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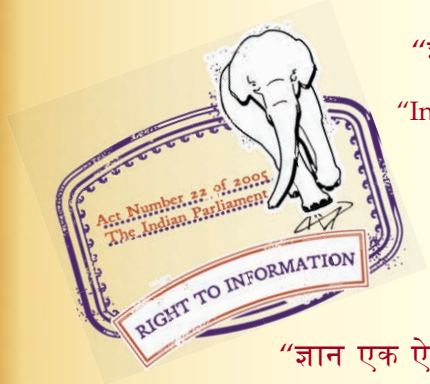
"पुराने को छोड नये के तरफ"
Jawaharlal Nehru
"Step Out From the Old to the New"

IS 5456 (2006): Testing of Positive Displacement Type Air Compressors and Exhausters - Code of Practice [MED 22: Compressor, Blowers and Exhausters]



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"ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है"
Bhartṛhari—Nītiśatakam
"Knowledge is such a treasure which cannot be stolen"

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भारतीय मानक

निश्चित विस्थापन टाइप वायु कम्प्रैसर और एक्जास्टर के परीक्षण — रीति संहिता

(दूसरा पुनरीक्षण)

Indian Standard

TESTING OF POSITIVE DISPLACEMENT TYPE AIR COMPRESSORS AND EXHAUSTERS — CODE OF PRACTICE

(Second Revision)

ICS 23.140

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

November 2006

Price Group 7

FOREWORD

This Indian Standard (Second Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Compressors, Blowers and Exhausters Sectional Committee had been approved by the Mechanical Engineering Division Council.

This standard was first published in 1969 and subsequently revised in 1985. This second revision incorporates Amendments No. 1 to 4 and other changes which were felt necessary as a result of experience gained in testing of positive displacement type compressors and exhausters.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analyses shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be same as that of the specified value in this standard.

Indian Standard

TESTING OF POSITIVE DISPLACEMENT TYPE AIR COMPRESSORS AND EXHAUSTERS — CODE OF PRACTICE

(Second Revision)

1 SCOPE

This standard prescribes type tests and routine tests for both reciprocating and rotary type positive displacement air compressors and exhausters.

1.1 This standard does not deal with:

a) centrifugal and axial flow compressors, and

b) machines giving a pressure rise of less than 0.01 MPa and greater than 6 MPa.

2 REFERENCES

The following standards contain provisions which through reference in this text, constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
325 : 1996	Three phase induction motors — Specification (*fifth revision*)
5727 : 1981	Glossary of terms relating to compressors and exhausters (*first revision*)
10431 : 1994	Measurement of air flow of compressors and exhausters (*first revision*)

3 TERMINOLOGY

For the purpose of this standard the following definitions, in addition to those given in IS 5727 shall apply.

3.1 Supplier — The party supplying the machines. The supplier may or may not be the actual manufacturer of the machines. The term 'supplier' shall also cover any party with whom the supplier places an order for partial compliance.

3.2 Purchaser — The party purchasing the machines. The term 'purchaser' shall also cover person or persons authorized in writing by the purchaser to act on his behalf for inspection of the machines.

3.3 Manufacturer — The party manufacturing the machine. The manufacturer may or may not be the supplier.

3.4 New Design — A design which will give an altogether new set of performance as regards pressure and output capacity shall be considered as a new design of the compressor. New design implies distinctly different values of design parameters, for example, input power, theoretical work done during compression, important dimensions like bore and stroke (in case of reciprocating compressor), material of construction as against those of the old design. Change in the performance parameters and design parameters should be substantial and appreciable and not marginal to give rise to the new design.

3.5 Major Modification — Any modification which substantially alters the performance of the compressor, can be termed as major modification, whereas a modification which does not in any way affect the performance of the compressor can be termed as minor modification. Major modification implies marginal change in the performance caused due to alterations/replacement of the main components/sub-assemblies of the compressor.

4 TESTS

4.1 The object of the tests is to verify the performance guaranteed by the supplier as covered in **4.2**.

4.2 The following two tests shall be conducted.

4.2.1 *Type Tests* — Whenever a new design of compressors is manufactured or major design changes affected in the existing model, one unit from the series shall be selected and subjected to a series of tests as given in **6**, to establish its mechanical reliability and performance characteristics. In case of minor changes made by manufacturer, subsequent to type test, such changes shall be indicated. The proforma for type test report shall be as given in Annex A. Type test report shall be given to the purchaser if requested.

4.2.2 *Routine Tests* — Routine tests as given in **8** shall be carried out on all compressors before acceptance by the purchaser.

5 GENERAL CONDITIONS FOR CONDUCTING TESTS

5.1 If the site of tests is not specified in the contract, these tests shall be carried out at the supplier's or manufacturer's premises.

5.2 When routine tests are conducted at the premises of the supplier, he shall be responsible for providing all the material, measuring instruments and the required personnel.

