS HORSEPOWER (HP)						
☐ SPEED (rpm)						
☐ ADIABATIC / POLYTROPIC EFFICIENCY (Exp / Comp, %)						
○ _____						
○ _____						
○ GUARANTEE CASE (check one case)						

VARIABLE INLET GUIDE VANE PROCESS CONTROL SIGNAL SOURCE:

TYPE: ○ ELECTRONIC RANGE: _____ mA
○ PNEUMATIC _____ (psig)

GAS ANALYSIS: ○ MOL % ○ WT %	MW	NORMAL EXP	NORMAL COMP	CASE A EXP	CASE A COMP	CASE B EXP	CASE B COMP	SEAL GAS	REMARKS:
HELIUM	4.000								
HYDROGEN	2.016								
NITROGEN	28.016								
WATER VAPOR	18.016								
CARBON DIOXIDE	44.010								
HYDROGEN SULFIDE	34.076								
METHANE	16.042								
ETHYLENE	28.052								
ETHANE	30.068								
PROPYLENE	42.078								
PROPANE	44.094								
I-BUTANE	58.120								
n-BUTANE	58.120								
I-PENTANE	72.146								
n-PENTANE	72.146								
HEXANE PLUS									
TOTAL									
AVG. MOL. WT.									

REVISION	0	1	2	3	4
DATE					

TURBOEXPANDER / COMPRESSOR DATASHEET (API 617-7th, Part 4)
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JOB NO. _____ ITEM NO _____
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CONSTRUCTION FEATURES

☐ **SPEEDS:**
MAX. CONT. _____ RPM TRIP _____ RPM
TIP SPEEDS: EXPANDER _____ (fps) @ MCS
COMPRESSOR _____ (fps) @ MCS

LATERAL CRITICAL SPEEDS (DAMPED)
☐ FIRST CRITICAL _____ RPM BENDING MODE
○ UNDAMPED CRITICAL SPEED MAP
○ COMPLETE ROTORDYNAMIC ANALYSIS (API 617 TYPE)

CASINGS:
☐ MODEL _____

	EXP	BRG HSG	COMP
☐ CASING SPLIT			
☐ MATERIAL			
☐ ASTM A-351 CF8			
☐ ASTM A-352 LC3			
☐ ASTM A-352 LCC			
☐ ASTM A-216 WCB			
☐ _____			
○ DESIGN PRES (psig)			
○ MAX DESIGN TEMP, (°F)			
○ MIN. DESIGN TEMP (°F)			
○ VISUAL INSPECTION			
○ CHARPY TESTING			
○ MAGNETIC PARTICLE			
○ LIQUID PENETRANT			
○ CRITICAL AREA X-RAY			
_____			
_____			

☐ HYDROTEST PRESS ☐ 1.5 X DESIGN ☐ _____
○ CASING LEAK TEST ☐ 1.1X DESIGN ☐ _____
○ 100% NITROGEN
○ NITROGEN / HELIUM MIX (90 / 10)
○ 100% HELIUM
NOTE: LEAK TEST PERFORMED FOLLOWING HYDROTEST USING SOAP BUBBLE METHOD

IMPELLERS:

	EXP	COMP
☐ DIAMETER (IN.)		
☐ TYPE (OPEN, ENCLOSED)		
☐ TYPE FABRICATION		

☐ EXPANDER WHEEL MATERIAL
☐ YIELD STRENGTH (psi) MAX _____ MIN _____ (TYP)
☐ HARDNESS: _____ BNH / R_C (TYP)
☐ COMPRESSOR WHEEL MATERIAL _____
☐ YIELD STRENGTH (psi) MAX _____ MIN _____ (TYP)
☐ HARDNESS: _____ BNH / R_C (TYP)

SHAFT:
☐ MATERIAL _____
SHAFT END: ☐ TAPERED ☐ CYLINDRICAL
☐ YIELD STRENGTH (psi) _____
☐ SHAFT HARDNESS (BNH)(Rc) _____

☐ **SHAFT SEALS:**
☐ SINGLE PORT BUFFERED LABYRINTH
☐ DOUBLE PORT BUFFERED LABYRINTH
☐ TRIPLE PORT BUFFERED LABYRINTH
BLEED PRESSURE: _____ (psig)
☐ DRY GAS SEAL: _____
○ TYPE BUFFER GAS _____
○ BUFFER GAS SUPPLY PRESSURE _____ (psig)
☐ OTHER _____

SEAL GAS REQUIREMENTS :
☐ TYPE: _____
☐ MIN. SUPPLY PRESS. _____ (psig)
☐ MAX SUPPLY PRESS. _____ (°F)
☐ MIN SUPPLY TEMP. _____ (°F)
☐ MAX SUPPLY TEMP. _____ (°F)
☐ NORMAL FLOW _____ (scfm) _____ (psi) ΔP
☐ MAX FLOW _____ (scfm) _____ (psi) ΔP
NOTE: PURCHASER TO SUPPLY SEAL GAS COMPOSITION ON SHEET 1.

CASING CONNECTIONS:

CONNECTION	☐ SIZE NPS / RATING	☐ FACING	☐ POSITION	☐ FLANGED OR STUDDED	○ MATING FLG & GASKET BY VENDOR	☐ GAS VELOCITY (fps)
EXPANDER INLET						
EXPANDER DISCHARGE						
COMPRESSOR INLET						
COMPRESSOR DISCHARGE						

☐ OTHER CONNECTIONS

SERVICE:	NO.	SIZE	TYPE
LUBE-OIL INLET			
LUBE OIL OUTLET			
SEAL GAS INLET			
SEAL GAS OUTLET			
CASING DRAINS, EXP / COMP			
INTERMEDIATE BLEED			

SERVICE:	NO.	SIZE	TYPE
THRUST PRESSURES			
WHEEL PRESSURES, EX / COM			
BEARING HOUSING PRESS			

CASING DRAINS:
○ PLUGGED ○ FLANGED AND VALVED
○ FLANGED ○ FLANGED, VALVED, AND MANIFOLDED

○ **ALLOWABLE PIPING FORCES AND MOMENTS:**
○ 1.85 X NEMA SM 23
○ 3 X NEMA SM 23
○ OTHER: _____

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JOB NO. _____ ITEM NO _____
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CONSTRUCTION FEATURES (CONTINUED)

BEARINGS:

RADIAL:

☐ TYPE:
- ☐ SLEEVE BEARING
- ☐ TILTING PAD BEARING
- ☐ ACTIVE MAGNETIC BEARING
- ☐ OTHER _____

☐ MATERIAL:
- ☐ ALUMINUM (BABBITTED)
- ☐ BRASS / BRONZE(BABBITTED)
- ☐ CARBON STEEL (BABBITTED)
- ☐ OTHER _____

☐ SHAFT DIA. (in.) _____
☐ MANUFACTURER _____

BEARING TEMPERATURE DEVICES:

○ **TYPE**
- ○ THERMOCOUPLES TYPE: _____
- ○ RESISTANCE TEMP DETECTORS
  - ○ RESISTANCE MAT'L _____ ○ _____ OHMS

○ **LOCATION / QTY** _____
- ☐ SINGLE DUAL ELEMENT (MAIN & SPARE) _____ PER BRG

○ **TEMPERATURE PROTECTION LOGIC DEVICE:**
- ○ TEMPERATURE MONITOR ○ DCS
- ○ PLC ○ OTHER _____
- ○ LOGIC DEVICE SUPPLIED BY: ○ VENDOR PURCH
- ○ LOCATION OF TEMPERATURE PROTECTION LOGIC DEVICE:
- ○ LOCAL CONTROL PANEL ○ REMOTE CONTROL PANEL
- ○ MAIN CONTROL ROOM ○ OTHER _____

○ **BEARING TEMPERATURE DISPLAY TYPE:**
- ○ TEMPERATURE MONITOR ☐ MODEL _____
- ○ ALPHANUMERIC DISPLAY
- ○ MMI / VDU
- ○ PURCHASER
- ○ OTHER _____

○ DISPLAY DEVICE PROVIDED BY: ○ VENDOR ○ PURCH
- ○ LOCATION OF TEMPERATURE DISPLAY DEVICE:
- ○ LOCAL CONTROL PANEL ○ REMOTE CONTROL PANEL
- ○ MAIN CONTROL ROOM ○ OTHER _____

SPEED PROBES:

○ **TYPE:** ○ ELECTROMAGNETIC ○ EDDY CURRENT
○ **QUANTITY** _____
○ **MACHINE PROTECTION LOGIC DEVICE:**
- ○ SWITCH ○ SPEED MONITOR ○ _____

○ **LOCATION OF SPEED DISPLAY:**
- ○ LOCAL PANEL ○ REMOTE DISPLAY

THRUST:

☐ TYPE:
- ☐ TAPERED LAND THRUST BEARING
- ☐ TILTING PAD THRUST BEARING
- ☐ ACTIVE MAGNETIC THRUST BEARING
- ☐ OTHER _____

☐ MANUFACTURER _____
LUBRICATION: ☐ FLOODED ☐ DIRECTED ☐ N/A
THRUST COLLAR / DISK: ☐ INTEGRAL ☐ SEPARATE

VIBRATION DETECTORS:

TYPE: ☐ EDDY CURRENT ☐ INDUCTIVE ☐ _____
- ○ MFR _____
- ☐ MODEL _____

○ **LOCATION AND QUANTITY:**
- ○ NO. PER JOURNAL BEARING _____ TOTAL NO. _____
- ○ IF REQ'D, OSCILLATOR-DEMODULATORS SUPPLIED BY:
  - ○ VENDOR ○ MODEL _____
  - ○ PURCHASER ○ MODEL _____

○ **MACHINE VIBRATION PROTECTION LOGIC DEVICE:**
- ○ VIBRATION MONITOR ○ DCS
- ○ PLC ○ OTHER _____
- ○ LOGIC DEVICE PROVIDED BY: ○ VENDOR ○ PURCH
- ○ LOCATION OF VIBRATION PROTECTION LOGIC DEVICE:
- ○ LOCAL CONTROL PANEL ○ REMOTE CONTROL PANEL
- ○ MAIN CONTROL ROOM ○ _____

○ **VIBRATION AMPLITUDE DISPLAY**
- ○ VIBRATION MONITOR ☐ MODEL _____
- ○ ALPHANUMERIC DISPLAY
- ○ MMI / VDU
- ○ OTHER _____
- ○ DISPLAY DEVICE PROVIDED BY: ○ VENDOR ○ PURCH
- ○ LOCATION OF DISPLAY DEVICE:
- ○ LOCAL CONTROL PANEL ○ REMOTE CONTROL PANEL
- ○ MAIN CONTROL ROOM ○ _____

○ KEY PHASOR ○ YES ○ NO

MAGNETIC BEARING CONTROL CABINET, IF REQUIRED

○ UPS SUPPLIED BY: ○ VENDOR ○ PURCHASER
○ **LOCATION OF CONTROL CABINET:**
- ○ LOCAL PANEL ○ REMOTE PANEL
- ○ MAIN CONTROL ROOM ○ _____

