

AIR SYSTEMS SUPPORTING THE HV NETWORK

This document is for internal and contract specific use only.

Disclaimer

NGG and NGET or their agents, servants or contractors do not accept any liability for any losses arising under or in connection with this information. This limit on liability applies to all and any claims in contract, tort (including negligence), misrepresentation (excluding fraudulent misrepresentation), breach of statutory duty or otherwise. This limit on liability does not exclude or restrict liability where prohibited by the law nor does it supersede the express terms of any related agreements."

TABLE OF CONTENTS

PURPOSE AND SCOPE	1
PART 1 – PROCEDURAL	1
1 AIR SYSTEM GENERAL REQUIREMENTS	1
2 AIR COMPRESSOR PERFORMANCE REQUIREMENTS	4
3 AIR COMPRESSOR TEST REQUIREMENTS	5
4 AIR DRYER GENERAL REQUIREMENTS	6
5 AIR DRYER PERFORMANCE REQUIREMENTS	7
6 AIR DRYER TEST REQUIREMENTS	8
7 MEMBRANE AIR DRYERS	8
8 COMPRESSED AIR SYSTEM CONTROL BOARDS GENERAL REQUIREMENTS	8
9 COMPONENT GUIDANCE	10
10 ELECTRICAL CONTROLS	11
11 ADDITIONAL REQUIREMENTS	12
12 ANCILLARY COMPONENTS, GENERAL REQUIREMENTS	12
13 CONDENSATE DRAIN TRAPS	14
14 FORMS AND RECORDS	15
PART 2 - DEFINITIONS AND DOCUMENT HISTORY	15
15 DEFINITIONS	15
16 AMENDMENTS RECORD	16
17 IMPLEMENTATION	16
PART 3 - GUIDANCE NOTES AND APPENDICES	17
18 REFERENCES	17
APPENDIX A - SCHEDULE OF SITE COMMISSIONING TESTS (SCTS) FOR AIR COMPRESSORS	19
APPENDIX B - SCHEDULE OF SITE COMMISSIONING TESTS (SCTS) FOR AIR DRYERS	22
APPENDIX C - SCHEDULE OF SITE COMMISSIONING TESTS (SCTS) FOR AIR CONTROL BOARDS	24
APPENDIX D - ALTERNATIVE DESIGN LAYOUT CONFIGURATIONS AND CONTROL SYSTEMS	27
APPENDIX E - ASSEMBLY INSTRUCTIONS FOR PARKER HANNIFIN COMPRESSION FITTINGS	52

PURPOSE AND SCOPE

This document defines the functional performance and test requirements for air compressors, air dryers and air control boards for high pressure air systems.

PART 1 – PROCEDURAL

1 AIR SYSTEM GENERAL REQUIREMENTS

- 1.1** External air system shall meet an ambient air temperature operating range of -25°C to +40°C. Internal air system equipment shall meet an ambient air temperature operating range of -10°C to +40°C.

- 1.1.1 The supplier shall indicate the maintenance requirements (both time based and duty based), and any mid-life refurbishment activity required to achieve the anticipated asset life.

1.2 Air Systems at Air Blast Circuit-Breaker Sites

- 1.2.1 As required by TP183 Air Compressors shall be Type Registered by National Grid. The manufacturer shall complete the National Grid Type Registration Data Sheet, Schedule A. TS 3.02.11 –Compressors.
- 1.2.2 To supply air from a central compressed air system, it is the designer's responsibility to ensure suitable redundancy to cater for maintenance and or unavailability of any single unit within the fixed installation. In addition to this requirement a mobile compressor / dryer connection shall be provided.
- 1.2.3 The air compressors shall be rated for continuous operation over its full operating temperature range and shall require the provision of an auto-blowdown system to discharge condensate.
- 1.2.4 Centrally located air compressor houses shall be surveyed to ensure adequate ventilation / cooling is provided. For water cooled air compressors the separate location of radiators outdoors shall be considered. For air cooled compressors, and as an alternative for water cooled air compressors, the provision of louvre doors and shrouding to ensure adequate ventilation shall be reviewed prior to the installation of new air compressors.
- 1.2.5 The normal operation and unloading arrangements of air compressors and associated equipment shall not cause oil vapour or dust contamination such as to cause a health hazard within the compressor house, and the installation shall satisfy UK Health and Safety at Work Regulations.
- 1.2.6 Each substation air system shall have a means of condensate collection for proper disposal. Condensate must not be discharged into the ground.
- 1.2.7 The compressor delivery output, shall be such that when supplying site leakage and circuit-breaker conditioning air, the total running time with all the compressors running shall not exceed 4 hours per day on any individual compressor.
- 1.2.8 The effective compressor capacity shall be such that replenishment of the air system main air receivers after refilling a circuit-breaker from atmospheric pressure to normal operating pressure shall be achieved in a time not exceeding 100 minutes.
- 1.2.9 Where two substations are on the same site two separate compressed air installations shall be provided. There shall be no normal operational interconnection between air system installations, however an emergency interconnection facility may be provided.
- 1.2.10 The relationship between the compressor start pressure, the capacity of the high pressure storage air receivers and the effective compressor delivery rate shall be such that when auto-started to restore conditioning and leakage losses, the compressor(s) shall run until full operating temperatures are reached and preferably for not less than 30 minutes.
- 1.2.11 The air system shall be arranged such that the air pressure in the circuit-breaker local air receiver can be raised from trip lock-out to 95% normal pressure in not more than 5 minutes with the high pressure storage at compressor start pressure.
- 1.2.12 The main high pressure storage receivers shall be of sufficient capacity as to raise the air pressure of the most remote circuit-breaker from atmosphere to its normal operating value without replenishment from the compressors and the minimum pressure in the high pressure storage main air receivers shall always be at least 10% greater than the normal operating pressure of the circuit-breaker. The high pressure storage receivers shall be arranged in two separate banks.