5.3 If routine tests are to be conducted at the premises of the purchaser; the purchaser shall provide necessary help and equipment for installing the apparatus for testing at mutually agreed terms.

5.3.1 During type tests, if any major modification is necessary, the complete test shall be repeated.

5.3.2 When the routine tests are conducted at the premises of the purchaser, the supplier shall always have the right to conduct, prior to these tests, an examination of the compressor or the complete unit to ensure that the compressor or the complete unit is in perfect working condition. If any major modification to the installation is effected by the supplier which does not form part of the general maintenance work, the examination of the compressor of the complete unit shall be conducted again.

5.4 If the test, as conducted by the supplier, is not acceptable to the purchaser, by mutual agreement, the purchaser and the supplier may appoint a competent person or body for conducting the final tests. The report of the tests shall be supplied to the supplier and the purchaser within four weeks of the test.

5.4.1 The expenses of the competent person or body shall be borne by the purchaser, if the equipment is found to comply with the specification; and the expenses shall be borne by the supplier, if the equipment does not comply with the specification.

5.5 If the results obtained during the tests do not conform to the contract values, the supplier shall have the right to effect minor modifications to enable the machine to satisfy the guarantee requirements, at his own cost, within a specified period to be agreed mutually between the purchaser and the supplier.

6 PRECUATIONS TO BE TAKEN WHILE CONDUCTING TESTS

6.1 There shall be no leakage of air between the compressor outlet and the location at which the pressure is measured.

6.2 The tests shall be carried out when the complete unit has reached a steady condition, as shown by the constancy of temperature and pressure.

6.3 If different tests are to be conducted under different working conditions, they shall be done one after the other. But, it is essential to provide between two successive tests, a period long enough generally half an hour, for the new working conditions to stabilize.

6.4 Care shall be exercised to maintain the driving unit of the compressor throughout the period of the test at a constant speed, within the limits as specified in **D-1.2** and **E-1.2**.

6.4.1 Throughout the test, the right flow of cooling water shall be maintained in the case of water-cooled compressors and exhausters.

6.4.2 While conducting the tests, the operating personnel shall not alter any of the controlling devices except with the specific instructions of the person in-charge of the test.

6.4.3 During the tests arrangement shall be made to take readings of all measuring devices, as far as possible, simultaneously. The time of each set of reading shall also be recorded. All accepted readings from any test run shall be consecutive.

6.4.4 It is recommended that four sets of readings, spaced at an interval of 15 min, may be obtained during each test.

7 TYPE TESTS

7.1 These tests may be carried out in the premises of the manufacturer or a well recognized inspecting authority or by any of the natural research laboratories or a well-equipped technological institution.

7.2 Type test shall constitute the following tests and measurements:

a) Mechanical tests;

b) Capacity (free air delivery);

c) Specific power consumption at various pressures from minimum to maximum working pressure under full flow conditions;

d) Maximum operating speed;

e) Volumetric and overall efficiency of machine;

f) Lubricating oil consumption;

g) Testing of loading and unloading mechanism; and

h) Flow of cooling water, if applicable, with rise in temperature.

NOTE — The procedure for calculating the overall efficiency of the compressor is given in Annex B.

7.3 The mechanical tests are intended to ascertain the reliability of the machine and its accessories. Prior to the starting of this test, essential working parts of compressor and its accessories shall be checked for accuracy with the manufacturer's drawings. All mechanical parts shall also be checked for proper functioning when assembled and in operation.

7.3.1 At the end of these tests, as shown in Table 1, the compressor shall be opened and the parts checked again.

7.4 The duration of the separate stages of type tests shall be as given in Tables 1 and 2 for reciprocating and rotary compressors respectively.

8 ROUTINE TESTS

8.1 The routine tests shall constitute the following:

a) Capacity (free air delivery),

b) Speed, and

c) Specific power consumption in the case of electrically driven compressors and specific fuel consumption with other drives at full load.

8.2 The various stages of the routine tests shall be conducted for the duration shown in Table 3.

9 TEST LAYOUT

The recommended arrangements of test layout for the compressors and the exhausters shall be as shown in IS 10431.

10 MEASUREMENT OF PRESSURE

10.1 For pressure above 2 MPa, calibrated bourdon gauges, dead weight gauges, mercury manometers or their equivalent shall be employed. Diaphragm gauges shall not be used.

10.1.1 For type tests, the gauges selected shall be of such size that one percent pressure difference or 0.01 bar whichever is greater, shall easily be read and the pressure to be read shall lie between one-fourth and three-fourths of the total scale reading.

10.1.2 For type tests, the bourdon gauges shall be calibrated against standard dead weight test gauges before and after the tests. The difference between the two calibrations shall not exceed one percent for the test to be taken into consideration.

