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14 AIR BLOWERS AND COMPRESSORS

14.1 GENERAL

14.1.1 Scope

- 1 This part specifies the requirement for the design, manufacture, construction, installation, testing and commissioning of air blowers and compressors.
- 2 Related Sections and Parts are as follows:

Section 1	General
Section 8	Drainage Works
Section 10	Instrumentation, Control and Automation
Section 13	Building Electrical Works
Section 21	Electrical Works

14.1.2 References

- 1 The following standards or revised/updated versions are referred to in this part:

BS 970 (ISO 683) Specification for wrought steels for mechanical and allied engineering purposes; (ISO 683-1 Heat-treatable steels, alloy steels and free-cutting steels — Part 1: Non-alloy steels for quenching and tempering; ISO 683-2 Heat-treatable steels, alloy steels and free-cutting steels — Part 2: Alloy steels for quenching and tempering; ISO 683-3 Heat-treatable steels, alloy steels and free-cutting steels — Part 3: Case-hardening steels; ISO 683-4 Heat-treatable steels, alloy steels and free-cutting steels — Part 4: Free-cutting steels; ISO 683-5 Heat treatable steels, alloy steels and free-cutting steels — Part 5: Nitriding steels; EN 10250-4: Open die steel forgings for general engineering purposes - Stainless steels; EN 10095 Heat resisting steels and nickel alloys; BS PD 970 Wrought steels for mechanical and allied engineering purposes. Requirements for carbon, carbon manganese and alloy hot worked or cold finished steels; EN 10089 Hot rolled steels for quenched and tempered springs. Technical delivery conditions; EN 10277 Bright steel products. Technical delivery conditions; EN 10278 Dimensions and tolerances of bright steel products; EN 10088-1 Stainless steels - List of stainless steels; EN 10088-3 Stainless steels - Technical delivery conditions for semi-finished products, bars, rods, wire, sections and bright products of corrosion resisting steels for general purposes)

BS 1042..... Measurement of fluid flow in closed conduits.; (ISO/TR 12767 Measurement of fluid flow by means of pressure differential devices — Guidelines on the effect of departure from the specifications and operating conditions given in ISO 5167; ISO 5167 Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full; ISO 3966 Measurement of fluid flow in closed conduits. Velocity area method using Pitot static tubes; ISO/TR 9464 Guidelines for the use of ISO 5167; ISO/TR 15377 Measurement of fluid flow by means of pressure-differential devices — Guidelines for the specification of orifice plates, nozzles and Venturi tubes beyond the scope of ISO 5167; ISO/TR 3313 Measurement of fluid flow in closed conduits — Guidelines on the effects of flow pulsations on flow-measurement instruments)

BS 1123 Fusible plugs for steam boilers and compressed air applications. Specification

- BS 5169 Specification for fusion welded steel air receivers; (EN 286-1 Simple unfired pressure vessels designed to contain air or nitrogen - Pressure vessels for general purposes)
- BS 5493..... Code of practice for protective coating of iron and steel structures against corrosion
- BS 6739..... Code of practice for instrumentation in process control systems: installation design and practice
- BSI PD 5500. Specification for unfired pressure vessels
- ISO 1217 Displacement compressors — Acceptance tests
- ISO 2151 Acoustics — Noise test code for compressors and vacuum pumps — Engineering method (Grade 2)
- ISO 10474 ... Steel and steel products — Inspection documents
- ISO 10816 ... Mechanical vibration — Evaluation of machine vibration by measurements on non-rotating parts
- ISO 10816-1. Mechanical vibration — Evaluation of machine vibration by measurements on non-rotating parts — Part 1: General guidelines; (ISO 20816-1 Mechanical vibration — Measurement and evaluation of machine vibration — Part 1: General guidelines)
- ISO 10816-3. Mechanical vibration — Evaluation of machine vibration by measurements on non-rotating parts — Part 3: Industrial machines with nominal power above 15 kW and nominal speeds between 120 r/min and 15 000 r/min when measured in situ; (ISO 20816-3 Mechanical vibration — Measurement and evaluation of machine vibration — Part 3: Industrial machinery with a power rating above 15 kW and operating speeds between 120 r/min and 30 000 r/min)
- ISO 12944 Paints and varnishes. Corrosion protection of steel structures by protective paint systems; (ISO 12944-1 Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 1: General introduction; ISO 12944-2 Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 2: Classification of environments; ISO 12944-3 Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 3: Design considerations; ISO 12944-4 Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 4: Types of surface and surface preparation; ISO 12944-5 Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 5: Protective paint systems; ISO 12944-6 Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 6: Laboratory performance test methods; ISO 12944-7 Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 7: Execution and supervision of paint work; ISO 12944-8 Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 8: Development of specifications for new work and maintenance; ISO 12944-9 Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 9: Protective paint systems and laboratory performance test methods for offshore and related structures)
- ISO 21940 Mechanical vibration — Rotor balancing
- VDI (Verein Deutscher Ingenieure) 3836: Measurement and evaluation of mechanical vibration of screw-type compressors and Root blowers - Addition to DIN ISO 10816-3.