- 1.2.13 With the pressure in the main storage receiver at compressor start pressure, the high pressure storage capacity shall be able to provide sufficient air to replenish the maximum number of circuit-breakers which can trip in the event of a single bus-bar fault.
- 1.2.14 Notwithstanding the above, the minimum high pressure storage capacity shall be sufficient to provide at least 6 circuit-breakers Open-Close-Open operations and the minimum pressure in the high pressure storage main air receivers shall always be 10% greater than the master shut down valve set point.
- 1.2.15 With the pressure in the main storage receivers and in circuit-breakers at their normal operating pressure and with the compressors switched off, the circuit-breaker isolating valves and conditioning air valves closed, but with all remaining valves open, the rate of fall of pressure at the main air receivers when measured over a period of 4 hours shall not exceed 1% per hour.
- 1.2.16 Compressor screening manufactured from impact absorbency material shall, where practicable, be provided around air compressors. Consideration shall be given to compressor maintenance access requirements in the provision of the screening. General pipe-work shall be installed with suitable clamping such that in the event of a pipework coupling failure the movement shall be restrained.
- 1.2.17 The use of high pressure flexible hose shall be kept to an absolute minimum because of the much reduced service life compared to rigid pipe work. When flexible high pressure air hose is used, the installation supplier shall declare the anticipated service life and securely attach a label to the hose stating the advised replacement date and / or service hours.
- 1.2.18 The air compressor(s) should subject to statutory inspection in accordance with a written scheme of examination (WSE) immediately prior to commissioning, in order to comply with the Pressure Systems Safety Regulations 2000.

Note: This system general specification will require enhancement for application with a type DBG 20P air blast circuit breaker as the air enters the electrically stressed interrupters. A site specification should be produced with guidance from Asset Integrity.

1.3 Additional information to Supply Mechanism Air for SF₆ and Oil Circuit-Breakers and Switch Disconnectors.

- 1.3.1 To supply air from a central compressed air system, it is the designer's responsibility to ensure suitable redundancy to cater for maintenance and or unavailability of any single unit within the fixed installation. In addition to this requirement a mobile compressor / dryer connection shall be provided.
- 1.3.2 The air compressors shall be rated for continuous operation over its full operating temperature range, and shall require the provision of an automatic blow-down system to discharge condensate.
- 1.3.3 Half the installed compressor capacity should not exceed a running time of 2 hours per day on any individual compressor when supplying site air losses. Air losses should not exceed 1% per hour.
- 1.3.4 Unit air compressors, used to supply mechanism air for only one circuit-breaker or switch disconnector need not be rated for continuous operation, but should be rated for 2 hour operation with 4 hour shutdown cyclical operation. The air compressor must be capable of filling the required storage capacity to normal maximum pressure from atmosphere within a 2 hour period.
- 1.3.5 When fitting new unit air compressors and associated storage receivers, it is necessary to verify adequate space and ventilation exists.

- 1.3.6 The air supplied to the circuit-breaker or switch disconnector shall have a relative humidity of 50% or less. An air sampling test point shall be provided in the low pressure ring main.

1.4 Additional information to supply air for Diesel Generator Starting

These supplies are normally provided by an A.C. motor driven compressor together with a separate back up D.C. motor driven compressor. An air supply derived from the main low pressure air system via a pressure regulating valve and safety valve may be provided to replace the A.C. motor driven compressor, but the D.C. motor driven compressor must be retained for emergency manual diesel starting.

2 AIR COMPRESSOR PERFORMANCE REQUIREMENTS

- 2.1 The manufacturer shall complete the National Grid Type Registration Data Sheet, Schedule A. TS 3.2.11 – Compressors.
- 2.2 The Manufacturer shall state the maximum operating pressure and the compressor output (free air delivered at 1.013 bar and 15°C) for the compressor operating at normal working pressure. The air compressor design maximum continuous operating pressure shall not be less than the outlet safety valve set pressure. The normal working pressure shall be specified in the contract tender document.
- 2.3 All air compressors shall be suitable for operation with fully synthetic lubricants.
- 2.4 All continuously rated compressors shall be supplied with a test certificate detailing the works test steady state stage operating pressures, temperatures and free air delivery.
- 2.5 To prevent high discharge temperatures in the event of valve failure, or loss of coolant from water cooled machines, the compressor shall be supplied with a suitable fusible plug fitted at the final stage delivery. The air compressor manufacturer shall advise the fusible temperature.
- 2.6 To minimise moisture and oil vapour carry-over continuously rated air compressors shall be provided with after-cooling and vapour traps such that the temperature of the air at the final discharge shall not exceed 15°C above the inlet air temperature.
- 2.7 All pressure gauges graduated to a scale exceeding 250 psig (17.2 barg) shall be safety pattern construction as specified in BS EN 837-1. New equipment shall be supplied with damped gauges dual calibrated in barg and psig. Continuously rated air compressors shall be provided with pressure gauges monitoring all inter-stages and final delivery pressures.
- 2.8 Air compressors operating at 3000 psig (206 barg) and also 600 psig (41 barg) machines with a delivery exceeding 40 SCFM at 15°C shall be provided with the following protection trip facilities:
- a) Loss of lubricating oil pressure where a pressurised lubricating oil system is used. An oil pressure gauge shall also be fitted.
 - b) High discharge air temperature.
 - c) Loss of cooling water.
 - d) Electrical overload of any motor.
 - e) Failure to attain working pressure within a pre-determined period.
 - f) Operation at excessive high pressure (e.g. 3300 psig trip [227 barg] for 3000 psig [206 barg] operation).

