On:

Lead compressor: 0 kPa

Lag compressor: manual working pressure less 15%

Off:

Lag compressor: manual working pressure

1.8.1.3. Plant control indication

There shall be indicators for each compressor as follows:

1. Green "mains supply on"
2. Green "compressor called for" which indicates that the compressor motor is electrically energised.
3. An indicator of the pressure produced by the compressor.

1.8.1.4. Compressor starter units

There shall be individual starter units for each compressor, which operate a single designated compressor. The starters shall be provided with safety interlocks as specified by the compressor manufacturers, which shall inhibit plant operation until manually reset by means of a button. The starters shall allow automatic restart after an interruption to the power supply. Each starter unit shall contain the following.

1. An isolator interlocked with the covers
2. Either HRC fuses to BS 88 or suitable circuit breakers to BS 4752 and/or BS 3871.
3. An industrial grade ammeter to BS 89.
4. A total counter if not included in the plant control unit
5. A green "mains supply on" indicator if mounted separately from the plant control unit.

1.8.1.5. Dryer control unit

The dryer control unit may be mounted on the dryers or may be located with the plant control unit. There shall be separate power supplies for the duty and standby dryer assemblies taken from the same phase.

The dryer control unit shall contain the following:

1. Duty dryer selector switch
2. Service function to enable selection of continuous/normal running
3. Individually fused, separate cycling systems for each dryer
4. A system to control regeneration of the dryers in relation to pipeline demand
5. Hygrometer and a pressure sensor
6. An automatic change-over to the stand-by dryer system in the event or failure of the duty unit by either dryness or pressure. This requires:
   - electrical and pneumatic isolation of the "duty" sub-assembly so that it is taken off-stream;
   - electrical and pneumatic energisation of the "stand-by" sub-assembly so that it is brought on-stream;
   - activation of the appropriate fault indicator and associated volt-free contacts;
   - the sub-assembly to remain in this mode of operation until the fault has been rectified;
7. Green function indicators for each dryer sub-assembly to indicate:
   - dryer 1 selected;
   - dryer 2 selected;
   - selected dryer – "normal:;
   - selected dryer – "failed" (this fault indicator shall remain on until manually reset by means of a re-set button);
8. a fail-safe system which on failure of the power supply causes the following:

- closure of the exhaust and purge valves;
- opening of the inlet and outlet valves

1.8.1.6. Plant management and building management systems

Connections shall be provided which allow monitoring of plant alarm conditions (b) to (e) and pump running for each compressor. These connections shall be volt-free contact N/O and N/C for each condition having minimum rating of 50 V dc 50 mA. The BMS shall not be used to control the plant.

1.8.1.7. Plant status monitoring

A monitoring system shall be provided to detect the following faults in the air compressor systems:

1. Plant faults: for each compressor:
   - Control circuit failed;
   - Overload tripped;
   - Activation of other safety devices supplied by the manufacturers.

   For each dryer unit:;
   - Pressure fault;
2. Plant emergency
   - Receiver pressure 50 kPa below the stand-by cut in pressure
   - Receiver pressure 50 kPa above cut out pressure
3. Pressure fault (cylinder reserve)
   - Pressure in duty bank below 50% (of normal cylinder pressure)
4. Pressure fault (pipeline)
   - Low pipeline pressure
   - High pipeline pressure

1.8.2. Vacuum system pump operating and indicating system

The operating and indicating system shall perform the following functions:

1. overall plant control and indication;
2. individual pump starting;
3. plant status monitoring and indication;
4. plant alarm status

Individual pump starters shall be housed in a separate compartment. The operating and indicating system shall be housed in separate sections of a common panel and located on the plant or on the plant room wall.

Pneumatic components shall have ventilation. All functions shall be appropriately identified. Indicators shall have a design life of at least one year. The operating system shall be capable of automatically restarting after reinstatement of the power supply.

All components of the vacuum supply system shall be connected to the stand-by electrical system. The control system shall ensure that pumps restart in sequence, to avoid overloading the stand-by power supply.

1.8.2.1. Plant control unit

The control unit shall have a separate power supply for each pump, controlled by a separate sub-circuit derived from the yellow phase. It shall be manufactured and installed in accordance with IEE regulations, and the design shall be such that no single component failure in the control unit will result in loss of plant output.

The unit shall allow either manual selection of duty/standby for each of the pumps or have an automatic sequence selection with a means for manual override. The control unit shall ensure that two or more pumps do not start simultaneously when power is applied.

For testing purposes each pump shall have a selector switch which when turned to the "on" position allows the pump to run continuously.

The lead vacuum pump shall run continually and may only switch off if no vacuum drop is detected for a period of 60 minutes.

The normal operating pressure of the vacuum pump shall be less than or equal to 60 kPa (Absolute pressure) below atmosphere. A maximum pressure difference of 7 kPa of the normal working pressure is allowed between load and un-loads.

In addition to the normal vacuum pump controls the installation shall be fitted with a controller that allows for lead/lag operations and automatic lead/lag selection.

Lead/lag selection shall be done to achieve a 60/40 run hour ratio.

The lead/lag operations shall ensure that the lead machine carry the base load demand and the lag machine remain as automatic standby. If the system pressure drops the lag machine shall start-up to assist the lead machine to attain system pressure.

Set the pressure switches as follows:

ON:

Lead vacuum pump: 0 kPa (Atmosphere)

Lag vacuum pump: -60 kPa

OFF:

Lag vacuum pump: -75 kPa

1.8.2.2. Plant control indication

There shall be indicators for each pump as follows:

1. Red "mains supply on"
2. green "pump energised" which indicates that the pumps motor is electrically energised
3. green "pump operating" which indicates that the pump is drawing vacuum
4. an indicator of the vacuum produced in the pipeline

1.8.2.3. Pump starter units

There shall be individual starter units, each one operating a single designed pump. The starters shall be provided with safety interlocks as specified by the pump manufacturers, which shall inhibit plant operation unit manually reset by means of a button. The starters shall allow automatic restart after an interruption to the power supply. Each starter unit shall contain the following:

1. an isolator interlocked with the covers
2. either HRC fuses or suitable circuit breakers to SANS.
3. starter
4. an industrial grade ammeter
5. a total hours counter if not included in the plant control unit
6. a green "mains supply on" indicator if mounted separately from the plant control unit.

1.8.2.4. Plant status monitoring

A monitoring system shall be provided to detect the following faults in the vacuum supply system

7. plant faults for each pump
   - control circuit failed
   - overload tripped
   - pump failed to go on load
   - activation of other safety devices supplied by the manufacturers

8. plant emergency – receiver vacuum has fallen for example by 5 kPa below the cut-in setting for the pump
9. pressure fault/pipeline – pipeline vacuum less than 48 kPa.

1.8.2.5. Plant status indicator unit

In addition to the plant control indication there shall be a plant status indicator panel, which may be mounted on the plant room wall or adjacent to either the pump starter unit or the plant control unit.

There shall be indicators for each pump to show the following conditions:

1. Green "mains supply on"
2. Red "overload tripped"
3. Red "pump failure"

1.8.2.6. Plant indicator unit

A plant alarm status unit shall be provided as part of the control system. If provided it shall display the following conditions.

1. green "normal"
2. red plant fault"
3. red "plant emergency"
4. red "pipeline vacuum fault"

conditions 1 to 4 shall be transmitted to the central alarm system by normally energised relays.

1.8.2.7. Plant management/BMS

Connections shall be provided which allow monitoring of plant alarm conditions (b) to (e) and pump running for each vacuum pump. These shall be volt-free contacts n/o and n/c for each condition having a minimum rate of 50 V dc mA.

Plant shall be operated in accordance with the manufacturer's instructions and covered by a sound, effective preventive maintenance policy.

1.8.3. Oxygen supply system

1.8.3.1. Standby manifold in use

Shall the oxygen supply from the VIE fail, the primary bank of the standby manifold will automatically supply oxygen and simultaneously a 'standby is use' alarm will be given. The alarm is initiated at 900 kPa (g) falling and supply from the standby manifold at 850 kPa (g) falling.

The VIE level alarm and 'standby in use' alarm will remain on until the VIE operation is restored.

1.8.3.2. Standby manifold low

Shall no action be taken after liquid supply failure; the standby cylinders will supply until pressure falls to a pre-set pressure of 6800 kPa (g) at which time a "standby manifold low" alarm will be given. Change over to the secondary bank of the standby manifold shall be made by manual change over and the primary cylinders shall also be replenished. It is possible that this alarm has been initiated due to leakage over a period. Therefore, all joints shall be checked for leaks whenever this alarm condition is initiated,

1.8.3.3. VIE filling

After commissioning, subsequent filling of the VIEs are controlled by the gas supplier's driver. The driver shall fill the VIE without disturbing the customer's supply pressure or flow and without lifting safety valves or blowing bursting discs. On filling, the driver shall report any defects to the gas supplier.

The following alarm conditions shall be required:

1. 'liquid O_2 level low' – 25% of contents
2. 'fill O_2 immediately" – control panel inlet pressure dropped to 690 kPa (g)
3. "compressed stand-by low" – compressed supply pressure dropped below 50%.
4. "line pressure" – High 490 kPa (g) rising low 375 kPa (g) falling

1.8.4. Other Cylinder Manifold systems for 400 kPa installation

Manifold control unit

The control unit shall include a green 'mains supply on' indication.

Manifold monitoring

Each manifold system shall be provided with monitoring to detect:

1. Duty bank operating
2. Duty bank empty and stand-by bank operating
3. Stand-by bank below 10% capacity when the duty bank is empty.
4. Reserve bank below nominal 1400 kPa and below 6800 kPa pressure for other gases.
5. Pipeline faults as shown in figure 1.

1.8.4.1. Indicator/alarm panels

A panel shall contain at least the following:

- Battery power supply – 12V Acid free sealed rechargeable battery.
- Battery capacity shall be sufficient to operate system for at least 48 hours.
- Battery charger – shall be able to take the connected load and charge the battery.
- Battery test button – test the 12v battery supply. Button to break 220V mains.
- Panel test button – tests the panel circuit, LED's, and buzzer
- Electric main supply indication LED – Green
- Surge/lightning protection – protection shall be installed on the pc card i.e., sedactors. Protection shall be provided for the entire unit (input and Output)
- Normally closed input – broken circuit activates indication and alarm

- Parallel input signal connection to other panels
- Press fit terminal on all connections
- All programming software – to be supplied on a CD
- Color coded signal wiring – color code to match SANS codes for gas piping
- LED's – 6mm complete with grommets. Continuous green for normal condition and flashing red for fail condition
- Audible alarm/buzzer

Panel control:

- Normal conditions

All green LED's illuminated and no audible alarm

First supply failure:

Vacuum Insulated Evaporator (0_2) – Green LED out, two red flashing LED's and audible alarm on. Accept cancels audible alarm only.

N_20 – Green LED out, two red flashing LED's and audible alarm on. Accept cancels audible alarm only.

Compressed Air – Green LED out, two red flashing LED's and audible alarm on. Accept does not cancel audible alarm. Normal condition cancels audible alarm.

Vacuum – Green LED out, two red flashing LED's and audible alarm on. Accept does not cancel audible alarm. Normal condition cancels audible alarm.

Main power supply failure:

Electric main supply indicating green LED out,

1.8.4.2. Active bank indication panel

Each panel shall contain at least the following:

- Battery power supply – 12V Acid free sealed rechargeable battery
- Battery capacity shall be sufficient to operate system for at least 48 hours
- Battery charger – shall be able to take the connected load and charge the battery
- Battery test button – test the 12V battery supply. Button to break 220V mains
- Panel test button – tests all the LED's
- Electric main supply indication LED – Green
- Surge/lightning protection – Protection shall be installed on the pc card i.e., sedactors. Protection shall be provided for the entire unit. (Input and Output).
- LED's – 6mm complete with grommets. Continuous green
- Provide all indicator/alarm panels with emergency power

1.9. Pipework standards

The British Standards or SANS or ANSI equivalents applicable to this Section include but are not limited to the following:

SANS 1453:2018 Copper tubes for medical gas and vacuum services

SANS 15614 Specification and qualification of welding procedures for metallic materials – welding procedure test Part 6: Arc and gas welding of copper and its alloys

SANS 10140-3:2003 Identification colour markings.

1.9.1. Installation

Generally, gas pipelines shall be kept away from areas where they may be subject to any of the following:

1. mechanical damage

2. chemical damage
3. excessive heat
4. splashing, dripping or permanent contact with oil, grease or bituminous compounds, electrical sparks etc.

Service ducts or voids containing gas pipelines shall have adequate ventilation, to prevent gas concentrations in the event of any leakage occurring.