10.1.3 For type tests, the bourdon gauges shall be calibrated by means of a standard dead weight gauge in which the pressure is transmitted through the medium of oil. The piston of the dead weight gauge shall have minimum working clearance. Before making a test, all moving parts of the dead weight gauge shall be given a slight rotary motion to reduce the frictional effects. The weights used for the dead weight loading shall be compared with standard dead weights. The diameter of the piston of the dead weight gauge shall be measured and the force related to the weights. The calibration of the bourdon gauges shall be carried to the nearest 1/100 MPa.

10.1.4 For routine tests, the bourdon gauges shall be calibrated against a master gauge once in every three months. The difference between the two calibrations shall not exceed five percent, allowing one percent error in calibration of master gauge when checked against dead weight gauge.

10.2 For measurement of pressures below 2 MPa, manometer or vacuum gauges shall be employed. Closed mercury columns known as absolute vacuum gauges shall not be used. This condition is applicable only for those pressure readings which are required for calibration purposes and is not applicable for the readings which are required for checking purposes only, for example, intermediate stage pressure.

10.2.1 Manometers or columns for low pressure measurement shall comprise of glass tubing of not less than 10 mm bore for single limb and not less than 6 mm bore for double limb U-type and with a scale clearly graduated to allow the column to be read within 1 mm.

10.2.2 The manometer glass tube shall be degreased, dried and filled with stable liquids of known mass density.

10.2.3 Where pressure difference is evaluated from the difference of levels of the mercury in the two branches of the manometer, the effective pressure expressed in kgf/cm^2 is given by the product of difference in mercury levels in the two branches expressed in mm, and the specific weight of mercury expressed in kg/dm^3 corresponding to the temperature of the mercury in the manometer.

10.2.4 Due account shall be taken of the variation in the specific weight of the mercury with temperature as shown below:

Temperature, °C	0	10	20	30	40	50
Specific mass of mercury, kg/cm^3	13.60	13.67	13.55	13.52	13.50	13.47

10.2.5 The connecting piping shall not be less than 6 mm in bore for pressure gauges and not less than 10 mm bore for vacuum gauges to eliminate the capillary effect.

Table 1 Stages of Type Tests for Reciprocating Compressors

(*Clauses* 7.3.1 *and* 7.4)

Sl No.	Stage No.	Tests	Duration of the Working of the Compressor h
(1)	(2)	(3)	(4)
1	*Mechanical Tests*:		
	a) Running of the compressor on low discharge pressure:	i) At 20 percent of rated pressure	3
		ii) At 40 percent of rated pressure	5
		iii) At 60 percent of rated pressure	7
		iv) At 80 percent of rated pressure	10
	b) *Endurance Tests*	Running of compressors on load at the rated discharge pressure. The compressors shall be run at full load for a minimum of 8 h at a stretch. At least for half an hour in the 8 h running, the compressor shall be loaded and unloaded at frequent intervals to check the performance of the unloading mechanism. In addition, the compressor with diesel engine as prime motor shall be run at 110 percent of rated pressure (gauge) for one hour in every 12 h distributed over the entire run of endurance test In case electric motor is the prime motor the compressor shall be run at 10 percent overload for 10 percent of the time distributed over the entire run of endurance test	400
2	—	Determination of other characteristics as given in **7.2**	Time required for the actual test

Table 2 Stages of Type Tests for Rotary Compressors

(*Clause* 7.4)

Sl No.	Stage No.	Tests	Duration of the Working of the Compressor h
(1)	(2)	(3)	(4)
1	*Mechanical Tests*:		
	a) Running of the compressor on low discharge pressure:	i) At minimum discharge pressure specified by the manufacturers	12
		ii) At pressure in between the above minimum discharge pressure and rated discharge pressure	12
	b) *Endurance Tests*	Running of compressors on load at the rated discharge pressure. The compressors shall be run at full load for a minimum of 8 h running, the compressor shall be loaded and unloaded at frequent intervals to check the performance of the unloading mechanism. In addition, the compressor with diesel engine as prime motor shall be run at 110 percent of rated pressure (gauge) for 1 h in every 12 h distributed over the entire run of endurance test In case electric motor is the prime motor the compressor shall be run at 10 percent overload for 10 percent of the time distributed over the entire run of endurance test	400
2	—	Determination of other characteristics as given in **7.2**	Time required for the actual test

Table 3 Stages of Routine Tests
(*Clause* 8.2)

Stage No.	Description of Stages	Duration of Tests in the Manufacturer's Factory or Purchaser's Premises for All Compressors h
(1)	(2)	(3)
1	Running of the compressor on load at rated discharge pressure	1
2	Preparation of the stage requirement for getting the final characteristic of the compressor at the rated discharge pressure	2
3	Determination of the characteristics as given in **7.1**	Time required for the actual tests

10.2.6 The connecting piping to pressure gauges and manometers shall be as short as possible. It shall be ensured that there is no water, grease or oil in the connecting pipes. A leakage test of all pipe connections shall be made with soap solution and leaks rectified.

10.3 Delivery Pressure — The delivery pressure shall be measured by a bourdon gauge placed on the main receiver which is nearest to the compressor.