g) Low sump oil level.

2.9 The drive motors shall be 400/230 V, 50 Hz and comply with the general requirements of BS 4999. The drive shall comply with the technical requirements of BS 50347. The air compressor shall be securely bonded to the main substation earthing system. Drive motors at multiple compressor installations shall be sequentially started.

The insulated windings shall be Class F, or better, as defined in BS EN 60085. Motors and their starter equipment shall be designed for a life endurance of at least 18,000 starts. The motor shall be capable of two successive start ups and also three starts per hour equally spaced. The minimum enclosure protection shall be drip proof, screen protected IP 22 to BS EN 60529.

2.10 Suitable electrical motor protection must be provided by appropriate fuse selection and motor overload relays. Where old air compressors are replaced with new machines, utilising existing electrical supplies, it is essential to review the suitability of the electrical supplies for the new compressor. Where the new air compressor utilises star-delta starting or soft start systems it is particularly important to review the electrical supply fuse rating.

2.11 New compressors shall normally be provided with star-delta starting. At sites where 400 V supplies or diesel generators may be operating near maximum capacity the provision of a soft start system shall be considered.

2.12 The control voltage supplies shall nominally be 110 V D.C in accordance with TS3.12.4. If battery supplies are unavailable then 110V A.C. may be specified in the contract tender document on a site specific basis.

2.13 All compressors shall be fitted with inter-stages relief valves and also a relief valve at the final delivery stage with a set dynamic pressure that does not exceed the design pressure (often referred to as the safe working pressure) of any directly connected air receiver.

2.14 The running noise level figures in db (a) must be provided for the compressor unit at 1 metre distance. If a separate radiator is used then similar noise figures must be provided. In addition the impulse and steady state noise levels shall not exceed the action levels specified in the UK Health and Safety at Work Regulations.

2.15 Air compressors shall be fitted with an intake suction filter and silencer.

2.16 The ancillary electrical equipment for air compressor control shall be to a recognised standard to ensure reliable and safe control. An example of a suitable technical specification is EA 50-18 or BS EN 60204- 1; however equipment complying with a recognised national or international specification such as CENELEC/IEC/BS is generally acceptable.

2.17 At the time of Type Registration, the Manufacturer shall advise of the recommended maintenance regime for the equipment and the anticipated spares requirement.

2.18 The air compressor shall be supplied with an electro-mechanical hours run meter and number of starts counter.

3 AIR COMPRESSOR TEST REQUIREMENTS

3.1 New designs of air compressor shall be Type Registered as per TP183. As part of the National Grid Type Registration process the manufacturer shall provide evidence of the ability to operate for 2000 hours running duration, without any intermediate maintenance, in an environment similar to that of a National Grid substation and with a similar duty.

3.2 The manufacturer shall provide evidence of cyclic performance. A minimum duty cycle of 12 cycles of ½ hour duration throughout a 24hour period is required.

- 3.3** Air compressors shall be subjected to routine tests prior to despatch to site. A certificate detailing this testing shall be supplied.

4 AIR DRYER GENERAL REQUIREMENTS

4.1 Air Blast Circuit-Breaker Sites

As required by NG TP183 new designs of Air Dryers shall be Type Registered and the manufacturer shall complete the Type Registration Data Sheet, Schedule B. TS 3.2.11 – Air Dryers.

