Specification No. ELRS/SPEC/AUX/0026

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

IR;eo t;r

TECHNICAL SPECIFICATION FOR MOTOR DRIVEN AIR COMPRESSOR FOR ELECTRIC LOCOMOTIVES

Specification No. ELRS/SPEC/AUX/0026

Issue Date/Year : April - 2004

RESEARCH, DESIGNS AND STANDARDS ORGANISATION
MANAK NAGAR, LUCKNOW –226 011

SPECIFICATION FOR MOTOR DRIVEN AIR COMPRESSOR FOR ELECTRIC LOCOMOTIVES.

0. FOREWORD:

0.1 This specification is based on general guidelines of RDSO Spec. No.MP.0.0700 – 08 (Rev.April,1994) for motor driven compressors for locomotives application.

0.2 In this specification, following Standards have also been referred:

IS : 5456 – 1985	Code of Practice for Testing of Positive Displacement type air compressors and exhausters.
IS : 10431 – Pt-I – 1982	Measurement of air flow of compressors and exhausters Part I – 'Nozzles'.
IS : 5727 – 1981	Glossary of Terms relating to compressors and exhausters.
RDSO Spec./E-10/3/09 (motor) with Amendment –2 of June, 2003.	Specification of induction motors for driving auxiliary machines of 3 phase Electric Locomotives.
IEC 61373	Railway applications - Rolling stock equipment – Shock and vibration tests

0.3 This specification covers clauses, which call for agreement between the purchaser and the supplier and supply of certain technical information by the manufacturer/supplier at the time of submitting tenders for the equipment.

1.0 SCOPE:

This specification covers motor driven air compressors working on power supply from static auxiliary converter provided on electric locomotives. This is a technical specification and does not cover all the necessary provisions of a contract.

2.0 TERMINOLOGY:

2.1 For the purpose of this standard, following definitions in addition to those given in 'Indian Standard Glossary of Terms Relating to Compressors and Exhausters IS – 5727-1981 shall apply.

2.2 **Engineers:**

The term 'Engineers' shall apply to the Director General(Electrical), Research Designs & Standards Organization, Ministry of Railways, Lucknow – 226 011, and person or persons authorized by him.

3.0 DESIGN FEATURES AND SERVICE CONDITIONS:

3.1 Basic Design:

The compressor shall be positive displacement, two stage air cooled reciprocating type, of compact, light weight and energy efficient design, suitable for underframe mounting on locomotives. Compressor being mounted on underframe outside the locomotive, will be subjected to sun temperature, high humidity, dusty conditions and rain in service. The compressor, therefore, should be capable of giving satisfactory performance under such conditions.

3.2 Capacity:

3.2.1 The compressor capacity should be sufficient to meet requirements of air delivery, after derating for working at 160 M above msl, at 55^0 C ambient temperature, 95% RH and delivery of 1500 lpm FAD from loco compressors at 10 kg/cm^2 for all types of locos. (with this incorporated, the nominal FADs of compressors would be in the region of 1745 lpm)

3.2.2 Manufacturer will supply compressor design/test data and calculations to confirm that it meets requirements specified above.

3.2.3 Compressor working speed will be 750/1000 rpm (Nominal). However, higher speed upto a maximum of 1500 rpm can be considered if supplier furnishes details and data. Where machine speed is higher than 1000 and upto 1500 rpm, documentation provided should be adequate to establish that higher speed would not result in undue wear.

3.2.4 The compressor shall be suitable for continuous operation at a pressure of 10.0 kg/cm^2 with governor setting to cut out at 10 kg/cm2 and safety valve setting of 10.5 kg/cm^2.

3.2.5 The temperature of air at the discharge of the compressor mounted Aftercooler shall not be more than **30ºC above ambient** when working at a pressure of 10.0 kg/cm^2.

3.3 Normal Duty:

The compressor shall work continuously, in duty cycle of 50% ON and 50% OFF upto 30 cycles per hour without causing higher temperature, damage and unusual wear to the components, at the maximum working pressure of 10.0 kg/cm^2.

3.4 Drive :

3.4.1 The compressor shall be driven by a single speed motor to RDSO specification No.E-10/3/09 (Motor) with amendment – 2 of June 2003 for induction motors for driving auxiliary machines of Electric Locomotives. **Motor** used to drive compressor shall be of make and type **approved by RDSO** for the application.