British Compressed Air Society's Code of Practice and the Pressure Systems and Transportable Gas Containers Regulations 1989

List of 'Approved Suppliers' prepared by the Public Works Authority

14.1.3 Submittals

- 1 In addition to the requirements of Part 1 of this Section, the Contractor shall reconfirm the information provided in the Technical Submission Schedules submitted with his Tender.

14.2 PRODUCTS

- 1 The Contractor shall assess which type and configuration of blowers or compressors that will offer the best whole life cost benefit for use on the plant to supply the process air requirements.
- 2 The number of blower/compressor sets provided shall be sufficient to ensure the full range of process air requirements can be met and that a minimum of one standby unit for each application is available at maximum process airflow. Blower/compressor sets shall be the same model with the same rated capacity for each separate application.
- 3 The motor rating shall be rated at least 10% greater than the maximum power required under all climatic and operating conditions.
- 4 Each blower/compressor set shall be provided with an acoustic enclosure and a surge protection system. The acoustic enclosure shall limit the noise level to not more than 75Db(A) when measured at 1 metre distance from any point at the enclosure surface at any time. The enclosure ventilation shall be designed to ensure that adequate cooling of the blower set is maintained. Consideration should be given to ducting the enclosure exhaust direct to atmosphere to limit the temperature rise within the blower house to a maximum of 5°C above ambient. The enclosure shall be designed to allow for ease of access to the blower set, without the necessity to lift the complete enclosure, to allow for routine inspection and maintenance procedures.
- 5 The level of vibration in each blower / compressor shall be within the limits and comply with ISO 10816, Part 1 and Part 3.
- 6 The blower/compressor sets shall be of a proven design with at least five years operational experience in similar applications. Where multiple units are required to meet the duty in addition to single duty applications, the design shall be proven in applications where two or more units are automatically controlled to meet the varying air demand.

14.3 AIR BLOWERS

14.3.1 Centrifugal Blowers

- 1 Blower sets shall be either single stage or Multistage centrifugal type air blowers depending up on the duty and applications with modulating powered inlet and outlet guide vanes, gearbox, lubrication system, electric drive motor, and suction and discharge flexible stainless steel connection compensators, all mounted on a common baseplate. The sets shall be installed on flexible machine mounts.
- 2 The volume flow rate from the blowers shall be modulated control on the inlet and outlet guide vanes which shall be capable of varying the delivery rate down to 45% of the rated output without causing the blower to go into surge when operating either singly or in parallel. A high operating efficiency shall be maintained throughout the flow range.

