MATERIAL AND EQUIPMENT STANDARD

FOR

PACKAGED, INTEGRALLY GEARED

CENTRIFUGAL AIR COMPRESSORS

FOR PETROLEUM, CHEMICAL

AND

GAS INDUSTRY SERVICES

FIRST EDITION

JUNE 2002

This standard specification is reviewed and updated by the relevant technical committee on Jun. 2012. The approved modifications are included in the present issue of IPS.

FOREWORD

The Iranian Petroleum Standards (IPS) reflect the views of the Iranian Ministry of Petroleum and are intended for use in the oil and gas production facilities, oil refineries, chemical and petrochemical plants, gas handling and processing installations and other such facilities.

IPS is based on internationally acceptable standards and includes selections from the items stipulated in the referenced standards. They are also supplemented by additional requirements and/or modifications based on the experience acquired by the Iranian Petroleum Industry and the local market availability. The options which are not specified in the text of the standards are itemized in data sheet/s, so that, the user can select his appropriate preferences therein

The IPS standards are therefore expected to be sufficiently flexible so that the users can adapt these standards to their requirements. However, they may not cover every requirement of each project. For such cases, an addendum to IPS Standard shall be prepared by the user which elaborates the particular requirements of the user. This addendum together with the relevant IPS shall form the job specification for the specific project or work.

The IPS is reviewed and up-dated approximately every five years. Each standards are subject to amendment or withdrawal, if required, thus the latest edition of IPS shall be applicable

The users of IPS are therefore requested to send their views and comments, including any addendum prepared for particular cases to the following address. These comments and recommendations will be reviewed by the relevant technical committee and in case of approval will be incorporated in the next revision of the standard.

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GENERAL DEFINITIONS:

Throughout this Standard the following definitions shall apply.

COMPANY:

Refers to one of the related and/or affiliated companies of the Iranian Ministry of Petroleum such as National Iranian Oil Company, National Iranian Gas Company, National Petrochemical Company and National Iranian Oil Refinery And Distribution Company.

PURCHASER:

Means the “Company” where this standard is a part of direct purchaser order by the “Company”, and the “Contractor” where this Standard is a part of contract documents.

VENDOR AND SUPPLIER:

Refers to firm or person who will supply and/or fabricate the equipment or material.

CONTRACTOR:

Refers to the persons, firm or company whose tender has been accepted by the company.

EXECUTOR:

Executor is the party which carries out all or part of construction and/or commissioning for the project.

INSPECTOR:

The Inspector referred to in this Standard is a person/persons or a body appointed in writing by the company for the inspection of fabrication and installation work.

SHALL:

Is used where a provision is mandatory.

SHOULD:

Is used where a provision is advisory only.

WILL:

Is normally used in connection with the action by the “Company” rather than by a contractor, supplier or vendor.

MAY:

Is used where a provision is completely discretionary.

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0. INTRODUCTION

This Standard gives technical specifications and general requirements for the purchase of "Packaged, Integrally Geared Centrifugal Air Compressors for Petroleum, Chemical, and Gas Industry Services" for use in oil, Gas and Petrochemical Industries and is based on API Standard 672 fourth Edition March 2004, Errata Oct. 2007 & Errata2 July 2010, and shall be read in conjunction with that document. **(Mod.)**

Note 1:
This is a revised version of the standard specification for packaged, integrally geared centrifugal compressors for utility and instruments, which is issued as revision(1). Revision(0) of the said standard specification is withdrawn.

Note 2:
This standard specification is reviewed and updated by the relevant technical committee on June 2012. The approved modifications by T.C. were sent to IPS users as amendment No. 1 by circular No. 340 on June 2012. These modifications are included in the present issue of IPS.

Guidance for Use of this Standard

The amendments/supplement to API Standard 672 given in this Standard are directly related to the equivalent sections or clauses in API Standard 672. For clarity, the section and paragraph numbering of API Standard 672 has been used as for as possible. Where clauses in API are referenced within this Standard, it shall mean those clauses are amended by this Standard. Clauses in API that are not amended by this Standard shall remain valid as written.

The following notations, as specified hereunder, have been used at the bottom right hand side of each clause or paragraph to indicate the type of change made to the equivalent clause or paragraph of API.

Sub. (Substitution) : The clause in API shall be deleted and replaced by the new clause in this Standard.

Del. (Deletion) : The clause in API shall be deleted without any replacement.

Add. (Addition) : The new clause with the new number shall be added to the relevant section of API.

