

Supplementary Specification to API Standard 672 Packaged, Integrally Geared Centrifugal Air Compressors

Revision history

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Acknowledgements

This IOGP Specification was prepared by a Joint Industry Project 33 Standardization of Equipment Specifications for Procurement organized by IOGP with support by the World Economic Forum (WEF).

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Foreword

This specification was prepared under a Joint Industry Project 33 (JIP33) “Standardization of Equipment Specifications for Procurement” organized by the International Oil & Gas Producers Association (IOGP) with the support from the World Economic Forum (WEF). Ten key oil and gas companies from the IOGP membership participated in developing this specification under JIP33 Phase 2 with the objective to leverage and improve industry level standardization for projects globally in the oil and gas sector. The work has developed a minimized set of supplementary requirements for procurement, with life cycle cost in mind, based on the ten participating members’ company specifications, resulting in a common and jointly approved specification, and building on recognized industry and/or international standards.

This specification has been developed in consultation with a broad user and supplier base to promote the opportunity to realize benefits from standardization and achieve significant cost reductions for upstream project costs. The JIP33 work groups performed their activities in accordance with IOGP’s Competition Law Guidelines (November 2014).

Recent trends in oil and gas projects have demonstrated substantial budget and schedule overruns. The Oil and Gas Community within the World Economic Forum (WEF) has implemented a Capital Project Complexity (CPC) initiative which seeks to drive a structural reduction in upstream project costs with a focus on industry-wide, non-competitive collaboration and standardization. The vision from the CPC industry is to standardize specifications for global procurement for equipment and packages, facilitating improved standardization of major projects across the globe. While individual oil and gas companies have been improving standardization within their own businesses, this has limited value potential and the industry lags behind other industries and has eroded value by creating bespoke components in projects.

This specification aims to significantly reduce this waste, decrease project costs and improve schedule through pre-competitive collaboration on standardization. This document defines the supplementary requirements to recognized international standard API standard 672 4th Edition 2004, integrally geared centrifugal air compressors for petroleum, chemical and gas industry service, which is indispensable for the application of this specification.

Following agreement of the relevant JIP33 work group and approval by the JIP33 Steering Committee, the IOGP Management Committee has agreed to the publication of this specification by IOGP. Where adopted by the individual operating companies, this specification and associated documentation aims to supersede existing company documentation for the purpose of industry-harmonized standardization.

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Introduction

The purpose of this specification is to define a minimum common set of supplementary requirements for procurement of packaged, integrally geared centrifugal air compressors in accordance with API standard 672 4th Edition 2004 for application in the petroleum and natural gas industries.

This JIP33 standardized procurement specification follows a common document structure comprising the four documents as shown below, which together with the purchase order define the overall technical specification for procurement.



JIP33 Specification for Procurement Documents Supplementary Technical Specification

It is required to use all of these documents in conjunction with each other when applying this specification, as follows:

S-612: Supplementary specification to API Standard 672 for Packaged, Integrally Geared Centrifugal Air Compressors

This specification is written as an overlay to API Std 672, following the clause structure of the parent standard, to assist in cross-referencing the requirements. Where clauses from the parent standard (API Std 672) are not covered in this specification, there are no supplementary requirements or modifications to the respective clause. The terminology used within this specification follows that of the parent standard and otherwise is in accordance with ISO/IEC Directives, Part 2.

Modifications to the parent standard defined in this specification are identified as Add (add to clause or add new clause), Replace (part of or entire clause) or Delete.

S-612D: Data sheets for Packaged, Integrally Geared Centrifugal Air Compressors

This document provides project specific requirements where the supplementary specification and its parent standard require the purchaser to define an application specific requirement. It also includes information required by the purchaser for technical evaluation. Additional purchaser supplied documents are also listed in the data sheets, to define scope and technical requirements for enquiry and purchase of the equipment.

S-612L: Information requirements for Packaged, Integrally Geared Centrifugal Air Compressors

This document defines the information requirements, including format, timing and purpose, for information to be provided by the vendor. It also defines the specific conditions which must be met for conditional information requirements to become mandatory. The information requirements listed in the IRS have references to the source of the requirement.

S-612Q: Quality requirements for Packaged, Integrally Geared Centrifugal Air Compressors

This document includes a conformity assessment system (CAS) which specifies standardized user interventions against quality management activities at four different levels. The applicable CAS level is specified by the purchaser in the data sheets.

The data sheet and IRS are published as editable documents for the user to specify application specific requirements. The supplementary specification and QRS are fixed documents.

Unless defined otherwise in the purchase order, the order of precedence (highest authority listed first) of the documents shall be:

- a) regulatory requirements;
- b) contract documentation (e.g. purchase order);
- c) purchaser defined requirements (data sheets, IRS, QRS);
- d) this specification;
- e) the parent standard.

1 Scope

1.1

Add to section

This specification covers constant speed electric motor driven integrally geared centrifugal air compressor, with a shaft power range of up to 1500 kW, for plant and instrument air application.

Note: This specification may also be applied for a steam turbine driven air compressor package. However, the requirements for the steam turbine driver are not covered within this specification.

1.2

Add to section

This specification is applicable for basic duty packages, using the proven vendor's standard design.

Note: The compressor is assumed to be spared.