- 3 Materials and equipments of construction shall give a design running life of at least 100,000 hours before major maintenance is necessary.
- 4 The impeller shall be statically balanced and the whole rotor shall be dynamically balanced. The first responsive critical speed of the rotating assembly shall be at least 10% above the maximum operating speed.
- 5 Vibration level and procedures shall be in accordance with ISO 10816 for the measurement and classification of mechanical vibration.
- 6 The gearboxes shall be of the parallel shaft high speed helical type. The gears shall have a minimum AGMA service factor of 1.5. A labyrinth oil seal shall be fitted to each shaft to prevent oil seepage from the casing under operating and static conditions. The seals shall be designed to ensure there is no contamination of the process air.
- 7 Each gearbox shall be fitted with an oil level sight glass and a drain plug which shall be readily accessible in operation.
- 8 The baseplate shall be provided with lifting points to allow the complete set to be handled using chain slings.
- 9 Instrumentation for the safety monitoring of air blowers shall include oil temperature, oil level, air temperature at inlet and outlet from the blower, outlet air pressure, surge conditions, bearing temperature and vibration and motor running current. The instruments shall provide signals for the shutting down of air blowers if unsafe conditions arise and for visual indication of the fault. Additionally, the contractor shall provide all necessary instrumentation for measuring the airflow from each blower.
- 10 Each blower shall be equipped with an inlet air filter, automatic unloading device, pressure relief valve, pressure switch, temperature switch and under load (no flow) detection device to trip the blower in case of drive/flow failure.
- 11 Each blower shall be performance tested at the manufacturer's works, using the job motors, to ISO 1217:1996. Air flow measurement for these tests shall be carried out in accordance with BS 1042. Blower casings shall be works hydro-statically tested to 1.5 times the maximum working pressure.

14.3.2 Positive Displacement Blowers

- 1 The blowers shall be complete with all ancillary equipment which may be required to enable the units to operate correctly.
- 2 Blowers shall be air-cooled and of the double rotor positive displacement rotary type with cast iron casings delivering oil-free air.
- 3 Each blower shall be complete with an automatic unloading device, dead-weight pressure relief valve, or spring type pressure relief valve, pressure gauge, pressure switch, temperature switch and non return valve of the wafer or nozzle ring check pattern.
- 4 The blower speed shall not exceed 70% of the maximum designed speed or 2300 rpm whichever is the lower.
- 5 Vibration level and procedures shall be in accordance with ISO 10816 for the measurement and classification of mechanical vibration.
- 6 Each blower shall have an under load detection relay or other similar device to trip the blower in the event of a drive or flow failure.

- 7 The blower casing shall be high-grade cast iron adequately ribbed to assist cooling and avoid distortion. The rotors shall be spheroidal graphite iron with integral shafting. Timing gears shall be of nickel cast iron positively keyed to the rotor shafts, they shall be accurately ground with close clearances to prevent interference between rotors.
- 8 The blower shall be fitted with an oil lubrication system for the bearings and timing gears. The blower shall be fitted with mechanical seals to prevent the ingress of oil into the rotor chamber.
- 9 The lubrication system shall include filling and drain plugs and oil level indicators visible from outside the acoustic cover.
- 10 The drive between the blower and motor shall be of the vee belt or flat toothed belt type and of approved design.
- 11 The complete blower assembly shall be mounted on steel section frame which shall incorporate a blower mounting plate, motor adjustment slides and guard support brackets, the frame is to be supported on anti vibration mounts.
- 12 An inlet silencer complete with replaceable filter element shall be fitted to each blower, the silencer shall be fitted with a visual indicator to warn of filter blockage.
- 13 Outlet silencer shall be fitted to maintain noise levels as low as possible. A flexible coupling shall be fitted to prevent vibration transmission to the air supply system.
- 14 Silencers are to be of the reactive type, absorptive type silencers will not be permitted.
- 15 Components likely to wear in the course of normal operation shall be capable of replacement with readily available replacement components.
- 16 Provide all necessary instrumentation for safe operation of the blower.

14.4 AIR COMPRESSORS

14.4.1 General

- 1 The design and installation of the compressed air system shall be in accordance with the requirements of the British Compressed Air Society's Code of Practice and the Pressure Systems and Transportable Gas Containers Regulations 1989.
- 2 Compressors shall be rated to achieve the duty at optimum efficiency and may be selected from one of the following types unless otherwise specified in the particular specifications:-
 - (a) Reciprocating Single Stage
 - (b) Reciprocating Multi Stage
 - (c) Rotary Screw

14.4.2 Reciprocating Compressors

- 1 Reciprocating Single Stage Compressors shall be of inherently oil free design. The compressor shall be of cast iron construction with aluminium cylinder heads and shall be air cooled. The unit, complete with electric motor, shall be mounted on a rigid bedplate incorporating anti vibration mountings. The drive arrangement shall be belt or shaft driven and shall be fully guarded. A suitable means of achieving alignment shall be provided and where appropriate flexible couplings shall be used.
- 2 Reciprocating Multi-Stage Compressors shall be as above but incorporate interstage cooling and be of the short stroke design for low piston speeds.