Mod. (Modification) : Part of the clause or paragraph in API shall be modified and/or the new description and/or statement shall be added to that clause or paragraph as given in this Standard.

1. SCOPE

This standard, contains the minimum technical requirements for "Packaged, Integrally Geared Centrifugal Air Compressors" for use in refinery services, chemical plants, gas plants, petrochemical plants and where applicable in exploration, production and new ventures. Compliance with the provision of this standard does not relieve the vendor of the responsibility of furnishing compressors of proper design, mechanically suited to meet operating guarantee at the specified service condition.

Unless specific exception accompanied by a description of the proposed substitute is recorded under the heading "Exception" in manufacturer's proposal, it shall be mutually understood that the proposal is based on equipment, which complies strictly with the requirements of this Standard. For instrument air standard ISO 8573 Part I class 0 shall be considered. **(Add.)**

1.4 Conflicting Requirements

In the case of conflict between documents relating to the inquiry or order, the following priority of document (whichever more stringent realized by the Company) shall govern:

First priority : Purchase order and variation thereto.

Second priority : Data sheets and drawings.

Third priority : This specification.

All conflicting requirements shall be referred to the purchaser in writing. The purchaser will issue conforming documentation if needed for clarification. **(Sub.)**

2. NORMATIVE REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

IPS (IRANIAN PETROLEUM STANDARDS)

IPS-E-EL-110 “Engineering Standard for Hazardous Area”

IPS-G-SF-900 “General Standard for Noise Control and Vibration”

IPS-M-EL-132 “Material and Equipment Standard for Medium and High Voltage Induction Motors”

IPS-M-PM-240 “Material and Equipment Standard for General Purpose Steam Turbine”

IPS-G-PM-250 “General Standard for Petroleum, Petrochemical and Natural Gas Industries- Steam Turbines -Special-Purpose Applications”

IPS-G-PM-260 “General Standard for Gas Turbines for Petroleum, Chemical, and Gas Industry Services”

IPS-M-PM-300 “Material and Equipment Standard for Special Purpose Gear Units”

IPS-M-PM-310 “Material and Equipment Standard for Special Purpose Couplings”

IPS-M-PM-320 “Material and Equipment Standard for Lubrication, Shaft-Sealing, Oil-Control System and Auxiliaries”

ASTM (AMERICAN SOCIETY FOR TESTING AND MATERIALS)

A 609	"Ultrasonic Examination of Carbon and Low-alloy Steel Casting"
E 94	"Radiographic Testing"
E 186	"Heavy-walled Steel Casting (51-114 mm)"
E 280	"Heavy-walled Steel Casting (114-305 mm)"
E 446	"Steel Castings up to 51 mm in Thickness" **(Mod.)**

5. REQUIREMENTS

5.1 Units of Measurement

The international system of units (SI), dimension and rating in accordance with IPS-E-GN-100 shall be used, unless otherwise specified. **(Sub.)**

5.4 Refer to 1.4 **(Sub.)**

5.5 Selected equipment shall be in all respects well within the range of the manufacturer's proven experience and shall not involve the use or application of any prototype design or components. **(Add.)**

6. BASIC DESIGN

6.1 General

6.1.3.1 All definitions, notations, measuring equipment, measuring procedures, test reporting, calculation methods and calculation procedures shall be in accordance with IPS-G-SF-900. **(Add.)**

6.1.3.2 Unless otherwise specified the following limits shall be met at any measuring location 1 m from the equipment surface.

SURFACE

SOUND PRESSURE LIMIT IN dB re 20 µPa	
COMPRESSOR	87 dB (A)
COMPRESSOR + DRIVER	90 dB (A)

If the equipment produces impulsive and/or narrow band noise, the above limits shall be taken 5 dB (A) lower, thus 82 (A) for compressor and 85 dB (A) for the compressor + driver.

Noise levels shall have an upper tolerance of +0 dB.

The above requirements apply in the absence of reverberation and background noise from other sources, and for all operating conditions between minimum flow and rated flow. **(Add.)**

6.1.3.3 Where excessive noise from equipment can not be eliminated by low noise design, corrective measures may take the form of acoustic insulation for pipes, gear boxes etc.

Where noise hoods are proposed, prior approval of the purchaser shall be obtained regarding construction, materials and safety requirements.

