

**Kassala Health Citadel, Construction of the General
Surgical Unit, Kassala State, Eastern Sudan**

Medical Gas

Technical Specifications

September, 2026

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1.1 Storage System O2

This storage comprises a bottle system, which will be installed in its own prepared place.

The contract consists of the supply and assembly of the plant (exclusion of bottles that will be the property of the gas distributor).

This central consists of:

- A reduction-inversion assembly comprising two "HP" reducers with medium pressure manometer (16 bar). This allows automatic passage of the source in service to the standby source without any manual intervention as soon as the gas pressure contained in the first source low of 8 bar +/- 5%;
- The cylinder bank comprises 70 x 50-litre Oxygen cylinders arranged in duty/standby ramps, equipped with articulated unions with specific nut of the gas and of manual grip (without key). Each union is equipped with an anti-return valve and each source equipped with a purge valve.

These valves will be placed in the gas central door;

- Three parietal fixation grids, which allow the individual bottles to be immobilized with safety chains;
- A signalling device designed to ensure control of the plant shall equip this plant. This device will consist of 1 box containing one control circuits controlled by 2 "HP" contactors placed on the "HP" plumbing of the power supplies, acting on the signals as soon as the pressure of the pipeline on which they are placed low of 8 to 10 bar (+/- 5%);
- The fourth control circuit should be available.
- The alarm system shall indicate by sound and light any abnormal low of normal operating pressure and condition of operation or failure of each equipment.
- In any of these situations, the buzzer must be able to be interrupted manually, while the light signal will only be switched off when normal operating conditions are restored.

This information shall be transmitted by the alarm system and repeated to the centralized This storage comprises a bottles system, which will be installed in its own prepared place.

- Technical management system.

1.2 Storage System N2O

The contract consists of the supply and assembly of the plant (exclusion of bottles that will be the property of the gas distributor).

This central consists of:

- A reduction-inversion assembly comprising two "HP" reducers with medium pressure manometer (16 bar). This allows automatic passage of the source in service to the standby source without any manual intervention as soon as the gas pressure contained in the first source low of 8 bar +/- 5%;
- The cylinder bank comprises 8 x 40-litre Nitrous Oxide (N2O) cylinders arranged in duty/standby ramps, equipped with articulated unions with specific nut of the gas and of manual grip (without key). Each union is equipped with an anti-return valve and each source equipped with a purge valve.

These valves will be placed in the gas central door;

- Three parietal fixation grids, which allow the individual bottles to be immobilized with safety chains;
- A signalling device designed to ensure control of the plant shall equip this plant. This device will consist of 1 box containing one control circuits controlled by 2 "HP" contactors placed on the "HP" plumbing of the power supplies, acting on the signals as soon as the pressure of the pipeline on which they are placed low of 8 to 10 bar (+/- 5%);
- The fourth control circuit should be available.

- The alarm system shall indicate by sound and light any abnormal low of normal operating pressure and condition of operation or failure of each equipment.
- In any of these situations, the buzzer must be able to be interrupted manually, while the light signal will only be switched off when normal operating conditions are restored.
- This information shall be transmitted by the alarm system and repeated to the centralized technical management system.

Automatic N2O/O2 Cut-Off Safety Device

An automatic cut-off safety device shall be supplied and installed on the Nitrous Oxide (N2O) line, arranged to automatically shut off the N2O supply in the event of a loss of Oxygen (O2) pipeline pressure, preventing the delivery of a hypoxic gas mixture to any anaesthesia workstation. This fail-safe device is mandatory under NFPA 99 / ISO 7396-1 and shall be tested as part of the system commissioning.

1.3 Storage System Medical Compressed Air

This storage comprises a bottle system, which will be installed in its own prepared place.

The contract consists of the supply and assembly of the plant (exclusion of bottles that will be the property of the gas distributor).

This central consists of:

- A reduction-inversion assembly comprising two "HP" reducers with medium pressure manometer (16 bar). This allows automatic passage of the source in service to the standby source without any manual intervention as soon as the gas pressure contained in the first source low of 8 bar +/- 5%;
- The backup cylinder bank comprises 24 x 50-litre Medical Compressed Air cylinders, serving as the emergency/backup source only, equipped with articulated unions with specific nut of the gas and of manual grip (without key). Each union is equipped with an anti-return valve and each source equipped with a purge valve. The primary source

of Medical Compressed Air (MCA) shall be a Centralized Duplex Medical Air Compressor Plant, fully compliant with HTM 02-01 / ISO 7396-1, comprising oil-free (scroll or tooth type) compressors in a 1 Duty / 1 Standby auto-alternating configuration, with a minimum Free Air Delivery (FAD) capacity of 170 L/min at 8.0–10.0 bar, complete with a 500-litre vertical, hot-dip galvanized (internally/externally) air receiver tank fitted with an automatic electronic drain valve, desiccant dryers and 0.01 micron filtration.