6 Basic Design

6.1 General

Add to section

6.1.3 Sound Pressure Level

The A-weighted sound pressure level, for the compressor unit at rated duty under free field operating conditions, shall be limited within the noise limit specified in the data sheet.

Sound pressure level measurement shall be taken at 1.0 m (3.3 ft) from the skid boundary and at 1.0 m (3.3 ft) from the discharge blow-off silencer outlet.

6.1.4 Packaged Equipment

Replace section with

The scope of the compressor package shall include, as a minimum, the following:

- a. Integrally geared centrifugal air compressor
- b. Compressor gear box breather and screen
- c. Main drive coupling and coupling guard
- d. Main driver
- e. Inlet air filter and silencer with weather hood and support leg
- f. Variable inlet guide vane
- g. Discharge blow-off valve and silencer
- h. Inlet and discharge expansion joint
- i. Blow-off line expansion joint for off-skid blow-off valve and silencer

- j. Intercoolers and aftercooler
- k. Moisture separator and automatic drainer, or drain traps
- l. Lube oil system (common) for compressor, gear and driver with lube oil reservoir including demister, lube oil filter, lube oil pump (main and auxiliary including coupling and driver for auxiliary lube oil pump), lube oil heater complete with piping, valves and instrumentation
- m. On-skid interconnecting piping, fitting and valves including control valves and pressure relief valves, as applicable
- n. Control, monitoring and protection instruments with on-skid instruments, control panel, control, signal and power cables, and junction box
- o. Noise attenuation device such as acoustic insulation and noise enclosure to meet required noise limit
- p. Skid baseplate with lifting lugs
- q. Local emergency stop push button.

For off-shore installation, the compressor package shall be a complete unit installed on a single skid.

6.1.5 Environmental Conditions

Add to section

The compressor package shall be suitable for outdoor installation with ambient conditions as specified in the data sheet.

Any additional requirements for weather protection, such as enclosure, winterization, topicalization based on any special site, or environmental conditions shall be specified in the data sheet.

6.1.6 Cooling Water Systems

Add to section

For alternative cooling medium, the fouling factor specified in the data sheet, shall be used.

The cooling water maximum inlet temperature specified in the data sheet, based on project environmental maximum ambient conditions shall be used.

6.1.7 Package Arrangement

Add new section

6.1.7.4

The package shall conform to skid envelope dimension limits, as specified in the data sheet.

Add new section

6.1.7.5

If specified by the purchaser, the intake opening shall be located opposite to the prevailing wind direction.

The vendor shall propose the location and orientation of the air intake. The purchaser shall verify the proposed location and orientation with respect to exhaust gas emissions from nearby equipment.

6.1.8 Motors and Electrical Components

Replace first sentence with

Motors, 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 the applicable sections of IEC 60079 or NFPA 70, Articles 500, 501, 502, and 504, as well as local codes.

Add new section

6.1.8.1

Unless otherwise specified in the data sheet, motors and other electrical components shall be rated for safe area application.

Add new section

6.1.8.2

Unless otherwise specified in the data sheet, the compressor skid shall be non-Ex zone certified.

6.1.9 Performance Criteria

Add to section

Compressor thermodynamic and mechanical performance, as specified in the data sheet, shall be validated by the vendor during the performance and mechanical run tests. The thermodynamic performance test may be performed on one machine of multiple order of identical machines.

6.1.10 Purchaser Connections

Replace first sentence with

All openings or nozzles for purchaser connection shall be DN 20 (NPS $3/4$) or larger in accordance with ISO 6708.

Add new section

6.1.10.1

Nozzles for purchaser connections larger than DN 50 (NPS 2) shall be flanged per ASME B16.5.

Add new section

6.1.10.2

Nozzles for purchaser connections smaller than DN 50 (NPS 2) may be threaded per ASME B1.20.1 or flanged.

Add new section

6.1.10.3

Proprietary connection types shall not be used for purchaser connections unless specifically approved by the purchaser.

6.1.12 Compressor Performance

6.1.12.1

Add to section

The turn down capacity shall be at least 15 % less than the rated capacity.

6.1.13 Mounting Surfaces

Replace first sentence with

Mounting surfaces shall meet the following criteria:

Add to section

When shims are used under the driver mounting pad, they shall be full-face stainless steel shims.

6.2 Pressure Casings

6.2.2

Add to section

The maximum discharge pressure shall not be less than the discharge pressure based on maximum rotational speed.

Add new section

6.2.4

Jackscrews, guide rods, cylindrical casing-alignment dowels or other necessary devices shall be provided to allow disassembly and reassembly.

Add new section

6.2.4.1

When jackscrews are used as a means of parting contacting faces, one of the faces shall be relieved (counter bored or recessed) to prevent a leaking joint or improper fit caused by marring of the face.

Add new section

6.2.4.2

Guide rods shall be of sufficient length to prevent damage to the internals or casing studs by the casing during disassembly and reassembly.

Add new section

6.2.5

Lifting lugs or eyebolts shall be provided for lifting the top half of the gear casing.

6.3 Casing Connections

Add new section

6.3.10

The package shall be provided with means of draining of compressor casing.

6.5 Rotating Elements

6.5.1 Shafts

6.5.1.5

Add new section

For shafts with keyways, ISO 21940-32 shall be followed for shaft and fitment key conventions.

