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Date: 29<sup>th</sup> May 2020

## **Schedule 27**

### **Positive Displacement Air Compressors**

#### **1. SCOPE**

This schedule specifies the requirement for participating in the star labeling program for electrically driven positive displacement, fixed speed rotary and reciprocating, oil lubricated/oil-injected, air-cooled and water cooled, air compressor having a full load operating gauge pressure greater than equal to 500 kPa or 5 bar[g] and motor rating between 0.37 to 500 kW with rated voltage of 230 / 415 V and frequency 50Hz AC. covered under the scope of IS 5456 and IS/ISO 1217: 2009 with all its amendments, being manufactured, imported or assembled for the purpose of commercial sale in India.

#### **1.1 In particular, this schedule specifies the following:**

- 1) Packaged Input Power
- 2) Full Load Operating Outlet Pressure
- 3) Rated Volume Flow Rate at full load
- 4) Isentropic Efficiency at full load
- 5) Performance requirements and Test Methods.
- 6) Star Rating plan
- 7) Validity period of the label.
- 8) Test report format, and
- 9) Label design and its contents.

## 2 REFERENCE

This schedule shall be read in conjunction with the following standards for the purpose of star labelling program:

| Reference Standard                    | Title of the Standard                                                                                                      |
|---------------------------------------|----------------------------------------------------------------------------------------------------------------------------|
| IS/ISO 1217: 2009 with all amendments | Displacement compressors — Acceptance tests and Calculation of isentropic efficiency and relationship with specific energy |

### 3 TERMINOLOGY

For this schedule, the following definitions in addition to those given in IS 5456 and IS/ISO 1217 and its amendments shall apply:

- 3.1 Packaged Air Compressor:** It is defined as a compressor with prime mover, transmission, fully piped and wired internally, including ancillary and auxiliary items of equipment stationary or mobile (portable unit) where these are within the scope of supply. Auxiliaries shall include oil pump, cooling fan and integral compressed air dryer.
- 3.2 Volume Flow Rate:** It is defined as the air compressed and delivered at the standard discharge point, referred to conditions prevailing at standard inlet point. It is measured at terminal outlet of packaged compressor.
- 3.3 Full Load Operating Pressure:** It refers to the discharge pressure, determined at full-load conditions. It shall be measured at the packaged air compressor discharge terminal after the aftercooler.
- 3.4 Packaged Input Power:** It is the sum of the electrical power inputs to the prime mover and any ancillaries and auxiliaries driven from the compressor shaft or by a separate prime mover.
- 3.5 Specific Power Consumption:** It is defined as packaged power input in kW per unit of compressor actual volume flow rate. For the purpose of this star rating program of air compressors, it shall be specified as kW/ 100 cfm or kW/m<sup>3</sup>/s.
- 3.6 Isentropic Power:** It is power that is theoretically required to compress an ideal gas under constant entropy, from given inlet conditions to a given discharge pressure. It is given by the formula in Annexure H.3 of ISO 1217 Amendment 1:

$$P_{isen} = q_{v1} \cdot P_1 \cdot \frac{\kappa}{\kappa - 1} \cdot \left[ \left( \frac{P_2}{P_1} \right)^{\frac{\kappa-1}{\kappa}} - 1 \right]$$

- 3.7 Isentropic Efficiency:** It is ratio of the required isentropic power to measured power for the same specified boundaries with the same gas and the same inlet conditions and outlet pressure. It is expressed as percentage given by the formula:

$$\eta_{isen} = \left( \frac{P_{isen}}{P_{real}} \times 100 \right) \%$$

Where  $P_{isen}$  refer to isentropic power and  $P_{real}$  refers to the packaged input power of the compressor.

- 3.8 Label:** Any written, printed, marked, stamped or graphic matter affixed to, or appearing on the product and the packaging provided always that the product inside the packaging to which the label is thus applied conforms to every requirement of this schedule.
- 3.9 Validity of Label:** The validity period of Isentropic Efficiency Rating table specified in this schedule.