3.4.2 The coupling shall be required to withstand shocks due to frequent starting and stopping upto **30 cycles per hour** in cycle of 50% OFF and 50% ON time and variation of load on compressor motor set.

3.4.3 The **drive arrangement** of the compressor shall be subject to the approval of the "Engineers".

3.5 Mounting & Lifting Arrangements :

3.5.1 The compressor and drive motor shall be rigidly secured together and suspended from brackets on locomotive underframe through resilient mountings. The mounting arrangement will be such that compressor motor set will be suspended through two brackets on motor side and one bracket on compressor side. The details for provision of underslung compressors in various locomotives are as above:

3.5.1.1 The arrangement of bracket on the underframe of the for 3-phase locomotive are given in the enclosed drawing No.SKEL/4672. The mounting arrangement of compressor with dimensions of compressor motor unit after installation on existing 3-phase locomotives is also shown in the same drawing.

3.5.1.2 The overall space envelope including mounting brackets for WAP-4 locomotives for provision of underslung compressor shall conform to RDSO Drg. no. SKEL 4681

3.5.1.3 The overall space envelope including mounting brackets for WAG-7 locomotives as per RDSO Drg. no. SKEL 4680.

3.5.1.4 The supplier has to ensure that the height of the lowest part of the compressor motor unit after mounting on the locomotive underframe is **not less than 176 mm** above rail level for **new wheel conditions**. The details of arrangement of bracket on the underframe of the locomotives shall be submitted along with FEM stress analysis .

3.5.2 Compressor motor set and resilient mounts provided shall be of robust design and shall be able to withstand shocks and stresses normally encountered in locomotive operation. It will be provided with additional safety chain arrangement to prevent its falling to the ground in any eventuality. The details of the arrangement of

securing the compressor to loco body through a chain would be given by the manufacturer.

3.5.3 Compressor set when mounted in the locomotive shall be free from excessive vibrations and semi amplitude of vibrations shall be within the limits indicated in GDP 674.

It should be able to withstand vibration and shocks as per clause 'A' category 1 of IEC 61373. Any special anti-vibration mounting required shall be specifically indicated and supplied as a part of the unit.

3.5.4 Design of compressor will facilitate lowering of motor and compressor set from underframe of locomotive with ease.

3.6 Lubrication:

3.6.1 The compressor shall have lubricating system of proven design. The lubrication arrangement shall be reliable and capable of withstanding continuous operation under sun temperature encountered on a locomotive, **without undue carbonization of the moving parts and discharge ports/valves.**

3.6.2 The **oil consumption** shall be low and shall be specified. The capacity of oil tank will be adequate for not requiring oil topping between **preventive maintenance** schedule of locomotive, i.e. **90 days**.

3.6.3 Metallic dip-stick/oil sight window shall be provided for checking oil level.

3.6.4 The lubrication system shall have a filter of adequate capacity. The filter shall be easily removable for maintenance.

3.6.5 Lubricating oil sump shall be designed to permit easy drainage/cleaning.

3.6.6 Inter-connecting pipes of the lubricating system shall be so designed so that there is no possibility of damage during transit, service, storage and handling.

3.7 **Cooling**:

3.7.1 The compressor shall be air cooled. A cooling fan of adequate capacity, of simple and rugged design and light weight shall be provided.

3.7.2 The fan shall be mounted on the shaft and shall be dynamically balanced. Suitable protection cover should be provided to cover the fan so as to prevent any case of its hitting by an external object like ballast etc. during operation of the locomotive.

3.8 Intercooler / Aftercooler:

A radiator type Intercooler / Aftercooler of adequate cooling capacity shall be provided as an integral part of the compressor unit. The Intercooler / Aftercooler shall not interfere with free access to other equipment of the compressor.

3.9 Miscellaneous:

3.9.1 For securing protective hoods, pipe brackets etc. foundation and cylinder head bolts shall not be utilized.

3.9.2 Wherever bearings are grease lubricated, easily accessible grease nipples to IS:4974 shall be provided. Suitable vent for overflow of excess grease shall also be provided. Type of indigenously available grease to be used, shall be specified.

3.9.3 Direction plate with 50mm arrow shall be fitted on the compressor and motor, separately to indicate the normal direction of rotation.

3.9.4 Parts like oil filter caps etc. shall be secured to the compressor body by means of a chain.

3.10 **Ambient conditions**:

The compressor shall be capable of working satisfactorily, except for air delivery for which clause 3.2.1 will apply, under the following conditions:

1.	Ambient temperature	-	0º to 55º C.
2.	Maximum temperature of air at inlet port	-	60ºC.
3.	Relative humidity	-	0% to 100%.
4.	Altitude	-	Sea level to 1000m.

5. The equipment shall be capable of operating satisfactorily under conditions of dust, dirt, mist, rain and vibration encountered in rolling stock operation on Indian Railways.

4.0 ACCESSORIES:

The compressor shall be supplied with the following accessories:

4.1 Cut in / Cut out Device:

A suitable device shall be provided to cut in/cut out the compressor at limits of air pressure to be decided by purchaser. It will be ensured that compressor does not start against high back pressure.

4.2 Suction Air Filter:

A suction filter of adequate capacity shall be provided at the air inlet to the compressor. The suction filter shall be of dry type air filter. The filter shall be of compact construction and shall be able to withstand the conditions prevailing in the locomotive. The filter shall be easy to clean and maintain.

4.3 Intercooler Safety Valve:

A safety valve of suitable capacity shall be provided, matching with the pressure of output of L.P. stage.

4.4 Intercooler / Aftercooler Drainage:

An auto drain valve for draining the condensate of the Intercooler / Aftercooler shall be provided.

4.5 Oil Pressure Gauge:

In case pressure lubrication is adopted, a suitable pressure gauge (not less than 50mm size) shall be provided. Pressure gauge will be of standard quality suitable for application on locomotives. The pressure gauge shall be so located that it can be read in running condition of the locomotive.

5.0 TESTING & INSPECTION:

5.1 The testing of the compressor shall generally conform to IS : 5456 – 1985.

5.2 Type Tests:

5.2.1 Whenever a new type of compressor is offered by supplier, a unit shall be subjected to a series of tests to evaluate its performance & establish its reliability.

5.2.2 The type tests shall consists of following tests and additional tests indicated in para – 5.2.3.

(a) Mechanical tests.

(b) Capacity (output) measurements at 8,9 & 10 kg/cm^2 pressure.

(c) Power consumption with :

(i) Compressor unloaded.
(ii) Compressor working at 8, 9 & 10 kg/cm^2 pressure.

(d) Speed measurements.

(e) Volumetric efficiency.

(f) Lube oil consumption.

(g) Testing of cut in/cut out mechanism.

5.2.2.1 The mechanical tests are intended to ascertain the reliability of the machine and its accessories. Prior to the starting of this test, all mechanical parts shall also be checked for proper functioning as assembled and in operation.

5.2.2.2 The duration of the separate stages of type tests shall be as given in the table below:

Stage No.	Tests	Duration (hours)
1	**Mechanical Tests**	
(a)	**Running of compressor on discharge pressure of**	
	(i) 8 kg/cm^2	5
	(ii) 9 kg/cm^2	7
	(iii) 10.0 kg/cm^2	10
(b)	**Endurance Tests**: see clause 5.2.2.3 below	400
2	**Determination of other characteristics** as given in para – 5.2.2	

5.2.2.3 **Endurance Test**.

5.2.2.3.1 Endurance test is a continuous test and shall be carried out by running the compressor with compressor delivery pressure at 10kg/cm^2 running at rated speed. The test shall be of 400 hours duration. Normally, interruptions are not permitted during the testing except under following circumstances:-

(i) Interruptions are permitted if any adjustment is required to be carried out during the course of testing which warrants stopping of compressor or driving motor. Under these circumstances, the period of interruptions should not exceed 2 minutes. The aggregate total of such interruptions should be totaled at the end and duration of endurance test prolonged by this aggregate amount.

(ii) During endurance test, a maximum of 4 interruptions shall be tolerated when they are required for attending defects in the equipment but in such case more than 20 minutes shall not be allowed to lapse between the interruption and restart. In all such cases consent to RDSO or its representative should be obtained before recommencing the test. The

aggregate total of such interruptions should be totaled at the end and duration of endurance test prolonged by this aggregate amount. In case of more than 4 interruptions, the endurance testing should be done afresh.

(iii) If endurance testing is interrupted for reasons unconnected with compressor such as due to defect in drive motor and coupling, the test should be started within 24 hours, after the interruption. Only one such interruption will be allowed and in case the testing is interrupted by more than one interruption, RDSO or its representative shall decide whether the endurance tests must be recommenced from the beginning or merely prolonged for the period equal to that of interruption. In case of such interruption, the reasons of interruption as well as time of beginning and end of the interruption should be entered in the column provided immediately after data prior to interruption.

5.2.2.3.2 Following measurements shall be made during the of endurance tests at intervals **one hour**:

(i) Ambient temperature.
(ii) Discharge air pressure.
(iii) Temperature of air at inlet to compressor.
(iv) Discharge air temperature.
(v) Intercooler inlet and outlet temperatures.
(vi) Temperature of cylinder heads (L.P & H.P) & Valve caps, where fitted.
(vii) Temperature of crank case oil.
(viii) Lube oil pressure, in case of pressure lubrication.
(ix) Lube oil consumption (after completion of the tests)

5.2.2.3.3 Before and after completion of the endurance tests, the compressor shall be opened and dimensions of all wearing parts shall be recorded.

5.2.2.3.4 The endurance tests of 400 hours shall also be applicable to the existing design of compressors, in case of changes in operating requirements such as increase in speed of operation, working pressure etc.

5.2.3 Additional tests:

In addition to the tests mentioned above, following tests shall also be conducted as type tests:

5.2.3.1 Tests at higher environmental temperature:

A test run of 48 hours shall be conducted at inlet temperature of 60º C. The compressor shall run at 10.0 kg/cm^2 pressure for 8.00 hrs and will be stopped for half an hour for cooling under prevailing atmospheric conditions. Six such cycles

shall be performed. During these tests, measurements as for endurance tests (para – 5.2.2.3) shall be made.

5.2.3.2 Run in tilted position:

With the oil filled upto the minimum level of oil sump, the unit shall be mounted on a platform of 1 in 20 inclination with the compressor raised. The platform shall also have a side tilt of 1 in 10. The compressor shall be worked at the rated capacity and 10 kg/cm^2 pressure for 12 hours in this position. At the end of the test, the parts shall be examined for any starvation of oil etc.

5.2.3.3 Test at reduced and increased voltages:

The compressor shall be tested at input supply voltage of 415 + 10% = 457V and 415 – 10% = 383 V to check the performance of motor with regard to its power factor, current drawn, speed and its effect on the capacity of the compressor.

5.2.3.4 Tests on motor:

The motor used shall be type tested as per RDSO's Specification No. E-10/3/09 with Amendment - 2 of June 2003 and the results of motor type test shall be furnished by the manufacturer at the time of type testing of compressor unit along with the motor.

5.3 Routine tests:

These tests shall be carried out on all the compressors for acceptance of equipment by purchaser. The supplier shall also supply a copy of the routine test report with every machine. Following tests shall be conducted.

5.3.1 Run all the compressors at rated speed at 10.0 kg/cm^2 pressure for two hours and check for undue heating and leakage. The time taken to build up pressure, discharge air temperature, speed and current drawn and temperatures of inter cooler, after cooler, crack case, motor casing and delivery air shall be recorded at ½ hours interval.

5.3.2 Measure the capacity (output) of all the compressors at rated speed and 10.0 kg/cm^2 pressure.

5.3.3 Run compressor at rated voltage. Measure the rpm, motor current, power, ambient conditions of barometric pressure, temperature and RH, air delivery readings. Calculate volumetric efficiency.

5.4 Testing of accessories:

5.4.1 The supplier shall indicate the test specification for the following accessories/components:

(i) Oil Pump, if applicable.
(ii) Inter cooler,
(iii) Filter-Suction air and lube oil,
(iv) Inter cooler safety valve,
(v) Oil pressure gauge, if applicable.
(vi) Any other accessory not included above.

5.4.2 The test specification of the accessories shall be got approved by Engineers approval prior to the commencement of tests.

6. CRITERION FOR EVALUATION TESTS :

Results of tests should conform to guaranteed performance parameters submitted by firm with their offer (Item 14 of Annexure – I).

7. GENERAL CONDITONS FOR INSPECTION & TESTS:

7.1 All tests shall be conducted at manufacturers premises. Any shortcoming or defect noticed during the type test shall be pointed out to the manufacturer by the purchaser/engineer or his representative to enable him to incorporate the necessary improvements before bulk manufacture is commenced, without affecting the guaranteed performance characteristics. The detailed test scheme for the type and routine tests shall be decided jointly by the Engineers/Purchaser and the Manufacturer at the time of finalisation of the contract based on clause 5 above.

7.2 Any additional tests, trials, if considered necessary, by the Engineers, shall also be arranged by the supplier free of cost.

7.3 The purchaser/engineer or their representative shall have access for stage inspection, to those portions of the manufacturers works in which production is being carried out and where the testing is taking place. This also applies to the items procured from sub-contractors by the suppliers.

7.4 The inspecting officer shall have the power to adopt any means he may consider necessary to satisfy himself that proper materials and parts specified are actually used during the manufacture of the unit.

7.5 The supplier/manufacturer shall provide labour or appliances required by the inspecting officer free of charge, for inspection and testing of the whole unit and its components, if required.

7.6 Should any part of the compressor unit require alteration or any defect appear during the tests or trials, the supplier shall, without any extra charge, make such alterations or rectify the defects to the satisfaction of the purchaser, engineer or his representative.

7.7 Any modification or alteration to the components shall be made only after the approval of the purchaser. The unit after such modifications/alterations shall be subjected to such tests as considered necessary by the purchaser/engineer.

8.0 SPARES:

Along with the quotation for supply of the air compressor the tenderer shall also furnish a recommended list of spares for two years with quotations thereof. The tenderer shall also agree to hold the price of spares for a period of one year from the date of the supply of the compressors. Also tenderer shall confirm whether spares would be indigenously available or localized.

9. INFORMATION TO BE FURNISHED BY TENDERER:

9.1 Data as per Annexure – I shall be furnished by the tenderer along with the quotations, in triplicate. Tenderer will also furnish the list of bought out items with sources of supply and specification.

9.2 Detailed information as per Annexure- II & III shall be furnished by the tenderer, after the order is placed.

10. TOOL KIT :

10.1 For every 20 compressor units or a part thereof, one complete set of tool kit shall be supplied.

10.2 The price for tool kit, when procured independent of the order, shall also be indicated with offer for compressor.

11 MAINTENANCE MANUALS:

11.1 The tenderer shall supply copies of exhaustive, fully illustrated manuals both in hard copy and digital format covering among other items, the following vital details, to the “Purchaser” and “Engineer”.

1. Description and arrangement.
2. Technical data.
3. Dismantling and assembly instructions.
4. Commissioning instructions.
5. Particulars of recommended lubricants and indigenous equivalents.

6. Periodical inspection schedules.
7. Periodical maintenance instructions along with compressor overhaul schedule and trouble shooting instructions.
8. Testing procedure for the equipment and other auxiliaries like oil pump etc., if applicable.
9. Wear limits for vital components.
10. Detailed parts catalogue with description of items. The parts shall be detailed by sketches to facilitate ordering.
11. Instructions for reclamation of worn out components.
12. List of special tools with instructions for use.

11.2 Two copies of the **Maintenance manual shall be supplied with the quotation.**

11.3 One copy of the manual shall be supplied with every 10 compressor sets or a part thereof.

ANNEXURE – I

BROAD TECHNICAL FEATURES OF THE COMPRESSOR

1. Type, make and model.

2. Graph showing air delivery against 8, 9 and 10.0 kg/cm^2 and maximum working speed . Calculations to show Air delivery under adverse operating conditions specified in clause 3.2.1

3. Displacement at working r.p.m.

4. Horse power consumption at rated capacity and speed against 8, 9 and 10.0 kg/ cm^2.

5. Maximum working temperature at inlet and exhaust ports.

6. Weight of the unit complete with accessories.

7. Details of drive arrangements.

8. Details of lubrication arrangement.

9 Details of couplings including alignment data an method of checking alignment.

10. Details of mounting arrangement with resilient mounts and overall dimensions.

11. Overall space requirements of compressor in mounted condition on locomotive, inclusive of all accessories. (Any additional space required for removal of valves in position, attending to air/inlet filters and topping up of oil etc. shall also be indicated). Lay out drawings shall be supplied.

12. List of major wearing components and their expected life.

13. Guaranteed Performance -

- FAD at 8,9, 10kg/cm^2 under various operating conditions.
- Temperature rise of outlet temp. above suction air.
- Wear rate of wearable items.
- Lube oil consumption.
- Power consumption at operation conditions.
- Life of compressor.
- Motor parameters as per RDSO's Specification No.E-10/3/09 (Motor).

ANNEXURE - II

General data of Compressors.

1. Type, make and model.
2. Details of Technical Collaboration, if any.
3. Basic design data :-

   i) Cylinder arrangement.
   ii) No. of LP cylinders.
   iii) No. of H.P cylinders.
   iv) L.P cylinder dia –mm.
   v) H.P cylinder dia – mm.
   vi) Details of inlet and the exhaust valves and their expected life.
   vii) Stroke-mm
   viii) Piston speed (max.)
   ix) Head clearance.
   x) Ratio of compression per stage.
   xi) Air temperature at L.P discharge and intercooler discharge and final delivery at rated capacity and 8,9 and 10 kg/cm^2 with inlet temperature range upto 60ºC.
   xii) Operating Pressure.
   xiii) Power Consumption.
   xiv) Compressor delivery calculations under operating conditions (160m height above sea level, 55ºC temperature and 95% Relative Humidity)
   xv) FAD Vs. Crankshaft Speed Graph.
   xvi) Speed Vs. Power Graph.
   xvii) Compressor Motor Temperature Calculations.
   xviii) Torque requirements.
   xix) Intercooler and after cooler details.
   xx) Details of connecting rod and Crankshaft bearings used.
   xxi) Dimensions, material specification, heat treatment & method of manufacture of :-

   Piston, piston rings, valves, cylinder heads, crank shafts, connecting rods, crank pin.

4. Type, details of suction air filter used in the compressor. Indicate filtering efficiency and dust retentivity.
5. Type, details and life of lube oil filter used and its efficiency, if applicable.
6. Average consumption of lube oil with oil consumption calculations.
7. Sump capacity-
   (i) Maximum dip stick/oil gauge level.
   (ii) Minimum dip stick/oil gauge level.

8 Recommended brand and class of lubricating oil.

9. Gaskets and seals with specifications/drawings and sources.

10. Rubber or synthetic sealing media, if used in assembly.

11. Details of unloading arrangement, if provided.

12. Details of cooling fan including mounting drawings.

13. Details (with overall dimensions) of coupling used and calculations regarding factors of safety. The permissible limits of misalignments and guaranteed trouble free service life shall also be indicated.

14. Details with overall dimensions, specifications and arrangement of resilient mounts used along with permissible set value limits and expected life.

15. Type, specifications, make and average life of main and connecting rod bearings.

16. Life of equipment **:** ……..years

17. Reliability.

i) MTBF :

ii) MTTR.

******

BROAD TECHNICAL FEATURES OF THE COMPRESSOR

1. Type, make and model.		
2. Graph showing air delivery against 8, 9 and 10.0 kg/cm^2 and maximum working speed . Calculations to show Air delivery under adverse operating conditions specified in clause 3.2.1		
3. Displacement at working r.p.m		
4. Horse power consumption at rated capacity and speed against 8, 9 and 10.0 kg/ cm^2		
5. Maximum working temperature at inlet and exhaust ports.		
6. Weight of the unit complete with accessories.		
7. Details of drive arrangements.		
8. Details of lubrication arrangement.		
9. Details of couplings including alignment data an method of checking alignment.		
10. Details of mounting arrangement with resilient mounts and overall dimensions.		
11. Overall space requirements of compressor in mounted condition on locomotive, inclusive of all accessories. (Any additional space required for removal of valves in position, attending to air/inlet filters and topping up of oil etc. shall also be indicated). Lay out drawings shall be supplied.		
12. List of major wearing components and their expected life.		

.