These valves will be placed in the gas central door;

- Three parietal fixation grids, which allow the individual bottles to be immobilized with safety chains;
- A signalling device designed to ensure control of the plant shall equip this plant. This device will consist of 1 box containing one control circuits controlled by 2 "HP" contactors placed on the "HP" plumbing of the power supplies, acting on the signals as soon as the pressure of the pipeline on which they are placed low of 8 to 10 bar (+/- 5%);
- The fourth control circuit should be available.
- The alarm system shall indicate by sound and light any abnormal low of normal operating pressure and condition of operation or failure of each equipment.
- In any of these situations, the buzzer must be able to be interrupted manually, while the light signal will only be switched off when normal operating conditions are restored.
- This information shall be transmitted by the alarm system and repeated to the centralised technical management system.

1.4 Storage System Medical Vacuum

The Medical Vacuum system is a mandatory central plant service for the Operating Rooms, Surgical Unit, ICU, and Recovery areas, and shall be supplied, installed, tested and commissioned in accordance with NFPA 99 / ISO 7396-1 / HTM 02-01.

- Duplex oil-lubricated rotary vane vacuum pump set, 2 x 40 m³/hour (approx. 670 L/min combined), 1.5 kW, arranged for automatic lead-lag duty cycling with an

automatic control panel for both pumps and automatic changeover on failure of the duty pump;

- A vacuum receiver vessel of 250-litre capacity, fitted with a vacuum gauge, drain valve, and non-return valve;
- Local and master alarm monitoring for high vacuum level (low vacuum pressure), duty/standby pump run status, and pump fault, integrated with the same alarm system as the O₂, N₂O and MCA plants;
- This information shall be transmitted by the alarm system and repeated to the centralised technical management system.

1.5 Storage System AGSS (Anesthetic Gas Scavenging System)

The anesthetic Gas Scavenging System (AGSS) is a mandatory system for the Operating Rooms, removing waste anesthetic gases from the anesthesia breathing circuit and disposing of them safely outside the building, in accordance with HTM 02-01 / ISO 7396-2.

- A centralized duplex AGSS blower plant, fully compliant with HTM 02-01 / ISO 7396-2, delivering a minimum volumetric extraction capacity of 15 CFM (390 L/min) at a differential static pressure of 60 in. water gauge;
- The blower package shall be arranged for automatic duty/standby changeover on failure of the operating unit;
- The discharge line shall be routed via a dedicated stack to a safe location above roof level, terminating clear of any window, door, air intake, or occupied area;
- Local and master alarm monitoring for blower run status and fault shall be integrated with the same alarm system as the O₂, N₂O, MCA and Vacuum plants.

1.6 Primary pipeline work

The primary pipeline (8 bars) will leave the central with progressive opening sectioning valves installed at the start of the piping.

All pipeline works are insulated by easily accessible valves, placed in suitably protected areas or passages, with boxes with appropriate identification panels.

The uprights, shafts, will feed the different services.

1.7 Secondary pipeline work

Starting from the stings carried out in the pipework primary, the secondary pipework is considered starting from the double reduction sets, which will feed the different points of use (terminal units and valves).

Secondary pipework will be individually equipped with double sealed box (reduction of pressure), consisting boxes of:

- A sectional device;
- reducer, regulator ensuring the stability of the pressure to 4,0 bars (+/- 10%) in the sockets or valves of use for O₂;
- reducer, regulator ensuring the stability of the pressure to 4,0 bars (+/- 10%) in the sockets or valves of use for N₂O
- reducer, regulator ensuring the stability of the pressure to 4,0 bars (+/- 10%) in the sockets or valves of use for MCA
- A pressure gauge allowing control of pressure in the secondary pipework;
- Two special couplings (1 upstream and 1 downstream of the gear unit) to enable the installation of a distress reducer in the event of service intervention.
- These pressure reduction sets shall be placed in permanently accessible areas and shall be equipped with appropriate operating instructions and legends.
- These second reduction assemblies will be placed so as to control the sockets placed at the same level.

The pipework will also be provided with 8 bars; this pipework MCA it suits purposes pneumatic for the operating room. Surgical Tool Air (Instrument Air) shall be maintained at 7,0 to 8,0 bars at the point of use, distinct and separately regulated from the 4,0-bar Medical Compressed Air (MCA) pipeline service. This service shall be uniformly designated "AM7" (or equivalently "SA7") throughout all drawings, schedules and labelling; the Contractor shall correct any inconsistent use of "AM7"/"AM8" nomenclature currently present across the tender drawings prior to fabrication.