## 4 TESTING PARAMETERS

All the tests shall be conducted as per IS/ISO 1217.

**4.1 Full Load Operating Pressure:** The test shall be carried out as per IS/ISO 1217 section 5.2.

**4.2 Rated Volume Flow Rate at Full Load Operating Pressure:** The test shall be carried out as per IS/ISO 1217 section C.2.2.

**4.3 Total Package Input Power at Rated Capacity and Full Load Operating Pressure:** The test shall be carried out as per IS/ISO 1217 section C.2.4.

**4.4 Specific Power Consumption at Rated Capacity and Full Load Operating Pressure:** The test shall be carried out as per IS/ISO 1217 section C.4.4.

**4.5 Isentropic Efficiency at Rated Capacity and Full Load Operating Pressure:** The test shall be referred to Annexure H specified in ISO 1217 Amendment 1: 2016 and calculated using formula mentioned in clause 5 testing guidelines.

## 5 TESTING GUIDELINES

**Methods of Tests:** The methodology and the test protocol for measurement of the test parameters specified in this schedule shall be as per latest version of IS/ISO 1217 with all amendments. The methodology and the test protocol for calculating Isentropic Efficiency shall also be in accordance new Annexure H specified in ISO 1217 Amendment 1: 2016. The energy efficiency parameter for the allotment of star ratings under this scheme shall be based on Isentropic Efficiency.

**Calculation of Isentropic Efficiency of fixed speed positive displacement air compressors:** The isentropic efficiency of reciprocating and rotary air compressors shall be calculated at full load conditions, as per IS/ISO 1217 and its amendments using the formula shown below. Appropriate correction factors shall be applied as per section C.4 of IS/ISO 1217. It is assumed that isentropic exponent,  $\kappa$  is equal to 1.4.

$$\eta_{isen} = \left( \frac{3.5 * q_{V1} (m^3/s) * P_1 (Pa) * \left( \left( \frac{P_2 (Pa)}{P_1 (Pa)} \right)^{0.2857} - 1 \right)}{P_{real} (W)} \times 100 \right) \%$$

Where:

$\eta_{isen}$  = isentropic efficiency of the air compressor, at full load conditions

$q_{V1}$  = volume flow rate ( $m^3/s$ ), at full load;

$P_2$  = outlet absolute pressure (Pa), at full load;

$P_1$  = inlet absolute pressure (Pa), at full load;

$P_{real}$  = package electric input power (W), at full load.

## **6 TEST REPORT**

Test reports will only be accepted from laboratories accredited by accrediting agencies such as NABL in India or any other accreditation bodies who are signatory to MRA with APAC and/or ILAC in India as well as overseas/other countries. The results of test shall be reported in the prescribed format as given in Annexure A of this schedule.

## **7 TOLERANCE LIMIT**

For the purpose of rating allotment and check testing, tolerance limits shall be applicable only on measured parameters tested as per IS/ISO 1217 including, but not limited to, volume flow rate, inlet pressure, discharge pressure and packaged input power. The declared performance values (nominal ratings) shall be considered valid if the measured parameters lie within their respective tolerances as defined in IS/ISO 1217.

## 8 RATING PLAN

The star rating parameter for the labelling program shall be Isentropic Efficiency.

Isentropic efficiency thresholds for Air Cooled Positive displacement compressors (Reciprocating and Rotary) are specified in Table 1.