6.5.2 Impellers

6.5.2.2

Add to section

Impeller construction and attachment method shall ensure positive retention of the impeller-to-shaft connection with necessary locking arrangement to prevent impeller loosening in service, especially during start-up, over speed, reverse rotation and surge events.

6.6 Seals and Sealing System

6.6.3

Add to section

If specified in the data sheet, a buffered-seal design shall be provided for compressors.

6.7 Dynamics

6.7.1 Critical Speeds

6.7.1.4

Replace section with

For the purposes of this standard, critical speeds and other resonant conditions of concern are those with an amplification factor (AF) equal to or greater than 2.5.

6.7.2 Lateral Analysis

Replace second sentence with

A report is not required, unless specified in the data sheet. The vendor shall specify lateral critical speed values in the data sheet.

6.7.3 Torsional Analysis

6.7.3.1

Replace second sentence with

A report is not required, unless specified in the data sheet. The vendor shall specify torsional natural frequencies in the data sheet, based on the drive train supplied.

6.7.4 Vibration and Balancing

Add new section

6.7.4.4

Rotor assembly shall be dynamically balanced to balance grade G1 as per ISO 21940-11.

Add new section

6.7.4.5

The total combined electrical and mechanical runout shall not exceed 6.35 μm (0.25 mils).

6.8 Bearings and Bearing Housings

6.8.1 Bearings – General

6.8.1.1

Replace section with

If approved by the purchaser, anti-friction bearings may be used only for low speed bull gear shaft rotors. Rolling element bearings shall not be used on pinion shaft rotors.

Add new section

6.8.1.3

Basic rating life (L10 bearing life) for anti-friction bearing, as defined in ISO 281, shall be 50000 hours or more.

6.9 Lubrication

Add new section heading

6.9.5 Lube Oil Cooler

Add new section

6.9.5.1

When an air-cooled design is specified for lube oil cooler, oil shall be cooled in a single bay two fan air-cooled unit. The tube bundle design shall be per TEMA Class C as a minimum, with header box design to be of the removable cover plate, removable bonnet or plug type construction.

Add new section

6.9.5.2

The heat exchanger materials shall comply with Table 4.

Add new section heading

6.9.6 Lube Oil Filter

Dual filters shall be provided, each sized for 100 % of the flow as a minimum.

Add new section

6.9.6.1

The filters shall be designed for on-line change-over and on-line replacement of the off-line unit.

Add new section

6.9.6.2

The filters shall be equipped with a differential pressure local indicating transmitter.

Add new section

6.9.7

Lubrication system design shall guarantee priming of the main oil pump prior to compressor start-up.

Add new subheading

6.9.8 Lube Oil Reservoir

Add new section

6.9.8.1

Lube oil reservoir capacity shall be based on minimum 3 minutes retention time. Retention time less than 3 minutes shall be subject to the purchaser's approval.

Add new section

6.9.8.2

A temperature controlled electric immersion heater shall be provided.

6.10 Materials

Add new section heading

6.10.6 Material Selection

Add new section

6.10.6.1

Material selection requirements shall be in accordance with this specification and the mechanical data sheet for air compressor package.

Add new section

6.10.6.2

Material selection philosophy shall be in accordance with the recommendations and guidelines of ISO 21457, unless explicitly specified in Table 4.

Add new section

6.10.6.3

Material selection for components and accessories shall be based on following minimum requirements specified in Table 4. Alternative materials per the vendor's standard, if equivalent or superior than specified may be considered, subject to the purchaser's approval.

Add new section

6.10.6.4

Material of construction for core compressor and gear components shall follow the vendor's standard approved by the purchaser.

Add new section

6.10.6.5

Depending on service conditions, if specified in the data sheet, volutes shall be internally coated with a corrosion or erosion resistant coating.

Table 4 – Material selection

Item	Material of construction (base case) (Note 1)	Material of construction (harsh environment) (Note 1)
Diffuser	Manufacturer's standard	Stainless steel
Inlet Air Filter/Silencer	Carbon steel (hot dip galvanized)	316 stainless steel
Intercooler/ Aftercooler (Water Cooled) (Note 2)		
Shell	Carbon steel or cast iron (coated) (Note 3)	Carbon steel or cast iron (coated) (Note 3) or 316 stainless steel
Tube	316 stainless steel or 90/10 Cu-Ni or admiralty brass	316 stainless steel or 90/10 Cu-Ni or admiralty brass
Tube sheet / Baffle	Compatible with the tube material	Compatible with the tube material
Intercooler/ Aftercooler/ Lube Oil Cooler (Air Cooled) (Note 2)		
Tube	Carbon steel with aluminium fins	316 stainless steel
Tube sheet / Header Box/ Tube Support	Carbon steel (coated)	316 stainless steel
Lube Oil System Components		
Lube Oil Cooler		
Shell	Carbon steel	316 stainless steel
Tube	90/10 Cu-Ni or admiralty brass	90/10 Cu-Ni or admiralty brass
Tube sheet	Brass	Brass
Lube Oil Reservoir	Carbon steel (coated)	316 stainless steel
Lube Oil Piping	Carbon steel	316 stainless steel
Lube Oil Piping (downstream of lube oil filter)	Stainless steel	316 stainless steel
Lube Oil Filter	Carbon steel (coated)	316 stainless steel
Piping, Tubing and Miscellaneous Items		
Air / Cooling Water Piping	Carbon steel (coated) (Note 3)	
Tubing and fittings	316 stainless steel	316 stainless steel
Blow-off Silencer housing	Carbon steel (hot dip galvanized)	316 stainless steel
Blow-off Silencer internals	316 stainless steel	316 stainless steel
Base Frames	Carbon steel (coated or hot dip galvanized) (Note 3)	Carbon steel (coated or hot dip galvanized) (Note 3)
Instrument Housing	Stainless steel or aluminium	316 stainless steel or aluminium
Junction Box	Carbon steel (hot dip galvanized) or 304 stainless steel or aluminium	316 stainless steel or aluminium
Noise Enclosure	Carbon steel (coated)	Carbon steel (coated)
Local Control Cabinet	Carbon steel (coated)	Carbon steel (coated)
Note 1	Base case requirements apply to atmospheric corrosion category C1 to C3 (low to medium corrosivity). Harsh environments apply to corrosion category C4 to CX (high to extreme corrosivity) as per ISO 12944-2 definition.	
Note 2	Cooling water is assumed to be fresh water or glycol-water mixture.	
Note 3	Refer to 6.10.7	