1.8 Pipeline

The pipes must be made of electrolytic copper, phosphorus, deoxidized and seamless.

Pipe Sizing Schedule

Service Name	System Pressure	Plant Header (mm)	Sub-Spine Core (mm)	Corridor Branch (mm)	Terminal Drop (mm)
Medical Oxygen (O2)	4.0 Bar	Ø 28 x 1.2 mm	Ø 22 x 1.0 mm	Ø 15 x 1.0 mm	Ø 12 x 1.0 mm
Medical Air (MA4)	4.0 Bar	Ø 22 x 1.0 mm	Ø 22 x 1.0 mm	Ø 15 x 1.0 mm	Ø 12 x 1.0 mm
Surgical Air (SA7)	7.0 Bar	Ø 15 x 1.0 mm	Ø 15 x 1.0 mm	Ø 12 x 1.0 mm	Ø 12 x 1.0 mm
Nitrous Oxide (N2O)	4.0 Bar	Ø 15 x 1.0 mm	Ø 12 x 1.0 mm	Ø 12 x 1.0 mm	Ø 12 x 1.0 mm
Medical Vacuum (VAC)	-0.6 to -0.9 Bar	Ø 42 x 1.5 mm	Ø 35 x 1.5 mm	Ø 22 x 1.0 mm	Ø 15 x 1.0 mm
AGSS Exhaust	High-Volume, Low Static	Ø 35 x 1.5 mm	Ø 28 x 1.2 mm	Ø 22 x 1.0 mm	Ø 15 x 1.0 mm

1.8.1 Piping installation

The connections must be soldered, with a minimum content of 40% silver. All brazing operations shall be performed with continuous internal oil-free dry nitrogen purging (2–5 l/min) to prevent internal oxidation.

All changes of direction must be carried out with accessories of the same material.

Hot bending is strictly prohibited. All bends and changes in direction shall be made using factory pre-formed degreased copper fittings or approved cold-bending tools without heating, to prevent internal oxide scaling.

The tubing must be mounted externally, fixed to the wall or ceiling by clamps.

1.8.2 Pipe supports

The pipeline should be adequately supported at sufficient intervals in accordance with Table to prevent sagging or distortion. Support for surface mounted pipework should provide clearance to permit painting of the surface. Where it is essential for pipes to cross electric cables or conduit, they should be supported at intervals on either side of the crossing to prevent them from touching the cables or conduit. Supports should be of suitable material or

suitably treated to minimise corrosion and prevent electrolytic reaction between pipes and supports.

1.8.3 Protection of pipeline work

Where pipes are to be hidden (i.e. buried in walls or structures) they shall run in conduit or other suitable hard protective piping, or run in metal channels built in and flush with the finished wall surface, with suitable covers painted to match the wall finish.

Where pipes are to be run in a location where they may be damaged by trolleys, stretchers or similar mobile equipment, or where they may be interfered with by the general public or other unauthorized person, they shall be protected by encasement in pipes or metal channels up to a height of 2 m. The route of the pipes shall be so selected that they are out of the reach of traffic and the general public.

Piping in ducts, roof spaces or above suspended ceilings shall be laid in Admiralty type cable trays. These cable trays must wherever possible be installed 150mm clear of any other piping or conduits run in the same roof space, unless otherwise authorized by the health certification entity

All pipes in operating theatres shall be concealed or built in.

Where the pipes pass through walls and ceilings, etc., they shall be sleeved and provided with wall plates, which shall be rust free and painted to match the general wall finish. Where several pipes of different diameter are surface mounted side by side, the saddle centre distance appropriate for the smallest diameter pipe shall also be used for the larger pipes.

1.9 Brackets

Pipe support brackets and clamps shall be hot-dip galvanised.