**Table 1**  
**Star Rating Plan – Voluntary Phase**  
**(Valid from Date of Launch to 31<sup>st</sup> December 2022)**

| Range of Isentropic Efficiency $\eta_{isen}$ % for Motor Ratings |                                                        |                                                          |                                                           |                                                            |                                                            |
|------------------------------------------------------------------|--------------------------------------------------------|----------------------------------------------------------|-----------------------------------------------------------|------------------------------------------------------------|------------------------------------------------------------|
| Star Rating                                                      | Motor Ratings (kW)                                     |                                                          |                                                           |                                                            |                                                            |
|                                                                  | $0.37\text{kW} \leq \text{Motor rating} < 11\text{kW}$ | $11\text{ kW} \leq \text{Motor rating} \leq 30\text{kW}$ | $37\text{ kW} \leq \text{Motor rating} \leq 55\text{ kW}$ | $75\text{ kW} \leq \text{Motor rating} \leq 185\text{ kW}$ | $200\text{ kW} \leq \text{Motor rating} \leq 500\text{kW}$ |
| 1                                                                | $44 \leq \eta_{isen} < 50$                             | $54 \leq \eta_{isen} < 60$                               | $66 \leq \eta_{isen} < 70$                                | $71 \leq \eta_{isen} < 75$                                 | $73 \leq \eta_{isen} < 77$                                 |
| 2                                                                | $50 \leq \eta_{isen} < 56$                             | $60 \leq \eta_{isen} < 66$                               | $70 \leq \eta_{isen} < 74$                                | $75 \leq \eta_{isen} < 79$                                 | $77 \leq \eta_{isen} < 81$                                 |
| 3                                                                | $56 \leq \eta_{isen} < 62$                             | $66 \leq \eta_{isen} < 72$                               | $74 \leq \eta_{isen} < 78$                                | $79 \leq \eta_{isen} < 83$                                 | $81 \leq \eta_{isen} < 85$                                 |
| 4                                                                | $62 \leq \eta_{isen} < 68$                             | $72 \leq \eta_{isen} < 78$                               | $78 \leq \eta_{isen} < 82$                                | $83 \leq \eta_{isen} < 87$                                 | $85 \leq \eta_{isen} < 89$                                 |
| 5                                                                | $\eta_{isen} \geq 68$                                  | $\eta_{isen} \geq 78$                                    | $\eta_{isen} \geq 82$                                     | $\eta_{isen} \geq 87$                                      | $\eta_{isen} \geq 89$                                      |

Isentropic efficiency thresholds for Water Cooled Positive displacement compressors (Reciprocating and Rotary) are specified in Table 2.

**Table 2**  
**Star Rating Plan – Voluntary Phase**  
**(Valid from Date of Launch to 31<sup>st</sup> December 2022)**

| Range of Isentropic Efficiency $\eta_{isen}$ % for Motor Ratings |                                                          |                                                           |                                                            |
|------------------------------------------------------------------|----------------------------------------------------------|-----------------------------------------------------------|------------------------------------------------------------|
| Star Rating                                                      | Motor Ratings (kW)                                       |                                                           |                                                            |
|                                                                  | $30\text{ kW} \leq \text{Motor rating} \leq 55\text{kW}$ | $75\text{ kW} \leq \text{Motor rating} \leq 185\text{kW}$ | $200\text{ kW} \leq \text{Motor rating} \leq 500\text{kW}$ |
| 1                                                                | $68 \leq \eta_{isen} < 72$                               | $73 \leq \eta_{isen} < 77$                                | $75 \leq \eta_{isen} < 79$                                 |
| 2                                                                | $72 \leq \eta_{isen} < 76$                               | $77 \leq \eta_{isen} < 81$                                | $79 \leq \eta_{isen} < 83$                                 |
| 3                                                                | $76 \leq \eta_{isen} < 80$                               | $81 \leq \eta_{isen} < 85$                                | $83 \leq \eta_{isen} < 87$                                 |
| 4                                                                | $80 \leq \eta_{isen} < 84$                               | $85 \leq \eta_{isen} < 89$                                | $87 \leq \eta_{isen} < 91$                                 |
| 5                                                                | $\eta_{isen} \geq 84$                                    | $\eta_{isen} \geq 89$                                     | $\eta_{isen} \geq 91$                                      |

There is no negative tolerance for star rating band; the products tested must be at par or better than the star rating band threshold.

## **9 FEES**

- 9.1** For the purpose of registration with BEE, every brand would be required to deposit a refundable label security fee of INR 1,00,000/- (Rupees One Lakh Only), payable by only electronic mode in favor of the Bureau of Energy Efficiency, New Delhi. In case of small-scale industry, the label security fee shall be INR 25,000/- (Rupees Twenty-five thousand only).
- 9.2** Application fee payable for a new model registration shall be INR 2000/- (Rupees Two thousand only), payable by only electronic mode in favor of the Bureau of Energy Efficiency, New Delhi.
- 9.3** Application fee payable on application for renewal of authority to affix labels is INR 1000/- (Rupees One Thousand only) as per BEE norms.
- 9.4** Labelling fee for affixation of label on each unit of air compressor is Rs. 10/kW up to 3-star models and Rs. 5/kW for 4 and 5-star models. The labelling fees shall be collected based on the production data submitted by manufacturers through the online portal.

## **10 LABEL DESIGN AND MANNER OF DISPLAY**

### **10.1 Label Content**

The content of the label shall include the following information:

- 1) Efficiency parameter: Isentropic Efficiency(full load) in percent up to 2 decimal places with rounding off as per IS 2.
- 2) Appliance type: Fixed Speed Reciprocating/Rotary
- 3) Brand
- 4) Model and Year of Manufacture
- 5) Operating Pressure (full load) in bar[g] or kPa (gauge pressure)
- 6) Rated Capacity (full load) in cfm or m<sup>3</sup>/s
- 7) Specific Power Consumption (full load) in kW/100 cfm or kW/m<sup>3</sup>/s up to 2 decimal places with rounding off as per IS 2.
- 8) Cooling Method: Air Cooled/Water Cooled
- 9) Lubrication Method: Oil-injected/Oil-lubricated
- 10) No. of Stages: One/Two/Three/Four/Five

### **10.2 Placement of label**

The placement of the label shall be at the discretion of the manufacturer where it has clear visibility and is not easily removable. For units not on display, the label shall be attached to the unit and on the exterior of the packaging of the air compressor, at the time of sale.

### 10.3 Material, Dimension and Shape

The label shall be made of any self-adhesive, corrosion resistant and durable material (aluminum anodized) and shall be cut out as per the dimensions, design and colour scheme as given in Figure 1 to 3.

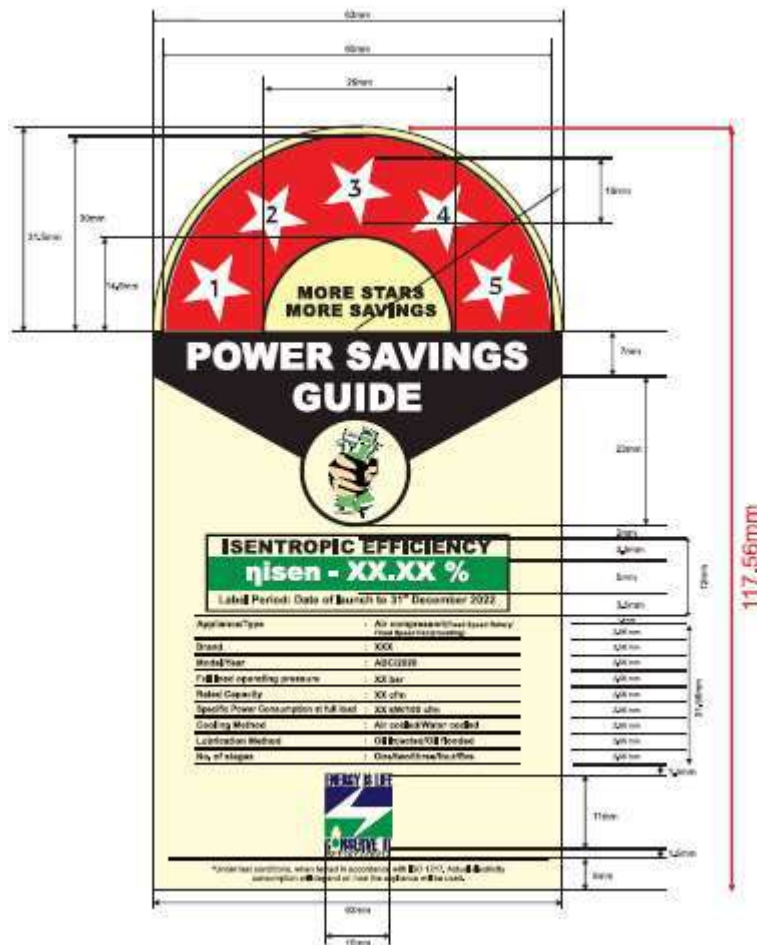


Figure 1 Dimension of the logo

## Bureau of Energy Efficiency

The label shall be printed as per the color scheme given in Figure 2.



Figure 2 Color Scheme for the Label

**Note: CDR File is available on BEE Website ([www.beestarlabel.com](http://www.beestarlabel.com))**

### 10.5 Sample Label

An example of a printed star label to be affixed on the model is shown in Figure 3.

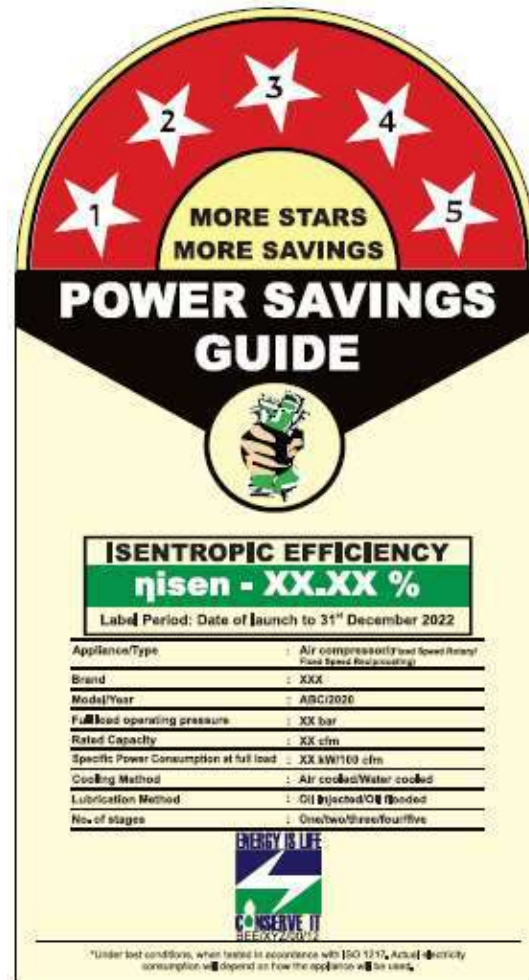


Figure 3: Sample Label

## 11 CHECK TESTING

- a) The Bureau shall from time to time carry out verification process to ensure that the air compressors conform to the star level and other related information displayed on its label and that it complies with the other terms and conditions of permission. All the tests shall be conducted by the BEE, SDA or its authorized representative for the purpose of verification and check testing.
- b) For the purpose of verification, the one sample will be picked up at random from the manufacturer's or supplier's facility by Bureau and testing shall be carried out in an independent laboratory duly accredited by the NABL or the Bureau could conduct testing of registered/labelling model at the facility of permittee by using calibrated test equipment. Either of the method could be used at BEE's discretion.
- c) If the sample fails, the Bureau shall draw two more samples of the model and conduct all the relevant tests specified in this schedule in the presence of authorized representatives from the manufacturer and an officer from by the BEE, SDA or its authorized representative.
- d) Even if one sample fails in the second check testing sample, the Bureau shall direct corrective measures to the concerned manufacturer and shall publish the details of the model for the benefit of the consumers. If those directions are not complied with, the Bureau may initiate adjudication proceedings against the manufacturer.

## ANNEXURE A

### Form for reporting test results

#### 1. General details of Model

|   |                                                   |  |
|---|---------------------------------------------------|--|
| 1 | Manufacturer/Brand:                               |  |
| 2 | Model Number:                                     |  |
| 3 | Serial Number:                                    |  |
| 4 | Type (Reciprocating/Rotary):                      |  |
| 5 | Cooling Method (Air-cooled/Water-cooled):         |  |
| 6 | Lubrication Method (Oil-injected/Oil-lubricated): |  |
| 7 | Number of Stages:                                 |  |
| 8 | Rated Voltage (V):                                |  |
| 9 | Rated Frequency (Hz):                             |  |

#### 2. Declared performance parameters

|   |                                                                               |                          |  |
|---|-------------------------------------------------------------------------------|--------------------------|--|
| 1 | Full Load Operating Pressure                                                  | kPa<br>(gauge pressure)  |  |
| 2 | Rated Volume Flow rate at Full Load Operating Pressure                        | m <sup>3</sup> /s        |  |
| 3 | Drive Motor Nominal Rating                                                    | kW                       |  |
| 4 | Drive Motor Nominal Efficiency                                                | percent                  |  |
| 5 | Total Package Input Power at Zero Flow                                        | kW                       |  |
| 6 | Total Package Input Power at Rated Capacity and Full Load Operating Pressure  | kW                       |  |
| 7 | Specific Power Consumption at Rated Capacity and Full Load Operating Pressure | kW/<br>m <sup>3</sup> /s |  |
| 8 | Isentropic Efficiency at Rated Capacity and Full Load Operating Pressure      | percent                  |  |

### 3. Tested performance parameters

Date of test:

Test report number:

Test officer:

|          |                                                                                      |                          |  |
|----------|--------------------------------------------------------------------------------------|--------------------------|--|
| <b>1</b> | <b>Full Load Operating Pressure</b>                                                  | kPa<br>(gauge pressure)  |  |
| <b>2</b> | <b>Rated Volume Flow rate at Full Load Operating Pressure</b>                        | m <sup>3</sup> /s        |  |
| <b>3</b> | <b>Drive Motor Nominal Rating</b>                                                    | kW                       |  |
| <b>4</b> | <b>Drive Motor Nominal Efficiency</b>                                                | percent                  |  |
| <b>5</b> | <b>Total Package Input Power at Zero Flow</b>                                        | kW                       |  |
| <b>6</b> | <b>Total Package Input Power at Rated Capacity and Full Load Operating Pressure</b>  | kW                       |  |
| <b>7</b> | <b>Specific Power Consumption at Rated Capacity and Full Load Operating Pressure</b> | kW/<br>m <sup>3</sup> /s |  |
| <b>8</b> | <b>Isentropic Efficiency at Rated Capacity and Full Load Operating Pressure</b>      | percent                  |  |

### 4. Star Rating declaration

|                                                               | <b>Specified/Declared Value</b> | <b>Observed Value</b> |
|---------------------------------------------------------------|---------------------------------|-----------------------|
| Cooling Type (Air cooled/Water cooled)                        |                                 |                       |
| Drive Motor Nominal Rating (kW)                               |                                 |                       |
| Isentropic Efficiency % at full load (up to 2 decimal places) |                                 |                       |
| Star Rating as applicable                                     |                                 |                       |

Note 1: The declared performance values shall be used for the star rating.

Note 2: The declared performance values shall be considered as performance guarantee values for the purpose of check testing conducted by BEE, SDA or its authorized representative. The measured performance values shall be verified based on the tolerance limits as per item 7 of this schedule.