- 3 Both single and multistage units shall be provided with the following:-
- (a) Low oil level cut out switch.
 - (b) Crank case oil sight glass.
 - (c) Air inlet filter.
 - (d) Silencer complete with pressure gauge and low pressure cut out (filter blockage protection).
 - (e) Pressure gauge tappings after each stage for compressors up to 15kW, and gauges and safety valves on compressors over 15kW.
 - (f) Oil pressure indicator on compressors over 100kW.
 - (g) Final air temperature indicator on compressors over 100kW.
 - (h) Unloader valve unit.
 - (i) Air dryer system (Dehumidifier) where dry air is required.

14.4.3 Rotary Compressors

- 1 Rotary Screw Compressors shall be of the inherently oil free design and shall be either the single stage or multi-stage type depending on the duty.
- 2 The separate stages shall be enclosed in individual housings, the male rotor being gearbox driven whilst the female rotor is driven via a timing gear.
- 3 The rotor shafts shall be supported by precision made ball and roller bearings
- 4 Lubrication to the driving gear, bearings and timing gear shall be via an oil pump driven by the main shaft. The lubrication system shall be complete with oil filter and cooler, pressure gauge and fail-safe pressure switch.
- 5 On multi stage units air cooling shall be undertaken by an intercooler.
- 6 The compressor shall be motor driven via a flexible coupling and gearbox common to both stages. A suitable means of alignment shall be provided.
- 7 The complete compressor set ie. compressor, motor, gearbox and associated cooling equipment shall be supplied on a rigid bed plate suitable for floor mounting via anti vibration mountings.

14.4.4 After Cooler

- 1 All types of compressor shall be fitted with an aftercooler. These shall be of the air cooled type comprising an air to air heat exchanger. The aftercooler shall cool the process air to a temperature of 10°C above ambient. The aftercooler shall be fitted with an automatic condensation drain which shall be provided with a manual bypass.
- 2 Delivery lines from the Compressor Sets shall be fitted with the following equipment:-
 - (a) Oil trap/filter prior to entry into the air receiver. The filter shall be fitted with an auto drain and manual by pass.
 - (b) Adjustable safety valve (lockable).
 - (c) A solenoid valve for unloading (dependant upon compressor size) for applications where the compressor is directly coupled to a surge vessel.
 - (d) A non return valve.
 - (e) A high efficiency coalescing oil filter (0.001 micron filtration).

14.4.5 Air Receivers

- 1 Unless otherwise stated, one air receiver shall be provided, normally being online, but with the capacity to be isolated from the system.
- 2 These shall be manufactured from fusion welded steel and shall comply with BS 5169 or equivalent for the appropriate pressure class.
- 3 Air receivers greater than 1000 litres capacity shall be designed and manufactured in accordance with BSI PD 5500 or equivalent.
- 4 Each integral air receiver shall have sufficient capacity to damp out air pulses from the compressor and to prevent pressure drops on process valve actuations.
- 5 The air receivers shall be connected such that the duty compressor delivers into either or, if two air receivers are specified, both of the air receivers. Diaphragm isolation valves shall be provided for isolating either of the receivers from the system.
- 6 The air receivers shall be suitable for floor mounting and shall be supplied with two inspection ports. The inspection ports shall be of the elliptical type and pressure sealed.

14.4.6 Fabrication Requirements

- 1 The air compressors shall be air-cooled. The cooling air shall be drawn directly from the ambient air, routed through the enclosure and exhausted upward through the enclosure box. The cooling air for the motor shall be drawn directly from the ambient air.
- 2 The drive motors shall be directly coupled to the air end by flexible coupling.
- 3 The compressors shall be suitable for indoor installation.
- 4 Each air compressor shall have an efficient filter for cleaning intake air and micro filter after the discharge. Each compressor shall be fitted with a silencer, which shall be sized to prevent excessive pressure drop.
- 5 All instrument tappings shall be via suitable bosses welded to the tank structure. The vessel shall be supplied with:
 - (a) Pressure gauge.
 - (b) Pressure relief valve.
 - (c) Drain valve.
 - (d) Lifting lugs.
- 6 The vessel shall be corrosion protected to give maintenance free service for a period of 20 years minimum, as defined in BS 5493 (partially replaced by ISO 12944) or equivalent and as specified in Section 8 part 8
- 7 Full certification in triplicate shall be supplied with the air vessel. The vessel shall also feature a stainless steel nameplate containing the following details.
 - (a) The manufacturers' name.
 - (b) The date of manufacture.
 - (c) The standard to which the vessel was built.
 - (d) The maximum design pressure.
 - (e) The minimum design pressure where it is other than atmospheric.
 - (f) The design temperature
 - (g) The test pressure