1.10 Identification of pipelines

Pipelines should be identified in accordance with BS 1710 / HTM 02-01 / ISO 7396-1, and colour banding for the pipelines should be used. Colour band identification (see Figure 35) should be applied near to valves, junctions, walls etc. A label applied every 3 m and bearing

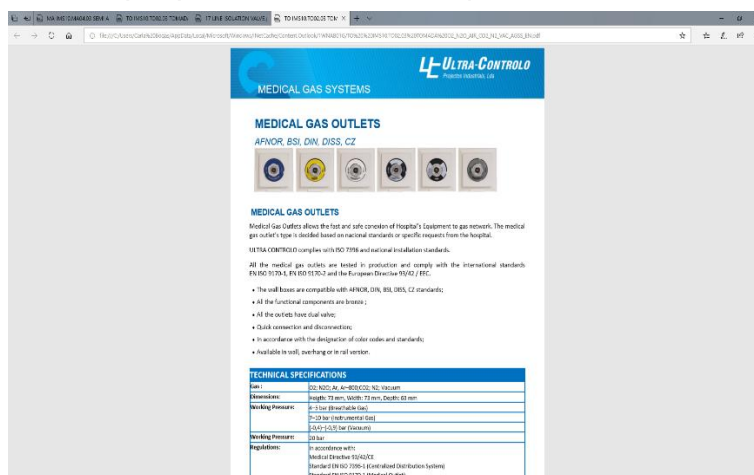
6 mm size letters should identify each gas. Self-adhesive plastic labels of approved manufacture may be used for this purpose. A band 150 mm wide is usually adequate. All colour-coded tapes applied by the pipe manufacturers should be removed before the systems are identified in accordance with this.



1.11 Medical gas outlets

All wall outlets shall be positioned 1,5 m above floor level in positions shown on the drawings. Fittings and outlets from the same supplier shall be used throughout the entire hospital. Outlet points on all new hospital installations shall be flush mounted, non-protruding, quick coupling, self-isolating types with safety keyed connections. The probes must be marked the same colour

as the cover plate.



For new installations in existing hospitals where surface mounting of tubing and fittings is specified, outlet points shall be as above and be of the surface mounted type. The use of check valves incorporated in the outlet point.



1.12 Ball valve

The ball valve just needs a quarter turn to isolate medical gas networks and ensure optimum safety during maintenance.

This device is supplied degraded and medical O₂, N₂O and MCA compatible. It should be installed all along the medium- and low- pressure network, easily and quickly mounted thanks to its ready-to-braze fitting.

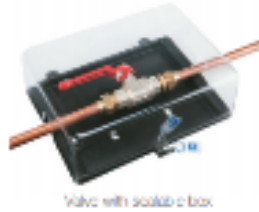
1.12.1 Technical characteristics

¼ turn to isolate the network:

- Max. operating pressure 20 bar;
- Connection to the network ready-to-braze on copper tube;
- Materials Nickel-plated brass body and hard chrome ball valve
- Weight 325 g for valve 08x10 3/8" up to 5.4 kg for valve 50x52 2"

1.12.2 Area valve service unit box

The area valve service unit Box is made to allocate the isolation valves and safety devices of the medical gas pipe system and to be used at emergency or maintenance purposes. It is a lockable box with quick emergency access. The construction is made of a metallic box (galvanised steel or aluminium) with protective coating in epoxy, fitted with a transparent pull-out/break-glass emergency front cover, giving an excellent finishing and easy surface cleaning, and satisfying hospital fire-rating requirements under HTM 02-01 / NFPA 99.



1.12.3 Pressure reduction

Pressure regulator is an essential device for double stage network standard.



This pressure regulator allows the safe pressure reduction of medical gasses from medium to low pressure and the network back-up in case of an emergency.

This accessory is a single pressure reducer.

Technical characteristics

- Safety plate: continuous supply, a network shut-off is impossible
- They have 2 pressure gauges: 1 upstream and 1 downstream, color-coded to facilitate pressure control
- The cover protects against chock and dust
- Quick and easy action in case of emergency
- On/Off in just one action
- Compatible with all gasses
- Easy and fool proof reversal of gas flow direction
- Optimised space: compact, lightweight with simplified installation
- Control lever for fast action in a single motion
- Interchangeable pressure reduction module, positioned vertically, no risk of falling
- Continuous gas distribution because modules can be maintained separately

Specifications:



Alarm System

To maintain a stable supply of medical gasses, it is necessary to establish a monitoring system which surely traces the flow of invisible gas from the source of supply through piping to the section to use the gas. We have been offering various monitoring systems which are able to grasp the information of the supply source such as the amount of gas remaining in the right and left banks of manifold and the operating condition of the supply station and the pressure of gas supplied at each area of section where the gas is used. In this system, a supply pressure down and a supply station's malfunction are surely grasped by audio-visual

tracing.



1.12.4 Alarm system

The alarm system provides security for the network from the high pressure gas station to the wall outlet.

This alarm monitors the whole network and indicates any error via audible, luminous, and visual signals. This alarm provides global monitoring, for the safety of all.