- 4.1.1** The air dryer shall have suitable capacity for continuous operation at the declared maximum inlet air temperature and with maximum declared throughput over the normal operating pressure range.
- 4.1.2** The air dryer shall deliver free air (atmospheric pressure) at a dew-point of -60°C or drier at the declared input temperature and maximum throughput.
- 4.1.3** The air dryer throughput capacity must equal or exceed the maximum input air supply, i.e. it must match the maximum air compressor(s) output capacity.
- 4.1.4** Manufacturers normally declare a maximum inlet temperature typically 40°C or 50°C. Prior to the installation of new air dryers the delivery temperature of the associated air compressors should be determined to be below this declared maximum inlet temperature of the air dryer to ensure compatibility.
- 4.1.5** If whilst the air dryer is shut down pressure vessels are isolated from safety valves, then fusible plugs should be fitted to prevent over pressurisation of pressure vessels in the event of a fire.
- 4.1.6** The design pressure (safe operating limit) of the air dryer shall exceed the maximum normal compressor out-put pressure by a suitable margin. As a general practice the air dryer pressure vessels should have a specified design pressure to match any existing main air receivers.
- 4.1.7** The air dryer shall deliver air with a hydrocarbon volume content of below 0.1 ppm.
- 4.1.8** Pipework shall be manufactured from non-corrodible material, e.g. Tungum or half hard thick walled copper tubing and fittings shall be stainless steel. Pipework shall be installed with suitable clamping such that in the event of a coupling failure the pipework movement shall be restrained. Where necessary, a panel enclosure and access doors shall be provided for additional safety. Good access for maintenance purposes shall be provided.
- 4.1.9** The air dryer shall be supplied with suitable indication to show operation and which vessel is on duty and which vessel is on purge.
- 4.1.10** The pressure vessels must be manufactured to BS EN 286-1 or BS 5500 or ASME VIII or another recognised suitable international standard. The pressure vessels shall be marked in accordance with The Pressure Equipment Regulations 1999 and the Pressure Systems Safety Regulations 2000.
- 4.1.11** The air dryer shall be subject to a statutory inspection in accordance with a written scheme of examination (WSE) immediately prior to commissioning, in order to comply with the requirements of The Pressure Systems Safety Regulations 2000.

5 AIR DRYER PERFORMANCE REQUIREMENTS

- 5.1** The Manufacturer shall state the rated input and losses incurred due to purge air and vessel changeover. The standard air inputs for 3000 psig (206 barg) operation are 75 SCFM and 150 - 170 SCFM at 15°C, and for 600 psig (41 barg) available up to 250 SCFM at 15°C.
- 5.2** The air dryer shall be supplied fitted with a suitable sampling valve on the inlet and outlet of each dryer to enable convenient measurement of dew-point. This is for dryer efficiency testing. An optional extra is the integral inclusion of dew-point monitors.
- 5.3** Pressure settings for safety valves must be advised and if fusible plugs are fitted the fuse temperature must also be certificated.
- 5.4** An appropriate pressure maintaining valve will normally be fitted to the air dryer outlet. The air dryer manufacturer shall advise of the required setting. This pressure maintaining valve shall normally be located within the main control panel.
- 5.5** All pressure gauges graduated to a scale exceeding 250 psig (17.2 barg) shall be safety pattern construction as specified in BS EN 837-1. New equipment shall be supplied with gauges that are dual calibrated in barg and psig. The gauge will have a minimum face diameter of 100mm.
- 5.6** The running noise level figures in db (a) must be provided at 1 metre distance when the air dryer changes cycle. In addition the impulse and steady state noise levels shall not exceed the action levels specified in the UK Health and Safety at Work Regulations.
- 5.7** The air dryer should be provided with an electro mechanical hour's run meter.
- 5.8** The manufacturer shall state the desiccant material and oil vapour filtration material used within the air dryer.
- 5.9** The air dryer shall include particle filters to not greater than 5 micron to provide effective protection for all valve and flow control orifices.
- 5.10** The control voltage supply shall be 110V D.C nominal. Alternatively 110 V A.C. supplied from a centre-tap earthed transformer is acceptable.
- 5.11** Normally the air dryer isolation valves will be separately located on the main control panel with a line diagram, however, if the air dryer is supplied with local vent valves these should be lockable in both the OPEN and CLOSED positions. All stop valves should be manufactured from non-corrodible material, e.g. stainless steel, aluminium bronze, brass etc. The Manufacturer shall advise of the procedure to fully depressurise the air dryer.
- 5.12** At the tender stage the Manufacturer should advise of the required maintenance regime for the air dryer and the anticipated spares requirement. The filtration and desiccant material shall not require replacement at intervals of less than 26 months or 2000 running hours.
- 5.13** The air dryer shall be fully automatic and shall fail safe in the event of a mal-operation. If the air dryer fails to cycle or purge air fails this should initiate a trip and alarm. Any accumulation of moisture should be automatically unloaded.
- 5.14** The pressure vessels shall be hydraulically tested by the Manufacturer and a test certificate must be provided detailing the standard to which the vessels were constructed and the hydraulic test pressure and duration.
- 5.15** The air dryer shall be securely bonded to the main sub-station earthing system.

- 5.16** The ancillary electrical equipment for air dryer control shall be to a recognised standard to ensure reliable and safe control. An example of a suitable Technical Specification is EA 50-18; however, equipment complying with a recognised national or international specification such as CENELEC/IEC/BS should be acceptable.

6 AIR DRYER TEST REQUIREMENTS

- 6.1** Prior to National Grid Type Registration of new designs of air dryer the manufacturer shall provide evidence of the ability to operate for a 2000 hours running duration without any intermediate maintenance.
- 6.2** The manufacturer shall provide evidence of cyclic performance. A minimum duty cycle of 12 cycles of ½ hour duration throughout a 24hour period is required.

7 MEMBRANE AIR DRYERS

- 7.1** Membrane air dryers (De-Hydrators) shall not be used for National Grid Air Systems.
- 7.2** Type registration for this equipment has been withdrawn.

8 COMPRESSED AIR SYSTEM CONTROL BOARDS GENERAL REQUIREMENTS

- 8.1** Air System Control Boards are not normally subjected to Type Registration; however shall comply with this general specification. The supplier shall provide a detailed component list (including all sub-components) defining spares and consumables by supplier and part number.

