

AXIAL AND CENTRIFUGAL COMPRESSORS AND EXPANDER-COMPRESSORS

Specification

This Standard replaces and cancels its previous revision.

The CONTEC - Authoring Subcommittee provides guidance on the interpretation of this Standard when questions arise regarding its contents. The Department of PETROBRAS that uses this Standard is responsible for adopting and applying the sections, subsections and enumerates thereof.

Technical Requirement: A provision established as the most adequate and which shall be used strictly in accordance with this Standard. If a decision is taken not to follow the requirement ("non-conformity" to this Standard) it shall be based on well-founded economic and management reasons, and be approved and registered by the Department of PETROBRAS that uses this Standard. It is characterized by imperative nature.

Recommended Practice: A provision that may be adopted under the conditions of this Standard, but which admits (and draws attention to) the possibility of there being a more adequate alternative (not written in this Standard) to the particular application. The alternative adopted shall be approved and registered by the Department of PETROBRAS that uses this Standard. It is characterized by verbs of a non mandatory nature. It is indicated by the expression: **[Recommended Practice]**.

Copies of the registered "non-conformities" to this Standard that may contribute to the improvement thereof shall be submitted to the CONTEC - Authoring Subcommittee.

Proposed revisions to this Standard shall be submitted to the CONTEC - Authoring Subcommittee, indicating the alphanumeric identification and revision of the Standard, the section, subsection and enumerate to be revised, the proposed text, and technical/economic justification for revision. The proposals are evaluated during the work for alteration of this Standard.

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Introduction

PETROBRAS Technical Standards are prepared by Working Groups - WG (consisting specialized of Technical Collaborators from Company and its Subsidiaries), are commented by Company Units and its Subsidiaries, are approved by the Authoring Subcommittees - SCs (consisting of technicians from the same specialty, representing the various Company Units and its Subsidiaries), and ratified by the Executive Nucleus (consisting of representatives of the Company Units and its Subsidiaries). A PETROBRAS Technical Standard is subject to revision at any time by its Authoring Subcommittee and shall be reviewed every 5 years to be revalidated, revised or cancelled. PETROBRAS Technical Standards are prepared in accordance with PETROBRAS Technical Standard N-1. For complete information about PETROBRAS Technical Standards see PETROBRAS Technical Standards Catalog.

CONTEC

 Comissão de Normalização
Técnica

SC - 11

Machines

1 Scope

1.1 This Standard is based on API Std 617 8th edition, published in September, 2014.

1.2 This Standard establishes the minimum requirements for Axial and Centrifugal Compressors, Expander-Compressors and their auxiliary equipment or systems, to be supplied in accordance with API Std 617 8th edition.

1.3 This Standard applies to design starting from its issue date.

1.4 This Standard only contains Technical Requirements.

2 Normative References

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 [Std 520](#) – Sizing, Selection, and Installation of Pressure-relieving Devices – Part I – Sizing and Selection

API [Std 614](#) – Lubrication, Shaft-Sealing, and Control-Oil Systems and Auxiliaries

API [Std 617](#) – Axial and Centrifugal Compressors and Expander-Compressors - Eighth Edition

API [Std 670](#) – Machinery Protection Systems

API [RP 686](#) – Recommended Practice for Machinery Installation and Installation Design

API [RP 687](#) – Rotor Repair

ASME [B1.20.1](#) – Pipe Threads, General Purpose

ASME [B16.1](#) – Gray Iron Pipe Flanges and Flanged Fittings - Classes 25, 125, and 250

ASME [B16.42](#) – Ductile Iron Pipe Flanges and Flanged Fittings - Classes 150 and 300

ASME [B16.47](#) – Large Diameter Steel Flanges - NPS 26 Through NPS 60

ASME [B16.5](#) – Pipe Flanges and Flanged Fittings - NPS ½ Through NPS 24

ASME [B31.3](#) – Process Piping

ASME [PTC-10](#) – Performance Test Code on Compressors and Exhausters

IEC [60079-10-1](#) – Electrical Apparatus for Explosive Gas Atmospheres – Part 10-1: Classification of Hazardous Areas – Explosive gas atmospheres

IEC [60529](#) – Degrees of Protection Provided by Enclosures (IP Code)

ISO [11342](#) – Mechanical Vibration - Methods and Criteria for the Mechanical Balancing of Flexible Rotors

ISO/IEC [17024](#) – Conformity assessment - General requirements for bodies operating certification of persons

ISO [1940-1](#) – Mechanical vibration - Balance quality requirements for rotors in a constant (rigid) state – Part 1: Specification and verification of balance tolerances

ISO 8501 – Preparation of steel substrates before application of paints and related products
- Visual assessment of surface cleanliness

ISO 9712 – Non-destructive testing – Qualification and certification of NDT personnel

SSPC-SP 6 – Commercial Blast Cleaning

3 Basic Considerations

3.1 The requirements of this Standard are additions to, or modifications of the API Std 617 8th edition, which shall be considered as an integral part of this Standard.