Add new section heading

6.10.7 Coating

Add new section

6.10.7.1

Surface preparation, coating and coating activities shall, as a minimum, conform to the requirements of ISO 12944 (all parts) or alternative equivalent standard approved by the purchaser.

Add new section

6.10.7.2

For offshore applications, the requirements of ISO 12944-9 shall be applicable.

Add new section

6.10.7.3

Cast iron, carbon steel and low alloy steel external surfaces shall be coated.

Add new section

6.10.7.4

Bearings, seals, flange mating faces, instrument dials, instrument cases, cable trays and cables, shafts, polished or machined surfaces, control valve stems, nameplates and item tags shall not be coated. These items shall be protected from blasting and coating being applied to adjacent equipment.

Add new section

6.10.7.5

Stainless steel equipment items and piping shall be coated when:

- a. operating at a temperature exceeding 60 °C (140 °F) in an offshore environment
- b. insulated.

Add new section heading

6.10.7.6 Coating Procedure Specification

Add new section

6.10.7.6.1

If specified in the data sheet, surface preparation and coating shall be in accordance with a qualified coating procedure specification, conforming to ISO 12944-8 or alternative equivalent standard, and following the recommendations of the coating manufacturer.

Add new section

6.10.7.6.2

The coating procedure specification proposed by the vendor shall describe complete coating related works to be performed, including surface preparation, coating application, qualification and inspection.

7 Accessories

7.1 Drivers

7.1.1 General

7.1.1.5

Replace section with

The driver nameplate rating, exclusive of the service factor, shall be at least 110 % of the maximum power required for all of the specified operating conditions.

7.1.2 Electric Motors

Replace section with

7.1.2.1

Add new section

7.1.2.1.1

Motors shall conform to either IEC 60034, NEMA MG-1 or IEEE 841, unless otherwise specified in the motor data sheet.

Add new section

7.1.2.1.2

Enclosure for main driver motors shall be totally enclosed fan cooled (TEFC), totally enclosed air to air cooled (TEAAC) or totally enclosed water to air cooled (TEWAC).

Add new section

7.1.2.1.3

For general outdoor environments, motors shall have, as a minimum, weather protection class IP55.

For environments with areas exposed to powerful water jets and deluge or offshore open deck, IP56 weather protection class shall be used, as a minimum.

Add new section

7.1.2.1.4

Motor shall be supplied with a minimum of Class F insulation.

Add new section

7.1.2.1.5

Motor shall be suitable for direct on line starting, unless otherwise specified in the data sheet.

Add new section

7.1.2.1.6

Main driver motor shall be provided with stator winding anti-condensation type space heater. The space heater shall remain energized when the motor is not running.

Add new section

7.1.2.1.7

Motors with sleeve bearings shall be equipped with one x and one y radial proximity probes per bearing.

Add new section

7.1.2.1.8

Lube oil for motors equipped with sleeve bearings shall be fed through the common pressurized lube oil system as used by the compressor and gearing.

Add new section

7.1.2.1.9

Motor equipped with sleeve bearings shall have one dual element resistance temperature detector per bearing.

Add new section

7.1.2.1.10

Medium voltage motors shall have two embedded 3-wire PT100 resistance temperature detectors for windings per each phase of stator windings.

Add new section

7.1.2.1.11

For a vendor supplied local control panel, bearing and winding resistance temperature detectors shall be connected to a local controller.

Add new section heading

7.1.2.3 Electric Motor Testing

Add new section

7.1.2.3.1

Routine tests are not required for low-voltage motors which are already type tested to an approved standard, such as IEC 60034-1:2017, 9.1.

Add new section

7.1.2.3.2

For medium voltage motors, the following minimum testing shall be performed by the motor manufacturer:

- a. No load test (measurement of no-load characteristics, losses and determination of locked-rotor current)
- b. Measurement of stator-winding resistance
- c. Insulation resistance test of stator winding
- d. Determination of efficiency for 50 %, 75 % and 100 % rated load
- e. Vibration measurement at bearing housings
- f. Phase sequence, direction of rotation, terminal marking
- g. Noise test.

