MATERIAL AND EQUIPMENT STANDARD

FOR

PACKAGED, INTEGRALLY GEARED CENTRIFUGAL COMPRESSORS

FOR UTILITY AND INSTRUMENTS

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0. INTRODUCTION

This specification gives the amendment and supplement to API Std. 672 second edition April 1988 "packaged, Integrally Geared Centrifugal Air Compressors" for General Refinery Service.

It shall be used in conjunction with data sheets for centrifugal air compressors.

For ease of reference, the clause or section numbering of API Std. 672 has been used throughout of this specification.

Clauses in API Std. 672 not mentioned remain unaltered.

For the purpose of this specification the following definitions shall hold:

Sub.	(Substitution)	:	The API Std. clause is deleted and replaced by a new clause.
Del.	(Deletion)	:	The API Std. clause is deleted with no replacement.
Add.	(Addition)	:	A new clause with a new number is added.
Mod.	(Modification)	:	Part of the API Std clause is modified, and/or a new description and/or statement is added to that clause.

Problems stemming from the publication of revisions or amendments to the API Std. 672 by the American petroleum Institute in subsequent years shall be referred to the purchaser.

1. GENERAL

1.1 Scope

This specification, 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 resposibility 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 propsal, it shall be mutually understood that the proposal is based on equipment, which complies strictly with the requirements of this Standard. (Mod.)

1.2 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.)

1.3 Definition of Terms

1.3.2.2 Diameter Nominal

The international nomenclature-diameter nominal-written as DN 15, 25, 32, etc., has been used for pipe size in accordance with Appendix C in this Standard specification. (Add.)

1.3.2.3 Pressure Nominal

The international nomenclature-pressure nominal written as PN 20, 50, 68, 100, etc., has been used for pipe flange ratings in accordance with Appendix D in this Standard specification. (Add.)

1.4 Referenced Publications

1.4.1 The latest edition of the following standards and publications to the extent specified herein, form part of this standard.

IPS (IRANIAN PETROLEUM STANDARDS)

E-EL-110 "Electrical Area Classification and Extent"

E-SF-900 "Vibration and Noise Control"

M-EL-132 "Induction Motors"

M-PM-240 "General Purpose Steam Turbine"

M-PM-250 "Special Purpose Steam Turbine"

M-PM-260 "Industrial Combustion Gas Turbine for Process Services"

M-PM-300 "Special Purpose Gear Units for Process Services"

M-PM-320 "Lubrication, Shaft Sealing and Control Oil System for Special Purpose Application"

M-PM-310 "Special Purpose Couplings"

ASTM (AMERICAN SOCIETY FOR TESTING AND MATERIALS)

A 609 "Utrasonic 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.)

2. BASIC DESIGN

2.1 General

2.1.11 Motor drivers shall comply with IPS Std. M-EL-132. (Mod.)

2.1.15 All equipment furnished shall be designed to minimize the generation of noise and shall not exceed the noise limits given in the supplementary clauses below. (Sub.)

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

2.1.15.2 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.)

2.1.15.3 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 safty requirements.

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

2.2.4 Controls and instrumentation

2.2.4.3 Instrument and control panel

2.2.4.3.1 Following additional instrumentation shall be provided:

n) Ammeter for compressor motor driver.

o) Air flow indicator.

P) Final stage air discharge pressure gage.

q) Compressor and driver bearings temperature indications.

r) Inter stage air pressure and temperature gages after inter coolers and before intercoolers respectively.

s) Lube oil pump discharge pressure gage.

t) Oil filter difference pressure gage.

u) Tachometer for turbine driver units.

v) Oil reservoir oil temperature indicator.

w) Oil reservoir oil level gage.

(Mod.).

2.2.4.5 Alarms and shutdowns

2.2.4.5.1 The following additional alarm and shut downs shall be provided:

a) At least 3 spare annunciator panels.

b) Emergency oil pump (if provided) inoperable.

(Mod.).

2.2.4.7 Vibration and position detectors

2.2.4.7.1 Vendor shall provide equipment for monitoring and measurement of shaft radial vibration within each high speed pinion bearing housing and one end of the bull gear, in the case where compressor design involves pinion and bull gear. (Mod.)

2.2.4.7.2 Delete "when specified" from this clause. (Mod.)

2.2.4.7.3 Delete "when specified" from this clause. (Mod.)

2.3 Integrally Geared Compressor

2.3.7 Dynamic

2.3.7.4 Torsional analysis

2.3.7.4. 2 No actual torsional resonant speeds shall be within 10% of the first or second harmonic of the rotational frequency in the operating speed range including up to trip speed. (Sub.)

2.3.7.5 Vibration and balancing

2.3.7.5.5 For the assembled machine operating at maximum continuous speed or at any other specified speed within the operating range, the overall unfiltered peak-to-peak amplitude of vibration, including run out, in any plane measured on the shaft adjacent and relative to each radial bearing shall not exceed the following values:

SPEED rpm	PERMISSIBLE SHAFT VIBRATION in μ m
BELOW 3000	50
3000 - 15000	$10^{\frac{q}{\frac{75000}{n}}}$
ABOVE 15000	$\frac{355000}{n}$

in which n=maximum continuous speed in revolutions per minute. At the trip speed of the driver, the vibration shall not exceed the above values plus 25%. (Sub.)

2.3.9 Materials

2.3.9.2 Casting

2.3.9.2.3.1 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.)

2.3.9.2.3.2 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. (Mod.)