○ CABLE LENGTH FROM MACHINE SKID TO CONTROL CABINET: _____ (ft)
○ **POWER AND SIGNAL CABLES:**
- ○ SUPPLIED BY PURCHASER ○ SUPPLIED BY VENDOR

○ **COMUNICATION PROTOCOL**
- ○ MODBUS ○ OTHER: _____

☐ POWER CONSUMPTION: (HP)

REMARKS: _____

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TURBOEXPANDER / COMPRESSOR DATASHEET (API 617-7th, Part 4)
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JOB NO. _____ ITEM NO _____
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ACCESSORIES

○ **EXPANDER INLET TRIP VALVE:**

○ TYPE:
- ○ BUTTERFLY VALVE ○ SIZE: _____ ○ RATING: _____ ○ ALLOWABLE PRESSURE DROP: _____ (psi)
- ○ OTHER: _____

○ DESIGN PRESSURE: _____ (psig) ○ DESIGN TEMPERATURE (MIN / MAX) _____ / _____ (°F)

○ MATERIAL:
- ○ STAINLESS STEEL ○ LOW TEMP CARBON STEEL ○ CARBON STEEL ○ OTHER: _____

○ TRIP VALVE SUPPLIED BY: ○ VENDOR ○ PURCHASER

○ **INLET SCREENS AND PIPE SPOOLS:**

INLET SCREENS:	EXP	COMP
TYPE: (CONE, BASKET, OTHER)		
SIZE (DIA.) (in.)		
MESH SIZE		
PRESSURE DROP (psi)		
MATERIAL:		
STAINLESS STEEL	○	○
OTHER _____	○	○

INLET SCREENS SUPPLIED BY: ○ VENDOR ○ PURCHASER

INLET SPOOLS FOR INLET SCREENS:	EXP	COMP
SIZE		
RATING		
FACING		
DESIGN PRESSURE: (psig)		
DESIGN TEMPERATURE (MIN/MAX) (°F)		
DESIGN TEMPERATURE (MIN/MAX) (°F)		
MATERIAL:		
STAINLESS STEEL	○	○
LOW TEMP CARBON STEEL	○	○
CARBON STEEL	○	○
OTHER:		
SPOOL CONSTRUCTION:		
SLIP-ON / SOCKETWELD	○	○
SOCKETWELD	○	○
WELDNECK / BUTTWELD	○	○

PIPE SPECIFICATION: _____

○ **COMPRESSOR ANTI-SURGE SYSTEM** FURNISHED BY ○ PURCHASER ○ SUPPLIER

○ CONTROLLER: ○ PID CONTROLLER ○ OTHER: _____
○ RECYCLE VALVE ○ BY SUPPLIER ○ SIZING ONLY
TYPE: _____ MTL: _____ NOISE LIMIT: ○ VENDOR STD ○ SPECIAL: _____
○ DESIGN PRESSURE: _____ (psig) ○ DESIGN TEMPERATURE (MIN/MAX) _____ / _____ (°F)
PRESSURE UPSTREAM: _____ (psig) DOWNSTREAM Δ P _____ (psig)
☐ Δ P VALVE _____ STROKE TIME OPEN - CLOSE _____ (sec) _____
○ INLET FLOW DEVICE TYPE: _____ ○ BY: _____
○ COMP. INLET FLOW TRANSMITTER ○ COMP. DIFF. PRESSURE TRANSMITTER
○ PIPING: ○ BY PURCHASER ○ BY SUPPLIER

REMARKS: _____

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TURBOEXPANDER / COMPRESSOR DATASHEET (API 617-7th, Part 4)

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SITE DATA

○ ELEVATION _____ (ft) BAROMETER _____ (psia)

○ RANGE OF AMBIENT TEMPS:

NORMAL _____ (°F)

MAXIMUM _____ (°F)

MINIMUM _____ (°F)

LOCATION:

○ INDOOR ○ OUTDOOR ○ GRADE

○ HEATED ○ UNDER ROOF ○ MEZZANINE

○ UNHEATED ○ PARTIAL SIDES ○ _____

UNUSUAL CONDITIONS: ○ DUST ○ FUMES

○ WINTERIZATION REQ'D. ○ TROPICALIZATION REQ'D.

○ OTHER _____

INSTRUMENT AND CONTROLS

STANDARD ○ NEMA ○ IEC

	INDOOR	OUTDOOR
CONTROL ENCLOSURE		
TERMINAL BOX		

SHOP INSPECTION AND TESTS:

	REQ'D	OBSRV	WTNS
CLEANLINESS	○	○	○
HYDROSTATIC	○	○	○
LOW SPEED BALANCE (ISO 1940 G2.5)	○	○	○
IMPELLER OVERSPEED (115% OF MCS)	○	○	○
IMPELLER RESONANCE TEST	○	○	○
MECHANICAL RUN	○	○	○
○ MAIN ○ SPARE			
○ CONTRACT PROBES ○ SHOP PROBES			
VARY LUBE & SEAL OIL PRESSURES AND TEMPERATURES	○	○	○
POLAR FORM VIB DATA	○	○	○
TAPE RECORD VIB DATA	○	○	○
TAPE DATA TO PURCHASER	○	○	○
PERFORMANCE TEST (AIR)	○	○	○
COMPLETE UNIT TEST	○	○	○
HE/N2 CASING LEAK TEST	○	○	○
SOUND LEVEL TEST	○	○	○
FULL POWER TEST	○	○	○
	○	○	○
	○	○	○

PAINTING:

○ VENDOR STANDARD

○ OTHER _____

SHIPPING PREPARATION:

○ DOMESTIC PACKING

○ EXPORT PACKING (MIL-P 116J METHOD II)

○ SPECIAL: _____

SPARE ROTATING ASSEMBLY:

○ WOODEN SHIPPING CONTAINER

○ METAL STORAGE CONTAINER

○ N2 PURGE ○ OTHER:

APPLICABLE SPECIFICATIONS:

○ VENDOR STANDARD

○ API 617, 7TH EDITION

○ OTHER: _____

NOISE SPECIFICATIONS:

○ VENDOR STANDARD

○ PURCHASER SPECIFICATION

○ SEE SPECIFICATION _____

ACOUSTIC COVERING: ○ YES ○ NO

○ ELEC. AREA CLASS. ○ NEC ○ IEC

EQUIPMENT

CLASS _____ GROUP _____ DIV. _____

ZONE _____ GROUP _____ TEMP CLASS _____

CONTROL PANNELS

CLASS _____ GROUP _____ DIV. _____

ZONE _____ GROUP _____ TEMP CLASS _____

○ **UTILITY CONDITIONS:**

INSTRUMENT AIR FOR GUIDE VANE ACTUATOR:

MAX PRESS _____ (psig) MIN PRESS _____ (psig)

MISCELLANEOUS:

☐ RECOMMENDED STRAIGHT RUN OF PIPE DIAMETERS

AT EXPANDER DISCHARGE: _____

AT COMPRESSOR INLET: _____

○ VENDOR TO REVIEW & COMMENT ON PURCHASER'S PIPING & FOUNDATION

○ VENDOR TO REVIEW & COMMENT ON PURCHASER'S CONTROL SYSTEMS

○ _____

○ _____

○ _____

☐ **WEIGHTS** (lb)

EXP / COMP UNIT _____ (lb)

MAINTENANCE (SPARE ROTATING ASSY) _____ (lb)

TOTAL MACHINERY SKID WEIGHT: _____ (lb)

TOTAL SUPPORT SYSTEM SKID WT. (IF SEPARATE): _____ (lb)

☐ **SPACE REQUIREMENTS** (ft)

MACHINERY SKID: L _____ W _____ H _____

SUPPORT SYSTEM SKID: L _____ W _____ H _____

SPECIAL TOOL PACKAGING

○ METAL STORAGE CONTAINER

○ OTHER: _____

DELIVERY:

○ FCA FACTORY

○ FOB SITE (DOMESTIC ONLY)

○ OTHER: _____

REMARKS: _____

Annex B
(informative)

Vendor (Supplier) Drawing and Data Requirements

B.1 VDDR for Integrally Geared Compressors (See Text for Details of the Description)

EXPANDER-COMPRESSOR SUPPLIER DRAWING AND DATA REQUIREMENTS	Job No.	Item No.
	Purchase Order No.	Date
	Requisition No.	Date
	Inquiry No.	Date
	Revision ……. by	Manufacturer
	For	Unit
	Site	Service

Proposal [a]— Bidder shall furnish number of paper copies/number of electronic copies of data as indicated
Review—Supplier shall furnish number of paper copies/number of electronic copies of data as indicated
Final—Supplier shall furnish number of paper copies/number of electronic copies of data as indicated

			Description (see text)	**Distribution Record**				
				Review Due from Supplier [b c]	Review Received from Supplier	Review Returned to Supplier	Final due From Supplier [c]	Final Received from Supplier
/	/	/	1. Certified dimensional outline drawing and list of connections					
/	/	/	2. Cross-sectional drawings and part numbers					
/	/	/	3. Rotor assembly drawings and part numbers					
/	/	/	4. Thrust-bearing assembly drawings and part numbers					
/	/	/	5. Journal-bearing assembly drawings and bill of materials					
/	/	/	6. Coupling assembly drawings and bill of materials					
/	/	/	7. Lube-oil schematic and bill of materials					
/	/	/	8. Lube-oil arrangement drawing and list of connections					
/	/	/	9. Lube-oil component drawings and data					

a Proposal drawings and data do not have to be certified. Typical data shall be clearly identified as such.
b Purchase may indicate in the column the desired time frame for submission of data.
c Bidder shall complete these two columns to reflect the actual distribution schedule and include this form with the proposal.

EXPANDER-COMPRESSOR SUPPLIER DRAWING AND DATA REQUIREMENTS	Job No. ..... Item No. ..... Purchase Order No. ..... Date ..... Requisition No. ..... Date ..... Inquiry No. ..... Date ..... Revision ……. by ..... Manufacturer ..... For ..... Unit ..... Site ..... Service .....

Proposal [a]— Bidder shall furnish number of paper copies/number of electronic copies of data as indicated
Review—Supplier shall furnish number of paper copies/number of electronic copies of data as indicated
Final—Supplier shall furnish number of paper copies/number of electronic copies of data as indicated

Description (see text)				**Distribution Record**				
				Review Due from Supplier [b c]	Review Received from Supplier	Review Returned to Supplier	Final due From Supplier [c]	Final Received from Supplier
/	/	/	10. Seal system schematic and bill of material					
/	/	/	11. Seal system arrangement drawing and list of connections					
/	/	/	12. Seal system component drawings and data					
/	/	/	13. Seal assembly drawing and part numbers					
/	/	/	14. Electrical and instrumentation schematics and bill of materials					
/	/	/	15. Electrical and instrumentation arrangement of drawing and list of connections					
/	/	/	16. Buffer gas system schematic and bill of material					
/	/	/	17. Buffer gas system arrangement drawing and list of connections					
/	/	/	18. Buffer gas system component drawing and data					
/	/	/	19. Datasheets (proposal/as-built)					

a Proposal drawings and data do not have to be certified. Typical data shall be clearly identified as such.
b Purchase may indicate in the column the desired time frame for submission of data.
c Bidder shall complete these two columns to reflect the actual distribution schedule and include this form with the proposal.