7.2 Couplings and Guards

7.2.1 Couplings

7.2.1.1

Replace second sentence with

The flexible elements shall be corrosion-resistant alloy. Coated flexible elements shall not be used.

Add to section

Unless otherwise specified in the data sheet, coupling and guard design and manufacture shall conform to ISO 14691.

7.2.1.2

Add to section

Main drive coupling spacer shall be 200 mm (8 in.) length minimum.

7.2.1.7

Replace section with

The coupling-to-shaft juncture shall be designed to transmit power at least equal to the power rating of the coupling including any service factor and any transient operating conditions.

Add new section

7.2.1.8

The coupling assembly shall be dynamically balanced to Grade 2.5 as per ISO 21940-11.

7.3 Baseplate/Support Structure

7.3.2

Add new section

7.3.2.1

Baseplate shall be provided with a drain connection of DN 50 (NPS 2).

Add new section

7.3.2.2

All welding shall be continuous.

Add new section

7.3.2.3

Design code for baseplate lifting lugs shall be specified in the data sheet.

Add new section

7.3.2.4

For off-shore installation of skid, additional certifications for lifting lugs and lifting beams shall be specified by the purchaser.

7.3.4

Add to section after first sentence

Baseplate structural members provided for supporting the compressor, gear and driver shall be in full contact with the foundation or grout to ensure direct transmission of dynamic forces to the foundation or support beneath the baseplate.

7.3.10

Replace first sentence with

The driver mounting plates shall be furnished with axial and lateral jackscrews the same size as or larger than the vertical jackscrews.

7.4 Controls and Instrumentation

7.4.1 General

7.4.1.2

Replace section with

Unless otherwise specified, controls and instrumentation shall be designed for outdoor installation and meet the requirements of IP65 or NEMA 4X.

Instrumentation and control systems shall be designed for continuous operation at the specified ambient temperature without any degradation of the measurement and control accuracy specified by the manufacturer.

7.4.1.4

Replace first sentence with

The microprocessor shall be capable of communication with the purchaser's distributed control system (DCS).

Add new section

7.4.1.4.1

The local control panel shall have a communication interface with the purchaser's control system, as specified in the data sheet, via a high integrity ethernet communication link for remote operation and control, data monitoring and retrieval.

Add new section

7.4.1.4.2

Any interface between the vendor's local control panel and the purchaser's safety instrument system shall be through hard-wired signal interface.

Add new section

7.4.1.7

The vendor supplied local control panel shall have provision for:

- a. Remote start and stop of compressor
- b. Remote and local read-out of vibration data.

7.4.2 Control Systems

7.4.2.1

Replace section with

Unless otherwise specified in the data sheet, capacity modulation with variable inlet guide vane shall be provided.

Add new section

7.4.2.3.1

When surge control and detection is based on monitoring motor current as the primary monitoring signal, an additional secondary monitoring signal based on process conditions (discharge pressure or flow) shall be provided, if specified by the purchaser in the data sheet.

Add new section

7.4.2.7

If specified by the purchaser, complete control system or parts thereof (anti-surge controller, performance controller, vibration monitoring) may be integrated into the purchaser's control system. For such cases, the vendor shall provide suitable termination in junction boxes or skid edge remote input and output cabinet for interface to the purchaser's cable.

Add new section

7.4.2.7.1

All field analogue instruments such as transmitters and control valves shall be provided with a suitable communication protocol, as defined in the data sheet, to facilitate effective communication, remote monitoring and diagnostics from the purchaser's control system.

Add new section

7.4.2.7.2

The vendor shall provide control narrative and control algorithm which will be required by the purchaser to develop control logic and system control documentation for implementation in the purchaser's control system.

The control narrative and control algorithm shall include:

- a. List of network interface
- b. Cause and effect
- c. Logic drawing
- d. Hardwired signal list.

Add new section heading

7.4.2.9 Parallel Operation

Add new section

7.4.2.9.1

For systems comprising of more than one compressor unit, a load-sharing controller for parallel operation of the units shall be provided and integrated into the compressor control panel.

Add new section

7.4.2.9.2

Automatic start of standby compressor in case failure of duty compressor shall be provided and integrated into the compressor control panel.

7.4.3 Instrument and Control Panels

7.4.3.1

Replace first sentence with

When provision of a local control system is included in the vendor's scope, a panel from which startup and shutdown can be accomplished shall be provided and shall include the following:

Add to list

- r. Ammeter for the electric motor.

7.4.4 Instrumentation

7.4.4.3 Thermocouples and Resistance Temperature Detectors

Add to section

If specified in the data sheet, bearing metal temperature sensors shall be provided for hydrodynamic bearings.

7.4.4.5 Vibration and Position Detectors

7.4.4.5.1

Replace item a. with

- a. Radial vibration probes as per 7.4.4.5.2.1;

Add new section heading

7.4.4.5.2 Radial vibration monitoring

Replace section with

7.4.4.5.2.1

One x and one y radially oriented non-contacting shaft vibration probe shall be provided for each pinion shaft bearing next to an impeller stage.

7.4.4.5.2.2

Angular orientation of probe mounting holes shall be the same for both ends of each pinion.