Exposed pipelines shall not be installed in lift shafts, kitchens, laundries, power houses, generator rooms, incinerator rooms, storage rooms designed to house combustible materials or in any other fire-risk area. Where pipelines in hazardous areas are unavoidable, they shall be enclosed in non- combustible materials that will prevent the possibility of the liberation of gases into the room in the event of pipeline failure.

Pipelines need not be laid with falls in the case of vacuum; the sub-atmospheric pressure will result in the evaporation of any moisture entering the system. It is possible however for vacuum jars to overflow and thus for systems to require flushing through.

The connection from individual vacuum terminal units into the main unit shall be taken from the top of the pipeline to avoid flooding other vertical pipe drops during flushing. Each vacuum main riser shall be provided with a double valve arrangement to permit drainage when the system is under vacuum. One of the valves shall be lockable in the closed position. No other sipping or drainage arrangements are required.

Pipelines shall be provided with further protection in circumstances as follows:

1. where copper pipes or steel pass through walls, partitions, or floors they shall be fitted with sleeves of the same material and provided with appropriate wall or ceiling plates.
2. in radio diagnostic procedure rooms, etc, radio frequency (r/f) screening by means of extended sleeves will be necessary. The advice of the equipment manufacturer shall be sought.
3. corrosion of pipes can occur where they are in contact with timber treated with fire-resistant or flame-retardant compounds, for example some timber used for roof trusses and floor joists.

   This contact shall be avoided using impermeable non-metallic materials in the area where contact may occur, like PVC spacers or adhesive PVC tape. If spacers are used, they shall not be liable to drop out due to shrinkage or subsequent movement of the pipe or timber.

The installation shall conform to the following:

1. The distribution system outlet shall comprise a general stop valve and pressure relief valve, or an equivalent device. This mechanism shall permit the gas contained in the distribution system to be released into the atmosphere in the event of the normal working pressure, restricted to 1000 kPa, being exceeded. It shall be designed and adjusted in such a way that the downstream pressure cannot under any circumstances exceed 1500 kPa.
2. The fixed pipes, fittings, and equipment through which the oxygen flows shall be in materials carrying guarantees at least equal of those of copper, with regard to mechanical strength, fire resistance and the conditions of oxidation and ignition in oxygen. The materials used for these pipes, fittings and equipment shall be carefully degreased.
3. The pipes shall be joined by welding or with silver alloy soldered connections, depending on the nature of the material used, or by means of special fittings whose permanent tightness is guaranteed for a pressure of 1500 kPa, considering the environment of oxygen with a very low water vapour content.

The pipes shall be marked with the same identifications as those used for the central supply unit.

Wherever possible, the pipes shall be capable of inspection along their entire length. At any event, they shall not have any joints in the sections, which cannot be inspected. They can be recessed into walls, floors or partitions, provided that:

1. their location is easily identifiable
2. they are not located in places where holes or anchor points could be made,
3. they are not in contact with the metal framework of the structure,
4. the walls of the hollow cavities in the structure, such as double walls, suspended ceilings, etc., which may be crossed by the pipes, are in fire-proof material.

If all the above-mentioned conditions are not met, the recessed pipe shall be placed inside a continuous sleeve guaranteeing the same safety conditions.

The ducts and sleeves used for the non-recessed oxygen pipes shall be efficiently ventilated and made fireproof materials.

Pipework lines carrying oxygen can use the same ducts, sleeves, casing or suspended ceiling as the electric or heating pipes, provided that there is a clearance of at least 3 centimetres between the outer surface of the pipes and that the installation standards concerning the latter are observed.

They shall be as far as possible from any gaseous or liquid fuel pipes. As a rule, the distance between the two types of pipes shall not be less than 1 metre. However, in case of necessity, they may be permitted to cross or be close to each other for short stretches. In such cases, the points at which they cross or are close to each other shall be outside narrow or poorly ventilated sleeves and the fuel pipe shall always pass below the oxygen pipe with a clearance of at least 3 centimetres.

It is prohibited to install in premises representing a fire risk, and in the operating wings, general oxygen distribution pipes supplying other premises.

If the distribution system supplies several buildings, a stop valve shall be located at the inlet to each building.

If the distribution system supplies the operating wings or premises representing special fire risks, a stop valve shall be located at the inlet to each building or group of buildings supplied.

In addition to the above-mentioned statutory specifications, the installation rules to be observed are as follows:

Underground pipelines shall be installed at a depth of at least 0:90m in a protective sleeve (generally asbestos cement) and they shall not have any joints in the concealed part.

The sleeve shall be buried in sand and covered by plastic-coated wire mesh

The use of ducts susceptible to flooding or intended for water drainage is prohibited. If an outside duct is to be provided, it is advisable to ensure a satisfactory tightness of the covering slabs and natural ventilation at the ends.

The entire system shall be earthed. The earth connections to be checked periodically shall have a value of less than 8 ohms.

To illustrate the above-mentioned conditions concerning the installation techniques, the following sketches give examples of tools for working on the pipes, as well as examples of assembling and fixing the pipes.

1.9.2. Structural Penetrations and Sleeves

There shall be no pipeline joints within the thickness of walls or floors and pipework shall not be embedded in the structure unless specifically identified as part of the design.

Where pipes pass through walls or floors a compatible pipe sleeve shall be built in, comprising a length of tube, of the same material as the pipeline, of sufficient length for the sleeve to finish not less than 3mm nor more than 12mm clear of the finished wall or floor. The sleeve shall be of internal diameter at least 25mm greater than the OD of the pipe passing through. A greater clearance may be necessary to accommodate expansion movement and insulation. Where necessary to affect a noise or fire barrier the space between the pipeline and the sleeve shall be packed with appropriate material (e.g., mineral wool) and sealed at both ends with water and fire retardant mastic.

Pipes passing through external walls, floors and roofs shall be installed with puddle flanges or sleeves as appropriate, sealed against water, gas, vermin, dust and spread of fire.

Water protecting pipe sleeves through floors shall be supplied and fixed in the following locations:

1. In plantrooms
2. In kitchen areas
3. In floors provided with a waterproof membrane.

The pipe sleeves shall be set to extend for the full thickness of the structural element and 50mm above finished floor level.

1.9.3. Venting and draining

All piping systems shall be pitched for proper circulation, venting and draining. Piping shall be arranged so that drainage of the complete installation is possible.

1.9.4. Copper pipework

1.9.4.1. Tube

The manufacturer shall be a licensee of ISO9000 for pipes and for fittings up to 79.38 mm.

Where materials are obtained from supplies from other countries, the suppliers shall be registered in accordance with SANS or ISO9000.

Tube SANS 1453-2018 imperial sizes shall be used throughout the installation unless otherwise specified. The pipes are supplied in the annealed condition, in 5.5 straight meters lengths for all diameters.

The table below gives the essential characteristics for normalised annealed tubes with the dimensions generally used for the construction of medical gases pipework.

Nominal size of tube (mm)	Thickness (mm)	Theoretical mass (kg/m)	Working pressure (mPa)
9.53	0.71	0.175	8.20
12.70	0.76	0.254	6.58
15.88	0.81	0.342	5.61
19.05	0.89	0.453	5.14
22.23	1.02	0.606	5.05
28.58	1.02	0.787	3.93
34.93	1.22	1.152	3.84
41.28	1.40	1.563	4.88
53.98	1.65	2.418	4.40
66.68	1.78	3.235	3.84
79.38	2.03	4.397	3.68

Unless otherwise stated, droppers shall be no less than 9.53mm for pressurised medical gases and 12.7mm for vacuum. No horizontal supplies to vacuum droppers shall be less than 15.8mm.

All droppers and piping through inaccessible areas (which will be buried, embedded or be difficult for access, used underground in non-aggressive soil conditions) shall be medical grade annealed copper according to SANS 1453. All other piping shall be medical grade hard tempered copper piping supplied in straight lengths. Branch off piping of smaller than 34.93mm shall be in "half-hard" condition. However, tubes shall not be bent, formed or anneld and shall not be used with silver brazed joints.

Copper tube shall carry the maker's identification marks and the appropriate SANS symbol.

When stored on site the pipe bundles shall be capped at each end with distinctive colour caps in accordance with SANS. Remove caps only when the joint is made. When a first joint is made on a pipe length the remaining length shall be capped.

1.9.5. Pipeline jointing

1.9.5.1. General

Except for mechanical joints, copper-to-copper joints only will be permitted on site, made with brazing filler rods, which can be used without flux and in the presence of nitrogen, which will be blown through the pipeline during the brazing procedure to prevent the formation of oxides.

CO_2 shall no longer be used as an inert gas shield.

This method eliminates the formation of oxide within the pipe, leaving a clean bore. Some slight burnishing may occasionally be observed on sectioned joints. Purging is still required to remove the internal shield gas and the other particulate matter not associated with the brazing operation.

Copper joints to brass or gunmetal fittings will require the use of flux with subsequent cleaning to remove the flux residues and oxide deposits.

Heating of the joint for brazing shall be carried out with oxygen/acetylene or hydrogen, LPG/ambient air torches. Additional heating may be required for some fittings, for example by means of a second torch.

In order to maintain the pipeline cleanliness and prevent formation of verdigris after completion, it will be necessary to maintain the completed system charged with medical air until the installation is finally commissioned.

The techniques recommended cover all copper-to-copper joints and all copper-to-brass/gunmetal/bronze joints in an MGPS and are explained in more detail below.

Capillary fittings for sizes up to 54mm shall comply with respective BS standard or SANS 1067 Part 1. They shall be of copper and either integral solder ring or end feed type jointed with soft solder except as below. Sizes 67mm and above shall be gunmetal and of the wedge ring type. Lead-free solder shall be used on all hot water and cold water supplies.

Pressure limitations imposed by the BS and SANS on the use of soft solder for capillary fittings and of compression fittings (when acceptable) shall be observed and when necessary silver brazing shall be used. Joints in inaccessible positions shall be avoided, but where there is no alternative they shall be silver brazed.

Fittings for brazing shall have socket ends for brazing with copper/silver/phosphorous rod to BS 1845. Pressure rating and service conditions for fittings shall be equal to the specified tube.

Fittings incorporating screwed threads to BS 21 shall be jointed using compounds to BS 5292 and hemp PTFE tape approved for potable water pipework.

Care shall be exercised at any points of junction between copper tube and steel to avoid direct contact.

A suitable fitting of dielectric material shall be used to prevent electrolytic action taking place.

Note: Where non-listed materials are to be used, due to there being no alternative, the procedure used shall be consistent with the manufacturer's instructions taking particular note of the following precautions:

1. Use least quantity of material to produce good quality joints;
2. Keep jointing materials clean and free from contamination;
3. Remove cutting oils and protective coatings, and clean surfaces;
4. Prevent entry of surplus materials to waterways;
5. Remove excess materials on completion of the joint.

Where pipework is indicated on the drawings as chromium plated such pipework shall be sent to a specialist for plating after all pulled bends and soldered joints are complete. Where completed sections are to be site jointed in exposed locations unions shall be used.

Where silver brazing is required close control of tolerances and workmanship shall be exercised. Only suitably skilled and experienced operatives shall be used.

Forming techniques may be used but only for straight couplings on Class 1 and Class 2 tube and for branches on Class 2 tube.

All fittings shall be installed in accordance with the manufacturer's instructions. Flux and solder shall be according to the fitting manufacturer's recommendations and chosen to avoid any corrosion of the piping before flushing and filling.

Fittings made of duplex brass (having zinc content above 30%) shall not be used.

1.9.5.2. Brazing

Copper pipework up to DN 200 with wall thickness up to 4.5mm shall be brazed in accordance with the recommendations in HVCA Code of Practice TR/3, as modified below.

Joint designs, brazing procedures, brazer certification and production joint quality shall comply with the requirements as interpreted by the appointed Inspection Body.

Brazing procedures shall include auxiliary heating for pipe sizes DN 75 and larger, for solid copper flanges, and in other circumstances where exposure, weather, wall thickness etc. indicate sound joints will not be otherwise assured.

1.9.6. Pipe fittings

Do not butt braze pipes.

Use only copper capillary sockets, tee joints, short bends and pipe reducers with internal stop ends at all joints in piping installation.

Use copper to copper to weld all capillary joints and silver solder for brass to copper fittings.

Compression unions shall be of the flat faced or similar capillary type. Oxygen compatible "O" ring unions shall be used.

Compression unions shall be used on vacuum lines only at the following points to allow for cleaning:

- On branch lines to wall points where these join the main line.
- In main lines at top and bottom of rising section.
- In main lines and distances not exceeding 18m.

All fittings shall be in accordance with BS 864.2: 1983 or SBS 1067. More stringent requirements shall prevail.

All fittings shall be clean and degreased and supplied to site in individual heat-sealed plastic bags which shall be only opened just prior to installation.

1.9.6.1. Pulled Bends

For sizes up to 54mm bends, springs and sets in specified copper tube may be site made where standard fittings cannot be used, or where this method will give a neater appearance.