10.3.1 The receiver shall have sufficient capacity such that the pressure gauge readings are not affected to any marked degree by pulsatory discharge of the compressor. The minimum receiver capacity shall be as specified in IS 10431.

10.3.2 The connection between the compressor and the main receiver, in which the pressure measurements are made, shall be so designed that the loss of head produced at entry shall be neglected in calculation.

10.3.3 Where the main receiver is located at a considerable distance away from the compressor, the effective delivery pressure shall be determined by adding to the pressure reading on the main receiver, the loss of head evaluated for the connecting piping as given in Annex B. As far as possible, the layout of the test arrangement shall be such as to avoid the use of this correction.

10.4 If the intermediate stage pressure has to be measured according to the contractual clause; the calibrated bourdon type pressure gauges shall be mounted on the inter-cooler between the various stages of the compressor to obtain the inter-stage gauge pressure.

10.5 Suction Pressure — The intake pressure shall normally be measured with the manufacturer's standard intake filter.

10.5.1 If the intake pipe is short and introduces a friction pressure below 20 mm of water gauge, the absolute pressure at suction shall be taken as the atmospheric pressure.

10.5.2 If the intake piping is long and it is not possible to disconnect the same; the absolute intake pressure shall be calculated by deducting from the atmospheric pressure, the loss of head in the piping as shown in Annex B. If special filter is used, correction shall be made as agreed to between the supplier and the purchaser. The effective intake pressure shall be measured by means of a mercury manometer or water manometer.

10.6 Atmospheric Pressure — The atmospheric pressure shall be determined by means of a mercury in-glass barometer which shall be read up to 0.5 mm.

10.6.1 The barometer shall be located in the neighbourhood of the compressor and the pressure reading shall be taken at the time of the test. The pressure reading shall be corrected for the expansion of the mercury and the scales carrying the graduations.

10.6.2 Aneroid barometers of sound construction, calibrated against a mercury barometer, may also be used.

10.6.3 The atmospheric pressure data, as furnished by the meteorological station located in the neighbourhood where the tests are conducted, may also be used, provided proper corrections are applied.

10.7 The variation in pressure measurement shall not exceed the values shown in Table 4.

11 MEASUREMENT OF TEMPERATURE

11.1 The temperature shall be measured by any of the following:

a) Calibrated mercury in-glass thermometer,
b) Thermocouple,
c) Resistance thermometer, and
d) Thermistors.

Table 4 Allowable Variations in Pressure Measurement During Test
(*Clause* 10.7)

Variable	Maximum Allowable Variations from Average During Any Set of Readings in Percent	
	Type Test	Routine Test
(1)	(2)	(3)
Absolute intake pressure	±1	±1.5
Pressure ratio	±1	±1.5
Fall in pressure due to other auxiliaries	—	1.5

Commercial or industrial metal-encased thermometer shall not be used.

11.2 The thermometer shall be calibrated against a standard thermometer by immersion in a liquid bath maintained at a uniform temperature.

11.3 Mercury in-glass thermometers shall have an etched stem.

11.3.1 The thermometer shall be inserted directly into the air stream, where possible. When this is not possible, the thermometer wells shall be of thin steel or brass tube which may be welded or brazed to a hole pierced in the pipe. The internal diameter of the wells shall be as small as practicable with their outside surface substantially free from corrosion or oxide. The wells shall be partially filled with a suitable fluid of sufficient quantity to cover the thermometer bulb.

11.3.2 The thermometer well shall extend into the pipe a distance of 100 mm, or one-third of diameter of the pipe, whichever is less.

11.3.3 When taking readings the thermometer shall not be lifted out of the well.

11.3.4 The thermometer reading shall be corrected for the emergent stem according to the following formula:

$$t = t_r + n\gamma\ (t_r - t_{av})$$

where

t = true temperature,

t_r = actual reading,

n = length of the emerging fluid column in degrees,

γ = apparent expansion coefficient of the thermometer fluid for mercury in-glass $\frac{1}{6300}$, and

t_{av} = average temperature of the emergent fluid column.

11.4 The average air velocity shall not exceed 30 m/s at the point of measurement. The average velocity shall be computed from the capacity of the machine and the area of the pipe.

11.4.1 The immediate vicinity of the thermometer well and the projecting parts of the connection shall be well insulated so that the well is sensibly at the same temperature as the medium being observed.

11.4.2 The sensitive part of any temperature measuring device or well shall be swept by the air under measurement.

11.5 The thermocouples shall have a welded jot junction and shall be calibrated together with their wires for the anticipated operating range. They shall be made of materials suitable for air and the temperature being measured. The electromotive force of the thermocouple shall be established by a potentiometer-type instrument. The cold junction shall be established by an ice-bath or by a compensating circuit built into the potentiometer.

11.5.1 If thermocouples are used with thermometer wells, the hot junction of the thermocouple shall, where possible, be welded to the bottom of the well.