EXPANDER-COMPRESSOR SUPPLIER DRAWING AND DATA REQUIREMENTS		
	Job No.	Item No. .....
	Purchase Order No.	Date .....
	Requisition No.	Date .....
	Inquiry No.	Date .....
	Revision ……. by	Manufacturer .....
	For	Unit .....
	Site	Service .....

Proposal [a]—Bidder shall furnish number of paper copies/number of electronic copies of data as indicated
Review—Supplier shall furnish number of paper copies/number of electronic copies of data as indicated
Final—Supplier shall furnish number of paper copies/number of electronic copies of data as indicated

			Description (see text)	**Distribution Record**				
				Review Due from Supplier [b c]	Review Received from Supplier	Review Returned to Supplier	Final Due from Supplier [c]	Final Received from Supplier
/	/	/	20. Allowable external forces and moments for each nozzle in tabular form (with proposal)					
/	/	/	21. Predicted noise sound level (proposal)					
/	/	/	22. Metallurgy of major components (in proposal)					
/	/	/	23. Lateral analysis report					
/	/	/	24. Torsional analysis report					
/	/	/	25. Vibration analysis report					
/	/	/	26. Performance curves for each compressor and expander					
/	/	/	27. Impeller overspeed test report					
/	/	/	28. Mechanical running test report					
/	/	/	29. Coupling selection and rating					

[a] Proposal drawings and data do not have to be certified. Typical data shall be clearly identified as such.
[b] Purchase may indicate in the column the desired time frame for submission of data.
[c] Bidder shall complete these two columns to reflect the actual distribution schedule and include this form with the proposal.

EXPANDER-COMPRESSOR SUPPLIER DRAWING AND DATA REQUIREMENTS	Job No. ..... Item No. ..... Purchase Order No. ..... Date ..... Requisition No. ..... Date ..... Inquiry No. ..... Date ..... Revision ……. by ..... Manufacturer ..... For ..... Unit ..... Site ..... Service .....

Proposal [a]—Bidder shall furnish number of paper copies/number of electronic copies of data as indicated
Review—Supplier shall furnish number of paper copies/number of electronic copies of data as indicated
Final—Supplier shall furnish number of paper copies/number of electronic copies of data as indicated

			Description (see text)	**Distribution Record**				
				Review Due from Supplier [b c]	Review Received from Supplier	Review Returned to Supplier	Final Due from Supplier [c]	Final Received from Supplier
/	/	/	30. List of recommended spare parts					
/	/	/	31. List of special tools					
/	/	/	32. Preparation for storage at job site before installation					
/	/	/	33. Weather protection and winterization required at job site					
/	/	/	34. Tabulation of all utilities					
/	/	/	35. List of similar machines					
/	/	/	36. Operating restrictions to protect equipment during start-up operation and shutdown					
/	/	/	37. List of components requiring purchaser's approval					
/	/	/	38. Summary of materials and hardness of materials exposed to H_2S					

[a] Proposal drawings and data do not have to be certified. Typical data shall be clearly identified as such.
[b] Purchase may indicate in the column the desired time frame for submission of data.
[c] Bidder shall complete these two columns to reflect the actual distribution schedule and include this form with the proposal.

EXPANDER-COMPRESSOR SUPPLIER DRAWING AND DATA REQUIREMENTS		
	Job No.	Item No. .....
	Purchase Order No.	Date .....
	Requisition No.	Date .....
	Inquiry No.	Date .....
	Revision ……. by	Manufacturer .....
	For	Unit .....
	Site	Service .....

Proposal [a]—Bidder shall furnish number of paper copies/number of electronic copies of data as indicated
Review—Supplier shall furnish number of paper copies/number of electronic copies of data as indicated
Final—Supplier shall furnish number of paper copies/number of electronic copies of data as indicated

			Description (see text)	**Distribution Record**				
				Review Due from Supplier [b c]	Review Received from Supplier	Review Returned to Supplier	Final Due from Supplier [c]	Final Received from Supplier
/	/	/	39. Seal leakage rates					
/	/	/	40. Interstage cooler system data					
/	/	/	41. Drawings, details and description of instrumentation and controls					
/	/	/	42. Minimum length of straight pipe required at machine inlet or side inlets					
/	/	/	43. Maximum and minimum allowable seal pressure for each compressor					
/	/	/	44. Statement of manufacturer's testing capabilities					
/	/	/	45. Performance test data and curves					
/	/	/	46. Back-to-back impeller machine supplier to provide thrust-bearing loads versus differential pressure curve					
/	/	/	47. Balance piston leakage rates					

[a] Proposal drawings and data do not have to be certified. Typical data shall be clearly identified as such.
[b] Purchase may indicate in the column the desired time frame for submission of data.
[c] Bidder shall complete these two columns to reflect the actual distribution schedule and include this form with the proposal.

EXPANDER-COMPRESSOR SUPPLIER DRAWING AND DATA REQUIREMENTS		
	Job No.	Item No. .....
	Purchase Order No.	Date .....
	Requisition No.	Date .....
	Inquiry No.	Date .....
	Revision ……. by	Manufacturer .....
	For	Unit .....
	Site	Service .....

Proposal [a]—Bidder shall furnish number of paper copies/number of electronic copies of data as indicated

Review—Supplier shall furnish number of paper copies/number of electronic copies of data as indicated

Final—Supplier shall furnish number of paper copies/number of electronic copies of data as indicated

			Description (see text)	**Distribution Record**				
				Review Due from Supplier [b c]	Review Received from Supplier	Review Returned to Supplier	Final Due from Supplier [c]	Final Received from Supplier
/	/	/	48. When specified, supplier shall supply curves of balance piston line differential pressure versus thrust load					
/	/	/	49. Production/delivery schedule					
/	/	/	50. Testing procedures					
/	/	/	51. Progress reports					
/	/	/	52. Installation manual					
/	/	/	53. Operating and maintenance manual					
/	/	/	54. Technical data manual					

[a] Proposal drawings and data do not have to be certified. Typical data shall be clearly identified as such.

[b] Purchase may indicate in the column the desired time frame for submission of data.

[c] Bidder shall complete these two columns to reflect the actual distribution schedule and include this form with the proposal.

EXPANDER-COMPRESSOR SUPPLIER DRAWING AND DATA REQUIREMENTS		
	Job No.	Item No. .....
	Purchase Order No.	Date .....
	Requisition No.	Date .....
	Inquiry No.	Date .....
	Revision ……. by	Manufacturer .....
	For	Unit .....
	Site	Service .....

Notes:

1. Where necessary to meet the scheduled shipping date, the supplier shall proceed with manufacture upon receipt of the order and without awaiting the purchaser's approval of drawings.

2. The supplier shall send all drawings and data to the following:

_____

_____

_____

3. All drawings and data shall show project, purchase order, and item numbers as well as plant location and unit. One set of the drawings and instructions necessary for field installation, in addition to the copies specified above, shall be forwarded with shipment.

4. See the descriptions of required items that follow.

5. All of the information indicated on the distribution schedule shall be received before final payment is made.

6. If typical drawings, schematics, and bills of material are used for proposals, they shall be marked-up to show the expected weight and dimensions to reflect the actual equipment and scope proposed.

Nomenclature:

S number of weeks before shipment.

F number of weeks after firm order.

D number of weeks after receipt of approved drawings.

Supplier_____

Date_____ Supplier Reference _____

Signature_____

(Signature acknowledges receipt of all instructions)

B.2 Descriptions

1) Certified dimensional outline drawing and list of connections including the following:

   a) the size, rating, and location of all customer connections;

   b) approximate overall and handling weights;

   c) overall dimensions and maintenance and dismantling clearances;

   d) shaft centering height;

   e) dimensions of baseplate (if furnished) for train or skid mounted package, complete with diameters, number and locations of bolt holes, and thicknesses of sections through which the bolts pass;

   f) grounding details;

   g) forces and moments allowed for suction and discharge nozzles;

   h) center of gravity and lifting points;

   i) shaft end separation and alignment data;

   j) direction of rotation;

   k) winterization, tropicalization, and/or noise attenuation details, when required;

   l) sketches to show lifting of assembled machine and major components and auxiliaries.

2) Cross-sectional drawings and part numbers of major equipment.

3) Rotor assembly drawings and part numbers.

4) Thrust-bearing assembly drawings and part numbers.

5) Journal-bearing assembly drawings and bill of materials.

6) Coupling assembly drawing and bill of materials.

7) Lube-oil schematic and bill of material including the following:

   a) oil flows, temperatures, and pressure at each point;

   b) control alarm shutdown settings for pressure and temperature;

   c) total heat loads;

   d) utility requirements including electrical, water, air, and steam;

   e) pipe, valve, and orifice sizes;

   f) instrumentation, safety devices, control schemes, and wiring diagrams.

8) Lube-oil arrangement drawing and list of connections.

9) Lube-oil component drawings and data including the following:

   a) pumps and drivers;

   b) coolers, filter, and reservoir;

   c) instrumentation.

10) Seal system schematic and bill of material including the following:

   a) flows oil or gas, temperatures, and pressures at each point;

   b) control, alarm, and shutdown settings for pressure and temperatures;

   c) total heat load for coolers, if required;

   d) utility requirements, including electrical, water, air, and steam;

   e) pipe, valve, and orifice sizes;

   f) instrumentation, safety devices, control schemes, and wiring diagrams;

   g) filtration requirements;

   h) height of overhead tank above centerline of machine.

11) Seal system arrangement drawing and list of connections.

12) Seal system components drawing and data, including the following:

   a) pumps and drivers;

   b) coolers, filter, and reservoirs;

   c) instrumentation.

13) Seal assembly drawing and part numbers.

14) Electrical and instrumentation schematics and bill of materials.

15) Electrical and instrumentation arrangement drawing and list of connections.

   a) vibration warning and shutdown limits;

   b) bearing temperature warning and shutdown limits;

   c) lube-oil temperature warning and shutdown limits;

   d) lube-oil pressure warning and shutdown limits;

   e) lube-oil level warning and shutdown limits;

   f) machine discharge pressure and temperature warning and shutdown limits;

g) seal, pressure, temperature, flow warning, and shutdown limits.

16) Electrical and instrumentation arrangement drawing and list of connections.

17) Buffer gas system schematic and bill of material.

18) Buffer gas system arrangement drawing and list of connections.

19) Buffer gas system component drawings and data, including the following:

a) control devices,

b) pressure and filtration requirements.

20) Datasheets provided with proposal as-built.

21) The supplier shall furnish the allowable forces and moments for each nozzle in tabular form with the proposal.

22) Predicted noise level, sound pressure, and sound power level.

23) Metallurgy of major components identified with ASTM, AISI, ASME, or SAE numbers stated in proposal.

24) Lateral analysis report when specified shall also include a stability analysis.

25) Torsional analysis report.

26) Vibration analysis conducted on machines that require disassembly after balancing to allow machine assembly. The supplier shall also provide historic unbalance data for the machine size and type.

27) Performance data and curves shall be submitted to the purchaser with proposal.

28) Dimensions taken from each impeller before and after overspeed testing shall be submitted for review.

29) Mechanical running test report to include the following:

a) unfiltered vibration;

b) plots showing synchronous vibration and phone angle, filtered and unfiltered;

c) when specified data shall be furnished in polar form;

d) when specified tape recordings shall be made of all real time vibration data;

e) electrical and mechanical runout at each probe.

Immediately upon completion of each witnessed mechanical or performance test, copies of the log and data recorded during the test shall be given to the witnesses.

30) Coupling selection and rating.

31) List of spare parts recommended for start-up and normal maintenance purposes.

32) List of the special tools furnished for maintenance.

33) The supplier shall provide the purchaser with instructions necessary to preserve the integrity of the storage preparation after the equipment arrives at the job site and prior to start-up.

34) A description of any special weather protection required for start-up, operation, and period of idleness under the site conditions specified on the datasheets.

35) A complete list of utility requirements: quantity, filtration and supply pressure of the following:

    a) steam,

    b) water,

    c) electricity,

    d) air,

    e) gas,

    f) lube oil and seal oil (quantity and supply pressure),

    g) heat loads,

    h) power ratings and operating power requirements for auxiliary drivers.

36) A list of machines similar to the proposed machines that have been installed and operating under conditions analogous to those specified in the inquiry.

37) Any start-up, shutdown, or operating restrictions required to protect the integrity of the equipment, including any unacceptable speeds due to natural frequencies.

38) A list of any components that can be construed as being of alternative design, requiring purchaser's acceptance.

39) A summary of the materials of construction for the compressor, including hardness for materials exposed to H_2S.

40) The maximum seal gas rates (injection or eduction) and rated or expected inner seal-oil leakage rates, if applicable.

    When self-acting dry gas seals are supplied, expected seal gas consumption, minimum seal gas supply flow and primary vent flow should be given at maximum sealing pressure and at conditions over the operating envelope of the machine.

41) When interstage coolers are furnished, the supplier shall provide the following:

    a) drawing showing cooling system details;

    b) data for purchasers heat and material balances;

    c) details of provisions for separating and withdrawing condensate;

    d) supplier's recommendations regarding provision for support and piping expansion.

42) Drawings, details, and descriptions of the operations of instrumentation and controls as well as the makes, materials, and type of auxiliary equipment. The supplier shall also include a complete description of the alarm and shutdown facilities to be provided.

43) The minimum length of straight pipe required for proper flow characteristics at the inlet and at any side inlet connection.

44) Maximum and minimum allowable seal pressure for each compressor.

45) A statement of the manufacturer's capability regarding testing (including performance testing) of the compressor and any other specified items on the train. Details of each optional test specified shall be included.

46) Predicted performance curves shall be provided for compressor and expander including the following:

    a) expander power versus flow;

    b) compressor power versus flow;

    c) compressor head and ratio, four speed lines from 70 % to 110 % of normal speed lines;

    d) expander v/c versus efficiency.

    If a performance test is specified as tested, then curves and data shall be provided.

47) For compressors that have a back-to-back impeller arrangement, the supplier shall furnish a curve showing the expected loading on the active or inactive side of the thrust bearing versus any combination of differential pressures across the low pressure and high pressure sections of the casing.

48) The supplier shall supply balance piston leakage based on design clearances and twice design clearances for the rated conditions.

49) When specified, the supplier shall supply curves of balance piston line differential pressure versus thrust load.

50) The supplier shall provide production and delivery schedules.

51) The supplier shall submit detailed procedures including acceptance criteria for the mechanical running test and all optional tests, at least 6 weeks prior to the first running test.

52) The supplier shall submit progress reports.

53) All information required for the proper installation of the equipment shall be compiled in a manual that shall be issued no later than the time of final certified drawings.

54) A manual containing all required operating and maintenance instructions shall be supplied not later than 2 weeks after all specified test shall have been successfully completed.

55) The supplier shall provide a "technical data manual within 30 days of completion" of shop testing including the following:

    a) necessary certification of materials,

    b) purchase specification for all items on the bill of materials,

c) test data to verify requirements of specifications have been met,

d) heat treat records,

e) results of quality test and inspections,

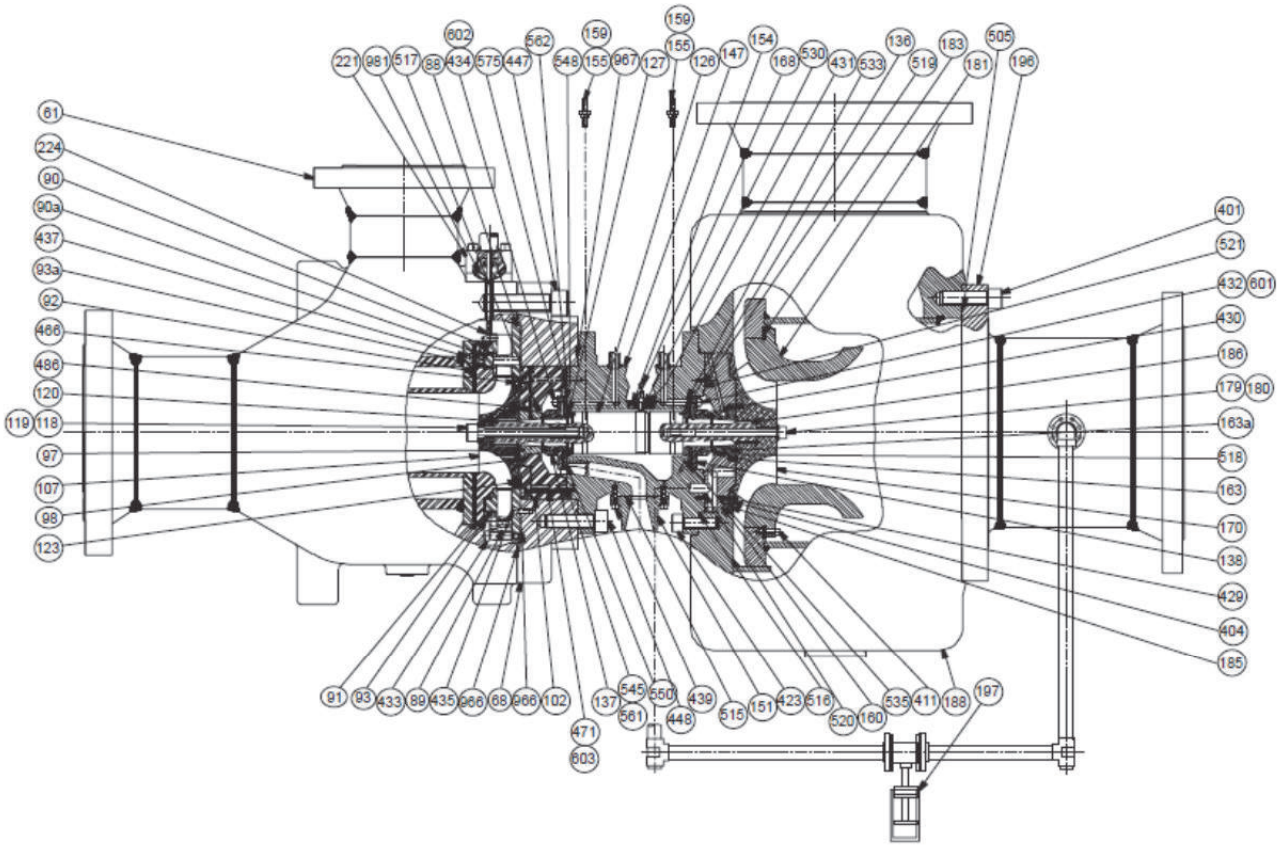
f) mechanical running test data log,

g) final assembly maintenance and running clearances.

The supplier is also required to keep this data available for examination by the purchaser, upon request, for at least 5 years.

Annex C
(informative)

Nomenclature



Key

Item No.	Description
61	Expander case
68	Labyrinth seal housing
88	Nozzle cover
89	Nozzle segment and cam roller
90	Nozzle adjusting ring
90a	Nozzle clamping ring
91	Nozzle fixed ring
92	Shim-nozzle fixed ring
93	Piston ring
93a	Seal ring
97	Heat barrier wall insert
98	Shim-heat barrier wall insert
102	Heat barrier wall
107	Expander wheel
118,119	Retaining screw and retaining washer

Item No.	Description
120	Shaft key (expander)
123	Expander wheel back seal
126	Shaft
127	Bearing thrust washer (expander)
136	Bearing thrust washer (compressor)
137	Bearing-drive
138	Bearing-load
147	Bearing housing
151	Bearing housing drain
154	Tachometer pick-up insert
155,159	Vibration pick-up and lock nut
160	Compressor seal
163	Compressor seal insert
163a	Shim-compressor seal insert
168	Tachometer pick-up

Item No.	Description
170	Compressor wheel
179,180	Retaining screw and retaining washer
181	Compressor follower
183	Shim-compressor follower
185	Compressor wheel back seal
186	Shaft key (compressor)
188	Compressor case
196	Compressor inlet spacer
197	Auto thrust balance assembly
221	Actuator mount assembly
224	Nozzle actuator rod
401 – 486	Screw
505 – 575	O-ring
601 – 603	Washer
966 – 981	Raco seal

Figure C.1—Typical Expander–compressor Showing Nomenclature of Key Parts

Annex D
(informative)

Typical Materials for Major Components

Component [g]	Materials [a]	Specification [b e]	Equivalent JIS Material	Equivalent EN Material	
Casing					
Cast	Cast iron	ASTM A278, Class 30	JIS G5501 FC200	EN 1561 EN-GJL-250	EN-JL1040
		ASTM A278, Class 40	JIS G5501 FC300	EN 1561 EN-GJL-300	EN-JL1050
	Austenitic cast iron	ASTM A436, Type 2	JIS G5510 FCA-NiCr202	NA	
		ASTM A571, Type D-2M Class 1 & 2	JIS G5510 FCDA-Ni22	NA	
	Ductile iron	ASTM A395	JIS G5502	EN 1563 EN-GJS-400-18U-RT	EN-JS1059
	Cast steel	ASTM A216, Grade WCB [d]	JIS G5102 SCW450	EN 10213 GP240GH ISO 4991 G240 similar reference DIN 1681 GS-38	1.0619 1.0420
		ASTM A216, Grade WCC			
		ASTM A352, Grade LCB	JIS G5152 SCPL1	GC24E	1.1156
		ASTM A352, Grade LC2	JIS G5152 SCPL21	EN 10213 G9Ni10	1.5636
		ASTM A352, Grade LC3	JIS G5152 SCPL31	EN 10213 G9Ni14	1.5638
		ASTM A352, Grade LC4	similar reference JIS G5152 SCPL31	similar reference EN 10213 G9Ni14	1.5638
		ASTM A352, Grade LCC	similar reference JIS G5152 SCPL1	EN 10213 G17Mn5 EN 10213 G20Mn5 similar reference SEW 685 G26CrMo4	1.1131 1.6220 1.7221
		ASTM A217	JIS G5151	EN 10213	
	Cast stainless steel	A351, Grade CF3M,	CF3M: JIS G5121 SCS16A CF8: JIS G5121 SCS13A CF8M: JIS G5121 SCS14A	CF3M: EN 10213 GX2CrNiMo19-11-2	1.4409
		CF8 or CF8M		CF8: EN 10213 GX5CrNi19-10 or SEW 685 GX6CrNi18-10 CF8M: EN 10213 GX5CrNiMo19-11-2	1.4308 1.6902 1.4408
		ASTM A351, Grade CF8A			
		ASTM A351, Grade CF3MA or CF8MA	JIS G5121 SCS19A	CF3MA: EN 10213 GX2CrNiMo19-11-2 CF8MA: EN 10213 GX5CrNiMo19-11-2	1.4409 1.4408

Component [g]	Materials [a]	Specification [b e]	Equivalent JIS Material	Equivalent EN Material	
		ASTM A487 Grade CA6NM Class A and B		EN 10213 GX4CrNi13-4	1.4317
		ASTM A757 Grade E3N		EN 10213 GX3CrNi13-4	1.6982
		ASTM A757 Grade D1Q1		SEW 685 G15CrMo9-10	1.7377
	Cast aluminum	ASTM A356 or A357	JIS G5151	NA	
		ASTM B26M 356	JIS H5202 AC4C	EN1706 AC-42000 (Al-Si 7Mg)	
	Cast titanium	ASTM B367, Grade C3 or C4	C3: JIS H4600 2 C4: NA	NA	
Casing Fabricated	Steel	ASTM A285, Grade C	JIS G3118 SGV450		
		ASTM A516, Grade 55, 60, 65, 70	55: JIS G3118 SGV410 60: JIS G3118 SGV410 65: JIS G3118 SGV450 70: JIS G3118 SGV480	55: EN 10028-2 P235GH 60: EN 10028-2 P265GH 65: EN 10028-2 P355GH EN 10025 S355J2+N 70: EN 10028-2 P355GH	1.0345 1.0425 1.0473 1.0577 1.0473
		ASTM A203, Grade Aor B	A: JIS G3127 SL2N255 B: NA	12Ni9	1.5635
		ASTM A203, Grade D or E	D: JIS G3127 SL3N255 E: JIS G3127 SL3N275	EN 10028-4 12Ni14	1.5637
		ASTM A537, Class 1 or 2	1: JIS G3115 SPV355 2: JIS G3115 SPV450	EN 10028-6 P355QH EN 10028-6 P460QH	1.8867 1.8871
		ASTM A353	JIS G3127 SL9N520	EN 10028-3 X8Ni9	1.5662
		ASTM A553, Type Ⅰ	JIS G3127 SL9N590	EN 10028-3 X8Ni9	1.5662
		ASTM A553, Type Ⅱ	JIS G3127 SL9N590	EN 10028-3 X8Ni9	1.5662
		ASTM A266, Class 1 or 4	JIS G3202 SFVC1	EN 10222-4 P355NH	1.0565
		ASTM A336, Class F1	JIS G3202 SFVA F1	EN 10222-2 16Mo3	1.5415
		ASTM A414	JIS G3116	EN 10120	
		ASTM A508, Class 5a [now: Grade 5 Class 2]	JIS G3204 SFVQ3	20NiCrMo14-6	1.6742
		ASTM A350, Grade LF2	JIS G3205 SFL2	EN 10222-3 12Ni14	1.5637
		ASTM A350, Grade LF3	JIS G3205 SFL3	EN 10222-3 12Ni14	1.5637

Component [g]	Materials [a]	Specification [b e]	Equivalent JIS Material	Equivalent EN Material	
		ASTM A266 CL.1	JIS G3202 SFVC1		
		ASTM A662 Grade B		EN 10028-4 P355N EN 10028-4 P355NL2	1.0562 1.1106
		ASTM A765 Grade IV		EN 10222-4 P355QH1	1.0571
		ASTM A350 Grade LF6 Class 1		DIN 17103 TStE 355	1.0566
	Stainless steel	ASTM A240, Type 304, 304L, 316, 316L or 321	304: JIS G4304 SUS304, JIS G4305 SUS304 304L: JIS G4304 SUS304L, JIS G4305 SUS304L 316: JIS G4304 SUS316, JIS G4305 SUS316 316L: JIS G4304 SUS316L, JIS G4305 SUS316L 321:JIS G4304 SUS321, JIS G4305 SUS321	304: EN 10028-7 X5CrNi18-10 304L: EN 10028-7 X2CrNi18-9 316: EN 10028-7 X5CrNiMo17-12-2 316L: EN 10028-7 X2CrNiMo17-12-2 or EN 10028-7 X5CrNiMoTi17-12-2 321: EN 10028-7 X5CrNiTi18-10	1.4301 1.4307 1.4401 1.4404 1.4571 1.4541
		ASTM A182, Grade F304, F304L, F316 or	F304: JIS G3214 SUS F304 F304L: JIS G3214 SUS F304L F316: JIS G3214 SUS F316	F304: EN 10222-5 X5CrNi18-10 F304L: EN 10222-5 X2CrNi18-9 F316: EN 10222-5 X5CrNiMo17-12-2 or EN 10222-5 X5CrNiMoTi17-12-2 F321: EN 10222-5 X5CrNiTi18-10	1.4301 1.4307 1.4401 1.4571 1.4541
		F321	F321: JIS G3214 SUS F321		
		ASTM A182, Grade F 6NM		EN 10222-5 X3CrNiMo13-4	1.4313
		AISI 304L	JIS G3214 SUS 304L		
Casing Fabricated	Aluminum	ASTM B209, Alloy 6061 or 7075	6061: JIS H4000 6061 7075: JIS H4000 7075		
		ASTM B211, Alloy 6061 or 7075	6061: JIS H4040 6061 7075: JIS H4040 7075		
		ASTM B247, Alloy 6061 or 7075	6061: JIS H4140 6061 7075: JIS H4140 7050		
		AMS 4108, Alloy 7050	JIS H4140 7050		
Diaphragms, guide vanes, and	Cast iron	ASTM A48 or A278, Class 30	JIS G5501 FC250	EN 1561 EN-GJL-250	EN-JL1040
inner casings	Ductile iron	ASTM A536	JIS G5502	EN 1563 EN-GJS-400-15U	EN-JS1072

Component [g]	Materials [a]	Specification [b e]	Equivalent JIS Material	Equivalent EN Material	
	Cast iron	ASTM A216, Grade WCB	JIS G5102 SCW450	EN 10213 GP240GH ISO 4991 G240 similar reference DIN 1681 GS-38	1.0619 1.0420
	Steel	ASTM A283, A284, A285, A516 or	JIS G3101 SS400	EN 10025 S235JR EN 10025 S355J2+N	1.0038 1.0577
		A543			
		ASTM A36	JIS G3101 SS400	EN 10025 S235JR	1.0038
	Stainless steel	ASTM A743/744 or A351, Grade CA15,	JIS G5121 SCS13A, JIS G5121 SCS19A	CF8: EN 10213 GX5CrNi19-10 or SEW 685 GX6CrNi18-10 CF8M: EN 10213 GX5CrNiMo19-11-2	1.4308 1.6902 1.4408
		CF3, CF3M, CF8 or CF8M			
		ASTM A240, Type 410	JIS G4304 SUS410, JIS G4305 SUS410	EN 10088-2 X12Cr13	1.4006
		ASTM A276, Type 410	JIS G4303 SUS410	EN 10088-3 X12Cr13	1.4006
		AISI304	JIS G4304 SUS304		
		AISI304L	JIS G3214 SUSF304L	similar reference EN 10250 X6CrNiTi18-10	1.4541
		ASTM A182, Grade F321, F316Ti		F316 Ti: EN 10250 X6CrNiMoTi17-12-2 F321: EN 10250 X6CrNiTi18-10	1.4571 1.4541
		ASTM A662 Grade B		EN 10028-4 P355N EN 10028-4 P355NL2	1.0562 1.1106
		ASTM A350 Grade LF6 Class 1		DIN 17103 TStE 355	1.0566
		ASTM A182, Grade F 6NM		EN 10250 X3CrNiMo13-4	1.4313
		ASTM A487 Grade CA6NM Class A and B		EN 10213 GX4CrNi13-4	1.4317
		ASTM A757 Grade E3N		EN 10213 GX3CrNi13-4	1.6982
	Aluminum	ASTM B26, Alloy 355 or C355	JIS H5202 AC4D	NA	
Shaft	Steel	ASTM A470, Class 1	similar reference JIS G3201 SF540A		
		ASTM A470, Class 7	similar reference JIS G3204 SFVQ3	SEW 555 26NiCrMoV11-5 SEW 555 26NiCrMoV14-5	1.6948 1.6957
	Stainless steel	ASTM A336, Grade F6	G3214 SUS F410-C	EN 10088-3 X12Cr13	1.4006
		ASTM A473, Type 410	JIS G3214 SUS F410	EN 10088-3 X12Cr13	1.4006
		ASTM A182, Grade F 6NM		EN 10250 X3CrNiMo13-4	1.4313

Component [g]	Materials [a]	Specification [b e]	Equivalent JIS Material	Equivalent EN Material	
	Precipitation hardening stainless steel	ASTM A705, Types 630 or XM-12	JIS G3214 SUS F630	EN 10250 X5CrNiCuNb16-4	1.4542
		ASTM A564, Type 630 or XM-12	JIS G4303 SUS630	EN 10250 X5CrNiCuNb16-4	1.4542
Impellers	Aluminum	ASTM B26, Alloy C355 or AL7050	JIS H5202 AC4C		
Cast	Precipitation hardening stainless steel	ASTM A747, Type CB7CU-1 or CB7CU-2	G5121 SCS 24		
	Steel	ASTM A148	JIS G5111		
		ASTM A487 Gs 4Q	JIS G5111 SCMnCrM2		
	Stainless steel	ASTM A743/744 or A351, Grade CA15	JIS G5121 SCS1		
		or CA6NM			
		ASTM A743/744 or A351, Grade CF3, CF3M,	CF3: JIS G5121 SCS19A CF3M: JIS G5121 SCS16A		
		CF8 or CF8M	CF8: JIS G5121 SCS13A CF8M: JIS G5121 SCS14A		
	Aluminum	ASTM A356 or A357	JIS G5151		
	Titanium	ASTM B367, Grade C3 or C4	C3: JIS H4600 2 C4: NA		
		ASTM A367, Grade C5	A367 maybe replaced to B367. JIS H4600 Class 3		
Fabricated (covers, hubs, blades)	Aluminum	ASTM B209, Alloy 6061 or 7075	6061: JIS H4000 6061 7075: JIS H4000 7075		
		ASTM B211, Alloy 6061 or 7075	6061: JIS H4040 6061 7075: JIS H4040 7075		
		ASTM B221, Alloy 6061 or 7075	6061: JIS H4040 6061 7075: JIS H4040 7075		
		ASTM B247, Alloy 2618,	2618: JIS H4140 2618 6061: JIS H4140 6061 7075: JIS H4140 7050		
		6061 or 7075			
		AMS 4108, Alloy 7050	JIS H4140 7050		
		7175			WL 3.4334

Component [g]	Materials [a]	Specification [b e]	Equivalent JIS Material	Equivalent EN Material	
Impellers	Steel	AISI Types 4130-4140 [c]	JIS G4053 SCM430	EN 10083-3 42CrMo4	1.7225
Fabricated					
		AISI Types 4320-4345 [c]	JIS G4053 SNCM431	EN 10083-3 30CrNiMo8	1.6580
		ASTM A470, Class 8		14CrMoV6-9	1.7735
		AISI Type 3140[C]	similar reference JIS G4102 SNC236		
		ASTM A543	JIS G3101 SS400		
		ASTM A522, Type Ⅰ	JIS G3127 SL9N520	EN 10222-3 X8Ni9	1.5662
		ASTM A522, Type Ⅱ	JIS G3127 SL9N520	EN 10222-3 X8Ni9	1.5662
		ASTM A353	JIS G3127 SL9N520	EN 10222-3 X8Ni9	1.5662
		AISI Type 403 [c]	JIS G3214 SUS F403	EN 10088-3 X6Cr13	1.4000
		ASTM A473, Type 410	JIS G3214 SUS F410	EN 10088-3 X12Cr13	1.4006
		ASTM A240, Type 304, 304L, 316	304: JIS G4304 SUS304, JIS G4305 SUS304 304L: JIS G4304 SUS304L, JIS G4305 SUS304L 316: JIS G4304 SUS316, JIS G4305 SUS316 316L: JIS G4304 SUS316L, JIS G4305 SUS316L	304: EN 10028-7 X5CrNi18-10 304L: EN 10028-7 X2CrNi18-9 316: EN 10028-7 X5CrNiMo17-12-2 316L: EN 10028-7 X2CrNiMo17-12-2	1.4301 1.4307 1.4401 1.4404
		or 316L			
		ASTM A473, Type 304, 304L, 316, or 316L	304: JIS G3214 SUS F304 304L: JIS G3214 SUS F304L 316: JIS G3214 SUS F316 316L: JIS G3214 SUS F316L	F304: EN 10222-5 X5CrNi18-10 F304L: EN 10222-5 X2CrNi18-9 F316: EN 10222-5 X5CrNiMo17-12-2 F316L: EN 10222-5 X2CrNiMo17-12-2	1.4301 1.4307 1.4401 1.4404
		UNS S42400	NA	EN 10250 X3CrNiMo13-4	1.4313
		AISI 410	JIS G4303 SUS410$_{\text{-MOD}}$	NA	
		ASTM A638 Grade 660 Type 2 (A286)		EN 10302 X6NiCrTiMoVB25-15-2	1.4980
	Precipitation hardening stainless steel	ASTM A705, Type 630 or XM-12	JIS G3214 SUS F630	EN 10250 X5CrNiCuNb16-4	1.4542
		AISI S17400	JIS G4303 SUS630		
		ASTM A693, Type 630 or XM-12	JIS G4304 SUS630, JIS G4305 SUS630	EN 10088-2 X5CrNiCuNb16-4	1.4542

Component [g]	Materials [a]	Specification [b e]	Equivalent JIS Material	Equivalent EN Material	
	Ni-Cu	SAE AMS 4646	NA	?	
		ASTM B127	JIS H4551		
		QQ-N-286	JIS H4551 NW5500		
		ASTM B865 UNS N05500		DIN 17743 NiCu30Al ISO 9725 NiCu30Al3Ti	2.4375 NW5500
	Titanium	ASTM B381 Grade F5		DIN 17864 TiAl6V4	3.7165
Labyrinths					
Impeller interstage	Aluminum	ASTM B26, Alloy 443, 335, 850,	JIS H5202	EN 586	
shaft seal and		A850 or B850			
balance piston		6061-T6 or 1100	6061: JIS H4000 6061 1100: JIS H4000 1100		
		ASTM B209 Grade 5083		EN 586 EN-AW-5083 [Al Mg4.5Mn0.7]	AW5083
		7175			WL 3.4334
	Babbit	ASTM B23	JIS H5401		
	Brass	ASTM B16 or B21	JIS H3250	EN 12420	
		ASTM B36	JIS H3100	EN 1652	
		ASTM B171	JIS H3100	EN 1652	
		ASTM B564 UNS N04400		DIN 17743 NiCu30Fe ISO 9725 NiCu30	2.4360 NW4400
	Bronze			Cu Sn 10/12	
	Stainless steel	AISI Type 403, 410, 416,	403: JIS G3214 SUS F403 410: JIS G3214 SUS F410 416: JIS G3214 SUS F416	EN 10088-3 X6Cr13 EN 10088-3 X12Cr13 additional: X19CrMo12-1	1.4000 1.4006 1.4921
		420		EN 10088-3 X20Cr13	1.4021
		303, 304, or 316	403: JIS G3214 SUS F303 410: JIS G3214 SUS F304 416: JIS G3214 SUS F316	EN 10088-3 X6CrNiTi18-10 EN 10088-3 X6CrNiMoTi17-12-2	1.4541 1.4571

Component [g]	Materials [a]	Specification [b e]	Equivalent JIS Material	Equivalent EN Material	
		304, 304L,316			1.4301 1.4306 1.4401
	Cr-Ni-Fe-Mo-Cu-Cb alloy	ASTM B462	JIS H4551 NW6007	EN 10088-3 X1NiCrMoCuN25-20-7	1.4529
	Stainless steel honeycomb	ASTM A240, Type 304, 304L, 316 or 316L	304: JIS G4304 SUS304, JIS G4305 SUS304 304L: JIS G4304 SUS304L, JIS G4305 SUS304L 316: JIS G4304 SUS316, JIS G4305 SUS316 316L: JIS G4304 SUS316L, JIS G4305 SUS316L	304: EN 10028-7 X5CrNi18-10 304L: EN 10028-7 X2CrNi18-9 316: EN 10028-7 X5CrNiMo17-12-2 316L: EN 10028-7 X2CrNiMo17-12-2	1.4301 1.4307 1.4401 1.4404
	Ni-Cu alloy	ASTM B164	JIS H4553	DIN 17743 NiCu30Fe ISO 9725 NiCu30	2.4360 NW4400
	Nonmetallic TFE [f]				
	Nonmetallic TFE [f]				
	carbon-filled				
	Nonmetallic TFE [f]				
	mica-filled				
	Lead	ASTM B29	H2105	NA	
	Nickel-graphite				
	Phenolic resin impregnated materials	Micarta, NEMA, Grade LE	NA		
		Micarta, NEMA, Grade G10 or G9	NA		
Balance piston	Steel (new)	ASTM A470, Class 1	similar reference JIS G3201 SF540A		
		ASTM A470, Class 7	similar reference JIS G3204 SFVQ3	SEW 555 26NiCrMoV11-5 SEW 555 26NiCrMoV14-5	1.6948 1.6957
		AISI Types, 1040-1050 [c]	JIS G4051 S40C	EN 10083-2 C45E	1.1191
		AISI Types, 4130-4145 [c]	JIS G4053 SCM440	EN 10083-3 42CrMo4	1.7225
		AISI Types, 4330, 4345 [c]	JIS G4053 SNCM431	EN 10083-3 30CrNiMo8	1.6580
		AISI Type, 2320 [c]	NA		

Component [g]	Materials [a]	Specification [b e]	Equivalent JIS Material	Equivalent EN Material	
		ASTM A522, Type I	JIS G3127 SL9N520	EN 10222-3 X8Ni9	1.5662
	Stainless steel (new)	ASTM A336, Grade F6	G3214 SUS F410-C		
		ASTM A473, Type 410	JIS G3214 SUS F410	EN 10088-3 X12Cr13	1.4006
		AISI Type 403 or 410 [c]	403: JIS G3214 SUS F403 410: JIS G3214 SUS F410	EN 10088-3 X6Cr13 EN 10088-3 X12Cr13	1.4000 1.4006
	Precipitation hardening stainless steel	ASTM A705, Type 630 or XM-12	JIS G3214 SUS F630	EN 10250 X5CrNiCuNb16-4	1.4542
		ASTM A470, Class 8		14CrMoV6-9	1.7735
		UNS S42400	NA	EN 10250 X3CrNiMo13-4	1.4313
		ASTM A638 Grade 660 Type 2 (A286)		EN 10302 X6NiCrTiMoVB25-15-2	1.4980
	Ni-Cu alloy	ASTM B865 UNS N05500		DIN 17743 NiCu30Al ISO 9725 NiCu30Al3Ti	2.4375 NW5500
		SAE ANS 4676	NA		
Shaft sleeves	Steel	AISI Types, 4130-4150 [c]	JIS G4053 SCM440	EN 10083-3 42CrMo4	1.7225
		AISI Types, 4320, 4345 [c]	JIS G4053 SNCM431	EN 10083-3 30CrNiMo8	1.6580
		AISI 4330	JIS G4053 SNCM431		
		ASTM A470, Class 7	similar reference JIS G3201 SF540A	SEW 555 26NiCrMoV11-5 SEW 555 26NiCrMoV14-5	1.6948 1.6957
		ASTM A522, Type I	JIS G3127 SL9N520	EN 10222-3 X8Ni9	1.5662
		ASTM A106	JIS G3456	EN 10216	
		ASTM A350	JIS G3205	EN 10250	
		ASTM A350, Grade LF-3	JIS G3205 SFL3	EN 10250 12Ni14	1.5637

Component [g]	Materials [a]	Specification [b e]	Equivalent JIS Material	Equivalent EN Material	
	Stainless steel	AISI Types 403 or 410 [c]	403: JIS G3214 SUS F403 410: JIS G3214 SUS F410	EN 10088-3 X6Cr13 EN 10088-3 X12Cr13	1.4000 1.4006
	Ni-Cu alloy	ASTM B164 or SAE AMS 4676	JIS H4553		
	Ni-Mo-Cr alloy	ASTM B574, Alloy N10276	JIS H4551 NW0276	DIN 17744 NiMo16Cr15W ISO 9725 NiMo16Cr15Fe6W4	2.4819 NW0276
		ASTM A494, Grade CW-12M-1	similar reference JIS H5701 NMCrC		
	Precipitation hardening stainless steel	A705 Type 630 or XM-12	JIS G3214 SUS F630	EN 10250 X5CrNiCuNb16-4	1.4542

[a] The materials shown in this table are those commonly used by compressor manufacturers, but the list is not all inclusive. Other suitable materials may exist and may be used as indicated by specific design considerations.