Bends, springs and sets shall be made where standard formers and bending machines are used. Centre line radii shall be approximately 5 x OD.

Pulled bends or offsets, which show flattening, ripples creasing buckling, thinning of the tube well or constriction of bore shall be rejected.

1.9.6.2. Joints to Equipment

On threaded equipment, capillary adapters, threaded BSPT, internal or external as required, shall be used.

Unions shall be fitted where threaded equipment is required to be removable and flanges (or flange adapters for compression fittings) for flanged equipment.

Flanges shall otherwise be installed only where a section of piping needs to be readily removable for access, or for testing purposes.

Flanges for Class 1 and Class 2 tube shall be bi-metal type with gunmetal or low zinc brass inserts for brazing to the tube.

Bi-metal flanges shall not be used for Class 1 tube but either flange adapters or flanges requiring soft solder capillary joints, may be used.

1.9.6.3. Internal cleanliness

The tube and fitting shall be internally clean and free from oxides and particular matter. Some heat burnishing may be apparent and is acceptable.

1.9.6.4. Penetration of brazing alloy

The minimum penetration at any point on the joint shall be three times the wall thickness of the tube or 3mm whichever is greater.

1.9.6.5. Capping

Sections of pipeline shall be capped to prevent the ingress of air as soon as they are completed.

1.9.6.6. Removal of flux residues and oxides

The residue of flux and oxide resulting from the brazing of copper-to-brass/gunmetal/bronze fittings shall be removed before components are delivered to site. The following procedure shall be used or alternatively one, which is no less effective, may be substituted.

Allow joints to cool naturally to room temperature, or at least to a temperature at which they can be handled. This is specifically for gunmetal fittings, which if cooled or quenched from the brazing temperature by dipping in cold water could result in cracked fittings.

The flux residues shall be removed by immersion in hot water and brushing with stainless-steel type wire brushes.

The oxides formed shall be removed by immersing in a 5-10% sulphuric acid solution at 65°C (nominal) to which 25-50 g/l of potassium dichromate has been added. The components shall then be thoroughly rinsed in hot water at 80°C (nominal). This shall result in a bright, clean component.

The fitting shall be degreased if necessary and bagged.

1.9.6.7. Purging with the working gas

Purging shall be carried out strictly in accordance with the procedure specified by Health technical Memorandum – validation and verification section.

1.10. Provision for pipework supports & expansion

1.10.1. General

Full details of hangers and supports shall be indicated on the Contractor's working drawings. All pipe runs in roof or ceiling spaces, cowered ways under roof eaves and on the external wall surface of buildings shall be secured in place by brass type holder bolts. Same applies for pipes in ducts and bedhead trunking.

A proprietary support system shall be used to support all pipework in order to achieve technical and visual compatibility.

Piping at all equipment and valve positions, and at main junctions, shall be adequately supported to prevent any distortion or transmission of strain to equipment or valves.

Brackets and supports shall be so arrange and set out to allow sufficient access for adjustment, maintenance and removal of equipment, valves and accessories with the minimum of dismantling and without the need for additional temporary supports after items are removed.

Hangers for piping requiring to be thermally insulated shall be provided with high quality segmental wooden bearing inserts capable of withstanding the clamp compression and allowing the hanger to support the pipe without metal-to-metal contact.

Inserts shall be of the same thickness as the thermal insulation specified for application and shall further have extended cylindrical insulation shields of galvanised sheet steel or glass fibre reinforced plastic of not less than 2mm thickness with adequately sealed joints to maintain vapour barriers where applied.

Contact of dissimilar metals shall be avoided; steel pipes shall have steel supporting members in contact with the pipe. Copper and stainless-steel tubing shall be supported by contact members of copper alloy.

Multiple pipes supports for pipes of differing sizes shall be spaced at intervals required for the smallest pipe.

Exposed pipework fixed to walls in occupied areas shall be supported on brass or mild steel pipe rings as appropriate with screw on back plates.

Where chrome plated pipework is indicated it shall be supported on chrome plated brass pipe rings and back plates.

1.10.2. Support spacing

Supports and fixings, whether standard patterns or purpose-made, shall be appropriate in style and material to the pipe and to the structure to which fixed with due regard to appearance.

Pipe supports shall be arranged as near as possible to joints and changes in direction. They shall carry piping neatly, without excessive deflection between supports and so that it is free to move during expansion.

Where swinging pipe hangers are used, they shall be able to move freely for the full distance necessary. The support rod shall be not less than 300mm long and shall be clear of the full thickness of any insulation. Hemispherical washers shall be used on swinging hangers. Pipes of like temperature may be double hung from a single bracket.

Sliding supports, where unavoidable, shall be faced with PTFE permanently attached. Rollers shall be avoided.

Vertical pipework shall be supported at the base of the riser and guided at intervals not exceeding those indicated below. Vertical pipes shall be guided at not less than two points. Branches from a riser shall not be used as a means of support for the riser.

The installer shall supply full information to enable provision to be made in the structure for the fitting of supports and fixings during construction and be responsible for any necessary marking out.

Pipework shall be supported at the following minimum centres.

Exposed pipelines shall be retained by supportive clamps with the following spacing

Pipe size [mm]	Maximum interval for vertical runs [m]	Maximum interval for horizontal runs [m]
9.53	1.0	1.0
12.7	1.2	1
15.88	1.2	1.2
22.23	2.4	1.8
28.22	2.4	1.8
34.93	3	2.4
41.28	3	2.4
54 and above	3	2.7

1.10.2.1. Horizontal services

Pipe Size	Support Centres
15mm – 22mm	1.2m
28mm	1.5m
35mm – 54mm	1.8m

1.10.2.2. Vertical services

Pipe Size	Support Centres
15mm – 22mm	1.8m
28mm	2.4m
35mm – 54mm	3.0m
65mm – 150mm	3.7m

1.10.3. Pipeline Flexibility

1.10.3.1. General

All support systems shall provide for expansion, contraction and anchoring of the piping system and be constructed in accordance with SANS.

Allowance for the expansion of pipework shall be made adequately to limit pipeline stresses, to provide the controlled movement of pipes to ensure that forces applied to equipment and to the building are consistent with their construction and characteristics.

Pipeline flexibility to control expansion stresses shall be provided preferably by changes in direction or fabricated pipe offsets.

1.10.3.2. Expansion of Copper Pipework (up to 35mm nominal bore)

High expansion stresses cannot be accommodated by allowing copper pipe to bend as that may result in work hardening and fracture. For any unavoidable cases involving constrained movement, bellows shall be used with guides and anchors properly designed.

Nominal expansion movement of copper pipework shall be accommodated by the free support of piping, care being taken in the location of fixings to avoid local stress concentrations.

1.10.3.3. Anchors and Guides

Rigid mild steel pipe anchors capable of carrying the maximum loads resulting from the expansion arrangements shall be provided. Agreement with the Employer shall be obtained for the location of the loadings imposed by the attachment of anchors and guides to the structure or other base.

1.11. Pipeline fittings

1.11.1. General

All pipework fittings shall be compatible with the gas and associated pressures to be conveyed and the pipeline material into which they are to be installed.

1.11.1.1. Isolation valves

All valves shall be of the lever ball type, which open and close with a 90° turn. When installed in the pipeline external to plantrooms, they shall be provided with a means for locking in the open or closed position.

At the entrance to the department or a building, these valves are provided for user access in an emergency or for maintenance purposes. The ball valve shall be installed within an enclosure, with a lockable door permitting locking with valve open or closed. The means of emergency operation shall not introduce the possibility of injury. The means of isolation shall be readily operable, shall blank both the pipeline and the valve port, and shall be visible when deployed.

In an emergency, the user shall be able to gain access in order to operate the isolating valves quickly and simply without the need for a key. There are several methods of providing such emergency access, for example, break-glass panels, plastic push-out inserts, etc, whichever method is used shall be safe and secure, but not provide a risk of injury to the user. The method of emergency access shall be obvious and clearly labelled and its use shall be evident.

The enclosure shall have adequate ventilation to prevent the accumulation of gas in the event of a leak. Pipe entries and other penetrations shall be sealed to prevent gas escape by routes other than the vents or openings into the user space. The enclosure shall be designed to facilitate sealing of these entries on site.

The enclosure shall be clearly labelled to indicate the function and the areas/beads etc, served. Emergency access shall not compromise the labelling.

1.11.2. Pressure sensors

Pressure sensors to provide the alarm function will require to be fitted to pipeline distribution systems. In all cases they shall be installed in a location which is adequately ventilated and having access for maintenance.

1.11.3. Pressure and altitude gauges

Generally, valved pressure gauges shall be installed at the following locations:

1. at each compressor discharge and suction, both installed at the same height,
2. on each side of pressure reducing valve sets,
3. on closed expansion vessels,

The pressure gauge range shall be chosen in such a way that the indicator will be situated near a middle position during normal operating conditions. The gauge shall have an adjustable pointer.

Gauges shall be Bourdon tube type to BS 1780, 100mm diameter, except those installed in plantrooms which shall be 150mm diameter. Gauges shall have enamelled mild steel case with chrome bezel, substantial glass face, and phosphor bronze Bourdon tube. Dial face shall be white with black scale graduations and numbering.

Gauges shall have overall accuracy of one per cent (1%) of scale range.

Gauge shop drawings and gauges shall be approved by the Architect and gauges shall all be of the same manufacture.

Gauges shall comply with the following schedule:

Pressures (kPa)	1000	450	300	250	150
Gauge range (kPa)	0–2000	0–1000	0–600	0–500	0–300
Figure Intervals (kPa)	200	100	50	50	50
Intermediate (kPa)	25	10	5	5	5

1.11.4. Valve cabinets

Valve cabinets for line isolation valves shall be made of 1.6mm steel plate, powder coated in white. Finish shall be UV resistant as well as be resistant to scratch and high impact. Engraved caution plate securely fixed to the door shall read:

MEDICAL GAS

ISOLATING VALVES

DO NOT SHUT OFF

Isolating cabinets shall be not less than 200 mm high x 380 mm wide x 100 mm deep or in increments of these standard sizes. Where practical, they shall house more than one valve. In any case, engraved name plates shall be provided inside the cabinet to identify each valve.

All valves within isolating cabinets shall be with flat faced, o-ring sealed unions on either side.

The isolation cabinets shall be fixed securely to walls or support subframes. Where inside the buildings they shall be mounted 2000m above finished floor level to avoid accidental and in authorised operation.

1.11.5. Ball valves

Ball valves for pressurised gases up to DN 50 shall have be three-piece stainless steel, and inhibited brass body with chrome coated ball plug and valve stem, and nitrile seat for vacuum. Nitrile seats and 'O' rings shall provide the stem seal.

Valves shall be 1/4 turn lever handle operated. The valves shall be top entry type provided with a locking plate suitable for gas services.

1.12. Pipeline fittings

1.12.1. General

Pipeline fittings, which may be attached to a medical gas pipeline system (MGPS), include various types of terminal unit, shut-off valves, area valve service units (AVSUs) and other components such as emergency inlet ports. All pipeline fittings shall be suitable for the system in which they are installed.

1.12.2. Terminal units – service outlet valves

Terminal units shall be mounted in positions as shown on the drawings, which given the shortest practicable routes for flexible connecting assemblies, between the terminal unit and apparatus. Terminal units may be surface or flush-mounted. They be incorporated with electrical services, nurses call systems and TV and radio/audio services in proprietary fittings such as bed-head trunking, wall-panel systems and theatre pendant fittings, etc.

Bedhead trunking, technical wall units, gas pendants and vertical trunking within wards shall all be supplied and installed by the electrical Subcontractor.

The holes for installation of medical gases outlets shall also be provided however, piped gases Subcontractor shall through issue of detailed installation drawings coordinate and ensure that the correct requirements are known to the electrical Subcontractor. Terminal units shall be quick coupling, self-isolating type with safety keyed connection. They shall be gas specific and constructed in such a manner that it is impossible to insert the connector from a different gas service into the outlet valve of another gas.

The connectors and outlet valves shall also be such that instantaneous identification is possible by means of configuration or shape of connectors and sockets or by permanent colouring of the connectors and sockets by means of a vitreous enamel insert or ring or other approved means.

Each outlet and connector shall have permanently and clearly engraved upon it "0_2", "N_20", "LPA", "HPA", "VAC" or the name of each gas in English.

The service outlets shall be such that the valve mechanism is easily accessible for maintenance purposes without having to undo pipe connections or break into walls.

Probes used in outlets shall be unidirectional

Terminal units shall conform to SANS 1409 for medical gases and vacuum services. Terminal units intended for installation with the socket axis horizontal, that is, wall-mounted include a non-swivel device, so that directly connected equipment such as flow meters remain vertical. Terminal units intended for installation with the socket axis vertical for example in certain types of pendants, do not include a non-swivel device. Secondary locks are no longer included in terminal units.