3.2 Except for new clauses, item numbers used in this Standard are the same API Std 617 8th edition paragraph one.

3.3 All deviations from the requirements stated in this Standard and/or in API Std 617 8th edition shall be clearly identified in the proposal and submitted to PETROBRAS for approval. Any requirement exception or deviation from any of the listed documents not clearly mentioned in tender will be considered by PETROBRAS as full compliance with the material requisition.

3.4 All deviations from the contracted design or scope of supply made by vendor during time of drawings and documents review shall be clearly mentioned in the particular document to be approved.

3.5 Vendor's compliance with the requirements of these specifications does not exempt him from the responsibility of supplying equipment and accessories suitable for the specified service conditions.

3.6 Compressors and auxiliary equipment shall be in accordance with API Std 617 8th edition, plus the following changes, as noted in parenthesis for each clause, according to the definitions stated below. The information of each clause shall be read as follows, whenever starting with:

- addition - continuation of that particular API Std 617 8th edition paragraph;
- modification - replacement of part of that affected API Std 617 8th edition paragraph;
- substitution - replacement of that API Std 617 8th edition paragraph in its entirety;
- new - insertion of a requirement not found in API Std 617 8th edition;
- deletion - removal of that particular API Std 617 8th edition paragraph;
- comment - clarification or interpretation on that API Std 617 8th edition paragraph.

3.7 Annex A contains the data sheet form to be used for axial and centrifugal compressors and expander-compressors, according to API Std 617 8th Edition.

3.8 Annex B contains the Vendor Drawing and Data Requirements (VDDR) form to be used for axial and centrifugal compressors and expander-compressors, according to API Std 617 8th Edition.

3.9 Annex C establishes the shop vibration equipment configuration to be used by the vendor during the shop tests.

4 General Requirements (Part 1 of API Std 617)

4.1 Normative References (Section 2 of API Std 617)

4.1.1 Substitution (2.2 of API Std 617)

In case of conflict between the inquiry documents, the hierarchy of documents shall be as follows:

- a) data sheets;
- b) supplementary job or technical specifications (if any);

- c) this PETROBRAS Standard and all other PETROBRAS standards specifically referenced in the inquiry;
- d) API [Std 617](#) 8th edition.

Concerning any conflict after placement of order, the following hierarchy shall govern:

- a) formal correspondence regarding any changes in the scope of supply or technical specifications, mutually agreed upon by PETROBRAS and vendor;
- b) approved documentation;
- c) revised data sheets and other material requisition documents (applicable to purchase);
- d) this PETROBRAS Standard and all other PETROBRAS standards specifically referenced in the inquiry or order;
- e) API [Std 617](#) 8th edition;
- f) vendor's proposal.

4.2 Terms, Definitions and Abbreviations (Section 3 of API [Std 617](#))

4.2.1 Substitution (3.1.65 of API [Std 617](#))

unit responsibility

Obligation for coordinating the documentation, delivery, and technical aspects of the equipment and all auxiliary systems included in the machinery train package.

4.2.2 New (3.1.67)

hazardous service

when so stated on the data sheets, shall apply to all parts of compressor, seal system, piping, instruments and auxiliary equipment that are to (or may eventually) be in contact with the process gas, and refers to the following fluids and operational conditions:

- a) H₂S (Hydrogen Sulphide) concentrations above 500 ppm;
- b) hydrocarbons with hydrogen at a partial pressure above 7 bar a (101 psi a);
- c) hydrogen-rich services (more than 90 % molal concentration at any pressure);
- d) other toxic and lethal substances, which will result in death or permanent personal injury through inhalation, exposition, or contact, to be specified and defined in the inquiry documents.

4.3 General (Section 4 of API [Std 617](#))

4.3.1 Unit Responsibility (4.3 of API [Std 617](#))

4.3.1.1 Substitution (4.3.1 of API [Std 617](#))

Unless otherwise specified, the compressor vendor shall assume unit responsibility and shall assure that all sub-vendors comply with the requirements of this standard and all reference standards.

4.3.2 Basic Design (4.4 of API [Std 617](#))

4.3.2.1 General (4.4.1 of API [Std 617](#))

4.3.2.1.1 Substitution (4.4.1.2 of API [Std 617](#))

The equipment (including auxiliaries) covered by this standard shall be designed and constructed for a minimum service life of 20 years and at least 5 years of uninterrupted continuous operation.

4.3.2.1.2 Substitution (4.4.1.4 of API Std 617)

A complete liquid injection system manifold and control devices shall be provided whenever such system is specified. Liquid injection system shall be, as a minimum, according to the following requirements:

- a) a fluid type and source: as specified on the data sheets, injection liquid may be either supplied by a process stream or suctioned from a reservoir;
- b) injection points: unless otherwise specified, there shall be an injection point at each stage/casing inlet and at each impeller entrance;
- c) distribution of flow: unless otherwise specified, 60% of required flow shall be assigned to stage/casing inlet(s) and 40% distributed to impeller entrances, considering respective pressure levels;
- d) required fluid flow: unless otherwise specified or, else, recommended by the vendor, injection liquid flow shall be continuous and within 1% - 3% of compressor rated mass flow;
- e) nozzles: unless otherwise specified, injection nozzles shall be of the full-cone atomizing type, with size 90 % less than 100 μm , maximum size of 120 μm . Whenever feasible, nozzles shall be replaceable while compressor is in operation;
- f) injection manifold and controls: liquid injection manifold shall include a throttle valve, an armored flow meter, a check valve, a pressure indicator, and a block valve for each injection point. As specified on the data sheets, injection system may also require pressurization, filtration, cooling (or heating), piping, reservoir and other accessories needed for proper operation;
- g) construction materials: in accordance with compressor requirements or, unless otherwise specified, in 300 series stainless steel, as a minimum;
- h) liquid injection supply line(s) shall be provided with automatic blockage and interlock in case of compressor shutdown.

4.3.2.1.3 Addition (4.4.1.7 of API Std 617)

Compressor components that are very similar among each other (such as impellers, shafts, seals and seal glands, sleeves, diffusers and casings) shall be indelibly identified with the order of assembly and to which sub-set they belong to (e.g.: stage number, suction side, coupling end, etc). Lifting lugs or eyebolts shall be provided for any equipment or component that weighs more than 30 kg (66 lb). Precision assembly components (such as bearing housings, bearings, seals, diffusers, diaphragms, couplings, etc.), regardless of weight, shall always be fitted with suitable provisions to facilitate assembly / disassembly activities or any other maintenance task.

4.3.2.1.4 Substitution (4.4.1.10 of API Std 617)

Unless otherwise specified, the whole train furnished by the vendor (compressor, driver, gear unit and auxiliary equipment) shall conform to the maximum allowable sound pressure level of 85 dBA, slow-response, measured at 1 m (3.28 ft) from the equipment surfaces. Unless otherwise specifically stated on the data sheets, noise level tests need not to be performed. On the other hand, bidder/vendor shall guarantee that equipment actual sound pressure level will remain within allowable limits, informing in his proposal the expected (or guaranteed) maximum sound pressure level per octave band for the quoted equipment and including copies of noise level test certificates performed on similar equipment.

4.3.2.1.5 New (4.4.1.13)

All supplied equipment shall be new. Refurbished equipment or parts are not acceptable.

4.3.2.1.6 New (4.4.1.14)

New models or prototypes are not acceptable. A minimum of 25 000 hours continuous operation under similar operating conditions shall be demonstrated for, at least, 15 machines of the same model and 10 machines of the same size as the one offered.

The following parameters shall be considered to indicate similar operating conditions and shall be plotted in an experience plot:

Type of equipment/component	Most common set of parameters
Shaft seals	Peripheral speed and sealing pressure
Blades	Power per stage and peripheral speed
Impellers	Tip speed, head coefficient, hardness, gas composition and flow coefficient
Couplings	RPM and power
Gears Units	RPM and power
Compressors	Power, RPM, head & pressures, capacity, gas composition and density, critical speed ratio

4.3.2.2 Modification (4.4.4 of API Std 617)

Replace the third sentence by:

The vendor's representative shall witness:

- a check of the piping alignment performed by unfastening the main process connections of the equipment;
- the initial shaft alignment check at ambient conditions (cold alignment);
- check shaft alignment at the operating temperature (hot alignment).

4.3.2.3 Substitution (4.4.5 of API Std 617)

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, as well as local codes specified and furnished by the purchaser.

4.3.2.4 Substitution (4.4.7 of API Std 617)

Compressors shall be suitable for field run on air. Performance parameters, including any required precautions, shall be indicated by vendor in the proposal and are subject to PETROBRAS approval. If a test run on air is not feasible, vendor shall indicate alternative procedure. Additional equipment required for the field test run shall be quoted separately.

4.3.3 Materials (4.5 of API Std 617)**4.3.3.1 General (4.5.1 of API Std 617)**

4.3.3.1.1 Substitution (4.5.1.15 of API Std 617)

O-ring materials shall be compatible with all specified services. Unless otherwise specified, the maximum allowable depressurizing rate shall be in accordance with the design criterion established in API Std 520. 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), where the use of redundant O-ring arrangements or other approved design countermeasure might be necessary. For vertically split case designs, the vendor shall state the maximum allowable depressurizing rate of the compressor casing required to prevent explosive decompression of the O-ring material supplied.

4.3.3.1.2 Low Temperature Service (4.5.1.19 of API Std 617)**4.3.3.1.2.1 Substitution (4.5.1.19.2 of API Std 617)**

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.

4.3.4 Casings (4.6 of API Std 617)**4.3.4.1 Material Inspection of Pressure-containing parts (4.6.3 of API Std 617)****4.3.4.1.1 Addition (4.6.3.2 of API Std 617)**

Inspectors for non-destructive testing – in order to perform visual inspection, liquid penetrant, magnetic particle, radiographic and ultrasonic testing in Brazil, inspector qualification and certification shall be in accordance with the Brazilian National System of Personnel Qualification and Certification in NDT (SNCQ/END - ABENDI), in conformity with ISO 9712. For services rendered abroad, inspector qualification and certification shall be in accordance with the requirements established above or performed by independent international entities that meet the requirements of ISO/IEC 17024 and operate in conformity with ISO 9712.

4.3.4.2 Pressure Casing Connections (4.6.4 of API Std 617)**4.3.4.2.1 General (4.6.4.1 of API Std 617)****4.3.4.2.1.1 Substitution (4.6.4.1.7 of API Std 617)**

Valved drains shall be provided on all casings. For multistage equipment, individual stage casing drains (including a drain for the balance piston cavity) shall be provided if the vendor cannot demonstrate, during bid stage (with drawings), that complete drainage of all inner parts is attainable with the vendor's standard casing drain arrangement.

4.3.4.2.2 Main Process Connections (4.6.4.2 of API Std 617)**4.3.4.2.2.1 Addition (4.6.4.2.11 of API Std 617)**

The vendor shall also supply blind flanges for hydrostatic testing of piping connected to the machine with nonstandard connections.

4.3.4.2.3 Auxiliary Connections (4.6.4.3 of API Std 617)**4.3.4.2.3.1 Substitution (4.6.4.3.5 of API Std 617)**

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 40 (NPS 1 1/2) and smaller.

4.3.4.2.3.3 Requirements for Threaded Connections (4.6.4.3.8 of API Std 617)**4.3.4.2.3.3.1 Substitution (4.6.4.3.8.1 of API Std 617)**

Threaded connections are only acceptable for air, inert gas or water. Threaded openings for tapered pipe threads shall conform to ASME B1.20.1. Bosses for pipe threads shall conform to ASME B16.5.

4.3.4.2.3.3.2 Substitution (4.6.4.3.8.2 of API Std 617)

Pipe threads shall be taper thread conforming to ASME B1.20.1.

4.3.5 Dynamics (4.8 of API Std 617)**4.3.5.1 General (4.8.1 of API Std 617)****4.3.5.1.1 Modification (4.8.1.3 of API Std 617)**

Replace the first sentence by:

The vendor with unit responsibility shall communicate the existence of any undesirable running speeds in the range from zero to trip speed.

4.3.5.1.2 Substitution (4.8.1.4.2 of API Std 617)

Unless otherwise specified, the reporting requirements identified as required for independent audit of the results shall be provided.

4.3.5.1.3 Substitution (4.8.1.4.3 of API Std 617)

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.

4.3.5.1.4 Substitution (4.8.1.5.2 of API Std 617)

Unless otherwise specified, the reporting requirements identified as required for independent audit of the results shall be provided.

4.3.5.1.5 Substitution (4.8.1.5.3 of API Std 617)

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.

4.3.5.2 Lateral Analysis (4.8.2 of API Std 617)

4.3.5.2.1 Substitution (4.8.2.2 of API Std 617)

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).

4.3.5.2.2 Substitution (4.8.2.3 of API Std 617)

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 free-free to rigid support rotor modes.

4.3.5.2.3 Addition (4.8.2.4 b of API Std 617)

The clearance ranges to be used in the analysis shall be:

minimum bearing clearance and maximum preload, calculated using maximum pad, minimum bearing and maximum shaft radius;
average bearing clearance and preload, calculated using mean pad, bearing and shaft radius;
maximum bearing clearance and minimum preload, calculated using minimum pad, maximum bearing and minimum shaft radius;
these calculated coefficients for the speed range, shall be presented in the damped unbalance response analysis report. Bearing circumferential temperature profile shall also be included.

4.3.5.2.4 Addition (4.8.2.4 c of API Std 617)

The pad inertia and thermal effects, convection and pad conduction shall also be considered.

4.3.5.2.5 New (4.8.2.4 k)

The influence over the operating range of the damper seals stiffness and damping, considering also the tolerance on the component clearance.

4.3.5.2.6 Modification (4.8.2.7 of API Std 617)

Replace the first sentence by:

A separate damped unbalance response analysis shall be conducted for each critical speed in the range from ZERO to trip speed, as well as the next mode occurring above the trip speed.

4.3.5.2.7 Substitution (4.8.2.8 of API Std 617)

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, such as actual bearing clearances used during the test and pedestal stiffness. If the chosen location of the unbalance does not excite the critical(s) of concern, the unbalance shall be placed in the plane(s) that would excite the critical most adversely.

4.3.5.2.8 Substitution (4.8.2.9 a of API Std 617)

If the AF at a particular critical speed outside the operating speed range is less than 2.5, the response is considered critically damped and no separation margin is required ($SM_r = 0$). However, even though amplification factor calculations for a given rotor may indicate critically damped response and then no separation margin would be required, critical speeds within the operating speed range will only be accepted if the vendor can demonstrate that all efforts to remove the critical speed from the operating speed range have been exhausted.

4.3.5.2.9 Modification (4.8.2.11 of API Std 617)

Replace Equation (9) by:

$$S_{cc} = A_{vl} / A_{max}$$

4.3.5.2.9.1 Addition (4.8.2.11.2 of API Std 617)

For machines with abradable seals, the rotor response amplitudes, corrected in accordance with 4.8.2.11 at any speed from zero to trip speed shall not exceed 100 % of the minimum design diametral running clearances throughout the machine.

4.3.5.3 Unbalanced Rotor Response Verification Test (4.8.3 of API Std 617)

4.3.5.3.1 Substitution (4.8.3.1 of API Std 617)

An unbalanced rotor response test (URT) 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 This test may be performed on an on-speed balancing machine if previously approved by PETROBRAS.

4.3.5.3.1.2 Substitution (4.8.3.1.3 of API Std 617)

The machine shall then be brought up to trip speed after being held at maximum continuous speed until bearing temperature and vibration have been stabilized, and the indicated vibration amplitudes and phase shall be recorded during the coastdown using the same procedure as 4.8.3.1.1.

4.3.5.3.1.3 Substitution (4.8.3.1.4 of API Std 617)

The location of critical speeds below the trip speed shall be clearly identified during the test.

NOTE This may be accomplished on an on-speed balancing machine if previously approved by PETROBRAS.

4.3.5.3.1.4 Addition (4.8.3.1.5 of API Std 617)

If, after vectorial subtraction, the unbalance mass does not change the vibration at critical speed in more than 2.5 μm (0.1 mil), then the unbalance weight shall be increased and the test shall be repeated.

4.3.5.4 Level 1 Stability Analysis (4.8.5 of API Std 617)

4.3.5.4.1 Addition (4.8.5.2 of API Std 617)

All components shall be analyzed using the extremes of the operating limits for clearance and oil inlet temperature and pressure, to produce the minimum log decrement.

4.3.5.4.2 Substitution (4.8.5.3 of API Std 617)

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

4.3.5.4.3 Modification (4.8.5.8 of API Std 617)

Replace item a.2) by:

2) $\delta_a < 0.2$

Replace item b. by:

b. For axial flow rotors:

If $\delta_a < 0.2$, a Level II stability analysis shall be performed. Otherwise, the stability is acceptable and no further analyses are required.

4.3.5.5 Level II Stability Analysis (4.8.6 of API Std 617)

4.3.5.5.1 Substitution (4.8.6.4 of API Std 617)

All the operating conditions defined for the complete operational range (including surge and choke conditions) shall be extrapolated to both N_{ma} and N_{mc} .

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

4.3.5.5.2 Substitution (4.8.6.9 of API Std 617)

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 0.2.

4.3.5.5.3 Substitution (4.8.6.10 of API Std 617)

A stability test, to measure damping ratio (and to determine the corresponding log decrement), shall be performed in accordance with item 6.3.8 if one of the following conditions is satisfied:

- a) the machine fails to meet the criteria specified in item 4.8.6.9;
- b) the test has been specified in compressor data sheet.

NOTE Some particular applications which have not proven rotordynamic design may require special consideration in determining the actual compressor damping ratio (thus demanding stability test to be performed), such as CO₂ injection, high-pressure and high-density gases, etc.

4.3.5.6 Torsional Analysis (4.8.7 of API Std 617)

4.3.5.6.1 Substitution (4.8.7.2 of API Std 617)

For direct driven turbine trains, the vendor 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.

4.3.5.6.2 Substitution (4.8.7.6 of API Std 617)

All other torsional natural frequencies (including blade pass 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).

4.3.5.7 Vibration and Balancing (4.8.8 of API Std 617)

4.3.5.7.1 New (4.8.8.2.3)

After completion of final balancing, all major elements of the assembled rotor shall be match marked. Balance quality data (as designed / as final) for all rotating equipment and components shall be provided in the installation, operation and maintenance manuals and other applicable documents.

4.3.5.7.2 Substitution (4.8.8.3.1 of API Std 617)

Unless otherwise specified, after low speed sequential balancing, flexible rotors as defined per ISO 11342 shall be operating speed balanced in accordance with 4.8.8.4.

4.3.5.7.3 Substitution (4.8.8.4.4 of API Std 617)

The high speed drive assembly shall be shown to have an effect less than 25% of the balance tolerance. Job-coupling half moment shall be simulated either by means of the facility drive coupling and adapter or by means of the job-coupling hub with moment simulator.

4.3.5.7.4 Modification (4.8.8.11 of API Std 617)

Replace the first sentence by:

If the supplier can demonstrate that electrical or mechanical runout is present, a maximum of the level from Equation (13) or 6.35 μm (0.25 mil), whichever is greater, may be vectorially subtracted from the vibration signal measured during the factory acceptance test.

4.3.5.7.5 Substitution (4.8.8.8.1 of API Std 617)

At any speed greater than the MCS, up to and including the trip speed of the driver, the vibration level shall not exceed 12.7 μm (0.5 mil) above the value recorded at the maximum continuous speed for each probe or half of the value from Equation (12), whichever is less.

4.3.6 Shaft End Seals (4.10 of API Std 617)

4.3.6.1 General (4.10.1 of API Std 617)

4.3.6.1.1 Modification (4.10.1.5 of API Std 617)

Replace the first sentence by:

Unless otherwise specified, gas compressors shall be provided with dry gas seals.

4.3.6.1.2 Substitution (4.10.1.9 of API Std 617)

Unless otherwise specified, the method of control (flow control or pressure control) and system configuration shall be mutually determined.

4.3.7 Nameplates and Rotation Arrows (4.12 of API Std 617)

4.3.7.1 Substitution (4.12.4 of API Std 617)

SI units shall be used on the nameplates, except for pressure units (which shall be indicated in kgf/cm², unless otherwise specified).

4.4 Accessories (Section 5 of API Std 617)

4.4.1 Couplings and Guards (5.2 of API Std 617)

4.4.1.1 Modification (5.2.2 of API Std 617)

Replace the last sentence by:

Unless otherwise specified, couplings shall be of non-lubricated, flexible stainless steel diaphragm or disk type.