[b] Descriptions of AISI Types (cross-referenced to UNS) can be found in SAE HS1086. Descriptions of UNS Types can can also be found in ASTM DS 56J.

[c] The temperature limits shown in this table are those commonly observed by compressor manufacturers and are not necessarily the same as any temperature limits specified in the applicable material specifications.

[d] Normalized or normalized and tempered.

[e] AISI and UNS designations are only a description of chemical analyses of types of steels; they are not procurement specifications. All materials should be purchased to a specification that adequately defines the required properties and controls.

[f] TFE = tetrafluoroethylene.

[g] See nomenclature in cross sections of either the centrifugal or axial compressor for part names in Annex C.

Annex E
(informative)

Inspector’s Checklist

Item	API 617		Date Inspected	Inspected By	Status
	Section	Part			
4.5 MATERIALS					
Coating applied prior to acceptance balance	4.5.1.15	1			
PMI	4.5.1.16.1	1			
Impact testing	4.5.1.17.5	1			
Castings—material specification compliance	4.5.2.1	1			
Castings—purchaser approval of repairs	4.5.2.3.3	1			
Castings—ductile (nodular) iron	4.5.2.5	1			
Forgings—repairs	4.5.3.2	1			
Welding—nonpressure components	4.5.4.1	1			
Welding—pressure-containing and rotating parts	4.5.4.2	1			
4.6 CASINGS					
Jackscrews, dowels and special tools	4.6.1.4	1			
Provisions for lifting casings	4.6.1.3	4			
Depth of threaded holes	4.6.1.5	1			
Studs instead of cap screws	4.6.1.7.2	1			
Adequate clearance at bolts	4.6.1.7.3	1			
Bolting materials	4.6.1.7.6	1			
Welding	4.6.1.8	1			
Casing repair—minimum level of inspection and purchaser review	4.6.2.1	1			
Casing repair—major repairs	4.6.2.2	1			
Casing repair—material standards	4.6.2.3	1			
Pressure casings—plate edges	4.6.2.4.1	1			
Pressure casings—MPT or LPT	4.6.2.4.2	1			
Pressure casings—weld QC	4.6.2.4.3	1			
Pressure casings—full penetration welds	4.6.2.4.4	1			
Casings—heat treatment	4.6.2.4.5	1			
Pressure containing weld inspection	4.6.2.4.6	1			
Materials inspection standards	4.6.3.2	1			
Cast steel casings—acceptability of defects	4.6.3.3	1			
Pressure casing connection size	4.6.4.1.3	1			
Casing connections—welding before hydrotest	4.6.4.1.5	1			
Main process connection orientation	4.6.4.2.1	1			
Flanges	4.6.4.2.2	1			
Cast iron flanges	4.6.4.2.6	1			
Concentricity of bolt circle and bore	4.6.4.2.12	1			
Steel flange facing finish	4.6.4.2.13	1			
Machined and studded connections	4.6.4.2.14	1			
Flanges parallel within 0.5 degrees	4.6.4.2.15	1			
Auxiliary connections—minimum size	4.6.4.2.1	4			

Auxiliary connections—flanges	4.6.4.3.2	1			
Auxiliary connections—allowable types	4.6.4.3.3	1			
Auxiliary connections—pipe nipples	4.6.4.3.4	1			
Auxiliary connections—socket weld gap	4.6.4.3.6	1			
Auxiliary connections—lube or seal service	4.6.4.3.7	1			
Threaded openings for tapered pipe threads	4.6.4.3.8.1	1			
Tapered pipe threads	4.6.4.3.8.2	1			
Seal welding tapered pipe threads	4.6.4.3.8.3	1			
Pipe nipples for threaded openings	4.6.4.3.8.4	1			
Plugs for threaded openings	4.6.4.3.8.5	1			
Machine mounting surfaces	4.6.5.1	1			
4.7 ROTATING ELEMENTS					
Shaft ends for couplings	4.7.1	1			
Impeller and shaft marking	4.7.1.2	4			
Shaft sensing areas for probes	4.7.2	1			
Shaft sensing areas—final surface finish	4.7.3	1			
Shaft weld NDE	4.7.3.2	4			
Coating or overlay to prevent wire wooling	4.7.3.3	4			
Thrust collar surface finish and TIR	4.7.6	1			
Fabricated impeller inspection	4.7.10.3	1			
Cast impeller inspection	4.7.10.4	1			
Cast impeller repair	4.7.10.5	1			
Welding not permitted for impeller balancing	4.7.10.6	1			
MPT or LPT of impellers after overspeed	4.7.10.7	1			
4.8 DYNAMICS					
Confirmation of critical speeds	4.8.2.2	1			
Unbalanced rotor response verification test	4.8.3	1			
Additional testing	4.8.4.1	1			
Blaancing method for single shaft expander-compressors	4.8.1.1	4			
Rotating element—component balance	4.8.8.1	1			
Rotating element—sequential multiplane balance	4.8.8.2	1			
Rotating element—if disassembled after balance	4.8.8.2.1	1			
Rotating element—assembly and balance verification	4.8.1.6	4			
Rotating element—reassembly check balance	4.8.8.2.2	1			
Rotating element—residual unbalance check	4.8.1.7	4			
Operating speed balance	4.8.8.3	1			
Operating speed balance procedure	4.8.8.4	1			

4.12 NAMEPLATES AND ROTATION ARROWS					
Nameplate at readily visible location	4.12.1	1			
Nameplate material	4.12.2	1			
Nameplate contents	4.12.2	4			
Lateral critical speeds on nameplate	4.12.5	1			
5.4 MOUNTING PLATES					
Jackscrews	5.4.1.2.1 5.4.1.1	1 4			
Alignment shims	5.4.1.2.2	1			
Machinery mounting surfaces	5.4.1.2.3	1			
Anchor bolt clearance	5.4.1.2.8	1			
Vertical leveling screws	5.4.1.2.9	1			
Radiused corners for grout	5.4.1.2.10	1			
Hold-down bolt clearance	5.4.1.2.12	1			
Wrench clearance	5.4.1.2.13	1			
Grout contacting surface preparation	5.4.1.2.15	1			
Mounting surface preservation	5.4.1.2.17	1			
Seal welded joints	5.4.2.3	1			
Leveling pads or targets	5.4.2.6.1	1			
Additional pads or targets	5.4.2.6.2	1			
Lifting lugs	5.4.2.7	1			
Grout fill and vent holes	5.4.2.8	1			
Soleplate thickness	5.4.3.1.1	1			
Soleplate size	5.4.3.1.2	1			
Soleplates fully machined	5.4.3.1.4	1			
Subsoleplates	5.4.3.1.5	1			
5.5 CONTROLS AND INSTRUMENTATION					
Controls ingress protection level	5.5.1.6	1			
Terminal box ingress protection level	5.5.1.7	1			
Conduit and cable location and installation	5.5.1.8	1			
Transducers per API 670	5.5.1.1	4			
Axial probes per API 670	5.5.1.2	4			
Monitors per API 670	5.5.1.3	4			
Radial bearing temperature sensors per API 670	5.5.2.1	4			
Thrust bearing temperature sensors per API 670	5.5.2.2	4			
Bearing temperature monitors per API 670	5.5.2.3	4			
Magnetic bearing temperature sensors	5.5.3	4			

5.6 PIPING AND APPURTENANCES					
Piping terminate at skid edge	5.6.1	4			
Breakout spools	5.6.1.4	1			
Provisions to bypass bearings	5.6.1.5	1			
Provisions to bypass dry gas seals	5.6.1.6	1			
Instrument piping	5.6.2	1			
Process piping	5.6.3	1			
5.7 SPECIAL TOOLS					
Use of tools	5.7.1	1			
Tool packing and marking	5.7.2	1			
6.1 INSPECTION, TESTING, AND PREPARATION FOR SHIPMENT—GENERAL					
Access to vendor's quality control program	6.1.7	1			
6.2 INSPECTION					
Painting before hydrotest	6.2.1.1	1			
Cleanliness	6.2.1.3	1			
Hardness of parts, welds, and heat affected zones	6.2.1.5	1			
Radiographic inspection	6.2.2.2	1			
Ultrasonic inspection	6.2.2.3	1			
Magnetic particle inspection	6.2.2.4	1			
Liquid penetrant inspection	6.2.2.5	1			
6.3 TESTING					
Contract probes and accelerometers used	6.3.2.1	1			
Contract shaft seals and bearings used	6.3.3.1.1	4			
Oil system cleanliness before testing	6.3.3.1.4	4			
Joint and connection tightness	6.3.2.5	1			
Warning, protective and control devices	6.3.2.6	1			
Instrument calibration	6.3.2.7	1			
Hydrostatic test—pressure	6.3.3.1	1			
Hydrostatic test—duration	6.3.3.2	1			
Hydrostatic test—chloride content	6.3.3.3	1			
Impeller overspeed test	6.3.4.1	1			
Residual magnetism	6.3.5	1			
Dry gas seals	6.3.6	1			

Mechanical running test—operation of equipment and test instrumentation	6.3.7.1.1	1			
Mechanical running test—unfiltered vibration	6.3.7.1.2	1			
Mechanical running test—vibration plots	6.3.7.1.3	1			
Mechanical running test—real time vibration data recorded	6.3.7.1.4	1			
Mechanical running test—seal flow data	6.3.7.1.5	1			
Mechanical running test—lube oil and seal oil variations	6.3.7.1.6	1			
Mechanical running test—hydrodynamic bearing inspection	6.3.7.2.1 6.3.3.4.1	1 4			
Mechanical running test—shaft end seal inspection	6.3.7.3 6.3.3.4.2	1 4			
Spare mechanical center sections tested	6.3.3.3.6	4			
Gas test after hydro	6.3.9.3	1			
Assembled compressor gas leak test	6.3.4.1	4			
Sound-level test	6.3.9.4	1			
Auxiliary equipment test	6.3.9.5	1			
Post-test inspection of internals	6.3.9.6	1			
Full-pressure/full-load/full-speed test	6.3.9.7	1			
Post-test inspection of coupling fit	6.3.9.8	1			
Spare parts test	6.3.9.9	1			
6.4 PREPARATION FOR SHIPMENT					
Preparation for shipment	6.4.1	1			
Spare center section prepared for storage	6.4.1	4			
Testing completed and equipment released	6.4.3	1			
Coating on exterior surfaces	6.4.3.1	1			
Exterior machined surfaces coating	6.4.3.2	1			
Interior of equipment	6.4.3.3	1			
Internal surfaces of bearing housings	6.4.3.4	1			
Flange covers	6.4.3.5	1			
Threaded openings	6.4.3.6	1			
Beveled welding openings	6.4.3.7	1			
Lifting point identification	6.4.3.8	1			
Equipment tagging and packing lists	6.4.3.9	1			
Spare rotor storage preparation	6.4.3.10	1			
Spare rotor container	6.4.3.10.1	1			
Cradle support liner	6.4.3.11	1			
Rotor preparation for vertical storage	6.4.3.12	1			
Fit-up and assembly of piping and intercoolers	6.4.3.13	1			
Shaft and coupling protection	6.4.3.14	1			
Auxiliary connection marking	6.4.4	1			
Auxiliary piping match marks	6.4.5	1			
IOM shipped with equipment	6.4.6	1			
Wood used in export shipping	6.4.7	1			