Add new section heading

7.4.4.5.3 Axial position monitoring

Add new section

7.4.4.5.3.1

Axial position monitoring with two proximity probes shall be provided for thrust bearings.

Add new section

7.4.4.5.3.2

For compressors with pinion shafts using only thrust collars, axial displacement probes on pinion shaft are not required.

Add new section

7.4.4.5.3.3

Probe shall be installed to sense the shaft itself or an integral axial surface of the shaft, within an axial distance of 300 mm (12 in.) from the thrust bearing.

Add new section heading

7.4.4.5.4 Accelerometers

Add new section

7.4.4.5.4.1

Gear casing shall have a machined surface for mounting high frequency accelerometer in accordance with API Std 670.

Add new section

7.4.4.5.4.2

If specified in the data sheet, a high frequency accelerometer shall be supplied, installed and calibrated in accordance with API Std 670 on the machined surface of the gear casing.

Add new section heading

7.4.4.5.5 Vibration monitoring system

Add new section

7.4.4.5.5.1

For a vendor supplied local control panel, all vibration and position detectors shall be monitored by the compressor local control panel.

Add new section

7.4.4.5.5.2

The vendor shall state the target material for the probes.

Add new section

7.4.4.5.5.3

Vibration monitoring system shall be calibrated as per API Std 670.

Replace section heading with

7.4.4.7 Pressure Limiting Valve and Pressure Relief Valves

Add new section

7.4.4.7.1

Relief valves shall not discharge to a location within normal operation or maintenance access areas that can impact personnel.

Add new section

7.4.4.7.2

If radial relief valves are used, they shall have a guard installed to prevent discharge impacting personnel.

Add new section

7.4.4.7.3

Calculations shall be provided for all relief valve sizes and settings, including accumulation, to verify that all possible modes of equipment failure have been taken into account.

Add new section

7.4.4.9

All pressure transmitters on the skid shall be provided with single block and bleed manifolds.

Add new section

7.4.4.10

Level gauge span shall encompass maximum and minimum operational level including high and low trip set points.

Add new section

7.4.4.11

The scale on level glass or magnetic level gauges shall indicate percentage or units of length consistent with system of units used in the data sheet.

Add new section

7.4.4.12

Control valves shall be mounted with sufficient clearance around to permit servicing and disassembly without removing valve body from the line.

Add new section

7.4.4.13

Mechanical switches shall be approved by the purchaser.

Add new section

7.4.4.14

Instrument tubing fittings shall be of the double-ferrule type.

Add new section

7.4.4.15

Tubing fittings and fitting components shall be from a single manufacturer and not interchanged with fittings from other manufacturers.

Add new section

7.4.4.16

Discharge blow-off valves shall have stainless steel internals with soft polytetrafluoroethylene (PTFE) seat.

7.4.5 Alarms and Shutdowns

7.4.5.1 General

Add to Table 3

Table 3 – Equipment Monitoring

Condition	Alarm	Shutdown
Compressor Axial Position (high / high-high)	X	X
High Motor Radial vibration (high / high-high)	X	X
High Motor Bearing temperature ^f (high / high-high)	X	X
High Motor Winding temperature (high/ high-high)	X	X
Seal air pressure ^g (low)	X	

Add to Notes

^f When motor equipped with sleeve bearing

^g If applicable

7.4.5.3 Alarm and Shutdown Devices

7.4.5.3.4

Replace section with

If specified, shutdown system shall be provided with switches or another suitable means to permit testing without shutting down the unit.

7.4.6 Electrical Systems

Add new section

7.4.6.7 Purchaser's Interface

The vendor shall provide cable trays, conduits, transit frames etc. for routing the purchaser's electrical power and control cables to the respective consumer on the skid.

For an enclosed skid, single-point electrical interface shall be provided. For medium voltage motors a separate electrical interface shall be provided for the main driver motor.

7.5 Piping

7.5.1 General

7.5.1.2

Replace first sentence with

A manifolded cooling water piping system shall terminate with flanged single-supply and single-return connections at the edge of the package.

7.5.1.5Replace section with

Seal welding of galvanized pipe in cooling water service shall not be used.

Add new section**7.5.1.9**

All utility lines such as instrument air, cooling water supply and cooling water return shall be provided with single-point tie-in connection with isolation valve located at skid edge.

Add new section**7.5.1.10**

Drain lines shall be terminated to the edge of the baseplate with an isolation valve at the purchaser's tie-in point.

Add new section**7.5.1.11**

All ASTM A105/A105M carbon steel flanges shall be limited to design minimum temperatures of -9.4 °C (15 °F) and warmer. For colder climates, ASTM A350/A350M Grade LF2 Class 1 material shall be used.

Add new section**7.5.1.12**

All slip-on flanges shall be double welded.

Add new section**7.5.1.12**

The installation of permanent in-line strainer shall permit dismantling of strainer elements without removing strainer body or housing.

Add new section**7.5.1.13**

If expansion joints are used in compressed air service, they shall be metallic bellows type joints.

Add new section**7.5.1.14**

Compressor discharge check valves shall be of piston type or dual plate (dual disk) design and of full stainless steel construction.

Add new section

7.5.1.15

Ball valves constructed so that the ball is held in place with a threaded portion of the valve body shall not be used, unless the valve halves are positively secured together (such as sealwelding) by the valve manufacturer.

Add new section

7.5.1.16

Quarter turn block valves used for critical isolation such as isolation valves upstream and downstream of the control valve and isolation valves for safety transmitter, shall include a mechanism capable of accepting a pad lock or car seal for the purpose of locking or car-sealing the valve in its intended position.

Add new section

7.5.1.17

Valve stems and shafts for all valves (including check valves with external shafts) shall be blow-out proof if:

- a. The stem or shaft becomes separated from the closure device
- b. The stem nut becomes detached from the yoke
- c. The packing gland is removed.

Valve stems shall be designed such that the weakest link is outside of the pressure boundary.

Add new section

7.5.1.18

Ball and butterfly valves shall have anti-static device.

Add new section

7.5.1.19

All carbon steel air and water piping shall have 1.5 mm ($1/16$ in.) corrosion allowance as a minimum.

7.5.2 Oil Piping

7.5.2.1

Add new section

7.5.2.4

Tubing may be used on sizes DN 15 (NPS $1/2$) and smaller. Tube fittings shall be of double-ferrule type.

Add new section heading

7.5.4 Pipe Support

Add new section

7.5.4.1

The vendor shall provide the purchaser with the allowable load and movement at the tie-in point.

Add new section

7.5.4.2

Piping shall be designed to withstand reaction forces from pressure relief and blow-off valves.

Add new section

7.5.4.3

Bracings shall be provided for vent, drain and small-bore connections.

Replace section heading with

7.6 Intercoolers, Aftercoolers and Other Pressure Equipment

7.6.2

Add new section

7.6.2.1

The drain valve shall be fitted at the lowest point of the cooler inclusive of moisture separator.

Add new section

7.6.2.2

Electronically operated automatic drain traps with bypass shall be provided.

Add new section

7.6.2.3

Solenoids for the drain traps, if used, shall be H-rated, with full stainless steel body and soft seal (PTFE, etc.).

7.6.3

Add to section

Alternative configuration, based on the vendor's standard proven design may be used, if approved by the purchaser.

Approval shall be subject to the vendor submitting a satisfactory proposal on heat exchanger maintenance and cleaning of shell and tube side for fouling.

Water on the shell side of a sea-water cooled heat exchanger is not acceptable.

7.6.5

Replace second sentence with

U-bend shall not be used unless approved by the purchaser.

Replace Note 1 with

Note 1: Refer to 6.10.6.3 and Table 4 for material selection of the intercooler and aftercooler components.

7.6.6

Add to section

Refer to 6.10.6.3 and Table 4 for material selection of the air-cooled cooler.

Add new section

7.6.7

Non-integral aftercooler, oil cooler and any other fabricated pressure equipment part of the package shall be designed and constructed to the pressure design code specified in the data sheet.

Add new section

7.6.8

Integrated intercooler and aftercooler part of compressor casing or extended pressure casing shall be as per the vendor's standard design and construction.

Add new section

7.6.9

If specified in the data sheet, vessels shall be ASME code stamped or be compliant with the essential safety requirements of the Pressure Equipment Directive (PED) 2014/68/EU.

7.7 Inlet Air Filter/Silencer

Add to section

Refer to 6.10.6.3 and Table 4 for material selection of the inlet air filter and silencer. The piping between the inlet air filter or silencer and the compressor's air inlet flange, shall be 316 stainless steel or carbon steel with non-metallic lining or insert.

Add new section

7.7.1

If specified in the data sheet, a self-cleaning pulse-jet type inlet filtration system shall be provided.

8 Inspection, Testing and Preparation for Shipment

8.2 Inspection

8.2.1 General

Add to item c.

Final assembly maintenance and running clearances for bearings and seals shall be submitted with as built data.

8.2.2 Material Inspection

Add to section

Material certificates shall be provided in accordance with Annex B of S-612Q.

8.3 Testing

8.3.2 Hydrostatic Tests

8.3.2.1

Add after first sentence

Minimum hydrotest pressure shall not be less than 150 kPa (20 psi).

Add new section

8.3.2.5

The minimum hold time of hydrotest pressure shall be 30 minutes.

8.3.3 Impeller Overspeed Test

8.3.3.2

Replace first sentence with

After the overspeed test, each impeller shall be examined by magnetic particle or liquid penetrant methods.

Add to section

Linear indications on the impeller shall not be acceptable.

8.3.4 Combined Mechanical and Performance Tests

Add new section heading

8.3.4.8 Lube Oil Flushing Test

Add new section

8.3.4.8.1

Lube oil flushing and cleanliness test shall be carried out using a 100 mesh stainless steel screen.

Add new section

8.3.4.8.2

The flushing test shall be performed at least 1 hour prior to the combined performance and mechanical run test, in accordance with the cleanliness standard as per ISO 4406-3 Grade 17/14 or SAE AS 4059 Class 8.

Add new section heading

8.3.4.9 Noise Test

Add new section

8.3.4.9.1

Noise tests shall be conducted as per ISO 2151-2 using sound intensity scanning method as per ISO 9614-2 and using a sound intensity system meeting the requirements of IEC 1043 Class 1.

Add new section

8.3.4.9.2

For multiple, identical compressor packages, it may be sufficient to carry out noise testing on only one compressor package.