4.4.1.2 New (5.2.7)

For turbine driven units, couplings shall incorporate a feature that allows transmission of load for a limited period, in the event of a complete flexible element failure.

4.4.2 Mounting Plates (5.4 of API Std 617)

4.4.2.1 General (5.4.1 of API Std 617)

4.4.2.1.1 Substitution (5.4.1.2.13 of API Std 617)

The supplier shall define the specific type of grout to be used for field installation.

4.4.2.1.2 Substitution (5.4.1.2.14 of API Std 617)

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 type of grout defined by the supplier.

4.4.2.2 Baseplates (5.4.2 of API Std 617)

4.4.2.2.1 Modification (5.4.2.1 of API Std 617)

Replace the first sentence by:

Unless otherwise specified, the driver and the driven equipment (including any gear unit) shall be furnished mounted on a baseplate.

4.4.2.2.1.1 Modification (5.4.2.1.1 of API Std 617)

Replace the first sentence by:

Baseplates shall be equipped with a drip rim (see Figure 6) or drip pan.

4.4.2.2.2 Substitution (5.4.2.4 of API Std 617)

Unless otherwise specified, nonskid decking covering all walk and work areas shall be provided on the top of the baseplate.

4.4.2.2.2.1 Substitution (5.4.2.4.1 of API Std 617)

Horizontal solid decked surfaces shall be sloped to avoid collection of liquid.

4.4.2.2.3 Modification (5.4.2.6 of API Std 617)

Replace the first sentence by:

The baseplate shall be designed to facilitate the use of optical, laser or other instruments for field leveling during installation.

4.4.3 Controls and Instrumentation (5.5 of API Std 617)

4.4.3.1 General (5.5.1 of API Std 617)

4.4.3.1.1 Substitution (5.5.1.6 of API Std 617)

Unless otherwise specified, controls that are installed outside shall have a minimum ingress protection level as follows:

IP 65 (as per IEC 60529) for on-shore installations;

IP 56 (as per IEC 60529) for off-shore installations.

The controls and instrumentation, equipment and wiring shall comply with the construction requirements of IEC 60079.

4.4.3.1.2 Substitution (5.5.1.7 of API Std 617)

Unless otherwise specified, terminal boxes shall have a minimum ingress protection level as follows:

IP 65 (as per IEC 60529) for on-shore installations;

IP 56 (as per IEC 60529) for off-shore installations.

4.4.3.2 Control Systems (5.5.2 of API Std 617)

4.4.3.2.1 Substitution (5.5.2.2 of API Std 617)

Unless otherwise specified, an anti-surge system shall be provided by the supplier.

4.4.3.2.2 Modification (5.5.2.3 of API Std 617)

Replace first sentence by:

Unless otherwise specified, the supplier shall supply the anti-surge valve.

4.4.3.2.3 Substitution (5.5.2.4 of API Std 617)

The supplier shall supply the results of an anti-surge system transient response simulation.

4.5 Inspection, Testing, and Preparation for Shipment (Section 6 of API Std 617)**4.5.1 General (6.1 of API Std 617)****4.5.1.1 Substitution (6.1.4 of API Std 617)**

Unless otherwise specified, all shop tests to be carried out shall be witnessed by the purchaser or the purchaser's representative.

4.5.2 Testing (6.3 of API Std 617)**4.5.2.1 Hydrostatic Test (6.3.2 of API Std 617)****4.5.2.1.1 New (6.3.2.4)**

The liquid used for the hydrostatic test shall be at a temperature higher than the nil-ductility transition temperature of the material being tested.

4.5.2.2 Mechanical Running Test (6.3.5 of API Std 617)**4.5.2.2.1 Substitution (6.3.5.2 of API Std 617)**

Shop test facilities shall include the capability of continuously monitoring, displaying, recording, and printing vibration displacement and phase, vibration spectra, Bode plots, shaft orbits, bearing metal temperatures and oil pressures and temperatures. Shop test facilities shall also include a dedicated station fully available for PETROBRAS use, and capable of handling and analyzing all real time data collected during all tests.

4.5.2.2.2 New (6.3.5.2.3)

The shop vibration equipment used during the tests shall be configured in accordance with Annex C of this standard. All cables shall be identified. ADRE system is preferred for data collecting and monitoring. If vendor uses another system, then visualization (or translation into ADRE files) software shall be included as well.