Annex F
(normative)

Nozzle Forces and Moments

F.1 General

F.1.1 The April 1988, November 1979, and October 1973 issues of this standard referred nozzle forces and moments calculations to appropriate NEMA documents, with the stipulation that the constants in the equations be multiplied by 1.85. Experience has shown that there has not been a uniform interpretation of “1.85 times NEMA.” Therefore, the equations have been adapted to expander-compressors by identifying all the constants and clarifying that the equivalent of the exhaust nozzle in the NEMA calculation is the largest expander or compressor nozzle. This is usually, but not necessarily, the outlet nozzle.

F.1.2 For expanders designed for driving separate gearboxes or generators, which require high tolerance of alignment between the expanders and the gearboxes/generators, the supplier shall identify the maximum allowable forces and moments.

NOTE 0.2 times NEMA is often required for this type of the arrangement**.**

F.2 Equations

The design of each expander-compressor body shall allow for limited piping loads on the various casing nozzles. For maximum system reliability, nozzle loads imposed by piping should be as low as possible regardless of the expander-compressor load-carrying capability. For single stage expander-compressors, the forces and moments acting on expander or compressor due to the inlet and discharge connections should be limited by the following.

The total resultant force and total resultant moment imposed on the compressor at any connection should not exceed the values shown in Equation (F.1).

In SI units:

$$F_r + 1.09M_r \leq 54.1D_e \tag{F.1a}$$

In U.S. customary (USC) units:

$$3F_r + M_r \leq 927D_e \tag{F.1b}$$

where

F_r is the resultant force, in Newtons (lb) (see Figure F.1);

M_r is the resultant moment, in Newton-meters (ft-lb) from Figure F.1.

$$M_t = \sqrt{M_z + M_y + M_z} \quad \text{(F.2)}$$

For sizes up to 200 mm (8 in.) in diameter:

D_e is equivalent pipe diameter of the connection, mm (in.).

For sizes greater than 200 mm (8 in.), use the following values.

In SI units:

$$D_e = \frac{(400 + D_{\text{nom}})}{3} \text{ (mm)} \quad \text{(F.3a)}$$

In U.S. Customary units:

$$D_e = \frac{(16 + D_{\text{nom}})}{3} \text{ (in.)} \quad \text{(F.3b)}$$

where

D_e is the equivalent pipe diameter of the connection, mm (in.);

D_{nom} is the nominal pipe diameter, mm (in.).

The combined resultants of the forces and moments of the inlet, sidestream, and discharge connections resolved at the centerlines of the largest connection should not exceed the following.

The resultants shall not exceed the following.

In SI units:

$$F_c + 1.64M_c \leq 40.4D_c \quad \text{(F.4a)}$$

In USC units**:**

$$2F_c + M_c \leq 462D_c \quad \text{(F.4b)}$$

where

F_c is the combined resultant of inlet, sidestream, and discharge forces, Newtons (lb);

M_c is the combined resultant of inlet, sidestream, and discharge moments, and moments resulting from forces, Newton-meters (ft-lb);

D_c is the diameter [mm (in.)] of one circular opening equal to the total areas of the inlet, sidestream, and discharge openings. If the equivalent nozzle diameter is greater than 230 mm (9 in.), use a value of D_c equal to the following.

In SI units:

$$D_c \frac{(460 + \text{Equivalent Diameter})}{3} \quad \text{(mm)} \tag{F.5a}$$

In USC units:

$$D_c \frac{(18 + \text{Equivalent Diameter})}{3} \quad \text{(in.)} \tag{F.5b}$$

The individual components (Figure F.1) of these resultants should not exceed the following.

In SI units:

$F_x = 16.1D_c$ $M_x = 24.6D_c$

$F_y = 40.5D_c$ $M_y = 12.3D_c$

$F_z = 32.4D_c$ $M_z = 12.3D_c$

In USC units:

$F_x = 92D_c$ $M_x = 462D_c$

$F_y = 231D_c$ $M_y = 231D_c$

$F_z = 185D_c$ $M_z = 231D_c$

where

F_x is the horizontal component of F_c, parallel to the compressor shaft, Newtons (lb);

F_y is the vertical component of F_c, Newtons (lb);

F_z is the horizontal component of F_c at right angles to be compressor shaft, Newtons (lb);

M_x is the component of M_c, around the horizontal axis, Newton-meters (ft-lb);

M_y is the component of M_c, around the vertical axis, Newton-meters (ft-lb);

M_z is the component of M_c around the horizontal axis at right angles to the compressor shaft, Newton-meters (ft-lb).

These values of allowable forces and moments pertain to the turbo-expander structure only. They do not pertain to the forces and moments in the connecting pipes, flanges, and flange bolting, which should not exceed the allowable stress as defined by applicable codes and regulatory bodies.

Loads may be increased by mutual agreement between the purchaser and supplier; however, it is recommended that expected operating loads be minimized.

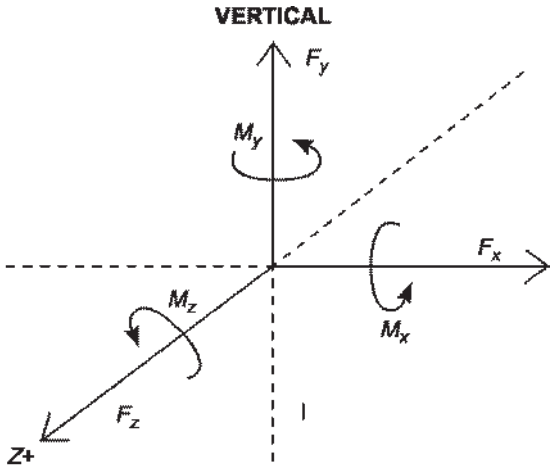


Figure F.1—Combined Resultants of the Forces and Moments of Corrections

Annex G
(informative)

Lubrication and Sealing Requirements

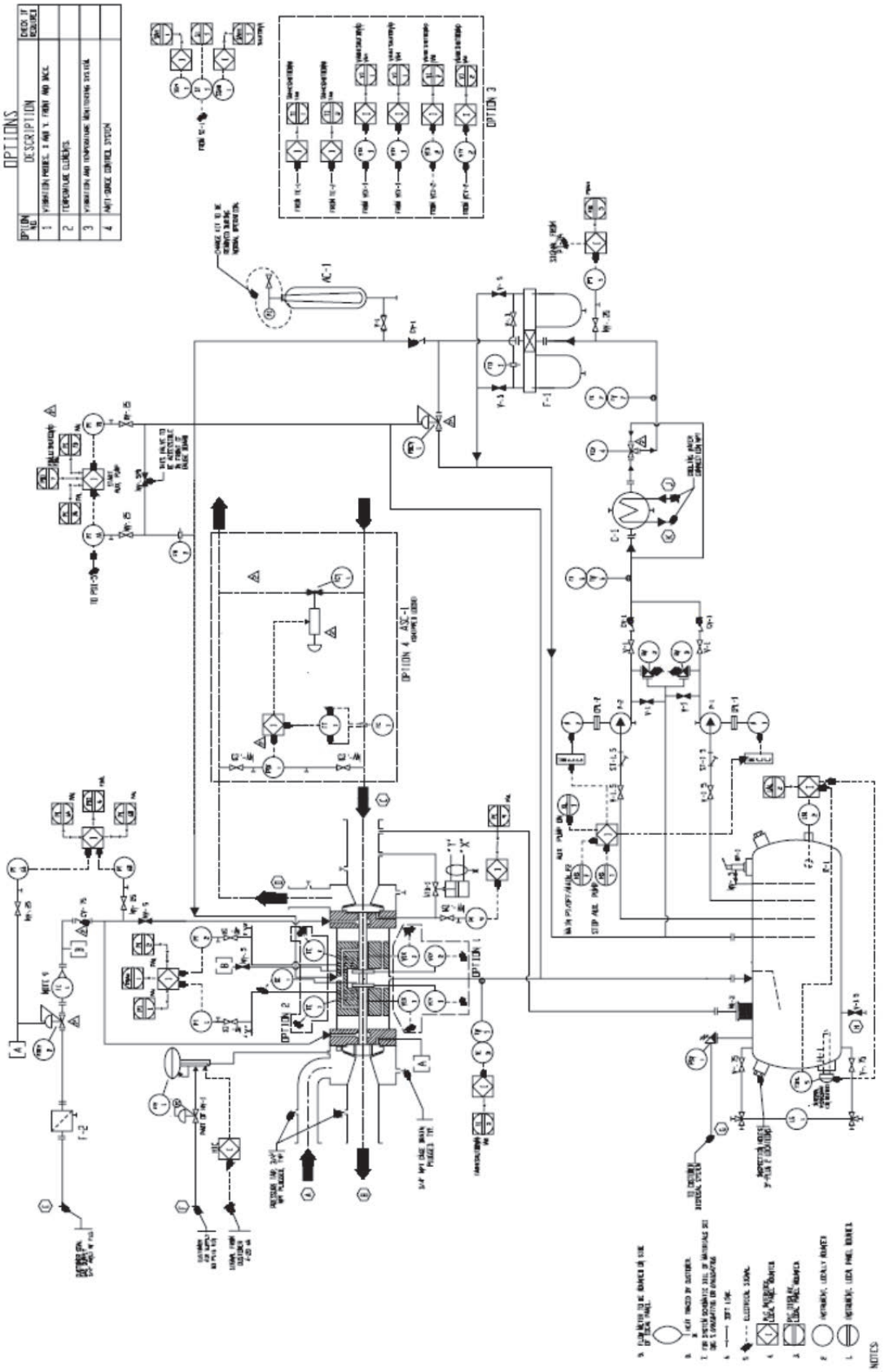


Figure G.1—Typical Lubrication System for an Expander-compressor

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