8.2 Panel Construction

The air control board shall comprise:

- 8.2.1** A rigid fabricated stainless steel structure, comprising of a front panel and side panels. All air control boards shall be totally enclosed, with rear access doors. The control board shall normally be located directly above an access trench. The panel shall be formed from segregated separate sections with mechanical barriers for physical safety.
- 8.2.2** The panel shall provide good access to all components for maintenance activities i.e. convenient access to components shall not be obstructed by pipework or other components.
- 8.2.3** The design arrangement shall normally comprise two completely discrete air systems such that one system can be taken out of service without affecting the integrity of the second system. Unless operated as a range system each discrete system shall normally be assigned as:

No. 1 Air System

No. 2 Air System

The main air receivers are similarly normally identified as:

No. 1 Bank or

No. 2 Bank.

- 8.2.4** The front panel shall be provided with a line mimic diagram showing the system configuration. The mimic diagram shall be represented in a durable finish. Adhesive markings are not resilient and shall not be used. Isolation valves shall be line mounted on the mimic diagram. The line diagram shall identify the main components with the line colour coding as follows:

Red	High pressure system (200 barg or 40 barg)
Yellow	Low pressure system
Green	2nd low pressure system where required
Blue	Indicating electrical connection to pressure transducer location positions.

8.2.5 The control board shall incorporate the following:

- a) Lockable isolation and vent valves shall where reasonably practicable be lockable from the front of the panel and each sequentially numbered with the numbering visible both in front and behind the mimic.
- b) Master shut down valves – settings provided by National Grid
- c) Pressure reduction valves – settings provided by National Grid
- d) Pressure relief valves – as required
- e) Non return valves – as required
- f) Pressure gauges
- g) Pressure transducers – as specified
- h) Dew point test points. One test point shall be provided in the high pressure cross pipe. One test point shall be provided in the low pressure cross pipe. The external coupling shall be selected to suit the site test equipment requirements.
- i) Filters – as specified
- j) Mimic indication of main air receivers, air dryers, remotely located pressure relief valves, non-return valves and other major system components.
- k) A single flashing orange, non-strobe, beacon operating from 30 seconds prior to any compressor start, up to compressor start time.
- l) The above system components shall be manufactured from non-corrodible materials e.g. brass, bronze, aluminium bronze, or stainless steel.

8.2.6 The complete air control board, for the larger installations, shall normally comprise of two or three discrete sections, for convenient transportation and assembly. For example:

Section 1 – No. 1 air system

Section 2 – Electrical control and alarm cubicle

Section 3 – No. 2 air system

The arrangement shall be by agreement between the supplier and National Grid and shall generally be required to fit within an existing compressor housing installation.

Each discrete section of the air panel shall be internally illuminated by IP54 low energy, long life luminaire. All the luminaires shall be supplied from a single 230V ac supply and controlled appropriately by panel door switches. A safety isolation facility shall be provided within the air panel to isolate all luminaires from the incoming supply.

- 8.2.7 The panel shall be manufactured from stainless steel sheet to a minimum grade 1.4301 or BS EN 10088-2. A sequential number label shall be provided next to each valve.

9 COMPONENT GUIDANCE

The components used shall satisfy the following requirements:

- 9.1 **Lockable isolating valves.** These shall operate freely and shall be securely lockable from the front of the panel in both the open or closed positions using padlocks as detailed in the contract tender document.

- 9.2 **Master shutdown valves.** The operation may be either mechanical or electrical. If electrical operation is provided then the operating voltage must be 110 V D.C. and loss of supplies must not cause valve operation. These valves must be installed on all 200 barg (3000 psig) air systems and also on the larger 40 barg (600 psig) installations. Operation of an electrical operated valve (closure) should initiate an alarm.

- 9.3 **Pressure reduction valves.** The operation may be a “conventional” mechanical pressure reduction valve or electrical via a solenoid stop valve with in-line downstream flow control restrictor. For 40 barg application conventional pressure regulators have given reliable service. When using 200 barg electrical solenoid valves, a downstream restrictor is required. Where a solenoid valve and downstream restrictor is installed the restrictor should not be located less than 400mm from the solenoid valve so that the freezing effect due to adiabatic expansion does not affect the valve operation. Loss of electrical supply should be such that the solenoid reduction valve remains closed. The supplier shall advise of the required flow rates (restrictor diameter); This is generally determined by the circuit breaker type and number of circuit breakers at the specific location.

- 9.4 **Pressure relief devices.** The discharge capacity of each relief device shall exceed the maximum air supply from air compressors or pressure reduction valves so that operation shall achieve a pressure reduction. The pressure relief device setting shall be specified by National Grid, and the device must start to open at 103% rising and be fully open within 110% rising of the setting value. The device shall be fully reset / closed at 90% falling pressure. The discharge direction shall be such as to avoid injury and particularly must not be horizontal at or near head height.

- 9.5 **Non return valves.** The bore of any non-return valves fitted shall not be less than the bore diameter of the associated pipework. All Non Return valves (NRV's), bodies and internals shall be constructed from stainless steel.