Where an array of terminal units is provided at a location, they shall be arranged as follows:

For a horizontal array, when viewed from the front, left to right Oxygen, Nitrous oxide, nitrous oxide/oxygen mixture (50% v/v), medical air 400 kPa surgical air 700 kPa, vacuum, anaesthetic gas scavenging (AGS). That is: O_2, N_20, LPA, HPA, VAC, AGS.

Mounting heights for terminal units shall be between 900 mm and 1,400 mm above finished floor level (FFL) when installed on walls or similar vertical surfaces.

When installed in pendants or similar situations, terminal units shall be of a type suitable for mounting within the specified fitting.

Pressure losses across terminal units shall be in accordance with BS5682 Terminal units which are wall mounted shall be located as follows:

Distance between centres of adjacent terminal units or centre of terminal unit and walls

135 ± 2.5mm for three or more terminal units

150 ± 2.5 mm for two terminal units only

This shall be sufficient for double flow meters to be used, for example between an oxygen terminal unit and a vacuum terminal unit serving two bed spaces the distance between the centre of the terminal unit and potential obstruction on either side (for example when installed in a corner) shall be a minimum of 200mm on either side.

1.12.2.1. Ceiling pendant fittings rigid, multi-purpose type

The construction shall provide segregation of low voltage, FELV electrical services by means of flexible partitions or conduit as appropriate. Access to 'live" components shall be via panels which are removable by means of tools only.

When these fittings include flexible connecting assemblies for the gas supply, the method of attachment to rigid pipework or terminal units shall be either by means of the appropriate non-interchangeable screw thread (NIST) connector or by means of permanent ferruling.

The fittings shall be provided with adequate venting to allow escape of gas in the event of rupture of one or all of the medical gas services.

The normal height for rigid pendants shall be at least 1,900 mm FFL.

All medical gas piping in Operating theatres, Accident and Emergency and ICU wards shall be electrically isolated from the main supply piping by means of medical flexible hose. The flexible hose shall have crimped on fittings. The free distance between the copper ends of piping shall be at least 100 mm.

1.12.2.2. Flexible pendant fitting

These shall comply with the requirements of BS 5682. All loose assemblies shall be provided with appropriate NIST connections.

1.12.2.3. Bed-head trunking/walling system

These fittings shall generally be in accordance with engineering data provided for electrical Subcontract. Separate compartments shall be provided for electrical services, nurse call/radio etc and medical gas pipelines so that joining of pipework within trunking shall not affect the electrical wiring or progress of their installation.

The medical gas compartments shall be provided with ventilation by means of louvres, slots, etc to prevent the accumulation of any gas in the event of rupture of the medical gas pipeline services.

1.12.2.4. Isolation valves

All valves shall be of the lever ball type, which open and close with a 90° turn. When installed in the pipeline external to plantrooms, they shall be provided with a means for locking in the open or closed position.

At the entrance to the department or a building, these valves are provided for user access in an emergency or for maintenance purposes. The ball valve shall be installed within an enclosure, with a lockable door permitting locking with valve open or closed. The means of emergency operation shall not introduce the possibility of injury. The means of isolation shall be readily operable, shall blank both the pipeline and the valve port, and shall be visible when deployed.

In an emergency, the user shall be able to gain access to operate the isolating valves quickly and simply without the need for a key. There are several methods of providing such emergency access, for example, break-glass panels, plastic push-out inserts, etc, whichever method is used shall be safe and secure, but not provide a risk of injury to the user. The method of emergency access shall be obvious and clearly labelled and its use shall be evident.

The enclosure shall have adequate ventilation to prevent the accumulation of gas in the event of a leak. Pipe entries and other penetrations shall be sealed to prevent gas escape by routes other than the vents or openings into the user space. The enclosure shall be designed to facilitate sealing of these entries on site.

The enclosure shall be clearly labelled to indicate the function and the areas/beads etc, served. Emergency access shall not compromise the labelling.

1.12.3. Area Valve Service Units (AVSUs)

Secondary pressure reducing stations (SPRS) shall be gas specific and shall be installed in proprietary enclosures in or against service duct walls as indicated on drawings.

The set shall comprise of:

- Pressure reducing/regulating valve with optimum regulation around desired higher/lower pressures for service, adjustable for ±50% of regulating pressure difference.
- Pressure gauges of suitable range on both inlet and outlet side of set (changing to be possible without gas interruption).
- Filter on incoming side.
- Emergency inlet port – gas specific.
- Non return valve towards main supply
- Purge points

1.12.4. Pressure sensors

Pressure sensors to provide the alarm function will require to be fitted to pipeline distribution systems. In all cases they shall be installed in a location which is adequately ventilated and having access for maintenance. They may be incorporated within AVSUs.

1.12.5. Pressure and altitude gauges

Generally, valved pressure gauges shall be installed at the following locations:

- at each pump discharge and suction, both installed at the same height,
- on system Hydro module equipment,
- on each side of pressure reducing valve sets,
- on closed expansion vessels,
- on inlet and outlet of evaporators, condensers, and cooling towers,

The pressure gauge range shall be chosen in such a way that the indicator will be situated near a middle position during normal operating conditions. The gauge shall have an adjustable pointer.

Gauges shall be Bourdon tube type, 100mm diameter, except those installed in plantrooms which shall be 150mm diameter. Gauges shall have enamelled mild steel case with chrome bezel, substantial glass face, and phosphor bronze Bourdon tube. Dial face shall be white with black scale graduations and numbering.

Gauges shall have overall accuracy of one per cent (1%) of scale range.

Gauge shop drawings and gauges shall be approved by the Architect and gauges shall all be of the same manufacture.

Gauges shall comply with the following schedule:

Pressures (kPa)	1000	450	300	250	150
Gauge range (kPa)	0–2000	0–1000	0–600	0–500	0–300
Figure Intervals (kPa)	200	100	50	50	50
Intermediate (kPa)	25	10	5	5	5

1.12.5.1. Emergency inlet port

Medical oxygen, nitrous oxide and 400 kPa medical air systems shall be provided with an emergency inlet port to the pipeline distribution system. This shall be located downstream from the main source of supply, to permit connection of temporary supply plant. The emergency inlet shall comprise a lockable valve and blanked connecting port and shall incorporate a non-return valve. Emergency port shall be gas specific.

An emergency inlet port is not required for 700 kPa surgical air systems. Portable cylinders shall be available for use in an emergency.

1.13. Positioning the components

1.13.1. General

The following components of the medical gas system shall be located as described herein:

the general stop valve (V.S.P. Assembly), the stop valves,

the regulators (compressed gas only),

the low-point drainage traps and flasks (vacuum only),

the warning devices,

the terminal units.

1.13.2. Valves and regulators

The locations of valves and regulators shall comply with the following conditions:

they shall be permanently accessible, thus excluding any room which can be locked (toilet, private room, etc.)

they shall be protected against inadvertent handling, which necessarily implies their being placed in a sealed box,

they shall have suitable natural ventilation,

they shall not be located in ducts or inspection holes dug in the ground.

The condition of the labels shall be checked periodically; particularly following work carried out by cleaning or painting companies who often do not take any precautions to protect the markings before carrying out their work.

1.13.3. Components for compressed gas system (except for terminal units)

The double stage pressure system shall comprise:

A GENERAL STOP VALVE with pressure relief valve and additional terminal unit, whose purpose, at the supply plant centre, is:
to cut off the general supply in case of emergency or if the supply plant centre must be repaired,
to protect the primary system against any accidental overpressure (above 1000 kPa, in accordance with French regulations),
to supply the pipework by means of an emergency source, if necessary, in the event of maintenance work on the supply plant centre.
STOP VALVES on the primary circuit:
at the inlet of each building supplied,

at the inlet of each operating wing,
at the inlet of each room or group of rooms representing special fire risks,
if necessary, at certain characteristic points: main by-pass, end of loop, point for a future new pipeline connection.
REGULATORS at the head of each secondary system, to stabilize the pressure at 300 kPa 10% at the terminal units.
WARNING DEVICES permitting the detection of any abnormal pressure on the primary and secondary system, at the stations, pressure, safety boxes etc.

1.13.4. Components for the vacuum system (except for terminal units)

STOP VALVES intended to shut off the various parts of the installation, to be located in particular:

- on the supply plant centre,
- at the inlet to each building,
- at the foot of each riser,
- at the inlet to each department (near the second stage pressure reduction unit).
- WARNING DEVICES per group of terminal units connected to the same riser permitting the detection of vacuum anomalies.

The valves chosen shall be straight through passage type so as to reduce the pressure losses; in general, these are of the disc or ball type. It is recommended to use ball models.

1.14. Control, warning, and alarming systems

1.15. Warning and Alarm Systems

1.15.1. General

Warning and alarm system shall indicate the condition of each service, bank sensed at the point of supply.

Warning and alarm system shall provide audible and visual monitoring of the following systems:

a) Oxygen Supply System-left bank-right-bank-supply pressure.
b) Nitrous Oxide Supply System-left bank-right-bank-supply pressure.
c) Medical Air left bank-right-bank-main supply pressure
d) Vacuum supply
e) Air Supply System-run-trip - supply pressure.

1.15.2. Warning and Alarm Panels

Warning and alarm panels shall be provided with a display indicator for each service.

Warning and alarm panels shall have fascia panel hinged to facilitate access and subsequent maintenance working on the alarm.

Warning and alarm panels shall be clearly marked for each alarm state.

a) Gas Alarm with the type of gas, plant room number and individual system condition.

Warning and alarm system shall include the following in addition to the signal indicators for each service:

a) A green indication for system normal.
b) A red alarm system for fault state.

Warning and alarm systems shall have a mutable auditory alarm.

Warning and alarm system shall have provision for remote auditory signal repeaters.

1.15.2.1. Audible alarm.

The audible alarm will reinstate after 15 minutes if the fault has not been rectified.

During prolonged periods of plant or pipeline shutdown, the auditory alarm can be cancelled by means of a mute key.

1.15.2.2. Alarm Sensing Devices

Alarm system sensing devices shall comprise of contact gauges to initiate the alarm condition. In a normal state the communication cable will have a rating of 18 volts. In the case of a fault the cable will have a rating of 0 volts.

1.15.2.3. Standby Battery System

The standby battery system shall have the capacity to power the warning and alarm system fault indicator and auditory alarm for a minimum period of 48 hours.

The standby battery system shall be a sealed, rechargeable type.

1.15.2.4. Test Facilities

A test button shall be included for each warning and alarm system for testing the indicators and audible alarm. Indicator/alarm panels

1.15.3. Compressed air system

1.15.3.1. Operating and indicating system

The operating and indicating system shall perform the following functions:

1. Overall plant control and indication
2. Individual compressor starting
3. Control of dryers
4. Plant status monitoring and indication
5. Indication of the plant alarm status

The individual compressor shall be housed in a separate compartment. The above functions shall be carried out by separate units installed in a common panel and located on the plant on the plantroom wall. Control panels containing components shall have vents to permit release of pressure in the event of components failure. All functions and indicators shall be appropriately identified and shall have a design life of at least one year.

The operating system shall be capable of automatically restarting after reinstatement of the power supply.

All components of the medical air supply shall be connected to the stand-by electrical supply. The control system shall ensure that compressors restart in sequence, to avoid overloading the stand-by power supply.

1.15.3.2. Plant control unit

The control unit shall have a separate power supply for each compressor, controlled by a separate sub-circuit derived from the yellow phase.

The unit shall allow either manual selection of duty/stand/by for each of the compressors or have an automatic sequence selection with a means for manual override. The unit shall ensure that two or more compressors do not start simultaneously when power is applied.

A warning notice which complies with BS5378 shall be affixed which indicates the presence of low voltage.

Load and un-load cycle shall be incorporated for lead compressor only. The load compressor shall run continuously and may only switch off if no pressure drop is detected for a period of 60 minutes. A maximum pressure difference of 10% of the normal working pressure is allowed between load and un-loads.

Lead/lag automatic selection shall be controlled by the fitted controller and shall be set to achieve 60/40 run hour ratios. The lead/lag operations shall ensure that the lead machine carry the base load demand and the lag machine remains as automatic standby.

If the system pressure drops, the lag machine shall start-up to assist the lead machine to attain system pressure.

Pressure switches shall be set as follows:

On:

Lead compressor: 0 kPa

Lag compressor: manual working pressure less 15%

Off:

Lag compressor: manual working pressure

1.15.3.3. Plant control indication

There shall be indicators for each compressor as follows:

1. Green "mains supply on"
2. Green "compressor called for" which indicates that the compressor motor is electrically energised.
3. An indicator of the pressure produced by the compressor.