Technical characteristics:

- Normal operation indicated by a green LED ●

- Default situation indicated by:
 - A red LED 
 - An audible alarm 
 - An explicit message on the LCD screen
 - Test button to check LED, LCD and sound alarm
 - Simultaneous monitoring of 3, 5 channels
 - Use of analogue or digital sensors

1.12.5 Central station

Alarms with digital readings of the Pressures should be installed in the Central plant for the following situations:

Manifolds with dewars or cylinders (usually O₂, N₂O, MCA,) each gas will most often have lights for:

- High main line pressure
- Low main line pressure
- Secondary in use (changeover)
- Reserve in Use
- Reserve low pressure

1.13 Secondary Network Alarms

Alarms and secondary networks shall be installed in the following zones:

- In all services.

The alarms should be of the acoustic and luminous type, digital reading of the pressures, the acoustic being switched off manually, while the light will stop acting only when the normal conditions of the networks are restored.

They should be installed, in a visible place, normally next to the nursing workstations, next to the O₂ / N₂O pressure safety coffrets and 2nd reduction pressure.

They are intended to control the operating conditions of secondary networks, where:

- if there are anomalies in the O₂ / N₂O safety sets and 2nd reduction sets
- if there are variations in the net pressure of:
- -10% for pressure networks.

This equipment must comply with the Standards ISO 7396-1 and HTM 02-01 (EN 737-3 has been withdrawn and superseded).

Specifications alarms:

1.14 Pressure sensor

Analogue pressure sensors are the key components in pressure monitoring. Installed all along the pipeline work, from the high-pressure gas station to the wall outlet, they are an information



source for all the gasses.

1.15 Auxiliary Facilities

1.15.1 Electrical Installations

All the equipment of medical gasses should be powered from the Hospital's emergency distribution network, as provided for in the Electrical Installations project.

The equipment to be installed must comply with the requirements required by the environment in which it is located.

Its construction and connections to the diverse equipment, must obey the regulation in force.

The alarms of the secondary networks will be fed from terminal boxes at nearby points.

It will be executed in accordance with the regulations in force, and with the specifications included in these specifications.

The following assemblies are included:

- Switchboards of the Central Air Compressed Medicinal and Oxygen and N₂O;
- Ground connections of different equipment and networks.

1.15.2 Tests And Experiences

Initial pressure test: Each section of the piping system must be subjected to a test pressure of 1.5 times the normal system working pressure (depending on service), sustained for a duration of 2 to 4 hours with zero leaks or pressure drop;

- Cross-connection test: The installer must make sure that the right gas is delivered at each wall outlet, i.e. there are no "cross-connections". Each wall outlet is tested to ensure that the correct gas emerges only from the outlets being tested, rather than from some extra random outlets somewhere.
- Pipeline purge: a high-pressure gas purge of each outlet; "until no discoloration is produced on a white cloth that is held over the outlet"
- Standing pressure test: the entire system is subjected to a 24-hour test with a pressure 20% above the normal operating line pressure and with all the valves closed. The maximum allowable pressure decay after this 24-hour period is $\leq 1\%$, corrected for ambient temperature variation. This test is to identify leaks.
- These should be performed by somebody competent who is not associated with the installer.
- Standing pressure test: just like the 24-hour test, except for 10 minutes.
- Cross-connection test: more or less identical to the installer's version
- Valve test: to ensure all the valves actually work
- Alarm test: one must ensure that gas failure alarms are actually working
- Piping purge test: again, observing the appearance of blown out particulate matter on a piece of white cloth.

- Piping purity test: a test whereby the outlet gas is tested for dew point, methane, and halogenated hydrocarbons. The dew point of compressed air lines shall not exceed $\leq -40^{\circ}\text{C}$ at atmospheric pressure.
- Final tie-in test: this is performed when you have commissioned the entire system, and then decide to add extra pipes. The new system extensions must be tested for leaks at normal system pressure.
- Operational pressure test: The outlets must all deliver a certain flow, and they must all this without a significant drop in pressure. The specifics are:
 - Flow rate no less than 100 L/min (and 140 L/min for nitrogen).
 - Pressure drop no more than 35 kPa for any gas

1.15.3 Staff training

All personnel handling medical gas cylinders must be trained on the risks associated with this activity.

This includes paramedics, stretcher bearers, caregivers, nurses, technical and biomedical staff, doctors, pharmacists, preparers and handlers.

Likewise, in departments equipped with medical fluid rescue devices (blocks, post-operative follow-up care, etc.), anesthesiologists must be trained regularly for the procedure to be implemented in the event of a lack of fluid supply medical.

Finally, the addition of a "medical fluids module" during initial training must be advised.

Medical gas suppliers offer training for different categories of staff