- 9.6 **Pressure gauges and pressure transducers.** All pressure gauges graduated to a scale exceeding 17.2 barg (250 psig) shall be safety pattern construction as specified in BS EN 837-1. New equipment to be supplied with gauges that are dual calibrated in barg and psig. The gauge will have a minimum face diameter of 100mm.

For control purposes, pressure transducers may be fitted and are preferred. Pressure transducers have an advantage that the facility of remote interrogation can be introduced via a modem / pc system. National Grid shall specify for each system whether the control system display shall be in barg or psig. Pressure transducers shall have an accuracy of 1%.

Where rapidly fluctuating pressures are experienced, the supplier shall suitably “snub” the pressure gauges or pressure transducers. Pressure transducers shall be positioned so that they accurately reflect the true system operating pressures.

- 9.7 **Filters.** If filter installation is required then the filter housing design pressure shall not be less than the design pressure for the system. Any filter provided, if practicable, shall have a maximum pressure x volumetric capacity of less than 250 barg-litres to remove the need to comply with the full requirements of The Pressure Systems Safety Regulations 2000. The supplier and National Grid shall discuss and agree the filtration specification including the micron particulate requirement. Filter elements shall be easily accessible for replacement.

10 ELECTRICAL CONTROLS

- 10.1** The control supplies shall be 110 V D.C. and the equipment shall operate over a voltage range in accordance with NGTS 3.12.4. If 110 V battery supplies are not readily available then an alternative supply shall be proposed for National Grid approval. Where the control panel contains 230/400 V mains supplies a label ('warning 230/400 volts') shall be attached to the access door. The access door shall be lockable. All wiring shall be shrouded to IP 20 specification to prevent finger contact.
- 10.2** The electrical controls and alarm signals shall generally be marshalled within a separate metal enclosure on the air control board. The individual air compressors shall have separate local control cubicles for motor starting and protection. A convenient means of rendering remote alarms inoperative shall be provided either by master switch or isolation links. This arrangement shall be subject to National Grid agreement.
- 10.3** Each air compressor shall be provided with the following features:
- a) Run / Off / Auto selector switch.
 - b) Low oil pressure trip indication (where fitted).
 - c) High air temperature trip indication (where fitted).
 - d) High air pressure trip indication (where fitted).
 - e) High coolant temperature or low coolant level (where fitted).
 - f) Emergency stop indication shall be fitted to each compressor control panel.
 - g) Emergency stop trip buttons shall be fitted externally and adjacent to the compressor house access door at all installations.
- Alternative system layout arrangements and control systems are specified in Appendix D.
- 10.4** In the 'Run' selector switch position the compressor will run but should shutdown if an over pressure or other compressor trip facility operates. In the 'Off' position the air compressor shall be inoperative but this should not provide electrical safety isolation. In the 'Auto' position the air compressor shall automatically cut-in to run at the declared pressure specified and similarly shut-down at the declared higher pressure specified by National Grid.
- 10.5** Each air compressor shall be provided with a switch-disconnector or other suitable device to provide safety isolation from 230/400 V mains supply.
- 10.6** In the event of loss of either or both A.C. or D.C. supplies upon restoration of these supplies the system shall automatically revert to normal operation.
- 10.7** Where L.E.D. or lamp indication is provided of a trip or alarm operation, a test push button to check indication must be provided. All illuminated indications shall be LED or comparable long life technology. Indication of alarms and trips should be provided on the main air system control board.
- 10.8** Duplication of air system control is required including, where practicable, duplication of power supplies. For example where Programmable Logic Controllers (PLC) are provided for control two separate units must be provided with auto changeover to the second PLC. Each PLC shall have an independent power supply fed, where practicable, from different sources. No single component or assembly failure should render either or both discrete systems inoperative. PLCs shall not contain maintainable items and shall be modular by design and easily interchangeable to comply with the different asset lifecycle of the air panel.

11 ADDITIONAL REQUIREMENTS

- 11.1** Prior to manufacture the supplier shall provide detailed drawings for National Grid acceptance.
- 11.2** The system shall be pressure and functionally tested prior to delivery to site. National Grid shall be advised of the planned date of such testing and shall advise the supplier if this testing is to be witnessed by National Grid.
- 11.3** Provision shall be made for the control panel to be securely electrically bonded to the substation earth mat.
- 11.4** Labelling provided on the control board shall be agreed with National Grid prior to the commencement of manufacture.
- 11.5** The air control board should be inspected on site by the Insurance Inspector immediately prior to commissioning, in order to comply with the requirements of The Pressure Systems Safety Regulations 2000.
- 11.6** The contract tender document shall advise the supplier of any additional requirements such as fine control sampling (needle) valves for dew-point measurement.
- 11.7** The system shall be provided with vent valves to fully depressurise the complete air system. It is imperative that the system is designed such that no section of the air system retains trapped air at working pressure.

12 ANCILLARY COMPONENTS, GENERAL REQUIREMENTS

12.1 Installation

National Grid has extensive test evidence and service history of the following stainless steel pipe fittings and recommends their use for general application on air and gas systems at Transmission Substations.

The correct selection of tubing and fittings is essential to ensure a safe and reliable assembly. Transmission substation air pipework installed in ground level trenches is at risk from mechanical damage and it is for this reason that thick walled half hard copper tubing and thick walled tungum tubing are specified for substation application.