1.15.3.4. Compressor starter units

There shall be individual starter units for each compressor, which operate a single designated compressor. The starters shall be provided with safety interlocks as specified by the compressor manufacturers, which shall inhibit plant operation until manually reset by means of a button. The starters shall allow automatic restart after an interruption to the power supply. Each starter unit shall contain the following.

1. An isolator interlocked with the covers
2. Either HRC fuses to BS88 or suitable circuit breakers to BS4752 and/or BS3871.
3. An industrial grade ammeter to BS89.
4. A total counter if not included in the plant control unit
5. A green "mains supply on" indicator if mounted separately from the plant control unit.

1.15.3.5. Dryer control unit

The dryer control unit may be mounted on the dryers or may be located with the plant control unit. There shall be separate power supplies for the duty and standby dryer assemblies taken from the same phase.

The dryer control unit shall contain the following:

1. Duty dryer selector switch
2. Service function to enable selection of continuous/normal running
3. Individually fused, separate cycling systems for each dryer
4. A system to control regeneration of the dryers in relation to pipeline demand
5. Hygrometer and a pressure sensor
6. An automatic change-over to the stand-by dryer system in the event or failure of the duty unit by either dryness or pressure. This requires:
   - electrical and pneumatic isolation of the "duty" sub-assembly so that it is taken off-stream;
   - electrical and pneumatic energisation of the "stand-by" sub-assembly so that it is brought on-stream;
   - activation of the appropriate fault indicator and associated volt-free contacts;
   - the sub-assembly to remain in this mode of operation until the fault has been rectified;
7. Green function indicators for each dryer sub-assembly to indicate:
   - dryer 1 selected;
   - dryer 2 selected;
   - selected dryer – "normal:;
   - selected dryer – "failed" (this fault indicator shall remain on until manually reset by means of a re-set button);
8. a fail-safe system which on failure of the power supply causes the following:
   - closure of the exhaust and purge valves;

- opening of the inlet and outlet valves

1.15.3.6. Plant management and building management systems

Connections shall be provided which allow monitoring of plant alarm conditions (b) to (e) and pump running for each compressor. These connections shall be volt-free contact N/O and N/C for each condition having minimum rating of 50 V dc 50 mA. The BMS shall not be used to control the plant.

1.15.3.7. Plant status monitoring

A monitoring system shall be provided to detect the following faults in the air compressor systems:

1. Plant faults: for each compressor:
   - Control circuit failed;
   - Overload tripped;
   - After-cooler temperature high;
   - Compressor temperature high;
   - Compressor failed to go on-load;
   - Activation of other safety devices supplied by the manufacturers.

   For each dryer unit:
   - Dryness failure (hygrometer > -26° C);
   - Pressure fault;
2. Plant emergency
   - Receiver pressure 50 kPa below the stand-by cut in pressure
   - Receiver pressure 50 kPa above cut out pressure
   - Dryness above 0.51 g/m (dewpoint at -26°C at atmospheric pressure)
3. Pressure fault (cylinder reserve)
   - Pressure in duty bank below 50% (of normal cylinder pressure)
4. Pressure fault (pipeline)
   - Low pipeline pressure
   - High pipeline pressure

1.16. Electrical installation for the piped gases power and controls system

1.16.1. Power and Controls System Cableways

Cableways for power and control system cables shall comprise steel conduits – black enamelled for dry interior applications and galvanised for damp conditions or for exterior applications – and perforated cable trays or galvanised steel trunking. The permitted conduit diameters are 20mm, 25mm and 32mm. No other sizes shall be employed in the installation. PVC conduits shall not be used for any application.

Cableways shall be provided for all power and control system cables. All cableways and wiring shall be concealed in the fabric of the building, above suspended ceilings and in floor slabs or screeds. The exceptions to this requirement are inside plantrooms and on the rooftop plant areas. The cabling systems employed will be designed to be fully re–wirable.

1.16.2. Power and Controls System Cables

The power and control system wiring shall be carried out using a combination of the following:

1. PVC insulated single core non–armoured cables to BS 6004: 1995 installed in screwed steel conduits run inside the building.
2. PVC insulated single core non–armoured cables to BS 6004: 1995 installed in PVC covered flexible (Kopex) conduits run inside dry–wall partitioning systems.

3. Non–armoured flexible cords and cables in steel conduits run inside the building.
4. Non–armoured flexible cords and cables installed in PVC covered flexible (Kopex) conduits run inside dry–wall partitioning systems.
5. PVC/SWA/PVC cables run on perforated trays inside the buildings and outside. These cables shall also be drawn into underground uPVC ducts and sleeved entries.
6. Twisted pair PVC/SWA/PVC cables run on perforated trays inside the buildings and outside. These cables shall also be drawn into underground uPVC ducts and sleeved entries as necessary.
7. Twisted pair PVC/screened cable in screwed steel conduits run inside the building.
8. All wiring shall be carried out using one or more of the above wiring systems.

All cables shall have a copper conductor of size of not less than 1.5mm2. No joints shall be made in any cables.

Where PVC/SWA/PVC cables pass through walls, floors, or fire partitions, a steel sleeve shall be installed to facilitate installation and subsequent withdrawal of the cable. The internal diameter of the sleeve shall be not more than 20mm larger than the outside diameter of the cable, and the annular space between them shall be packed, after installation of the cable, with fire resisting material to achieve the same resistance to fire as the structure through which they pass.

Where cables are to be terminated directly on motors, or apparatus subject to vibration, then a suitable expansion loop or bend shall be formed in the cable immediately prior to the termination in accordance with the cable manufacturer's recommendations. Any loop shall be formed such that the two sections of cable do not touch at the point of crossover.

Cables shall not be directly connected to motors or other apparatus subject to vibration. Cables shall be terminated in a BS conduit box or suitable adaptable box adjacent to the motor or apparatus and final connection shall be made with PVC single core cables in flexible conduit.

1.16.3. Steel Conduit

The Subcontractor shall be responsible for work coordination with other trades and for working to any conduit layout drawings that may be issued. Where conduit layout drawings are not issued the Subcontractor shall prepare drawings showing all conduit routes for submission to and approval by the Architect, prior to erection.

Surface mounted conduit shall be run truly horizontal or vertical. Where these requirements cannot be met conduit shall run parallel to the building lines.

Concealed conduit work in concrete or composition slabs, walls cast in–situ and in plaster shall be offered to the Architect for inspection prior to concealment.

Conduit boxes shall be fixed securely within the shuttering to prevent movement during the pouring of the concrete and, in addition, for added stability, conduit shall be tied to the re–inforcement with wire of not less than 1.5mm diameter. Where conduit is fixed to, or in contact with, structural or reinforcement steelwork they shall be electrically bonded together with a bonding conductor.

No conduit smaller than 20mm diameter shall be installed unless shown on the drawings.

The maximum number of cables drawn into any one conduit shall not exceed those allowed by the IEE Wiring Regulations.

Immediately on completion of erection of each conduit run, all exposed open terminations shall be plugged effectively against the entry of foreign solids and liquids. Where concrete is to be poured, seals of polystyrene waste shall be used. All seals shall be maintained in good order until it is necessary to complete wiring and connection of fittings.

Conduit runs in damp situations shall be arranged to be self-draining to specific drain points which shall consist of BS boxes. Conduit runs shall not drain to boxes containing socket outlets or other electrical apparatus containing live terminations.

The whole of the conduit system in any section shall be completed and free from any dirt or loose matter before cables are drawn in.

Final connections from the conduit installation to all motors, other apparatus subject to vibration and as specified elsewhere, shall be made using weather–proof, PVC–sheathed, rust–proof flexible conduit with a minimum length of 500mm. A protective conductor shall be provided and drawn inside each flexible

conduit. The conductor shall be PVC insulated green/yellow stranded copper wire not less than 2.5mm2, connected to the apparatus earth terminal at one end and bonded to an earthed conductor at the other end.

All conduit, bends and couplers shall comply with SANS. The conduit shall be heavy galvanised gauge screwed, 'Push- fit' type conduit shall not be accepted. Internally screwed couplers shall be made from steel.

Conduit fittings and components shall comply with SANS and be suitable for use with screwed conduit. Inspection elbows or bends, tees and manufactured bends will not be allowed.

For internal use conduit and all ancillary items to SANS shall be to Class 2. Unless otherwise stated Class 4 shall be used externally, in plant rooms, horizontal floor ducts, areas where dampness could occur, underground and where the conduit is to be cast into concrete or floor screeds. Only galvanised fittings and components shall be used with galvanised conduit.

All conduits shall be free of rust patches or other defects on delivery and shall be protected from mechanical damage and weather when stored on site.

Flexible conduit and adapters shall comply with requirements of SANS.

Adapters shall be of the solid type in brass with an external earthing terminal. The flexible conduit shall be PVC–sheathed unless otherwise stated.

All conduit systems shall be provided with a separate internal protective conductor of not less than 2.5mm2 cross section.

Electrical continuity and resistance of conduit systems intended to be encased in concrete shall be tested immediately prior to pouring.

Conduits shall be installed at the maximum practical distance from cold water, hot water and gas pipes or other metal enclosed services. Where conduits must run near these services, the metal of the services shall be electrically bonded together and to the conduits with a bonding conductor.

For galvanised conduit the use of running couplers and back nuts shall be avoided in preference to three-piece conduit unions. Running couplers in another conduit shall be kept to the absolute minimum.

Where long externally threaded couplers or similar items are essential and at any other position where hexagonal lock nuts are not practicable, circular lock nuts with knurled edges shall be fitted and fully tightened. In all instances, conduit shall be screwed firmly into fittings, full use being made of the total length of threads. The use of nippling will not be permitted. Ends of conduit shall be cut square and all burrs on cut ends shall be removed.

Conduit shall be supported in accordance with Regulation 529–2 of the IEE Wiring Regulations with maximum spacing of supports as Table 11C in Appendix 11. Where conduit is connected to surface–mounted equipment or accessories, it shall be additionally supported within 150mm of each side of the item.

Where bends and sets occur, the conduit shall be fixed at 150mm, on each side of such diversion.

Unless otherwise indicated on the drawings, all concealed conduit work shall be installed on the 'loop–in' system.

The inner radius of any conduit bend shall not be less than 2 times the external diameter of the conduit. Where conduit must be bent it shall be bent or set cold without altering its section, using a suitable bending machine. No more than two 90° angle bends shall be installed in any run of conduit without a conduit draw–in box.

Surface mounted conduit shall have all exposed threads, vice marks, scratches, etc, treated as follows:

Class 2: Two coats of oil bound enamel paint of the same colour as the Basic conduit finish.

Class 4: Two coats of either a zinc rich epoxy primer or equal alternative.

Where an exposed galvanised surface has been cut or otherwise damaged, including exposed threads and connections, it shall be repaired by application of either a zinc rich epoxy primer or equal alternative, with a generous overlap on the existing sound metal coating.

The epoxy primer shall not be applied to damp surfaces, when the air temperature drops below 5°C, during periods of rain, fog, snow or mist and when conditions are humid, and condensation occurs.

Where conduit is to be buried within the building fabric two coats of bitumastic paint shall be applied to exposed threads, vice marks, etc, immediately the conduit is erected.

Conduit buried in concrete shall have a minimum of 25mm depth of cover over its entire length. Conduit buried in plaster shall have a 5mm minimum depth of cover over its entire length.

Where conduits cross the expansion joints, they shall be installed to avoid resisting any relative movement between the sections. A suitable arrangement will comprise of conduits telescoped one inside the other connected into adaptable boxes installed immediately adjacent to each side of the section. The outside conduit shall be stopped at one joint face whilst the inner conduit shall be continued across the joint into the box where it shall be bushed and the two boxes shall be earth bonded together by a green/yellow PVC insulated conductor of not less than 2.5mm2 stranded copper wire, run inside the conduits.

Conduits in chases shall be held in place by purpose made crampets.

For normal internal work all black enamelled conduit accessories shall be securely fixed by means of not less than two round head black japanned fixing screws correctly spaced.

Galvanised conduit accessories shall be fixed by means of not less than two sherardised or cadmium plated roundhead screws.

In damp and exterior situations or when fixing into concrete sherardised or cadmium plated screws or stainless-steel screws in bronze inserts shall be used.

Where specified or where necessary because of roughness or other conditions, surface conduit shall be fixed by means of distance saddles. The conduit shall be set within 300mm of boxes to permit fixing of boxes to the surface. The requirements for supporting conduit within 150mm of boxes, bends and sets may be met by spacer bar saddles on the set position of the conduit.

Draw–in boxes shall be provided to give access to all conduits for the drawing in or out of any cable. Draw–in boxes shall be of ample size to enable the cables to be neatly diverted from one conduit to another without undue cramping. No cable joints will be allowed in draw–in boxes under any circumstances. Generally, where conduit is to be installed, from point to point in a straight line, draw–in boxes shall be installed every 9m of conduit run.