Add new section

8.3.4.9.3

For vendor's standard equipment, data from previous tests on identical equipment may be accepted, if agreed by the purchaser.

Add new section

8.3.4.9.4

Any safety margin required to cover for measurement uncertainty between the measured sound power level and guaranteed sound power level shall be specified by the purchaser.

8.4 Preparation for Shipment

Add new section

8.4.8

All exposed machined and un-coated surface shall be protected with vapour-proof corrosion inhibitor to protect against onset of corrosion.

Add new section

8.4.9

All visible display units and control panel front face shall be adequately protected against damage during transportation and handling.

Add new section

8.4.10

The vendor shall provide completed preservation checklists and preservation report detailing all preservation activities performed.

Add new section

8.4.11

Provision for turning on the anti-condensation heater for motors while they are idle shall be clearly stated in the preservation procedure.

Add new section

8.4.12

Open pipes, flexible hoses, open tubes, etc. shall be blanked-off and capped with material of compatible metallurgy. Valves that are open to the atmosphere in the final installed position shall have their outboard connection either plugged or blinded.

Add new section heading

8.6 Control Panel Test

Add new section

8.6.1

The compressor control panel shall be functionally tested to verify correct functioning of control logic, alarms, shutdown functions and trip set points.

Add new section

8.6.2

The anti-surge controller shall be tested to verify the surge anticipation and surge detection algorithm. The anti-surge controller test procedure shall be developed and mutually agreed between the purchaser and the vendor.

Add new section

8.6.3

Control panel hard-wire verification testing and wiring continuity check on the skid shall be performed by the vendor and documented in the test report.

9 Vendor Data

9.2 Proposals

9.2.3 Technical Data

Add to list

- s. A list of priced capital spares.

9.3 Contract Data

9.3.4 Parts Lists and Recommended Spares

Add to section

The vendor shall submit separate lists for following three categories of spares:

- a. Capital spares
- b. Commissioning spares
- c. Operation and maintenance spares.

9.3.4.2

Replace first sentence with

The vendor shall provide recommended stocking quantities of commission spares and operation and maintenance spares.

Add new section

9.3.4.3

The list of capital spares shall include the following items, as a minimum:

- a. Set of high speed (pinion shaft) rotors
- b. Set of impellers for individual stages
- c. Set of diffusers
- d. Set of radial bearing for all high speed pinions
- e. Set of thrust bearing for all high speed pinions
- f. Set of shaft seals
- g. Set of lube oil pumps (main and auxiliary)
- h. Spare compressor service kit.

Add new section

9.3.4.4

Maintainable items such as instruments, shaft seals, gearbox seal, solenoids, control valve, actuated valve, pressure relief valve, air Inlet filter, lube oil filter, heater and lube oil pump motor shall be included as a minimum in the list of operation and maintenance spares.

Add new section

9.3.4.5

Spare parts shall comply with all requirements applicable as for the original component.

Annex B (normative) Referenced Documents

Delete from list

API Std 541	Form-Wound Squirrel Cage Induction Motors – 250 Horsepower and Larger
API Std 546	Brushless Synchronous Machine – 500 kVA and Larger, Second Edition
API Std 617	Axial and Centrifugal Compressors and Expander-Compressors for Petroleum, Chemical and Gas Industry
ASME B16.1125	Cast Iron Pipe Flanges and Flanged Fittings Classes 25 and 250
ASTM A515/A515M	Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service
IEC 79	

Add to list

ASME B1.20.1	Pipe Threads, General Purpose (Inch)
ASTM A105/A105M	Standard Specification for Carbon Steel Forgings for Piping Applications
ASTM A350/A350M	Standard Specification for Carbon and Low-Alloy Steel Forgings, Requiring Notch Toughness Testing for Piping Components
IEC 1043	Electroacoustic - Instruments for the Measurement of Sound Intensity - Measurements with Pairs of Pressure sensing Microphones
IEC 60034	Rotating Electrical Machines
IEC 60079	Explosive atmospheres
ISO 281	Rolling Element Bearing – Dynamic Load Ratings and Rating Life
ISO 2151-2	Acoustics – Noise test code for compressors and vacuum pumps Engineering method (Grade 2)
ISO 4406-3	Hydraulic fluid power – Fluids – method for coding the level of contamination by solid particles
ISO 9614-2	Acoustics - Determination of sound power levels of noise sources using sound intensity - Part 2: Measurement by scanning
ISO 12944	Paints and varnishes – Corrosion protection of steel structures by protective paint systems
ISO 14691	Petroleum and natural gas industries: Flexible couplings for mechanical power transmission - General purpose applications
ISO 21457	Petroleum, Petrochemical and natural gas industries- Material selection and corrosion control for oil and gas production systems
ISO 21940-11	Mechanical vibration — Rotor balancing — Part 11: Procedures and tolerances for rotors with rigid behaviour
ISO 21940-32	Mechanical vibration — Rotor balancing — Part 32: Shaft and fitment key convention
NEMA MG-1	Motors and Generators
NFPA 70	National Electrical Code
SAE AS 4059E	Aerospace Fluid Power - Contamination Classification for Hydraulic Fluids

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This specification supplements
API Standard 672 Packaged, Integrally
Geared Centrifugal Air Compressors
referring sequentially to the same clause
numbers.