Repairs and modifications to existing installations should comply with this guidance. To repair a leak a ferrule must never be removed from an existing tube and a new ferrule fitted to the existing groove. The end of the pipe must always be cut off and the new ferrule allowed to cut a new groove. Any loss of pipe length must be compensated by inserting a new additional length of pipe. The loss of tubing caused by replacing a failed coupling must never be recovered by forcing the shortened tube into the new coupling.

Because of a small number of failures of brass fittings due to stress corrosion cracking, for future application at pressures of 40 barg / 600 psig and above, only stainless steel fittings as specified should be used. Existing brass fittings, however, are considered satisfactory for continued service.

As a general safety precaution, it is advised that where practicable, staff take up a remote or guarded position when new pipe work is first pressurised.

This guidance supersedes that previously advised in TDC 777 which has been withdrawn.

12.2 Pipework

12.2.1 All airblast switchgear sites were originally installed using Imperial tube then this continues to be specified and is preferred. Alternatively, metric tubing of similar tube wall thickness may be specified, however, it is essential that only Metric pipe fittings are used on Metric pipe work and Imperial pipe fittings are used on Imperial pipe work. A mixture can result in an unsafe assembly causing a safety hazard to personnel in the immediate vicinity. The use of stainless steel pipe-work is **NOT** permitted for any application.

12.2.2 Pipework shall be appropriately sized for the maximum anticipated flow rates. As all new National Grid installations are upgrading old mainly air blast sites which were built using imperial pipework sizes then the preference is to build the new control boards also using imperial pipework to avoid a mix condition of imperial and metric sizes. However, metric pipework may be used if this achieves a significant cost benefit and subject to agreement in the site specific contract. Where metric pipework is used tube wall thickness similar to that specified for imperial sizes, as detailed below, should be provided.

12.2.3 Copper Tubing

All copper tubing shall comply with the requirements of BS 1306 and shall be generally to BS EN 12449, in the half hard, C106, non-arsenic form.

Copper tubing for use up to 83 barg (1200 psig) used generally on ring mains, main control and storage panel and compressor and circuit breaker connections, shall be of the following sizes:

¼	inch	OD 18 swg
⅜	inch	OD 18 swg
½	inch	OD 16 swg
⅝	inch	OD 14 swg
¾	inch	OD 14 swg
⅞	inch	OD 14 swg
1	inch	OD 12 swg
1¼	inch	OD 12 swg
1½	inch	OD 12 swg

12.2.4 Tungum Tubing

Tungum tubing (Specification TCL 100/C) is suitable for use up to 240 barg (3500 psig) used on main control panels, storage receivers and compressor connections. The grade specification TCL100/C is colour coded yellow-brown-yellow at each end of each complete tube length.

¼	inch	OD 18 swg
⅜	inch	OD 16 swg
½	inch	OD 14 swg
⅝	inch	OD 12 swg

¾ inch OD 12 swg

7/8 inch OD 10 swg

1 inch OD 10 swg

12.3 Pipe Fittings

The following stainless steel fittings have been extensively tested and have been accepted on National Grid installations.

Manufacturer	Type	Medium	Maximum Pressure BAR / PSIG	Tubing
Parker Hannifin	"A Lock" Twin Ferrule	Air and SF ₆	83 / 1200	Copper
Parker Hannifin	CPI Single Ferrule	Air	241 / 3500	Tungum

12.3.1 Pipework clamps shall be fitted to limit movement in the event of a coupling failure and prevent operational vibration.

12.3.2 It is essential that metric fittings are not used on imperial sizes of pipework and vice-versa. On air compressors and air dryers these items shall generally be supplied with the manufacturers own specified pipe fittings which have been proven as being suitable for that specific duty. The above advised stainless steel fittings are specifically recommended for universal site application on compressed air systems. Application guidance is detailed in Appendix E.

13 CONDENSATE DRAIN TRAPS

Air compressors produce condensate consisting of a lubricating oil – water mixture which is automatically unloaded (dumped) periodically. This condensate is typically 98% water and 2% oil, however, it forms a messy emulsion and discharge into the ground is environmentally unacceptable.

At certain air blast switchgear sites the air compressors supply air dryers which remove both oil vapour and moisture and deliver clean high pressure air to main air receivers at an atmospheric dew-point of below -50°C. Condensate is normally trapped in the air dryer filters which may either be manually or automatically unloaded. It is necessary to arrange to collect this condensate.

At other switchgear sites where air dryers are not installed, air compressors feed directly into air receivers and condensate accumulates in these main air receivers. It is necessary to arrange to collect this condensate at these locations.

13.1 De-pressurisation of individual air compressors, air dryers or main air receivers (individual or banks) shall be arranged so as not to create a significant back pressure on other individual units such that any person carrying out maintenance activity on other equipment could sustain injury or discomfort caused by blowback of condensate.

13.2 The condensate shall be collected in a controlled pressure manner and then drained into a suitable vessel. The energy from the pressurised condensate shall be suitably dissipated by means of filters, deflectors, coalesces or other means agreed locally with National Grid.

13.3 Protection against discharge line obstruction or filter blockage shall be provided such that energy is dissipated safely. This shall normally be provided by the use of bursting discs or safety valves.