No box shall be fixed in such a position as to be inaccessible on the completion of the building structure or other services. Where 'spout' type boxes are used, lock nuts shall be employed to ensure a tight fit for the conduit.

Ceiling point boxes or draw–in boxes on a concealed installation shall finish flush with the underside of the ceilings.

All conduit boxes not carrying lighting or other fittings shall be installed with a suitable cover fixed with brass or stainless-steel round head screws.

Where conduit boxes are flush with the surface finish, covers shall be of the overlapping type.

Covers for external application shall have machined faces and shall be provided with neoprene type gaskets.

Where any surface mounting control gear or other equipment is to be installed in conjunction with concealed conduit work, the conduit shall be terminated at a flush mounted adaptable box. The back of the equipment shall be drilled and bushed for back entry and the equipment mounted to conceal the adaptable box. Where fused connection units are specified, a separate conduit shall be run to the equipment position and terminated as stated above.

Where conduits connect to distribution boards, trunking, switch and fuse units, single and multiple switch boxes, etc, they shall be secured to the apparatus by means of flanged couplings comprising flanged socket, lead washer and hexagon male, smooth bore, brass bush.

1.16.4. Cable tray

Cable trays shall be perforated and manufactured from cold rolled mild steel.

All accessories including bends (vertical and horizontal), intersections, tees, risers and reducing sections shall be purpose made by the tray manufacturer. Only one manufacturer's tray and accessories shall be used on the project.

The thickness of normal cable tray and accessories shall comply with the following requirements:

Width of tray accessory (mm)	Minimum thickness (mm)
above 152 up to and including 152	1.2
above 152 up to and including 457	1.5
above 457 up to and including 914	2.0

Where heavy duty cable tray is shown on the drawings or where the span between supports and/or cable loading necessitates its use then the thickness of tray and accessories shall comply with the following requirements:

Width of tray accessory (mm)	Minimum thickness (mm)
up to and including 457	1.5
above 457 up to and including 914	2.0

Heavy duty cable trays shall be manufactured with plain return flanges.

Except where specified or shown otherwise the Subcontractor shall be responsible for the selection of the correct grade of cable tray to meet site conditions and the requirements of this Specification.

Where site conditions necessitate site fabrication the standards of fabrication and finish shall not be less than that of standard manufacturers' items, and full details shall be shown on the Fabrication Drawings.

Sections of cable tray and accessories shall be jointed in accordance with the recommendations of the manufacturers or alternatively by using mushroom–head roofing bolts, nuts, and washers.

Cable tray and accessories shall be supplied with a hot–dip galvanised finish to BS 729. Any damage caused to the tray, accessories, and finish during cable installation and prior to Practical Completion shall be made good using either a zinc rich epoxy primer or equal alternative with a generous overlap on the existing sound metal coating. The jointing screws, nuts and washers shall all be galvanised or sherardised steel, brass shall not be used.

Cable trays shall be cut along a line of plain metal and not through perforations. Burrs or sharp edges shall be removed prior to the installation of tray sections or accessories. Holes cut in cable tray shall be suitably bushed with grommets complying with BS 1767. In either case the cut or damaged metal shall be made good by the Subcontractor by first treating the surfaces with a suitable rust–proofing agent, similar to that used in its original manufacture and then applying finishes comparable to the remainder of the surface.

Fixings and supports shall be formed from sections of purpose made racking with purpose made accessories.

Fixings and supports shall be installed at regular intervals of 1200mm and not more than 150mm from all bends, tees, intersections and risers. Midspan joints between cable tray sections shall be avoided and they shall be positioned as close as practicable to the tray fixing or support.

A minimum clear space of 25mm shall remain behind all installed runs of cable tray.

Cables shall be installed on trays in a single layer, leaving 25% of the tray width spare for future use.

Cable trays shall preferably be installed such that they offer direct support to cables without the use of cleats or saddles. Purpose made straps, cleats, or saddles shall be employed, however, to maintain a neat and regular disposition of cables. Where trays do not directly support cables, e.g., vertical tray, then load bearing cable cleats or saddles shall be employed and securely fixed to the tray. All cable cleats, saddles and straps shall comply with the cable manufacturer's recommendations and shall be compatible with the cable tray finish and cable sheath or serving.

Where horizontal runs of cable tray cross building or structural expansion joints, then the tray shall be cut between supports installed on either side of the expansion joint. The tray sections shall then be jointed with bolts, nuts and washers installed in elongated holes permitting a lengthwise movement of +10mm from the initial fastening position. Vertical runs of cable tray shall not be installed such that they straddle vertical expansion joints of the building structure.

Cable tray and accessories shall be electrically and mechanically continuous throughout its length and bonded to the earth system. Tray carrying LV cables shall be bonded to earth with green/yellow PVC insulated stranded copper, single core cable. Tray carrying HV cables shall be bonded to earth with copper strip.

1.17. Control & starter panels

1.17.1. General requirements

The control panel shall be of wall-mounted type, single door, not exceeding a height of 900mm, a depth of 300mm or a width of 900mm.

Shall not have external fixing lugs.

Shall have suitable provision for incoming cable connection from provided isolator in panels' vicinity.

A main on-load isolator shall be provided to isolate the whole panel.

Each control panel shall house suitable rated power starters for each bank of heaters as well as for each pump motor, all relays, timers, pilot lights, alarm and annunciation elements as well as the controller.

All volt free contacts shall be pre-wired to a set of rails mounted clip-on terminals, all clearly labelled with slide-on ferules.

All control wiring to and from the panel shall be also through set of clip-on terminals.

1.17.2. Finger protection

All components shall be 'finger protected' using insulating material like 'paxolin' such that live parts cannot be accidentally touched.

1.17.3. Construction

Panel shells shall be manufactured in best quality pickled and oiled mild steel plate to a minimum thickness of 2mm, in all folded and welded construction. Panels located in exterior or semi–exterior locations shall be manufactured from Zintec (i.e., zinc coated) steel.

The back of the panel shells shall be detachable, mild steel, secured by bolts and shake–proof washers, without separate nuts, to a minimum thickness of 1.65mm. Panels shall be fitted with removable base plates to a minimum thickness of 2mm.

Mounting plates within panels, for fitting internally mounted equipment, shall be in mild steel to a minimum thickness of 2mm. Equipment shall be fitted to Avdel Nutserts, or similar fixings, so that back nuts are not required. Alternatively, the mounting plate may be tapped, and equipment fixed with screws. Self-tapping screws will not be allowed. The mounting plates shall be suitable for supporting all equipment within any section without visible distortion.

Doors shall have a maximum width of 700mm and shall be flush fitting mild steel with folded edges and welded corners suitable for eliminating distortion and whip, to a minimum thickness of 2mm. They shall have concealed hinges with removable pins and door stays which prevent them opening more than 90°.

All framework associated with doors shall be fitted with foamed plastic dust protective strip or neoprene tube sealing gaskets.

Main isolators shall be front mounted with shrouded terminals on both sides.

The main isolator shall be mounted on a separate fixed mounting plate with the handle assembly on its own switch section door.

Panel construction shall be such that adequate ventilation shall be provided for the internal heat dissipation and under no circumstances shall the internal temperature rise above 40°C. Shall louvred sections and/or ventilation fans be required they shall be provided.

The panel shall be provided with space on the mounting plate(s) for future requirements. This shall be available in a sensible position and shall be not less than 10% of the usable area. For single door panels this space shall permit one starter and one relay to be added.

Control switches and lamps not associated with individual starters shall be located on common control section doors which shall be constructed and hinged as for individual cubicles and shall span at least two tiers of the panel and be secured by barrel locks. Each barrel lock shall be supplied with two keys. Unless otherwise detailed one key shall fit all locks provided on panels.

1.17.4. Finishes and labelling

All surfaces shall be smooth and free from burrs, weld marks and sharp edges. After prefabrication the panel sections shall be degreased and chromate etched before being sprayed with two coats of primer.

Paint finishes shall be in full–gloss stoved enamel.

Internal mounting plates shall be white. Externally and internally the finish shall be SANS blue.

Generally, labels, both internal and external, shall be in 'Formica' engraving laminate coloured white with black engraving. All labels shall be fixed with bright finish instrument head screws or plastic flat headed push in rivets of the same colour as the label. Labels for switch plates shall cover the entire area taken up

by a switch and its associated lamps and be drilled and engraved for each group of items. Embossed 'Dymo' type labels will not be accepted.

A warning label shall be fitted to each main door with the inscription "Danger Live Terminals – Isolate Elsewhere".

Actual engraving details shall be agreed between the Architect and panel manufacturer prior to engraving. In those cases where any item of equipment or section of panel is not de-energised when normal isolation procedures are followed, such items or sections shall bear clearly visible warning labels of yellow 'Formica' engraving laminate with black engraving.

1.17.5. Wiring and terminations

All low voltage wiring shall use PVC insulated cable to SANS. Power wiring shall be type BR (stranded) with a minimum cross-sectional area of 2.5mm² – phase coloured. Control wiring (243V) shall be type BK (flexible) with a minimum cross-sectional area of 1.0mm² – red.

All control circuits shall use the red phase and shall be wired in red cable.

All neutral wiring shall be in black cable.

All extra low voltage wiring shall use PVC insulated cable to BS 6231 type BK with a minimum cross-sectional area of 0.75mm².

The colour coding shall be as follows:

1. Phase connections – red, yellow, and blue.
2. Neutral connections – black.
3. Earth connections – green/yellow.
4. a.c. voltages below 50V – brown; if the return connection is earthed a green ferrule shall be fitted.
5. d.c. circuits – grey with red and black ferrules to denote polarity.

Wiring shall be carried on the front surface of the mounting plate, neatly strapped in plastic cable trunking of the ventilated type, with clip-on covers. Cable sizes shall be rated considering all grouping, bunching and enclosing factors.

All wiring to the switch section doors shall be wired in looms with mechanical protection. Any one loom of control cables shall have a limit of 25 cables. Within plastic trunking the cables shall not occupy more than 50% of the trunking volume. Wiring outside the trunking shall be neatly set for connection to terminals or equipment.

All control wiring shall be identified with resistor colour coded and numbered ferrules. These numbers shall be shown on the schematic wiring diagrams. Control neutral wiring shall be of the ring main principle with no more than 20 items on any one ring.

Panel wiring for BMS/electronic controls shall be in screened flexible cable. Extra low voltage wiring and terminals shall be separated from wiring and terminals for higher voltages.

Each screened cable shall have its screen wired to its own terminal on the outgoing terminal strip.

The screen shall be earthed at the equipment and not at the terminal strip.

All control wiring shall be fitted with cable crimps.

Terminals shall be of the Klippon Electrical Ltd. (flexible) type or alternative, approved by the Architect, suitably rated, fully numbered and fitted so that extra units may be added. They shall be, suitably sized to cater for long runs of externally mounted cable where voltage drops necessitate a larger size than standard for the connected load.

Provision of 20 spare terminals shall be fitted to each control panel. Each terminal rail shall have sufficient length for 10% additional terminals.

All wiring for BMS/control devices shall be via hinged 'link' type terminals,

Entry to the panel terminals shall be via detachable, undrilled gland plates. Gland plates shall cover the length of the terminal strip.

All panel mounted equipment shall be wired out to terminal strips.

The IEE Regulations with amendments to the date of issue of this Specification shall be used as the basis of all earthing, wiring and selection of components in respect of connections to the panels.

1.17.6. Isolators

Main isolating switches and fuse switches where used, shall be capable of opening and closing on–load. Isolating switches shall conform to SANS, fuses shall comply with the requirements of SANS. Isolating switches and fuse switches shall be suitable for 50Hz, 3–phase, 4 wire connections.

A bolted neutral link shall be provided for termination of the incoming cable.

1.17.7. Short time rating & fault levels

Short time ratings and fault levels shall for tender purposes be taken as 10kA.

1.17.8. Starters

1.17.8.1. General requirements

They shall all be suitable for use on 3–phase, 4–wire, 400/230V, 50Hz supplies and fitted with 220–230V a.c. operating coils.

Starters up to and excluding 11kW rating shall be direct on-line. 11kW and up to and including 37.5kW they shall be open transition automatic star–delta. Above 37.5kW they shall be closed transition automatic star–delta or auto–transformer.

Starters shall be selected on the basis that the maximum motor/machine starting times comply with SANS. Where these time limits are exceeded the Controls, Subcontractor shall consult the starter manufacturer regarding the overload protection.

Unless housed in a type of MM panel, all starters shall be housed in IP51 enclosures and incorporate an integral on–load mains isolator having sufficient auxiliary contacts to isolate all incoming feeds with a facility for being padlocked in the 'OFF' position.

All starters up to and including 37.5kW shall be fitted with interchangeable thermal overloads. They shall include single phasing protection of the differential heater type, to switch the motor off when a phase is lost even if the resulting currents in the healthy phases do not exceed the full load current rating of the motor. For motors above 37.5kW starters shall be provided with an electronic overload.