2.3.10 Name plates and rotation arrows

2.3.10.2 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. (Mod.)

2.4 Driver

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

2.4.7 Steam turbine drivers shall conform to IPS-M-PM-240 and M-PM-250, whichever applicable.

Gas turbine drivers shall conform to IPS-M-PM-260. (Mod.)

2.5 Driver - to - compressor Coupling and Guard

2.5.2 When specified, coupling and guards shall conform to IPS-M-PM-310. (Sub.)

4. INSPECTION, TESTING AND PREPARATION FOR SHIPMENT

4.1 General

4.1.1 Purchaser's representative shall have the right to reject any part of the equipment which does not conform to the order. (Mod.)

4.1.6 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.)

4.1.7 All certificates shall contain the following information:

- Name of manufacturer
- Purchase order number and date
- Identification number of certificate and its date of issue
- Material specification
- Dimensions in SI units
- Material charge number or batch number
- Mechanical properties recorded from test results
- Chemical composition recorded from results of chemical analysis
- NDT methods and results, where applicable
- Heat treatment procedures, furnace charge number and heat treatment records, where applicable
- Name of the independent inspector who has withnessed the tests.

4.2 Inspection

4.2.2 Material inspection

4.2.2.2 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. (Mod.)

4.2.2.6 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.)

4.2.2.7 The inspection requirements specified in this specification can be relaxed at the discretion of the purchaser if the manufacturer can stablish 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.)

4.3 Testing

4.3.1 General

4.3.1.2 Change 5 working days by 15. (Mod.)

4.3.3 Impeller over speed test

After final machining, each impeller shall be subject to an over speed test of at least 115% of maximum continuous speed for a minimum period of 3 minutes.

Before, and after the over speed test. critical dimensions such as outside diameter and impeller eye diameter shall be measured.

In principle, no dimensional change is permitted.

Should any dimensional change occur, it shall be reported and acceptance shall be subject to the purchaser's approval.

After the over speed test, impellers shall be checked for cracks and defects, then rebalanced. (Sub.)

4.3.4 Combined mechnical and performance test

4.3.4.1 A vibration amplitude/frequency sweep shall also be conducted at each test point. Also the vibration shall be measured at the shaft adjacent to each bearing. (Mod.)

4.3.4.3.1 The actual weights of coupling and sleeves shall be simulated by the addition of weights to the compressor rotor during the mechanical running test(Mod.)

4.3.4.5.3.2 Gear contact pattern shall not be less than 80% of the effective width of the gear mesh. (Sub.)

4.3.5 Optional test

4.3.5.1 Performance test shall be performed unless otherwise specified. Performance curves for capacity, discharge pressure , and brake horse power (kw rating) shall be developed from surge to maximum capacity at 100% speed. Tests shall be conducted in accordance with ASME power test code 10, Class I where conditions permit. Otherwise class II is required. (sub.)

4.3.5.3 Sound - level test

The sound level test shall be performed in accordance with IPS-E-SF-900. (sub.)

4.4 Preparation for Shipment

4.4.3.2 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. (sub.)

4.4.3.11 Each compressor shall be identified as required by the purchase order. No material shall be shipped separately. Miscellanous 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 baseplate and shipped with the unit. (sub.)

5. VENDOR'S DATA

5.1 Proposal

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

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

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

Z') Standard type bearings applicable to the machine.

5.2 Contract Data

5.2.3 Drawings

5.2.3.3 The information shall include the documents for controls and instrumentation. (mod.)

5.2.4 Data

5.2.4.2 The vendor shall give the listed data to the purchaser's representative at the time of or before final inspection. Additionally , the following data shall be included:

d) Material data for impellers.

e) Certified copies of test data.

f) Measured critical speed and shaft vibration at point of measurement.

(Mod.).

6. GUARANTEE AND WARRANTY (Add.)

6.1 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.)

6.2 Performance

The compressor shall be guaranteed for satisfactory performance at all specified operating conditions, inlcuding 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.)

APPENDICES

APPENDIX A
SI UNITS DATA SHEET SHALL BE APPLIED UNLESS OTHERWISE SPECIFIED

APPENDIX C
PIPE COMPONENTS NOMINAL SIZE

The purpose of this appendix is to present the equivalent identities for the piping component nominal size in imperial and SI systems.

TABLE C-1

NOMINAL SIZE		NOMINAL SIZE		NOMINAL SIZE		NOMINAL SIZE	
DN (1)	NPS (2)	DN	NPS	DN	NPS	DN	NPS
15	½	100	4	500	20	1000	40
20	3/4	125	5	600	24	1050	42
25	1	150	6	650	26	1100	44
32	1¼	200	8	700	28	1150	46
40	1½	250	10	750	30	1200	48
50	2	300	12	800	32	1300	52
65	2½	350	14	850	34	1400	56
80	3	400	16	900	36	1500	60
90	3½	450	18	950	38	1800	72

(1) Diameter nominal, mm.

(2) Nominal pipe size, Inch.

APPENDIX D
PIPE FLANGE PRESSURE TEMPERATURE RATING

The purpose of this Appendix is to present the equivalent identities for the pipe flange nominal pressure temperature ratings in imperial and SI Systems.

TABLE D-1

PN RATING - BAR (1)	ANSI RATING CLASS
20	150
50	300
68	400
100	600
150	900
250	1500
420	2500

(1) The indicated PN ratings are introduced by ISO standard No. 7268.