- 13.4** All pipework subjected to pressure above 5 barg (including transient overpressures) shall be manufactured from rigid non-corrodible material. Generally this will be half hard copper tube to gauge sizes specified in Section 12.2.3 and also stainless steel pipe fittings specified in Section 12.3.
- 13.5** To control pressure rise in discharge lines the use of restrictors / small bore pipework should be considered as appropriate. Restrictors should be arranged to minimise a risk of blockage.
- 13.6** If various items of discharge at pressure into a common vessel then warning label must be attached to that vessel advising that all discharge lines must be rendered inoperative prior to maintenance work. A typical maintenance activity would be replacement of filter elements.
- 13.7** Discharge lines shall be adequately clamped to prevent "whiplash" movement particularly if subjected to rapid discharges.
- 13.8** Following controlled dissipation of stored energy the pipework used to transfer condensate at nominal atmospheric pressure to storage vessels may be plastic, PVC or other similar material.
- 13.9** The capacity of the condensate storage vessel shall be capable of retaining at least the volume of condensate produced in one month's operation. For guidance a Hamworthy 4TH8 air compressor which operates 8 hours per day at an air ambient temperature of 20°C with a relative humidity of 50% would typically produce 558 litres of condensate per month.
- 13.10** The design layout shall prevent condensate from freezing in drain lines during sub-zero temperature conditions and cause blockage. The use of lagging, trace heating and large diameter very low pressure drain lines should be considered as appropriate. If air compressors run frequently then it is unlikely that the temperature in the air compressor house will fall to sub-zero, hence initial collection of condensate within the compressor house is recommended. The condensate can then be drained to an external tank if required.

14 FORMS AND RECORDS

- TS 3.02.11.A Schedule A – Schedule of General and Technical Details (Compressors)
- TS 3.02.11.B Schedule B – Schedule of General and Technical Details (Air Dryers)
- TS 3.02.11.C Schedule Of Site Commissioning Tests (SCTs) For Air Compressors (Appendix A)
- TS 3.02.11.D Schedule Of Site Commissioning Tests (SCTs) For Air Dryers (Appendix B)
- TS 3.02.11.E Schedule Of Site Commissioning Tests (SCTs) For Air Control Boards (Appendix C)

PART 2 - DEFINITIONS AND DOCUMENT HISTORY

15 DEFINITIONS

Not applicable.

16 AMENDMENTS RECORD

Issue	Date	Summary of Changes / Reasons	Author(s)	Approved By (Inc. Job Title)
1	December 2000	First issue	Bill Marley	John Scott ENI Manager
2	November 2015	General update with new format. Removal of Betabite & Ermeto Fittings TGN(T)46 removed from publication. Prohibit use of membrane dryers. Revised guidance on fitting assemblies.	Martin Dimmock Asset Integrity Andrew Ridley Asset Policy	EEPIG

17 IMPLEMENTATION

17.1 Audience Awareness

Audience	Purpose Compliance (C) / Awareness (A)	Notification Method Memo / letter / fax / email / team brief / other (specify)
Network Engineering Capital Delivery	A	E-mail/Intranet
Suppliers	C	E-mail/Extranet

17.2 Training Requirements

Training Needs N/A / Informal / Workshop / Formal Course	Training Target Date	Implementation Manager
N/A	N/A	N/A

17.3 Compliance

Compliance with this specification will be verified by Asset Policy as part of Type Registration.

17.4 Procedure Review Date

5 years from publication date.

PART 3 - GUIDANCE NOTES AND APPENDICES

18 REFERENCES

18.1 International, European and British Standard Documents

BS EN 837-1	Pressure Gauges Part 1: Bourdon Tube Pressure Gauges – Dimensions, Metrology, Requirements and Testing
BS 4999	General requirements for rotating electrical machines
BS EN 60529	Classification for degrees of protection provided by enclosures (IP Code)
BSEN 286-1	Simple unfired pressure vessels designed to contain air or nitrogen. Part 1: Pressure vessels for general purpose
BS PD 5500	Specification for unfired fusion welded pressure vessels
The Pressure Equipment Regulations 1999	
The Pressure Systems Safety Regulations 2000	
BS EN 60085	Electrical insulation (thermal evaluation and designation)
BS EN 50347	General purpose three-phase induction motors having standard dimensions and outputs Frame numbers 56 to 315 and flange numbers 65 to 740
BS EN 12449	Copper and copper alloys - Seamless, round tubes for general purposes
BS 1306	Specification for Copper and Copper Alloy Pressure Piping Systems
BSEN 10088-2	Stainless Steels – Technical delivery conditions for sheet/plate & strip corrosion resisting steel for general purposes.
BSEN 60204-1	Safety of machinery – Electrical equipment of machines

18.2 National Grid Technical Specifications

The following NGTS documentation is relevant to high pressure air systems and associated electronic equipment and should be read in conjunction with this document as appropriate.

NGTS 1	Ratings and General requirements for Plant, Equipment and Apparatus for the National Grid system
NGTS 2.1	Substations
NGTS 2.02	Switchgear
NGTS 2.12	Substation Auxiliary Supplies
NGTS 3.12.3	Substation LVAC Supplies
NGTS 3.12.4	48V and 110 V D.C. Supplies