All overload devices shall be arranged for hand resetting. A reset button shall not be provided on the starter enclosure. All overload relays shall have overload contacts of the single–pole changeover type. The overload scale shall be clearly identified as representing either amps to trip or full load current.

Direct on-line (DOL) starters

For voltages up to and including 1000V a.c. shall comply with SANS. They shall be rated for intermittent periodic duty or intermittent duty class 0.3 and comply with the requirements of utilisation category AC–3.

1.17.9. Contactors

Shall be of the same manufacture as the starters.

They shall be suitable for use on 3–phase, 4–wire 415/240V, 50Hz supplies and fitted with 220–250V 50Hz coils. Only contactors which have been type tested, to meet the requirements shall be used.

Shall be rated for intermittent periodic or intermittent duty Class 0.3. The utilization category shall generally be AC–3 but category AC–1 may be used where the load is positively identified as being non–inductive but excluding tungsten filament lamps.

Unless housed in a type of MM panel all contactors shall be housed in IP51 enclosures and shall incorporate an integral on–load mains isolator having sufficient auxiliary contacts to isolate all incoming feeds with a facility for being padlocked in the 'OFF' position.

Relays: shall be of the same manufacturer as the starters. Relays shall be fitted with 220–230V, 50Hz coils. All relays shall have a clearance of 3mm between them.

1.17.10. Timers

Shall have adjustable ranges.

1.17.11. Ammeters

Instruments shall be of the moving iron type, with external zero adjustment. They shall be flush mounted, housed in a pressed steel or plastic case with escutcheon plate, finished matt black. Instruments shall have a compatible appearance, size and finish and be mounted on, or as near as possible to, the equipment with which they are associated. Instrument terminals shall be shrouded.

When used with starters, overload scales shall be provided.

Ammeters shall have a maximum burden of 3VA at full scale deflection.

Direct connected ammeters may be used for loads up to and including 20A. Above this load, current transformer operated ammeters shall be used. The current transformer ratio, scaling and coil ratings shall be stated on the wiring diagrams. Current transformers shall conform to BS 3938 with accuracy as Class1.

Groups of current transformers used on 3–phase systems shall have their secondary connections starred and earthed. When measuring line current values using a common meter with a selector switch, they shall be connected so that the current transformers shall be shorted out when not being used for indication. This shall be carried out in the selector switch by 'make before break' contacts.

1.17.12. Indicator Lamps

Indicator lamps shall be of the long-life LED type with in–built electronic circuitry and chrome bezels. Test relays and a push-button actuator shall be provided to test lighting-up of all lamps. Fuse failure lamps can be of the neon type with current limiting devices.

Colours of lamp lenses shall be as detailed in BS 4099: Part 1.

1.17.13. Miniature circuit breakers (MCB's)

May be installed as an alternative to HRC fuses. They shall be rated according to their manufacturer's recommendations. Spare ways shall be provided as for fuse ways but spares clipped inside the panel are not required.

Details of the MCB's shall be provided together with the characteristic curves.

1.17.14. Panel alarm system

An audible alarm system shall be provided in the form of a facia mounted electronic siren, with alarm muted lamp, mute switch and latching relay. Muting the audible signal shall not extinguish the lamp which shall remain on until the fault is cleared.

The alarm system shall permit audible indication of sequential alarms when a previous fault has been accepted but not cleared.

All 'Overload Trip' lamps and other alarm functions in any panel, shall be wired to an alarm system and to a common pair of outgoing terminals suitable for connection to a remote alarm panel. Feedback, to alarm indicators not under fault conditions, shall be eliminated. The alarm system shall be of the repeating type to permit audible indication of sequential alarms when a previous fault has been accepted but not cleared.

The alarm system shall comprise an electronic alarm integrator, alarm siren, mute button, and alarm muted lamp.

1.17.15. Testing of electrical components

All wiring within control panels shall be Works checked, prior to despatch, for loose connections, correct terminations, and compliance with wiring diagrams. In addition, functional checks shall be carried out in the Works to ensure that all interlocking and sequencing is in accordance with the performance requirements of the Specification. The Architect shall be given seven days written notice of such tests so that he may attend if he so desires.

With all control circuits disconnected but with all isolators closed and power fuses fitted, the panels shall be subjected to a pressure test of 2.5kV for one minute, across the following points:

1. Phase to phase

2. Phase to neutral
3. Phase to earth
4. Neutral to earth

This shall be followed by an insulation resistance test with an approved type of 500V testing instrument.

With all electronic components and time switches removed and with all isolators closed and power fuses fitted, an insulation resistance of not less than 50 Megohms shall be obtained between each of the following points:

1. Phase to phase
2. Phase to neutral
3. Phase to earth
4. Neutral to earth

Certified schedules detailing all tests and their results shall be submitted to the Architect within fourteen days of the tests.

1.17.16. Drawings associated with control panels

The following drawings shall be provided for each panel:

1. Schematic and external wiring diagrams which shall be presented in an approved style.
2. General arrangement drawings detailing internal and external equipment layouts.
3. Detailed label engraving drawings.
4. A drawing pocket shall be provided in each control panel

1.18. Painting

1.18.1. General

The clauses which appear under the heading shall be considered as forming part of each of the following paint specifications:

Paint shall not be applied over any surface containing traces of grit, grease, oil, etc. loose rust, loose mill scale or corrosion products of any kind.

All metal surfaces to which paint is applied shall be moisture dry. Paint surfaces which are to be overcoated shall be hard dry before overcoating unless the specification states otherwise.

All traces of soluble salts and corrosive air–borne contaminants shall be thoroughly washed from the surface prior to painting, dried and painted immediately thereafter.

Unless otherwise stated, no paint shall be applied within 50 mm of areas which are to be welded.

Welds and adjacent parent metal shall be deslagged, inspected and approved and all spatters shall be removed prior to painting.

The weld area shall be wire brushed and all contaminants shall be removed prior to painting. The weld area shall then be flushed with fresh water and allowed to dry before receiving the full specified paint system.

Surfaces which are to rest on concrete or other floors shall receive the full paint system prior to erection.

Areas where the paint coating has been damaged during transportation, erection or by any means whatever, shall be repaired as follows: Rust spots shall be removed by means of a wire brush or emery paper and the surrounding paint which is still intact shall be feathered for 20 mm beyond the damaged area. spot priming shall consist of all the coats previously applied and shall overlap the undamaged area by 20 mm.

Where the shop coat has been allowed to age for a few months before painting, it shall be light sanded or rubbed with steel wool or scrubbed with clean water, using a bristle brush.

Mating or contact surfaces shall be protected from corrosion by ensuring that the two surfaces brought into contact with each other are prepared and primed in accordance with the specification. The primed surfaces shall be brought together while the paint is still wet.

Areas which will be inaccessible after erection shall receive the full specified coating system, before erection or assembly.

Unless otherwise specified, steel embedded within concrete shall not be painted except to within 50 mm below the concrete/air interface.

All sharp edges and cut ends shall receive the specified dry film thickness of paint.

All air used for blast cleaning spraying shall be free from all traces of water and oil.

When blast–cleaning, a satisfactory blast profile (i.e., anchor pattern) shall be achieved. If the abrasive used for blast cleaning is and, then it shall be free of clay.

The contractor shall ensure that the manufacturer's recommended thinners are used for any paint.

The contractor shall ensure that the final finishing coat obscures the previous coat.

The contractor shall ensure that primed steelwork, piping etc. which is to be delivered to site is stacked on bearers and is clear of the ground. Wherever possible channels, angles, etc., shall be stacked so that water cannot collect on the steel.

Surfaces which are to be friction bolted shall be prepared in accordance with the specification (i.e., wire brushed) but shall receive no paint coating.

The paint manufacturer's instructions shall be strictly adhered to.

1.18.2. Painting of steelwork, pumps, motors, gearboxes etc.

The paint specification will be referred to as Class "D" painting.

All steelwork which is not galvanised, chrome plated or otherwise protected against corrosion shall be given a coat of protective paint at the manufacturer's works and the Contractor shall maintain this protective coat until the work is finally painted.

For surface preparation, the surfaces shall be wire brushed to remove loose rust and loose mill. One shop coat shall be applied as a primer.

One undercoat of MERIT UNIVERSAL UNDERCOAT (UC – 1) shall be applied, for site painting.

One finishing paint coat of UNIVERSAL HIGH GLOSS ENAMEL (G) in the specified colour shall be supplied.

The total dry film thickness for the coating system shall not be less than 90 micrometres.

1.19. Identification of Services

1.19.1. Requirements

The contractor shall provide identification for the purposes of commissioning, operation and maintenance of systems of all pipework, ductwork, equipment, appliances and ancillaries comprising the various systems. Comprehensively label and colour code throughout works as indicated.

Colours as indicated to colour ranges given in BS 381C and BS 4800.

1.19.1.1. Location

To be effective the identification shall be placed where it can be easily see and at positions where identification will be required. To ensure that the symbols are seen, the following shall apply:

- The symbols shall be on the surfaces, which face the positions of normal access to the completed installation.
- The symbols shall be on the surfaces, which face the positions of normal access to the completed installation.
- Structural members shall not hide the symbols from view; nor shall other ducts, pipework, plant or other services distribution systems.
- The symbols shall be placed, where possible at points with adequate natural or artificial light.
- Identification symbols shall be provided in plant rooms and remote areas. Symbols shall occur frequently enough to avoid the need for services to be traced back to their point of origin. Symbols

shall be placed at any service and access points to the distribution system including points where the distribution system has reduced to a single branch.

1.19.1.2. Method of Application of Symbols

The following methods for applying are acceptable however the main factor being that the symbol is permanently affixed. Suitable methods are:

Painting, using stencilled letters and figures.

Self-adhesive plastics or transfers with water soluble backing. Ensure that the surface is smooth and clean, and that the adhesion will not deteriorate due to the surface rounding atmosphere.

Purpose-made plastics or metal labels. 'Dino' type tape shall not be used

- LPG yellow

In practice, it is recommended to use stick-on labels of the type shown below which also have the name of the gas to facilitate the identification of the pipes.

1.19.1.3. Preparation of surface for painting

Preparation of steel surface for coating and corrosion protection of structural steelwork, where applicable to supports etc shall be in accordance with SABC 064 and SABC 1200 HC respectively.

1.19.1.4. Primary identification

Apply colour bands 300mm wide, to each pipe at least once in every room or enclosed area; at intervals not exceeding fifteen metres, at every junction; at every valve; and at every inspection and access position into service shafts, false ceilings, bulkheads etc.

1.19.1.5. Secondary identification

Apply colour bands, 50mm wide, and superimpose a legend identifying circuit, direction of fluid or gas flow, nominal pipe bore and, where appropriate, fluid or gas pressure.

1.19.1.6. Legends

Apply to colour bands by transfers of an approved type.

1.19.2. Plant and Equipment Identification, Engraved Plates

1.19.2.1. Standards

Identify each item of equipment by name and where appropriate, by agreed reference characters. Provide colour identification as called for in work sections and, in all cases, colour firefighting equipment red.

1.19.2.2. Identification Colours

Use primary and secondary identification colours of associated system.

1.19.2.3. Plates

Use rectangular metal or laminated plastic, securely fixed to each item of equipment.

Lettering – engraved plates filled with paint.

1.19.2.4. Legends

Engrave plates with an approved test. Incorporate operating duty of equipment where this is not incorporated in other labelling.