14.4.7 Booster Compressor

- 1 In case discharge pressure in excess of 15 bar is required, then booster compressors will be required. Alternatively multistage piston type air compressor can also be proposed. The booster compressor package shall comprise the following items:
 - (a) Booster compressor and motor mounted on common base plate.
 - (b) V-belt drive with guard.
 - (c) Oil/water separator or after cooler with automatic drainage and associated unloaded start.
 - (d) Solenoid valve to close the inlet at standstill.
 - (e) Safety valve on the oil/water separator or after cooler.
 - (f) Anti vibration floor mounts.
 - (g) Suitably sized air receiver.

14.5 FACTORY INSPECTION AND TESTING

- 1 The Contractor shall secure from the blower manufacturer certification that the following inspections and tests have been conducted on each blower at the factory, and submit to the Engineer prior to shipment:
 - (a) the blower casing shall be tested hydrostatically to 1.5 times the maximum closed valve pressure
 - (b) the motor rating and electrical connections to be checked for compliance with the Specifications
 - (c) motor insulation tested for moisture content or insulation defects
 - (d) the insulation test (c) above shall be performed again after the performance test (2) below.
- 2 The Contractor/Manufacturer shall submit detailed and complete shop testing procedure for the blower at early stage of factory internal performance test.
- 3 Each blower shall be factory tested for performance according to ISO 1217, including:
 - (a) Air flow in accordance with BS 1042
 - (b) intake pressure
 - (c) discharge pressure
 - (d) motor power
 - (e) intake temperature
 - (f) discharge temperature
 - (g) main rotor speed
- 4 Functional test shall be done at the factory for each blower to confirm the following:
 - (a) Vibration level
 - (b) Noise level
- 5 Factory internal test reports for all the blowers shall be submitted for review and approval.
- 6 The Contractor shall secure from the blower manufacturer the following 3.1 type certification and submit to the Engineer prior to shipment.
 - (a) certified copies of the blower test reports generated by the tests described above and as required by ISO 1217.

- (b) foundry Composition Certificates for all major castings (blower case, rotor, motor housing) showing exact material composition and tests conducted to ensure compliance with the blower manufacturer material specifications
- (c) non-destructive test certificates for major parts as "blower shaft" to be issued under ASME V requirements
- (d) driving shaft balancing certificate as ISO 21940 requirements

14.6 SPARE PARTS AND TOOLS

- 1 The Contractor shall provide from the blower manufacturer all the spare parts and tools required during the commissioning and maintenance periods as specified in Part 1, including those below:
- 2 In addition to the spare parts required in part 1, the following spare parts for each blower shall be furnished to the Employer.
 - (a) two set of complete bearings (Blower, motor and gear box)
 - (b) one set of complete coupling (close coupled)
 - (c) one set of pulley and three set of belt complete (belt driven)
 - (d) one set of mechanical seal
 - (e) three set of intake air filter
 - (f) three sets of gasket.
 - (g) Additional spare parts as recommended by blower manufacturer to cover two years of operation.
- 3 The Contractor shall supply, furnished by the blower manufacturer, a complete set of all special tools required for maintenance of the blower equipment, in a lockable tool box, complete with the list of spares.

14.7 INSTALLATION AND COMMISSIONING

14.7.1 Installation and Commissioning

- 1 The equipment delivered to Site shall be examined by the Engineer to determine that it is in good condition and in conformance with the approved working drawings and certification. All equipment shall be installed in strict accordance with Part 1 of this Section 9.

14.7.2 Site inspection and Testing

- 1 Test Procedures shall be in accordance with Part 1 of this Section 9 and the particulars of the Contract.

END OF PART