Noise control measures shall cause no hindrance to operation nor any obstruction to routine maintenance activities. **(Add.)**

6.1.5 Environmental condition unless otherwise specified, the compressor and its supporting system shall be design for outdoor installation. **(Mod.)**

6.1.7.4 Piping, conduit, instrument and all other accessories and appurtenances shall be removed to change rotors without the need to disassemble, move or remove them. **(Add.)**

6.1.8 Motor drivers shall comply with IPS-M-EL-132. **(Mod.)**

6.1.13 Mounting surfaces shall meet the following criteria:

1. They shall be machined to a finish of 6 µm (250 µin.) arithmetic average roughness (Ra) or better.

2. To prevent a soft foot, they shall be in the same horizontal plane within 25 µm (0.001 in.).

3. Each mounting surface shall be machined within a flatness of 80 µm per linear meters (0.001 in. per linear foot) of mounting surface.

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

5. The upper machined or spot faced surface shall be parallel to the mounting surface.

6. Hold-down bolt holes shall be drilled perpendicular to the mounting surface or surfaces, spot faced where necessary to accommodate fasteners and tools.

Note: Spot face is typically not necessary if surface is perpendicular to bolting within 1 degree. **(Mod.)**

6.7 Dynamic

6.7.1 Critical speeds

6.7.2 Lateral analysis

Add to the beginning of the first sentence of this clause "if approved by purchaser" **(Mod.)**

6.7.3 Torsional analysis

6.7.3.1 For synchronous motor driven compressors and variable speed drive systems (VSDS) driven compressors, a torsional analysis shall be performed. **(Mod.)**

6.9 Lubrication

6.9.2 Lubrication System shall conform to IPS-M-PM-320. **(Mod.)**

6.9.4 The oil Reservoir shell be fabricated stainless steel. **(Mod.)**

6.10 Materials

6.10.1.1 The materials of construction for casing shall be steel or nodular cast iron. Casing shall be made of steel, if any of the following applies:

- The maximum allowable working pressure exceeds 28 Bar A.

- The calculated discharge temperature exceeds 205.c at any point within the operating range. **(Mod.)**

6.10.1.8 The bolting material for pressure joints shall be in accordance with the piping class. **(Add.)**

6.10.3 Casting

6.10.3.1.1 Approval by the purchaser shall be obtained before any major weld repair* is carried out. All repairs shall meet the inspection requirements and acceptance standards for the original material. *The definition of a major weld repair is to be taken as either a removal of more than 50% of the wall thickness, or a length of more than 150 mm in one or more directions, or a total surface area of all repairs exceeding 20% of the total casting surface area. The total quantity of weld metal deposited shall be less than 10% of the mass of the casting. Detail of all major weld repairs, and of the heat treatment where applicable, shall be recorded and reported to the purchaser. **(Mod.)**

6.10.3.1.6 Detail of all repairs shall be recorded and reported to the purchaser, who shall be informed the need for plugging before any repair is carried out. **(Add.)**

6.10.4.3 Unless otherwise specified, documentation of major defects shall be submitted to the purchaser prior to any repairs being conducted at the manufacturer's shop and shall include the following

a. Extent of the repair

b. Location

c. Size

d. Welding procedure specification

e. Detailed photographs of the defect prior to any preparatory work and after preparation but prior to the actual repair. If the location of the defect cannot be clearly defined by photographic means, the location shall be indicated on a sketch or drawing of the affected component. **(Mod.)**

6.11 Name Plates and Rotation Arrows

6.11.5 The text on name plates shall be in English language and, unless otherwise specified, the data shall be in SI units.

The information on name plates shall include the year of manufacture. **(Add.)**

6.12.3 The vendor shall provide a damped unbalanced response analysis for each machine to assure acceptable amplitudes of vibration at any speed from zero to trip. **(Mod.)**

6.12.4 A damped unbalanced response analysis shall be conducted and confirmed by test stand data in accordance with Annex C. **(Mod.)**

6.12.5 The vendor shall perform a torsional vibration analysis of the complete coupled train and shall be responsible for directing the modifications necessary to meet the requirements of 6.7.3.2 – 6.7.3.5.

Note:
Excitations of undamped torsional natural frequencies may come from many sources, which should be considered in the analysis. These sources may include but are not limited to the following:

a. Gear phenomena such as unbalance and pitch line runout

b. Startup conditions such as speed detents and other torsional oscillations

c. Torsional transients such as start-ups of synchronous electric motors and transients due to generator phase-to-phase fault or phase-to-ground fault

d. Torsional excitation resulting from drivers

e. One and two times line frequency

f. Running speeds. **(Mod.)**

6.12.8 After the final balancing of each assembled rotating element has been completed, a residual unbalance check shall be performed and recorded in accordance with the residual unbalance work sheet (see Annex F). **(Mod.)**

6.12.10 Thrust bearings and radial bearings shall be fitted with bearing-metal temperature sensors. **(Mod.)**

6.12.11 Installation of bearing-metal temperature sensors shall be in accordance with API Std. 670. **(Mod.)**

6.12.13 An austenitic stainless steel oil reservoir shall be supplied. **(Mod.)**

7. ACCESSORIES

7.1 Driver

7.1.1 General

7.1.1.5 Unless otherwise specified, 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. **(Mod.)**

7.1.2 Electric motors

7.1.2.1 Electric motor drivers and motors for auxiliary drivers shall comply with IPS-M-EL-132. **(Mod.)**

7.1.3 Steam turbines

7.1.3.1 Steam turbine drivers shall conform to IPS-M-PM-240 and M-PM-250, whichever applicable. **(Mod.)**

7.2 Couplings and Guards

7.2.1.8 Coupling and guards shall conform to IPS-M-PM-310. **(Add.)**

7.3 Base Plate/Support Structure

7.3.4.1 Base plate shall be designed for continuous grouting under structure members. **(Add.)**

7.4 Controls and Instrumentation

7.4.3 Instrument and control panel

7.4.3.1 Following additional instrumentation shall be provided:

a) Ammeter for compressor motor driver.

b) Air flow indicator.

c) Final stage air discharge pressure gage.

d) Lube oil pump discharge pressure gage.

e) Oil filter difference pressure gage.

f) Tachometer for turbine driver units.

g) Oil reservoir oil temperature indicator.

h) Oil reservoir oil level gage. **(Mod.)**

7.4.5 Alarms and shutdowns

7.10 Additional requirements for “special duty” packages

7.10.1 The product of driver nameplate rating and any applicable service factor shall be no less than the power required (including losses from shaft-driven oil pump, coupling, and gear) when the compressor is operated unthrottled (inlet throttle device wide open) at the specified low-ambient operating conditions. The purchaser will specify the inlet air temperature and the inlet cooling water temperature to be used by the vendor in calculating the maximum unthrottled power.

Note:
The specified inlet temperature is not necessarily the minimum ambient temperature.
(Mod.)

7.10.3 The vendor shall commercially sand blast, in accordance with ISO 8501, Grade Sa2 or SSPC SP6, all grout contact surfaces of the baseplate, and coat those surfaces with a primer compatible with epoxy grouting. **(Mod.)**

7.10.5 A surge avoidance system shall be provided.

Note:
Typically this requires additional instrumentation for measuring flow, pressure and temperature, a modulating type anti-surge (blow-off) valve and additional control logic.
(Mod.)

7.10.7 Provisions for phase reference (phase angle probes) shall be made on all pinions in accordance with API Std. 670. **(Mod.)**

7.10.10 Vibration and axial position transducers shall be supplied, installed, and calibrated in accordance with API Std. 670. **(Mod.)**

7.10.11 Vibration and axial position monitors shall be supplied, installed, and calibrated in accordance with API Std. 670. **(Mod.)**

7.10.12 A bearing-temperature monitor shall be supplied and calibrated in accordance with API Std. 670. **(Mod.)**

7.10.14 Each alarm device and each shutdown device shall be furnished as separate devices.
(Mod.)

7.10.18 Piping on external return lines and upstream of filters shall be stainless steel (excluding slip-on flanges). **(Mod.)**

7.10.23 Unless otherwise specified, thread connections are not allowed. All connections should be terminated at the edge of the base plate with flanged connections. **(Add.)**

8. INSPECTION, TESTING AND PREPARATION FOR SHIPMENT

8.1 General

8.1.3 The manufacturer shall provide the purchaser with assurance that materials of construction are in accordance with the purchase order.

Material certificates giving the chemical composition and the mechanical and test data for the materials used for the pressure containing parts and for the main components of the compressor shall be submitted by the manufacturer.

Unless otherwise specified, the necessary testing shall have been carried out by a testing center which is independent of production in the manufacturing works. **(Add.)**

8.2 Inspection

8.2.1 General

8.2.2 Material inspection

8.2.2.1.3 Cast impellers shall satisfy the manufacturer's spot radiographic examination prior to finish machining. Radiographic shall be taken at all critical points including areas of high stress. **(Add.)**

8.2.2.1.4 When specified, full non-destructive inspection shall be carried out on all critical areas, such as abrupt changes in section, weld ends, at the junction of risers, gates or feeders to the casting and areas of high stress prior to inspection, the purchaser and the manufacturer shall agree the critical areas and the type of nondestructive testing which shall be applied. Radiographic inspection shall be applied wherever possible.

Radiographic inspection procedure shall be in accordance with ASTM E-94.The interpretation of radiographs shall be in accordance with ASTM

E 186, ASTM E 280 or ASTM E 446, whichever is applicable.

Ultrasonic inspection shall be used where radiography is not possible. Ultra sonic inspection shall be in accordance with ASTM A-609. **(Add.)**

8.2.2.1.5 The inspection requirements specified in this specification can be relaxed at the discretion of the purchaser if the manufacturer can establish proven good experience with the same casing material and the same casting technique. The purchaser and the manufacturer shall then agree the revised extent of the inspection. **(Add.)**

8.3 Testing

8.3.3.1 Minimum duration for over speed test shall be considered 3minutes. **(Mod.)**

8.3.3.2 After the overspeed test, each impeller shall be examined by magnetic particle or liquid penetrant methods. Impeller dimensions identified by the manufacturer as critical (such as bore and outside diameter) shall be measured before and after the overspeed test. Any permanent deformation of the bore or other critical dimensions outside drawing tolerances shall be resolved to the satisfaction of the vendor and the purchaser. **(Mod.)**

8.3.4 Combined mechanical and performance test

8.3.4.1 Testing shall be done for a continuous 3-hour period. **(Mod.)**

8.4 Preparation for Shipment

8.4.8 Unless otherwise specified the rust preventive applied to unpainted exterior machined surfaces shall be of a type:

1) To provide protection during outdoor storage for a period of twelve months exposed to a normal industrial environment.

2) To be removable with mineral spirits or any standard solvent. **(Add.)**

8.4.9 Each compressor shall be identified as required by the purchase order. No material shall be shipped separately. Miscellaneous parts shall be properly tagged or marked with the item number for which they are intended. All such parts shall be suitably boxed, firmly attached to the base plate and shipped with the unit. **(Add.)**

8.5.1 The vendor shall keep final assembly maintenance and running clearances for at least 20 years. **(Mod.)**

8.5.6 The combined test shall be for a continuous 4-hour period. **(Mod.)**

8.5.7 A minimum of five test points shall be recorded, including surge, rated, and maximum capacity. **(Mod.)**

8.5.9 While the equipment is operating at rated speed, sweeps shall be made for vibration amplitudes at frequencies other than synchronous. As a minimum, these sweeps shall cover a frequency from 0.25 times to 8 times the rated speed of the shaft being observed. If the amplitude of any discrete, nonsynchronous vibration exceeds 20% of the allowable vibration as defined in 6.7.4.3, the purchaser and the vendor shall mutually agree on requirements for any additional testing and on the equipment's suitability for shipment. **(Mod.)**

8.5.12.1 Guide vane test

The package shall be tested at the number of guide vane settings. Each setting shall include surge, rated, and maximum capacity. **(Mod.)**

9. VENDOR DATA

9.2 Proposal

9.2.3.1 The following additional data shall be included in the vendor's proposal.

S) The make and model of vendor's standard instruments to be furnished.

T) Proposed material of construction, including alternatives to base proposal, for air side of intercoolers.

U) Standard type bearings applicable to the machine. **(Mod.)**

9.3 Contract Data

9.3.2 Drawing and technical data

9.3.2.1 The information shall include the documents for controls and instrumentation. **(Add.)**

10. GUARANTEE AND WARRANTY (Add.)

10.1 Mechanical

Unless exception is recorded by the vendor in his proposal, it shall be understood that the vendor agrees to the following guarantees and warranties:

During a period of 12 months after the date of commissioning, the vendor shall, with all possible speed and without cost to the purchaser, replace or repair the goods or any part thereof found to be defective due to faulty material, workmanship or to any act or omission of the vendor. In particular the vendor shall reimburse any transportation and other charges incurred by the purchaser in effecting such replacement or repair at the point of use. **(Add.)**

10.2 Performance

The compressor shall be guaranteed for satisfactory performance at all specified operating conditions, including rated operating point. At this point, no negative tolerance is permitted on capacity and discharge pressure and the brake horse power may not exceed 104 percent of the quoted horsepower. **(Add.)**