11.6 The variation in temperature measurement shall not exceed the values shown in Table 5.

Table 5 Allowable Variations in Temperature Measurement During Test

Description of Measurement	Maximum Allowable Variations from Average During Any Set of Readings in °C	
	Type Test	Routine Test
(1)	(2)	(3)
Temperature of air at intake	±2	±2
Temperature of cooling water at inlet	±1	±2
Temperature of oil (for rotary compressors)	±2	±2

11.6.1 For outdoor tests with portable compressors, the allowable inlet temperature fluctuation shall be taken as ±3°C.

11.7 Cooling Water Flow Rate and Temperature

11.7.1 No correction is necessary for the rate of flow of cooling water, provided the deviation from contract value is not more than ±10 percent.

11.7.2 Tests shall be conducted to ascertain that the minimum flow rate, as mentioned in the contract, is achieved. The coolant flow may be determined with the aid of a vessel of known volume and a stop watch or a calibrated flow meter, or with a nozzle as specified in IS 10431.

11.7.3 If no minimum flow rate is mentioned in the contract, the flow rate of cooling water shall be such that the rise in temperature does not exceed 15°C.

11.7.4 The inlet water temperature shall not differ more than ±8°C from the contractual temperature.

11.7.5 If the inlet temperature differs from that given in **11.7.4**, the power consumption of multi-stage compressors, and capacity of single and multi-stage compressors shall be corrected. The correction factor shall be obtained by running the compressor at two different

temperatures and the required value obtained by interpolating or extrapolating the specified conditions with a straight line through the two test points.

12 MEASUREMENT OF HUMIDITY

12.1 The humidity conditions (hygrometric state) of the air drawn in shall be determined on the basis of the readings obtained by means of a psychrometer.

12.2 The psychromotor consists of a wet and dry bulb thermometer arrangement capable of reading correctly to 0.5°C. The thermometer may be placed at the mouth of the intake pipe to obtain correct results.

13 MEASUREMENT OF SPEED

13.1 The speed shall be measured by any of the following:

a) Tachometer,

b) Speed counter,

c) Tachoscope, and

d) Stroboscope.

13.1.1 The use of a separate revolution counter and a stop watch is not recommended for the measurement of the compressor speed.

13.2 All instruments mentioned in **13.1** shall be tested and calibrated periodically.

13.3 The error of the speed measuring instruments shall lie within ±2 percent.

14 MEASUREMENT OF AIR FLOW

14.1 The air flow measurement shall be carried out in accordance with IS 10431. In particular cases, the measurement may be carried out as shown in Annex C.

14.2 Corrections for air flow measurement due to variation in speed during tests from the value specified in the contract, variations in polytropic exponent and pressure ratios, from the contractual values, shall be applied as shown in Annex D.

15 MEASUREMENT OF OIL CONSUMPTION

15.1 The oil consumption shall be measured over a period of at least 50 h.

15.2 Prior to the commencement of the test, the compressor shall be run and warmed up to its operating temperature. The compressor shall then be stopped and the oil drained from the bearing frame or the oil sump for a period of at least 30 min.

15.2.1 The oil shall then be weighed and poured back into the oil sump of the compressor.

15.2.2 At the end of the test, the oil shall once again be weighed in accordance with the procedure laid down in **15.2**, observing that the oil is at the same operating temperature.

15.2.3 The difference in weight of oil plus the weight of any oil filled in during the test shall be taken as the consumption of lubricating oil.

16 MEASUREMENT OF POWER

16.1 Shaft Power

16.1.1 The shaft power shall be measured by any of the following:

a) Torsion meter, mounted on the compressor shaft, with an accuracy of ±1 percent;

b) Calibrated electric motor whose efficiency has been determined in accordance with IS 325 and not older than 3 years; and

c) Prime mover other than an electrical drive, which has previously been tested in accordance with the relevant Indian Standard.

16.1.2 When any intermediate form of power transmission, such as belt drive or gear box is interposed between the prime mover and the machine, its power consumption shall be taken into account.

16.1.3 As a basis for the efficiency of the transmission, the following figures shall be used unless reliable information is available:

For properly lubricated precision gear drive	98 percent for each step
For flat belt drive	97 percent
For V-belt drive	95 percent

16.1.4 When an electric motor is used as the prime mover, the fluctuations of voltage and frequency shall not be more than ±6 percent and ±3 percent of the rated value for that machine respectively.

16.1.5 When an electric motor is used as the prime mover, the fluctuations of voltage and frequency during any test shall not be more than ±2 percent and ±0.5 percent of rated value respectively.

16.2 Total Power

When the power consumption of the compressor is guaranteed jointly with its prime mover, the power

consumption recorded on tests shall be corrected for any deviation of the test conditions from the guaranteed conditions of the prime mover.

16.3 Power Consumption

Power consumption shall be corrected for variation in shaft speed during tests from the value specified in the contract, variations in polytropic exponent and pressure ratio from the contractual values, as shown in Annex E.

17 ALLOWABLE DIFFERENCE BETWEEN MEASURED AND CONTRACT VALUES

17.1 The maximum allowable difference between corrected test value and contract value shall be as shown below:

Variable	*Maximum Limit*
Inlet pressure, *pa*	±8 percent
Pressure ratio, *r*	±5 percent
Shaft speed, *n*	±4 percent
Inlet water temperature	±5°C
Difference between the coolant and air temperature	±10 percent
Coolant flow rate	±10 percent
Voltage	±5 percent
Frequency	±1 percent

17.2 If the deviation from test conditions, after due corrections as specified in this standard, results in a deviation in specific power consumption above 7 percent of the contractual value for machines less than 10 kW and above 4 percent for machines of 10 kW and above, the test shall not be considered.

17.3 Test at a shaft speed other than the specified value shall not be permitted, if reasonant pressure pulsations occur at the test speed.

17.4 If the deviation exceeds the values specified in **17.1**, the method mentioned in **17.4.1** shall be adopted with the agreement of the purchaser and the manufacturer.

17.4.1 When the specified operating conditions cannot be met, the influence of the operating conditions on the performance of the actual compressor shall be determined by a method of variation, so that the amount of each correction to the specified operating conditions, may be determined by interpolation or, in extreme cases, by extrapolation.

18 TOLERANCES

18.1 Tolerances on flow rate and specific power consumption shall be as shown below:

Compressor Shaft Inputs	*At 100 Percent Flow Rate*		*At 50 Percent Flow Rate*		*No Load Power*
	Flow rate	Specific power consumption	Flow rate	Specific power consumption	
Below 10 kW	±6	±7	—	—	±20
10 to 100 kW	±5	±6	±7	±7	±20
Above 100 kW	±4	±5	±5	±6	±20

18.2 If the specific power consumption is guaranteed for only one flow rate, and the specific power consumption, according to the test, meets the guarantee at a flow rate that does not deviate more than ±5 percent from the flow rate for which the guarantee is valid, the specific power consumption shall be considered as acceptable.

18.2.1 If the specific power consumption values are guaranteed for more than one flow rate or pressure, then weighted averages shall be used both for the test results and for the guarantees. If no agreement has been made, the weight of every point may be taken as 1.

19 TEST REPORT

The recommended form of test report is given in Annex F.

ANNEX A
(*Clause* 4.2.1)

PROFORMA FOR TYPE TEST REPORT (As per IS 5456)

1. Date of test .....
2. Location of test .....
3. Name of the Agency who carried on type test .....
4. Manufacturer's Model No. & Sl No. for the type tested compressor .....
5. Duration of test .....
6. Remarks from Test Agency .....

1. Dimensional Measurement of Wear Parts

Name of the Part	(A) Prior to test (to be given from drawing with tolerances)	(B) After the test

NOTE — The manufacturer shall specify the expected life between overhaul and the expected wear during first 500 h.

Running Test

1) Mechanical Test

i) Compressor working pressure (rated pressure) .....

ii) Compressor – Maximum overload pressure .....

iii) Compressor – Speed at working pressure at unload condition .....

iv) Type of coupling and details .....
.....

v) *Stages of compressor*	Pressure (MPa)		Temperature (°C)	
	Suction	Discharge	Suction	Discharge
First stage compressor	.....	.....	.....	.....
Second stage compressor	.....	.....	.....	.....
Third stage compressor	.....	.....	.....	.....

vi) Intercooling – Temperatures above ambient		A	B
(A) After first stage	(B) After intercooling	°C	°C
(A) After second stage	(B) After intercooling	°C	°C
(A) After third stage	(B) Final	°C	°C

vii) Medium of intercooling and details of intercooling ....

viii) Leakage through the systems ....

ix) *Engine details*

Manufacturer's name .....

Type and Model No. .....

BHP corrected at RPM.....at altitude.....m .....

Fuel consumption 1/h.....at RPM .....

Lubricating oil pressure.....at RPM .....

Type of governing .....

x) *Motor details*

Manufacturer's name .....

Type and Model No. .....

Rating of the motor .....

2) Free Air Delivery

Free air delivery at rated pressure

i) .....

ii) .....

iii) .....

iv) .....

Free air delivery is corrected for:

a) Altitude .....

b) RPM .....

c) Humidity .....

3) Specific Power Consumption/Specific Fuel Consumption at:

i) 40 percent rated pressure .....

ii) 80 percent rated pressure .....

iii) Full rated pressure .....

iv) 110 percent rated pressure .....

4) Volumetric and Overall Efficiency of the Machine

5) Lubricating Oil Consumption:

Compressor..... in 50 hours .....

Engine..... in 50 hours .....

6) Lubricating Pump Type and Specification .....

7) Safety Valve Setting Make and Type .....

8) Total Weight of Compressor .....

9) Portability Test .....

Running Trials and Brake Trials .....

10) Overall Dimensions of the Compressor .....

Remarks

i) Major breakdown/defects during type test to be indicated .....

ii) Major tests/adjustments carried out during tests with running periods specified .....

ANNEX B

[*Clauses* 7.2 (*Note*), 10.3.3 *and* 10.5.2]

OVERALL EFFICIENCY AND CORRECTION FOR LOSS OF HEAD IN CONNECTING PIPES

B-1 Overall efficiency is the ratio of theoretical power required to compress the amount of air actually delivered to input power to the compressor. To determine the overall efficiency of the compressor, the following procedure may be followed:

a) Measure the output of the compressor (FAD),

b) Measure the suction and delivery pressure and input power to the compressor,

c) Find out swept and clearance volume from the bore, stroke and total volume of the cylinder, and

d) By drawing the *PV* diagram work done per swept volume of air shall be found out. Multiply it by the ratio of output capacity to swept volume. This shall give theoretical power required to compress the amount of air actually delivered.

Ratio of this to the input power to compressor shall give overall efficiency of the compressor.

B-2 Loss of head Δh in the piping connecting compressor and receiver and from the inlet end to the compressor is given by:

$$\Delta h = \lambda \frac{V^2}{2g} \cdot \frac{L}{D}$$

where

Δh = loss of head in meters,

λ = dimensionless quantity known as friction factor,

V = mean velocity of fluid = $\left(\frac{\text{Volume of flow}}{\text{Cross-sectional area}}\right)$ in m/s,

g = acceleration due to gravity in m/s^2,

L = length of pipe in meters, and

D = diameter of the pipe in meters.

The friction factor shall be assessed in accordance with IS 10431. For installations in which the length of connecting pipes is kept short, this correction may be neglected.

ANNEX C

(*Clause* 14.1)

CALCULATION OF FLOW RATE WITHOUT THE USE OF NOZZLE

C-1 FLOW RATE MEASUREMENT

C-1.1 When the compressor functions under wide pressure variation as in the case of compressors filling air bottles and those used for starting large engines, the flow rate measurement shall be made by charging a receiver of known capacity.

C-2 CALCULATION OF FLOW RATE

C-2.1 The charging flow rate of cubic metres per minute

$$(m^3/\text{min}) = \frac{V_F - V_E}{\text{Time of charging in minutes}}$$

where

V_F = volume of air in receiver at the end of test reduced to intake conditions =

$$V_r \frac{P_F (t_a + 273)}{P_a (t_F + 273)}$$

V_E = volume of air in receiver at the start of test reduced to intake conditions =

$$V_r \frac{P_E (t_a + 273)}{P_a (t_E + 273)}$$

V_r = calibrated volume of receiver,

P_F = pressure at receiver at the end of test (absolute),

t_a = intake temperature,

P_a = intake pressure (absolute),

t_F = temperature at receiver at the end of test after stabilization,

P_E = pressure at receiver at start of test (absolute), and

t_E = temperature at receiver at start of test.

C-2.2 The receiver used for measurement of flow rate shall be well insulated against heat losses.

C-2.3 The receiver temperature at the end of test shall be measured after the temperature has stabilized.

ANNEX D
(*Clause* 14.2)

CORRECTION OF FLOW RATE

D-1 CORRECTION FOR VARIATION IN SPEED

D-1.1 If the speed during the tests is different from contractual value, correction shall be applied to the flow rate for deviations in values within the limits specified in **17**.

$$\text{Flow correction factor, } K_1 = \frac{n_c}{n_m}$$

where

n_c = contractual speed, and

n_m = measured shaft speed during test.

D-1.2 The fluctuation in speed during any test shall be within ±1 percent from the average value during the test.

D-2 CORRECTION FOR VARIATION IN THE VALUES OF POLYTROPIC EXPONENT AND PRESSURE RATIO

D-2.1 When the intake and delivery pressures during test differ slightly from the contractual value, the flow rate shall be assumed constant. For larger variations, corrections shall be applied to the flow rate of single stage reciprocating compressors only. However, it is recommended that the compressor on test shall be run as near the specified pressure ratio as possible.

D-2.2 A change in the ratio of specific heats and in the pressure ratio shall influence the capacity as the expansions of the gas trapped in the clearance volume is affected. For deviations in values within the limits specified in **17**, correction for flow rate shall be as given below:

$$\text{Flow correction factor, } K_2 = \frac{1 - c\left(r_c^{\frac{1}{u_c}} - 1\right)}{1 - c\left(r_m^{\frac{1}{u_m}} - 1\right)}$$

where

c = relative clearance volume,

r_c = specified pressure ratio,

u_c = polytropic exponent (as stated in contract),

r_m = measured pressure ratio, and

u_m = polytropic exponent (= 0.9 × ratio of specific heats).

D-3 CORRECTED FLOW RATE

D-3.1 Corrected flow rate is then given by:

$$q_1 = K_1 \times K_2 \times q_{1m}$$

where

q_1 = corrected flow rate, and

q_{1m} = measured flow rate reduced to intake conditions.

ANNEX E
(*Clause* 16.3)

CORRECTION OF POWER CONSUMPTION

E-1 CORRECTION FOR VARIATION IN SPEED

E-1.1 If the speed is different from the contractual value during tests, correction shall be applied to power consumption for deviations in values within the limits specified in **17**.

$$\text{Power correction factor } K_3 = \frac{n_c}{n_m}$$

where

n_c = contractual speed, and

n_m = measured shaft speed during test.

E-1.2 The fluctuation in speed during any test shall be within ±1 percent from the average value during the test.

E-2 CORRECTION FOR VARIATION IN POLYTROPIC EXPONENT AND PRESSURE RATIO

E-2.1 When the intake and delivery pressures during a test differ from the contractual values within the limits specified in **17**, correction shall be applied to the power consumption evaluated during the tests on the basis of theoretical isentropic work in the case of multi-stage compressors.

E-2.1.1 Theoretical isentropic work is given by:

$$\frac{P_1 q_1}{36.7} \cdot \frac{k}{k-1} \left(\left(\frac{k-1}{k} \right) \right) \text{KW}$$

where

P_1 = absolute intake pressure, kgf/cm²;

q_1 = free air delivered, m³/h;

k = ratio of specific heats; and

r = pressure ratio.

For single-stage machines, cooled or uncooled, power correction factor K_4 is given by:

$$K_4 = \frac{P_{1c}}{P_{1m}} - \frac{\left(\frac{k}{k-1}\right)_c \cdot \left[r_c \left(\frac{k}{k-1}\right)_c - 1 \right]}{\left(\frac{k}{k-1}\right)_m \cdot \left[r_m \left(\frac{k}{k-1}\right)_m - 1 \right]}$$

where subscript c refers to contractual values and subscript m to measured values.

E-2.1.2 Theoretical isothermal work is given by:

$$\frac{P_1 q_1}{3.67} \log_e r \text{ kW}$$

For multi-stage machines with intercooling, power correction factor K_4 is given by:

$$K_4 = \frac{P_{1c} \log_e r_c}{P_{1m} \log_c r_m}$$

E-2.2 During the test, if the pressure ratio is maintained within ±0.2 percent of the contract value, the power correction factor k_4 for all displacement compressors may be simplified to:

$$K_4 = \frac{P_{1c}}{P_{1m}}$$

E-3 CORRECTED POWER CONSUMPTION

E-3.1 Corrected power consumption is then given by:

$$N = K_3 \times K_4 \times N_m$$

where

N = corrected power consumption, and

N_m = measured value of power consumption.

ANNEX F
(*Clause* 19)

TEST REPORT

F-1 REPORT

F-1.1 It is recommended that the following type of report may be adopted:

F-1.1.1 On trial of a .....
at .....
made at the request of .....
under the direction of .....
and in the presence of .....
on .....

Signature of the Engineer
Directing the Test

F-2 GENERAL INFORMATION

F-2.1 The test report shall include the following information:

a) Supplier's name;
b) Number and year of manufacture;
c) Type of prime mover;
d) Name of manufacturer of prime mover and its number;
e) Type of speed increasing or reducing gear, if fitted; and
f) Name of manufacturer of speed gear.

F-3 GUARANTEED PERFORMANCE ON TEST

F-3.1 Guaranteed performance test shall include:

a) Specified intake pressure and temperature;
b) Free air delivered;
c) Delivery pressure;
d) Power consumption;
e) Speed; and
f) Any other requirement of this standard.

F-3.2 Test Observations — Only those measurements necessary to verify any guarantee given by the supplier to the purchaser shall be taken, together with any other observations called for when placing the contract or as may be subsequently agreed to between the purchaser and the supplier.

F-4 SIZE OF NOZZLE

F-4.1 Where the diameters and lengths of upstream and downstream pipes do not conform to IS 10431, the facts shall be recorded in addition to the details shown below:

Speed.....rev/min
Barometric pressure ..... mm of mercury
Pressure at intake ..... .MPa
Pressure drop across nozzle .....mm of water
Pressure on downstream side of nozzle .....mm of water
Pressure at delivery .....MPa
Temperature of air at intake .....K
Temperature of air at nozzle .....K
Power consumption .....kW

F-4.1.1 Any other observations that are required to verify a guarantee, for example, quantity of cooling water, inlet and outlet temperature of cooling water, etc, may also be recorded.

F-5 RESULTS DERIVED FROM THE OBSERVATIONS

The following results shall be derived from the observations:

a) FAD, and
b) Corrected power consumption. (This is the power consumption corrected for any deviation of the test condition from the guaranteed conditions of the prime mover).

ANNEX G
(Foreword)

COMMITTEE COMPOSITION

Compressors, Blowers and Exhausters Sectional Committee, CHD 22

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