Volume 1 Part A Piped Gases Specification Section 2

Equipment data sheets

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3. Equipment data sheets

Note: All equipment to be de-rated to suit altitude

3.1. Piped gas installation

3.1.1. Vacuum pump – Plantroom

Pump serves	Medical vacuum system
Drawing no.	TBA
Reference no.	TBA
Associated control panel ref.	TBA
Type	Duty & 2 standby.
Location	Vacuum plantroom
Fluid	Air with body liquids
System temperature (°C)	Body temperature or below
Pump data	
Type	Dry vane
Nominal design flow rate (l/min)	666
Vacum level kPa	65-76
Suction diameter (mm)	Min 22 mm
Discharge diameter (mm)	Min 22 mm
Efficiency (Minimum %)	60
Method of mounting	Designated frame
Type of mounting	Pump and motor on common baseplate
Impeller	Bronze
Accessories	- Spacer coupling on drive back pull-out impeller & mechanical seals - Silencer on outlet - Large access panels for maintenance - Automatic drain to remove condensate - Run-hours inveter - Emergency stop button per pump
Controler	integral
Maximum permissible noise level within 1m from unit	79 dbA
Benchmark Manufacturer	Busch
Motor data	
Type of drive	Electric
Electricity supply (V/Ph/Hz)	400/3/50
Motor speed (RPM)	2900 max
Motor rating (kW)	1.25 max

3.1.2. Medical air compressors

Compressor serves	Central medical compressed air system [independent reticullations for medical air at 400kPa and medical air at 700kPa]
Drawing no.	TBA
Reference no.	TBA
Associated control panel ref.	TBA
Type	Duty & standby – 6 units
Location	Plantroom
Fluid	Medical compressed air
System temperature (°C)	Ambient or below
Plantroom conditions (°C)	0 -42
Compressor data	
Type	Oil free, air cooled,
Nominal design flow rate at 860 kPa(l/min)	786
Maximum Pressure (kPa)	860
Regulation Pressure (kPa)	420 + 720
Working pressure (kPa)	420
Discharge & suction diameter (mm)	Min 15 mm
Efficiency (Minimum %)	60
Method of mounting	Base plate on anti vibration mountings
Type	Compressor and motor on common baseplate
Cooling and lubrication by	Air/oil
Accessories	-- Anti insect grade and filter on inlet - Silencer on inlets - Large access panels for maintenancer - Automatic drain to remove condensater - Run-hours inveter - Emergency stop button per compressor
Maximum permisible noise level within 1m from unit	81 dbA
Air inlet temperature	Max 39.5°
Benchmark Manufacturers	OSG or approved
Motor data	
Type of drive	Electric
Electricity supply (V/Ph/Hz)	220
Motor speed (RPM)	2900 max
Motor rating (kW)	2 max

3.1.3. Cylinder Manifolds

System	Oxygen	Medical Air	
Plantroom	Oxygen reserve manifold at plantroom	Medical Air manifod at plantroom	
Size of manifold	TBA	N/a	
Mode of switching over to reserve	automatic	automatic	
Pressure at change over	Shall be set to maximise the usage of cylinders in duty bank		
Acessability to cylinders	Removal and replacement of any one cylinder shall be possible without disruption of the utilisation of the bank		
Suitable for use with cylinders up to 200bar	YES	YES	
Type of tail pipe cylinder connections	Gas specific with non return valve	Gas specific with non return valve	
Accessories	Non-return valve; filtering purge valve; pressure gauges; reducers/regulators; High Pressure switches		

3.1.4. Cylinders

Gas	Size	Nominal capacity (l)	Usable capacity (l)	Colour labeling
Oxygen [O2]	10.2	7200	6800	white
Medical Air	10.2	7200	6800	Black/grey

3.1.5. Pressure Regulators

BS standard	Type of regulator covered in the standard
BS EN 738-1	Pressure regulators for medical gases – regulators with flow meters
BS EN 738- 2	Pressure regulators – Manifold and line pressure regulators
BS EN 738-3	Pressure regulators integrated with cylinder valves
BS EN 738-4	Pressure regulators – low pressure regulators intended for incorporation into medical equipment

3.1.6. Refrigeration dryer

System	Compressed air
Number off	2
Capacity	To suit compressors output
Refrigerant	R404Aa or R 134 a
Power connection	230V/1Ph/50Hz
Dimensions	Max 600 x 600 mm
Rated test conditions	For continuous use at the system demand flow with air at 100% relative humidity at 35°c.

3.1.7. Pipework / fittings

Service	Pipe Grade	Pipes	Fittings	Jointing methods
Medical piped gases [O2; N2O; MA4 and SA7]	S.A.B.S. 1453- Copper in imperial sizes or BS EN 737 1– Medical grade copper Painted and identified as specified	Plant rooms; main reticullation; branches and trmination to units Sizes in accordance with S.A.B.C 1453 or BS 2871 9.53 to 34.88mm Pipes for oxygen must be degreased	End fed Capilary fittings to BS 864-2: SABS 1067 copper based fittings for copper tubes Phosphorus; de-oxidised; non-arsenical copper to BS 1172	Brazed joints using silver-copper-phosphorus brazing alloy to BS 1845. No flux shall be used
Vacuum	S.A.B.S. 1453- Copper in imperial sizes or BS EN 737 1— Medical grade copper Painted and identified as specified	Plant rooms; main reticullation; branches and termination to units Sizes in accordance with S.A.B.C 1453 or BS 2871 9.53 to 79.38mm	End fed Capilary fittings toBS 864-2 SABS 1067 copper based fittings for copper tubes Phosphorus; de-oxidised; non-arsenical copper to BS 1172	Generally as above For 74mm and above screwed or flanged compression fittings
Flexible hoses		BS EN 739 for low pressure hose assemblies for use with medical gases		
LPG systems – pipes imbeded in concrete	Black steel Schedule 80	Pipes from plantroom to the cooking islands / laboratory equipment	Na	Na
LPG systems – pipes exposed	S.A.B.S. 1453- Copper in imperial sizes or BS EN 737 1– Medical grade copper Painted and identified as specified	Plant rooms; main reticullation; branches and trmination to units Sizes in accordance with S.A.B.C 1453 or BS 2871 15 to 34.88mm	End fed Capilary fittings toBS 864-2: SABS 1067 copper based fittings for copper tubes Phosphorus; de-oxidised; non-arsenical copper to BS 1172	Brazed joints using silver-copper-phosphorus brazing alloy to BS 1845. No flux shall be used

3.1.8. Painting/Identification

Service	All piped gases installation
Identification standards	BS 1710 & BS 4800
Basic identification banding	Gas specific clour 150 mm 100mm Gas specific colour 150mm
Identification material	2 ply tape- printed vinyl substrate with a protective polypropylene laminate. Temperature range –10°C to 50°C (70°C intermittently). The banding shall wrap around the full circumferance of the pipe with a minimum 13mm overlap.
Identification locations	Refer to Part 3 Section 4
Indication arrows/lettering	Self adhesive to be securely adhered on above banding.
Valve & pipe tags	Engraved red on traffolite with tie fixing- each tag shall indicate if valve is normally open (N/O) or normally closed (N/C) and a unique valve ref cross referenced to 'As Installed Drawings'. All other items of equipment shall also be tagged in a similar manner e.g. sprinkler alarm valves, flow switches etc.
Other notices and labels	As per HYM 2022 specification. Engraved labels to be mounted in aluminium retaining strips and not direct to panel facsia. Plantroom and safety labels in accordance with HTM 2022 and BS standards
Benchmark Manufacturer	Focal Display Ltd (UK) or equal and approved

3.1.9. Filters

System	Medical compressed air
Note: Rating of filter assembly	Each filter assembly shall be rated for continuous use at the system demand flow, with air at 100% relative humidity at 35°C.
Pre-filter : primary stage: PRFS/CA/01 & 02	Test conditions: 1000 kPa at full flow in accordance with BS 3928
	Type: prime efficiency coalescer for removal of aerosols and solid particles down to micron 99.5% efficiency.
	Materials: sutered polyethylene element and aluminium housing
	Size: to suit compressor
After filter second stage AFSS/CA/01 & 02	Test conditions: 1000 kPa at full flow
	Type: high efficiency coalescer for removal of fine oil mists aerosols and microscopic particles down to 0.01 micron at 99.996% efficiency.
	Material: borosilicate glass mincrofibere filter element and aluminium housing
	Size: to suit compressor
Activated carbon filter – final stage ACF FS/CA/01 & 02	Test conditions: 1000 kPa at full flow
	Type: activated carbon absorption filter for removal of oil vapour and associated odors at 0.003 micron.
	Material: activated solid dralon carbon or carbon granules in full length element and aluminium housing.
	Size: to suit the compressor
Bacterial filters for vacuum BF/MV/01 & 02	Test conditions – 75kPa at full flow
	Type: in accordance with BS 3928; when tested by sodium plaque test filter efficiency shall be less than 0,005% at systems design flow.

3.1.10. Compressed air control panel MCP/CA/01

Compressors served	CMP/MG/01 & 02
Drawing No.	TBA
Volt water	Yes
Ammeter	Yes to BS 89:1977
IP rating	IP 54
Total hours counter	Yes
Pressure indicator	Yes
Thermal overload protection	Per compressor
Selector switch for compressors	CMP01/CMP02
Selector switch for dryers	RAD/01 & RAD02
Phase failure protection	Common
Automatic load / lag selection	Yes
Functions	Lamp colour
Mains supply on	Green
Compressor operating	Green
Control circuit failed	Red
Pressure fault	Red
Main motor trip	Red
Dryness fault	Yellow
Dryer pressure fault	yellow
Benchmark Manufacturer	OSG or approved

3.1.11. Vacuum pump panel MCP/MV/01

Pumps served	VP/MG/01 & 02
Drawing no.	TBA
Volt meter	Yes
Ammeter	Yes to BS 89:1077
IP rating	IP 54
Vacuum indicator	Yes
Total hours counter	Yes
Functions	**Lamp colour**
Mains supply on*	Green
Pump operating	Green
Control circuit failed	Red
Pipeline pressure fault*	Red
Benchmark Manufacturer	OSG or equal and approved

Volt free contacts for interface with annunciator panel
* these indications to be transmitted to BMS by means of volt free contacts H/D & H/C for each condition, minimum rating of 50vdc 50ma

3.2. Master alarm panel

System served	Each of following systems: Oxygen manifold; medical air and vacuum system
Drawing no.	TBA
Function	**Lamp Colour**
System *On*	Green
System *Fault*	Red
Mains Fail	Red
Control Circuit Fail	Red
Pump/ compressor Run	Green
Pump/compressor Fail	Red
Manifold duty bank on	Green
Manifold duty bank on	Red
Low system pressure	Red
Alarm Accept Push Button	Red Button
Benchmark Manufacturer	OSG or approved

3.3. Pressure Vessels / Receivers

Equipment reference no.	RCV/MV/01	RCV/CA/01
Drawing No.	TBA	TBA
Location	Pl;antroom	Plantroom
Service	Vacuum system	Medical air
British standard	BS 5169:1992 or EN 286	BS 487
Insulated	No	No
Vessel material	Steel	Steel
Vessel configuration	Vertical	Vertical
Type of ends	Fixed	Fixed
Min test pressure (bar)	10	10
Working pressure (bar)	- 850mbar	7.6
Max allowable working pressure (bar)	- 650 mbar	8.6
Max working fluid temperature °C	100	100
Compressible gas	Air or Nitrogen	Air or Nitrogen
Membrane	N/a	N/a
Capacity (litres)	200	200
Support	By purpose made stand integral to unit	By purpose made stand integral to unit
Connections	25 mm	15 mm
Safety relief valve (BS 6759 Part 2)	N/a	Yes
Drain point	Manual drain valve	Electronic drain valve
Other accessories	Vacuum guage	Pressure gauge and safety valve.
Manufacturer	OSG or approved	OSG or approved

Gas	Size
Oxygen	14.0 kg
Nitrous	31.3 kg
LPG	48.0 kg
Argon	17.4 kg
Carbon dioxide	31.3 kg
Helium	1.51 kg
Acytelene	6.90 kg

As defined on an international basis to ISO standard R 32.

3.3.1. Compressed air filters

System	Compressed air
Drawing No.	TBA
Reference no.	TBA
Location	Air compressor plantroom
Note: Rating of filter assembly	Each filter assembly shall be rated for continuous use at the system demand flow, with air at 100% relative humidity at 35°C.
Pre-filter : primary stage:	Test conditions: 1000 kPa at full flow in accordance with BS 3928
	Type: prime efficiency coalescer for removal of aerosols and solid particles down to micron 99.5% efficiency.
	Materials: sutered polyethylene element and aluminium housing
	Size: to suit compressor
After filter second stage	Test conditions: 1000 kPa at full flow
	Type: high efficiency coalescer for removal of fine oil mists aerosols and microscopic particles down to 0.01 micron at 99.996% efficiency.
	Material: borosilicate glass mincrofibere filter element and aluminium housing
	Size: to suit compressor
Activated carbon filter – final stage	Test conditions: 1000 kPa at full flow
	Type: activated carbon absorption filter for removal of oil vapour and associated odors at 0.003 micron.
	Material: activated solid dralon carbon or carbon granules in full length element and aluminium housing.
	Size: to suit the compressor

3.3.2. Vacuum air filters

System	Vacuum
Location	Vacuum plantroom
Bacterial filters for vacuum	Test conditions – 75kPa at full flow Type: in accordance with BS 3928; when tested by sodium plaque test filter efficiency shall be less than 0,005% at systems design flow.

Part C4: Site Information

PG-03.2 (EC) SITE INFORMATION – JBCC 2000 PRINCIPAL BUILDING AGREEMENT (edition 4.1 of March 2005)

Project title:	**Kimberley:DCS:Tswelopele Prison:Facilities Management contract:Building related,electrical and mechanical services**		
Tender no:	***KIM 10/22***	**Reference no:**	***19/2/4/2/2/2327/486***

C4 Site Information

Tswelopele Prison is located at Cnr Nobengula Street & Schmidtsdrift Road, Kimberley, 8301. Refer to locality/ site view below: