Azadi Ka Amrit Mahotsav

सत्यमेव जयते

स्वच्छ भारत
एक कदम स्वच्छता की ओर

CPWD GENERAL SPECIFICATIONS FOR MEDICAL GAS PIPELINE SYSTEM 2022

CPWD



Published under the Authority of
Director General CPWD, Nirman Bhawan, New Delhi

सत्यमेव जयते

भारत सरकार
Government of India

केन्द्रीय लोक निर्माण विभाग

C P W D

GENERAL SPECIFICATIONS FOR MEDICAL GAS PIPE LINE SYSTEM (MGPS)

CPWD

महानिदेशालय, के.लो.नि.वि., निर्माण भवन, नई दिल्ली 110011

DIRECTORATE GENERAL, CPWD, NIRMAN BHAWAN, NEW DELHI 110011

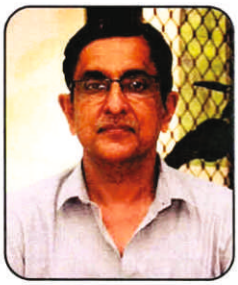
COPYRIGHT

© All rights reserved. No part of this publication, either in English, Hindi or any other language, may be reproduced in any form or by any means, electronic or mechanical including photocopy, recording or any information storage and retrieval system, without permission, in writing, from the Director General, CPWD, New Delhi.

DISCLAIMER

1. **Whereas every care has been taken to ensure that all relevant and essential provisions required for execution of Construction and Maintenance Works are incorporated in this Specification in a simplified and transparent manner, all executing entities referring to are requested to bring it to the notice of the Directorate, if any conflicting provisions/ discrepancies are noticed in the Specification.**

2. **This specification is prepared for the use of CPWD. However, this may be used by other government departments, PSUs, private bodies & other institutions or individuals at their own discretion only. CPWD shall not be responsible for any ambiguity, discrepancy, dispute or financial loss, arising directly or indirectly by using or following items in specification by such Government/ Private bodies or individuals.**



Shailendra Sharma
Director General

सत्यमेव जयते

भारत सरकार
Government of India

CPWD

केन्द्रीय लोक निर्माण विभाग
निर्माण भवन, नई दिल्ली-110011
Central Public Works Department
Nirman Bhawan, New Delhi-110011
Tel : 23062556/1317, Fax : 23061884
E-mail : cpwd_dgw@nic.in

FOREWORD

CPWD has been maintaining and executing hospitals all over the country. New hospital works right from system design to installation, testing and commissioning are executed by CPWD and also operated and maintained under our supervision in many cases. Hospital buildings and projects have become even more important due to Government's priority and commitment towards providing world class health infrastructure to the citizens of India. Due to a variety of services being involved, most of the hospital projects are complex in nature, sensitive due to human life being involved and also critical due to requirement of 24x7 operation. In recent past many major hospital projects have been allotted to CPWD all over the country for constructing AIIMS, CAPFIMS hospital project, ESI hospitals etc. besides others. Hence, the need for bringing out the CPWD Specifications for highly specialized services like Modular OT, MGPS, Nurse Call System and Pneumatic tube Transport system was felt.

Medical Gas Pipe Line System is a critical area of hospital infrastructure which involves complex design catering to essential gases & services covering Medical Oxygen (O_2), Nitrous oxide (NO_2), Carbon dioxide (CO_2), Medical Air Supply System, Medical Vacuum (Suction) Supply System and Anaesthetic Gas Scavenging (AGSS) system along with related Automatic Control Panels, Distribution Piping, Valves, Alarm systems, Gas Outlets, Bed Head Panels etc. The works have to be planned and executed with high degree of precision and complying to standards to ensure trouble free and smooth operation of OTs, ICUs, wards, etc. keeping in mind utmost important aspect of minimizing/avoiding infections and ensuring availability of essential gases at all times.

These specifications incorporate the latest technology & developments in the field. References have been taken from the leading international standards and best practices being followed globally.

I would also like to put on record my appreciation of Sh.Dharmesh Chandra Goel, ADG(Tech.), Sh.Surendra Singh, then ADG(W), Sh.Vimal Kumar, CE(E) CSQ and his team, for putting in untiring efforts in preparing the specifications. We also acknowledge the initial contribution of Late Sh.D.K. Tulani, SE (E) TAS for giving his inputs in framing these specifications.

Any errors, omissions or suggestions for modification in this specification may be referred to CE (E) CSQ in the office of Chief Engineer, CSQ (E), CPWD, Nirman Bhawan, New Delhi-110011 on email delceecsq.cpwd@gov.in.

New Delhi
June, 2022

(SHAILENDRA SHARMA)



Dharmesh Chandra Goel
Addl. Director General (Tech)

सत्यमेव जयते

भारत सरकार
Government of India

केन्द्रीय लोक निर्माण विभाग
निर्माण भवन, नई दिल्ली -110011
Central Public Works Department
Nirman Bhawan, New Delhi-110011
Tel: 23063389, Fax : 23061833
Email: adgtd@nic.in

PREFACE

Various healthcare facilities & infrastructure are being dealt by CPWD for a long time on the basis of norms fixed by different statutory bodies. With changing needs and passage of time, various modifications were proposed and inputs given by different organizations with respect to norms & guidelines related to healthcare. Since, there are no Specifications available by BIS on the subject of Medical Gas Pipe Line System, which is a critical component in Hospital Projects, a need was felt to compile CPWD specifications for Medical Gas Pipe Line System for the use of architects as well as engineers of CPWD.

CPWD General Specifications for Medical Gas Pipe Line System provides detailing regarding critical components of Medical Gas Pipe Line System.

Whole hearted commitment and considerable efforts has gone in to the preparation of this edition of CPWD Specifications for Medical Gas Pipe Line System. I convey my deep appreciation and sincere thanks to Shri. Vimal Kumar, CE (E) CSQ, Sh. Saurabh Kumar, SE (E) TLQA, Shri. Rajiv Gupta, EE(E)TLQA, Shri Bhagwan Ram, AE(E) TLQA and staff of CSQ(E) unit whose names are not mentioned here for the sake of brevity for their sincere efforts made in the preparation of this document. Various individuals, firms dealing in similar type of work, field units, have immensely contributed with substantial inputs. CSQ (E) unit is indebted for their support.

I convey my gratitude to field offices at Delhi who rose to the occasion and provided sufficient data base to CSQ (E) office and thus enabled them to come out this publication. The team shall now be working on developing schedule of rates of various items involved for execution of Medical Gas Pipe Line System.

This maiden effort has been to bring out this publication in the due care. However, there is possibility of inadvertent errors made. Error or omission may be brought to the notice of Chief Engineer (E) CSQ, CPWD, Room No. 229-A Wing, Nirman Bhawan, New Delhi-110011 (Tele:- 011-23061418) for strengthening these specifications further in larger public interest and in the interest of service towards healthy Bharat.

Suggestions for improvement are welcome.

Place: New Delhi
Date: July, 2022

(Dharmesh Chandra Goel)
Additional Director General (Technical)

REFERENCES OF AMENDMENTS

Sl.No.	Reference under which issued	Chapter No	Item No	Page

INDEX

Chapter	Description	Page No.
Chapter 1	General	1
Chapter 2	Planning for Medical Gas Pipe Line System (MGPS)	17
Chapter 3	Medical Oxygen Supply Installation Including Liquid Oxygen Systems & Oxygen 93 Systems	33
Chapter 4	Nitrous Oxide Supply Installation	43
Chapter 5	Medical Compressed Air Installation	47
Chapter 6	Medical Vacuum System Installation	62
Chapter 7	MGPS Plant Control System for Medical Air System And Medical Vacuum Systems	71
Chapter 8	Medical Carbon Dioxide Supply Installation	73
Chapter 9	Anaesthetic Gas Scavenging (Disposal) Systems (AGSS) Installation	77
Chapter 10	Pipeline Distribution System	81
Chapter 11	MGPS Pressure Monitoring and Alarm Systems	98
Chapter 12	Commissioning and Handing Over	106
Chapter 13	Medical Gas Pipeline System Maintenance	109
Chapter 14	Terminology	112
Chapter 15	Technical Specification of Medical Gas Pipeline System	118
Chapter 16	Sample BOQ of MGPS	148
Chapter 17	Sample Compliance Sheet of Medical Gas Pipe Line System (MGPS)	154
Chapter 18	Indian/ International Standard Applicable for The Work of MGPS System	164
Chapter 19	Codes & Guidelines for MEP and other Hospital Services in Hospitals	166
Chapter 20	Licenses, Permits & Statutory Obligations for Hospitals in India	168

CHAPTER 1

GENERAL

1.1 SCOPE OF WORK

The scope of this specification cover works of Supplying, Installation, Testing and Commissioning of MEDICAL GAS PIPE LINE SYSTEM (MGPS) on turn key job basis including the following:

(i) a. Primary Liquid Medical Oxygen (LMO) tank system including Control Panel & Automatic Switchover arrangement.

b. Secondary oxygen manifold and emergency oxygen manifold with automatic control panels.

(ii) Nitrous oxide (NO_2) manifold and emergency NO_2 manifold with automatic control panel.

(iii) Carbon dioxide (CO_2) Manifold with automatic control panel.

(iv) Medical Air Supply System (4 Bar & 7 Bar) complete.

(v) Medical Vacuum (suction) Supply System complete.

(vi) Anaesthetic Gas Scavenging (AGSS) system complete

(vii) Distribution Piping Complete with accessories.

(viii) Area Valve Service System.

(ix) Alarm systems (master & area).

(x) Gas Outlets with Probes.

(xi) Bed Head Panels.

(xii) Control cabling from / to control panel and associated sensors

(xiii) Other associated works.

(xiv) Site modifications

(xv) Comprehensive maintenance of MGPS installation

1.2 In the above context, the General Specification for MEDICAL GAS PIPE LINE SYSTEM (MGPS) lays down general guidelines to ensure safe, efficient, reliable and economical provision and use of MGPS infrastructure.

1.3 While these Specifications serve as general guidelines, appropriate technical sanctioning authority can depart from such guidelines to meet the particular requirements of any work or for other technical reasons including requirement of hospital authority.

1.4 This chapter covers the general commercial and technical requirements applicable to works contract for execution of MEDICAL GAS PIPE LINE SYSTEM (MGPS).

1.5 These General Specifications are subject to revision from time to time.

1.6 The site modification works if and as required (particularly for existing sites) shall include all modifications to the built up space provided at the hospital site as those required for the Installation of MGPS equipment, related control and communication systems, civil modifications, electrical works, plumbing works, piping, interiors, Medical Gas Pipe Lines installations, and other related works of the MGPS required for the smooth and efficient functioning. These works shall comply with all relevant safety and standards guidelines. The firm shall be fully responsible for installation, testing and commissioning of all equipment mentioned in the tender complete as required.

1.7 Integration and Co-ordination Works with other service agencies:–

1.7.1 MGPS firm has to share the MGPS layout , piping and cabling drawings with the other firms working in the same area as required for superimposing the MGPS system components, piping, cabling etc with other services to identify clashes and take remedial measures, before the commencement of MGPS work at site, as per the finally approved drawings from department.

1.7.2 In case of new construction in which MGPS firm is involved from the beginning, they will ensure that the required cutouts for cabling and piping are made during the construction. However, if not available or in case existing site the MGPS firm has to provide required cutouts for piping and cabling works wherever required for their works. This exercise shall be taken up in coordination with Integration firm/other firms and requisite markings shall be done and got approved from consignee/institute/ department, as required.

1.7.3 MGPS firm has to make provision in ceiling for installation of MGPS system or its piping/ cabling etc. as per approved drawings

1.7.4 Bidders are strongly advised to visit the existing site (if applicable) for assessment before the submission of tender offer.

1.7.5 The layout of the building plans and other drawings as attached with the NIT, if any, are to be referred to.

1.7.6 MGPS firm has to integrate their services with other services being executed in the building or existing already.

1.7.7 In composite works, the planning and integration of MGPS has to be done along with other multiple services provided in the building in BIM software at the initial stage so that clashes of services can be identified and suitable decision can be taken at the planning stage. MGPS firm will be responsible to provide requisite autocad drawings and inputs as required, at appropriate stage.

1.8 The following shall be in the scope of the Bidder:-

1.8.1 Supplying, Installation, Testing and Commissioning of complete MGPS system and all items indicated in the NIT etc. as per technical specification described therein.

1.8.2 All piping, cable conduit, trenches and railings wherever required.

1.8.3 All electrical accessories like cable wire, electrical outlets, switches, Control panels, etc should be fire rated, of reputed make as stipulated in NIT, certified for electrical safety as per related standards of the item/ service.

1.8.4 Testing, Installation and commissioning of all equipment/services.

1.8.5 Any other necessary work required for satisfactory working/performance of the MEDICAL GAS PIPE LINE SYSTEM (MGPS) and not mentioned/specified otherwise.

1.9 Eligibility Criteria for MGPS Contractor:-

MGPS work is a specialized work as per CPWD Works Manual and the contractor shall have to fulfill the eligibility criteria or in case of composite contract engage a specialized MGPS agency for complete design, supplying, installation, testing, commissioning and comprehensive maintenance of Medical Gas Pipe Line System as required.

The eligibility criteria shall be as per following:

The MGPS firm should have successfully completed following Medical Gas Pipeline System (MGPS) works during the last seven years ending last date of the month previous to the one in which tenders are invited:

Three similar works, each costing not less than 40% of the estimated cost put to tender,

OR

Two similar works, each costing not less than 60% of the estimated cost put to tender,

OR

One similar work costing not less than 80% of the estimated cost put to tender.

Here similar work shall mean supply, installation, testing and commissioning of MGPS work in India, which may also include comprehensive maintenance of MGPS installations. Comprehensive maintenance of MGPS installations standalone work are not covered in similar work.

(The value of executed works shall be brought to current costing level by enhancing the actual value of work at simple rate of 7% per annum, calculated from the date of completion to the last date of submission of bid).

In case, the qualifying experience certificate is from Private sector/ Charitable Hospital, the firm/ vendor should submit the TDS certificate as a proof of having executed the said work.

1.10 RESPONSIBILITY OF THE CONTRACTOR

1.10.1 The contractor shall be primarily responsible for successful supply, installation, testing, commissioning of complete MGPS, OEM warranty for products, defect liability and comprehensive maintenance of MGPS installations for ten years (5 years warranty plus 5 years CAMC) from the date of completion of the work.

1.10.2 The MGPS firm shall execute complete work including submission of layout drawings, walk-through view and working drawings. If stand-alone MGPS work is to be executed in an existing building, the auto-cad or PDF or hard copies of building layout drawings will be provided by the hospital/ department for preparation of MGPS drawings.

1.10.3 The contractor shall provide dedicated power supply distribution within the MGPS plant room, yard, manifold rooms and dedicated earthing for MGPSs as per scope of work defined in NIT. The earthing shall conform to CPWD Specifications.

1.10.4 The contractor, shall carry out necessary modification in civil and electrical components, demolition and other works as may be required for complete installation and trouble-free functioning of the MGPSs.

1.10.5 The MGPS firm shall coordinate with fire-safety (Fire Alarm, Fire Fighting, Security) firm for installation of fire-safety sensor/instrument wherever required.

1.10.6 The MGPS firm shall coordinate with other firm/s working in the same area/ premises for the successful completion of MGPS.

1.10.7 The MGPS firm shall cooperate for installation and commissioning of other medical equipment (like integration equipment in OTs, ICUs, wards, monitors, etc.) in coordination with hospital authorities, respective firm/s and the department.

1.10.8 The MGPS firm shall successfully complete installation, testing and commissioning of all MGPSs along with all equipment included in the scope of MGPS work as per technical specifications of MGPS.

1.10.9 The MGPS firm shall provide factory test certificates for the materials/equipment used for the installation of MEDICAL GAS PIPE LINE SYSTEM (MGPS).

1.10.10 The MGPS firm shall supply complete set of manuals for all the systems and sub-systems.

1.10.11 The MGPS firm shall arrange at his cost on-site training of consignee/user for a week or more as required by original equipment manufacturer (OEM), wherever required.

1.10.12 Final electrical safety test, system test, and calibration shall be done as per required standard for the equipment installed by authorized persons using calibrated test equipment, and declaration to this effect shall be submitted by the MGPS firm.

1.10.13 Outlets of the anesthesia and surgeon pendants shall match with the existing outlet, if any, in the same building/block.

1.10.14 The MGPS firm shall execute all the electrical, mechanical and other works as per CPWD Specifications, as specified NIT.

1.10.15 All queries/clarifications along with pre-installation requirements shall be submitted before pre-bid meeting.

1.10.16 The contractor shall supply only new, unused material/goods and incorporate all recent improvements in design and materials in the work.

1.10.17 The contractor shall be responsible for defect liability, OEM warranty of products and comprehensive maintenance of MGPS installations for ten years (5 years warranty plus 5 years CAMC) from the date of completion of the work through the same MGPS firm. The comprehensive maintenance of MGPS installations includes complete MGPS installations, labour, spares, all consumables, filters etc. In the case of MGPS equipment, the comprehensive maintenance shall be done with back-to-back support from OEMs.

Note: NIT authority may incorporate suitable clause in NIT to safe guard the interest of Govt/ work. for front loading of tender in respect of the warranty period.

1.11 RESPONSIBILITY OF CONTRACTOR FOR SITE MODIFICATION (APPLICABLE ONLY FOR STANDALONE MGPS WORK TO BE EXECUTED IN EXISTING BUILDING).

1.11.1 The "Site Modification" work includes all modifications to the built-up space at the hospital site like civil works, electrical works, plumbing works, interior decoration, air conditioning ducting and other related works required for smooth and efficient functioning of the MGPS. These works shall comply with all relevant safety and standards guidelines. The contractor shall be fully responsible for installation and commissioning of all equipment mentioned in the tender. Bidders are strongly advised to visit the site for assessment before the submission of tender offer.

1.12 RESPONSIBILITY OF CONSIGNEE/CPWD (APPLICABLE ONLY FOR STANDALONE MGPS WORK TO BE EXECUTED IN EXISTING BUILDING).

1.12.1 The hospital/institute/department will provide MGPS shell structure/ premises where work is to be executed.

1.12.2 The hospital/institute/department will provide hot and cold water supply as and where required with drain and 5A/15 A switch sockets at required locations.

1.12.3 The hospital/institute/department will provide electrical power supply for installation free of cost.

1.12.4 The hospital/institute/department will provide LAN cable and telephone outlets at required plant room/ control room as required.

1.12.5 The MGPS firm shall associate the engineers and technicians of the Institute/hospital/ department during installation, testing and commissioning.

1.13 Related Documents

1.13.1 Each work has its own particular requirements. Therefore, in addition to this General Specifications, governing HTM/ ISO/ NFPA/IEC, I.E. Rules, Standard Contract

Conditions and necessity of additional conditions/ specifications for a particular work. In case of any discrepancy such additional conditions/ specifications will override these General Specifications. Para No 1.34 a) of this specification should also be referred to.

1.14 Terminology

The definition of terms shall be in accordance with HTM/ ISO/ NFPA/IEC, I.E. Rules which are defined in above mentioned specifications. Some of the commonly used terms are indicated in Chapter 14.

1.15 Submission of Tenders

1.15.1 The tender shall be submitted complete with the following:-

(i) Complete tender documents as purchased/downloaded from CPWD website duly filled in and submitted. The price part of the tender shall be indicated only on the tender schedule of work as per NIT.

(ii) Earnest Money deposit in one of the specified forms as per laid down rules issued from time to time, as applicable.

(iii) Any other supplementary details required for the evaluation of the tenders such as drawings, technical literature/ catalogues, data etc.

1.15.2 Where two part tendering system is proposed to be adopted in any particular work, the procedure for submission and opening of tenders shall be indicated in tender documents for that work.

1.16 Rates

1.16.1 The work shall be treated as on works contract basis and the rates tendered shall be for complete items of work (except the materials, if any, stipulated for supply by the department) inclusive of all taxes (including GST etc. if any), duties, and levies etc. and all charges for items contingent to the work, such as, packing, forwarding, insurance, freight and delivery at site for the materials to be supplied by the contractor, watch and ward of all materials (including those, if any, supplied by the department) for the work at site etc.

1.16.2 Prices quoted shall be firm. Price adjustments shall however be governed by Clause 10C/ 10CC of the Conditions of Contract as given in form CPWD 7 or 8 of the tender documents, for works executed under these forms. All relevant documents shall be produced by the contractor to the Engineer-in-charge, whenever called upon by him to do so, for working out such adjustments in rates.

1.17 Taxes and Duties

1.17.1 Being an indivisible works contract, GST, Excise Duty etc. are not payable separately.

1.17.2 The works contract tax shall be deducted from the bills of the contractor as applicable in the State in which the work is carried out, at the time of payments.

1.17.3 Octroi shall not be paid separately for the materials supplied by the contractor, but the Department, on demand, can furnish octroi exemption certificate. However, the Department is not liable to reimburse the octroi duty in case the concerned authorities do not honor such exemption certificates.

1.18 Mobilization Advance

1.18.1 No mobilization advance shall be paid for the work, unless otherwise stipulated in tender papers for any individual work.

1.19 Works to be Arranged by the Department (in case of stand alone work of MGPS).

1.19.1 Unless and otherwise specified in the tender documents, the following works shall be arranged by the Department:

(i) Storage space for all equipment, components and materials for the work.

(ii) Supply of materials to the contractor as stipulated in the tender documents.

(iii) Space/structure for erection of MGPS structure and related equipment/services.

(iv) Required shaft/s for MGPS riser.

(v) Provision of electrical power & data input at all Bed Head Panel (BHP) Locations at the height of 1250mm or as approved (wrt centre of the BHP) from FFL as per approved plan of consignee.

Note: In case of EPC contracts, the firm shall be responsible for above as a whole since the complete building/structure to be built shall be within his scope and hence the above item also as per scope defined in NIT.

1.20 Works to be done by the Contractor

1.20.1 Unless and otherwise mentioned in the tender documents, the following works shall be done by the contractor, and therefore their cost shall be deemed to be included in their tendered cost: -

(i) Foundations for equipment and components where required, including foundation bolts.

(ii) Cutting and making good all damages caused during installation and restoring the same to their original finish.

(iii) Sealing of all floor openings provided by him for pipes, cables,etc from fire safety point of view, after laying of the same.

(iv) Painting at site of all exposed metal surfaces of the installation other than pre-painted items. Damages to finished surfaces of these items while handling and erection, shall however be rectified to the satisfaction of the Engineer-in-charge.

(v) Testing and commissioning of completed installation.

1.21 STORAGE AND CUSTODY OF MATERIALS

1.21.1 Suitable space for storage shall be provided by the Department free of cost to the contractor but the required arraignment / set up for storage of materials in the spared space including locking arrangement shall be provided by the agency. Also, the watch and ward of the stores and their safe custody shall be responsibility of the contractor till the final taking over of the installation by the Department.

Note: In case of EPC contracts, the firm shall be responsible for above as a whole since the complete building/structure to be built shall be within his scope and hence the above item also shall be deemed to be in the scope of firm, as per details give in the NIT

1.22 POWER SUPPLY, WATER SUPPLY AND DRAINAGE

1.22.1 Power Supply

(i) Unless otherwise specified, 3 phase, 415 Volts, 50 Hz power supply shall be provided by the department free of charge to the contractor at one point for installation at site. Termination switchgear however, shall be provided by the contractor. Further extension if required shall be done by the contractor.

The firm will provide the details of electrical power/load of each equipment proposed to be installed to the department, and also the total electrical power requirements for the complete MGPS installations so that power supply can be arrange accordingly.

(ii) The power supply for testing and commissioning of the complete installation shall be made available by the Department free of charge to the contractor. For this purpose, the power supply shall be given at the main incomer unit of the main electrical panel (provided by the contractor) through U.G. cable, or bus-trunking arrangement. The termination of this feeder in the main incomer unit shall be the responsibility of the contractor and nothing extra shall be paid on this account.

(iii) Unless otherwise specified in the contract, further power distribution to the various equipment shall be done by the contractor.

(iv) Where the power supply has to be arranged by the Department at more than one point as per the terms of the contract, the termination of all such power feeders in the incomer of respective control panels (provided by the contactor) shall be the responsibility of the contractor.

(v) The contractor shall not use the power supply for any other purpose than that for which it is intended for. No major fabrication work shall be done at site. Power shall be used only for soldering/ welding/ cutting works or as approved by Engineer in Charge. The power supply shall be disconnected in case of such default and the contractor shall then have to arrange the required power supply at his cost.

(vi) Contractor may have to install their DG Set for construction activity. The department do not guarantee for continuous power supply for the work to be carried out.

Note: In case of EPC contracts, the firm shall be responsible for above as a whole since the complete building/structure to be built shall be within his scope and hence the above item also as per scope defined in NIT

1.22.2 Water Supply

(i) Water supply shall be made available to the contractor by the Department free of charge at only one point for installation. Further extension if required shall be done by the contractor.

Note: In case of EPC contracts, the firm shall be responsible for above as a whole since the complete building/structure to be built shall be within his scope and hence the above item also as per scope defined in NIT.

1.22.3 Drainage

(i) Drain traps in MEDICAL GAS PIPE LINE SYSTEM (MGPS) rooms/ plants shall be arranged by the department at one location only.

(ii) All drainage arrangements from the drain traps etc. to the drain line shall be arranged by the Department as required.

(iii) Piping Connections from the equipment to the drain trap including providing valves at the drain points shall be done by the contractor. These items of work shall be separately measured and paid as per contract.

Note: In case of EPC contracts, the firm shall be responsible for above as a whole since the complete building/structure to be built shall be within his scope and hence the above item also as per scope defined in NIT.

1.23 Tools for Handling and Erection

(i) All tools and tackles required for handling of equipment and materials at site of work as well as for their assembly and erection and also necessary test instruments shall be the responsibility of the contractor.

1.24 PAYMENT TERMS

Payment shall be made through electronic transfer in NEFT/RTGS subject to recoveries, if any, by way of liquidated damages or any other charges as per terms & conditions of contract in the following manner:

Payment shall be made in Indian Rupees as specified in the contract in the following manner.

a) On delivery: 70% payment of the contract price on prorata basis shall be paid on receipt of goods in good condition and upon the submission of the following documents:
Original copies of supplier's invoice showing contract number, goods description, quantity, packing list, unit price and total amount.

b) On installation: 20% payment of the contracts would be made against successful installation of the item at site, as per NIT requirements.

c) On Testing, commissioning and completion: Balance 10% payment would be made against Testing, commissioning and completion, subject to recoveries, if any, either on account of non-rectification of defects/deficiencies not attended by the by firm or otherwise. "Final Installation, Testing, Commissioning and Acceptance Certificate" need to be issued by the department after successful installation, commissioning, testing and successful trial run in coordination with hospital authorities.

d) Payment of Civil/Electrical Works at site: The payment related to Civil/Electrical Works at site will be made as indicated in the contract.

e) Payment for Comprehensive Annual Maintenance Contract Charges: The payment of CAMC will be made on six monthly basis after satisfactory completion of said period, duly certified by the department in coordination with client department, on receipt of bank guarantee for an amount equivalent to 2.5% of the cost of the equipment as per contract in the prescribed format valid till 3 months after expiry of entire CAMC period. The firm will associate the supplier/authorised channel partner of OEM of the equipment for CAMC for the required period and submit coy of agreement to the department.

1.25 Warranty and CAMC

1.25.1 Comprehensively all the goods supplied under the contract shall be new, unused and incorporate all recent improvements in design and materials unless prescribed otherwise in the contract. The firm further warrants that the goods supplied under the contract shall have no defect arising from design, materials (except when the design adopted and/or the material used are as per the Purchaser's/Consignee's specifications) or workmanship or from any act or omission of the supplier, that may develop under normal use of the supplied goods under the conditions prevailing in India.

1.25.2 The warranty shall include all spares, labour and preventive maintenance from the date of completion of the satisfactory installation and acceptance till warranty period.

1.25.3 The Comprehensive Annual Maintenance Contract shall include all spares, labour and preventive maintenance from the date of completion of the satisfactory installation and acceptance till warranty period and there after till the period of completion of CAMC as stipulated in the NIT.

1.25.4 Warranty as well as Comprehensive Annual Maintenance Contract will be for complete work inclusive of all accessories and turnkey work and it will also cover the following, wherever executed in the contract:-

(i) a. Primary (Liquid Medical Oxygen) LMO tank system including Control Panel & Automatic Switchovers.
b. Secondary oxygen manifold and emergency oxygen manifold with automatic control panels.

(ii) Nitrous oxide manifold and emergency NO_2 manifold with automatic control panel.

(iii) CO_2 Manifold with automatic control panel.

(iv) Medical Air Supply System (4 Bar & 7 Bar) complete.

(v) Medical Vacuum (suction) Supply System Complete.

(vi) AGSS system complete
(vii) Distribution Piping Complete with accessories.
(viii) Area Valve Service System.
(ix) Alarm systems (master & area).
(x) Gas Outlets with Probes.
(xi) Bed Head Panels.
(xii) Control cabling from / to control panel and associated sensors.
(xiii) Other items executed in contract.

Note: Check for the requirement of spares and consumables in the system. The NIT authority can list these consumables on paid basis also on actual consumption, as deemed fit, for which suitable items needs to be incorporated in the BOQ.

1.26 Related Documents

1.26.1 These General Specifications shall be read in conjunction with the General conditions of contract. These General Specifications shall also be read in conjunction with the tender specifications, schedule of work, drawings and other documents connected with the work.

1.27 Safety Codes and Labour Regulations

(i) All the safety procedures outlined in the safety codes applicable for the works shall be complied with.

(ii) In respect of all labour employed directly or indirectly on the work for the performance of MGPS contractor's part of work, the contractor at his own expense, will arrange for the safety provisions as per the statutory provisions, B.I.S. recommendations, factory act, workman's compensation act, CPWD code and instructions issued from time to time. Failure to provide such safety requirements would make the tenderer liable for penalty as provided in the labour laws/GCC for each violation. In addition the Engineer-in-charge, shall be at liberty to make arrangements and provide facilities as aforesaid and recover the cost from the contractor.

(iii) The contractor shall provide necessary barriers, warning signals and other safety measures while laying pipelines, duct cable etc. or wherever necessary so as to avoid accident. He shall also indemnify CPWD against claims for compensation arising out of negligence in this respect. Contractor shall be liable, in accordance with the Indian Law and Regulations for any accident occurring due to any cause. The department shall not be responsible for any accident occurred or damage occurred or claims arising there from during the execution of work. The contractor shall also provide all insurance including third party issuance as may be necessary to cover the risk. No extra payment would be made to the contractor due to the above provisions thereof.

1.28 COMPLETENESS FO THE TENDER, SUBMISSION OF PROGRAMME, APPROVAL OF DRAWINGS AND COMMENCEMENT OF WORK

1.28.1 Completeness of the tender

All sundry equipment, fittings, assemblies, accessories, hardware items, gaskets, masonry platforms/ foundation for MGPS works. Supports for pipes foundation bolts, supports, termination lugs for electrical connections, cable glands, junction boxes, connections for medical gases and all other items which are useful and necessary for proper assembly and efficient working of the various equipment and components of the work shall be deemed to have been included in the tender, irrespective of the fact whether such items are specifically mentioned in the tender or not.

1.28.2 Submission of programme

Within 10 days from the date of receipt of the letter of acceptance or as stipulated in NIT, the successful tender shall submit programme for complete work including activities like submission of drawings, supply of equipment, installation, testing, commissioning and handing over of the installation to the Engineer-in- Charge etc. This programme shall be framed keeping in view the milestones stipulated in the contract, in which the building progress shall be given priority. In case of EPC contract, in which this is one of the work, the complete programme for the project will include MGPS work also with detailing, matching the over all completion target for the project.

1.28.3 Submission of Drawings and compliance sheet.

The contractor shall submit the drawings and compliance sheet to the Engineer-in-charge for approval before start of work.

1.28.4 Commencement of work

The contractor shall commence work as soon as the drawings and compliance sheet submitted by him are approved.

1.29 QUALITY OF MATERIALS AND WORKMANSHIP

1.29.1 The components of the installation shall be of such design so as to satisfactorily function under all conditions of operation.

1.29.2 The entire work including manufacture/ fabrication, assembly and installation shall confirm to sound engineering practice. The entire installation shall be such as to cause minimum transmission of noise and vibration to the building structure.

1.29.3 All equipment and materials to be used in work shall be manufactured in factories of good reputation have excellent track record of quality manufacturing, performance and proper after sales service.

1.29.4 None of the equipment/ machines supplied shall be more than six months old from date of supply at site. Copy of GST Gate Pass / Invoice / Shipment / Custom Clearance certificate / details (in case of imported equipment) shall be submitted to prove the date of manufacture & genuineness of the equipment / machines supplied.

1.30 CARE OF THE BUILDING

1.30.1 Care shall be taken by the contractor during execution of the work to avoid damage to the building. He shall be responsible for repairing all such damages and restoring the same to the original finish at his cost. He shall also remove all unwanted and waste materials arising out of the installation from the site of work from time to time.

1.31 INSPECTION AND TESTING

1.31.1 Initial inspection of materials & equipment at manufacturer's premises as per details given will be done by the engineer-in-charge or his representative. For item/ equipment requiring initial inspection at manufacturer's works, the contractor will intimate the date of testing equipment as applicable at the manufacturer's works before dispatch. The Contractor shall give sufficient advance notice regarding the dates proposed for such tests to the department's representative(s) to facilitate his presence during testing. The Engineer-in-charge at his discretion may witness such testing. Equipment will be inspected at the manufacturer/ authorised dealer's premises, before dispatch to the site by the contractor. For equipment sourced from abroad, the contractor shall at his own expense arrange for the required pre-dispatched tests at the manufacturer's works and submit to the department the details of the tests carried out and the results there of. Once the go head is given, the material shall be dispatched from manufacturer's works.

1.31.2 The department also reserves the right to inspect the fabrication job at factory and the successful tender has to make arrangements for the same.

1.31.3 The materials duly inspected by Engineer-in-Charge or his authorised representative shall be dispatched to site by the contractor.

1.31.4 No additional payment shall be made to the contractor for initial inspection/ testing at the manufacturer's works by the representative of the Engineer-in-Charge. However, the department will bear the expenses of its representative deputed for carrying out initial inspection/testing.

1.31.5 Final Inspection & Testing

Final inspection & testing will be done by the Engineer-in-Charge or his authorized representative for the equipment and services provided at site.

1.32 SAFETY MEASURES

All equipment shall incorporate suitable safety provisions to ensure safety of the operating personnel at the times. The initial and final inspection reports shall bring out explicitly the safety provisions incorporated in each equipment.

1.33 DRAWINGS, SCHEMATIC DIAGRAMS, LAYOUT PLANS ETC

1.33.1 In case of EPC contract for complete hospital project/ building, the main firm shall be responsible for the preparation of MGPS layout / Floor Plans of the Hospital and the site

plan having MGPS Plant Room layout, sections and GFC drawings of the MGPS Plant Room etc. In case of the existing building or stand alone work of MGPS, these shall be provided by the department.

1.33.2 Drawings, as provided by the Department shall constitute Preliminary Drawings and represent initial proposal for the proposed work. These drawings provide general guidance and broadly indicate the work to be carried out, showing the areas in the Hospital Building Blocks to be provided with MGPS Outlets and the space allocated for Plant Room of MGPS Installation in the Hospital campus.

1.33.3 The Equipment and pipe layouts, as shown on the drawings, represent a feasible scheme. MGPS firm will be responsible for the proper allocation of space and route for different equipment/ piping etc, as per the equipment requirement and standards.

1.33.4 Detailed Working Drawings shall be prepared by the MGPS firm for the complete MGPS Installation and get these drawings approved from the department/hospital authority. Approval of the drawings by the department shall not relieve MGPS installer (the bidder) of any part of his obligation to provide a complete MGPS Installation which works satisfactorily.

1.33.5 Detailed Working drawings shall be prepared in coordination with department and other firms for all other MEP services as laid out. Wherever required, the MGPS layout shall be integrated with MEP layout and evaluated using *Building Information Modelling* (BIM) or similar technologies for coordinated layouts and to identify the clashes etc.

1.33.6 Before proceeding with the work, the design must demonstrate fully, that all parts of the MGPS Installation to be furnished will conform to the specifications.

1.33.7 Full Information on, Basic Design Information, Commissioning Results, Validation Reports, Variation Reports, as to their designed mode of operation and recommended maintenance procedures shall be provided, as part of the handover documentation.

1.33.8 The firm shall use standard Symbols and abbreviations in drawings. All non-standard Symbols and abbreviations must be provided with their full context related explanation.

1.34 Other conditions

a) The complete Medical Gas Pipe Line System must follow the specifications as described herein in this document, amended uptodate. In case of further detailed specification/ additional details are required, the specifications shall be referred in the following order of preference:

1st) HTM 02-01,

2nd) ISO 7396-1,

3rd) NFPA 99.

The preference shall be to follow Single Standard as specified above for the relevant equipment except Copper Pipe, for which related standards as described shall be applicable.

b) The following systems/items must be from the same manufacturer for control panels & manifold for O_2, N_2O & CO_2, or as stipulated in NIT. For better coordination, it is preferable to have bed head panels also from the same manufacturer:

a. Medical Air Plant
b. Medical Vacuum Plant
c. AGSS Plant
d. Area & Master Alarm
e. All types of Outlets
f. Ares Valve Service Unit (AVSU)
g. Line Isolation Valves
h. High Pressure Tubes
i. Bed head panels

c) The third party compliance certification after installation to be done for the standard followed as described in para 1.34 a), from the authorised agency. The cost for the same will be borne by the bidder. Authorizied agency should submit valid certificate of AP/ASSE6020 competent personnel prior to taking up the execution of the works.

d) Bidder shall be responsible for suitable arrangement of heat dissipation and Air-Conditioning as required for the offered MGPS equipment requirement / recommendations from the Manufacturer and as per local site conditions.
Bidder shall also take care of 100% backup arrangement for AC and Exhausts as the MGPS Plant may run 24x7 as per the requirement.

e) Gas outlet configuration location wise may be as follows or as finalized in consultation with the hospital authorities:

i. General Ward Bed (on Wall) : O_2-1 & Vc-1 for each bed
ii. Super Speciality General Bed (On Wall): O_2-1 & Vc-1 for each bed and MA4-1 for each Cubicle
iii. Private Room & Isolation Room/Special Ward(like- Dialysis,etc) (On BHP): O_2-1, Vc-1 and MA4-1 for each bed
iv. ICU/CCU Bed (on BHP) : O_2-2, Vc-2 & MA4-2 for each bed.
v. Pre-Op Bed/Emergency (on BHP) : O_2-1, Vc-1 & MA4-1 for each bed.
vi. HDU/Post-Op Bed (on BHP) : O_2-2, Vc-2 & MA4-1 for each bed.
vii. Treatment/Procedure Room (On Wall): O_2-1, Vc-1 and MA4-1 for each bed.
viii. Endoscopy/Etc : O_2-1, Vc-1 , MA4-1, CO_2-1, N_2O-1.
ix. Minor OT/Cath Lab/CT/LINAC/Etc (On BHP): O_2-2, Vc-2, MA4-1, N_2O-1 for each Room (For MRI/LINAC/ETC.

- Pipe line of same services shall be provided upto/outside of the room).
- **The Configuration may change as per special request from consignee / institute specific requirements, if any.**

f) Bidder shall be responsible for providing dedicated earthing (metal plate earthing/ chemical earthing as stipulated in NIT) for MGPS Plant room equipment and panels and the same shall be in the scope of the work of the firm.

g) Zoning of MGPS shall be done to meet the peak flow requirement with suitable backup arrangements for all services, if required.

h) Interconnection to Manifolds with LMO Tank with necessary automatic switchover panels between LMO & Manifold will be responsibility of bidder.

i) All tanks (Air, Vac and AGSS if applicable shall be installed on dedicated platform in MGPS Plant room and this platform shall be responsibility of MGPS Bidder with shed as per their requirement.

j) Bidder shall submit the MGPS Plant and Manifold equipment loading design with foot print of all component as per their offered plant along with bid.

k) Bidder shall be responsible for complete development of LMO area from greenfield condition.

******

CHAPTER 2

PLANNING FOR MEDICAL GAS PIPE LINE SYSTEM

2.1 In the hospitals now days, medical gases system are being provided for a number of diverse clinical applications and its piped delivery to the patients/ critical areas is a highly sensitive and important parameter related to patient care. The design, installation, commissioning, and operation of medical gas pipeline systems (MGPS) is thus of paramount importance and requires proper and systematic approach in deliverance of this service. The MGPS system has to be kept operational round the clock, with practically zero downtime and its failure can be fatal if not restored at the earliest and needs to have prescribed redundancy.

2.2 The MGPS is a specialized service that supports healthcare delivery by delivering Gases (Drugs) to the point of use on a continuous basis. The MGPS planning, design, engineering and execution should be code compliant. The system so installed has to ensure for its maintenance, all critical components being available for periodical inspection & calibration and the overall system must have sufficient resilience to meet the varying loads that hospitals experience. After installation, it must always be validated, by a third party qualified MGPS inspector, and this validation must be witnessed by a representative of the Hospital authority/ department, as detailed later in these specifications. The MGPS Installer must co-ordinate with Hospital Consultant/ department for integration of the MGPS design with hospital layout, review of system routings, MGPS equipment installation and equipment locations along with other services running in the area.

2.3 MGPS is intended to be a safe, convenient and cost-effective alternative to the use of "portable" cylinders, portable compressors and portable suction units, providing gas or vacuum for clinical needs without the associated problems of porterage, noise and space wastage. It delivers Medical Gases, Medical Air and other gases from the source of supply to the appropriate terminal unit by means of a pipeline distribution system.

2.4 Major gases present in Medical gas pipeline system

MGPS Installation will provide all or some of the following piped Medical Gases and allied services:

a) Medical Oxygen
b) Medical Nitrous Oxide
c) Medical Compressed Air 4 and 7
d) Medical Vacuum
e) Medical Carbon Dioxide
f) Anaesthetic Gas Scavenging (Disposal) System (AGSS)
g) Gas Pressure and Flow Monitoring
h) MGPS Alarm System
I) Accessories for connection to Medical Devices

2.5 Role of oxygen in the Medical gas pipeline system

Oxygen is the life-sustaining gas on the planet. More than 21% of the earth's atmosphere is filled with it. In medical gas pipeline, oxygen is used to drive anesthesia machines and Ventilators.

2.6 Role of Nitrous oxide in Medical gas pipeline system

Nitrous oxide is used via an anesthesia machine. It gets mixed with oxygen and other gases while operating. Due to its purpose, nitrous oxide outlets are always put only in operation theatres.

2.7 Role of Medical air 4 bar in Medical gas pipeline system

This is compressed air at gauge pressure of 4.1 bar (414 kPa or 60 psi) at the Terminal Units and shall provide the drive for ventilators in Operating Rooms, on the recovery beds, on the ICU Beds, etc. as well as dilute the Oxygen concentration where required.
It's either supplied by Intake manifold or compressor system.

2.8 Role of Medical air 7 bar in Medical gas pipeline system

Slightly higher pressure on Medical air is also used in the medical gas pipeline system. It is used in applications where pneumatic devices such as a Bone sawand Tourniquet are used.

2.9 Role of Carbon dioxide in Medical gas pipeline system

Carbon dioxide is used for insuffation purposes during open heart and other important surgeries. Carbon dioxide is also used in Laparoscopy procedures.

2.10 Role of Medical vacuum in Medical gas pipeline system

A vacuum is used to drive suction related machines in any hospital. The negative pressure generated by Vacuum gets utilized in the anesthetic scavenging system.

2.11 Components of a medical gas pipeline system

There are multiple components used in a medical gas pipeline system. The number of components used depends on the size and design of the system.

The main components are:

a. Sources (for gases/ vacuum)
b. Piping networks
c. Inlets, Outlets
d. Valves
e. Warning and alarm systems
f. Secondary equipment

Sources are supplies that drive the pipeline system. There are different types of sources as per the gases involved.
The major types of sources include:

- Bulk systems

Bulk systems are constructed as large high-pressure manifolds or cryogenic tanks. They are usually made up of specially insulated vessels, vaporizers, and regulators.

- Manifold system

  It consists of high-pressure cylinders to supply gases. The main control panel is fixed on the manifold to regulate the pressure.

- Medical air treatment system

  Medical air treatment systems are usually equipped with compressors, pressure monitors, regulators, filters, dehumidifiers, and dew point monitors so that the air supplied is free of dust and moisture.

- Vacuum pumps

  Vacuum pumps are used for the suction line, they are used to derive negative pressure to operate various machines at the outlet. A Negative pressure at stipulated rate is required at all times from a vacuum pump.

- Piping networks

  Medical gases and vacuum are transmitted throughout the structure through the help of pipes. Pipes used in the medical gas pipeline are made of high-quality copper or stainless steel so that the process of corrosion doesn't occur. These pipes are color-coded and maintained frequently for effective utilization.

- Valves

  Valves are used to drive gases through the pipeline to various outlets. The main function of valves in a medical gas pipeline system is to stop the flow of gases during service. There are two types of valves, namely, service valves and zone valves which are used in different situations to shut off the flow of medical gases.

- Outlets and Inlets

  Outlet points are used to connect the medical gases with service applications such as ventilators or Anesthesia machines. Inlets are used for vacuum pipeline. Outlets are also supposed to be color-coded for effective usage.

- Secondary equipment

  Although Equipment such as hoses, Pressure regulators, and flow meters doesn't make up the primary system, they are essential for the smooth operation.

2.12 Applicable standards for MGPS

The complete Medical Gas Pipe Line System must follow the specifications as described herein in this document, amended upto date. In case of further detailed specification/ additional details are required, the specifications shall be referred in the following order of preference:

1st) HTM 02-01,

2nd) ISO 7396-1,

3rd) NFPA 99.

The preference shall be to follow Single Standard as specified above for the relevant equipment except Copper Pipe, for which related standards as described shall be applicable.

2.13 Medical gas pipeline system standards

Requirements for design, installation, function, performance, testing, commissioning and documentation of pipeline systems used in healthcare facilities shall be conforming to the standards as stated in para 1.34 a. of Chapter 1, for the following:

a. oxygen;
b. nitrous oxide;
c. medical air;
d. carbon dioxide;
e. oxygen/nitrous oxide mixtures (see Note 1);
f. helium/oxygen mixtures;
g. (*) oxygen 93;
h. Gases and gas mixtures classified as medical device, gases delivered to medical devices or intended for medical purposes or gases and gas mixtures for medicinal use not specified above;
i. air for driving surgical tools;
j. nitrogen for driving surgical tools;
k. vacuum.

2.14 Setting up medical gas pipelines in Hospitals.

In most Hospitals, piping is used for conveying Medical Oxygen, Medical Oxygen 93 Percent USP; Medical Air, Medical Nitrous Oxide, Medical Carbon Dioxide and other Medical Gases to wall outlets/inlets at the points of patient use.

The process of medical gas pipeline happens at different levels, namely Planning, Scheduling, Design, Simulation, Procurement, Fabrication, Installation, Testing, Review, and Operation and following aspects are to taken into consideration:

a) Analyze the different parts of the Hospital to identify:
- Location and numbers of inlet-outlet?
- Which are the different gases required?
- Which type of inlet-outlet system is beneficial for the hospital staff?
- Devices that are being utilized in the hospital and their requirement etc.

b) Analyze the construction plan properly; expansion of the building should be taken into account. (Vertical or Horizontal Expansion)
c) Determine the locations for various gas systems.
d) Determine the schematic design for valves, inlet-outlets, etc.
e) Ensure that medical gases are independent of other possible gas pipelines such as labs and manufacturing units in an organization.
f) Design medical gas pipeline to maintain a steady pressure across the structure.
g) Define total flow for different gases.
h) Define flow rates at each terminal and make sure they can be varied.
i) Make sure all the sources are provided with a backup in case of emergency.
j) Electrical back-up should also be provided.

k) All Hospitals may not require all the gases as described hereunder. Therefore, it is important that relevant inputs from the Hospital are taken to specify the following clearly.

i) The Medical Gas Service that they require.

ii) The Medical Air Service that they require.

l) Provide a schedule of provision of terminal units, providing requirements on bed locations.

m) Design Matrix for location of Area Alarms.

n) Design Matrix for location of control Valves.

o) Location of the MGPS Plant Room.

2.15 Continuous supply of oxygen is the primary requisite of any medical unit. There should be three independent supply sources: Primary, secondary, and a reserve source adequate to meet the demand in the event of primary and secondary supply failure. The manifold room should have 2 banks of D-type cylinders, each holding a minimum of 2 days consumption (or as decided by the hospital authority), attached to a fully automatic changeover control panel. Three-day consumption (or as decided by the hospital authority) should be kept in reserve, as a contingency plan. Now day, due to COVID, the standby requirements needs to be properly assessed in consultation with the hospital authorities and the capacity be suitably enhanced.

2.16 When selecting and specifying the components for MGPS installation, the following aspects needs to be considered:

a) For Medical Gases, consider the source of supply, lead time of supply and provision of backup for gas supply in the event of break in supply chain.

b) For MGPS Plants, consider availability of service engineers, lead time for maintenance visits, availability of spares, lead time for making available spares and provision of backup units.

2.17 There are multiple works involved in the work, including but not limited to MGPS specific installation as per below:

a) MGPS manifolds and MGPS Plant,

b) Pipeline Carcass,

c) Cylinder Store stands,

d) Liquid Oxygen Yard & Apron (Open but secured area where the Liquid Oxygen Vessel and accessories will be located and re-filling tanker will be parked – LMO Yard).

Whenever, MGPS Installation includes provision of Liquid Medical Oxygen Supply System, either as a Source of Primary supply or as a source of Primary and Secondary supply, the following shall be applicable.

The provision and maintenance of the Liquid Medical Oxygen Supply System, from the source, including the Vaporiser, pipeline upto its integration with the Oxygen manifold system and all the accessories, will be the responsibility of the Liquid Oxygen supplier

(henceforth called Gas Supplier) associated with the MGPS Installation and hence its provision in NIT should be taken up after verifying the same in consultation with the hospital authorities.

e) All needed Civil, Electrical and allied works, supply of accessories, Furniture, provision of Gates, making of road connections, Trench work,
f) Testing of all systems installed in this MGPS Installation, Commissioning of this MGPS Installation, etc. as specified in this specification.
g) Supply of Cylinders,
h) MGPS Plant Room and LMO Yard require Electrical Power Supply, Water Supply, Drainage Services, Communication Services and Integration with Central Fire Control Room and Hospital's Integrated Building Management System (IBMS) service.
i) The installation of LMO should be as per the requirement of SMPV rules under PESO and the MGPS firm will ensure required compliance, approvals and NOC from concerned authority, as applicable.

2.19 The core of the entire system is the manifold room which should be manned round the clock with trained personnel. It should have a suitable acoustic enclosure with 100% generator backup and fire security. The location should be marked clearly for ease of identification in the event of an emergency. It houses the control panel which allows a flow at stipulated rate at 4.1 bar from the vacuum insulated evaporator (VIE) and relays alarm to secondary panels located throughout the hospital.

2.20 MGPS also includes Area Valve Service Units (AVSUs). These permit isolation of certain parts of the system for servicing or repair. They are also provided for use by clinical or nursing staff in an emergency. It includes Line Valves and Line Valve Assemblies (LVA) (complete with NISTs) to permit isolation of larger parts of the Hospital Building for modification and/or repair.

In MGPS, Pressure Monitoring and Alarm Systems are integrated to alert the medical staff responsible for the administration of medical gases and clinical users about the status of the MGPS line pressures and flow as well as to give information to the Bio-medical Engineers, for changing the Medical Gas Cylinders (henceforth called Cylinder(s), for responding to plant faults, etc.

2.21 It requires that First layout the Medical Gas Terminal Units, as required, on the Hospital's Floor Plans. In coordination with end users, determine the Gas pressure and Flow rates required at each of these terminal units.

Design is made for use of 100% Terminal Units installed. Exception is Terminal Units installed for user convenience like Terminal Units installed on left and right of patient bed in the Bedhead unit where in actual effect only one of these shall be used. Determine all such duplicated Terminal Units installed.

Determine Actual number of installed Terminal Units that may be used (Value N).

Determine Operative Pressure and averaged Flow Rate of all gas types in Litres per Minute (LPM).

Determine Total Gas Quantity that is required at 100% Utilisation of all installed Terminal Units. (Value N x averaged LPM). This is the design capacity of the installation.

Carry out the correction based on Altitude (Height above the sea level) of the facility Location.

Considering the pipe as laid in the pipeline carcass to be an elongated cylinder, the Capacity of this cylinder should be more than the Total Gas Quantity that is required at 100% Utilisation.

Whenever addition to installed capacity is done, the pipeline carcass must be increased to the extent of gas capacity requirement of newly added terminal Units for all gas types.

Also determine the Diversified flow that is functionally required as per the relevant standards to ensure requisite redundancy.

2.22 All subsystems and installed components of a gas service Installation from source till the terminal unit shall be specified for Maximum Flow rate to be achieved. This must be ensured specifically for all Filters, Pressure Reducing Stations, Pressure Regulators and other components.
The gas pressures are different for supply and for Distribution. They also depend on the size of the system.

Determine the capacity of the Source for Primary Supply in consultation with hospital authorities to determine the design capacity of the specific Gas. This should be available at Hospital Site. As a minimum, the Primary Supply reorder level should ensure availability of usable quantity of product to meet expected usage between scheduled product deliveries. Diversified flow will not be considered in this analysis.

Depending upon Hospital Policy, Determine the capacity of the Source for Secondary Supply which should be more than 8 Hours requirement of the design capacity of the specific Gas. This should be available on Hospital Site in MGPS Manifold Room or MGPS Plant Room. This is primarily required for servicing the Source for Primary supply. Since the Source for Secondary Supply can be a bulk storage tank or a manifold of cylinders, sufficient number of Full cylinders should be available in Cylinder Store.

Depending upon Hospital Policy and the Lead Time of Gas Supply, determine the capacity of the Source for Emergency Reserve Supply which should be more than 4 Hours requirement of the design capacity of the specific Gas. This should be available on Hospital Site in MGPS Manifold Room or MGPS Plant Room.

Maintain Safety and a Record of all safety inspections to secure the Hospital liability due to MGPS Operations. The MGPS Manifold room shall be manned by a qualified MGPS Technician 24 x 7. The same technician can supervise the MGPS Plant Room, if close by. There shall be comprehensive pressure monitoring and an integrated Alarm System.

When installing the system, ensure that Oxygen free, Oil free, Nitrogen Purging is carried out. Before taking over the installation, physically check the condition of pipe interior by cutting a pipe, for all gas types, one cut every 100 meters of pipe length. Then also perform cotton contamination test on 5% of all terminal units installed. If Nitrogen purging has not been done, the cotton will collect the products of oxidation from the pipe.

2.23 THE DESIGN PROCESS

a) It requires that First layout the Medical Gas Terminal Units, on Hospital layout plans.

b) Then design the MGPS Pipeline Carcass upto feeder line start, mark all Pipe Routes on each floor plate.

c) Co-ordinate this layout with MEP Consultants, specifically assess the fire safety and gas accumulation in confined spaces and resolve ventilation requirements.

d) Locate the MGPS Manifold room, MGPS Plant Room, LMO Yard and MGPS Cylinder Storeroom on Hospital's Site Plan. Meet all statutory requirements.

e) Depending upon its size, the VIE Tank has to be placed 6 – 10 M away from any built structure as per the Explosives Act.

f) The installation of LMO should be as per the requirement of SMPV rules under PESO and the firm will ensure required compliance, approvals and NOC from concerned authorities, as applicable.

g) Design Hospital main supply Line for all gas Types and link them to the Hospital building Blocks.

h) Design the connecting trenches.

i) Now add the Pressure Control and monitoring system, locate various valves, add the MGPS Alarm System and integrate that with Hospital's HIT System.

j) Validate the Design Pressures and gas Flow.

2.24 Accommodation (for MGPS Plant Room & LMO Yard)

a) There shall be a unitary MGPS Plant Room, MGPS Manifold Room, LMO Yard with a Liquid Medical Oxygen apron, and a Medical Gas Cylinder Store (collectively called MGPS Plant Room & LMO Yard). Functionally, the MGPS Hospital Supply Pipes, originating from this MGPS Plant Room & LMO Yard, will be connected to main Hospital buildings through a trench/ suitable route.

b) Preferably, the MGPS installations will have the following accommodation for the MGPS Plant.

(i) MGPS Manifold Rooms

i. One Room For Medical Oxygen, Medical Nitrous Oxide, Medical Compressed Air. It will get connected to the LMO Yard. It will need to be linked to the MGPS Plant Room and Cylinder Store Room.

ii. One more Room For Medical Carbon Dioxide, wherever this gas service is provided. It will have floor based Ventilation to prevent gas accumulation.

iii. All manifolds, including the emergency reserve manifolds, of a gas service will be located within the same room.

(ii) MGPS Plant Room

This is required to house the Medical Air plant and the Medical vacuum Plant.

(iii) MGPS Cylinder Store Room

1. Cylinder Store, organised in bays for Gas specific Empty & Full Cylinders, for Medical Oxygen, Medical Nitrous Oxide, Medical Air and Medical Carbon Dioxide.

2. It will also provide storage space for Cylinder Trollies.

(iv) LMO Yard

1. It is a secured, fenced compound of adequate size with an apron for use of Normal commercial Lorry Truck.

2. Its location depends upon the size of the VIE Tank. It is located at least 5 Meters away from any built structure. (5 - 10 meters depending on the size of VIE Tank)

(v) AGSS Plant Room and Disposal Point

1. AGSS Pumps should be located close to the Surgical Operating Rooms. In smaller Hospitals, it can be in the MGPS Plant Room & LMO Yard.

2. The AGSS exhaust should be disposed off to outside of the Hospital Building. This can be at multiple points or at a designated point

(vi) Medical Oxygen 93 Percent USP Generation Plant Room & Yard (Purity 93 ± 3%)

i. At the least, the two vertical-type adsorber vessels where the adsorption process takes place are generally designed for Outdoor placement.

ii. So, if Hospital requires Oxygen Generators, a secured, fenced compound of adequate size is to be provided with a plant room.

iii. The size will be determined if the Oxygen Generators is only for pipe supply or for cylinder filling or for both.

(vii) Access to MGP Manifold Rooms specifically, and to MGPS Plant Room & LMO Yard shall be from the open air, not from corridors or other rooms.

(viii)Always provide a raised, Loading–Unloading platform for MGPS Cylinder Storeroom and raise the Plinth Level of the store to reduce cylinder handling hazards. If done, provide a ramp for moving Cylinder Trolley.

The MGPS Plant Room & LMO Yard and AGSS disposal system pumps can be located in Engineering Service Yard alongside other MEP services. They should not, however, be located with heating or hot water service equipment or equipment likely to produce any fumes or odour.

2.25 SITE INFORMATION

(i) The MGPS installation work should preferably be carried out only when the site has been secured and provision for Fire Safety has been made.

(ii) Since Medical Gases are considered oxidisers, commissioning of the MGPS shall be done just before commissioning of the Hospital. Actual gas priming shall be done only after the Hospital has been commissioned.

Check for the Seismic data for the site. This shall be used to design all pipe entries to the building.

2.26 All Medical Gases have an assigned Anatomical Therapeutic Chemical Classification System (ATC) Number, a system of alphanumeric codes developed by the World Health Organization (WHO) for the classification of drugs and other medical products.

1.1.	Medical Oxygen	O_2	V03AN01
1.2.	Medical Oxygen 93 Percent USP	O_2 93	
1.3.	Medical Nitrous Oxide	N_2O	N01AX13
1.4.	Nitrous Oxide/Oxygen 50:50 Mixture	O_2/N_2O	
1.5.	Medical Air	MA4	V03AN05
1.6.	Surgical Compressed Air 7	SA7	
1.7.	Medical Vacuum	VAC	
1.8.	Medical Carbon Dioxide	CO_2	V03AN02
1.9.	Nitrogen	N_2	V03AN04
1.10.	Helium/Oxygen Mixture	Helium Mix	V03AN03
			(For Helium Only)

2.27 SOURCES OF SUPPLY FOR MGPS PLANT ROOM

2.27.1 The MGPS supply system should be designed to achieve continuity of supply to the Terminal Units in normal condition and in a single fault condition. This requires, as far as practical, all MGPS services should comprise three sources of supply identified as "Primary", "Secondary" and "Reserve".

i) Loss of supply due to maintenance of a source pf supply (or a component within it) is not considered a single fault condition.

ii) For Medical Air Plant and Central Medical Vacuum Systems, Multiple Pump Systems (Multiplexing) shall be deployed on a cascading duty arrangement, operated in a sequential manner to achieve redundancy as well as energy saving. The following configuration may be considered for plant sizing:

SERVICE	SOURCE	PLANT SIZE
Medical Air	Duplex Compressor System	Each compressor sized at full design flow Note: In case of Duplex compressors system, the third source as tertiary should be medical air gas manifold system, as per standard guidelines.
	Triplex Compressor System	Each compressor sized at full design flow
	Quadruplex Compressor System	Each compressor sized at half design flow capacity
	Air Receiver	The minimum water capacity of the Air Receivers should be 50% of the compressor output in 1 minute, stated in terms of free air delivered at normal working pressure. Air receivers should comply with BS EN 286-1: 1998 for all vessels up to 10,000 bar litres, and should be supplied with test certificates. The minimum water capacity of the receivers should be 50% of the compressor output in 1 minute, stated in terms of free air delivered at normal working pressure. Receivers should also be fitted with an automatic drain. Electrically operated automatic drains have been found to be more reliable. For systems that have a design flow in excess of 500 L/min, two receivers should be provided with valve arrangements to permit isolation of one or the other for inspection purposes.
Medical Vacuum	Triplex Pump system	Each pump sized at full design flow with two pumps as primary supply and third pump as secondary supply.
	Quadruplex Pump system	Each pump sized at half design flow capacity with two pumps as primary supply and other two pump as secondary supply.
	Vacuum Reservoir (When multiple reservoirs are provided arrange them in parallel)	The water capacity of the Vacuum Reservoir should be equal to the plant design flow at 450 mm Hg 60 kPa) in terms of free air aspirated in one minute with the pump operating at 475 mm Hg (63.3 kPa).

AGSS	One Pump of AGSS disposal system pumps All pumps shall be sized for the Highest design flow, as determined across all Operating Rooms.	One pump is required for each set of 6 or less, Operating Rooms; and in addition, one pump is provided as backup for all Operating Rooms together.

iii) The Gas Flow Regulator provided in a line, of a specific gas service, must be of same capacity, based on calculation of the source size.

iv) MGPS Installation for all gases shall be provided with two Banks of Gas Cylinders with equal number of cylinders in each bank and fully Automatic Changeover Units, for all Medical Gases including Medical Oxygen, Medical Nitrous Oxide, Medical Carbon Dioxide and the Medical Air.

Each gas system should be interconnected with Emergency/Reserve supply from the particular source.

v) Whenever, required Oxygen Flow rate exceeds 2100 LPM, the Terminal Units will be grouped into two or more groups, each group will be served by its main supply pipe. The main supply will be sourced from a common Liquid Medical Oxygen supply which in turn can be sourced from one or more Liquid Medical Oxygen VIE Tanks. The main supply will be supported by group specific oxygen manifold. These Oxygen Manifold can be located at different locations as per site conditions. The Oxygen Manifolds shall be numbered starting with the Oxygen Manifold on ground floor or the lowest floor above ground floor being Number 01 - O2, Manifold. Other manifold shall be numbered sequentially upwards in the building.

vi) In large MGPS installations, for Medical Compressed Air and Medical Vacuum, one set of quadruplex pumps shall service at the most 1000 installed beds with respective Terminal Units. When the Number of installed beds to be serviced exceed 1000, a second set of quadruplex pumps shall be provided. The Medical Compressed Air plant and Medical Vacuum plant shall be numbered starting with the respective plants on ground floor or the lowest floor above ground floor being Number 01 plant. Other Medical Compressed Air plants and Medical Vacuum plants shall be numbered sequentially upwards in the building.

vii) In case, the lead time for supply of Medical Oxygen is long, provision may be kept in the Manifold Room for adding Oxygen Generator (Concentrator) at a later date.

viii) The MGPS installation will meet the requirements of NBC 2016, PART 4 Fire and Life Safety, or Delhi Fire Service Act and Rules, or Local Fire and Life Safety Rules, as applicable.

ix) The MGPS Plant Room, Manifold Rooms and the Medical Gases Cylinder Stores will be provided with Smoke or Heat Detector heads as part of Hospital's Fire Detection System Policy and will be provided with adequate Fire Fighting Systems & Equipment.

2.27.2 **Medical Carbon Dioxide** shall be provided in limited number of Operating Rooms in the Hospital. These Operating Rooms will have specified Ventilation Systems. These designated Operating Rooms shall be suitable marked and monitored.

a) It is required that the Carbon Dioxide Gas manifold be installed in a separate room. This room will not have any other gas.

b) The Carbon Dioxide Gas Cylinders, both empty and filled shall be stored in a separate room. This room will not store any other gas Cylinders. This room can be part of the Gas Cylinder Store.

c) Since Carbon Dioxide, as Gas, is heavier than Air, provide smooth level flooring and ventilation at Grade level of the room, where Carbon Dioxide manifold is installed, for the Vapours to leave the Manifold Room. This is required to take care of Gas Venting to maintain the pressure in the Cylinders.

2.27.3 **Anaesthetic Gas Scavenging System (AGSS)** is an active system, in which a high air flow, generated by an electrically driven pump, is used to exhaust air through the system's fixed pipework. Waste anaesthetic gas, from the patient, or patient ventilator, diluted by room air, is transmitted by vacuum generated in the exhauster system. The receiving system is designed to match the variable flow in the breathing system to the constant flow of the disposal system and ensure that very low induced flows are imposed (0.5 LPM to 0.05 LPM).

2.27.4 AGSS Terminal units are generally to be provided only in Operating Rooms where nitrous oxide and anaesthetic agents are used for anaesthetic procedures and where procedure times are likely to exceed 2 Hours. In all other locations, Room Ventilation shall be planned to take care of this scavenging requirement. The arrangement shall be finalized in consultation with the hospital authorities.

a) Since AGSS exhaust air is diluted (more than 30 times) using Operating Room ambient air, it is safe to be exhausted to outside air. Care be taken that it should not be interfacing any air intake of any system in the building.

b) It has to be ensured that Anaesthesia Work Stations in Hospitals are provided with open scavenger interface to operate AGSS.

For operation theaters, the number of AGS pumps should be selected in accordance with the number of air-handling units that are to be installed for each operating suite. For example, if a separate air-handling unit is supplied for each suite, a separate AGS disposal system pump should be installed. Where an air-handling unit supplies two or more operating suites, the AGS disposal system should serve the same number and in this case be a duplex system with automatic changeover. (Where a single pump is provided for an individual operating suite, a spare pump for up to six units should be provided for immediate connection into the system in the event of failure.)

2.28 MGPS IN VERY SPREAD-OUT HOSPITAL BUILDINGS

2.28.1 In big plots and very spread-out large Hospital Buildings, which are upto 37 M tall blocks, where Nominal Distribution Pressure across the longest supply pipe length of the system is likely to drop 5% or more, and/or where the maximum pipe diameter of distribution pipe carcass is likely to exceed 108 mm multiple units of MGPS Manifold and Plant Rooms, for every Building Block or a group of Building Blocks may be considered. The pipe length to be measured includes trunk mains, principal feeder mains and distribution branches.

2.28.2 The source of Primary Supply of Oxygen in these multiple units of MGPS Manifold and Plant Rooms can be supported by locally placed multiple Liquid Medical Oxygen (LOX) sources in consultation with hospital authorities.

2.28.3 Alternatively, the source of Primary Supply of Oxygen in these multiple units can be a centralised single Liquid Medical Oxygen source with multiple Liquid Medical Oxygen bullets, where the Nominal Supply System Pressure is increased from 400 kpa to over 1000 kpa.

2.29 MGPS IN TALL HOSPITAL BUILDINGS

MGPS in Tall Hospital Buildings (High Rise Building definition varies from city to city so this term is not used), where Nominal Distribution Pressure across the longest supply pipe length of the system is likely to drop 5% or more, and/or where the maximum Pipe diameter of distribution pipe carcass is likely to exceed 108 mm, and where a single MGPS plant room is provided, the following variation of MGPS installation will be provided. The pipe length to be measured includes trunk mains, principal feeder mains and distribution branches.

2.29.1 **For Oxygen**

a) Since the Source of primary supply is a Liquid Medical Oxygen source, the Double-Stage Pipeline Distribution System is provided where the Nominal Supply System Pressure is increased from 400 kpa to over 1000 kpa.
b) The Trunk Mains remain unitary at Nominal Supply System Pressure of 1000 kpa.
c) Two Principal Feeder Mains are provided in the tall building as double end feeders at Nominal Supply System Pressure of 1000 kpa.
d) The Distribution Branches on each floor are connected to create a ring main at the Nominal Distribution Pressure of 400 kpa by deploying pressure regulators. The Terminal units are connected to this ring main.

2.29.2 **For Medical Nitrous Oxide**

The supply is generally limited to Operating Rooms so no variation is generally required.

2.29.3 **For Medical Air 4**

a) The Double-Stage Pipeline Distribution System is provided where the Nominal Supply System Pressure is increased from 400 kpa to over 1000 kpa.
b) The Trunk Mains remain unitary at Nominal Supply System Pressure of 1000 kpa.

c) Two Principal Feeder Mains are provided in the tall building as double end feeders at Nominal Supply System Pressure of 1000 kpa.

d) The Distribution Branches on each floor are connected to create a ring main at the Nominal Distribution Pressure of 400 kpa by deploying pressure regulators. The Terminal units are connected to this ring main.

2.29.4 **For Medical Vacuum**

Since the Nominal Supply System Pressure cannot be varied, it is recommended to provide multiple units of multiplex pump based Vacuum generation on multiple floors based on standard MGPS design parameters.

2.29.5 **For Medical Carbon Dioxide**

The supply is limited to Operating Rooms only so place the Medical Carbon Dioxide manifold on the service floor which is serving the Operating Rooms.

This service floor must be served by at least one lift to move the Medical Carbon Dioxide Cylinders.

2.29.6 **For AGSS**

The supply is limited to Operating Rooms only so place the AGSS suction units on the service floor which is serving the Operating Rooms.

This service floor must be served by at least one lift to move the Equipment and its maintenance.

2.30 GAS CYLINDER STORES

2.30.1 The primary role of MGPS Gas Cylinder Store is to store filled Compressed Medical Gas Cylinders in a safe and secure manner. It must be so located that it can provide quick and easy connectivity to MGPS Manifold Room for moving the gas Cylinders.

2.30.2 It should always be located at ground level, as close as possible to the gas delivery point. It will never be provided in an underground location, for example in a basement, unless it is a dugout courtyard open to sky.

2.30.3 Care should be taken to ensure that different gas types and full and empty cylinders are segregated as clearly as possible in gas specific bays and provided with a labelling system that clearly indicates the cylinder status.

2.30.4 All cylinder stores should be covered and, ventilated by means of high and low level vents. Vent area will be more than 1.5% of total floor and wall area of the room.

2.31 SOURCES OF GAS SUPPLY

2.31.1 Typically for the MGPS Installation, there will be 3 sources of Gas supply as under.

(a) Primary Supply

(b) Secondary Supply

(c) Emergency Reserve Supply

2.31.2 For larger Hospitals, MGPS design shall be based on deploying multiple MGPS installations. A comprehensive MGPS installation can be planned by Building Block Wise or it can be planned by Zones where grouping of Gas Types can be varied (Usually done in high rise buildings). Larger number of components in large unitary MGPS installations are liable to cause prolonged interruption of MGPS services, throughout the Hospital, in case of faults.

2.31.3 The sizing of Gas sources shall be customised as per projected Gas consumption calculations. The projected Gas consumption calculations would be provided as part of design specification and must be evaluated by the MGPS installer.

2.31.4 The sizing of sources shall be linked to the lead time of Gas Supply by the Vendor. In addition, adequate amount of Gas must be available on site in Cryo tanks or in Gas Cylinder Store to provide sufficient back up to maintain continuity of supply.

2.31.5 In case of Mechanical plants, the sizing will be dependent on creating adequate redundancy.

2.31.6 In case of AGSS, Source sizing is also determined by extrinsic factors like number of rooms served by an AHU.

2.31.7 While designing the MGPS installation, it should be noted that a cylinder manifold larger than 2 x 10 D Type compressed gas cylinders is likely to prove cumbersome, because of the difficulties of manual handling of large number of compressed gas cylinders.

2.31.8 Sufficient Number of Cylinder Trolleys suitable for D Type Cylinders shall be provided.

******

CHAPTER 3

MEDICAL OXYGEN SUPPLY INSTALLATION INCLUDING LIQUID OXYGEN SYSTEMS & OXYGEN 93 PLUS SYSTEMS

3.1 MEDICAL OXYGEN SUPPLY INSTALLATION INCLUDING LIQUID OXYGEN SYSTEMS & OXYGEN 93 PLUS SYSTEMS

3.1.1 Medical Oxygen is one of the most extensively used Medical Gas. Medical Oxygen is a well-known product and its Medical use is well established. It is used for life-support respiratory therapy and additionally, anaesthetic procedures from the MGPS Installation.

3.1.2 It is provided in all Wards, Intensive Care Units, NICU, Treatment Rooms, Obstetric Suites, Operating Rooms and all other designated areas in a Hospital. Selectively, it is also provided for Hyperbaric Treatment Chambers.

3.1.3 Medical Oxygen is monographed in all leading pharmacopoeias of the world.

3.1.4 World Health Organisation has recommended that only high quality, medical-grade Oxygen should be given to patients. Medical-grade Oxygen administered to patients, as a Healthcare intervention, must contain at least 82% Oxygen and should be free from any contamination.

3.2 TYPES OF OXYGEN

3.2.1 World Pharmacopoeias include two monographs on Oxygen

a) The Drugs and Cosmetics Act, 1940 (23 of 1940) (as amended up to the 31st December, 2016) and The Drugs And Cosmetics Rules, 1945 (as amended up to the 31st December, 2016), of India, vide its Schedule K and as listed in Indian Pharmacopoeia (IP): Medical Oxygen is which contains not less than 99.0 per cent v/v of Oxygen; and Oxygen 93 Per Cent which contains not less than 90.0 per cent and not more than 96.0 per cent, v/v of O2, the remainder consisting mostly of Argon and Nitrogen. It is produced from air by the molecular sieve process.

b) The US Pharmacopoeia (USP 43)—National Formulary (NF 38) 2020, Monograph 7782-44-7 Medical Oxygen; Oxygen contains not less than 99.0% V/V of oxygen and Monograph 5231 Oxygen 93 Percent: Oxygen 93 is oxygen produced from air by molecular sieve process. Contains not less than 90.0 % V/V and not more than 96 % oxygen V/V, the remainder consists of mostly argon and nitrogen.

c) European Pharmacopoeia monograph No. 0417: Oxygen contains not less than 99.5% V/V of Oxygen and monograph No. 2455: Oxygen 93 per cent, produced by a single-stage adsorption process, which contains between 90.0% V/V to 96% V/V of Oxygen. Remainder mainly consists of Argon and Nitrogen.

3.2.2 As per European Pharmacopoeia monograph No. 3098 Oxygen 98 per cent, as under.

(i) Oxygen 98 per cent which contains between 96.0% V/V to 99.5% V/V of Oxygen. Remainder mainly consists of Argon and Nitrogen.

(ii) Oxygen (98 per cent) will be produced in double-stage concentrators by two successive modules of adsorption purification of ambient air using zeolites.

3.2.3 Medical Oxygen is supplied to Hospitals as Liquid Medical oxygen or as compressed Gas but is always used as a Gas only.

3.2.4 1 Litre of liquid oxygen produces 861 litres of gas at STP (standard temperature and pressure).

3.2.5 Its Boiling Point is -183 Degree C.

3.3 OXYGEN SOURCES AVAILABLE

3.3.1 Common Medical Oxygen sources are as under.

a. Liquid Medical Oxygen in Bulk Storage Tanks
b. Liquid Medical Oxygen in Cryogenic Storage Cylinders
c. Compressed Gas Cylinders
d. Medical Oxygen Generating Plants (PSA) with storage facility
e. Medical Oxygen Concentrators, generally for domestic use
f. Portable Medical Oxygen Dewar for small quantities of Liquid Oxygen for personal use

3.3.2 Cryogenically produced liquid oxygen is always generated off-site (not at a Hospital). Hospitals are provided large bulk liquid oxygen tanks refilled periodically by a supplier. The liquid oxygen tank supplies a centrally piped system for distributing oxygen throughout the Hospital after self-vaporization. The Electrical power is not required for distribution. The system requires adequate backup storage.

3.3.3 Compressed Gas Cylinders are suitable source for small Hospitals. These also are manifolded to a centrally piped system for distributing oxygen throughout the Hospital. In very-small Hospitals, cylinders are directly placed by the patient bedside.

3.3.4 Oxygen generation using PSA technology can serve as a large central source. Oxygen from a PSA plant can either be piped directly to bedside Terminal Units within Hospital or, with a booster compressor, be used to refill cylinders for oxygen distribution (either on-site or to neighbouring Hospitals).

3.4 DESIGN FLOW RATES FOR OXYGEN

a. Nominal Distribution Pressure to be considered is 400 kPa.
b. Average Rate of Oxygen consumption to be assumed for design calculations in wards shall be 5-6 Litres per minute, per patient. However, each terminal should be capable of passing 10 LPM Oxygen at standard temperature and pressure
c. Rate of Oxygen consumption to be assumed for design calculations in Operating Rooms and Ventilation stations shall be 100 Litres per minute, per patient.

d. Design Flow rate to be assumed for pipe sizing, for Oxygen, in all wards, in all Labour cum Delivery Room (LDR) Rooms and New-born Care Stations, shall be 10 Litres per minute.

e. Design Flow rate to be assumed for pipe sizing, for Oxygen, in all Operating Rooms, shall be 100 Litres per minute.

f. Design Flow rate to be assumed for pipe sizing, for Oxygen, in all Ventilator Stations, including but not limited to Emergency Ward, Recovery Ward, etc., shall be 100 Litres per minute.

g. Design Flow rate to be assumed for pipe sizing, for Oxygen, in all Bio-medical Equipment Service Stations, shall be 100 Litres per minute.

3.5 PROVISION OF OXYGEN TERMINAL UNITS

a. All Patient Bed Stations in the Hospital will be provided minimum one or more, Oxygen Terminal Units. As per Hospital Policy, these can be shared in General Wards, but the MGPS design must ensure that all Complement Beds in the Hospital have access to an Oxygen Terminal Unit.

b. Oxygen Terminal Units will be provided in all Treatment Rooms in all wards.

c. Oxygen Terminal Units will be provided on all New-borne care Units and new-borne Stabilisation Units

d. Oxygen Terminal Units will be provided in all Triage Stations, Pre-operative Wards, Post-operative Wards, Recovery Rooms, Procedure Rooms, Treatment Rooms and Patient Preparation Rooms. These Beds are collectively listed as Non-Complement Beds.

e. Oxygen Terminal Units will be provided in all Operating Rooms.

f. In addition, as per Hospital Policy, Oxygen Terminal Units will be provided in designated Procedure Rooms, Examination Rooms, Therapy Rooms, Dialysis Stations and Disaster Expansion Wards.

3.6 DIVERSITY FACTOR FOR OXYGEN

Ward	Diversity Factor
ICU	NIL
NICU	NIL
LDR Wards, New-borne care Units	50%
HDU Beds including Triage, Emergency n Disaster Wards	50%
General Ward	50%
Non-complement Beds	50%
Operating Rooms; New-borne Stabilisation Units	NIL
All other Stations	NIL

NOTE:

1. The nil diversity factor means that 100% utilization is to be considered.
2. The diversity factor should be decided in consultation with hospital authorities.
3. In COVID situation, the hospital authorities may go in for full utilization (or better diversity) ensuring availability of gas at more number of units at a time.

3.6.1 Disaster Beds and LDR Beds will need Oxygen very infrequently so 50% diversity has been applied.

3.6.2 Check Hospital Policy / requirement for installation of Terminal Units and determine additional diversified flow, if applicable.

3.7 Test Point

a. The Medical Oxygen supply system shall be provided with a test point comprising of a lockable valve and a terminal unit immediately upstream of the Isolation valve of the Hospital Distribution Line.

b. All sources of Medical Oxygen supply should be fitted with their respective test points.

3.8 Liquid Medical Oxygen Installation

A. The **Liquid Medical Oxygen VIE Tanks Supply System** consists of One or more, vacuum-insulated cryogenic bulk storage vessel to store the bulk liquid, Capacity 20,000/ 10,000 Litres or less, constructed from a stainless steel inner pressure vessel that is supported in a mild steel outer shell.

B. Cryogenic Liquid Cylinder Systems can also be used to store the Medical Oxygen as a liquid at cryogenic temperatures and to vaporise it into a gas for patient use. These systems are used where it is neither economical nor possible to supply Liquid Medical Oxygen VIE Tank System.

C. Liquid Medical Oxygen is a low-pressure high flow supply system and will be preferred to be used in any Secondary Care Hospital having 50 or more beds.

D. The gas Supplier will obtain and maintain requisite License to install maintain and operate the Liquid Medical Oxygen VIE Tank gas Supply System.

E. The MGPS Installer shall carry out all needed Civil Works of Foundation, provide for free approach by truck up-to the installation site, provide for security of the Installation, to the satisfaction of Project Engineer.

3.9 CONFIGURATION OF Liquid Medical Oxygen VIE Tank system

The Liquid Medical Oxygen VIE Tank System shall consists of;

a. One or more, vacuum-insulated cryogenic bulk storage vessel to store the bulk liquid, Capacity 20,000/ 10,000 Litres or as decided by hospital authority, constructed from a stainless-steel inner pressure vessel that is supported in a mild steel outer shell.

b. Provision of pressure-raising regulator system which can automatically control the pressure in the Liquid Oxygen System

c. Duplex (Two) ambient-heated vaporiser called main vaporiser to convert the cryogenic liquid into a gas for supply to patients via a pipeline system, with manual changeover.

d. Provision for water spraying facility for manual changeover of vaporisers.

e. Pressure Control Equipment to control the pressure and flow of gas to the pipeline deploying a system of duplex pressure regulators, valves and Pressure Alarms. In turn, this will get connected to Hospital Supply line, upstream of the Automatic Changeover Control Panel, through a non-return Valve.

f. As a system, on safety-valve operation, oxygen must be able to vent safely to atmosphere

g. The use of telemetry on the Liquid Storage System to monitor relevant supply conditions continuously, including storage vessel levels and pressure, is recommended. This shall provide a data output feed to Hospital's MGPS Monitoring and Alarm System for real time monitoring and gas consumption evaluation.

h. The layout of the Liquid Medical Oxygen installation shall provide adequate access to all components of the system and permit adequate airflow for the ambient vaporisers and provide for adding an additional bulk storage vessel in future, on additional plinth.

i. The design of the Liquid Medical Oxygen VIE Tank System installation shall meet the Gas Supplier's requirements for discharging the liquid medical oxygen from the cryogenic tanker.

j. A pipework and installation diagram (P&ID) of the Liquid Medical Oxygen VIE Tank System installation shall be displayed clearly to indicate the appropriate valves that are necessary to operate the plant safely.

k. The Liquid Medical Oxygen VIE Tank System design, its layout, its connectivity, shall be approved by the Hospital Consultant and the Project Engineer.

3.10 COMPRESSED GAS CYLINDER MANIFOLD INSTALLATION

3.10.1 The Compressed Gas Cylinder Manifold Installation in this MGPS installation will be provided with two Banks of Gas Cylinders with equal number of cylinders in each bank and fully Automatic Changeover Units, for it connected to two header bars as has been described earlier.

3.10.2 Depending on the size of the Hospital, its specialisation, this Compressed Gas Cylinder Manifold Installation can be the Source for Primary supply or Secondary supply or the Emergency Reserve supply of Oxygen. It means upto 3 Duplex Manifolds of compressed gas cylinders can be deployed depending upon the oxygen demand of the Hospital.

3.10.3 The Compressed Gas Duplex Cylinder Manifold is a High-Pressure, Low Flow System.

3.10.4 When provided as a source for primary supply or a secondary supply, it will have minimum 10 Gas Cylinders in each bank of the manifold. Another 10 cylinders shall be

stored in the MGPS Manifold Room itself. The additional Gas Cylinders, as required as per design calculations, will be stored in the Cylinder Store.

3.10.5 The changeover from the "Duty" to the "Stand-by" bank of cylinders shall be Automatic, preferably based on pneumatic pressure, without fluctuation in Hospital Distribution Line Pressure. The technology to be deployed for regulating line pressure and automatic changeover shall be discussed with the Project Engineer and the Hospital Consultant and its approval will be taken in writing.

3.10.6 On Automatic changeover, the Empty LED indicator will show a depleted bank by turning red. A buzzer will also sound to indicate an empty bank or banks. When the system is reset, by replacing the depleted cylinders, the indicator will turn green and will also silence the buzzer.

3.10.7 In this MGPS Installation, when it is connected to IBMS, this information shall be relayed and shown in Central Monitoring System, that the cylinder bank was depleted and, in turn, has been reset. This shall be applicable wherever, specifically mentioned in the NIT, as per site/ hospital requirements having IBMS.

3.10.8 The Automatic Changeover Control Panel shall be water resistant, complete with its master control valves, power supply & all Valves, Gauges and Pipes, etc. Suitable Electrical power outlet shall be fitted by the MGPS Installer in preparation for Installing the Unit. The control unit power supply shall provide a visible green LED indicator to display "Mains Supply On".

3.10.9 The Automatic Changeover Control Panel shall be wall type and so mounted that it can take a cylinder bank of 10 cylinders on either side. Average mounting Height for Automatic Changeover Control Panel Box is that its centre shall be 1650 mm from finished floor level.

3.10.10 Three pressure gauges on the front of the control cabinet will indicate left bank pressures, right bank pressures and Hospital Distribution Line pressures.

3.10.11 A main shut off valve will be installed between the Automatic Changeover Control Panel and the Hospital Distribution Line.

3.10.12 A pneumatic relief valve shall be incorporated, upstream of Pressure Regulator, in Hospital Distribution Line for regulating excessive line pressure. Its discharge pipeline shall be vented to atmosphere, outside the building, in an area where the discharge of oxygen, will not present a fire hazard or cause injury to personnel.

3.10.13 All the manifolds shall be capable of passing the full pipeline flow.

3.10.14 All critical connections shall be gas specific, designed to eliminate supply gas errors.

3.10.15 A linear space of 3600 mm will be provided for mounting the 10 Cylinders. Additional space shall be calculated and provided for cylinder stored in MGPS Manifold Room. For different configurations, the space requirement shall be suitably changed.

3.10.16 All Cylinders will be positioned where they can be easily moved, on floor and held in place, against the wall, with two (2) Cylinder Holding Brackets and tape restraints or Chains.

3.10.17 The Header Bar shall be gas specific high-pressure copper pipe, with integral check valves and cylinder pigtail assemblies of copper. confirming to IS 3224, incorporating a check valve at the header connection The Header Bar shall be provided with high pressure brass fittings made of high tensile brass and connections. These shall be cleaned prior to installation and supplied complete with wall mounting brackets.

3.10.18 Header bar shall be provided with cylinder pigtail connections to suit service specific cylinder valves. The manifold connections shall be Oxygen Specific (M20 x 2 Thread).

3.10.19 The manifold should be suitable to withstand working pressure of 150 Kg/cm2. The manifold shall be tested (hydraulically) at requisite pressure stipulated in relevant related standards and necessary test certificate from the manufacturer shall be provided.

3.10.20 A pipework and installation diagram (P&ID) of the Manifold installation shall be displayed in the Manifold Room. It will clearly indicate the pressure regulators, safely instructions and other statutory signs and instructions. It will also clearly state the location of sintered bronze inlet filters and the procedure to replace these, in the event of their choking.

3.11 EMERGENCY RESERVE SUPPLY OF OXYGEN

3.11.1 Another Manifold System shall be provided to form a source for emergency reserve supply, for emergency use, or to permit servicing or repair. It will connect to Hospital Supply line through a pressure regulator and a control valve.

3.11.2 As per Hospital Policy, multiple Emergency Reserve Medical Oxygen Supply Systems can be deployed through secured NIST connections provided at area alarm level. These sources can be a single cylinder or a Duplex Control Manifold System.

3.11.3 Located in the MGPS Manifold Room, the main Emergency Reserve Medical Oxygen Supply Systems will be provided with two Banks of Gas Cylinders with equal number of cylinders in each bank and fully Automatic Changeover Units, for it connected to two header bars as has been described earlier.

3.11.4 It will be a 4 or more + 4 or more (as per the design calculations) cylinder configuration with two header bars, and shall have automatic changeover units. Suitable number of cylinders shall be stored in the MGPS Manifold Room itself. The additional Gas Cylinders, as required as per design calculations, will be stored in the Cylinder Store.

3.11.5 A linear space of 1800 mm is required for mounting the 4 Cylinders and A linear space of 3600 mm is required for mounting the 10 Cylinders.

3.11.6 It is also a High-Pressure, Low Flow System.

3.11.7 Its specifications remain the same as for Main Gas Cylinder Manifold.

3.12 OXYGEN 93 PER CENT GENERATION & DISTRIBUTION

3.12.1 The Indian Pharmacopoeia defines Oxygen 93 per cent, as Oxygen produced from air by the molecular sieve process, by a Hospital or Medical Institute for their captive consumption.

3.12.2 It also requires the Hospital or Medical Institute to be covered by a manufacturing licence under the said rules, and make the production facilities open to inspection by an Inspector appointed under the Act, who can, if necessary, take samples of Oxygen 93 per cent USP, for test, if and as applicable.

3.12.3 Oxygen 93 Percent is defined as a "Medicinal Gas (mixture) used therapeutically for Oxygen supplementation". Oxygen 93 Percent is produced from air by the molecular sieve process. It contains no less than 90.0 percent, and no more than 96.0 percent by volume of Oxygen; the remainder consisting mostly of argon and nitrogen.

3.12.4 Technology deployed for the production of Oxygen 93 Percent functions on the principle of a Molecular Sieve. This involves the Pressure Swing Adsorption (PSA) which is the most commonly used non-cryogenic concentration method for the production of oxygen from ambient or compressed air and also most effective for small and medium capacity production facilities. The purification process works by using at least 2 columns filled with adsorbent, the zeolite molecular sieve. Pre-treated compressed air enters the first column and follows up through the zeolite. Nitrogen and some other gases are trapped while the oxygen is allowed to flow through. When the active column is saturated, the air flow is directed to second column. The first column depressurizes allowing nitrogen to be purged out to the atmosphere and the column regenerates completely.

3.12.5 The process is repeated continuously, when one column is productive, the other regenerates and at the end of each cycle they switch roles. The generator produces a constant flow of Oxygen 93 percent.

3.12.6 During the production process the oxygen content is continuously monitored by means of a suitable analyser.

3.12.7 The typical major components of the PSA system are the compressors, receiver(s), dryers, air filters, molecular sieves, filters and regulators. It leads to a Oxygen Storage Tank. The PSA Plant can distribute the gas via the "Oxygen" pipeline system. Alternatively, it deploys a Oxygen Compressor and provides generated Oxygen in Cylinders.

3.13 **Installation of a Oxygen Generation PSA Plant**

a) The Area required depends on Oxygen Generator PSA Plant capacity and related Design.

b) It is important to note that the waste gas from oxygen generators contains significantly less than 19.5% oxygen and without appropriate venting can create an oxygen-deficient atmosphere. Waste gas vents should be piped outside the building to safe areas.

c) Since air is the raw material, intake air quality (type and degree of contamination with foreign materials such as hydrocarbons, acid gases, and particulate matter) is a major concern in selecting the plant site.

d) Noise abatement and use of personnel ear protection shall be provided in accordance with national and local regulations.

3.14 **PRESSURE REGULATION FOR PIPED OXYGEN SUPPLY**

To harmonise the supply of Medical Oxygen from different supply sources on to the same Hospital Pipeline System, following design parameters are to be evaluated for implementation.

a. The Nominal Distribution Pressure should be within the range of 3.7 Bar to 5 Bar.

b. The respective Pipeline Pressure Regulator on supply sources, must consist of a system of duplex pressure regulators and valves. Both regulators must be online, and all isolation valves and regulators must be in the open position.

c. A Pressure Relief Device shall be provided, downstream of the Pressure Regulator connected by means of a three-way connection, so that the Safety Device can be replaced easily.

- A pressure Relief Device is a safety device designed to protect a pressurized pipeline during an overpressure event.

3.14.1 The Pressure Relief Device discharge should be run to the exterior of the building by providing a Vent Pipe of suitable dia.

3.14.2 Pressure sensors to provide the alarm function will need to be fitted to pipeline distribution systems.

3.14.3 The switchover from Primary Supply to Secondary Supply will occur automatically when pipeline distribution pressure deviates by more than ± 5%, or as per design.

3.14.4 The Emergency Supply System should be activated automatically when the Primary and Secondary Supply System is empty or fails to supply or when the Hospital Pipeline Pressure falls below 3.8 bar.

3.14.5 Typically,

a) Design Flow required at Terminal Units is 100 LPM at 4.1 Bar.

b) Actual Flow required is 20 LPM at 4.1 Bar.

c) Typical average consumption is 5 – 6 LPM at 4.1 Bar.

3.14.6 The Source Pressures & multi point, multi stage Pressure Regulation is as under:

A. In Liquid Medical Oxygen Tanks, the pressure of the VIE is automatically controlled by a pressure raising regulator which controls the flow of liquid to the pressure raising vaporiser as required. The vaporised liquid maintains the VIE gas space pressure at a minimum of 10.5 bar. The typical pressure is 10.6 Bar.

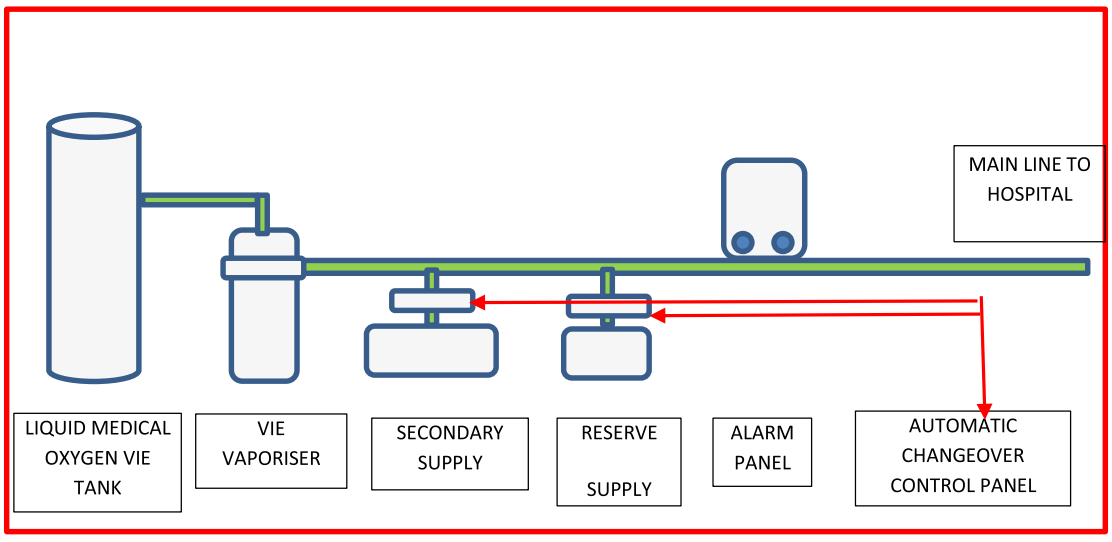
B. When Medical Oxygen Gas is delivered from Liquid Medical Oxygen Control Panel, the Pressure is 8.0 Bar. it is further reduced to 5.5 Bar before it enters the Pipeline Pressure Regulation Station where it is regulated to 4.2 Bar and delivered to the Hospital.

C. The Manifold Control Panel of the source for secondary supply of Medical Oxygen provides Automatic Changeover from Duty Bank to Stand-by Bank and a two stage reduction of Gas Pressure; to 4.5 Bar – 5.0 Bar, before it enters the Pipeline Pressure Regulation Station where it is regulated to 4.1 Bar and delivered to the Hospital.

D. The Manifold Control Panel of the Source for Emergency Reserve supply of Medical Oxygen provides Automatic Changeover from Duty Bank to Stand-by Bank and a two stage reduction of Gas Pressure; to 3.7 Bar, before it enters the Pipeline Pressure Regulation Station. This ensures its activation, automatically when the Primary and Secondary Supply System is empty or fails to supply or when the Hospital Pipeline Pressure falls below 3.8 bar.

Note: All pressure regulators, wherever, they are installed will be specified for Peak flow rate determined.

SCHEMATIC DIAGRAM OF MEDICAL OXYGEN SUPPLY SYSTEM



******

CHAPTER 4

NITROUS OXIDE SUPPLY INSTALLATION

4.1 NITROUS OXIDE SUPPLY INSTALLATION

Nitrous Oxide is used for anaesthetic and analgesic purposes, being mixed with air, oxygen, and nebulised anaesthetic agents. It will be provided only in the Operating Rooms in this MGPS Installation.

4.1.1 N_2O is liquefied by the high pressure within the cylinder. It is supplied and stored as a liquid in pressurised cylinders, at an average pressure of 5000 kPa, with N_2O Vapours present in the space above the liquid (Nearly 70% is liquid).

4.1.2 It is used as a Gas only. The ambient temperature of the cylinder (where the liquid resides) is the determining factor of flow rate.

4.1.3 In N_2O cylinders, the pressure remains relatively constant until all of the liquid is evaporated, after which the pressure drops rapidly as the remaining gas is removed.

4.1.4 When the N_2O gas decompresses and flows at a high flow rate, it chills and can block the orifice of pressure regulator leading to formation of ice crystals which hinder the gas Flow rates. For mitigating this the automatic changeover control panel will provide heating arrangement.

4.1.5 In addition, the N_2O manifold will be positioned in a shaded area, away from direct sunlight or source of heat. (Ideal Ambient Temperature is 20 Degree C)

4.2 SOURCES OF SUPPLY FOR NITROUS OXIDE

4.2.1 MGPS installation delivers N_2O in the gaseous form only, throughout the Hospital where it is to be used. It will be supplied from a combination of three sources.

a. The source for primary supply will be two banks of minimum 4 number of D Type, N_2O Gas Cylinders, (required number to be calculated based on number of Operating Rooms or other areas) in each bank, "Duty Bank" & the "Stand-by Bank" of a duplex control manifold with automatic changeover.

b. The source for secondary supply will be two banks of minimum 2 number of D Type, N_2O Gas Cylinders, (required number to be calculated based on number of Operating Rooms) in each bank, "Duty Bank" & the "Stand-by Bank" of a duplex control manifold with automatic changeover.

c. In no case, more than 10 Cylinders will be provided in a bank. The additional Gas Cylinders, as required, as per design calculations, will be stored in the cylinder store room.

d. Source for emergency reserve supply will be the locally placed cylinders in the Surgical Suite. These are smaller cylinders – A Type.

4.2.2 Thus, there will be 2 N_2O Gas Cylinder manifolds as supply sources.

4.3 DESIGN FLOW RATES FOR NITROUS OXIDE

a) Nominal Distribution Pressure to be considered is 410 kPa.

b) Consumption of N_2O is determined by the time taken for surgery and is variable. Currently, in low volume Anaesthesia, N_2O consumption is estimated to be in the range of 2 – 3 Litres per minute per patient of surgical time but for pipe design, standard design flow rate shall be taken.
(Earlier the N_2O consumption was upto 6 Litres per minute per patient of surgical time)

c) Design Flow rate to be assumed for pipe sizing, for N_2O for all Operating Rooms, shall be 15 Litres per minute.

4.4 TEST POINT

The N_2O supply system shall be provided with a test point comprising of a lockable valve and a terminal unit immediately upstream of the Hospital distribution line isolation valve.

4.5 PROVISION OF NITROUS OXIDE TERMINAL UNITS

i. N_2O Terminal Units will be provided in all Operating Rooms only or as per required of the hospital authorities.

4.6 DIVERSITY FACTOR FOR NITROUS OXIDE

a) Application of diversity is determined by the layout of Surgical Suite (s).

b) If the Operating Rooms are placed close together, no important economy is likely to arise from the application of diversity.

4.7 SYSTEM SIZE

Provide the calculations and basis of Design

4.8 COMPRESSED GAS CYLINDER MANIFOLD INSTALLATION

A. Source for Primary Supply of Nitrous Oxide

1) The N2O Primary supply will be provided with two Banks of Gas Cylinders with equal number of cylinders in each bank and fully Automatic Changeover Units, for it connected to two header bars as has been described earlier and which are connected to the Hospital supply pipeline via a control panel.

2) The Control Panel shall be wall type and so mounted that it can take a cylinder bank of 4 or more cylinders on either side. Average mounting height for control panel box, is that, its centre shall be 1650 mm from finished floor level.

3) Three pressure gauges on the front of the control panel will indicate left bank pressures, right bank pressures and Hospital Distribution Line pressures.

4) The changeover from the "Duty" to the "Stand-by" bank of cylinders shall be Automatic, preferably based on pneumatic pressure, without fluctuation in Hospital distribution line pressure. The technology to be deployed for automatic changeover shall be discussed with the Project Engineer and the Hospital Consultant and its approval will be taken in writing.

5) In Manifold Control Panel,

a) The "Duty" Bank is indicated by the green colour of LED

b) The "Stand-by" Bank is full indicated by the yellow colour of LED

c) The Red colour of LED indicates "Replace Empty Cylinders"

6) On Automatic changeover, the Empty LED indicator will show a depleted bank by turning red. A buzzer will also sound to indicate an empty bank or banks. When the system is reset,

by replacing the depleted cylinders, the indicator will turn green and will also silence the buzzer.

7) The Control Panel will have inbuilt heaters to prevent frosting of regulators.

8) In this MGPS Installation, when it is connected to IBMS, this information shall be relayed and shown in Central Monitoring System, that the bank was depleted and, in turn, has been reset. This shall be applicable wherever, specifically mentioned in the NIT, as per site/ hospital requirements having IBMS.

9) A pneumatic pressure relief valve shall be incorporated in Hospital distribution line upstream of Automatic Changeover Control Panel for regulating line pressure. The discharge pipeline of this valve shall be vented to atmosphere, outside the building, in an area where the discharge of Nitrous Oxide, will not present a hazard or cause injury to personnel.

10) The Control Panel shall be water resistant, complete with its master control valves, power supply & all Valves, Gauges and Pipes, etc. Suitable Electrical power outlet shall be fitted by the MGPS Installer in preparation for Installing the Unit. The control unit power supply shall provide a visible green LED indicator to display "Mains Supply On".

11) All manifold components shall be capable of passing the full pipeline flow.

12) All critical connections shall be gas specific, designed to eliminate supply gas errors.

13) A linear space of 1800 mm will be provided for mounting the 4 Cylinders. Additional space shall be calculated and provided for larger manifolds.

14) Cylinders, placed on floor, positioned where they can be easily moved, will be held in place, against the wall, with two (2) Cylinder Holding Brackets and tape restraints or Chains.

15) The Header Bar shall be gas specific high pressure copper pipe with integral check valves and cylinder pigtail assemblies of Copper, confirming to IS 3224. The Header Bar shall be provided with high pressure brass fittings made of high tensile brass and connections and supplied complete with wall mounting brackets.

16) Header bar shall be provided with cylinder pigtail connections to suit service specific cylinder valves. The manifold connections shall be N_2O Specific as per applicable standards.

17) The manifold should be suitable to withstand working pressure of 150 Kg/cm2. The manifold shall be tested (hydraulically) at required pressure and necessary test certificate from the manufacturer shall be provided, as per applicable standards.

B. Source for Secondary Supply of Nitrous Oxide

I. Secondary supply of Nitrous Oxide shall be provided with two Banks of Gas Cylinders with equal number of cylinders in each and fully Automatic Changeover Units, for it connected to two header bars as source for secondary supply of Nitrous Oxide. The secondary supply is provided to form a reserve source of supply for emergency use, when the primary source is depleted, or to permit servicing or repair of primary supply source.

II. The Gas Flow from Source of secondary supply will be determined by the main pipeline supply pressure and should be triggered by 5% to 10% drop of line pressure coming from source of primary supply.

III. This Duplex Control Manifold will be same, as has been described earlier. It will be a 2 or more + 2 or more, D Type, Compressed Gas Cylinder Manifold, with master control valve.

IV. All specifications remain the same as specified for Primary Supply. It will be located in the N_2O Cylinder Manifold Room.

C. Source for Emergency Reserve Supply of Nitrous Oxide

a) Source for Emergency Reserve Supply of N_2O will be "A Type" valved Cylinders, or any other type of smaller Cylinder, placed locally, in the Surgical Suite. They will be brought on line manually when required. These can be placed with the Anaesthesia Ventilators or at the level of Area Valve, where it gets connected via NIST connectors.

b) Source for Emergency Reserve Supply, including all other deployed cylinders, will be augmented with gas filled cylinders after the Emergency is over.

c) It is to be noted that N_2O gas shelf life is 3 years and N_2O Cylinder Shelf Life is 5 years, so all N_2O gas cylinders in Hospital Inventory should be rotated once a year.

d) Typically,
(i) Design Flow required at Terminal Units is 100 LPM at 4.1 Bar.
(ii) Actual Flow required is 20 LPM at 4.1 Bar.

D. SOURCE PRESSURES & REGULATION

1. In order to harmonise the supply of N_2O from different sources of supply on to the same Hospital Pipeline System, following design parameters are to be evaluated for implementation.

a) The Cylinder Vapour Pressure is about 5000 kPa.

b) The Nominal Distribution Pressure should be within the range of 370 kPa to 500 kPa. It will be set for 420 kPa.

c) The respective Pipeline Pressure Regulator on sources of supply, must consist of a system of duplex, double stage, pressure regulators and valves. Both regulators must be online, and all isolation valves and regulators must be in the open position.

d) A Pressure Relief Device shall be provided, downstream of the Pressure Regulator connected by means of a three-way connection, so that the Safety Device can be replaced easily.

e) The Pressure Relief Device discharge should be run to the exterior of the building by providing a Vent Pipe of suitable dia.

f) Pressure sensors to provide the alarm function will need to be fitted to pipeline distribution systems.

g) The automatic switchover from Primary Supply to Secondary Supply will occur automatically when pipeline distribution pressure deviates by more than ± 5 %.

h) The Emergency Reserve Supply System should be activated manually, when the Primary and Secondary Supply System is empty or fails to supply.

CHAPTER 5

MEDICAL COMPRESSED AIR INSTALLATION

5.1 MEDICAL COMPRESSED AIR INSTALLATION

5.1.1 Medical Compressed Air is primarily used as a blending agent with Medical Oxygen when it is delivered to a patient.

5.1.2 Medical Compressed Air is also used as a breathing air to expand the lungs and improve the respiratory functions of a patient.

5.1.3 Medical Compressed Air is a source of controllable energy. Since energy is required to compress the air, energy is released as the air expands and returns to atmospheric pressure.

5.1.4 This property is used in operating Ventilators, Nebulisers, Surgical Tools and Dental Tools.

5.1.5 Unlike the other piped medical gases which are typically delivered to Hospitals in cylinders, Medical Air is mostly manufactured on-site. This is accomplished by pulling outside air into a Medical Air Compressor which is connected to the MGPS piping system feeding the Hospital facility.

5.1.6 Medical Compressed Air, also called Medicinal Gas, compressed, in pharmacopeia; Medical Air 400 kPa in Gas Industry; and henceforth called Medical Air 4 (MA4) (as it is called in Hospitals), is Medical Compressed Air which is supplied at pressure of 370 kPa or more, at terminal units.

5.1.7 Since MA4 is breathed by the Patients, all types of Compressed Medical Air whether manufactured on-site in a Medical Air Plant or as supplied by a Gas Company, as Compressed Gas in Cylinders are categorised as a drug. It is always used on patients, under medical supervision.

5.1.8 Medical Air Cylinders contain compressed atmospheric dry air which is made up of 21% Oxygen and 79% Nitrogen. (It is different from Zero Air which has 20.5% Oxygen and is an Industrial Gas)

5.1.9 Medical Grade Air Compressors produce Medical air at different pressures. The MGPS designer must specify this requirement clearly as all other supply line accessories will be related to this specified pressure.

5.1.10 MA4, as generated must not contain any lubricant vapours, odours, excessive moisture or particles which are over 0.01 microns in size. It requires that the quality of Air Intake be monitored, the storage and supply system be non-corrosive and supply air is filtered to remove all particulate material.

5.1.11 MA4 supplied to the patient must be dry. It is required to prevent nosocomial infections. Moist Air also accelerates corrosion and shortens the useful life of equipment, and carryover of corrosion particles can plug valves, fittings, filters and instrument control lines. Additionally, design must prevent ingress of water at any stage of manufacturing the Medical Air.

5.1.12 MA4 is used in respiratory therapy for patient ventilators, and for blending with oxygen. It is also used as the driving (carrying medium) gas for nebulised drugs and chemotherapy agents. Therefore, it is essential that MA4, as manufactured and supplied, must be tested by a certified Laboratory to be compliant with the requirement of Indian or European Pharmacopeia, as stated in IS/ISO 7396-1. The MGPS Installation will be taken over only when this certificate is provided. In this MGPS Installation, the output air collected at a terminal Point will be subjected to testing.

5.1.13 In this MGPS Installation, MA4 will be provided in Surgical Suites, LDR Rooms, ICUs and in all critical care areas in the building block.

5.1.14 To contain impact of associated Noise Generation in MGPS Plant Rooms, it is recommended that MGPS Plant Rooms should be independent building blocks and located away from the Hospital Building Blocks. Care must be taken to provide these a good source of Clean Air Intake.

5.2 MA4 DESIGN FLOW REQUIRED AT TERMINAL UNITS

LOCATION	NOMINAL PRESSURE	DESIGN FLOW	TYPICAL FLOW	TEST FLOW
	kPa	LPM	LPM	LPM
Operating Rooms	400	40	40	80
Critical Care Areas, Neonatal, HDUs	400	80	80	80
Other areas	400	20	10	80

NOTE:

1. The design flow requirements to be decided in consultation with the hospital authorities.
2. In COVID situation, the hospital authorities may go in for full utilization (or better diversity) ensuring availability of gas at more number of units at a time.

5.2.1 Nominal Distribution Pressure for MA4 in smaller installations is 400 kPa.

5.2.2 Nominal Supply System Pressure in large installations is 1000 kPa. It will be reduced to 400 kPa in feeder lines before it is distributed to Terminal Units.

5.3 SOURCES OF SUPPLY FOR MEDICAL AIR 4

5.3.1 MA4 is generated by deploying a multiplex system of air compressors. It can be a Duplex (with stand by cylinder bank) , Triplex or Quadruplex system. The Compressed Air is then purified and supplied. The compressors are controlled by a PLC Controller which provides Cascaded Control & Sequenced operations.

5.3.2 If the Medical Air 4 requirement exceeds the ability of a Quadruplex System, provide a Second Multiplex System.

5.3.3 Depending upon the system design, one or more than one compressor in this multiplex system constitutes the Primary Source of Supply and the remaining compressors constitute the Secondary Source of Supply.

5.3.4 *Medical Compressed Air is produced at a pressure of 700 kPa by the compressors. (or at 1100 kPa when required). This air is introduced into Medical Air Generation System for drying and purification at this pressure. The pressure drop, in the various purification units and pipeline distribution, is accounted for and at Hospital main supply pipeline, the pressure regulated down to 400 kPa – 450 kPa. The further pressure drop, in the piping distribution, about 5%, is accounted for and the end use pressure is 370 kPa – 400 kPa*

5.3.5 The Air Quality parameter to be achieved shall be as per following:

Contaminant	Threshold
H_2O	67 ppm v/v
Dry particulates	Free from visible particulates in a 75 litre sample
Oil (droplet or mist)	0.1 mg/m³
CO	5 ppm v/v
CO_2	500 ppm v/v
SO_2	1 ppm v/v
NO	2 ppm v/v
NO_2	2 ppm v/v

The medical air purification module shall incorporate high efficiency water separators, oil coalescing filters, heatless regenerative desiccant dryers, activated carbon filters with hopcalite catalyst, bacterial filters and pressure regulators. The performance of the filters shall be according to below specifications: • Oil coalescing two-in-one high efficiency filter: mass efficiency of 99, 991%, tested according to ISO 8573-2 & ISO 12500-1 • Activated carbon filter: max remaining total oil content of 0,003 mg/m³, tested according to ISO 8573-5 & ISO12500-2 • Bacterial filter: particle count efficiency of 99,98% at MPPS=0.06µm, tested according to ISO 12500-3.

5.4 DESIGN FLOW RATES FOR MEDICAL AIR 4

a) Nominal Distribution Pressure to be considered is 400 kPa.

b) The Ventilators, when starting, consume a variable but larger volume of Medical Air 4. This value is generally 80 – 180 LPM at 400 kPa, depending upon the type of Ventilator deployed.

c) Typically Rate of Medical Air 4 consumption, after starting, also called continuous running consumption, for Ventilators in ICUs, LDR Rooms, shall be 42 LPM

d) Rate of Medical Air 4 consumption for Anaesthesia Ventilator shall be 40 – 80 (Typically 40) Litres per minute at 400 kPa.

e) Rate of Medical Air 4 consumption for Nebulisers in wards shall be 10 Litres per minute at 400 kPa.

f) Rate of Medical Air 4 consumption for Bio-medical Equipment Service Rooms shall be 40 Litres per minute at 400 kPa.

g) So, Design Flow rate to be assumed for pipe sizing, for Medical Air 4, shall be 80 Litres per minute at 400 kPa.

h) It must be ensured that all system components including the Compressors must be specified for Peak flow rate.

NOTE:

1. The design flow requirements to be decided in consultation with the hospital authorities.
2. In COVID situation, the hospital authorities may go in for full utilization (or better diversity) ensuring availability of gas at more number of units at a time.

5.5 PROVISION OF MEDICAL AIR 4 TERMINAL UNITS

(i) All Critical Care Patient Bed Stations in the Hospital will be provided minimum one or more Medical Air 4 Terminal Units.

(ii) Medical Air 4 Terminal Units will be provided in all Operating Rooms.

(iii) In addition, one Medical Air 4 Terminal Unit will be provided on all new-borne Stabilisation Units.

(iv) Medical Air 4 Terminal Units will be provided in all Triage Stations, designated beds in Pre-operative wards, Post-operative Wards, Recovery Rooms, Procedure Rooms and Treatment Rooms.

(v) For details, see Appendix A.

5.6 DIVERSITY FACTOR FOR MEDICAL AIR 4

(i) Use of Medical Air 4 is determined by Number of Ventilators procured and installed in the Hospital.

(ii) Even if the number of Medical Air 4 Terminal Units are provided in excess of One (1) per bed, or per therapy station, functionally, it will be considered One (1).

(iii) It will be further assumed that at any given time, only 90% of all installed Ventilators (maximum) will be used simultaneously.

(iv) All Treatment Rooms, attached to General Wards and other such wards where MA4 is not provided on beds, should be provided MA4 Terminal Units

(v) MA4 Terminal Units for Ventilators are provided in Radiology Preparation Rooms, Chemotherapy Wards, Radiology & Imaging Examination Rooms, Radiotherapy Units, Nuclear Medicine Units and Cardiac Cath Labs.

(vi) All patients on Ventilators will be treated in ICUs for Dialysis, Chemotherapy and other accessory therapies. Therefore, determine the Hospital Ventilation Points as per actual layout.

(vii) Further, it is assumed that all Operating Rooms will be provided with anaesthesia workstations. It is further assumed that all anaesthesia workstations are likely to be used simultaneously.

(viii) Therefore, in reference to installed Medical Air 4 Terminal Units, the diversified flow will be determined, as under for sizing the system.

WARD	DIVERSITY FACTOR
ICU	NIL
NICU	NIL
LDR Wards	10%
HDU Beds including Triage, Emergency n Disaster Wards	50%
Non-complement Beds	10%
Operating Rooms	NIL
All other Stations including Radiology, Cardiac Cath Labs, etc.	10%

NOTE:

1. The nil diversity factor means that 100% utilization is to be considered.
2. The diversity factor should be decided in consultation with hospital authorities.
3. In COVID situation, the hospital authorities may go in for full utilization (or better diversity) ensuring availability of gas at more number of units at a time.

5.7 TEST POINT

The Medical Air 4 supply system shall be provided with a test point comprising of a lockable valve and a terminal unit immediately upstream of the Hospital Distribution Line.

5.8 SYSTEM CONFIGRATION

(i) It must be recognised that Ventilators, which require MA4, are life saving devices and require a specified Air Pressure and Gas Flow rate. The MA4 system must be configured to meet this requirement.

(ii) Medical Air 4 supply system must be able to operate continuously to meet the peak calculated demand for long periods and provide adequate redundancy for maintenance of the system. So, a system of multiplexing smaller horsepower (hp) compressors should be provided.

(iii) When sizing the air compressor, it is important to size with the load being maintained even with one unit out of service.

(iv) Each compressor, of the multiplex system will be connected through a common header to a set of 2 Air Receivers.

(v) The Air Receivers, in turn will be connected to a duplex set of Driers, a duplex set of Filters and a duplex set of Pressure Regulators.

(vi) After that it will connect to the Hospital Distribution Line.

(vii) The Emergency Reserve Supply of Air Cylinder Manifold will connect to the Hospital Distribution Line, upstream of the Pressure regulator, after its Isolation valve.

(viii) All valves, regulators, relief valves, filter assemblies and other in line components must be able to operate at the pressure of 700 kPa (or 1100 kPa).

(ix) After the Pressure regulator, all valves, and other in line components must be able to operate at the pressure of 400 kPa and designed flow rate universally till the terminal unit.

(x) The whole system shall be controlled by a PLC Controller which provides Cascaded Control & Sequenced operations.

(xi) The Medical Air Plant Room, specifically, shall provide an open, protected drain, with suitable slope, to remove all water coming out from various drain ports.

5.9 AIR INTAKE

(i) The quality of Air Intake determines the quality of Medical Air delivered, particularly with respect to levels of carbon monoxide & ozone; therefore, the location of Air Intake for MGPS plant must be ensured as being suitable for use in MGPS MA4 Plant. if MA4 compressors draw in good clean ambient air, the air will stay clean through the compressor. It is then dried and purified, so, when it is delivered to the patient, its quality should be fit for breathing.

(ii) Each Compressor will have its dedicated Air Intake which must provide unhindered flow of adequate air as per design. It should not cause pump starvation at any time. Intake Air piping must be sized to induce no more than a 4 inch water column vacuum at the compressor when all compressors are operating.

(iii) The Air Intake shall be a ducted system of Copper Pipes (within the unit). It must be provided with suitable screens and a coarse filter, inspectable, to prevent ingress of ant insects or small birds, or particles of 100 micron or larger. Ideally, the Air Intake circuit should have a set of Inlet Filters comprising of a Coarse Filter of 20 micron and an active charcoal filter to filter particles and hydrocarbons.

(iv) It must be isolated from all piped and un-piped exhaust systems, of the Hospital, as per Compressed Gas Association Norms.

(v) Air Intake shall be at least 5 Meters above Ground, in opposite face of the plant room where pump exhaust is being sent, to ensure a reasonable quality of Air Intake. It is required to be 8 Meters away from any exhaust or vent, or from the any source or collection of noxious fumes and at least 3 Meters away from any window. It must be so protected that birds shall not contaminate the Air Intake

(vi) Ventilating systems with a fan motor or drive belts located in the airstream shall not be used as a source of Air Intake.

(vii) The Air Intake shall always be labelled as the source of Medical Air, to prevent accidents. The labelling must be illuminated and signed as a caution sign. This is required to alert the Housekeeping Staff of Hospital.

5.10 COMPRESSORS

A. A Medical Air Compressor is the main and essential component of a Medical Air Plant. To differentiate these from Industrial Compressors, they have come to be known as Medical Grade Compressors.

B. The capacity of Medical Air Compressor is expressed as “Free Air Delivery” or FAD.

C. Minimum 2 number of Medical Grade Air compressors shall be provided to provide redundancy.

D. A multiplex system of Medical Air Compressors shall be provided.

5.11 Requirement of Medical Air tend to vary in the Hospital, so, multiple number of Medical Air Compressor of smaller compression capacity are provided (also called multiplexing or banking) to meet varying demand in a cost-effective manner. When peak demand is required, all compressors can be turned on.

(i) All compressors in multiplex configuration will have same specifications. The individual compressors shall be arranged so that they will supply the system simultaneously, if necessary. Multiplexing should also allow for expandability.

(ii) The Medical Air Compressors must be suitable for continuous running on load and for high frequency start/stop operations.

(iii) They must be energy efficient. A minimum efficiency of 5 m3/kWh of air at 100% design flow is required to be achieved.

(iv) The power consumption at zero flow should be less than 1% of that at 100% design flow.

(v) Preferably, air cooled Medical Grade Air Compressors shall be used.

(vi) Medical Grade Air Compressors employ Electrical motors of required capacity. Typically, power is transmitted by V-Belt, gear or direct drive configurations.

(vii) The Medical Grade Air Compressors should use oil-free or oil-less technologies to reduce post compressor treatment of compressed air.

(viii) Medical Grade Air Compressors deploy both Reciprocating and Rotary Compressors Technologies. These include, but are not limited to, the following.

5.12 Reciprocating Air Compressors

i. Reciprocating Single Acting One Stage Compressor (suitable for 480 kPa – 930 kPa pressure)

ii. Reciprocating Single Acting Two Stage Compressor (suitable for upto 1200 kPa pressure)

iii. Reciprocating Diaphragm Compressor (suitable for low pressure, light duty only, but being non-lubricated, these provide un-contaminated air)

Reciprocating Compressors can be of a lubricated, non-lubricated or oil-less design.

5.13 Rotary Air Compressors

a) Rotary Helical Screw Compressors are suitable for low vibrations, continuous operation; are of compact size and are suitable for high output volume but are not particularly suited to frequent starting and stopping operations. (suitable for minimum 780 kPa discharge pressure)

b) Rotary Scroll Compressors are intrinsically oil-free. They are quiet, have low vibration, are compact and are suited to frequent starting and stopping operations. (suitable for 780 kPa discharge pressure)

c) Rotary Sliding Vane Compressor (Single Stage or multistage) are not oil free, and are considered suitable only for vacuum applications only

5.14 All moving parts, viz., fans, pulleys and belts, shall be fully protected by enclosures and guards.

5.15 Each compressor will be equipped with isolation valve, check valve, safety valve, electric motor, belts, belt guard, aftercooler and Thermal Malfunction Protection Device (TMPD), as appropriate.

5.16 Vibration mounting, by means of spring isolators, will be provided.

5.17 Design proper Compressors Control systems, to regulate their operation in accordance with compressed air demand.

(i) **Start-stop Controls** are recommended for a compressor when adequate air storage is provided, and air requirement is less than 75 percent of the compressor free air delivery.

(ii) **Variable Speed Controls** are provided to obtain energy efficiency. A variable speed drive will control the speed of the motor and dynamically adjust the speed (increase or decrease) in order to meet the air demand.

(iii) **Sequencing Controls** coupled with **Cascading Control** for operating a group of compressors at peak efficiency levels provide alternate operation of each compressor at each operating cycle. This also permits simultaneous operation of all compressors, if required

5.18 The Control System for the Compressor Plant shall include an "hours-run" counter.

5.19 Air Compressor Packaged Units are fully assembled air compressor systems, complete with air compressor, electric motor, belt, direct or gear drive and automatic controls. Optional equipment includes air receiver, Desiccant dryer, aftercoolers, automatic moisture drain, low oil safety control, magnetic starter, water separator and particulate filters and pressure reducing valve. Common types of packaged unit compressors include base mount, tank mount, tank mount duplex and tank mount with integrated or mounted dryer.

5.20 Medical Air Compressors, of any type, must be suitable for continuous running on load and for high frequency start/stop operation. Always consider energy efficiency factors.

5.21 Selection of Air Compressing technology depends on following parameters. The MGPS design will provide analysis of the selected Medical Grade Compressors based on these factors as a Table.

a) Initial Cost, Operating Cost, Maintenance Cost

b) Cost of One Cubic Meter of Air produced, averaged over Life Cost of Compressor, determined at compressor air discharge point

c) Lubrication, Energy Efficiency

d) Duty Cycle

e) Uptime, Durability

f) Service Intervals

g) Lead Time for Spares

h) Noise Levels

i) Noise Canopy Required

5.22 AIR RECEIVERS

A. The Medical Air Receiver Tank (Wet Air Tank or Primary Receiver) provides a steady stream of Medical Air to compressor controls, eliminating short-cycling and over-pressurization. It also cools Medical Air by 3 – 5 Degree C during its steady flow and storage in the Tank. It receives the Air at bottom of tank and delivers near the top of tank, thus entrapping some of the entrained moisture. It improves the efficiency of system's air dryer.

B. Air Receivers (for moist Air) should comply with BS EN 286, Air Receivers 2005 and should be supplied with test certificates.

C. The minimum water capacity of the Air Receivers should be 50% of the compressor output in 1 minute, stated in terms of free air delivered at normal working pressure. For all compressor systems with a design flow greater than 500 L/min, two receivers, each able to be isolated individually, should be installed.

D. Two (2) Vertical Air Receivers, each of suitable capacity, suitable to withstand a pressure of 10 Kg/cm2, (or higher pressure in 10 Kg/cm2 pipe) fitted with one Pressure Gauge, one Safety Valve and one Auto Drain Cock. The two Air Receivers shall be interconnected so they perform as a single unit.

E. Air Receivers Tanks should conform to ASME Boiler and Pressure Vessel Code 2017, Section VIII. It will preferably be a Vertical, Cylindrical, Stainless Steel Tank (304/ 304L), for providing rust protection. It must be durable, corrosion resistant and be able to maintain air purity. These shall be provided with valve arrangements to permit isolation of one or the other for inspection purposes.

F. Air receiver will provide two output lines, each line with an individual control valve.

5.23 COMPRESSED AIR PURIFICATION

(i) Compressed Air leaving the air compressor is not normally of a quality suitable for Medical use. It is Contaminated with Water, Oil Vapours (even in non-lubricating compressors) and Particles of varying sizes. This is due to several factors.

a. Atmospheric intake air contains particulate matter, moisture and hydrocarbons.

b. The air compressor itself will contribute contaminants in the form of wear particles and compressor oil carry-over.

c. The discharge temperature of the Compressed Air is high. And Cooling after compression results in condensation of moisture vapor and saturated air leaving the aftercooler.

(ii) It should be noted that

a. Air that leaves a compressor it is under both an elevated pressure and an elevated temperature. A delicate balance exists under this condition for air saturation, since the air under pressure has less capacity for water vapor, whereas air at an elevated temperature has a greater capacity for water vapor.

b. Dirt, Water, and Oil entrained in the compressed air will be deposited on the inner surfaces of pipes fittings, leading to pressure drop in the line and the reduced performance of medical devices.

c. Clean, Dry compressed air prevents frequent maintenance and loss of efficiency of the connected devices. It will result in lower operating costs of Hospital's Medical air System.

5.24 Moisture in Compressed Air

1) Compressed Air always has moisture which is directly proportional to the water vapours present in the Intake Air. The water holding capacity of Air depends on its temperature and pressure. Every 5 Degree C increase of Air Temperature doubles its water holding capacity.

2) Higher moisture content liquifies on compression, as well as by cooling.

3) Moisture Separators work; either on a maintenance free, cyclonic air motion principle, forcing particles to accelerate in a radial outward movement, eliminating particle size of 5 micron or larger; or a coalescing separator flow principle in which compressed air from the inside to the outside of the filter element.

4) This condensed water in Medical Air Plant is removed, as under, to make the air dry.

   a) The aftercooler drains some of this liquified moisture.

   b) Some water condensates and gets collected in the Air Receivers

   c) A moisture separator is deployed after the Air Receivers to remove some more of this condensate water.

   d) There should be a proper drainage system in MGPS Plant Room to remove this water from these condensate traps

5) Finally, Air Dryers are deployed to dry the compressed air. This helps to remove nearly 50% of total water contamination. It also results in 10 – 12% of volume loss of compressed air.

5.24 Dew Point

a. Dew Point indicates the concentration of water vapours in a compressed air system. The dew point is the temperature at which condensate will begin to form if the air cools at constant pressure.

b. When the compressed air temperature and dew point are equal, the relative humidity of the compressed air is 100%.

c. A distinction must be made between the dew point at atmospheric conditions and the dew point under operating conditions at elevated pressure. When water has been removed from the compressed air, the resulting atmospheric dew point is lower and is referred to as Pressure Dew Point.

Pressure Dew Point is temperature to which air must be cooled, at a given pressure and water-vapour content, for it to reach saturation; the temperature at which dew begins to form

Compressed Air Purification is a multi-stage process, which deploys a variety of equipment as under, and generally, in the stated order. This is because each stage supports and protects the next stage technology. The Air Purification process requires traps, valves, isolating valves and non-return valves to maintain stage wise purity as well as to provide isolation of components for maintenance or replacement. It also needs to be monitored. All components and accessories, that are specified, must be suitable for continuous use at the system demand flow at higher pressures than the distribution pressure.

5.26 Aftercooler

a) An aftercooler is a mechanical Heat Exchanger designed to remove the heat-of-compression from a compressed air stream. They also reduce compressed air moisture level. So, they are provided with a trap and drain to remove this condensate water.

b) Hot compressed air could cause unsafe surface temperatures and thermal expansion in piping systems and could adversely affect gaskets, seals and other downstream components. Adequate compressed air cooling is essential for the proper operation of Compressed Air Treatment Equipment.

c) In Medical Air plants, Air Cooled or forced Air Cooled, Aftercoolers are installed after the discharge of an Air Compressor and often as an integral part of the compressor package.

The Compressed Air from the compressor outlet can be at a temperature between 100 Degree C to 180 Degree C depending on the type of Air Compressor deployed. Aftercoolers should be designed, using Cold Temperature Difference Technique, to cool it to a temperature within 10 degree C of ambient air. (Note: The Air Dryers are designed for intake compressed air temperature of +/- 5 Degree of 40 degree C.)

5.27 The Compressed Air System Plant design must take care of the resultant pressure drop.

5.28 Moisture Separation

(i) A Moisture Separator is a mechanical device designed to remove condensate from an air stream. It employs cyclonic air motion guided by the baffle plates, fixed at angles, around the inner pipe, to separate the moisture. The inner pipe is provided with 100 micron

Stainless Steel mesh fixed inside the inner pipe. Moisture separators require a drain valve for removing condensate during its operation.

(ii) Depending on the design, a coalescing filter can be added to improve the efficiency of Moisture Separation.

(iii) It is installed immediately downstream of the Air Receiver tanks.

(iv) It should be noted that moisture separator is 85% (average) efficient and that some condensate passes through the device. Also, a moisture separator does not lower the compressed air dew point, meaning further cooling downstream will result in additional condensate in the piping system.

5.29 Oil Separation

a) It is required because the desiccant in Dryer is sensitive to oil and free water contamination, and MA4, when supplied to the patient, as breathing Air, must not contain oil vapours more than 0.1 mg/m3. Therefore, after the Moisture Separators, and before the Desiccant Dryers, online Oil Filters are provided to remove Hydrocarbon vapours, water vapours, particles and odours. Activated Carbon Filters bond hydrocarbon residue, odorants and oil vapours whereas the coalescing type filters remove extremely small solid or liquid particles down to 0.01 microns but not oil vapours or odours.

b) For Oil Separation, Adsorption filters which contain activated carbon granules and have an extremely high surface area and dwell time will be used. An adsorption filter must be protected by an upstream coalescing type filter to prevent gross contamination by liquid oil. The Air temperature should be +/- 20 Degree C.

c) If Oil free Air Compressors have been selected, determine if Oil Separation is required or not, based on quality of Intake Air or Compressor Contamination.

d) Deployment of an Oil Separation Filters with Oil free Air Compressors is preferred. It should be an air filtration system which utilizes a prefilter, high-efficiency coalescing filter and charcoal adsorber element; capable of removing particles down to 1 micron, and liquids down to 0.5 ppm, at air temperature of 21-degree C, and oils <0.01 mg/m3; to meet the requirement of ISO 8573.1, Class 1.1.1, Clean, dry and odour-free air. Additional treatment, when required to meet breathing or medical air requirements may be provided. Optionally, a carbon monoxide monitor may also be provided here, to meet the requirements for Grade D Breathing Air.

Provision of Duplex Moisture & Oil Separators reduce the pressure loss of Compressed Air output from these units

5.30 Air Dryer

A. Different methods can be used to remove moisture from compressed air. Current drying methods include the following:

(i) Refrigerant
   a. Cycling
   b. Non-cycling

(ii) Regenerative Desiccant
   a) Heatless (no internal or external heaters)

b) Heated (internal or external heaters)
c) Heated Blower
d) Heat of Compression
e) Non-regenerative Single Tower

(iii) liquescent

(iv) Membrane

B. Regenerative desiccant type dryers use a porous desiccant that adsorbs the moisture by collecting it in its myriad pores, allowing large quantities of water to be retained by a relatively small quantity of desiccant. Desiccant types include silica gel, activated alumina, and molecular sieves. The most common dew point rating for these dryers is -40 Degree C. Normally the desiccant is contained in two separate towers. Compressed air to be dried flows through one tower, while the desiccant in the other is being regenerated. Regeneration is accomplished by reducing the pressure in the tower and passing purge air through the desiccant bed. The purge air may also be heated, either within the dryer or externally, to reduce the amount of purge air required. Heated purge air may also be supplied by a blower. Desiccant dryers all have a built-in regeneration cycle, which can be based upon time, dew point, bed moisture load or a combination of these. Typically, purge air is expanded to atmospheric pressure.

C. When Regenerative Desiccant Type Dryers are deployed, purge flows can consume 12 – 20% of Supplied Air. Optimise purge rates through proper control, maintenance practices and control technologies. Design controls for its optimized performance adjusting to varying inlet and ambient conditions.

D. Each of the above listed Air Dryer methods has its advantages and disadvantages and needs to be properly evaluated.

E. The dryer control system should ensure that regeneration is operated in proportion to the compressed air usage. Each dryer will have capacity to take care of the 100% of Hospital demand.

F. The dryer control system shall include a dew-point hygrometer and display with a minimum accuracy of ±3° C in a range from –20° C to –60° C atmospheric dew-point, with a set point of –46° C.

G. Additionally, a water content not exceeding 67 VPM (volume parts per million – equivalent to dew-point – 46° C, at atmospheric pressure) must be specified for Medical Air Pipeline Systems.

H. The efficiency of the compressor system should be tested at 10% and 0% of the system design flow.

I. It should be arranged that in the event of open circuit, a “plant emergency” alarm be initiated.

J. There should be dual after-filters (for the desiccant dust) downstream of the dryers, to remove dust that is generated from the constant movement of the desiccant beads against one another caused by flow of air through the dryer, to filter particles down to 1 μm, each sized for 100 % dryer capacity.

K. Each Air Dryer installation shall consist of the following, as a minimum.

i. Twin Desiccant Vessels with Vessel Internal of 316 Stainless Steel
ii. Pre-filters and after-filters
iii. Interconnecting piping, valves, switch-over valves, relief valve, automatic drain and vent
iv. All Control Instrumentation, Control Panel, Dew point sensor with Indicator
v. First fill of desiccant
vi. Noise Attenuation Equipment including purge air outlet silencer
vii. All needed Accessories

L. The Design will provide adequate operational clearance and maintenance access.

M. The performance test of the dryer shall be carried out in accordance with section 7 of ISO 7183 to demonstrate the following.

(i) Pressure Dew Point at rated flow rate through the dryer
(ii) Pressure Drop across dryer package
(iii) Purge Flow Rate
(iv) Drying and Regeneration Cycle Time
(v) Pressurisation and De-pressurisation
(vi) Regeneration Temperature
(vii) Sound Pressure Level during purge outlet and blow down, as per ISO 3744 or ISO 9614-2.

5.32 Bacteria Filtration

a) After the Air dryer, a set of duplex, activated carbon filters may be installed for final odour removal.
b) Then a set of duplex high efficiency, low pressure loss, medical grade bacteria filter shall be installed with minimum of 98% efficiency, at 1 micron.
c) These filters shall be equipped with a continuous visual indicator showing the status of the filter element life.
d) Optionally, they should provide differential pressure of inlet and outlet to assist in determination of loss of filtration efficiency.

5.33 Pressure Control

i. After multistage treatment, filtration and Purification, a set of duplex line pressure regulators, with suitable isolating valves, shall be provided to maintain the nominal pipeline distribution pressure.

ii. The pressure regulators shall provide the specified air flow with inlet pressure of 8.5 Kg/cm2 and output pressure of 4.22 Kg/cm2, as per design.

iii. All Safety valves shall be certified for suitable air flow and pressure accordingly.

iv. The Medical Air plant may be provided with continuous monitoring system with central alarm capabilities for dew point and carbon monoxide contamination downstream of the dryers and upstream of the piping system.

v. An automatic pressure switch may be provided downstream of the main supply line shut-off valve along with a visual and audible alarm to indicate a rise or fall of the main line pressure above or below the nominal line pressure.

vi. The control panel for the Compressor Plant shall include an "hours-run" counter.

5.34 Additional Use of Medical Air Systems

A. Use of instrument/ Surgical Air 7 is permitted as a power source for pendant control and braking systems in the Operating Rooms. Surgical air at 700 kPa is only used as the power source for surgical tools. These tools typically require high flows – up to 350 L/min – at 700 kPa at the point of use. Where nitrogen is available on site, it may be used as an alternative source of supply.

B. When so used, the Medical Air System must be connected via a nonreturn valve and flow-limiting device. It must be capable of isolation by means of an AVSU labelled to identify the equipment controlled.

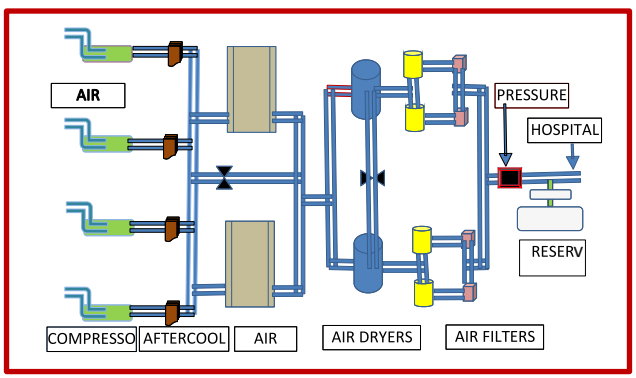
C. Medical Air Systems must not be used to provide air for sterilizer chamber or Operating Room door-seal use.

D. These additions must not compromise either the Medical Air System or operation of any connected equipment.

NOTE

Consider providing "Variable Speed & Variable Frequency Drive" (VSD/VFD) control of all pump motors as an energy saving mechanism controlled from the control panel manager of the system. The VSD starts the pump motor at a low frequency, allowing the motor to slowly ramp up to the required speed. This effectively eliminates the high voltage spikes during start-up that are common to systems without a VSD, thus reducing the amount of power the system uses. This is a design decision as the Air Compressors and the Vacuum Pumps will have to be selected, as being suitable for this control.

5.35 Schematic Diagram of Medical Air Systems



CHAPTER 6

MEDICAL VACUUM SYSTEM INSTALLATION

6.1 MEDICAL VACUUM SYSTEM INSTALLATION

a) The term Vacuum can be defined in two ways; as a space empty of matter, or a space in which the Atmospheric Pressure has been reduced. The latter, sub-atmospheric pressure, is also termed as Negative Pressure. This Negative Pressure is deployed in Medical Vacuum System to create movement of air, liquids or solids. In Hospital environment, it is called as Suction.

b) Suction, typically, is influenced by a number of parameters which are applied simultaneously. First is Vacuum Pipeline Diameter which regulates the flow; and the Negative Pressure, created by the capacity of the Vacuum Pumps deployed. It is also influenced by the resistance to flow, by the various sub-units deployed including the suction catheter, suction regulator and the Vacuum Terminal unit connection pipe.

c) Another dynamic in medical suctioning is the viscosity of the matter being suctioned.

d) Piped Medical Vacuum Systems provides immediate and reliable suction for medical needs, particularly in Surgical Healthcare delivery. They are optimal in for all Hospital Environments. They save floor space, are quiet, safe, readily available, can be easily manipulated and are convenient for the Hospital staff.

e) The Vacuum Pressures is expressed as gauge pressure, which is the pressure above or below ambient atmospheric pressure. The atmospheric pressure that indicates as zero on ordinary pressure gauges is 760 mm Hg, which is normal pressure at sea level. Negative pressure is therefore, defined as pressure less than atmospheric or pressure less than zero (atmospheric) on the pressure gauge.

f) Suction Pressure is pressure, at which air or liquid is removed through the system and from the patient.

g) In Hospitals with MGPS, source of Medical Vacuum is the Vacuum Terminal Unit (also sometimes referred to as Vacuum Outlet). It is deployed by using a tube, which is connected to the Suction Apparatus, which consists of a suction regulator, a Collection Receptacle and the catheter which connects to the patient.

h) This Suction Apparatus has a built-in resistance to flow which should always be considered.

i) The amount of Suction Pressure supplied by a piped vacuum system is upto 635 mm Hg (84 kPa). It is greater than that required for most clinical suction applications. A regulator, attached to the wall outlet of the vacuum system, enables the control of this Suction Pressure.

j) Generally, a Suction Pressure of 400 mm Hg (53 kPa) or lower is used. For Obstetric Cases and Paediatrics, even lower Suction Pressure is used through low suction regulators, from 0 to 300 mm Hg (40 kPa), as provided.

k) The capacity of the vacuum pump should be specified in terms of the free air aspirated (FAA) in LPM when the pump is operating at a vacuum of 475 mm Hg (63 kPa) and at 450 mm Hg (60 kPa) at the plant pipeline connection.

6.2 APPLICATION OF MEDICAL VACUUM

6.2.1 Medical Vacuum can be regulated from High Pressure + High Flow to Low Pressure and Low Flow as per clinical requirement by using Suction Regulators.

6.2.2 For Oral Care, Airway Management, Naso-gastric Drainage and Thoracic Suctioning in ICUs, multiplexing of suction sources may done to improve flow rates (and suction pressure) to manage removal of thick, purulent secretions. Generally, duplexing (maximum 4 sources can be applied simultaneously) is deployed by using continuous suction regulators and intermitting suction regulators.

6.2.3 If multiplexing of suction sources is required, the ICU bed must be provided with 2, 3 or 4 Vacuum Terminal Units. It can be done using Y connectors if suction apparatus is so designed.

6.2.4 **Collection Receptacle Placement** in relation to level of point of suction also influences the amount of suction generated and it becomes an important consideration for setting up the suction equipment.

a. When the Collection Receptacle is located above the level of the patient, at the point of connection to the suction regulator at the wall Vacuum Outlet, some suction pressure is consumed to counter the effect of Gravity Pull on the fluid being sucked. This coupled with intermittent suction, creates Hydraulic Push Action, in “Pressure Off” stage of intermittent suction cycle.

b. This Hydraulic Push Action is used for separating the suction catheter from the Mucous Membrane as well as for cleaning the lumen of the suction catheter.

c. This position of Collection Receptacle is clinically used for intermittent Nasogastric Suctioning. It also avoids siphon effect that could develop leading to continuous drainage. This placement also provides a mild gastric reflux to aid in maintaining nasogastric tube patency.

d. When the Collection Receptacle is placed at a level below the patient, a siphon action may develop resulting in continuous rather than intermittent suction even in “Pressure Off” stage of intermittent suction cycle. This low-pressure phase is clinically used for smoother drainage

e. This position of Collection Receptacle is clinically used for continuous Gastric Suction without vacuum due to the siphon effect. This position of Collection Receptacle is also used for pleural drainage to avoid the possibility of fluids being drawn back into the patient's chest. The Collection Receptacle is provided with an underwater seal.

f. Similarly, in Operating Rooms, where suction requirements must provide flexibility, from the High Flow and High Pressure needed in cases of massive haemorrhage or vomiting; to regulated fine control of suction needed to obtain full view in restricted surgical fields, Vacuum Regulators with a control knob is provided with the Collection Receptacle placed below the patient level on the Floor to prevent backflow. Consider providing duplexing of the Vacuum source also. To optimise suction flow rate in the Operating Room, use large bore tubing and large inner diameter suction catheters.

g. The Collection Receptacle for surgical wound drainage should also be placed on the floor as close to the patient as possible.

6.2.5 When required, as protection against accidental overflow of fluids into the suction regulator and piped vacuum system, an overflow safety trap and/or filter should be used with the Collection Receptacle.

6.2.6 The Collection Receptacles are available with multiple controls for various applications. There are other accessories to regulate pressure, to provide water seal, shut-off float, Overflow safety trap, etc., which can be deployed as part of Suction Apparatus to safely dispose off collected waste. The Clinicians will decide the type of Collection Receptacle and Size of Suction catheters to be deployed.

6.2.7 Supply of Suction Apparatus and its accessorises is not in the scope of MGPS installer. These are procured by the Hospital as part of Medical-Surgical Supplies.

6.3 SUPPLY OF MEDICAL VACUUM

6.3.1 Piped Vacuum Systems will be provided in Wards, Intensive Care Units, Treatment Rooms, Obstetric Suites, LDR Rooms, Operating Rooms and all other designated areas.

6.3.2 Medical Vacuum Demand in Hospitals varies due to multiple reasons over the days as well as over the weeks. So, a bank of multiple vacuum pumps of smaller capacity is deployed as a multiplex system.

6.3.3 This is controlled by a PLC Controller which provides Cascaded Control & Sequenced operations.

6.3.4 The Medical Vacuum will then be supplied to the user at Healthcare delivery point and suction pressure is regulated there by the Healthcare provider.

6.3.5 In MGPS Installation the Emergency Reserve Supply of Medical Vacuum is provided by the locally placed vacuum pump units.

6.4 DESIGN FLOW RATES FOR MEDICAL VACUUM

6.4.1 The Piped Vacuum Systems shall be designed to maintain a vacuum of 300 mm Hg (40 kPa) at each terminal unit.

6.4.2 Design Flow rate to be assumed for pipe sizing of Medical Vacuum in Operating Rooms shall be 40 Litres per minute at 300 mm Hg.

6.4.3 Design Flow rate to be assumed for pipe sizing of Medical Vacuum in wards shall be 15 Litres per minute at 300 mm Hg.

6.4.4 All component capacities specified, will be at 480 mm Hg (64 kPa)

6.5 PRESSURE CONTROL

6.5.1 A vacuum of 300 mm Hg is required at the connection point of each terminal unit with a flow of 40 LPM whilst the system is operating at system design flow.

6.5.2 The minimum pressure at the front of the most distal vacuum terminal unit should be 300 mm Hg (40 kPa) at a flow of 40 LPM. A pressure drop of 100 mm Hg (13 kPa) is allowed across the terminal unit at a flow of 40 LPM.

6.5.3 For preventing continuous running of Vacuum Pumps, a set of vacuum reservoirs are provided in MGPS Vacuum System. These maintain the pipeline vacuum pressure.

6.5.4 The cut-in pressure of Vacuum Pumps is usually set at 483 mm Hg (64 kPa).

6.5.5 The cut-out pressure of Vacuum Pumps is usually set at 635 mm Hg (85 kPa).

6.5.6 This pressure differential caters for the system pressure drop across the pipeline distribution and the bacteria filters as well as minimises frequency of stop/start operation.

6.5.7 The MGPS designer must evaluate these, to provide a system where vacuum is generated economically.

6.6 DIVERSITY FACTOR FOR MEDICAL VACUUM

6.6.1 In virtually all cases, vacuum is used via a suction control device and fluid is collected in suction jars. In wards, these are typically of approximately one or two Litre capacity. In Operating Rooms, two, three or four x 2 Litre capacity vessels are provided for the suction control regulator. Therefore, vacuum cannot be applied continuously.

6.6.2 Further, all vacuum outlets are not used simultaneously. So, to optimally size the vacuum pumps, 50% diversity will be applied or as per requirement finalized by the hospital authorities.

6.7 SYSTEM CONFIGRATION

6.7.1 The Medical Vacuum System shall be a centrally piped, vacuum system containing two (minimum) or more continuous duty vacuum pumps with two central vacuum receivers.

6.7.2 The Piped Vacuum Systems consists of Vacuum Terminal Units supplied with suction pressure from the Vacuum Pump System. The Vacuum Terminal Units, through a pipe carcass, is connected to a duplex filtration (0.3-micron hydrophobic filter or equivalent) & isolation system. Then it is connected to a set of Vacuum Pumps, the source of vacuum.

6.7.3 The Vacuum Pumps are connected to the discharge (exhaust) system which discharges the vacuum to atmosphere. The Vacuum Pump Exhaust is provided with a silencer to reduce the Noise generated.

6.7.4 It is aided by two vacuum reservoirs, installed in the MGPS Plant Room, to prevent continuous running of vacuum pumps.

6.7.5 The Medical Vacuum demand will be calculated based on diversified flow, as applicable. The whole system including Filters, Reservoirs, Pipeline, Valves and Vacuum Pumps will be sized on Peak Demand Flow.

6.7.6 In Hospitals, where a Terminal Unit is permitted to serve two adjoining beds in General Wards, where its use quotient is low, the use of "Y-connectors" as a means of increasing available inlets is not permitted. Any justified need for additional vacuum inlet shall be accommodated with another wall inlet, not a Y-connector. As per design redundancy, this factor of creating additional terminal units will be determined.

6.7.7 The system shall be sized so that if one vacuum pump fails, the remaining vacuum pump(s) can supply 100 percent of the total system demand.

6.7.8 The system design shall include automatic operation of the vacuum pumps including cascading and sequencing operations.

6.7.9 A flow rate of 80 LPM per inlet, at 40 kPa with no equipment attached, shall be measured at the farthest inlet. (without equipment is equivalent to the recommended 40 LPM per inlet, at 40 kPa with equipment.)

6.7.10 System pressure drop shall be a maximum of 75 mm of Hg (10 kPa) at the calculated demand flow rate.

6.7.11 The system is provided with an alarm to indicate vacuum pump failure that annunciates to the Master Medical Gas Alarm Panel.

6.7.12 All Medical Vacuum Terminal Units shall be used by deploying either a Ward Suction Unit or a Theatre Suction Unit.

6.8 VACUUM PUMPS

6.8.1 The Medical Vacuum Pump is the main and essential component of a Medical Vacuum Plant. Rotary vane /Screw pumps are to be used as a Medical Vacuum Pump. The Medical Vacuum Pumps must be suitable for continuous running on load and for high frequency start/stop operations.

6.8.2 The capacity of vacuum pumps is specified in different ways, depending on the type of vacuum pump and the manufacturer. Vacuum pump capacity is measured in terms of gas volume drawn in a length of time. Cubic Feet per Minute (cfm) or Cubic Meters per Hour (m3/h) are the two standard measurements. To be able to compare capacities of different pumps, one needs to calculate the actual capacity - Actual Cubic Feet Per Minute (ACFM) at different levels of vacuum. To be able to do this, one needs to know the volumetric efficiency of the pump at a specific vacuum level, which can vary anywhere between 40% and 90%, depending on the pump design.

6.8.3 The capacity of the vacuum pump should be specified in terms of the free air aspirated (FAA) in cfm (or L/min) when the pump is operating at a vacuum of 475 mm Hg (63 kPa) and at 450 mm Hg (60 kPa) at the plant pipeline connection.

6.8.4 Since Medical Vacuum is a closed system, Vacuum pumps shall neither be under rated nor overrated. In general, the next higher capacity of pump, that is available, is specified viz a viz calculated capacity. Also specify the Horsepower (HP) rating of the motor.

6.8.5 Vacuum Pumps are similar to Air Compressors and deploy both Reciprocating and Rotary Technologies, as detailed earlier. Differences between air compressors and vacuum pumps are as under;

(i) The maximum pressure difference produced by pump action can never be higher than 760 mm Hg (101 kPa) since this represents a perfect vacuum.
(ii) The mass of air drawn into the pump decreases as the vacuum level increases.
(iii) At high vacuum levels, all the heat generated by pump operation will have to be absorbed and dissipated by the pump structure itself.

6.8.6 The oil-lubricated types Vacuum Pumps provide about 20 percent higher vacuums because the lubricant acts as a sealant between moving parts and have 50% longer life, than oil-less units. They also are less subject to corrosion from condensed water vapor.

6.8.7 Rotary Vane Pumps, in multiplex configuration, may be provided with purging of the pump prior to pump shutdown. This is accomplished by the use of a PLC controller and provision of purge valves.

(i) Purge Operation is as under:
a) Pumps start based on vacuum setpoint demands.
b) When the pump shuts down, it operates the purge cycle (generally of 10 minutes).
c) The purge solenoid valve opens to allow atmospheric air into the system to remove condensable vapours. It also removes the heat generated due to pump operation.
d) After the purge cycle, pump shuts off, and is ready for next vacuum cycle.

(ii) The primary performance criteria for vacuum pump selection are as under.
a) Vacuum level that can be produced
b) Rate of air removal (volumetric efficiency or vacuum pump capacity)
c) Power required
d) Requirement of Purge Cycle

6.8.8 Also evaluate the efficiency of energy use by a vacuum pump, which is proportional to the product of gauge vacuum and air flow rate. All comparisons must be made at the same specific vacuum level, usually at 500 mm Hg (67 kPa) or above.

6.8.9 Effects of Temperature Rise
a) Vacuum Pump performance can be significantly affected by heating of the pump itself. At higher vacuum levels, when most of the air has been exhausted, there is very little transfer of internal heat to this remaining air. It impacts the service life of the pump.
b) To cool the Vacuum Pump, an intermittent- duty vacuum pump should be specified, when the off period is adequate for effective cool-down of the pump. If the off period is inadequate, the Vacuum Pumps should be operated with load/unload cycling. When the pump is unloaded, the atmospheric-pressure air is drawn through it which rapidly carries the accumulated heat away.
c) Install vacuum pumps in a room where ambient temperature is less than 40 degree C.

6.8.10 When the system vacuum is controlled by automatic on/off or load/ unload cycling of the vacuum pump, the maximum vacuum required shall relate to the cut-out pressure value of the system control.

6.8.11 When the vacuum reservoirs is used in the system, with either on/off or load/unload control of the vacuum pumps, pump size will be smaller because (in most cases) the pump will have a longer time to evacuate a given amount of air. It also provides a longer cooling period. The Vacuum Reservoir capacity affects the on/off duty Cycle. The off period must assure enough time to cool the pump.

6.8.12 After the type and size of vacuum pump has been established, based on required vacuum level and flow rate, determine the correct operating speed and horsepower required to drive the vacuum pump. Medical Vacuum Pump employ Electrical motors of 30 horsepower and below. Typically, power is transmitted by V-Belt, gear or direct drive configurations.

6.8.13 The drive unit must be powerful enough to assure satisfactory operation of the pump under all rated operating conditions. It also includes providing adequate energy to overcome friction and inertia effects at start-up. Drive Power requirements of a vacuum pump is relatively low, compared with those of an air compressor. As vacuum levels increase, because of the larger difference between inlet and discharge pressure, Power requirements also increase.

6.8.14 When the vacuum pump of the required type and size is available with its own integrally mounted electric motor drive, that should be preferred.

6.8.15 Requirement of Medical Vacuum tend to vary in the Hospital, so, multiple number of Medical Vacuum Pumps of smaller capacity are provided (also called multiplexing or banking) to meet varying demand in a cost-effective manner. When peak demand is required, all Medical Vacuum Pumps can be turned on.

6.8.16 Minimum 2 number of Medical Vacuum Pumps shall be provided to provide redundancy. Preferably, a multiplex system of Medical Vacuum Pumps shall be provided. All Medical Vacuum Pumps and motors in multiplex configuration will have the same specifications. Multiplexing should also allow for expandability.

6.1.17 Each Vacuum Pump shall be provided with non-return valve at its inlet and output.

6.1.18 The Vacuum pumps will be installed in a separate partitioned area from the Medical Air Compressors to prevent contamination of Medical Air with oil vapours of the Vacuum pumps.

6.8.19 Discharge from multiple Medical Vacuum Pumps can be combined into one discharge pipe, sized for no restriction while flowing the maximum discharge possible, and provide an isolation valve and non-return valve at the header connection for each pump served. It is preferred to oversize the common discharge pipe in relation to its length. Discharge check valves should be a low differential pressure type with positive shutoff.

6.8.20 The Vacuum Pump Exhaust pipe shall be provided with a silencer or the Exhaust Muffler. Vacuum Pump Exhaust Silencer is a low restriction, flow-through device designed to reduce the pump's exhaust noise, which functions as a low-pass acoustic filter that absorb energy from all but the lowest frequency sound waves. When Vacuum Pump Exhaust Mufflers are provided, they not only reduce the pump's exhaust noise but also trap oil entrained in the pump's exhaust.

6.8.21 The Vacuum Pump Exhaust pipe shall be provided with an automatic drain valve at its lowest point. The drain valve shall be provided with a collection Jar of capacity of at least 100 ml.

6.8.22 Ideally, the Vacuum Pump Exhaust discharge should be at the highest point of the building, and at least 7.6 m horizontally (may be more depending upon prevailing wind direction and velocity) away from any air intake, door, window, louvered or ventilating opening of the building, but it can vary.

6.8.23 Do not discharge within a 3 m radius of any air intake, door, window, or ventilation opening.

6.8.24 At the least, the Vacuum pump exhaust pipe termination point shall be 5 Meters from the ground and will be turned down to reduce the effect of wind pressure and prevent the ingress of rain.

6.8.25 The whole system shall be controlled by a PLC Controller which provides Cascaded Control & Sequenced operations. It will also include an "hours-run" counter.

6.9 VACUUM RESERVOIR VESSELS

6.9.1 A set of two Vacuum Reservoir Vessels, also called Vacuum Receiver, arranged in parallel, shall be provided so that the duty pump does not run continuously for low loads. The reservoir should be manufactured in accordance with BS EN 286, Air Receivers 2005, with test certificates provided by the Reservoir Vessel manufacturer.

6.9.2 In MGPS Vacuum System requiring 500 LPM or less, a single Vacuum Reservoir Vessel may be provided.

6.9.3 The water capacity of each Reservoir Vessel should be equal to the plant design flow at 450 mm Hg (60 kPa) in terms of free air aspirated in one minute with the pump operating at 475 mm Hg (63.3 kPa). Vacuum Reservoir Vessel should conform to IS:2825, ASME Boiler and Pressure Vessel Code 2017, Section VIII.

6.9.4 It will preferably be a Vertical, Cylindrical, Stainless Steel Tank (304/ 304L). The minimum test pressure of Vacuum Reservoir Vessels should be 450 kPa. It should be capable of withstanding a Pressure of 760 mm Hg (101 kPa).

6.9.5 Provision should be made for draining the Reservoir Vessel under vacuum conditions. By-pass facilities (isolation valve) should be provided so that the reservoir can be drained and inspected without interruption to the vacuum supply.

6.10 FILTERS

6.10.1 Piped Vacuum Systems shall be protected with appropriate filtration (0.3-micron hydrophobic filter or equivalent) on the suction side of the pumps to minimize the potential for contamination of the vacuum pumps.

6.10.2 The piping run may slope back to the vacuum source to facilitate the transportation of fluids and particles. Minimum required slope shall be 6.35 mm per 3 m.

6.10.3 The Bacteria Filters and drainage trap shall comprise two identical sub-assemblies with manually operated isolating valves, arranged to allow either of the two sub-assemblies, to be on stream. Each sub-assembly should contain a bacteria filter rated at the plant capacity.

The bacteria filters should have filter efficiency of 99% at 0.1 microns, at the system design flow.

6.10.4 The Bacteria Filter should be marked with the legend "bio-hazard", together with a description of a safe procedure for changing and disposing of the filters and emptying the drainage trap.

6.10.5 In addition, a Liquid Trap or Mechanical Filter, that use Gravity, is required in the system to prevent any of the material's being drawn through the vacuum line from getting into the pump.

6.10.6 The pressure drop across a clean filter at the system design flow should not exceed 25 mm Hg (3 kPa) at a vacuum of 475 mm Hg (63 kPa).

6.10.7 The drainage trap shall be integral with the bacteria filter and shall be provided with a transparent bowl to collect liquid. The bowl should be suitable for steam sterilization at 134°C.

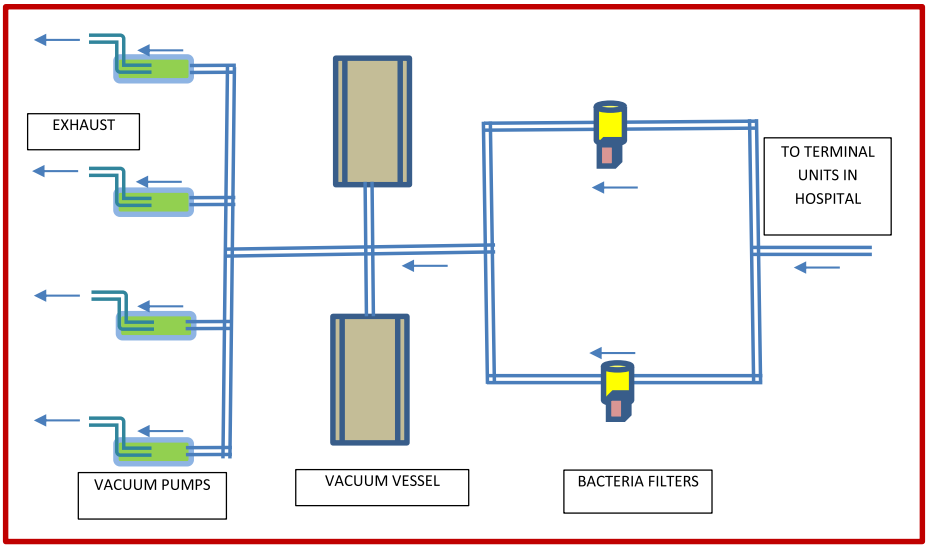
6.11 RESERVE SUPPLY OF MEDICAL VACUUM

It will be locally placed Vacuum pump units with suction regulators and jars.

6.12 AIR FLOW RATES AND VACUUM LEVELS FOR CLINICAL PROCEDURES

	PROCEDURE	STATIC VACUUM LEVEL	FLOW RATE
		mm of Hg	LPM
2.	Infant Oral-Nasal Tracheal Suction	0 - 100	0 - 40
3.	Adult Oral-Nasal Tracheal Suction	0 - 160	0 - 40
4.	Surgical Suction	0 - 500	0 - 40
5.	Gastrointestinal Abdominal Drainage	0 - 120	0 - 8
6.	Wound Drainage	0 - 95	0 - 2
7.	Pleural or Mediastinal Drainage	0 - 50	0 - 10
8.	Pleural or Mediastinal Drainage (Paediatric)	0 - 10	0 - 8
9.	Nasal-Gastric Drainage	0 - 120	0 - 3

6.13 SCHEMATIC DIAGRAM OF MEDICAL VACUUM SYSTEMS



CHAPTER 7

MGPS PLANT CONTROL SYSTEM FOR MEDICAL AIR SYSTEM AND MEDICAL VACUUM SYSTEMS

7.1 MGPS PLANT CONTROL SYSTEM FOR MEDICAL AIR SYSTEM AND MEDICAL VACUUM SYSTEMS

7.1.1 The Medical Air System and Medical Vacuum Systems shall be provided with a Control System. It will provide;

a. Overall Plant Operations and Centralised Control over operational parameters and Maintenance

b. A Display unit to display all major controls status and plant monitoring status, in an intelligent format for at-a-glance checking

c. The Display unit will also display all major Alarm conditions and Alarm signalling status

d. The Display unit will provide all maintenance Notifications

7.1.2 This can be a Combined Control System for both Medical Air System and Medical Vacuum Systems or a system wise 2 Control Panels.

7.1.3 In case, multiple packaged units have been selected, provide a Centralised Control Panel Manager to connect and control several Control Panels as a group. This should maximise the efficiency of the entire compressed Medical Air System, and the Medical vacuum System. When this is provided, adequate secured control wiring shall be provided to all peripheral units. If so designed, provide an independent LAN for this control.

7.1.4 The Centralised Control Panel Manager or the Combined Control System or Control Systems shall be integrated (not combined) with MGPS Central Alarm Panel.

7.1.5 The Centralised Control Panel Manager or the Combined Control System or Control Systems shall also be suitably integrated with Hospital IBMS, Hospital Messaging Engine and HIT Data Logger.

7.1.6 These integrations will be approved by the Project Manager, Hospital Bio-medical Engineer and the Hospital Consultant.

7.1.7 The user interface of Centralised Control Panel Manager or the Combined Control System or Control Systems shall reside in a computer, and provide an Easy-to-read, easy-to-use, touch screen colour LCD as well as a Keyboard Input. The System Control and System Level Alarms and notifications will be software driven and displayed on a single screen. Additional, upto 3 Slave Monitors for Display only, may be provided, if required.

7.1.8 The Centralised Control Panel Manager or the Combined Control System or Control Systems, henceforth called MGPS Plant Control System (MPCS), should provide easy configuration, remote monitoring, access to software upgrades, event history and data logging. It will have UPS power supply for its operation.

7.1.9 The MPCS will always be installed in a protected area, in the MGPS Plant Room. It will never be installed the MGPS Manifold Room or in the Gas Cylinder Storeroom. There will be a 600 mm clearance all around the panel and 900 mm clearance in front of the panel at installation point.

7.1.10 The MPCS will be suitable for the multiplex system and provide cascading and sequenced control to start and stop the Air Compressors and Vacuum Pumps. It will provide programmed delay to ensure that both Equipment Systems i.e. Air Compressors and Vacuum Pumps, do not restart simultaneously.

7.1.11 All internal components, control system components, and circuitry boards, needed for operation of the MPCS control system shall be Non- proprietary. These shall be readily available from local and standard electrical suppliers.

7.1.12 The MPCS will not provide any control or interactive alarms on Hospital AGSS system which shall be completely controlled by remotes control units placed in the Hospital Operating Rooms.

7.1.13 The MPCS will only indicate if main incoming power supply is available or not. All other parameters that need to be monitored by MPCS shall be directly monitored by MPCS, as part of its logical control, even if the monitoring is duplicated.

7.1.14 The MPCS will not provide any control over General Lighting of either the MGPS Plant Room or the MGPS Manifold Room or in the Cylinder Store. It will not provide any control on Air-conditioning units in MGPS Plant Room or the MGPS Manifold Room or in the Cylinder Store, or any other electrical sub-system. It will not provide any control on any other Power System including but not limited to MGPS Central Alarm Panels, Area Alarm Panels, etc.

7.1.15 Power distribution for General Lighting. Alarm Panels, Air-conditioning units, Energising the Medical Air System and Medical Vacuum Systems, etc. will require additional Electrical Distribution Board(s). Provision of this Electrical Distribution Board will be in the scope of the MGPS Installer.

7.1.16 All Electrical Works including power supply to Medical Air Compressors, Medical Vacuum Pumps, other System components, provision of Mains Incomer, Bus Bar arrangement, all required meters, contactors, relays, switches, indicators, Earthing, etc., shall be as per National Electrical Code and relevant Codes.

7.1.17 The detailed drawing of the Electrical Works shall be approved by the Project Engineer before execution.

7.1.18 All MPCS Panel and Sub-panel enclosure, Electrical Boards, etc., shall be powder-coated in approved colour.

7.1.19 If provided “Variable Speed & Variable Frequency Drive” (VSD/VFD), integrate the control of all pump motors from the control panel manager of the system.

CHAPTER 8

MEDICAL CARBON DIOXIDE SUPPLY INSTALLATION

8.1 MEDICAL CARBON DIOXIDE SUPPLY INSTALLATION

8.1.1 Medical Carbon Dioxide (CO_2) is commonly used as an insufflation gas for minimal invasive surgery (laparoscopy, endoscopy, and arthroscopy) to enlarge and stabilize body cavities to provide better visibility of the surgical area.

8.1.2 CO_2 is the most common insufflating agent for as it is easily obtained, chemically stable, non-flammable, highly soluble in blood and tissue, and rapidly absorbed from the peritoneal cavity, with metabolic end products easily exhaled through the pulmonary alveoli.

8.1.3 When pipeline systems are installed for such purposes, the general requirements for other Medical Gas Pipelines should be followed. The terminal unit should comprise a NIST connector with integral check valve contained in the surgeon's pendant. The level of provision of AVSUs should be provided as for other medical gas pipelines.

8.1.4 Ventilation is very critical for the rooms where CO_2 is used. It being a gas that is denser than air, its high concentrations can persist in open pits and other areas. It displaces atmospheric oxygen. It is dangerous even with adequate oxygen for life support.

8.1.5 In Hospitals, CO_2 shall be provided by a Pipeline system for use for insufflation during major, minimal invasive surgeries.

8.1.6 CO_2 is liquefied by the high pressure within the cylinder. It is supplied and stored as a liquid in pressurised cylinders, at a pressure of at least 5720 kPa. It becomes a gas at Normal atmospheric pressure and is used as a Gas only. 1 kg of liquid CO_2 expands to about 550 litres of gas at atmospheric pressure. Therefore, CO_2 Cylinders are used in the vertical position only with the valve uppermost.

8.1.7 As long as the gas flows at 35 scfh or less, enough liquid will boil off to maintain the cylinder pressure.

8.1.8 When the CO_2 gas decompresses and flows at a high flow rate, it chills and can block the orifice of pressure regulator leading to formation of ice crystals which hinder the gas Flow rates. For this, the pressure regulator will be provided with heating arrangement. The CO_2 manifold will be positioned in a shaded area, away from direct sunlight or source of heat.

8.1.9 In CO_2 cylinders, the pressure remains relatively constant until all of the liquid is evaporated, after which the pressure drops rapidly as the remaining gas is removed. The quantity of contents of these cylinders can only be estimated by weighing the cylinder.

8.1.10 Caution Notice should be put at suitable locations where CO_2 is used, especially in the Surgical Suites.

8.2 SOURCES OF SUPPLY FOR CARBON DIOXIDE

8.2.1 It will be delivered in the gaseous form only.

8.2.2 It will be supplied from a combination of following two (2) sources.

8.3 Source for Primary Supply

8.3.1 Source for Primary Supply shall be provided with two Banks of Gas Cylinders with equal number of cylinders in each bank and fully Automatic Changeover Units, for it connected to two header bars, with minimum 2 number of D Type Compressed Air Cylinders, (required number to be calculated based on number of Operating Rooms to be deployed) in each bank, "Duty Bank" & the "Stand-by Bank".

8.3.2 The warning and alarm system indicator for CO_2 supply system will normally be installed in the Operating Room control panel.

8.4 There will be no Source for Secondary Supply Source for Emergency Reserve Supply

8.4.1 Source for Emergency Reserve Supply of CO_2 will be "A Type" valved Cylinders, or any other type of smaller Cylinder, placed locally, in the Surgical Suite.

8.4.2 They will be brought online manually when required.

8.4.3 These can be placed at the level of Area Valve, where it gets connected via NIST connectors.

8.4.4 Source for Emergency Reserve Supply, including all other deployed cylinders, will be augmented with gas filled cylinders after the Emergency is over.

8.4.5 It is to be noted that CO_2 gas Cylinder Shelf Life is 5 years, so all CO_2 gas cylinders in Hospital Inventory should be rotated once in 3-4 years, preferably once every year, as a standard procedure.

8.5 DESIGN FLOW RATES FOR CARBON DIOXIDE

8.5.1 Nominal Pressure to be considered is 400 kPa.

8.5.2 The Carbon Dioxide insufflator devices are designed for a flow rate of 15, 20, 30, 43 or 50 (Maximum) litter per minute. The input pressure rating is 200 – 300 kPa.

8.5.3 Design Flow rate to be assumed for pipe sizing, for Carbon Dioxide, shall be 50 Litres per minute in this MGPS Installation.

8.6 DIVERSITY FACTOR FOR CARBON DIOXIDE

8.6.1 Each designated Operating Room will be provided with two (2) Gas Terminal Units but only one unit will be used.

8.6.2 Since, it is provided in designated Operating Rooms only, these are likely to be in use simultaneously therefore, no diversity is applied.

8.7 SPECIAL PRECAUTION FOR CARBON DIOXIDE SUPPLY LINE

8.1.1 Since Carbon Dioxide as Gas is heavier than Air, provide smooth level flooring and ventilation at Grade level of the room for the Vapours to leave the Manifold Room. This is required to take care of Gas Venting to maintain the pressure in the Cylinders.

8.7.2 Install upstream of the manifold, a shut-off valve, pressure regulator and a constant pressure header with heater.

8.7.3 In addition, provide a shut-off valve at each outlet tap.

8.8 TEST POINT

8.8.1 The Carbon Dioxide supply system shall be provided with a test point comprising of a lockable valve and a terminal unit immediately upstream of the Hospital Distribution Line.

8.9 COMPRESSED GAS CYLINDER MANIFOLD INSTALLATION

8.9.1 The CO_2 primary supply will be from a Duplex Control Manifold with automatic changeover in this MGPS installation, as has been described earlier and which are connected to the Hospital supply pipeline via a control panel. The manifold header shall be an extendable type.

8.9.2 The Control Panel shall be wall type and so mounted that it can take a cylinder bank of 2 or more cylinders on either side. Average mounting height for control panel box is that, its centre shall be 1650 mm from finished floor level.

8.9.3 The Automatic Changeover Control Panel will provide a Flow Capacity of over 100 LPM, or as calculated.

8.9.4 All critical connections shall be gas specific, designed to eliminate supply gas errors.

8.9.5 A linear space of 900 mm will be provided for mounting the 2 Cylinders. Some space will be provided to stack at least 2 more cylinders for immediate replacement.

8.9.6 Cylinders, positioned where they can be easily moved, will be placed on floor and held in place, against the wall, with two (2) Cylinder Holding Brackets and tape restraints or Chains

8.9.7 The Header Bar shall be gas specific high pressure copper pipe with integral check valves and cylinder pigtail assemblies of Stainless Steel or Copper, confirming to IS 3224. The Header Bar shall be provided with high pressure brass fittings made of high tensile brass and connections and supplied complete with wall mounting brackets.

8.9.8 Header bar shall be provided with cylinder pigtail connections to suit service specific cylinder valves. The manifold connections shall be Carbon Dioxide Specific, 7/8" UNF.

8.9.9 The manifold should be suitable to withstand working pressure of 150 Kg/cm2. The manifold shall be tested (hydraulically) at 20,000 kPa to 24,000 kPa pressure and necessary test certificate from the manufacturer shall be provided.

8.9.10 A pipework and installation diagram (P&ID) of the Manifold installation shall be displayed in the Manifold Room. It will clearly indicate the pressure regulators, safely instructions and other statutory signs and instructions.

8.9.11 Three pressure gauges on the front of the control panel will indicate left bank pressures, right bank pressures and Hospital Distribution Line pressures.

8.9.12 The changeover from the “Duty” to the “Stand-by” bank of cylinders shall be Automatic, preferably based on pneumatic pressure, without fluctuation in Hospital distribution line

pressure. The technology to be deployed for automatic changeover shall be discussed with the Project Engineer and the Hospital Consultant and its approval will be taken in writing.

8.9.13 In Manifold Control Panel,

8.9.14 The "Duty" Bank is indicated by the green colour of LED

8.9.15 The "Stand-by" Bank is full indicated by the yellow colour of LED

8.9.16 The Red colour of LED indicates "Replace Empty Cylinders"

8.9.17 On Automatic changeover, the Empty LED indicator will show a depleted bank by turning red. A buzzer will also sound to indicate an empty bank or banks. When the system is reset, by replacing the depleted cylinders, the indicator will turn green and will also silence the buzzer.

8.9.18 The Control Panel will have inbuilt heaters to prevent frosting of regulators.

8.9.19 In this MGPS Installation, when it is connected to iBMS, this information shall be relayed and shown in Central Monitoring System, that the bank was depleted and, in turn, has been reset.

8.9.20 A pneumatic pressure relief valve shall be incorporated in Hospital distribution line upstream of Automatic Changeover Control Panel for regulating line pressure. The discharge pipeline of this valve shall be vented to atmosphere, outside the building, in an area where the discharge of Carbon Dioxide, will not present a hazard or cause injury to personnel.

8.9.21 The Control Panel shall be water resistant, complete with its master control valves, power supply & all Valves, Gauges and Pipes, etc. Suitable Electrical power outlet shall be fitted by the MGPS Installer in preparation for Installing the Unit. The control unit power supply shall provide a visible green LED indicator to display "Mains Supply On".

8.9.22 All manifold components shall be capable of passing the full pipeline flow.

8.9.23 All critical connections shall be gas specific, designed to eliminate supply gas errors.

8.10 SOURCE PRESSURES & REGULATION

8.10.1 The Cylinder Vapour Pressure is about 5000 kPa.

8.10.2 The Nominal Distribution Pressure should be 420 kPa (maximum 500 kPa)

8.10.3 The Nominal Distribution Pressure shall be maintained by manifold regulator.

8.10.4 A Pressure Relief Device shall be provided, downstream of the Pressure Regulator connected by means of a three-way connection, so that the Safety Device can be replaced easily.

8.10.5 The Pressure Relief Device discharge should be run to the exterior of the building by providing a Vent Pipe of suitable dia.

8.10.6 Pressure sensors to provide the alarm function will need to be fitted to pipeline distribution systems.

8.10.7 The Emergency Reserve Supply System should be activated manually when the Primary Supply System is empty or fails to supply.

CHAPTER 9

ANAESTHETIC GAS SCAVENGING (DISPOSAL) SYSTEMS (AGSS) INSTALLATION

9.1 ANAESTHETIC GAS SCAVENGING (DISPOSAL) SYSTEMS (AGSS) INSTALLATION

9.1.1 When required and specified by the hospital authorities, the Operating Rooms (OR) will be provided with an active Anaesthetic Gas Scavenging (Disposal) Systems conforming to the Indian Standard, IS/ISO 7396-2 (2007): Medical Gas Pipeline Systems, Part 2: Anaesthetic Gas Scavenging Disposal Systems [MHD 11: Anaesthetic, Resuscitation and Allied Equipment].

9.1.2 Active AGSS is when a vacuum source is attached to the waste gas interface valve.

9.1.3 Anaesthetic Gas, to be disposed off, comprises of collection of exhaled mixtures of Medical Oxygen, Medical Nitrous Oxide and inhalation anaesthetics from the breathing circuit of the anaesthesia apparatus or from the exhaust port of the Ventilator.

9.1.4 ISO 7396-2 mandates provision of AGSS for patient safety and to minimize exposure of the OR Staff to waste anaesthetic gases.

9.1.5 The AGSS normally consists of five basic components, as under.

9.1.6 A gas collection assembly, which captures excess anaesthetic gases at the site of emission and delivers it to the transfer tubing.

9.1.7 Transfer tubing, which conveys the excess anaesthetic gases to the interface.

9.1.8 Gas Disposal Assembly tubing, which conducts the excess anaesthetic gases from the interface to the gas disposal assembly.

9.1.9 The Gas Disposal Assembly, which conveys the excess gases to a point where they can be discharged safely into the atmosphere, outside the building and away from any return air ducts or open windows, thus preventing the return of the waste gases back into the facility.

9.2 ACTIVE AN AESTHETIC GAS SCAVENGING SYSTEM

9.2.1 The proposed AGSS system shall be a dedicated, High Flow, active extraction and disposal system. It shall provide a maximum flow rate of 80 LPM with a 1 kPa resistance to flow and a minimum flow rate of 50 LPM with a 2 kPa resistance to flow at the terminal unit. It shall provide open scavenger interface.

9.2.2 The Hospital needs to ensure that their Anaesthesia Workstations provide open scavenger interface. These are found on most of newer Anaesthesia Workstations.

9.2.3 The AGSS shall have following system components.

a) Scavenging, Transfer and Receiving System Unit

b) Disposal System Unit

9.3 SCAVENGING, RECEIVING AND TRANSFER SYSTEM

9.3.1 It is a compact, integrated unit with pipe connections. It gets fitted on the Anaesthesia workstation using AGSS type-specific connections.

9.3.2 The Scavenging System of AGSS, when connected, entrains waste anaesthetic gases from either the APL (adjustable pressure limiting) valve of a breathing circuit or from the exhaust port of a Ventilator using the Induced Air Flow as generated. The Induced Flow Rate at the breathing circuit should be as low as possible (0.5 LPM), with the system ideally being passive, between the patient and the receiving unit. Typically, the interface consists of a manifold with four ports and two relief valves. The upper relief valve limits positive pressure, and the lower valve limits negative pressure. The rate of gas flow through the interface can be controlled by adjusting the needle valve.

9.3.3 The receiving system is designed to match the variable flow in the breathing system to the constant flow of the disposal system and ensure that very low induced flows are imposed (0.5 LPM to 0.05 LPM).

9.3.4 Then via a transfer hose, these waste anaesthetic gases are conveyed to the Disposal system.

9.3.5 Using a Type 1H Terminal Unit, usually placed on the Ceiling Supply Unit (Pendant), waste anaesthetic gases are transferred to the Disposal System. The anaesthetist makes connection and disconnections to this unit using Type 1H ISO probe and type-specific connection point.

9.3.6 From the Ceiling Supply Unit (Pendant) Type 1 H Terminal Unit, this transfer and receiving unit is connected to First Fix Bracket using flexible hose and NIST assembly. From the First Fix Bracket, using Copper Pipe, the connection is extended to the AGSS disposal unit.

9.3.7 Using a Type 2 Terminal Unit, usually placed on the AGSS disposal unit, waste anaesthetic gases are finally disposed off from AGSS discharge point. The connection is made using Type 2 ISO probe and type-specific connection point.

9.4 DISPOSAL SYSTEM UNIT

9.4.1 The AGSS disposal system shall be a skid mounted, Simplex pump with directly coupled impeller assembly, to its totally enclosed, fan-cooled, electric motor. It will be supplied complete with motor control unit, starter, air inlet filter, Vacuum flow regulator, moisture drain flask and flexible connector to connect the plant to the AGSS pipeline. Suitable stand by pump/s as per standards to be provided.

9.4.2 One such Disposal System Unit shall be provided for each Operating Room, as the Operating Rooms will have their respective Air Handling Units (AHU) or as per the requirement of the hospital authorities.

9.4.3 The pumps shall be air cooled and rated for continuous operation.

9.4.4 The AGSS disposal system will be provided with its dedicated Control Panel suitable for remote control.

9.4.5 The Control Panel display will also be integrated with or Control panel display.

9.5 DISCHARGE OF WASTE ANAESTHETIC GASES

9.5.1 The Waste Anaesthetic Gases Disposal into the atmosphere can happen in multiple ways. Since Waste Anaesthetic Gases have been diluted by AGSS, these can be disposed off to

atmosphere directly. Several methods are in use, including a nonrecirculating or recirculating ventilation system, a central vacuum system, a dedicated (single-purpose) waste gas exhaust system, a passive duct system, and an absorber.

9.5.2 The Discharge Outlets must provide protection for Rain ingress. The point where these AGSS Discharge Outlets are located is referred to as AGSS Discharge Point.

9.6 AGSS PUMP FOR BACKUP

9.6.1 In this MGPS Installation, a spare pump shall be provided for immediate connection into the system in the event of failure .

9.6.2 The same will also be used at time of repair or maintenance of the installed AGSS pump.

9.6.3 Suitable valved pipe connections will be provided for connecting the spare pump supply and exhaust pipes.

9.6.4 Means shall be provided to provide requisite power supply.

9.7 DESIGN FLOW RATES FOR AGSS

9.7.1 The flowrate through each type 1H terminal unit shall not exceed 80 LPM when the resistance to flow which is provided to simulate the resistance of the receiving system, is such as to produce a pressure drop of 1 kPa at 80 LPM , and shall not be lower than 50 LPM when the resistance to flow, which is provided, is such as to produce a pressure drop of 2 kPa at 50 LPM (see also ISO 8835-3,10.2). (ISO 7396-2)

9.7.2 AGSS disposal system with type 2 Terminal Units with a flowrate of 50 LPM through the socket of each AGSS type 2 terminal unit, the pressure drop shall not exceed 7.5 kPa. (ISO 7396-2) resistance to flow at each terminal unit, irrespective of the number of Terminal Units in use.

9.8 SYSTEM CONFIGURATION

9.8.1 The AGSS system shall use dedicated radial blowers in simplex configuration. Suitable stand by pump/s as per standards to be provided.

9.8.2 The AGSS pump assemblies shall be skid mounted and included on the skid shall be the pump, motor control unit with starter/isolator, moisture drain flask and flexible connectors to connect the plant to the pipeline.

9.8.3 The spare pump needs to be mobile and the skid can be mounted on a mobile platform.

9.8.4 Each pump including the spare pump, shall be rated for continuous operation, and shall include an air-cooled electric motor, motor control panel and directly coupled impeller assembly.

9.8.5 Each motor control panel shall incorporate an emergency panel isolation switch facility, which controls all electrical power to the exhauster unit, remote start switch-panels and system indication lights.

9.8.6 A green 'POWER ON' indicator shall be fitted to the starter/isolator panel and shall illuminate whenever power is available to the control and indication circuit.

9.8.7 A switch shall be provided to control operation of the pump in different modes – Manual, Auto, Off.

a) Manual mode will provide continuous running of the pump.
b) Auto mode pass the control of the pump to the remote control for start and stop.
c) The spare pump remote shall be provided when it is connected.

9.8.8 The starter/isolator panel shall incorporate a thermal protection over load device. The thermal protection overload device shall also monitor the electrical power supply and phase input. In the event of a fault, the overload device shall break the circuit to the pump, preventing operation until the system is manually re-set. Operation of the overload device shall also break the circuit to the remote start switch panels, extinguishing the green running indicator.

9.8.9 The system will incorporate a line pressure switch which monitors vacuum levels and provides an additional control of the remote start switch and starter/isolator panel green 'RUNNING indicators.

9.8.10 The pressure switch shall include a digital display providing readout of the vacuum level in the pipeline.

9.8.11 The remote-control unit shall provide the following indications, when the pump is called;

a) Mains On – Green Light
b) Air Flow Normal – Green Light
c) Plant Fault Indicator – Yellow Light
d) Plant Emergency indicator – Red Light
e) If the vacuum level falls below the set point level, A red alert shall illuminate on remote start switch panels.
f) Ability to operate the additional AGSS disposal system

9.8.12 Integration of AGSS control panel with Hospital BMS, for displaying alarm conditions, shall be provided.

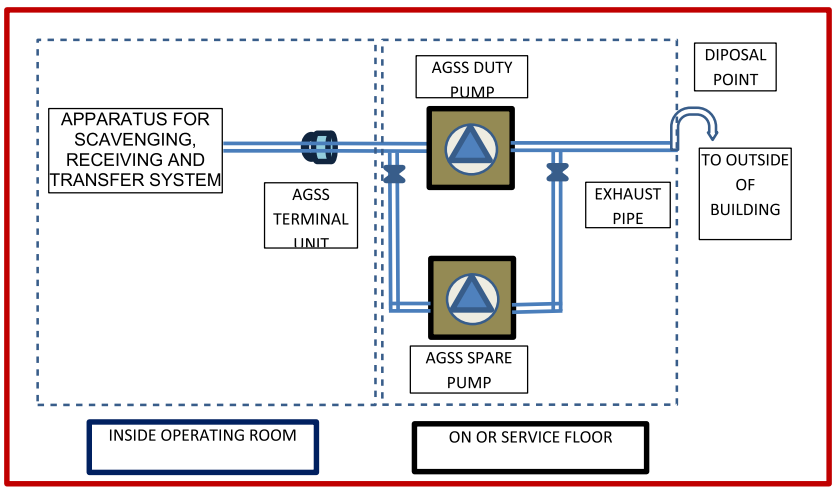
9.9 DIVERSITY FACTOR FOR AGSS

9.9.1 Although more than one AGSS terminal unit may be installed in an Operating Room for convenience, only one terminal unit in each room will be in use at any given time.

9.9.2 Similarly, when Induction rooms are provided, still only one terminal unit in each room will be in use at any given time.

9.9.3 Therefore, the AGSS plant is sized for one terminal unit for each Operating Room.

9.10 SCHEMATIC DIAGRAM OF AGSS



CHAPTER 10

PIPELINE DISTRIBUTION SYSTEM

10.1 PIPELINE DISTRIBUTION SYSTEM

10.1.1 The Medical Gases shall be distributed in this MGPS installation, using Copper Pipeline Caracas, from the source to the terminal unit, for all gases including Medical Vacuum and AGSS.

10.1.2 The MGPS Pipeline Carcass includes all fixed Medical Gas Pipelines, Terminal Unit base blocks (First Fix Limit) and Area Valve Service Units (AVSUs), Line Valve Assemblies (LVAs), as fitted but excludes pressure switches, flexible assemblies for all gas type service, upstream of the Pressure Regulating System and Pressure Relief Valve.

10.1.3 Terminal units may be wall mounted or installed within Medical Supply Units, as in operating room pendant fittings and bedhead panels. The AVSUs & LVAs permit isolation of parts of the system for servicing or repair.

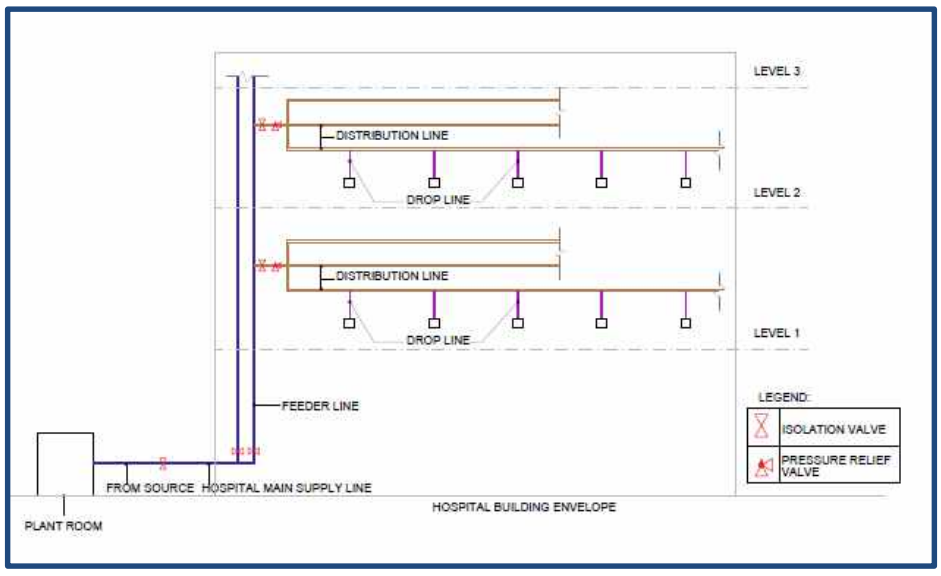
10.2 Nomenclature of Pipe Sections in Pipeline Caracas

10.2.1 Main Hospital Supply Pipeline or Gas Service Specific Trunk Pipeline

10.2.2 Feeder Pipeline which includes Risers which are Vertical Feeder Pipeline

10.2.3 Distribution Pipeline or Branch Pipeline

10.2.4 Drop pipe is the final segment of the pipeline which connects the Distribution Pipeline to the Terminal Unit



10.3 The Main Hospital Supply Pipeline runs from the MGPS Manifold Room or the MGPS Plant Room till the service enters a Building Block. There it is connected to the Feeder pipelines, which travel horizontally as well as vertically. On the floor, it is connected to the Distribution Pipelines, which serve only one floor or part of the floor and do not travel vertically. They, through Drop pipes, get connected to Terminal units.

10.4 In very tall buildings, where the Nominal Supply System Pressure is higher than Nominal Distribution Pressure, it is recommended that Two Principal Feeder Mains are provided as double end feeders. The Distribution Branches on each floor are inter - connected to create a ring main at the Nominal Distribution Pressure. It will ensure MGPS Service continuity at the desired pressure.

10.5 To optimise Gas Delivery in a safe manner at a specified pressure and to control oxidising effects of Medical Oxygen and Medical Nitrous Oxide or their mixture, it is required that MGPS pipelines run in Open Shafts or open on walls and not concealed in walls or false ceilings.

10.6 For aesthetic purposes only, the MGPS Drop Pipeline may be concealed, as it travels down to connect with the terminal unit.

10.7 PIPELINE PRESSURE

There are following 2 types of Nominal Pipeline Pressures.

a) Nominal Pipeline Distribution Pressure

b) Nominal Pipeline Supply System Pressure

10.8 Nominal Pipeline Distribution Pressure

This is the pressure in a pipeline carcass under design flow conditions at which the Terminal Units are provided the Positive Pressure Gas like Medical Oxygen, Medical Air, Medical Nitrous Oxide and Medical Carbon Dioxide. This value is used for designing the Pipeline Carcass and its components

10.9 Nominal Pipeline Supply System Pressure

(Applicable to only Oxygen Gas a Positive Pressure Gas Service, in this MGPS installation)

10.9.1 This is one of the two pressures in a pipeline carcass under design flow conditions.

10.9.2 The Nominal Supply Pressure is the pressure at which the Oxygen Gas is supplied to the pipeline carcass. In this MGPS Installation, it will be 1000 kPa.

10.9.3 This Nominal Supply Pressure is reduced to Nominal Pipeline Distribution Pressure of 400 kPa by deploying pressure reducing stations and supplied to the distribution part of the pipeline carcass where after, it is distributed to the Terminal units at the reduced pressure.

10.10 PIPELINE LAYOUT

Layout of MGPS Services other than for AGSS

10.10.1 From the source of supply of any MGPS Gas service, a pipe starts from the MGPS Manifold Room or the MGPS Plant Room, known as Main Hospital Supply Pipeline, which carries the Gas or the Vacuum, at Nominal Distribution Pressure.

10.10.2 This Main Trunk Pipeline feeds, one or more than one, Feeder Pipelines as per the Building design and layout of MGPS Service.

10.10.3 The Feeder pipelines travel horizontally as well as vertically.

10.10.4 The Feeder Pipelines carry the gas or vacuum at Nominal Distribution Pressure to all designated floors and feed one or more than one Distribution Branch pipelines.

10.10.5 The Distribution Branch pipelines feed through Drop pipelines, a specified number of MGPS Terminal Units at patient stations on the respective floors, at Nominal Distribution Pressure.

10.11 In Very Large MGPS Installations where pressure drop in pipeline distribution is likely to be more than 5% Layout of MGPS Services for Medical Oxygen Gas

10.11.1 From the source of supply of any MGPS Gas service, a pipe starts from the MGPS Manifold Room or the MGPS Plant Room, known as Main Hospital Supply Pipeline, which carries the Gas, at Nominal Supply Pressure.

10.11.2 This Main Trunk Pipeline feeds, one or more than one, Feeder Pipelines as per the Building design and layout of MGPS Service. The Feeder pipelines travel horizontally as well as vertically. The Feeder Pipelines carry the gas or vacuum at Nominal Supply Pressure to all designated floors.

10.11.3 At the floor, it deploys a pressure reducing station and feed one or more than one Distribution Branch pipelines at Nominal Distribution Pressure.

10.11.4 It should form a ring by interconnection to maintain the distribution Pressure.

10.11.5 The Distribution Branch pipelines feed through Drop pipelines, a specified number of MGPS Terminal Units at patient stations on the respective floors, at Nominal Distribution Pressure.

10.12 Layout of Medical Air Services

10.12.1 It is preferably operated at Distribution Pressure of 400 kPa.

10.12.2 Provide a second or third complete Medical Air Pipeline System complete with its Medical grade Compressors and Pipeline Distribution system on intermediate floors.

10.12.3 When so provided, it will be integrated with Hospital's MGPS Plant Control System (MPCS)

10.13 Layout of Medical Vacuum Services

10.13.1 It is always operated at Distribution Pressure of 300 mm Hg (40 kPa) at a flow rate of 40 LPM.

10.13.2 Provide a second or third complete Medical Vacuum Pipeline System complete with its Vacuum Pumps and Pipeline Distribution system on intermediate floors.

10.13.3 When so provided, it will be integrated with Hospital's MGPS Plant Control System (MPCS)

10.14 Layout of Medical Nitrous Oxide Services

10.14.1 It is to be operated at Distribution Pressure of 400 kPa only.

10.14.2 Since, it is used in Operating Rooms only, provide the N2O Pipeline System complete with its Manifold and Pipeline Distribution system at a service floor which can serve the

floor where the Operating Rooms are provided. This may be repeated for every set of Operating Rooms.

10.14.3 When so provided, it will be integrated with Hospital's MGPS Plant Control System (MPCS)

10.15 Layout of Medical Carbon Dioxide Services

10.15.1 It is to be operated at Distribution Pressure of 400 kPa only.

10.15.2 Since, it is used in Operating Rooms only, provide the CO2 Pipeline System complete with its Manifold and Pipeline Distribution system at a service floor which can serve the floor where the Operating Rooms are provided. This may be repeated for every set of Operating Rooms where CO2 is to be provided.

10.15.3 When so provided, it will be integrated with Hospital's MGPS Plant Control System (MPCS)

10.16 Layout of AGSS Services

10.16.1 This service is provided for Operating Rooms and the AGSS disposal system should be placed as close as possible to these Operating Rooms, preferably on the Operating Rooms service floor.

10.16.2 An independent AHU may be considered Class C Operating Room, therefore, one AGSS pump will be provided for each Operating Room.

10.16.3 Each Operating Room will be considered to deploy only one (1) AGSS terminal unit, at any given time, irrespective of actual number of AGSS Terminal Units deployed.

10.16.4 Maximum Flow rate to be considered is 100 LPM at 20 kPa negative pressure, maximum.

10.16.5 In case of failure, this will be backed up by providing an additional AGSS pump for every 6 Operating Rooms or less.

10.17 PIPE MATERIAL

10.17.1 The Copper Pipes used for internal or external installation shall be of Medical Grade Copper, which is phosphorous de-oxidised non-arsenical copper conforming to BS EN 1412:1996 grade CW024A (Cu-DHP).

10.17.2 The Copper Pipes will be seamless, round, solid drawn, sizes confirming to BS EN 13348, suitable for installing vertically or horizontally without sagging or distortion.

10.17.3 The material temper shall be as under.

a) For Tailpipe: R220

b) For Pipe of Nominal Outside Diameter (OD) 12 mm – 28 mm: R250 (half hard)

c) For Pipe of OD 35 mm – 54 mm: R250 (half hard)

d) For Pipe of OD 76 mm and above: R290 (hard)

10.17.4 Pigtail connections for Oxygen shall always be of Copper. (Polymeric lined stainless-steel braided pigtails will not be used for Oxygen anywhere in this installation including non-medical areas as these have been associated with fire incidents.)

10.17.5 Pigtail connections for Nitrous Oxide, Medical Air 4 and Carbon Dioxide manifolds shall preferably be of Copper. (as per code, these can be of Stainless Steel, Grade 304/316, internally lined with Teflon also).

10.17.6 All Copper Pipes must be inspected and certified by a Third-party Inspection Agencies like Lloyds, SGS, TUV as to their physical properties and chemical composition including cleanliness status before dispatch.

10.17.7 The Copper Pipes will be delivered on site, plugged or capped at both ends.

10.17.8 The pipes shall be accompanied with Manufacturer's Test Certificate.

10.17.9 Any MGPS pipe which have been retrieved from any installation will never be used for Medical Oxygen Supply in same or alternative installation.

10.18 PIPELINE JOINTING

10.18.1 All turns, offsets, and other changes in direction shall be made using Copper Pipe fittings.

10.18.2 Fittings, as required for jointing in pipe carcass, shall be end-feed capillary fittings of Medical Grade Copper, which conform to EN 1254-1.

10.18.3 All Copper Pipe Fittings, when supplied must be certified by the manufacturer to be clean and degreased. These shall be individually packed to maintain cleanliness. All Copper Pipe Fittings shall be cleaned and degreased before they are used, if so required.

10.18.4 All other fittings, for example, valve and control panel fittings, etc., can be of Copper, Brass, Gun-metal, Bronze or Stainless Steel.

10.18.5 Except for mechanical joints, only copper-to copper joints will be permitted on site, made with brazing filler rods that can be used without flux.

10.18.6 Copper to Copper joints shall be made on site by silver brazing (Recommended silver copper-phosphorus brazing alloy CP 104 conforming to BS EN 1044:1999).

Copper to Brass Brazed Joints shall be made off site by silver brazing using AG203 with 43% silver Brazing Filler Metal conforming to EN 1044. Copper to Brass Brazing is done using flux and the joint should be degreased before being used on Medical Gas Pipeline.

10.18.7 Provision of Tapered Threaded Fittings shall be limited to the connections for pressure and vacuum indicators, alarm devices, gas-specific demand check fittings, and source equipment on the source side of the source valve. Where these joints are needed, they may be made with un sintered (de-greased) Polytetrafluoroethylene (PTFE) tape.

10.18.8 The cleaning process shall not result in grooving of the surfaces to be joined. The use of steel wool or sand cloth shall be prohibited for cleaning exteriors of tube ends, etc.

10.18.9 Brazing, for all positive pressure gases and for vacuum pipelines – up to and including 22 mm pipes, that are run in Medical Gas Supply Units (Bedhead panels or Pendants) and to individual terminal-unit drops, shall be carried out using oil free, oxygen-free nitrogen as an internal inert gas shield to prevent the formation of oxides on the inside of the pipes and fittings. Pipes shall be continuously purged with oxygen-free nitrogen with terminal flow rate of 2 litres per minute, while brazing.

10.18.10 During and after installation, openings in the piping system shall be kept sealed to maintain a nitrogen atmosphere within the piping to prevent debris or other contaminants from entering the system.

10.19 PIPELINE SIZING

10.19.1 Pipe sizing is determined either by Volume of Gas to be delivered or by impact of overall negative pressure required.

10.19.2 When sizing, for Medical Vacuum, always provide pipes of one size higher diameter to prevent clogging.

10.19.3 The pipe sizing calculations will be provided by MGPS designer for approval by department /hospital authority.

10.19.4 The Pipeline sizing must take care of following parameters for all gas services in this MGPS Installation.

a) Desired Diversified Flow Rate at the Terminal Units

b) The diversity Factor

c) The allowable friction loss for all positive pressure gases including Oxygen, Nitrous Oxide, Medical Air 4 & Carbon Dioxide will be Nil.

d) Typically, the Equivalent Length of Piping will be derived by adding 50% of the measured run to account for bends, fittings, etc.

10.20 Pipe Size

10.20.1 No pipe smaller than 12 mm OD shall be used anywhere in this MGPS Installation.

10.20.2 No pipe smaller than 15 mm OD shall be used anywhere in this installation in the Surgical Suite including Operating Rooms, pre-operative and post-operative Wards.

10.20.3 No pipe smaller than 15 mm OD shall be used anywhere in this installation for the Medical Vacuum Service.

10.20.4 The following pipe specifications are mandated as per EN 13348, 2016.

OUTER DIAMETER	WALL THICKNESS
12 mm	1.0 mm
15 mm	1.0 mm
22 mm	0.9 mm
28 mm	0.9 mm
35 mm	0.9 mm
42 mm	1.2 mm
54 mm	1.2 mm
76 mm	1.5 mm
108 mm	2.0 mm

10.20.5 Wall Thickness Tolerance shall be ± 10% for tubes upto Outer Diameter of 54 mm and ± 15% for tubes of Outer Diameter of 76 mm & 108 mm.

10.21 PIPELINE ROUTING

10.21.1 MGPS pipes shall not be installed in lift shafts, kitchens, laundries, boiler houses, generator rooms, incinerator rooms, storage rooms designed to house combustible materials, or in any other fire-risk areas.

10.21.2 Where pipelines in hazardous areas are unavoidable, they should be enclosed in non-combustible, non-corrosive materials that have no electrolytic reaction with copper in order to prevent the possibility of the liberation of gases into the room in the event of pipeline failure.

10.21.3 Medical Gas Pipelines should be routed away from Natural Gas Pipelines where there is a potential for a flammable gas mixture to accumulate in the case of a leak.

10.21.4 The MGPS Designer and MGPS installer must ensure that all shafts, ducts or confined spaces, where MGPS pipelines travel through, must be adequately ventilated to prevent accidents. Accumulation of Oxygen or nitrous oxide or any gas mixture increases the risk of fire. Check this with HVAC consultant and if adequate ventilation is not possible for any reason, re-route these pipes.

10.21.5 Depending upon the Location of LMO Yard, Manifold Room, Manifold Plant Room, Building Entry Point, number of Terminal Units served and required Flow Rates, specifically for Oxygen supply and Medical Air supply, consider providing twin pipe supply or ring main design for Gas supply to insulate the MGPS installation from pressure failure. If double pipe supply design or ring main design; with or without double feed pipes; for Gas supply is provided, the design must be vetted by the Project Engineer or the Hospital Consultant.

10.22 Pipelines Laid Outside Of Buildings

10.22.1 All MGPS service pipes (except small sections provided for final disposal of gases or air intake) when provided outside of buildings shall be either buried at a sufficient depth or run on overhead on a bridge for pipes (not recommended), as appropriate, to protect the piping from excessive stresses. The potential hazard arising from this situation shall be assessed using risk analysis procedures in accordance with ISO 14971.

10.22.2 Temporary support, adequate protection and maintenance of all underground and surface structures, drains, sewers and other obstruction encountered in the progress of this work shall be furnished under the direction of the Project Engineer. The structures which may have been disturbed shall be restored upon completion of the work.

10.22.3 If practical, buried underground piping can be placed in a continuous conduit, of high density polyethylene (HDPE), after obtaining approval from the Project Engineer. In such cases, the ends of the conduit sleeve shall be sealed to prevent the entrance of ground water.

10.22.4 If practical, underground piping shall be run in properly drained ducts not less than 450 mm x 450 mm, when crossing the roads.

10.22.5 All underground piping shall be provided with valves in a convenient location at either end, housed in accessible manholes or valve chambers. The valves should comprise LVAs for the purposes of pressure testing and other tests.

10.22.6 The minimum backfilled cover above the top of buried piping outside of buildings shall be 1000 mm; except that the minimum cover shall be permitted to be reduced to 500 mm, where physical damage to the piping is not likely to occur.

10.22.7 Trenches shall be excavated so that the pipe has a firm, substantially continuous bearing on the bottom of the trench. Trenches will provide Sand padding of 100 – 150 mm, with suitable rock-free material.

10.22.8 Backfill shall be clean and compacted so as to protect and uniformly support the piping.

10.22.9 The MGPS Installer must get the pipe layout inspected by the Project Engineer, prior to backfill.

10.22.10 A continuous tape or marker shall be placed immediately above the pipe enclosure which shall clearly identify the pipeline by specific name.

10.22.11 The route of pipes placed underground should be indicated at the site by appropriate means, e.g. by continuous marking tape above the pipeline at approximately one-half the depth of burial, by placing proper all-weather signs, etc. Further the route of the pipeline should be identified on the surface by placing proper permanent warning signs, 300 mm above the top surface, in a manner that they are clearly visible. It should be clearly shown on site layout drawings also.

10.22.12 Suitably placed covered Manholes or valve chambers, with removable covers, shall be provided to enable access to the joints and valves, during visual inspection and leak testing.

10.23 AGSS Disposal System

10.23.1 The Exhaust pipe of AGSS disposal system is taken to Hospital's AGSS Discharge Point.

10.23.2 Depending on the design, the AGSS Discharge Point will have as many pipes as the number of Operating Rooms, as the design shall provide individual termination for AGSS pumps to prevent room to room infection. (Same logic that requires separate AHUs)

10.23.3 The Discharge Outlet shall be sited at roof level, far away from ventilation inlets, opening windows and other apertures, where it cannot be entrained into the air-supply system and re-enter the building.

10.23.4 It must provide protection for Rain ingress.

10.24 The First Fix connections (including gas specific NIST Connections), as well as second fix connections, specifically for Medical Supply devices and all peripherals, must be adequately staggered to prevent cross connections.

10.25 **Support for Pipeline**

10.25.1 The MGPS pipeline shall be adequately supported at sufficient intervals as tabulated hereunder.

10.25.2 The supports shall be suitably treated to minimise corrosion and prevent electrolytic action between the pipes and supports.

OUTSIDE DIAMETER	MAXIMUM INTERVALS	MAXIMUM INTERVALS
(mm)	For Vertical Runs (m)	For Horizontal Runs (m)
12	1.5	1.5
15	1.5	1.5
22 - 28	2.0	2.0
35 - 54	2.5	2.5
> 54	3.0	3.0

10.25.3 Where pipes pass through walls, partitions or floors they shall be fitted with sleeves of copper pipes and provided with appropriate escutcheon plates where to view.

10.25.4 The sleeves shall project at least 25 mm beyond the surface of penetration.

10.25.5 The annular space between the sleeve and pipe shall be tightly caulked with a suitable material.

10.25.6 Concealed pipe work shall not be sealed in until it has satisfactorily passed all visual inspections and pressure tests. Once covered, the route of the buried pipe work shall be clearly and continuously marked by chalk, coloured adhesive tape or otherwise during construction, to discourage the insertion of fixings in to or near the pipe by other trades.

10.25.7 Due allowance shall be made in the installation for building movement at all constructional expansion joints.

10.25.8 The design of supports, brackets and hangers for all pipe work shall be in accordance with BS 3974.

10.25.9 The MGPS Installer shall co-ordinate the tie-in of pipe supports with Structural and Architectural works and shall provide additional support structures, wherever necessary.

10.26 Identification, Marking, Colour Coding Of Pipelines

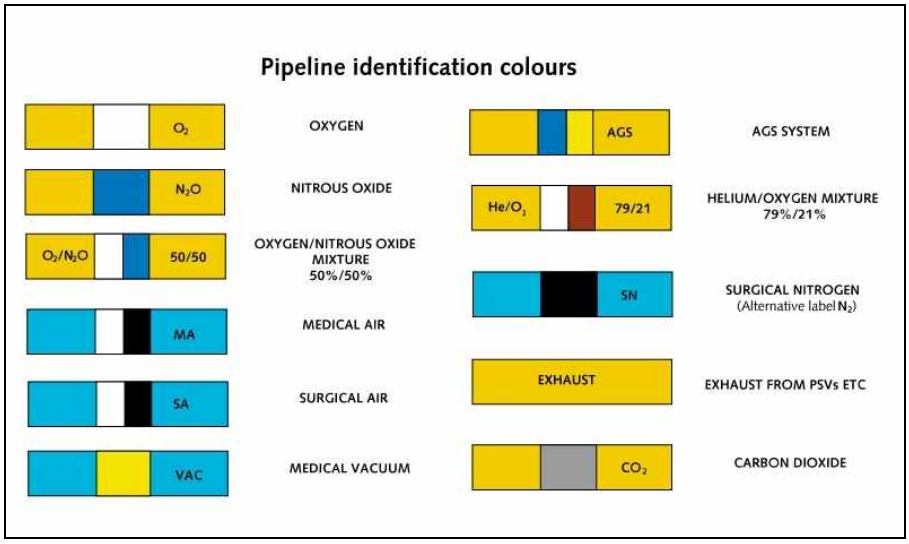
10.26.1 Color coding for the MGPS pipes should be as per applicable standards in this CPWD specifications or NIT amended upto date, based on the relevant standards i.e HTM 02-01/ ISO 7396-1 as per latest guidelines.

10.26.2 It also meets the requirements of IS/ISO 9170-1: 2008 for Terminal Units.

10.26.3 The Gas symbols are also indicated for marking on pipes, identification plates, etc.

10.26.4 The height of the lettering shall be at least 2.5 mm.

10.26.5 The indicative chart is as below.



10.26.6 In addition, arrows shall be marked on pipes to indicate direction of flow of gas.

10.26.7 The Warning Signs, illustrative Graphics and Signs shall be in English and Hindi either on the same panel, plate, poster, etc.

10.26.8 The identification plates shall be in English only and shall be white plastic plates engraved with black letters and screwed on to various Equipment, Components, Housings, etc.

10.27 Drawings provided for Pipeline Layout

10.27.1 The drawings, as provided, are indicative of Pipeline Routes.

10.27.2 All pipe layouts, either external or internal, will be adequately protected.

10.28 Pressure Control Equipment

10.28.1 When Nominal Supply System Pressure is higher than Nominal Distribution Pressure, the maximum supply system pressure should not exceed 1100 kPa.

10.28.2 This also requires provision of Pressure Control Equipment located at multiple locations in the pipeline carcass.

10.28.3 The Pressure Control Equipment includes duplex pressure-regulating valves, each with upstream and downstream isolating valves, safety valves and NIST connectors.

10.28.4 The safety valve discharges must be vented to the exterior of the building.

10.29 Pressure Gauges

10.29.1 Pressure Gauges are generally not required outside the MGPS plant and manifold room.

10.29.2 They may be incorporated within AVSUs, Operating Room Supply Fittings, etc.

10.29.3 Whenever provided, they should be installed with isolation cocks in adequately ventilated location.

10.30 Pipeline Testing

10.20.1 All the piping system shall be tested in the presence of the Project Engineer or his authorized representative.

10.31 PROVISION OF VALVES

10.31.1 Provision of valves is subject to Building Design and MGPS Design. In addition to providing access to MGPS in emergency, they also help in shutting off supply of Oxygen and Nitrous Oxide in case of fire and also assist in controlling movement of smoke in case of fire.

10.31.2 All valves shall be of the lever-ball type, having flanged O-ring seal connections which open and close with a 90-degree rotation: the handle should be in line with the pipeline when open. The Valves in open position shall permit full gas flow without any pressure loss.

10.31.3 Gas identity and flow direction arrows should be provided for each valve.

10.31.4 Valves are provided for all gas Services including Medical vacuum but not for AGSS.

10.31.5 All Valves are in Open position in a commissioned MGPS system. Therefore, Gas pressure loss by a closed valve should be notified to the MGPS Alarm System.

10.31.6 Placement of Valves is not mandated in codes but are required for Safety and maintenance of the MGPS system as well as general Life & Fire Safety. Therefore, discretion must be exercised to arrive at the logical number of Valves to be deployed to make MGPS a safe system. Provision of too many valves also leads to failure of the safety system.

10.32 VALVE DESIGNATIONS

a. All Medical Gas Valves shall be specially prepared for oxygen service. Valves shall be ball-type, with Teflon seats and adjusting stem packing gland with Teflon stem seal.

b. Ball valves shall be rated 600 WOG, actuate from full "ON" to full "OFF" by 90 degree turn of vinyl gripped valve handle.

c. Furnish and install only valves with factory installed BS EN 13348.

d. Valves not in valve boxes shall be provided with locking handles.

e. All valves shall be cleaned for oxygen, capped and sealed in a polyethylene bag for shipping and storage.

f. Brazing copper to brass/gun-metal/bronze is not performed on site.

10.32.1 Main Line Valve (Source Shut Off Valve)

a) A Source Shut Off Valve is always provided for each Medical Gas Service at the immediate outlet (or inlet, in the case of Medical Vacuum) of the source of supply, so that the entire supply source, including all accessory equipment, can be isolated from the entire pipeline system.

b) These are provided in MGPS Manifold Room or MGPS Plant Room.

c) The Source Shut Off Valve Location must always be a supervised Location and accessible to MGPS staff only.

d) These are not normally locked.

e) These are not normally enclosed in locked boxes.

f) These are not provided non-interchangeable screw thread connector (NIST) fittings.

10.32.2 Branch Valves including Riser Valves

a) Branch Valves are provided at every major branch and the base of each riser, which branches out from the Main Hospital Supply Pipeline, on all types of Gas Service, primarily for Fire Safety of the building. (A major branch is any line that serves two or more fire zones on a given Floor Plate).

b) Branch Valves are placed in secured locations and are accessible to MGPS staff only.

c) These are not normally locked.

d) These are not normally enclosed in locked boxes.

e) These are not provided NIST connector fittings.

10.32.3 Line Valves Assembly (LVA)

a) These are pipeline-isolating valve fitted to facilitate maintenance of defined section of the MGPS installation. These can substitute Branch valves, if so located.

b) LVAs shall be installed on branches from the Main Hospital Supply Pipeline, for all types of gas service, as under;

i. At the pipeline entry to a Building Block
ii. At the pipeline exit from a Building Block
iii. At the Emergency Inlet Port
iv. At the connection of branches to the main pipeline if branch valve has not been provided
v. At the connection of risers to the main pipeline if branch valve has not been provided

c) LVAs are normally locked in their operating positions.

d) These are not normally enclosed in locked boxes.

e) These are not provided non-interchangeable screw thread connector (NIST) fittings.

10.32.4 Zone Valves

a) Depending upon Floor Plate Configrations, a Zonal Valve will be provided upstream of LVA to control one (sometimes more than one Fire Zone) and should ideally be placed at the entry to the fire zone on the fire escape route, clearly visible, signed and away from the extent of the Fire Door.

b) Zone valves are usually provided on Medical Oxygen Supply Service and Medical Nitrous Oxide Supply Service.

c) Zone valves must be accessible to Floor Staff and Fire Service Staff.

d) Zone valve Location must be indicated in Floor Evacuation Plan Charts.

10.32.5 Area Valve Service Unit Modules (AVSU):

1) Area Valves, when provided with Non-interchangeable NIST Gas Specific Connectors, Gas Pressure Switch, and Pressure Gauge (optional), etc., are called Area Valve Service Unit Modules (AVSU). These multifunction units can monitor and control Gas Pressures as well as assist in Emergency Gas Alarm Management.

2) Area Valves are provided for user access to a limited area or zone of MGPS installation, in an emergency (or for maintenance purposes).

3) In case of gas supply interruption, AVSU are used to connect local external gas sources through the emergency inlets. This provision should always be made.

4) AVSU can be a Single Gas Service Unit or Multi-gas Service Unit. A single Multi-gas Service Unit shall service maximum 6 Gas Services, but the provision of Area Valves and other devices shall be gas specific. In Multi-gas Service Unit, Gas identity and flow direction arrows should be provided for each valve.

5) Typically, AVSUs are provided as per functional department layout and controls all Terminal Units in the respective departments. AVSU must be so located that they are visible from a reasonable distance and can be easily operated. The Area valves should be at a height of 1000 mm (lowest 800 mm) to maximum 1800 mm finished floor level, starting at lower level.

6) The AVSU is located in the Hospital street side of the Room or ward, after the Fire Zone separating door, in central location of the zone where it controls the terminal units, along the path of horizontal fire evacuation.

7) The Alarm and Monitoring Display Unit is placed in the Nursing Station.

8) An AVSU controls 36 or a smaller number of Terminal Units. (maximum 40 Terminal Units) in a multibed ward or 10 or a smaller number of rooms (or ward bays) with Terminal Units (maximum 12 Rooms). It controls only 8 Terminal Units or less when installed in Critical Care Areas including Triage Stations, Treatment Rooms, Labour Rooms, Class A and Class B Operating Rooms.

9) In case of a layout where a corridor crosses two fire zones in its evacuation path, additional Zone Valve should be provided to control Terminal Units, Fire Zone wise.

10) In case of provision of dual circuits, as may be provided in critical care areas with or without isolation facilities, AVSU provision is made separately for each circuit. Each AVSU must list all the terminal units, that it controls. In this situation, Alarm modules are not repeated.

11) Provision of AVSU shall be at a point immediately outside the entry door, individually, while the gas supply terminal unit and the alarm cum pressure monitoring unit will be in the room inside the room in the following locations.

i. Class C or higher, Surgical Operating Rooms
ii. Endoscopy Rooms (Can be combined for upto 8 Endoscopy rooms)
iii. All special use critical care rooms

12) In Operating Rooms where pneumatically powered pendant fittings are provided using medical air as the power source, the AVSU that controls the pneumatically-powered devices should be identified and marked out.

13) Provision of AVSU shall be in the control room of the machine while the gas supply terminal unit will be in the examination / Therapy room in the following locations.

i. Radiological Examination Rooms for CT, MRI, General X-ray, Cardiac Cath Lab, etc.
ii. Nuclear Medicine PET Scanner Examination Room, Gamma Camera Room, etc.
iii. Radiotherapy Room
iv. Brachytherapy Room

14) In Critical Care areas of the Hospitals, AVSUs should be labelled to identify the Terminal Units controlled.

15) For Functionally different departments on same floor, separate AVSUs shall be provided. For Example, if a floor has General Ward and a maintenance Dialysis Unit, each of these will have their respective AVSU to control the Gas Terminal Units, as provided.

16) AVSUs are lockable enclosures which can be closed with the valve either in the "open" or "closed" position. In an emergency, the user must 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 and plastic push/pull-out inserts, etc. AVSU with display units will require electrical power supply.

17) The AVSU enclosure should have adequate ventilation to prevent the accumulation of gas in the event of a leak.

10.33 PROVISION OF TERMINAL UNITS

10.33.1 The medical gas terminal units shall conform to BS EN ISO 9170-1 and accept probes to BS5682. Terminal units shall be capable of single-handed insertion and removal of the medical gas probe. The anaesthetic gas scavenging (AGS) terminal unit shall conform to BS6834.

OR

Terminal units conform to gas specific dimensions and connection requirements stated in DIN 13260-2. Components are designed and manufactured in accordance with BS EN ISO 9170 for medical gas distribution systems.

Terminal units installed in walls, bedhead trunking, headwalls or fixed pendants shall be connected to the pipeline with a copper stub pipe. Pressure gases and vacuum shall incorporate minimum 12mm O/D or more copper stub pipe. Terminal units for anaesthetic gas scavenging shall incorporate minimum 15mm O/D copper stub pipe.

Medical gas terminal units consist of two parts: First fix – the wall mounted assembly consists of brass pipeline termination block with copper stub pipe secured between a back plate and a gas specific plate to allow 130 degrees radial movement of the copper stub to align with the pipeline. The second fix components shall be manufactured with the pin index permanently moulded into the gas specific socket. The socket assembly shall retain a capsule assembly, containing the check valve and probe 'O' ring seals. Second fix terminal units shall be supplied with the anti-rotation pin loose and bagged to be fitted as

required. The socket is fixed to the base block with a design that ensure profile is always in the correct position. Probes are gas specific connectors that couple to the medical gas terminal unit sockets to provide access to gas systems. The replaceable capsule assembly shall enable all working parts subject to wear through usage to be replaced as a factory tested assembly, thereby reducing maintenance time. Each termination block assembly shall be pressure tested by the pressure decay method.

10.33.2 The Terminal units shall be suitable to dispense Medical Gases (or provide an inlet for medical vacuum) to the secondary equipment (flow meters, Suction regulators, etc.) at the point of use. These shall be gas specific. The outlets shall provide following features:

a) Terminal units shall be leak proof and allow plugging of probes from front.
b) Push to insert and press-to-release mechanism for probes.
c) Self-sealing valve on disengaging the probe
d) Non return valve for ease of line servicing and repairing
e) Color-coded, Gas Specific front plate
f) Terminal units shall be leak proof

10.33.3 Marking of Terminal units, probes, etc.

a) Terminal units, probes and their gas-specific components shall be marked durably and legibly with the symbol of the relevant gas, as under. In addition to the symbol, the name of the gas can be used.

b) The height of the lettering shall be at least 2,5 mm.

GAS	SYMBOL	WHITE
Oxygen	O_2	White
Nitrous Oxide	N_2O	Blue
Medical Compressed Air	MA4 or AIR - 4	Black & White
Vacuum	VAC	Yellow
Carbon Dioxide	CO_2	Grey
AGSS	AGSS	Red Magenta (3050-R40B in accordance with SS 19102, NCS Colour Atlas)

c) Terminal units and probes shall be marked with the manufacturer's name or identification mark and, if applicable, with additional means to ensure traceability such as type, batch or serial number or year of manufacture.

10.33.4 Terminal units intended for wall mounting where directly connected equipment such as flow meters are to be used must include a non-swivel device.

10.33.5 Terminal units intended for installation with the socket axis vertical, for example in pendant, or where horizontally mounted but intended for use with indirectly connected equipment by means of a flexible connecting assembly, should have a non-swivel device because flow meters may be attached.

10.33.6 Dimensions of probes shall be as per BS 5682:2005/ DIN 13260-2. It is essential that probes be machined from stainless steel.

10.33.7 Terminal units may also be incorporated with electrical services, nurse call systems, low voltage services, in proprietary fittings such as medical supply units, wall panel systems, Head Wall Panels and pendant fittings etc. When they are installed within such fittings, it is essential to maintain the concentricity of the terminal unit bezel with the fascia plate aperture.

10.33.8 All new Terminal Units will be supplied with "Do not use" labels. These labels shall remain in place until the final identity and quality tests have been completed.

10.33.9 The schedule of indicative locations for is given in Appendix A.

10.33.10 The drawings shall provide indicative numbers and room wise locations.

10.33.11 The estimated Numbers for Terminal Units will be listed in BOQ.

10.34 LOCATIONS OF TERMINAL UNITS

10.34.1 Terminal units should be mounted in positions, which will give short(est) routes for the flexible pipes connecting them to apparatus. These routes should not obstruct the movement of staff or equipment around the patient.

10.34.2 The recommended mounting height for installing Terminal Units on walls or similar vertical surfaces is 1300 mm (4 ft. 4 in) above finished floor level (FFL) to the centre of the socket. The range is 900 mm and 1600 mm to accommodate site conditions.

10.34.3 All Terminal Units at high level should provide minimal 1.8 m (5 ft. 10 in.) clearance above finished floor level especially for vertical probe mounts. (Ceiling pendants units).

10.34.4 In the Operating Rooms, Terminal Units are provided on pendant fittings, when available. It is recommended to use rigid pipework as much as possible.

10.34.5 AGSS Terminal Unit shall be provided on both pendants in the Operating Room.

10.34.6 Where more than one service is provided at one location, the Terminal Units should be arranged in the following order from left to right as seen when facing the terminal units:

O_2: N_2O: MEDICAL AIR: SURGICAL/INSTRUMENT AIR/ N_2: VACUUM: CO_2: AGSS

10.34.7 This arrangement will apply whether the individual Terminal Units are separate, of form part of an assembly.

10.34.8 For vertical arrangement, when appropriate, the same order will apply but reading from top to bottom.

10.34.9 Floor mounted Terminal Units are prohibited.

10.34.10 Vacuum System, in which body or other fluids are drawn through a fixed pipeline connecting a terminal unit or other connector to a remote suction jar, are prohibited.

10.34.11 There shall be a minimum clearance of 150 mm on either side of the terminal unit from another terminal unit for ease of connecting the secondary equipment.

10.34.12 For Terminal Units installed in recesses, provide additional 100 mm on each side of the outermost Terminal Units and 200 mm from centre to top of recess and 300 mm from centre to bottom of recess. The depth of the recess should be 150 mm. The surface should be clearly marked with suitable legend denoting medical equipment is installed within.

******

CHAPTER 11

MGPS PRESSURE MONITORING AND ALARM SYSTEMS

11.1 MGPS PRESSURE MONITORING AND ALARM SYSTEMS

11.1.1 This MGPS Installation will be provided a dedicated computerised MGPS Monitoring and Alarm System for continuous monitoring of the installed system and to provide system status information by deploying multiple display panels and generate alarms to warn the Hospital's Clinical and Engineering Staff at the time of abnormal conditions.

11.1.2 Should a system alarm condition occur, the alarm shall activate automatically.

11.1.3 The MGPS Monitoring and Alarm System will be operated by deploying a System Control Software that provides comprehensive monitoring over the whole MGPS installation, specifically over the Status of Equipment deployed and gas Pressures available. It provides comprehensive analysis of data as generated and presents the results in display panels and indicator panels. It activates the Alarm Module, monitors all alarm conditions and also generates required reports. The display and presentation formats shall be as per Hospital Policy.

11.1.4 The MGPS Monitoring and Alarm System will monitor all gas services installed, including AGSS. Typically, AGSS is controlled and monitored in the Operating Rooms but additional data shall be logged into MGPS Alarm and Monitoring System.

11.1.5 MGPS Alarm and Monitoring System, when installed, will become part of Hospital's Intra-facility communication system which are critical not only for Hospital's functioning but more so to respond to a disaster and these systems are an important part of disaster preparedness.

11.1.6 MGPS Monitoring and Alarm System will be a wired communications system (can be upgraded to be a wireless system when Hospitals deploy state of art, Wi-Fi systems). It will use its dedicated MGPS LAN which must reside on a separate dedicated structured cable network.

11.1.7 Typically, MGPS Monitoring and Alarm System consist of a central unit that receives signals and data that is generated by various sensors, transducers, devices, etc., installed as part of MGPS installation for monitoring its status, on 24 x 7 basis.

11.1.8 It will interface with third party Communication System and Software provided by the Gas Supplier to monitor the status of Liquid Medical Oxygen. This integration is in the scope of MGPS installer.

11.1.9 It will also interface with Hospital's Message Integration Engine (MIE), residing in the Hospital Information System. MIE does not replace messaging system contained in MGPS Alarm and Monitoring System. It is an interface system to allow messages generated by other Communication Systems to be sent to a range of receiving devices including Telephone System (EPABX) and Hospital Paging System. This integration is in the scope of MGPS installer. Provision of MIE is not in the scope of MGPS installer.

11.1.10 Typically, MGPS Monitoring and Alarm System, using MGPS LAN, will connect all PLC controlled panels, as deployed in MGPS installation, collect the data for analysis against pre-set bench marks and provide either Normal Condition Display or Emergency Condition display to display panels, as per Hospital approved format.

11.1.11 When an emergency condition occurs, it will automatically activate the Alarm Signal Module which will activate the alarms. Simultaneously, it will activate the Hospital's Message Integration Engine to broadcast notifications.

11.1.12 The MGPS Monitoring and Alarm System will provide Audio-visual display panels. The panels will provide physical, labelled, visual alarm indicators.

11.1.13 MGPS Monitoring and Alarm System Master Display will be provided in the Central MGPS Plant Room & Manifold Room or where the MGPS Duty Technician is located, and in other locations, as per Hospital Policy.

11.1.14 Slave of Master System Audible Alarms in the Central Fire Control Room of the Hospital as a Slave Monitor (also called Repeater Indicator Panel).

11.1.15 Area Audible Alarm Panels installed at the corresponding Nurse Station or Control Stations, in all areas of the Hospital, for those Gas Types which are being used there. The criteria is availability of Gas Specific Terminal Units.

11.1.16 MGPS Monitoring and Alarm System will be provided uninterrupted power supply (UPS), which will be supplied by the MGPS Installer.

11.1.17 MGPS Monitoring and Alarm System will be provided RF protection.

11.1.18 GPS designer will provide, on floor plan drawings, Location of Alarm Panels, Pressure Switches and related valves.

11.1.19 MGPS Installer will provide, on floor plan drawings the Low Voltage Control Wire Layout & Data Cable Layout.

11.1.20 All electrical systems, including plant control systems, alarm interfaces etc, should be designed in accordance with electromagnetic compatibility (EMC) directives according to HTM 02-01/ ISO 7396-1/ NFPA99 std (in this order of preference).

11.2 DESIGN PARAMETERS

11.2.1 The details of MGPS LAN to be established will be based on selection of Hardware installed in MGPS and Networking Software technology deployed. However, all trunking shall be based on CAT VI Cable system (Rating minimum 1 GB) with suitable switching system. LAN cable layouts shall comply with AT & T Specification for communications cabling, including RF protection.

11.2.2 It requires that all MGPS components are provided a unique ID which shall be used by the system to monitor and to display. It means all pumps, manifolds, LVA, AVSUs, etc. will be listed and provided a unique ID.

11.1.3 The MGPS Monitoring and Alarm System output will be Multi viewer, HD, display panels (Monitors) for simultaneous display of multiple screens related to multiple parameters. In addition, visual LED indicators or LED display units will be provided, where required.

11.2.4 The MGPS Monitoring and Alarm System output display can be wall mounted or a Table Top display unit. The audio-visual Alarm Panels must be installed where the alarms can be attended to.

11.2.5 The MGPS Monitoring and Alarm System is a comprehensive system that will collect gas specific data, pressure data, Gas Source data, on continuous basis, analyse it and provide MGPS status of normal conditions and activate alarms when abnormal conditions occur. It deploys a large number of digital Pressure, Airflow, Force, Magnetic and Tactile Sensors; Pressure Switches; Pressure Transducers, etc., to monitor and operate the MGPS Alarm and Monitoring System. Through MIE, it will generate Text messages and in advanced systems, generate calls to registered numbers for informing the occurrence of emergency condition, which require urgent action by the user. This alarm condition will require a rapid response by the engineering and clinical staff.

11.2.6 It requires that all MGPS components are provided a unique ID which shall be used by the system to monitor and to display. It means all pumps, manifolds, LVA, AVSUs, etc. will be listed and provided a unique ID.

11.3 ALARMS

11.3.1 Alarms are provided to caution the Healthcare Provider in the form of a quick Audio-visual notification that a Medical Gas or Vacuum System is failing, so they can take action to ensure the safety and well-being of their patient(s).

11.3.2 Depending upon the level of care being provided, the Alarm Panels must be visible and/or within the hearing range of the Healthcare Providers. The alarm should be loud enough to be heard over the surrounding ambient noise.

11.3.3 In any case, all local area Alarms are repeated in master Alarm and from there in the Central Fire Control Room. Hospitals must have a SOP to react to these Alarms in a timely manner.

11.3.4 In Critical Healthcare Delivery Areas, Hospitals must ensure that alarm panels are located in such areas which are manned when the care is being delivered. That is why, Nursing Station is considered appropriate location. When MGPS services are used in radiotherapy rooms, radiology examination rooms, Alarm panels are located in respective Control rooms.

11.3.5 If the Alarm Panels are combined, to reduce the number of audible notifications, the panel must indicate location of origin of the alarm.

11.3.6 Master Alarms, also called source alarms, panel will provide comprehensive information about the sources and give warning of any issues developing within the source equipment themselves. They also provide status of MGPS System, like the source being used, in case of Duplex manifolds, which bank is being used, etc.

11.3.7 Local Alarm panels provide information about the status of MGPS supply downstream of Area Valve or Line Alarm. Local Alarm panels may also provide relevant information about the Gas Pressure. The Alarm panel component of LVAs can be placed at a different location where it is more effective like at the Nursing Station in a ward where LVA is placed in ward evacuation path.

11.3.8 It is permitted to provide the Alarm panel inside the Operating Rooms. When provided, it must be tested every day, when surgery is planned in the Operating Room.

11.4 SENSORS

11.4.1 For all locations, the sensors will be placed on the pipe and wired to the alarm panel.

11.4.2 All Area Valves should be integrated with Alarm Sensors.

11.4.3 For all Critical Healthcare Delivery Areas, where an area alarm will monitor a single zone, the sensor should be placed on the patient side of the zone valve. Closing the valve should activate the alarm. Additionally, the sensor may be placed on the source side of the Zonal Valve to determine the extent of area affected.

11.4.4 For non-critical Healthcare Delivery Areas, it is recommended to place the sensors on the patient side of the zone valve.

11.5 DISPLAY PANELS

11.5.1 The display units can be wall mounted or a Table Top display unit. The panels shall be HD, Multi viewer display panels for simultaneous display of multiple screens related to multiple parameters. In addition, LED signal displays can be provided, where required.

11.5.2 All display panels, PLC Panels and PC integrated Units in MGPS installation will provide suitable Data Connections for networking.

11.5.3 The Display will be structured as under.

a) Normal Condition Display

1. The Normal condition for all piped MGPS should be displayed as a steady green visual signal.
2. The "Normal" indicator should extinguish in warning and alarm conditions.

b) Warning Condition Display

1. Warning conditions appropriate to each MGPS should be displayed as a flashing yellow visual signal that may be accompanied by a mutable audible signal.

c) Emergency Alarms Display

1. Emergency alarms are generated by loss of pipeline pressure or vacuum and are indicated by flashing red visual signals accompanied by mutable audible signals.

11.6 THE AUDITORY SIGNAL

11.6.1 The Auditory Signal(s) for emergency clinical alarms shall conform to the requirements of IEC 60601-1-8. The A-weighted sound pressure level of the auditory components of these alarm signals, at minimum volume, shall be at least 2 dB above the background level or 55 dB when tested in accordance with ISO 3746.

11.6.2 If an auditory signal can be silenced by the operator, the silencing shall not prevent the auditory signal from being activated by a new alarm condition.

11.6.3 If an emergency auditory signal can be silenced by the operator. the period of silencing shall not exceed 15 minutes.

11.6.4 If means to allow permanent audio pausing of the auditory signal are provided. such means shall only be accessible to authorized staff.

11.6.5 Visual Signal(s) for emergency clinical alarms shall conform to the requirements of IEC 60601-1-8. These shall be clearly visible upto a distance of 4 meters, and in ambient illumination of 100 LUX to 500 LUX.

11.6.6 For Emergency Clinical and Operating Alarms, there shall be a simultaneous Visual and Auditory Signal. When the condition which has caused the alarm has cleared, the auditory signal and the visual signal shall reset automatically or by deliberate operator action.

11.6.7 MGPS Monitoring and Alarm System will provide following 3 types of Display Panels. These may be with or without controlling valves, as per design. These will provide direct data connectivity for slave panels.

a) Master MGPS Alarms Display Panel
b) Area MGPS Alarms Display Panel
c) Local MGPS Alarm Display Panel

11.7 MASTER MGPS ALARMS DISPLAY PANEL

11.7.1 It will be located in the Central MGPS Plant Room & Manifold Room or where the MGPS Duty Technician is located, as per Hospital Policy.

11.7.2 One Slave Monitor Panel of Master Alarms Display Panel will be provided in the Hospital's Central Fire Control Station. If the MGPS Plant Room, manifold Room and the Liquid Medical Oxygen yard are in different locations, each will have Master MGPS Alarms Display by providing suitably located Master Panel and Slave Panels.

11.7.3 In addition, one or more Slave Monitor Panel of Master Alarms Display Panel may be provided in following locations.

11.7.4 Central HIT Hardware Room

11.7.5 Biomedical Engineer's Duty Room

11.7.6 In case of large MGPS installations, with multiple sources, all MGPS Master Alarms Display Panel shall be aggregated at one Location as a bank of Slave panels. The varied sources need to be individually identified along with fault condition, in the display.

11.7.7 In Master Alarms Display Panel, the number of lights and their arrangement can vary depending on the details of the source equipment being used. Some types of pumps require extra alarms and some backup systems will also require alerting the continuously attended location.

11.7.8 It will, at the least, provide the following information, grouped in a Gas Specific format.

1) AGSS Disposal Unit Status
2) Bacterial Filter Status
3) Dew Point Measurement

4) Dryer In Use
5) Duty Bank Pressure
6) Filter Service Date
7) Gas Distribution Pressure
8) Gas Flow Rate
9) Gas Pressure at defined Locations
10) Gas Supply Pressure
11) Liquid Medical Oxygen Tank Liquid Level
12) Outlet Pressure To Pipeline
13) Power Amps In Use
14) Pump Hours Run
15) Pump No. On Duty
16) Pump Oil Level
17) Pump Service Date
18) vacuum reservoirs Pressure
19) Standby Bank Pressure

11.7.9 OPTIONAL

a) Daily Gas Consumption
b) Data for Gas Audits
c) Status of Cylinder Inventory

11.7.10 It will, at the least, provide signals to indicate the following conditions.

1) **Oxygen**
   a) High main line pressure
   b) Low main line pressure
   c) Primary Liquid level Low (Less than an average day's supply)
   d) Reserve Liquid level Low (Less than an average day's supply)
   e) Reserve in use
   f) Reserve low pressure
2) **Manifolds with containers or cylinders (usually Medical Nitrous Oxide, Medical Carbon Dioxide)**
   a) High main line pressure
   b) Low main line pressure
   c) Changeover from primary to secondary supply
   d) Reserve in use (If reserve header is present)
   e) Reserve low pressure (If reserve header is present)
3) **Medical Air**
   a) High main line pressure
   b) Low main line pressure
   c) High Dew point (> 35° F)
   d) High Temperature* (operating temperature of the compressor)
   e) Lag Compressor*

4) **Medical Vacuum**

a) Low Vacuum pressure

b) Lag Pump*

* Will display "Maintenance Required"

11.8 AREA MGPS ALARMS DISPLAY PANEL

11.8.1 These are located in Functional Areas of the Hospital to monitor the gas specific pressure in specific areas or zones, like in a nurse Station for a multi bed ward or in a Surgical Suite.

11.8.2 These can be located alongside AVSUs.

11.8.3 These must always be placed where the alarm condition can be attended to.

11.8.4 A single panel can display all Monitored Gas Service Status, scrolling display.

11.9 LOCAL MGPS ALARM DISPLAY PANEL

11.9.1 These are located in Functional Areas of the Hospital to monitor the gas specific pressure in specific room, like in an Operating Rooms or Endoscopy Room, on the ward Nursing Station in Critical Care Wards, etc.

11.9.2 These must always be placed where the alarm condition can be attended to.

11.9.3 A single panel can display all monitored gas services.

11.10 MGPS MONITORING AND ALARM SYSTEM SOFTWARE

11.10.1 The MGPS Monitoring and Alarm System Software will be capable of being interfaced to Hospital HIT, can talk to most third party software(s) for any enhancements of the system and capable of being upgraded. It will retain MGPS data for a limited period and submit all data to HIS for archiving.

11.10.2 It will provide real-time monitoring and tracking of all transactions of all linked devices. By itself or by deploying third party add on, it will provide a comprehensive, stable, secure system with 100% backup.

11.10.3 It will provide

a) A comprehensive System Control with integrated alarms
b) Real-time system status Display and Graphics
c) Full System Statistics Tracking and Reporting, including messaging and E-mailing
d) Interface all needed third party Softwares
e) Ability to add additional plug-in Technologies
f) User-Friendly Programming Abilities

11.10.4 The Central Control Centre where this software resides requires tertiary Source of Power (UPS Power). UPS will be provided by the MGPS installer.

11.10.5 All Alarm Conditions will be supervised in addition to automatic control and monitoring.

11.10.6 All reconfiguration operations and all changes in operational bench marks; shall be carried out after due authorisation.

11.1 OTHER PARAMETERS

11.1.1 MGPS Monitoring and Alarm System as deployed in the Hospital is connected to Hospital LAN through a Low Voltage Integration Switch for Data management. Once this connectivity to Hospital LAN is established, the MGPS data and reports become part of HIS database and can be viewed anywhere in the Hospital depending upon the privileges of the viewer.

11.1.2 The design of all panels including Central Panel, Repeater Panel, Area Panels and Local Panels including its SLD shall be approved by the Project Engineer or the Hospital Consultant before these units are fabricated.

******

CHAPTER 12

COMMISSIONING AND HANDING OVER

12.1 COMMISSIONING AND HANDING OVER

12.1.1 MGPS Commissioning includes following activities to be carried out in the stated order.

12.1.2 The testing procedures as described in the HTM 02-01/ IS ISO 7396-1 Standard, IS ISO 7396-2 Standard will be followed.

12.1.3 A record shall be made of all tests performed and results.

12.1.4 All testing shall be witnessed by the Project Engineer.

12.1.5 All defects or errors, found during testing must be rectified, and the relevant systems must be retested as appropriate before the records are signed. All such repairs must be authorised specifically by the Project Engineer and a record be maintained.

12.1.6 The MGPS Installer will provide labour, materials, equipment, Instruments, Tools and Tackle to carry out these tests.

12.1.7 The MGPS Installer will co-ordinate with Test Laboratories for testing gas specificity.
In the MGPS Installation, no MGPS Accessories or Devices which require Gas Service shall be connected to the Installation, till the Project Engineer has certified the MGPS System to be a Commissioned System.

12.2 SPECIFIC ACTIVITIES

12.2.1 Pipeline Carcass
- a. Labelling and Marking
- b. Sleeving and Supports
- c. Physical Plant & Pipe Accommodation
- d. Signage including Construction Safety Signage
- e. Pipe Leakage Tests (First stage)
- f. Valve Leakage Tests
- g. Cross-connection Tests

12.2.2 Pipeline System Complete – System Test
(with Installed Terminal Units for safe Performance with test Gases)
- a) Leakage Tests (Second stage)
- b) AVSU/TU/NIST Identification, Function & Performance Tests

i. Closure of AVSUs and LVAs
ii. Zoning of AVSUs
iii. Terminal Unit Identification
- c) Cross-connection Tests
- d) Pipeline System Performance Tests

i. Flow and pressure drop at individual Terminal Units
- e) Supply System Performance Tests
- f) Safety Valves Performance Tests
- g) Alarm Systems Performance Tests
- h) Purging with Test Gases
- i) Particulate Contamination Tests
- j) Vacuum Disposal System
- k) AGSS Disposal System

12.2.3 MGPS System Complete with specific Medical gases
   i. Purging with Working Gases
   ii. Carry out Gas Identity and Quality Tests

12.2.4 Handing Over Documentation
   a. Check all OEM Manuals and Certificates
   b. Check Liquid Medical Oxygen License
   c. Check DFO NOC
   d. Check Maintenance Manual
   e. Check all "As Built" drawings
   f. Check all "As Installed" Equipment drawings
   g. Check Electrical Installation Drawings
   h. Remove Construction Labels
   i. Check Safety Signage
   j. Record Pressures immediately prior to commissioning

12.2.5 System Commissioned

12.3 VALIDATION AND VERIFICATION

12.3.1 The following test parameters must be met to functionally validate this MGPS Installation. These are in addition to other physical and safety testing that is carried out.

12.3.2 All validation tests shall be witnessed by the Project Engineer and test reports verified.

12.3.3 The MGPS Installer shall provide all instrumentation for the functional tests along with their Calibration certificates.

12.3.4 The Liquid Medical Oxygen system shall not be tested under no flow conditions.

12.3.5 In this MGPS Installation, the test gas shall be Compressed Air supplied in Cylinders, or generated by the Medical Air Plant, provided the Medical Air has been tested as complying to IP or EP or USP. Non-medical compressed air, from any source – cylinders or portable compressors, shall not be used.

12.3.6 When employing Medical Air Plant Compressors for this testing, the total flow under test shall not be more than 75% of the flow capacity of the dryers. This will be worked out before testing and approved by the Project Engineer.

12.3.7 The testing shall be carried out in three stages as under and as listed in detail above.

a) Tests and checks on the pipeline carcass.

b) Tests and commissioning of the complete pipeline system (with Terminal Units installed) for safety, performance and particulate contamination using test gas.

c) Only after tests for particulate contamination are validated, filling of the MGPS gas delivery systems with specific gases for the purposes of identity and quality tests of the specific gases will be done, prior to its use for patient care.

12.3.8 After the testing and validation, if MGPS is not to be commissioned, the pipeline will remain filled with test gas under pressure, till it is commissioned when respective gases shall be filled, and identity tests and quality tests of the specific gases repeated.

12.3.9 Always, the designated Authorised Person (MGPS) is responsible for the day-to-day management of the MGPS, after commissioning of this MGPS Installation. This shall be

included in this contract agreement. All works including maintenance works and repair works, modification works, addition or deletion of terminal units, etc. must be authorised before these works are carried out.

12.3.10 All new Terminal Units will be supplied with "Do not use" labels. These labels shall remain in place until the final identity and quality tests have been completed. They shall then be removed by the Authorised Person (MGPS).

12.3.11 The operators, whether in house or third party, will always work under the designated Authorised Person (MGPS).

12.3.12 The results of all tests must form part of the permanent records of the Hospital and should show details of the services and areas tested.

Medical Gas	**Nominal pipeline distribution pressure**	**Test flow (measured at terminal unit outlet)**	**Test location**	**Min. pressure at design flow measured on the test gauge**	**Plant pressure**
	(kPa)	(L/min)		(kPa)	(kPa)
O_2	400	100	Operating Rooms (ORs)	380	430–490
		10	All other Terminal Units		
N_2O	400	15	All Terminal Units	380	430–490
Medical Air 4	400	80	All Terminal Units	380	430–490
Vacuum	55.3 (400 mm Hg) below standard atmospheric pressure of 101.3 kPa (760 mm Hg)	40	All Terminal Units	40 (300 mm Hg)	73 - 86 (550 – 650 mm Hg) (typical plant operating range)
AGSS					

Note: The tests shall be as per the applicable standards and also as per the stipulation by the NIT authority in the NIT.

******

CHAPTER 13

MEDICAL GAS PIPELINE SYSTEM MAINTENANCE

13.1 GENERAL

13.1.1 The safe operation of the Medical Gas Pipeline System (MGPS), relies on skilled and trained staff who understand the system and who can co-ordinate with clinical users to ensure continuing Patient Safety. It requires comprehensive installation data and maintenance manuals.

13.1.2 Its proper operations are dependent on following three specific parameters applicable to MGPS. All other general administrative rules also apply as applicable to any other Hospital System and persons employed therein.

13.1.3 Supply of adequate Quantity of Medical Gases, which meet the specified Quality Criteria and are provided in Time as per Hospital Policy.

1) This is in the scope of Hospital authority.

2) It also requires maintaining active contract for MGPS Maintenance and Operation, as applicable; including keeping the Fire NOC and a valid storage license for Liquid Oxygen under "The Static & Mobile Pressure Vessel (Unfired) (also known as SMPV (U) Rules) Rules - 1981 of Indian Explosive Act- 1984 & amendments there-off".

13.1.4 Keeping the MGPS Installation in a state of fully functional and working 24 x 7, to provide all Medical Gases, on a continuous basis to the end user.

1) This is in the Scope of MGPS Installer.

2) It also requires maintaining adequate spares for all mechanical devices installed, spare cylinders, carry out frequent checks, carry out periodical training of MGPS Technical Staff, carry out periodical training of Clinical staff, carry out all planned preventive maintenance and carry out safe operation of the system.

13.1.5 Reporting

1) Since it is a Life Supporting System, all needed records must be generated to establish that the MGPS Installation is fully operational, in a state of full repair at all times to cover the libel liability of the Hospital for Patient care.

2) This also requires generating a proper Hospital MGPS Policy which should have been notified as a Hospital Order. It includes listing all key personnel involved in the operation, maintenance and use of this MGPS system. This will include nominated Medical and Nursing Staff, Fire Safety Officers, Pharmacy Staff and the competent personnel (who may be in-house staff or contractors).

3) These reports shall be generated as per the specified periodicity and always countersigned by Hospital's Medical Superintendent.

13.2 MGPS INSTALLATION

13.2.1 This MGPS Installation consists of following Gas Services.

(Strike out those not provided OR add which ever not indicated below, but are to be part of the maintenance)

a) Oxygen
b) Nitrous Oxide
c) Medical Air 4
d) Medical Vacuum
e) Medical Carbon Dioxide
f) AGSS

13.2.2 These Medical Gases are supplied to the Hospital Block.

13.2.3 This MGPS Installation includes following major Components

13.2.4 A MGPS Manifold Room which contains

a) Oxygen Manifolds
b) Nitrous Oxide Manifolds
c) Medical Air Manifolds
d) Carbon Dioxide Manifold

13.2.5 AGSS Disposal System

13.2.6 A MGPS Plant Room with a Liquid Medical Oxygen yard which contains

13.2.7 A Liquid Medical Oxygen Supply System with vacuum-insulated cryogenic bulk storage vessel, ## Number VIE Evaporators with manual change over and a Duplex Pressure Regulating Control Panel. It has an Apron for filling the bulk storage vessel.

13.3 The MGPS Plant Room contains

a) A Multiplex Medical Air Plant
b) A Multiplex Medical vacuum Plant
c) A Combined Electrical Control Panel for Cascading and Sequencing control over the Medical Air and Medical Vacuum Plants

13.4 A Medical Gas Cylinder Store Room

13.4.1 A Trench for carrying the main pipelines from the MGPS Plant Room to building blocks.

13.4.2 A Copper pipe carcass to distribute the Medical gases to user areas, as planned.

13.4.3 Adequate number of LVAs and AVSUs to Isolate and maintain subsections of the MGPS installation.

13.4.4 A MGPS Monitoring and Alarm System, primarily to monitor pipeline pressure and provide audio-visual warning to MGPS operators and to the Clinical staff responsible for administration of the medical gases.

13.2.5 Adequate number of Medical Gas Terminal Points, as per a separate record, distributed in the Hospital building blocks.

13.2.6 It provides all needed Accessories to make the installation fully functional.

13.5 CRITICAL COMPONENTS IN THIS MGPS INSTALLATION

13.5.1 This MGPS Installation has the following critical components which must be inspected, tested and provided preventive maintenance once in three months.

13.5.2 Master Alarm and Warning Panels

13.5.3 Area Alarm Panels

13.5.4 Automatic Pressure Switches

13.5.5 Shut-off Valves

13.5.6 Medical Gas Hoses

13.5.7 Terminal Units

13.5.8 Air intake for Medical Air 4

13.5.9 Medical Air Filters

13.5.10 Sanitary Status for Vacuum Pipes

13.6 CRITICAL ACTIVITIES FOR THIS MGPS INSTALLATION

13.6.1 The following activities shall always be performed when this MGPS Installation is commissioned, or when this MGPS Installation is modified or repaired, for whatever reason.

13.6.2 Pressure testing of Medical Gas Piping Systems

13.6.3 Cross Connection of Medical Gas Piping Systems

13.6.4 Purity of Medical Gases being delivered at the Terminal Units

13.6.5 The maintenance of primary supply source of oxygen i.e. Liquid Medical Oxygen Supply System with vacuum-insulated cryogenic bulk storage vessel, 2 Number VIE Evaporators with manual change over and a Duplex Pressure Regulating Control Panel, technically called the Cryogenic Liquid Medical Oxygen installation shall always remain in the scope of original manufacturer who is also the Gas Supplier. This maintenance shall be done once in three months.

13.6.6 All changeover functions shall be tested with online pressure reduction once in three months.

Note:

1. The scope of the work to be suitably modified depending upon the installation to be covered at site and also the frequency and details of the activities related to preventive maintenance can be suitably modified based on requirement of the hospital authorities and the OEMs recommendations.
2. The complete schedule to be prepared based on the required daily, weekly, monthly, 3 months, 6 months or annual activities required to be taken up and proper logs to be maintained for the same and documentations preserved for the checks and supervision by the department and the hospital authority.
3. The required technical and supportive manpower should be worked out and be clearly indicated in the NIT giving details of the required qualification, experience, numbers, duration etc.

******

CHAPTER 14

TERMINOLOGY

14.1 **After-cooler:**
A heat-exchanging device used to cool and hence release water by condensation from compressed air. It is usually mounted in the output pipework from a compressor.

14.2 **AGSS TYPE H Terminal Unit:**
AGSS type 1 terminal Unit to be used in high flow disposal systems.

14.3 **AGSS TYPE L Terminal Units:**
AGSS type 1 terminal Unit to be used in low-flow disposal systems.

14.4 **AGSS Type Terminal Unit:**
Connection point between the AGSS power device or the disposal hose and the remainder of the disposal system at which an operator makes connections and disconnections.

14.5 **Alarm System:**
A series of interconnected, electronically operated units, that continually monitor pipework pressure and plant operating conditions and relay these to appropriate personnel via coloured indicator display panels.

14.6 **Anaesthetic Gas Scavenging (Disposal) System (AGSS):**
It is a system to control exposure to Nitrous Oxide and other Anaesthetic Agents which are used for anaesthetic procedures in the Surgical Operating Rooms.

14.7 **Automatic Changeover, Gas Cylinder Banks:**
It is a system to control Changeover between cylinder banks from duty bank to stand-by bank. The system can be Pressure Regulator based or PLC Based Electronic System and is based on pressure generated by the respective Cylinder Banks.

14.8 **Automatic Switchover of Gas Flow from one source to another:**
It is a function of differential Line Pressure in main supply line where depleting pressures automatically switch over to lower pressure supply source.

14.9 **AVSUs:**
Area Valve Service Units, when provided, permit isolation of certain parts of the system for servicing or repair.
They are also provided for use by clinical staff and Fire Fighting Staff, in an emergency.

14.10 **Cascading Control:**
Cascading Control is used in context of the Pump installations where more than one pump from a group of pumps can be started to meet a design condition simultaneously. The cascaded control is built in the Control Panel. This provides energy saving and prolongs useful life of pumps by matching pump duty to required design parameters which vary in proportion to Hospital activity variation.

14.11 **Cryogenic Liquid:**
Liquid material that is extremely cold at more than –90 °C (–130 °F).

14.12 **Cut-In and Cut-Out:**
All Pressure switches have two operating points known as the cut-in (Reset Point) and cut-out (Trip Point) settings. The cut-in point is for the falling pressure and the cut-out point is for the rising pressure.

14.13 **Design Flow:**
A calculated value of gas flow which allows for flow diversity factors and which is used in estimation of primary gas source capacity.

14.14 **Dew Point:**
Temperature and pressure at which Medical Air will condense water vapor into liquid water within the Medical Air Pipeline System.

14.15 **Differential Pressure Switch:**
Switch with a low pressure and high pressure adjustment; fluid/Gas pressure actuates an electric switch to perform functions.

14.16 **Diversity:**
When calculating medical gas flows from, say, a ward area, an allowance is made for the fact that it would be exceedingly unusual for all Terminal Units to be in use simultaneously. This allowance is called a diversity factor and, for flow calculation purposes, will give a flow value for a particular area, that is less than the mathematical (algebraic) sum of the flows from all the terminal units.

14.17 **Diversity Factor:**
This factor represents the maximum number of Terminal Units in a defined clinical area which are likely to be used at the same time, at defined flow rates. It is expressed as a percentage of installed number of terminal units.

14.18 **Double-Stage Pipeline Distribution System:**
Pipeline distribution system in which gas is initially distributed from the supply system at a pressure higher than the **Nominal Distribution Pressure**, and is then reduced to the nominal distribution pressure by line pressure regulator(s).

This initial higher pressure is the **Nominal Supply System Pressure.**

14.19 **Duplex:**
A system which has two principal elements or parts.

14.20 **First-fix:**
The gas-specific back part of a terminal unit. It contains an automatic isolating valve.

14.21 **Gauge Pressure (Positive):**
The pressure differential above atmospheric pressure (see pressure gauge).

14.22 Gauge Pressure (Negative):
The difference between pressure remaining in an evacuated system and atmospheric pressure. In effect, it is the pressure drop produced by evacuating the system, measured in mm of mercury.

Caution: It is a potentially misleading term which must be carefully defined when used; Negative Pressure (absolute) doesn't exist.

14.23 **Load and Unload (Cycle):**
Load & Unload are the time slabs, for which the Air Compressors or Vacuum Pumps are engaged and disengaged, in the pressurizing or pressure decay cycles of a MGPS System.

14.24 **LVA:**
Line Valve Assemblies is a Line valve with non-interchangeable screw thread connector (NIST) used for isolating section of pipeline, to facilitate maintenance. It is recommended that all LVAs should be locked in their normal operating positions, unless sited in a locked plant room.

LVAs are not normally enclosed in locked boxes.

14.25 **Main Line:**
Portion of the pipeline distribution system connecting the supply system to risers and/or branches

14.26 **Manifold (Semi-automatic):**
A manifold that will change from empty to full cylinders automatically but will require manual resetting when new cylinders are installed.

14.27 **Manifold Control Unit:**
A cased assembly of components controlling the pressure and delivery of gas, alternately, from two banks of cylinders. It may be totally mechanical in operation or contain electronic and/or electrical components.

Whatever method of operation is chosen, a medical gas manifold must continue to supply gas in the event of an electrical failure.

14.28 **Manifold Room:**
A purpose-built room designed to accommodate a cylinder manifold installation and reserve cylinders as appropriate.

14.29 **Medical Device:**
Medical Device means any instrument, apparatus, implement, machine, Engineering Installation, appliance, implant, reagent for in vitro use, software, material or other similar or related article, intended by the manufacturer to be used, alone or in combination, for human beings, for one or more of the specific medical purpose(s) of:

- o Diagnosis, Prevention, Monitoring, Treatment or Alleviation of Disease.
- o Diagnosis, Monitoring, Treatment, Alleviation of or Compensation for an injury.
- o Investigation, Replacement, Modification, or support of the anatomy or of a physiological process supporting or sustaining life.
- o Control of conception.

Drugs are not Medical devices. (WHO, FDA, CE).

14.30 **Medical Gas:**
Any gas or mixture of gases intended for administration to patients for anaesthetic, therapeutic, diagnostic or prophylactic purposes

14.31 **Medical Gas Pipeline System:**
Complete system which comprises a supply system, a monitoring and alarm system and a distribution system with Terminal Units at the points where medical gases or vacuum are required.

14.32 **Monograph:**
A detailed description of a medicine, its composition, allowable impurities, methods of analysis etc contained in a Pharmacopoeia.

14.33 **Muffler (Exhaust)**
A low-restriction flow-through device that reduces air line noise. It also traps moisture (and oil, in lubricated systems).

14.34 **Nominal Supply System Pressure:**
Pressure which the supply system is intended to deliver at the inlet to the line pressure regulators.

14.35 **Non-interchangeable Screw Thread Connector (NIST):**
A gas-specific connector used as a termination for flexible hoses and copper pipe in a ceiling plate etc. Despite the name, it is the dimensions of the male part of the connector that make it gas-specific, not the outer screw threaded fastening ring.

14.36 **Oxygen Concentrator:**
A self-contained, electrically powered, generally portable, medical Device which produces Oxygen-enriched air - more than 90% concentrated oxygen, from ambient air by extraction of Nitrogen to provide a continuous source of Oxygen at 5LPM to 10 LPM.

14.37 **Oxygen-deficient Atmosphere:**
An oxygen deficient atmosphere occurs whenever the normal oxygen content of the air is less than 19.5 percent oxygen. (OSHA).

14.38 **Oxygen-enriched Air:**
Oxygen produced from air by an Oxygen concentrator, by the molecular sieve process.

14.39 **Oxygen Enriched Atmosphere:**
An oxygen enriched atmosphere occurs whenever the normal oxygen content of the air is allowed to rise above 22%. (OSHA)

14.40 **Pressure Relief Valve:**
Device intended to relieve excess pressure at a pre-set pressure value.

14.41 **Primary Source Of Supply:**
Portion of the supply system which supplies the Pipeline Distribution System.

14.42 **Pressure Swing Adsorption (PSA):**
Family of generators that separates one gas from another by passing a feed gas over a bed of absorbent material (Zeolites) at one pressure and cleaning the waste product off the adsorbent material at another pressure, hence the term pressure swing.

14.43 **PSA Oxygen Generator Plant:**
It is a unit designed to concentrate oxygen from ambient air, with output capacity varying according to calculated oxygen demand, typically ranging from 2 Nm3 /hr to 200 Nm3 /hr (average) to 500 Nm3 /hr.

Nm3/hr is Normal Meter Cubed per **Hour**, a Unit to measure gas flow rate.

14.44 **QUADRUPLEX:**
A system which has four principal elements or parts.

14.45 **Reserve Source of Supply:**
That portion of the supply system which supplies the complete, or a portion(es) of the Pipeline Distribution System, in the event of failure of (exhaustion of both the primary and secondary sources of supply.

14.46 **Riser:**
Portion of the pipeline distribution system traversing one or more floors and connecting the main line with branch lines on various levels.

14.47 **Secondary Source of Supply:**
Portion of the supply system which supplies the Pipeline Distribution System in the event of exhaustion of or failure of the primary source of supply.

14.48 **Sequencing Control:**
The term is used in context of Pump installations where individual pumps are used in a sequential manner. It means when required, first pump no. 1 of 4 pumps is started and second time the pump no. 2 of 4 pumps is started and so on. It can also apply to a group of pumps stating at the same time when Group No. one is started first time and Group No. two is started second time and so on.

This prolongs useful life of pumps by sequencing their duty time.

14.49 **Single Stage Pipeline Distribution System:**
Pipeline distribution system in which gas is distributed from the supply system at the nominal distribution pressure.

14.50 **Source Of Supply:**
Portion of the supply system with associated control equipment which supplies the Pipeline Distribution System.

14.51 **System Control:**
It is a Centralised Computer and Software, that controls all electro-mechanical devices and system-wide communications. It can interface with Hospitals Information System.

14.52 **TRIPLEX:**
A system which has three principal elements or parts.

14.53 **Vacuum Gauge:**
Device for determining the pressure level in a partial vacuum.

14.54 **Vacuum Pressure Swing Adsorption (VPSA or VSA):**
Subset of the PSA family, VPSA involves separating air into its constituent components by means of adsorption where one of the operating pressures is below atmospheric pressure (vacuum). In this, adsorbent material is alternately fed with pressurised air to produce the required product and regenerated by vacuum to remove the residual gases from the adsorbent.

14.55 **Zonal Valve:**
Area Valve, when provided, permit isolation of certain zones of the system for safety, servicing or repair. They are also provided for use by clinical staff and Fire Fighting Staff, in an emergency.

******

CHAPTER 15

TECHNICAL SPECIFICATION OF MEDICAL GAS PIPELINE SYSTEM

15.1 SCOPE OF WORK

15.1.1 The Medical Gas Pipe Line System (MGPS) includes the following items to be included on turn key basis, as per individual site requirements:

a. Primary LMO tank system (of required capacity) inclusive of Control Panel & Automatic Switchovers).

b. Secondary oxygen manifold and emergency oxygen manifold with automatic control panels.

Nitrous oxide manifold and emergency NO_2 manifold with automatic control panel.CO_2 Manifold and Emergency CO_2 Manifold with automatic control panel.Medical Air Supply System (4 Bar & 7 Bar) complete.Medical Vacuum (suction) Supply System Complete.
AGSS system complete
Distribution Piping Complete with accessories.
Area Valve Service System.
Alarm systems (master & area).
Gas Outlets with Probes.
Bed Head Panels.
Other associated works.
control cabling from / to control panel and associated sensors
Site modifications
Comprehensive maintenance of MGPS installations

15.1.2 **The design of this MGPS installation must;**

a) Ensure Quantity of Supply
b) Ensure Identity of Supply
c) Ensure Continuity of Supply
d) Ensure Quality of Supply

15.2 Scope and Technical Specification:

15.2.1 Oxygen Supply Systema.

a) **Primary Liquid Medical Oxygen Tank (Vaccum Insulated Evaporator) and Allied Equipment application:**

This comprises of storage of Liquid Oxygen and Supply of High purity Oxygen gas for medical use after conversion of liquid to gas through ambient atmospheric vaporizer.

b) Liquid Medical Oxygen Storage Tank:

The double walled Vaccum Insulated Evaporator (VIE) shall be constructed of stainless steel inner vessel contained within a carbon steel outer vessel. The annular space between the vessels shall be filled with non-inflammable perlite insulation material to insulate under vacuum. The VIE shall be self pressurizing type by partial evaporation of liquid oxygen through a pressure building coil by a non ferrous pressure regulator. The vessel shall be supplied as a functional whole with all materials of construction & the cleaning regime suitable for medical grade liquid oxygen.

Quantity: 20 KL X / 10 KL X / as per site requirement. The quantity of each to be indicated in NIT.
Installation: Outdoor
Type: Double walled, vertical
Capacity: Minimum capacity in KAL water capacity to be indicated. (20 KL X / 10 KL X / as per site requirement. The quantity of each to be indicated in NIT.)Design code :ASME Sec.VIII Div.I latest Edition / EN -13458-2 Annexure-C/ AD2000 MARKBLATTER 2004 Edition
Max. working pressure: 17 Bar G
Design temperature: –196ºC to +50ºC
Hydraulic Test Pressure: 26 bar G
Type of Insulation: Vacuum, Perlite filled
Safety Valve Set pressure : 17 Bar G (dual safety valve with three way diverter valve)
Bursting Disc Set Pressure : 23 Bar G (Bursting disc)

Standard fittings: Pressure rising coil, pressure building regulator of adequate capacity and size, dual safety valve with imported three way diverter valve, bursting disc., pressure gauges, liquid over flow line, Liquid level gauge and adequate numbers of extended spindle glove valve etc.

Maximum Evaporation Rate: <0.35% of net value.
Material of Construction: Inner shell and wetted parts of SS 304 Outer shell of CS ASTMA 516 Gr. 70 / CGA 341 2002 EN13455 S275/S355
Joint Efficiency : 100%
Radiography :100% for inner, for outer spot
External piping :From LMO Tank to Vaporizer : SS304 From Vaporizer to inlet of Pressure Reducing Station: SS304 From Outlet of Pressure Reducing Station to Main header:

Copper Cryogenic Valves: Non ferrous
Cryogenic Safety Valves
Pressure Building regulator :Non ferrous
Leak Detection test : Helium Leak detection
Painting :Primer and finish with White RAL 9010
Inspection : By 3rd party (SGS/LLOYDS/TUV)
Cleaning : Degreasing for Oxygen Service and Pressurize with Nitrogen.
Withdrawal rate :1000 cum per hr. at 12 Bar G or as per design

c) Accessories:
LMO Tank along with P&ID shall be fitted with the following accessories:
Top Fill Valve
Bottom Fill Valve
Liquid charging line blow valve
Liquid Delivery Valve
Overflow Valve
Gas blow valve
Filling Coupling
Vaporizer Coupling
Liquid Level Gauge (Dial 100 mm).
High Level Valve
Equalizing Valve
Low level Valve

Pressure Gauge (100mm dial, Range 0-25 kg/Cm^2)
Pressure Gauge Isolation Valve
Pressurizing Valve
Pressurizing Coil
Filter
Pressure Regulator
Economizer
Check Valve
Evacuation Port
Vacuum Gauge Connection Port/vacuum probe valve.

d) Safety Fitting:

Two safety valves for inner vessel fitted on pipe line with flow divert valve
Rupture disc for inner vessel.
Safety valve for inlet pipeline.
Safety valve for pipeline of pressurizing evaporator.
One rupture disc/ safety device on outer vessel.

e) Submittals:

The Liquid Medical oxygen tank shall accompany the Original Quality Test Certificate covering following Documents:
Approval letter from CCOE along with approved drawing from CCOE.
Approval letter from CCOE for use of cryogenic vessel(s) at site.
Certificate from the authorized inspection agency.
Heat chart for pressure parts.
Dimension checks report.
Dished End reports.
Mechanical properties test report for production test coupon.
Visual inspection report.
Radiography examination report.
Liquid penetrant examination.
Cleaning inspection report.
Hydro-pressure test report.

f) Liquid Oxygen supply system

One vessel of 1X20 KL/ 1 X 10 KL (or capacity as per design) Liquid oxygen VIE vessel system will be the primary (main) supply source and another vessel of design capacity will be secondary source. In case of failure in liquid oxygen supply, it shall automatically switch over to an emergency oxygen manifold having cylinders.The unit shall consist of a double walled vertical vessel (inner pressure vessel made of stainless steel and outer vessel of carbon steel).It shall be fitted with standard accessories and shall be "passed" as per the standard inspection requirement at factory for VIE. The copy of the certificate shall be forwarded to department prior to shipping and original shall be enclosed along with the shipping document. Bidder shall follow International Standards.

g). Product and Service Specification:

The capacity of the primary liquid oxygen storage tank shall be as per the design/ capacity calculation and as per capacity mentioned in NIT.
Gas outlet pressure to be maintained at 4.2 kg/Cm^2.
Suitable space for installation to be planned in conformity to the regulations of Indian

explosive controller and having easy access for LMO tank.
The site would be protected by fence around, well lit by sodium vapour lamps and demarcated with proper signage.
Indication of liquid oxygen level and outlet gas pressure shall be provided.
Automatic change over shall be provided between the primary and secondary LMO tanks. In case of failure in liquid oxygen supply, it shall automatically switch over to an emergency oxygen manifold having cylinders

h) Specification of Components

Product: The liquid medical oxygen (LMO) supplied at site shall be of IP grade. The LMO supplied shall comply with all relevant SMPV regulations and standards under the preview of the Indian Drugs and Cosmetic Act rules. They shall also satisfy the IP 2007 specifications.

i) Storage Tank Specifications

The storage tank and the vaporizer coils shall be designed as per the ASME Sec.VIII Div.I latest Edition / EN -13458-2 Annexure-C/ AD2000 , MARKBLATTER 2004 Edition

The cryogenic vessel will be of cylindrical shape with vaporiser and the pressure control system. It shall be provided with the essential components to fill the liquid, to build up pressure, to relieve pressure, to withdraw product and to evacuate the vessel. All protective, safety and alarm provisions mandatory to Liquid Medical Oxygen plants shall be supplied.

j) The requirement of the Cryogenic Vessel shall be:

1. Configuration: Vertical
2. Inner vessel maximum allowable working Pressure: 17 kg/Cm^2
3. Inner vessel hydrostatic test pressure: Greater than 26 kg/ Cm^2
4. Outer vessel material of construction: Carbon steel
5. Inner vessel material of construction: Stainless steel
6. Independent AV coil shall be provided with each vessel.

k) Storage Tank Capacity Primary Vacuum insulated evaporator vessel shall have a capacity of 20X1 kilo liters (or as per site requirement) and secondary with 1X10 kilo litres (or as per site requirement). The AV coil shall have adequate capacity to handle the gas flow requirements of the hospital.

l) Vaporiser Coil.

1. Maximum operating Pressure: 20 kg/Cm^2
2. Design Pressure: 22 kg/Cm^2
3. Pneumatic test Pressure: Greater than 24 kg/Cm^2
4. Inlet temperature: - 196 to +40°C.
5. Duty cycle: Continuous duty
6. Flow rate : 1200 cubic metre/ hour or per design The fence, foundation, lighting, signage, approach gate etc are to be designed and installed by the firm and the scope of the work should be clearly mentioned in the NIT.

m) Safety

The vendor shall ensure that all safety norms and standards applicable are implemented and certified by the CCE.

Following are the mandatory provisions for vessel:
Vessel low pressure alarm
Pipeline low pressure alarm.
Twin regulator
Twin safety valve
Non return valve and 3 way diverter (bypass) valve
Automatic changeover to manifolds with **control panel/regulator**. There should be dedicated VIE Panel for LOX source.
Alarm on indicating manifold in use in case the vessel is not in use.
Alarm on low pressure back-up manifold cylinders

n) Statutory Requirements

All statutory requirements of the Chief Controller of Explosives of India and SMPV rules need to be followed, besides all regulations and guidelines put forward by the Govt. Of India from time to time shall be followed.

o) Maintenance

All routine preventive maintenance and break-down maintenance of the liquid oxygen plant shall be done by the vendor and scope to be defined in the NIT. Experienced personnel shall be readily available.
Log of all works undertaken in the plant shall be meticulously maintained by the vendor.
Bulk cylinders for the manifold will be arranged by the hospital.

15.2.2 Oxygen Manifold Supply System (without Cylinders)

The size of Manifolds shall be as mentioned in BOQ of respective site/ hospital and it shall be compatible with Class-D type bulk cylinders.
Manifold shall consist of two high pressure header bar assemblies to facilitate connection of primary and secondary cylinder supplies. Each header bar shall be provided with respective numbers of cylinder pigtail connections to suit cylinder valves as per IS.3224/ BS/ ASME incorporating a check valve at the header connection.

Each header bar assembly shall be provided with a high pressure shut off valve. Oxygen Manifold shall consist of respective numbers of class D-type bulk oxygen cylinders. The manifold shall be hydraulically tested to atleast3000 psig. The manifold shall be so designed that it shall suit easy cylinder changing and positioning. The system shall have non – return valves for easy changing of cylinders without closing the bank along with individual cylinder valve and pressure relief valve. The cylinder shall be placed with the help of cylinder brackets and fixing chains which shall be galvanized. Shall be BIS/European CE certified with 4 digit notified body no./ UL Listed/ ETL listeda.

a) Oxygen Flow meter with Humidifier Bottle for other then ICU area

Back Pressure Compensated flow meter for accurate gas flow measurement with following features:

i. Control within a range of 0-15 LPM.

ii. It shall meet strict precision and durability standard.

iii. The flow meter body shall be made of brass chrome plated materials.

iv. The flow tube and shroud components shall be made of clear, impact resistant polycarbonate.

v. Flow tube shall have large and expanded 0-15 LPM range for improved readability at low flows.

vi. Inlet filter of stainless steel wire mesh to prevent entry of foreign particles

vii. The humidifier bottle is made of unbreakable & reusable polycarbonate /polysulfone material autoclavable at 121 degree centigrade .

viii Oxygen Flow meter & Humidifier Bottle for ICU–

The graduated scale should have an oval shape this allows a "lens effect" get the scale values easy-reading in any condition of use.

I/0 switch button green and red allows the operator to quickly lock and reactivate the flowmeter gas supply, keeping unchanged the previous flow preset value.

When the flowmeter is not working, the green button is visible and pushing it, the flow is activated. On the contrary, to stop the flow, the red button must be pushed.

It should have ADJUSTING KNOB WITH PUSH & LOCK SYSTEM: it keep locked the pre-set flow value. To adjust the flow pull the knob, set the flow value you need to deliver to the patient and push the knob to lock the selected value.

The flowmeter should have an integrated pressure reducer for the stabilization of supplied pressure at 2.8 bar, to guarantee always and in any condition the flow accuracy of the device. The flowmeter can be used in any hospital with different pressure from the plants and it is not necessary to calibrate it.

The outlet nipple should have a double thread interchangeable by the end user. The flowmeter should have 50 mm adjusting knob with soft grip inserts for easy handling

The humidifier should completely made of polycarbonate and it can be sterilized in autoclave at 121 °C for 15 min

For the inlet connection it should have some snap inserts, identified with color-code, with different threads to be chosen by the end user

An ergonomic and big size rotating nut allows to easily connect and disconnect the humidifier to the oxygen supply device, the 360° rolling positioning hose connector ø 6÷9 mm allows an easy use of the humidifier.

The bottle should have hollow shape, besides being a design unique element, offers the operator an easy and safe handling. The humidifier should have an integrated relief valve

ix. Shall be European CE certified with 4 digit notified body no./UL Listed/ETL listed.

b.) Fully Automatic Oxygen Control Panel (for High Pressure Oxygen Manifold Cylinder)

Automatic control panel shall be constructed in accordance with the requirement of international standards. The fully automatic oxygen control panel shall comply with HTM 02-01/ ISO- 7396-1/ NFPA 99C standards and Medical Device Directive 93/42/EEC. It shall be European CE Certified with 4 digit notified body number or American ETL/ American UL listed.

The specifications shall be referred in the following order of preference :1) HTM 02-01,2) ISO 7396-1 3) NFPA 99. The preference shall be to follow Single Standard as specified above for relevant equipment

Product should be mechanical tested & certified from Third party for:

1. Regulators Ignition Test
2. BAM Test
3. Adbiatic certification
4. Pressure Test
5. Flow Test
6. Pneumatic Test in case of power failure.
7. Indicators Test
8. Change Over manifold test
9. Gauge Calibration test

The manifold assembly shall provide two stages of pressure regulation Each manifold header bar assembly shall be provided with a high pressure shut off valve along with individual cylinder valve. The Control Panel must have 2 stage network pressure reducing system equipped with safety valves, first stage reducer to reduce the high pressure from the source to a medium pressure and the second stage reducer to reduce the medium pressure to the line pressure to ensure safety.. A single stage primary regulator, one for each cylinder bank shall be used to initially reduce cylinder pressure and two single stage pressure regulators shall be provided in the control cabinet for final delivery pressure regulation. One delivery pressure regulator in service and one shall be ready for service in a standby mode. The Manifold control panel shall be with digital display, fully automatic type and switches from "Bank in Use" to "Reserve bank " without fluctuation in delivery supply line pressure. It must have pressure gauges at all important control points so that the state of the system can still be assessed even in the event of a power failure. Changeover shall be performed by electrically/pneumatically operated valves contained in the control cabinet. In the event of an electrical power failure (in case of electronically operated) the valves shall automatically open to provide an uninterrupted gas flow. Major valve must be of brass to avoid wear and to have long lasting service free lifetime. It shall be 100% automatic and shall not require manual adjustment. An emergency supply point via NIST connector coupling must be provided to ensure uninterrupted gas supply in case of any emergency during maintenance/ service.

c. Indication for changing the cylinders shall be clearly identified on the front of the control panel.

All functional components shall be enclosed in corrosion resistant robust material. The electronic control unit must be enclosed in galvanized metal housing, terminal strip on electronic housing to ensure safety. The power supply (AC-DC Converter unit) must be external to the Control panel to ensure safety.

All components inside the Control Panel like Pressure Regulators, piping and control switching equipment shall be cleaned for Oxygen Service and installed inside the cabinet made of mild steel with epoxy powder coated with a viewing window to monitor digital display to minimize tampering with the regulators or switch settings.

The cabinet must have hydraulically operated doors and should be able to operate/open easily (hydraulically) to save space during service or maintenance.

d) The Control Panel shall include two pressure relief valves, one high pressure approximate 200/350psi and one low pressure approximate 75 psi.

The heavy duty control panel shall be provided with a flow capacity of 2000 or more LPM at 50 to 60 psi or as per design.

The Automatic Control Panel shall be installed in such a way to meet the peak flow requirement of the Hospital/Institute (If the requirement is more than flow capacity requirement automatic control panel the bidders has to supply 02 numbers of Automatic Control Panel and design the system in such a way to meet the flow requirement of respective institute)

Control Panel should have automatic acknowledgement/ reset facility.

The manifold panel must be connected with Master Alarm to show the parameters on Master Alarm Panel.

15.2.3 NITROUS OXIDE SYSTEM

a. Fully Automatic Nitrous Oxide Control Panel

The fully automatic N_2O control panel shall comply with HTM 02-01/ ISO 7396-1/ NFPA 99 C STANDARD and Medical Device Directive 93/42/EEC. It shall be European CE Certified with 4 digit notified body number or American ETL/American UL listed.

The specifications shall be referred in the following order of preference :1) HTM 02-01, 2) ISO 7396-1 3) NFPA 99. The preference shall be follow Single Standard as specified above for relevant equipment

Product should be mechanical tested & certified from Third party for:

1. Regulators Ignition Test
2. BAM Test
3. Adbiatic certification
4. Pressure Test
5. Flow Test
6. Pneumatic Test in case of power failure.
7. Indicators Test
8. Change Over manifold test
9. Gauge Calibration test

The manifold assembly shall provide two stages of pressure regulation. Each manifold header bar assembly shall be provided with a high pressure shut off valve along with individual cylinder valve. The Control Panel must have 2 stage network pressure reducing system equipped with safety valves, first stage reducer to reduce the high pressure from the source to a medium pressure and the second stage reducer to reduce the medium pressure to the line pressure to ensure safety. A single stage primary regulator, one for each cylinder bank shall be used to initially reduce cylinder pressure and two single stage pressure regulators shall be provided in the control cabinet for final delivery pressure regulation. One delivery pressure regulator in service and one shall be ready for

service in a Standby mode. The Manifold control panel shall be digital, fully automatic type and switches from "Bank in Use" to "Reserve bank "without fluctuation in delivery supply line Pressure. It must have pressure gauges at all important control points so that the state of the system can still be assessed even in the event of a power failure. Changeover shall be performed by electrically/ pneumatically operated valves contained in the control cabinet. In the event of an electrical power failure (in case of electrically operated) the valves shall automatically open to provide an uninterrupted gas flow. Major valve must be of brass to avoid wear and to have long lasting service free lifetime. The manifold shall not require any manual resetting or adjustments after the replacements of the depleted cylinders. An emergency supply point via NIST connector coupling must be provided to ensure uninterrupted gas supply in case of any emergency during maintenance/ service.

All functional components shall be enclosed in corrosion resistant robust material. The electronic control unit must be enclosed in galvanized metal housing, terminal strip on electronic housing to ensure safety. The power supply (AC-DC Converter unit) must be external to the Control panel to ensure safety.

The Control Panel shall include two pressure relief valves, one high pressure approximate 200 psi and one low pressure approximate 75 psi. The control panel shall also have heaters to prevent ice formation on the regulators at high flow rates.

The Control Panel shall be made to provide Heavy Duty and have a flow capacity of 1500 LPM or more at 50to 60 psi. The Automatic Control Panel shall be installed in such a way to meet the peak flow requirement of the Hospital/Institute (If the requirement is more than flow capacity requirement automatic control panel the bidder has to supply 02 numbers of Automatic Control Panel and design the system in such a way to meet the flow requirement of respective institute)

All components inside the Control Panel like Pressure Regulators, piping and control switching equipment shall be cleaned for Nitrous Oxide Service and installed inside the cabinet made of mild steel with epoxy powder coated with a viewing window to monitor digital display to minimize tampering with the regulators or switch settings. The cabinet must be able to operate/open easily (hydraulically) to save space during service or maintenance.

Control Panel should have automatic acknowledgement/ reset facility.

The manifold panel must be connected with Master Alarm to show the parameters on Master Alarm Panel.

b) Nitrous Oxide Manifold (Without Cylinders) The size of Manifolds shall be as mentioned in BOQ of respective Institute and it shall be compatible with Class-D type bulk cylinders.

Manifold shall consist of two high-pressure header bar assemblies to facilitate connection of primary and secondary cylinder supplies. Each header bar shall be provided with respective number of cylinder pigtail connections to suit cylinder valves as per IS.3224/ BS/ ASME incorporating a check valve at the header connection. Each header bar assembly shall be provided with a high pressure shut off valve along with

individual cylinder valve. The manifold shall be hydraulically tested to atleast 3000 psig. The manifold shall be so designed that it shall suit easy cylinder changing and positioning. The cylinder shall be locked with the help of cylinder brackets and fixing chains which shall be galvanized. Shall be BIS/European CE certified with 4 digit notified body no./ UL Listed/ETL listed

c) Emergency N_2O Manifold (Without Cylinders)

The size of Manifolds shall be as mentioned in BOQ of respective Institute and it shall be compatible with Class-D type bulk cylinders.

Manifold shall consist of high-pressure header bar assemblies to facilitate connection of cylinder supplies. Header bar shall be provided with respective numbers of cylinder pigtail connections to suit cylinder valves as per IS 3224/ BS/ ASME incorporating a check valve at the header connection. Header bar assembly shall be provided with a high pressure shut off valve. Nitrous oxide manifold shall consist of respective numbers of cylinders

The manifold shall be hydraulically tested to atleast 3000 psig. The manifold shall be so designed that it shall suit easy cylinder changing and positioning. The system shall have non – return valves for easy changing of cylinders without closing the bank. The cylinder shall be placed with the help of cylinder brackets and fixing chains which shall be galvanized .

Shall be BIS/European CE certified with 4 digit notified body no./ UL Listed/ETL listed .

15.2.4 CARBON DIOXIDE SYSTEM

The system shall consist of medical CO_2 Manifold Primary & Standby (as per the configurations mentioned in NIT) with Class-D type Cylinders and control panel . Control panel of CO_2 shall be European CE Certified or American ETL/ American UL listed.

The Modular Manifold supply system shall provide carbon dioxide piped distribution system.

The Modular Manifold system shall be in such a way that it increases flexibility and allows easy enlargement of the manifold capacity in case of future expansion. Shall be compliant with HTM 02-01/ISO 7396-1/ NFPA 99 C standard and Medical Device Directive 93/42/EEC.

The specifications shall be referred in the following order of preference :1) HTM 02-01, 2) ISO 7396-1 , 3) NFPA 99. The preference shall be follow Single Standard as specified above for relevant equipment.

The system shall have non – return valves for easy changing of cylinders without closing the bank along with individual cylinder valve and pressure relief valve. The cylinder shall be placed with the help of cylinder brackets and fixing chains which shall be galvanized.

a. Fully Automatic Control panel for CO2 System

The Manifold Control System shall supply any type of medical gas from both left and right hand manifold banks. Operation and performance criteria shall fully satisfy the requirements of HTM 02-01/ ISO 7396-1/ NFPA 99 C standard. The fully automatic CO2 control panel shall comply with the standard and Medical Device Directive 93/42/EEC. It shall be European CE Certified or American ETL/ American UL listed. The Manifold Control System shall supply on uninterrupted flow of 500 L/min. to a 400 k Pa (4 bar) distribution system. Either the left or right hand manifold bank may be designated "Duty" and shall automatically changeover to supply the distribution system from the "Standby" bank when pressure in the "Duty" bank falls to a predetermined level.

The Control Panel must have 2 stage network pressure reducing system equipped with safety valves, first stage reducer to reduce the high pressure from the source to a medium pressure and the second stage reducer to reduce the medium pressure to the line pressure to ensure safety. A single stage primary regulator, one for each cylinder bank shall be used to initially reduce cylinder pressure and two single stage pressure regulators shall be provided in the control cabinet for final delivery pressure regulation. One delivery pressure regulator in service and one shall be ready for service in a standby mode. The Manifold control panel shall be with digital display, fully automatic type and switches from “Bank in Use” to “Reserve bank “ without fluctuation in delivery supply line pressure. It must have pressure gauges at all important control points so that the state of the system can still be assessed even in the event of a power failure. Changeover shall be performed by electrically/pneumatically operated valves contained in the control cabinet. In the event of an electrical power failure (in case of electronically operated) the valves shall automatically open to provide an uninterrupted gas flow. Major valve must be of brass to avoid wear and to have long lasting service free lifetime. It shall be 100% automatic and shall not require manual adjustment. An emergency supply point via NIST connector coupling must be provided to ensure uninterrupted gas supply in case of any emergency during maintenance/ service.

All functional components shall be enclosed in corrosion resistant robust material. The electronic control unit must be enclosed in galvanized metal housing, terminal strip on electronic housing to ensure safety. The power supply (AC-DC Converter unit) must be external to the Control panel to ensure safety.

All components inside the Control Panel like Pressure Regulators, piping and control switching equipment shall be cleaned for Carbon Dioxide Service and installed inside the cabinet made of mild steel with epoxy powder coated with a viewing window to monitor digital display to minimize tampering with the regulators or switch settings. The cabinet must have hydraulically operated doors and should be able to operate/open easily (hydraulically) to save space during service or maintenance.

15.2.5 Medical and Surgical Air System (Package Unit) - Tolerance of +/-5% is acceptable on plant flow capacity

Air-cooled **Oil-Less** compressors for continuous duty application with highest output of compressed air, low power consumption and very low vibration resulting in low noise level.

Note: The system configuration shall be as per provisions in chapter 2 para 2.27

NOTE: The type of compressor to be decided and specifications to be mentioned in NIT accordingly. The above is for oil less compressor screw/ scroll. The medical air plant shall fully comply with the requirements of the HTM 02-01/ ISO 7396-1/ NFPA 99 C. It shall be European CE Certified with 4 digit notified body number or American ETL/ American UL listed (Incase of NFPA 99c the control panel of plant must be UL/ETL Listed and Undertaking from manufacturer for this tender reference must be submitted for using the same control panel in the system offered)

Air Compressor Modules

It shall be Oil-Less Screw Compressors /Scroll Compressors to produce the plant output of {minimum Liters Per Minutes(LPM) Plant capacity } as mentioned in BOQ of respective institute as primary and same capacity as standby.

The compressor shall have a sound insulating enclosure.

Medical quality air shall be delivered at a nominal pressure of 400 kPa (4 bar) and 700kPa(7 bar) gauge for supply of the hospital medical air and surgical air.

The Air Quality parameter to be achieved shall be as per following:

Contaminant	Threshold
H_2O	67 ppm v/v
Dry particulates	Free from visible particulates in a 75 litre sample
Oil (droplet or mist)	0.1 mg/m³
CO	5 ppm v/v
CO_2	500 ppm v/v
SO_2	1 ppm v/v
NO	2 ppm v/v
NO_2	2 ppm v/v

The medical air purification module shall incorporate high efficiency water separators, oil coalescing filters, heatless regenerative desiccant dryers, activated carbon filters with hopcalite catalyst, bacterial filters and pressure regulators. The performance of the filters shall be according to below specifications: Oil coalescing two-in-one high efficiency filter: mass efficiency of 99,991%, tested according to ISO 8573-2 & ISO 12500-1 Activated carbon filter: max remaining total oil content of 0,003 mg/m³, tested according to ISO 8573-5 & ISO12500-2 Bacterial filter: particle count efficiency of 99,98% at MPPS=0.06µm, tested according to ISO 12500-3.

Compressor plant shall be designed in such a way that compressors will switch on in a sequential manner as per flow demand.

The compressors shall be standalone ones with independent power supply. Each Compressor shall be suitable for both continuous and frequent start/stop operation at a nominal plant pressure of 10 bar or more.

The duty compressors shall be automatically rotated by the plant control system to ensure even wear compressors shall be supplied and installed. Desiccant dryer shall be provided with a dew point sensing switch that shall provide an alarm on the plant control

panel and central hospital alarm system when the water concentration in the delivered air rises above the limit. Duplex desiccant dryer and filtration modules shall be provided with three or more individual stages of filtration as follows:

Stage 1: Coalescing filter upstream of the desiccant dryer for removing liquid water particles down to 1micron.

Stage 2: Particulate filter after the desiccant dryer for dust protection and removing particles down to 1micron.

Stage 3: Bacteria filter for removing particles down to 0.01 micron.
Purity shall be tested as per the American Pharmacopeia / European Pharmacopeia standard.

The plant control and power management system shall monitor the safe operation of the plant, providing signal into the alarm system as per the requirements of the standard.
Pressure Reducing Station: For 4 bar and 7 bar shall fully comply and meet with the requirements of the standard. Simplex pressure reducing station shall comprise as in-line pressure regulator, with downstream pressure gauge. Isolation valves and pressure release valves shall be provided as per the standard. Duplex pressure reducing station to have two branches, connected to the MGPS in parallel in order to allow maintenance on the components of one branch, while the gas flow is maintained in the other branch.

Ball Valves - Full bore which operate from fully open to fully closed position with a quarter turn of the handle. Complete pressure reducing station with base plate mounted for ease of installation. Padlocks (if applicable to standards) available to allow locking of the valves in both open and closed positions and must have easy to read pressure gauges. Base plate mounted and supplied with copper stub pipes forease of installation using inert jointing procedures.

The compressor system shall have-

a) **Intake filter Delivery pipe**

b) Mounting on air tank along with all standard fittings viz. safety valve, pressure gauge, delivery valve, drain valve etc.

c) Bidder shall provide all electric control panels, starters etc required for proper functioning of MGPS.

d) Desiccant Air Dryer – 2 nos. (Duplex)

e) 2-Stage or more Breathing Air Filters – 2 sets(Duplex)

f) Outlet pressures for drills/equipment and ventilators shall be a minimum of 7 bar and 4 bar respectively.

g) Duplex pressure reducing station
The compressor shall be heavy duty, reliable with long MTBF (Mean Time Between Failure). Each compressor cylinder is to be protected by a temperature switch, which will stop the drive MGPS and provide an alarm signal in the event of abnormal discharge air temperature. Each compressor module shall include an inline filter with particle retention of 10 microns, inlet isolation valve, discharge isolation valve, and pressure relief valve. The capacity shall be capable to take care of total load of all the outlets.

h. Vertical Air Receiver Total air receiver capacity shall be at least 50% (+/- 5%) of the primary plant capacity (capacity as mentioned in the tender) in 1 minute in terms of free air delivered at normal working pressure. Each air receiver shall be protected by a pressure relief valve, a fusible plug and include a pressure gauge with isolating valve and a drain cock.

Air receivers should comply with BS EN 286-1: 1998 for all vessels up to 10,000 bar litres, and should be supplied with test certificates. The minimum water capacity of the receivers should be 50% of the compressor output in 1 minute, stated in terms of free air delivered at normal working pressure. Receivers should also be fitted with an automatic drain. Electrically operated automatic drains have been found to be more reliable. For systems that have a design flow in excess of 500 L/min, two receivers should be provided with valve arrangements to permit isolation of one or the other for inspection purposes.

Air Receivers Tanks should conform to ASME Boiler and Pressure Vessel Code 2017, Section VIII. It will preferably be a Vertical, Cylindrical, Stainless Steel Tank (304/ 304L), for providing rust protection. It must be durable, corrosion resistant and be able to maintain air purity. These shall be provided with valve arrangements to permit isolation of one or the other for inspection purposes.

The corrosion resistant coated receiver is to be equipped with tested safety pressure relief valve, sight glass pressure gauge, automatic drain, three-valve by-pass and source isolation valve.

i. Air Treatment Module

The air treatment module shall include dual dryers, dual filtration system and a dewpoint transmitter with local audible and visual signals and dry contacts for MGPS monitoring. The components shall be mounted on a common base with interconnecting copper/brass piping and upstream and downstream isolation valves. The isolation valves must allow either set of components to be serviced without shutting down the system.

Dryers shall be of heatless desiccant design and sized to provide for the peak calculated demand. The desiccant dryers shall be equipped with dew point dependent switching feature to minimize the need for purge air.

The dual filtration system shall remove liquid and particulate matter, consisting of 0.5micron coalescing filters with differential pressure indicators and automatic drain, airline pressure regulators with gauges, final pressure relief valve, and sampling valve. Each bank shall consist of three stage treatment. Digital dew point monitor is to be supplied with alarm contacts as per requirement of the standard.

j. System Controls

The “Continuous on Demand” feature will stop the operation of the MGPS during periods of low or no demand. The control include individual self-protected combination MGPS controls with short circuit protection, single phase and thermal overload protection, individual control circuit with transformers primary and secondary protection, pressure sensors, temperature switches with reset buttons, and an electronic controller to automatically change the operating sequence of the compressors. The cabinet shall have status display to include system pressure, dew point pump

operation, accumulated time, maintenance interval, fault conditions, and silence button, lighted Hand-Off-Automatic selector switches and safety disconnect operating handles. All required local alarm functions shall be integrated in to the packaged system. The system shall be designed to function even if the programmable controller fails.

k. Accessories

Accessories including for job site installation such as inlet and discharge flexible connectors, vibration mounting pads, and source isolation valve shall be supplied. All the filters shall be covered under warranty period and CMC Period.

15.2.6 VACUUM SYSTEMS (Package unit) - Tolerence of +/-5% is acceptable in plant flow capacity

It shall be European CE Certified with 4 digit notified body number or American ETL/ American UL listed (In-case of NFPA 99c the control panel of Plant must be UL/ETL Listed and Undertaking from manufacturer must be submitted for using the same control panel in the system offered)and shall comply with HTM 0201/ ISO 7396-1/ NFPA 99 C

a) Vacuum Pump Module

It shall be Oil Sealed Rotary Vane/ Screw Type to produces the plant output of {minimum Liters Per Minutes(LPM) Plant capacity } as mentioned in BOQ/NIT .Designed flow capacity shall be minimum of LPM capacity as mentioned in BOQ/NIT of respective institute. The vacuum plant shall comprise air-cooled, oil lubricated rotary vane vacuum pumps suitable for both continuous and frequent start/stop operation at inlet vacuum levels between 450 mmHg and 660 mmHg.

The control system shall normally employ automatic rotation of the lead pump to maximize pump life and ensure even wear. Vacuum pump inlets shall include a wire mesh filter and integral non-return valve to prevent oil suck back and pressure increases in the vacuum system.

Each vacuum pump shall be fitted with anti-vibration pads between the pump foot and mounting frame. The plant shall be fitted with duplex bacteria filter system.

b) Vacuum Receiver

The vacuum receiver shall be made of rust free corrosion resistant steel and fabricated as per ASME for a vacuum pressure of 760mmHg. It shall include bypass valves, manual drain valves, vacuum gauge. Vacuum reservoir shall have total volume of at least 100 % of primary plant output (+/- 5%) (capacity as mentioned in the tender) in one minute in terms of free air aspired at normal working pressure.

For systems that have a design flow more than 500 L/min, two receivers should be provided with valve arrangements to permit isolation of one or the other for inspection purposes.

c) System Controls

The control include individual self-protected combination MGPS controls with short circuit, single phase and thermal overload protection, individual control circuit transformers with primary and secondary protection, pressure sensors, temperature

switches with reset buttons, and an electronic controller to automatically change the operating sequence of the compressors. The system shall have a status display to show the system pressure, elapsed time, maintenance interval, fault conditions, and silence button, lighted Hand-Off- Automatic selector switches and safety disconnect operating handles.

All required local alarm functions shall be integrated into the packaged system. The circuitry shall be designed so that the audible signal can be silenced and the visual indicator will remain until the fault has been cleared and the reset button resets. Local alarm functions shall be annunciated for reserve pump in use

d) Bacterial Filters

The filters shall be designed for removal of solid, liquid and bacterial contamination from the suction side of vacuum pump systems, preventing damage to the pump and the potential biological infection of the surrounding environment. The dryer shall be particulate filter dryer with ability to remove particles as small as 1micron.

Each individual filter shall have the capacity to deliver full design flow such that one set is designated duty and the other will be standby. Bacteria filters shall have efficiency at least 99.999% when tested by the sodium flame method in accordance with BS 3928:1969/as per required standard utilising particles in the 0.02 to 2 micron size range. The pressure drop across each clean filter at 50% of the system design flow shall not exceed 25 mm Hg (3 kPa) at a vacuum of 475mm of Hg (63 kPa). Bacteria filters shall be marked with the legend 'Bio-Hazard'.

Each bacteria filter shall be provided with a transparent sterilizable collection jar to collect condensate. The total water capacity of the pressure vessels shall be at least 100% of the design flow rate of the plant in 1minute in terms of free air aspired.

e) Accessories

Accessories included for job site installation are inlet and discharge flexible connectors, vibration mounting pads, and source isolation valve, inlet check valve, thermal malfunction switch and vacuum control switch. Flexible connectors on inlet and exhaust of each pump, exhaust tee with union as well as copper tubing with Shutoff- cock for gauge/bypass valve and vacuum switch etc.

All the filters shall be covered under warranty period and CMC Period.

15.2.7 DISTRIBUTION PIPING

a) Piping specifications

Copper pipe shall be as per standard BS: EN 13348:2008/ ASTM B819 standards, Solid drawn, seamless, deoxidized, non-arsenical, half hard (hard can be accepted only for sizes 54mm or more), tempered and degreased copper pipe conforming to the standard. All copper pipes shall be degreased & delivered capped at both ends. The pipes shall be accompanied with manufacturers test certificate for the physical properties & chemical composition.

Copper pipe must have reputed third party inspection certificate (Eg. Lloyd's or TUV or SGS).

Fittings shall be made of copper and suitable for a working Pressure of up to 17bar and especially made for brazed socket type connections. All valves shall be pneumatically tested for twice the working pressure and factory degreased for medical gas service. Copper fittings shall comply with EN 1254:1 factory degreased and brazing filler metals shall comply with EN 1044. Fitting shall be degreased, individually packed for medical use.

The minimum thickness of copper pipes of 35mm and above outer diameter, shall be 1.2mm and the thickness of copper pipes less than 28mm outer diameter, shall be 1mm as mentioned in respective hospital/ site requirement.

b) Installation & testing

Installation of piping shall be carried out with utmost cleanliness. Only pipes, fittings and valves that have been degreased and fittings shall be used at site. Pipe fixing clamps shall be of nonferrous or non- deteriorating plastic suitable for the diameter of the pipe. Inert gas welding technique shall be used by passing oxygen Free Nitrogen Gas inside the copper pipes during silver brazing, in order to avoid carbon deposition inside the copper pipes. Only copper-to-copper joints are permitted on site except threaded or flanged joints may be made where pipelines are connected to items such as valves and control equipment. No flux shall be used for joining Copper to Copper joints and on for joints made on site. Copper to copper joints shall be brazed using a 5% silver-copper phosphorous brazing alloy CP104. A total of 5 joints shall be cut out for examination to establish the quality of the joints being made on site. The insides shall be clean and free from oxides and particulate matter and the minimum penetration of the brazing alloy at any point shall be three times the wall thickness of the tube. If the joints examined do not conform to these requirements, then adjacent joints shall be cut out and examined until the extent of faulty workmanship has been made good. Copper-to-brass or gunmetal joints shall only be made under controlled conditions off site. The joints are ordinarily used to join short copper pipe tails to brass, gunmetal or bronze fittings to permit their connection into the pipeline.

Adequate supports shall be provided while laying pipelines to ensure that the pipes do not sag. Suitable sleeves shall be provided wherever pipes cross through walls / slabs. All pipe clamps shall be non-reactive to copper.

After erection, the pipes are to be flushed with dry nitrogen gas and then pressure tested with dry nitrogen at a pressure equal to twice the working pressure or 150 psig, whichever is higher for a period of not less than 24hours.Length and quantity of individual items (Copper pipes, AVSUs, Alarm panels, Isolation valves, Outlets, pendants etc.) are to be provided as per the quantity stated in the NIT. For the EPC contract, the complete layout of different items including copper piping needs to be prepared to meet specific site requirement in conformity to the applicable standards and NIT and submitted for approval of the department and execution taken up accordingly thereafter as per the approved design and scheme.

Maximum interval between supports (Horizontal and Vertical) (12mm Pipe - 1.5m, 15mm pipe - 1.5m, 22mm pipe – 2m, 28mm pipe-2m, 35mm pipe-2.5m, 42mm pipe - 2.5m, 54mm pipe - 2.5m, 76mm pipe – 3meter)

NOTE: The interval between supports should be as per applicable standards.

c) Painting

All the pipes from manifold/plant upto the outlets shall be painted with two coats of synthetic enamel paint and colour codification shall be as per standards followed and with consultation with competent authorities of the hospital/ department.

15.2.8 AREA VALVE SERVICE UNIT with Inbuilt Area Alarm

Area valve service units shall fully comply and meet with HTM 02-01/ ISO 7396-1/ NFPA 99 C. It shall provide a zone isolation facility for use either in an emergency or for maintenance purpose The Area Valve Service Unit shall incorporate prefitted ball valve in a box with emergency access. It shall be reliable and easy to operate, easy purge, sample & pressure testing and emergency supply system. Quantity of valves to be worked out and mentioned in the BOQ. In case of EPC contract complete design/ scheme needs to be prepared to meet specific site requirement in conformity to the applicable standards & NIT and submitted for approval of the department and execution taken up accordingly thereafter as per the approved design and scheme.

Medical gas/vacuum services shall be fixed copper, piped to and from their respective area valve service units. A color coded service identity label shall be fitted behind the valve handle. The unit shall provide a zone isolation facility. Gas Flow direction shall be indicated.

Area Valve Service Unit must have Inbuilt Area Alarm System to minimize space consumption. Area valve Service Unit 2 gas to 6 gas must be in a single box with a lockable door. Separate box for each gas should not be used to save space consumption. Each area valve must be equipped with pressure gauge and pressure sensor along with gas identification plate. The valve block must be brass and the inlet and outlet in the upward position. The valve lever must be vertical in direction of flow and it must not hinder with the closing of the Valve box door in both Valve ON and OFF position to avoid unauthorized access. It must contain Emergency NIST connection to ensure uninterrupted gas supply during maintenance/service .

Area Valve Box or Zonal Valve Box.

Valve boxes shall be constructed of 18-gauge mild steel/aluminium with powder coated white enamel finish. The valve box shall have a sliding, opaque door with pull ring and clear gauge window. The removable window cannot be replaced when any valve is closed. The frame assembly shall be capable of adjusting for variances in wall thickness up to 1". The window shall conceal piping and mounting screws. Window shall be labeled "Caution Medical Gas Isolation Valves - Close Only in Emergency." Provide clear viewing space in the window to display the gas service, the pressure gauges and the label for areas controlled by the valve. Gas Valve box configuration up to 7 Valves fitting

inside the Valve Box. All Medical Gas Valves along with Gauges shall be incorporated with Valve box.

All wetted parts (except seals and gaskets) shall be brass or copper. Each unit assembly shall be factory tested for gas tightness. Rubber pipe grommets shall be provided to ensure any leaking gas does not escape from the unit into a wall cavity. All visible aluminum surfaces shall be powder coated.

Shall be European CE Certified with 4 digit notified body number or American ETL/ American UL listed .

15.2.9 AGSS (Anesthetic Gas Scavenging System) Plant -

Anesthetic Gas Scavenging System (AGSS) of minimum 2500LPM as Primary & 2500LPM as Standby (or as stated in the NIT based on specific site requirement). It shall be European CE Certified with 4 digit notified body number or American ETL/ American UL listed (In- case of NFPA 99c the control panel of Plant must be UL/ETL Listed and Undertaking from manufacturer must be submitted for using the same control panel in the system offered)and shall comply with HTM 02-01/ ISO 7396-1/ NFPA 99 C.

The package shall consist of duplex rotary vane/claw type vacuum pumps or blower as applicable to standards, a control panel with automatic changeover, and mounted on a common base frame.

AGSS pump: Each pump/blower shall be completely cooled and have absolutely no water requirements.

The requisite wiring from OTs to AGSS plant for MGPS control/suitable reservoir (as applicable) shall be within the scope of work to be done by the bidder.

System in-line non-return values shall allow individual pump servicing. Active anesthetic gas scavenging systems shall be designed to safely remove exhaled anesthetic agents from the operating environment and dispose of them to atmosphere from the highest point of the hospital building, thus preventing contamination of the operating department and providing a safe and healthy workspace for the personal. AGSS design shall be dependent upon flow rate and pressure drop characteristics of the individual components of systems. It is essential that terminal units, MGPS controls (If required) and pump units work in synchronized manner after connection of workstation to the AGSS System.

Installation shall be on roof top/suitable location. Piping, Non-Return-Valves (NRVs), and inlet nozzle shall be suitably placed. Connecting hose suitable to fit with anesthesia workstation shall be provided.

15.2.10 ALARM SYSTEM

a. Master Alarm (Digital) (Touch Screen)

Shall be European CE Certified with 4 digit notified body number or American ETL/ American UL listed.

Complies with HTM 02-01/ ISO 7396-1/ NFPA 99 C Standards and Medical Device Directive 93/42/EEC.

Each Master Alarm shall be modular in design and be fitted with required number of master alarm modules.

The master alarms shall be capable to monitor minimum 40 Point.

Each point represents an alarm condition that the source equipment might have. When an alarm condition exists, a red light flashes and the audible alarm sounds. If several alarm conditions occur simultaneously, the most recent alarm light shall flash, while the other alarm lights shall remain lit. When an alarm condition is created, an audible alarm+ shall be actuated. A dry contact module shall be available to interface with a building management system.

The box material shall be of gauge steel of requisite thickness and equipped with mounting brackets. The emissions from alarms shall conform with EMC standards.

Master alarm management system shall be designed to display alarm conditions from the source supply units indicating the broad status of the source equipment and manifolds as well as the master distribution status from the source supplies. Depending on the alarm priority, a visual and audible alarm shall be initiated to indicate an alarm condition.

Each panel shall display and/or input up to forty point alarms. Panel shall be ready to use with BMS system.

The master alarm must be able to monitor the following source alarm conditions.

- Oxygen Source Empty/Fault
- Oxygen Cylinder Bank Empty/Fault
- Oxygen Emergency Bank Empty/Fault
- Air Compressor Faulty/Operation
- Vacuum Pump Faulty/Operational
- Vacuum Deficiency Vacuum Reservoir
- And Other MGPS Signals & Alarms

Bidder shall be responsible for all cabling from local alarm panels(OTS & ICUs) to master alarm panel.
Master alarm shall be integrated with BMS/HIS

b) Medical Gas Area Alarm

The medical gas central alarms shall be capable of monitoring up to 6 medical gas services (As specified in BOQ of respective institute) by means of pressure sensors which detect deviations from the normal operating limits of either pressure or medical vacuum. The area alarm shall have a digital display of pressures. The medical gas area alarm shall fully satisfy the HTM 02-01/ ISO 7396-1/ NFPA 99 C requirements and shall be European CE Certified with 4 digit notified body number or American ETL/ American UL listed.

An audible warning shall sound simultaneously with any failure indication and a mute facility shall be provided. "

It should have each gas service shall be displayed on LCD touch screen Panel. The area alarm should be controlled by LCD display touch screen size minimum 5inch size. An audible warning shall sound simultaneously with any failure indication and a mute facility shall be provided. Following a mute selection, the audible will resound after

approximately 15 minutes or shall operate simultaneously should a further alarm condition occur. A “Mute” switch shall be provided inside the panel for use during any maintenance resulting in prolonged pipeline or plant shutdown. This facility shall automatically reset when the gas service returns to normal. The alarm panel shall have a 'Test' facility to prove the integrity of the internal circuits, visual and audible warning. The alarm panel shall incorporate a volt free normally closed relay to allow for interconnection to either a medical gas central alarm system or an event recording circuit of a building management system. In the event of an electrical power supply failure the 'System Alarm' LCD panel shall illuminate (flashing) and the audible warning shall be delayed for 30 seconds to enable standby generator tests. Line continuity monitoring circuits shall be provided to constantly monitor the integrity of the input sensors and interconnecting wiring. In the event of any fault the line continuity monitoring circuits shall initiate the specific gas service failure indication, a 'System Alarm' indication and an audible warning. Further aids to fault diagnosis shall be provided by means of varying flashing rates whilst operating the 'Test' switch. It should be connected through Pressure and Vacuum Switches: Pressure and vacuum switches shall be manufactured with brass wetted parts and house a PCBA with line continuity monitoring resistors. Electrical connectors shall be designed for frequent disassembly. Spade connectors are not acceptable. Pressure switches shall include both high and low-pressure settings in the same switch. The body and housing of the pressure switch shall be manufactured from impact resistance, rigid and inherently corrosion proof materials. Pressure switches shall connect directly to the area alarm panel. It is not acceptable to fit a separate connection box to convert switch signals to a data signal. Each gas service shall be displayed by coloured LEDs to show 'Normal' (green), 'Low' and 'High Pressure' (red) conditions. Medical vacuum systems shall be displayed in the 'Normal' (green) and 'Low Vacuum' (red) conditions only. Failure indicators shall be displayed by flashing lights and normal indications shall be steady. The emissions from alarms should conform with EMC standards or as per guideline of standard to be followed. All MGPS warning and alarm indicating panels, including all operating room panels should comply with the requirements of specific standard as mentioned herein/ NIT.

15.2.11 GAS OUTLETS

Terminal Units (Gas Outlets) with probes/Adaptors for O2, N2O, Compressed Air 4, Air 7, AGSS, Vacuum &CO2 (CO2 can be optional depending on the requirement).

Terminal units installed in walls, bedhead trunking, headwalls or fixed pendants shall be connected to the pipeline with a copper stub pipe. Pressure gases and shall incorporate a 12mm O/D copper stub pipe. Terminal units for vacuum and anaesthetic gas scavenging shall incorporate a 15mm O/D copper stub pipe. These terminal units must be in two fixes to have valve assembly.

Each terminal unit shall consist of a primary valve (or assembly) and shall be permitted to include a secondary valve. The secondary valve shall close automatically to stop the flow of gas (or vacuum, if provided) when the primary valve is removed. Front Loading Type Terminal Outlets shall be designed to dispense medical gases (or an

inlet for medical vacuum) to the secondary equipment (flow meters, Suction regulators, etc.) at the point of use and is gas specific so that secondary devices cannot be "attached" to the wrong gas. When not in use the gas in a non-flowing state within the Outlet (Terminal unit) sealed by "O" ring. The adapter when inserted pushes the poppet inside and the gas starts flowing and sealing is ensured by the "O" ring or a seat. The Outlets are Quick Connect Type and gas specificity is accomplished by "Pin indexing." The outlets shall have following features:

- Push to insert and press-to-release mechanism for probes.
- Allows plugging of probes from front.
- Self-sealing valve on disengaging the probe (Quick disconnect)
- Smooth quite action.
- Non return valve for on line servicing/ repairing
- Indexed to eliminate inter-changeability of gas services
- Color-coded gas specific front plate
- Totally leak proof, safe & easy to operate
- Configurations possible: surface, flush & Bead-head.
- Outlets shall be European CE Certified with 4 digit notified body number or American ETL/American UL listed
- All outlets shall have respective labels (i.e.O_2 / N_2O / CO_2 / Air4 / Air7/Vacuum/AGSS/etc.) displayed accordingly.

The medical gas terminal units shall conform to BS EN ISO 9170-1 and accept probes to BS5682. Terminal units shall be capable of single-handed insertion and removal of the medical gas probe. The anaesthetic gas scavenging (AGS) terminal unit shall conform to Bs6834.

OR

Terminal units conform to gas specific dimensions and connection requirements stated in DIN 13260-2. Components are designed and manufactured in accordance with BS EN ISO 9170 for medical gas distribution systems.

Terminal units installed in walls, bedhead trunking, headwalls or fixed pendants shall be connected to the pipeline with a copper stub pipe. Pressure gases and vacuum shall incorporate minimum 12mm O/D or more copper stub pipe. Terminal units for anaesthetic gas scavenging shall incorporate minimum 15mm O/D copper stub pipe.

Medical gas terminal units consist of two parts: First fix – the wall mounted assembly consists of brass pipeline termination block with copper stub pipe secured between a back plate and a gas specific plate to allow 130 degrees radial movement of the copper stub to align with the pipeline. The second fix components shall be manufactured with the pin index permanently moulded into the gas specific socket. The socket assembly shall retain a capsule assembly, containing the check valve and probe 'O' ring seals. Second fix terminal units shall be supplied with the anti-rotation pin loose and bagged to be fitted as required. The socket is fixed to the base block with a design that ensure profile is always in the correct position. Probes are gas specific connectors that couple to the medical gas terminal unit sockets to provide access to gas systems. The replaceable capsule assembly shall enable all working parts subject to wear through usage to be replaced as a factory tested assembly, thereby reducing maintenance time. Each termination block assembly shall be pressure tested by the pressure decay method

15.2.12 Horizontal/ Vertical Bed Head Panel

The design shall be approved by the respective hospital authority/ department before installation and it is responsibility of the bidder after getting order they have to interact with respective hospital authority/ department and finalize the Bed Head Panel (Vertical/Horizontal) as per site condition. Vertical BHP shall be upto False Ceiling Level and all outlets and sockets shall be located at a height of 1050-1250 mm from FFL, as per the site conditions. Horizontal BHP shall be of maximum 1000mm for 2 Gas outlet configuration, maximum 1200mm for upto 4 outlets configuration and maximum 1500mm for 6 Outlet configurations and maximum 1800mm for 8 Outlet configurations.

a. It shall have following features:-

Efficient, Safe & Robust design in extruded aluminium section.
Smooth curved surfaces, and choice of base colour and fascia plates.
Unit shall have integrated rail system to mount accessories

The headwall system shall be constructed of aluminium extrusions joined together to form a carcass to suit the particular application. Unit shall be factory assembled for electrical and mechanical components.

Segregation of services i.e. Low voltage supplies, High Voltage supply and Medical gases shall be maintained with minimum 2/3 tier/2/3 channel arrangements with built-in LED Lighting (with ON/OFF control)

Shall be European CE Certified with 4 digit notified body number or American ETL/ American UL listed.

Front fascia plate shall be removable individually to access for respective service.

b. It shall have one rail for mounting Accessories.

Each bed-head unit shall be supplied with electrical and electrical outlets pre-fitted, wired and certified.

c. Shall have per unit as under :

Oxygen – 2
Vacuum – 2
Medical Air-1
Holder for vacuum collection jar –1
Nurse call switch – 1 (not in the scope of MGPS Vendor only space for same has to provide)

5 /15A combined Electrical socket with switch – minimum 4 Nos. with 2 outlet combination, 6 Nos. with 4outlet combination and 8 Nos. with 6/8 outlet combination
RJ-45 socket/ Ethernet -01
Two spare spaces

15.2.13 (a) **Ward Vacuum Units (other than ICU area)**

It must consists of the following:-

a. 1no of Suction Regulator and 1no of 1000 ml polysulfone /polycarbonate collection jar.

b. Suction regulator (Digital/Analogue): Suction regulator shall be supplied with a safety jar, including and antibacterial filter and an anti-overflow safety device. Shall have wide membrane continuous suction controller.

c. Shall have vacuum levels: 0-750 mm Hg or more

d. Shall have vacuum gauge fitted with a protective bumper device.

e. Shall have on/off knob allowing for the quick restoration of a readjusted vacuum level.

f. Must have central adjustment knob with a color coded for 0 to 750 mm Hg or more. Shall have Polysulfone/ polycarbonate 100cc safety jar, autoclavable at 121º C at 5mins, unbreakable, fitted with an anti-overflow safety device and equipped with antibacterial filter. It shall be totally transparent, to ensure perfect sucked liquid visibility.

g. Low flow ward vacuum unit - Shall have vacuum levels: 0-150 mm of Hg ± 10%

15.2.13 (b) **Ward Vacuum Units (for ICU area)**

It must consists of the following:-

a. 1no of Suction Regulator and 1no of 1000 ml polysulfone /polycarbonate collection jar.

b. Suction regulator (Digital/Analogue): Suction regulator shall be supplied with a safety jar, including and antibacterial filter and an anti-overflow safety device. Shall have wide membrane continuous suction controller.

c. Shall have vacuum levels: 0-750 mm Hg or more

d. Shall have vacuum gauge fitted with a protective bumper device.

e. The digital vacuum regulator should have a digital vacuum gauge with monochromatic LCD display, it is available with three possible end of scale: -250 mbar, -600 mbar and -1000 mbar.

f. The scale should be able to set in mbar/hpa or mmhg by the end user

g. The numerical display should show the vacuum value and a sector bar proportional to the adjusted de-pressure. The reading resolution is 1 mbar/hpa (1 mmhg).

h. The frontal part of the digital gauge should be equipped with 3 buttons: one to switch ON/OFF the vacuum regulator, the other 2 for various settings such as: set the timer for the automatic switch off of the regulator; select the unit scale (mbar/hPa or mmHg); set up a preferred vacuum value; zeroing the device at any time.

i. The device should have a quick I/0 switch button that allows the operator to quickly lock and reactivate the vacuum, keeping unchanged the previous preset value. When the device is suctioning, the red button is outside and by pushing it, the operator can stop the vacuum at any time. While, to reactivate the vacuum, at the same pre-set value, the operator have to simply push the green button (visible when the device is not working).

j. A vacuum adjustment knob with Soft Grip inserts for an easy handling with a "Push & Lock" position system, the operator have to pull the knob, by rotating it regulate the level of vacuum needed and then push the know to lock the selected value.

k. Suction jar should be made of Polysulfone/polycarbonate autoclave up to 121ºC. The jar capacity is 1000 ml . The float & cap assembly includes a patient port inlet that is horizontal to help prevent kinking of suction tubing . All collection bottle assemblies allow visual inspection of fluid level, color & consistency & can be steam autoclaved or gas sterilized. Polycarbonate bottles offer the additional advantage of eliminating breakage.

15.2.14 **Theatre Vacuum unit for OT**

It must consist of the following: -

a. Suction Regulator **(Digital/Analogue)** and 2nos. 1500ml or more polysulfone/ polycarbonate collection jar and both to be mounted on a trolley.

Shall be European CE Certified with 4 digit notified body number or American ETL/ American UL listed.

In case of digital suction regulator, battery shall be replaced by the bidder during warranty & CMC period

Theater Suction Trolley

Theatre Suction Trolley shall be Certified as per Class I of Medical Device Directives (93/42/EEC) & CE marked. It should be manufactured in an ISO 13485:2003 quality management system duly certified constructed in accordance with the requirement of international standard. It will be trolley mounted. The unit will include one regulator having gauge and mounted on the trolley stand, having two reusable each 2000 ml plastic collection bottles mounted on the base of trolley unit and connected with regulator & low pressure tube inter-connections. Safety Jar 200 cc to be provided with regulator. The collection jar is made of unbreakable material, which is fully auto cleavable at 121 Degree Centigrade. The jars shall be mounted on mounted on Stainless Steel Trolley (SS304 material) having four (4) free moving castor wheels, with a stable base design and an easy grip handle.

b. Suction Regulator: Suction regulator shall be supplied with a safety jar, including an anti-bacterial filter and an anti-overflow safety device. Shall have wide membrane continuous suction controller

c. Shall have vacuum levels : **0-750 mm of Hg or more**

d. Shall have vacuum gauge fitted with a protective bumper device.

e. Shall have on/off knob allowing for the quick restoration of a readjusted vacuum level.

f. Must have central adjustment knob with a color coded for **0-750 mm Hg or more**. Shall have polysulfone/ polycarbonate safety jar, autoclavable at 121º C, unbreakable, fitted with an anti-overflow safety device and equipped with antibacterial filter.

g. Collection jar shall be totally transparent, to ensure perfect sucked liquid visibility.

15.2.15 Medical Gas Shut of Valves or Line Ball Valves or Isolation Valves

The Lockable line valves must be degreased and complete valve with stuffed pipe & fittings, factory tested and compliant with applicable standard.

a) All Medical Gas Valves shall be specially prepared for oxygen service and shall conform to latest international standard. Valves shall be ball-type, with Teflon seats and adjusting stem packing gland with Teflon stem seal.

b) Ball Valves shall operate from the fully open to the fully closed position by manual operation of a lever through 900. Valve nominal bores shall be equal to the nominal pipework size.

c) Furnish and install only valves with factory brazed Copper stub pipes shall be manufactured from medical grade copper pipe to BS EN 13348:2001 which should be Lloyds/SGS/TUV/DNVGL certified or any accredited third-party certified agency.

d) Ball valve shall be provided with locking handles.

e) All valves shall be cleaned for oxygen, capped and sealed in a polyethylene bag for shipping and storage.

f) Apply labels to each valve in the assembly for gas service identification according to manufactures recommendations.

g) Medical gas line ball valve assemblies shall be constructed in a two-piece full-bore design with brass body, Teflon ball seals, stem packing seal, stem 'O' ring seal and a hard chrome plated brass ball. Medical gas line ball valves complete with lockable NIST connections.

h) Ball Valve sizes 15 to 54mm inclusive shall have flat-face connectors with 'O' ring seals. The 76 to 108mm inclusive shall be flanged and installed with stainless steel bolts, nuts and spring washers with sealing gaskets. PTFE tape or any other thread sealing media is not acceptable.

i) All Medical Gas Valves should be factory tested and certified from OEM. Performance reports (Valve Size, Torque, Working pressure and material certification) has to be submit by the bidder on behalf of OEM.

15.2.16 Supply of O_2 Cylinders – Class D Type

Shall be as per BIS/IS/ASME Standard and confirming to the regulations of SMPV and Gas Cylinder Rules

15.2.17 High pressure tubes for O_2, N_2O, Compressed Air, & Vacuum

It shall be colour coded for individual services i.e. white for Oxygen, Blue for N_2O and Yellow for Vacuum, Black for air. Antistatic rubber tube shall be as per ISO standards. It shall be Shall be European CE Certified with 4 digit notified body number or American ETL/ American UL listed. (The 200m Hose- Gas wise requirement shall be taken from respective institute before supply total lengths shall be 200m inclusive of all type. If institute requires more than payment will be made on actual basis asper finalized BOQ rate)

15.2.18 Electrical Wiring with Electrical Panels –

All wiring inside the Manifold Room and Plant room required for MGPS equipment and General electrification. The department shall provide one point supply only. Other are under the scope of bidder. All the work shall be as per BIS/CE standard and material used shall be reputed make only.

15.2.19 Interconnection to LMO Tank (Optional Price shall be quoted)

Price shall be quoted per meter basis or as per scope defined in the NIT. The scope shall be inclusive of all installation, material (Copper Pipes, fittings, etc.), trenches and labour etc. charges as per site condition. The payment shall be made as per the conditions defined in the NIT.

15.2.20 Extra/ Other essential items to be covered in NIT as per actual requirement at site.

i. Bidder shall be responsible for antistatic rubber flooring in the manifold room and thickness of flooring not less than 1 inch.

ii. Bidder shall provide a raised Loading/Unloading Platform of suitable sized adjacent to manifold room, so that cylinder can be loaded & unloaded easily form the lorry/vehicle.

iii. Bidder shall be responsible for foundation of Plant Room (if required) for Medical Air Plant, Vacuum Pant& AGSS Plant.

iv. Bidder shall co-ordinate with respective hospital authorities/ department for the finalization of required Office/ Control Room for & Toilet for MGPS maintenace staff into Manifold/Plant Room.

v. Bidder shall be responsible for all civil modifications and repair for successful completion of MGPS Plant, Manifold, and Pipeline installation and commissioning throughout the proposed blocks/buildings

vi. Bidder shall be responsible for internal walls/partitions & doors for creating separation between MGPS Plant and Manifold room, etc. as per site requirement.

15.3 Site Modifications*

15.3.1 The MGPS firm shall carry out following site modification works wherever applicable (for existing site) for successful completion of the MGPS work :

15.3.2 Construction of 230 mm brick wall with plaster on both sides and paint matching the surrounding premises as per CPWD Specifications (Vol. 1 & Vol. 2) as amended up to the last date of receipt of tenders.

15.3.3 Demolition of brick wall.

15.3.4 75 mm thick (or as per site requirement) cement concrete flooring

15.3.5 Suitable power/ light wiring (including tray/pipes/casing as per requirement)

15.3.6 Control cabling

15.3.7 Any minor demolition, reconstruction, water proofing, necessary plumbing, anti-microbial painting, replacement of any door or windows within the MGPS area shall be carried out by the MGPS firm for successful installation and commissioning of MGPS.

15.3.8 All jobs such as providing cut outs, shifting and resizing of door/window up to 300 mm etc. with all minor repairing works inside the MGPS area for successful completion of MGPS works.

*Applicable only for standalone MGPS work to be executed in existing building.

Note: The scope of site modification works required should be stated in the NIT clearly as per the specific site requirements.

*Applicable only for standalone MGPS work to be executed in existing building

15.4 Comprehensive Maintenance:

15.4.1 The contractor shall be responsible for defect liability, OEM warranty of products and comprehensive maintenance of MGPS installations for ten years (5 years warranty plus 5 years CAMC) from the date of completion of the work through the same MGPS firm. The MGPS firm shall be approved on the basis of work experience as per provisions of eligibility described in the CPWD Works Manual/ Chapter 1 para 4 of this specification. The comprehensive maintenance of MGPS installations includes complete MGPS installations, labour, spares, all consumables etc. as required including the following.

a. All MGPS equipment mentioned in the NIT.

b. Plastic and glass parts against any manufacturing defects.

c. All kinds of sensors.

d. All kind of coils, probes and transducers.

e. Printers and imagers including laser and thermal printers with all parts.

f. UPS including the replacement of batteries, wherever applicable.

g. Air-conditioners

h. All kinds of painting, civil, HVAC and electrical works in MGPS related areas (as executed by firm).

i. Preventive maintenance including testing & calibration as per technical/service /operational manual of the manufacturer.

j. MGPS installation inside the MGPS plant room/ yards.

Note: Check for the requirement of spares and consumables in the system. The NIT authority can list these consumables on paid basis also on actual consumption, as deemed fit, for which suitable items needs to be incorporated in the BOQ.

15.4.2 In the case of MGPS equipment, the comprehensive maintenance shall be done with back-to-back support from OEM. In such cases, authorized agent of OEM shall reach the site within 24 hours of raising a service call.

15.4.3 The MGPS firm shall ensure uninterrupted service without compromising functioning of MGPS/ICU.

15.4.4 The MGPS firm shall set-up a maintenance base in the vicinity of the hospital, to provide maintenance service of the entire MGPS installations.

15.4.5 If the performance of any individual equipment or system is not satisfactory, the same shall be replaced free of cost.

15.4.6 If it is found that to meet the performance criteria, any extra equipment is required, the same shall be provided free of cost.

15.4.7 All faults and their rectification shall be promptly intimated to the hospital.

15.4.8 Any lacunae noticed in the functioning of the installation as a result of any design feature shall be rectified free of cost.

15.4.9 Proper marking has to be made for all spares for identification like printing of installation and repair dates.

15.4.10 On receipt of any complaint, the MGPS firm shall, within 8 hours on a 24(hours) X 7 (days) X 365 (days) basis respond to take action to repair or replace the defective goods or parts thereof free of cost. The MGPS firm shall take over the replaced parts/goods after providing their replacements and no claim, whatsoever shall lie on the hospital/institute for such replaced parts/goods thereafter. The penalty clause for non-rectification will be applicable as per tender conditions.

15.4.11 Upon failure of the MGPS firm to respond to take action to repair or replace the defect(s) within 8 hours on a 24(hours) X 7 (days) X 365 (days) basis, the hospital/institute may proceed to take such remedial action(s) as deemed fit by the hospital/institute, at the risk and cost of the contractor without prejudice to right of Government to take other remedial actions under the agreement.

15.4.12 If the MGPS firm fails to attend the complaint with in 8 hours a penalty of Rs. 5000/hour will be charged from the firm and recovery made accordingly. The decision of the Engineer in Charge shall be final and binding on the firm with respect to the imposition of overall penalty decision taking into view overall circumstances of the case.

15.4.13 The contractor/MGPS firm along with the Indian agent of the manufacturer shall ensure continued supply of the spare parts for the machines and equipment supplied by them for 10 years from the date of completion of the work.

15.4.14 The payment of comprehensive maintenance will be made on six monthly basis after satisfactory completion of said period duly certified by end user.

15.4.15 The contractor shall ensure regular updates of newer technology as and when evolved during warranty period for all the equipment.

15.4.16 The contractor shall deposit performance guarantee @ 3% of the value of the comprehensive maintenance contract before commencement of comprehensive maintenance, which shall be held by the hospital/institute/ department till completion of comprehensive maintenance period. Supplementary agreement can be drawn for the purpose of CAMC, after completion of the defect liability.

15.4.17 There shall be no extra cost for software upgradation/ supply and installation of security patches/ lifetime license fee for system (if and as required for MGPS system). The software upgradation including security patches shall be provided free of cost during the CAMC period. Bidder should submit OEM certificate to the effect that the software as well as security patches etc. shall be made available for enabling free upgradation of the system till the expiry of the defect liability period and CAMC period. The software

validity shall be till the end of the CAMC period and will be got done by the OEM/through their authorised channel partners within the tendered cost."

15.5 MAKE IN INDIA POLICY

The MGPS work shall fully comply to Public Procurement (preference to make in India) Order (PPP-MII order) 2017 issued by DPIIT and corresponding notifications issued by concerned nodal ministry/department as amended up to the last date of receipt of tenders.

NOTES:

1. Necessary modifications may be made in the additional conditions by the NIT approving authority as per actual requirements at site and/or to safeguard government interest.
2. It is advised not to stipulate makes of materials/equipment in the NIT. The makes which conform to the specifications in NIT may be accepted.
3. It is advised that procurement, installation, testing and commissioning of the MGPS medical equipment may preferably be included in the scope of EPC/composite contract in hospital projects by indicating minimum benchmark levels and related specifications.

******

CHAPTER 16

SAMPLE BOQ OF MGPS

16.1 Following is the Sample BOQ for Medical Gas Pipeline System. However, items and quantities of BOQ may be derived as per individual site/ design requirements:

Sl. No.	Name of Items as per tender specification	Unit	Qty	Rate	Amount
	Supplying, Installation, Testing, commissioning of the Medical Gas Pipeline System complete as per specifications given in the NIT (and CPWD specifications) of related item, comprising of the following: **Note: In case of EPC contract, the scope shall be suitably modified to include design also.**				
1	**Oxygen Supply System**				
a.	**LIQUID MEDICAL OXYGEN TANK (VACCUM INSULATED EVAPORATOR) AND ALLIED EQUIPMENTS APPLICATION** The system shall comprise of liquid medical oxygen storage tank, required accessories, safety fittings, liquid oxygen supply system, cryogenic vessel, vaporizer coil, automatic oxygen control panel etc complete as required as per the specifications. Note: The numbers and capacity of the tanks and design capacity of the flow required etc to be stated.	Nos.			
b.	**Fully Automatic Oxygen Control System :** Supply, Installation testing and commissioning of Fully Automatic Oxygen Control System etc complete as required as per the specifications.	Nos.			
c.	**Oxygen Manifold :** Supply, Installation, testing and commissioning of (2x * size) class D cylinder Oxygen manifold Supply System etc complete as required as per the specifications. Note: * - The configuration to be stated as per design/ site requirement.	Nos.			
d.	**Emergency Oxygen Supply System :** Supply, Installation, testing and commissioning of **(2x *)** class D cylinder Emergency Oxygen Supply System etc complete as required as per the specifications. Note: * - The configuration to be stated as per design/ site requirement.	Nos.			
e.	**Oxygen Flow meter with Humidifier Bottle:** Supply, installation, testing and commissioning of oxygen flow meter with humidifier bottle, as per specification For area other than ICU.	Nos.			

f.	**Oxygen Flow meter with Humidifier Bottle: Supply, installation, testing and commissioning ofoxygen flow meter with humidifier bottle, as per specification. For ICU**	Nos.			
2	**Nitrous Oxide (N_2O) System**				
a.	**Fully Automatic Manifold Control Panel for Nitrous Oxide:** Supply, installation testing and commission of fully automatic control panel for Nitrous Oxide complete as required as per the specifications.	Nos.			
b.	**Nitrous Oxide Manifold System, (2x * size):** Supply, installation, testing and commissioning of Nitrous Oxide Manifold system etc complete as required as per the specifications. Note: * - The configuration to be stated as per design/ site requirement.	Nos.			
c.	**Emergency Nitrous Oxide Manifold System, (2x * size):** Supply, installation, testing and commissioning of cylinder Emergency Nitrous Oxide supply system etc complete as required as per the specifications. Note: * - The configuration to be stated as per design/ site requirement.	Nos.			
3	**CARBON DIOXIDE SYSTEM**				
	Supply, installation, testing and commissioning of medical Co_2 Manifold **4 + 4 (*) Primary & 2+2 (*) Standby** with Class-D type Cylinders and control panel . Note: * - The configuration and flow capacity to be stated as per design/ site requirement.				
4	**Medical Air Plant (Medical and Surgical system-package unit) including electrical control panel:** Supply, Installation, testing and commissioning medical air plant having a minimum capacity of *** LPM as Primary & * LPM as standby or Total minimum Plant Capacity of * LPM** comprising of compressed medical air system with air compressors, air receiver, filtration and dryer system, control systems etc complete as per specification. Note: * - The configuration to be stated as per design/ site requirement and capacity be indicated accordingly.	Nos.			
5	**Medical Vacuum Plant (Package unit):** Supply, Installation, testing and commissioning of medical vacuum plant having a minimum capacity of *** LPM as primary and * LPM as standby** comprising of vacuum pump, vacuum receiver, bacterial filters, pressure switches, system controls etc complete as required as per specification. Note: * - The configuration to be stated as per design/ site requirement and capacity be indicated accordingly.	Nos.			

6 a)	**Ward Vacuum Unit (other than ICU area):** Supply, installation, testing and commissioning of Ward Vacuum Unit including suction regulator, adjustment knob etc as per specification. Note: * - The capacity and pressure range to be stated as per design/ site requirement accordingly.	Nos.			
6 b)	**Ward Vacuum Unit (for ICU area):** Supply, installation, testing and commissioning of ICU Vacuum Unit including suction regulator, suction jar, adjustment knob etc as per specification. Note: * - The capacity and pressure range to be stated as per design/ site requirement accordingly.				
7	**Theatre Vaccum Unit for Operation Theatres:** Supply, installation, testing and commissioning of Theatre Vacuum Unit including suction regulator, collection jar, adjustment knob etc as specification. Note: * - The capacity and pressure range to be stated as per design/ site requirement accordingly.	Nos.			
8	**Duplex AGSS System:** Supply, Installation, testing and commissioning of medical AGSS plant having a **minimum capacity of * LPM as primary and * LPM** as standby, comprising of vacuum pumps/ blowers, valves etc complete as per specification. Note: * - The configuration to be stated as per design/ site requirement and capacity be indicated accordingly.	Nos.			
9	**Copper Pipes**				
	Supplying, laying, testing and commissioning of Copper pipe as per standard BS: EN 13348:2008/ ASTM B819 standards, Solid drawn, seamless, deoxidized, non-arsenical, half hard (hard can be accepted only for sizes 54mm or more), tempered and degreased copper pipe conforming to the standard. All copper pipes should be degreased & delivered capped at both ends of required sizes, compliant to the specifications: Note: The quantities to be worked out as per the site and indicated accordingly.				
a.	108mm OD X 1.5mm thick	m			
b.	76mm OD x 1.5mm thick	m			
c.	54mm OD X 1.2mm thick	m			
d.	42mm OD X 1.2mm thick	m			
e.	35mm OD X 1.2mm thick	m			
f.	28mm OD X 0.9 mm thick	m			
g.	22mm OD X 0.9 mm thick	m			
h.	15mm OD X 0.9 mm thick	m			
i.	12mm OD X 1 mm thick	m			

10	**Gas Outlet Points/ Terminal Units with probe/ adaptors:** Supply, Installation, testing and commissioning of Gas outlet points for Oxygen, Nitrous Oxide, Medical Air 4 Bar , Vacuum, Co_2 and AGSS as per specification. Note: The quantities to be worked out as per the site and indicated accordingly.				
a.	Oxygen outlet with probe	Nos.			
b.	Nitrous Oxide outlet with probe	Nos.			
c.	Medical Air 4 outlet with probe	Nos.			
d.	Vacuum outlet with probe	Nos.			
e.	Medical Air 7 outlet with probe	Nos.			
f.	AGSS outlet with probe	Nos.			
g.	Co_2 outlet with probe	Nos.			
11	**AREA VALVE BOX (WITHOUT VALVES):** Supply, Installation, testing and commissioning of Area Valve Boxes. as per specification. Note: The quantities to be worked out as per the site and indicated accordingly.				
a.	Valve Box - 2 Gas Service	Nos.			
b.	Valve Box - 3 Gas Service	Nos.			
c.	Valve Box - 4 Gas Service	Nos.			
d.	Valve Box - 5 Gas Service	Nos.			
e.	**Valve Box - 6 Gas services**	No			
12	**MEDICAL GAS ALARM PANEL:** Supply, Installation, testing and commissioning of Medical Gas Alarm Panel. as per specification. Note: The quantities to be worked out as per the site and indicated accordingly.				
a.	Medical Gas Area Alarm for 2 services	Nos.			
b.	Medical Gas Area Alarm for 3 services	Nos.			
c.	Medical Gas Area Alarm 4 services	Nos.			
d.	Medical Gas Area Alarm 5 services	Nos.			
e.	Medical Gas Area Alarm 6 services	Nos.			
f.	Master Alarm Panel	No			
13	**LINE ISOLATION VALVES:** Supply, Installation, testing and commissioning of Line Isolation Valves as per specification. Note: The quantities to be worked out as per the site and indicated accordingly.				
a.	15 mm ball valve	Nos.			
b.	22 mm ball valve	Nos.			
c.	28 mm ball valve	Nos.			
d.	35 mm ball valve	Nos.			
e.	42 mm ball valve	Nos.			
f.	54 mm ball valve	Nos.			
g.	76 mm ball valve	Nos.			
h.	108 mm ball valve	Nos.			

14	Supply of O2 cylinders-Class D cylinders as per specification.	Nos.			
15	Supply of N2O cylinders-Class D cylinders as per specification.	Nos.			
16	Supply of CO2 cylinders-Class D cylinders as per specification.	Nos.			
17	Bed Head Horizontal/ vertical as per specification comprising of rail system to mount, made of aluminium extrusions, with provision of low an medium voltage supplies, gas outlets , electrical sockets, telephone sockets etc complete as required. Note: The quantities of horizontal and vertical panels should be worked out separately.	Nos.			
18	Supply, installation, testing and commissioning of Medical gas hose assemblies as per standard followed as per specification. Note: The quantity for oxygen, N_2O, compressed air, vacuum etc to be worked out as per the design/ site requirements.	m			
19	Electric wiring inside the gas manifold and plant room including electrical panel for plant &Manifold rooms, etc. work as per specification	job			
20	Interconnection from Local alarm panels to master alarm panel.	m			
21	Comprehensive maintenance of the complete Medical Gas Pipeline System installation for 5 years after completion of Defect Liability Period/Warranty Period of five years as per terms and conditions of comprehensive maintenance described in the NITas per following: The comprehensive maintenance of MGPS installations includes complete MGPS installations, labour, spares, all consumables (*) etc. as required including the following. a) All MGPS equipment mentioned in the NIT. b) Plastic and glass parts against any manufacturing defects. c) All kinds of sensors. d) All kind of coils, probes and transducers. e) Printers and imagers including laser and thermal printers with all parts. f) UPS including the replacement of batteries, wherever applicable. g) Air-conditioners h) All kinds of painting, civil, HVAC and electrical works in MGPS related areas (as executed by firm).				

	i) Preventive maintenance including testing & calibration as per technical/service /operational manual of the manufacturer. j) MGPS installation inside the MGPS plant room/ yards.				
	1st year	Job			
	2nd year	Job			
	3rd year	Job			
	4th year	Job			
	5th year	Job			

Note:

1. The above is a sample BOQ on tentative basis. The items to be selected and quantities to be worked out as per the design and site requirements. Thus, items can be suitably added or deleted to make BOQ to meet site specific requirements.
2. In case of EPC contracts, the detailed design and essential quantities of various items considered necessary for minimum benchmark should be clearly indicated.
3. (*) NIT authority can list the consumables on paid basis also based on actual consumption, as deemed fit, for which suitable items needs to be incorporated in the BOQ.

******

CHAPTER 17

SAMPLE COMPLIANCE SHEET

17.1 Sample Compliance Sheet of MEDICAL GAS PIPE LINE SYSTEM (MGPS)

NOTE :

- The compliance sheet as given below is a sample. It has to be suitably modified as per the actual NIT requirements/ items included.
- The compliance sheet covering the items in NIT, as per the format given below has to be submitted by the firm at appropriate stage prior to placing of orders for the supply of goods/equipment and execution of work.
- **Being sample sheet, only item 1 is indicated in detail. Rest of the items are mentioned name wise only. The NIT approving authority need to indicate the technical specification of respective item and their parameters in the relevant column for which technical compliance is required. The specifications as indicated in this document or as applicable in the NIT be referred to for the relevant details.**
- The firm will submit the compliance sheet in detail for each of the item along with the relevant catalogues and technical literature confirming compliance to NIT. The deviations, if any, to be categorically brought out.
- In case of non compliance of specification, the firm will be bound to offer alternate item of required specification.
- Only after approval of the same, the firm will place the order and take execution of work.

SN	Item of MGPS	Technical Specification as per NIT	As offered by firm	Deviation if any (Y/N), Remarks
Scope and Technical Specification:				
1	**Oxygen Supply System**			
1.1	**Primary Liquid Medical Oxygen Tank (Vaccum Insulated Evaporator) And Allied Equipment Application:**	Make /Model/Country of origin		
		Compliance to standards (mention as stated in NIT)		

a.	**LIQUID MEDICAL OXYGEN STORAGE TANK:**	The double walled Vaccum Insulated Evaporator shall be constructed of stainless steel inner vessel contained within a carbon steel outer vessel. The annular space between the vessels shall be filled with non-inflammable perlite insulation material to insulate under vacuum. The VIE should be self pressurizing type by partial evaporation of liquid oxygen through a pressure building coil by a non ferrous imported pressure regulator. The vessel shall be supplied as a functional whole with all materials of construction & the cleaning regime suitable for medical grade liquid oxygen.		
		Quantity: 20 KL X 1 No.and /or 10 KL X 1 No./ As per NIT		
		Installation: Outdoor		
		Type: Double walled, vertical		
		Design code :ASME Sec.VIII Div.I latest Edition / EN -13458-2 Annexure-C/ AD2000 MARKBLATTER 2004 Edition		
		Max. working pressure: 17 Bar G		
		Design temperature: –196ºC to +50ºC		
		Hydraulic Test Pressure: 26 bar G		
		Type of Insulation: Vacuum, Perlite filled		
		Safety Valve Set pressure : 17 Bar G (dual safety valve with three way diverter valve)		
		Bursting Disc Set Pressure : 23 Bar G (Bursting disc)		
		Standard fittings: Pressure rising coil, pressure building regulator of adequate capacity and size, dual safety valve with imported three way diverter valve, bursting disc., pressure gauges, liquid over flow line, Liquid level gauge and adequate numbers of extended spindle glove valve etc.		
		Maximum Evaporation Rate: <0.35% of net value.		
		Material of Construction: Inner shell and wetted parts of SS 304 Outer shell of CS ASTMA 516 Gr. 70 / CGA 341 2002 EN13455 S275/S355		
		Joint Efficiency : 100%		
		Radiography :100% for inner, for outer spot		
		External piping :From LMO Tank to Vaporizer SS304		
		From Vaporizer to inlet of Pressure Reducing Station SS304 From Outlet of Pressure Reducing Station to Main header Copper		
		Cryogenic Valves: Non ferrous (Imported)		

		Cryogenic Safety Valves : Imported		
		Pressure Building regulator :Non ferrous		
		Leak Detection test : Helium Leak detection		
		Painting :Primer and finish with White RAL 9010		
		Inspection : By 3rd party (SGS/LLOYDS/TUV/ as per NIT)		
		Cleaning : Degreasing for Oxygen Service and Pressurize with Nitrogen.		
		Withdrawal rate :1000 cum per hr. at 12 Bar G		
b.	**ACCESSORIES:**	LMO Tank along with P&ID shall be fitted with the following accessories:		
		Top Fill Valve		
		Bottom Fill Valve		
		Liquid charging line blow valve		
		Liquid Delivery Valve		
		Overflow Valve		
		Gas blow valve		
		Filling Coupling		
		Vaporizer Coupling		
		Liquid Level Gauge (Dial 100 mm).		
		High Level Valve		
		Equalizing Valve		
		Low level Valve		
		Pressure Gauge (100mm dial, Range 0-25 kg/cm2)		
		Pressure Gauge Isolation Valve		
		Pressurizing Valve		
		Pressurizing Coil		
		Filter		
		Pressure Regulator		
		Economizer		
		Check Valve		
		Evacuation Port		
		Vacuum Gauge Connection Port/vacuum probe valve.		
c.	**SAFETY FITTING:**	Two safety valves for inner vessel fitted on pipe line with flow divert valve		
		Rupture disc for inner vessel.		
		Safety valve for inlet pipeline.		
		Safety valve for pipeline of pressurizing evaporator.		
		One rupture disc/ safety device on outer vessel.		
d.	**SUBMITTALS FOR LMO:**	Approval letter from CCOE along with approved drawing from CCOE.		
		Approval letter from CCOE for use of cryogenic vessel(s) at site.		
		Certificate from the authorized inspection agency.		

		Heat chart for pressure parts.		
		Dimension checks report.		
		Dished End reports.		
		Mechanical properties test report for production test coupon.		
		Visual inspection report.		
		Radiography examination report.		
		Liquid penetrant examination.		
		Cleaning inspection report.		
		Hydro-pressure test report.		
e.	**Liquid Oxygen supply system**	One vessel of 1X20 KL Liquid oxygen VIE vessel system will be the primary (main) supply source and another vessel of 1X10 KL will be secondary source. In case of failure in liquid oxygen supply, it should automatically switch over to an emergency oxygen manifold having 2 X 20 cylinders. (Note: Mention as relevant as per NIT)		
		The unit should consist of a double walled vertical vessel (inner pressure vessel made of stainless steel and outer vessel of carbon steel).It should be fitted with standard accessories and should be "passed" the standard inspection requirement at factory for VIE.		
f.	**Product and Service Specification:**	Gas outlet pressure to be maintained at 4.2 kg/cm2.		
		Automatic change over should be provided between the primary and secondary LMO tanks. In case of failure in liquid oxygen supply, it should automatically switch over to an emergency oxygen manifold having 2 x 20 cylinders(or configuration as per NIT)		
g.	**Specification of Product Components**	The liquid medical oxygen (LMO) supplied at site should be of IP grade. The LMO supplied should comply with all relevant SMPV regulations and standards under the preview of the Indian Drugs and Cosmetic Act rules.		
h.	**Storage Tank Specifications**	The storage tank and the vaporizer coils should be designed as per the ASME Sec.VIII Div.I latest Edition / EN - 13458-2 Annexure-C/ AD2000 , MARKBLATTER 2004 Edition		
		The cryogenic vessel will be of cylindrical shape with vaporiser and the pressure control system. It should be provided with the essential components to fill the liquid, to build up pressure, to relieve pressure, to withdraw product and to evacuate the vessel.		

		All protective, safety and alarm provisions mandatory to Liquid Medical Oxygen plants should be supplied.		
i.	**The requirement of the Cryogenic Vessel should be:**			
		1. Configuration: Vertical		
		2. Inner vessel maximum allowable working Pressure: 17 kg/cm2		
		3. Inner vessel hydrostatic test pressure: Greater than 26 kg/ cm2		
		4. Outer vessel material of construction: Carbon steel		
		5. Inner vessel material of construction: Stainless steel		
		6. Independent AV coil should be provided with each vessel.		
j.	**Storage Tank Capacity**	Vacuum insulated evaporator vessel should have a capacity of 20X1 kilo liters and other with 1X10 kilo litres. The AV coil should have adequate capacity to handle the gas flow requirements of the hospital.		
k.	**Vaporiser Coil**	1. Maximum operating Pressure: 20 kg/cm2		
		2. Design Pressure: 22 kg/cm2		
		3. Pneumatic test Pressure: Greater than 24 kg/cm2		
		4. Inlet temperature: - 196 to +40°C.		
		5. Duty cycle: Continuous duty		
		6. Flow rate : 1200 cubic metre/ hour		
		The fence, foundation, lighting, signage, approach gate etc are to be designed and installed by the vendor.		
l.	**Safety**	The vendor should ensure that all international safety norms and standards applicable as implemented and certified by the CCE.		
		Following are the mandatory provisions for vessel:		
		Vessel low pressure alarm		
		Pipeline low pressure alarm.		
		Twin regulator		
		Twin safety valve		
		Non return valve and 3 way diverter (bypass) valve		
		Automatic changeover to manifolds with control panel / regulator. There should be dedicated VIE Panel for LOX source.		
		Alarm on indicating manifold in use in case the vessel is not in use.		
		Alarm on low pressure back-up manifold cylinders		

1.2	**Oxygen Manifold Supply System (without Cylinders)**	Make /Model/Country of origin		
		The size of Manifolds should be as mentioned in BOQ of respective Institute and it shall be compatible with Class-D type bulk cylinders.		
		* NIT approving authority need to indicate the technical specification of respective item and their parameters		
1.3	**Oxygen Flow meter with Humidifier Bottle for other then ICU area**	Make /Model/Country of origin		
		* NIT approving authority need to indicate the technical specification of respective item and their parameters		
1.4	**Oxygen Flow meter & Humidifier Bottle for ICU–**	Make /Model/Country of origin		
		* NIT approving authority need to indicate the technical specification of respective item and their parameters		
1.5	**Fully Automatic Oxygen Control Panel (for High Pressure Oxygen Manifold Cylinder)**	Make /Model/Country of origin		
		* NIT approving authority need to indicate the technical specification of respective item and their parameters		
1.6	**NITROUS OXIDE SYSTEM**	Make /Model/Country of origin		
		Fully Automatic Nitrous Oxide Control Panel		
		* NIT approving authority need to indicate the technical specification of respective item and their parameters		
1.7	**Nitrous Oxide Manifold (Without Cylinders)**	Make /Model/Country of origin		
		The size of Manifolds should be as mentioned in BOQ compatible with Class-D type bulk cylinders.		
		* NIT approving authority need to indicate the technical specification of respective item and their parameters		
1.8	**Emergency N_2O Manifold (Without Cylinders)**	Make /Model/Country of origin		
		The size of Manifolds should be as mentioned in BOQ of respective Institute and it shall be compatible with Class-D type bulk cylinders.		

		* NIT approving authority need to indicate the technical specification of respective item and their parameters		
1.9	**CARBON DIOXIDE SYSTEM**	Make /Model/Country of origin		
		The system should consist of medical CO_2 Manifold 4 + 4 Primary & 2+2 Standby with Class-D type Cylinders (12 Nos over and above than BOQ quantity of CO_2 cylinders) and control panel . (Note: Capacity as per NIT)		
		* NIT approving authority need to indicate the technical specification of respective item and their parameters		
		Fully Automatic Control panel for CO_2 System		
1.10	**Medical and Surgical Air System (Package Unit)**	Make /Model/Country of origin		
		Air-cooled **Oil-Less** compressors for continuous duty application with highest output of compressed air, low power consumption and very low vibration resulting in low noise level. **Note: The system configuration shall be as per provisions in chapter 2 para 2.27** NOTE: The type of compressor to be decided and specifications to be mentioned in NIT accordingly. The above is for oil less compressor screw/ scroll.		
		* NIT approving authority need to indicate the technical specification of respective item and their parameters		
1.11	**Air Compressor Modules**	Make /Model/Country of origin		
		* NIT approving authority need to indicate the technical specification of respective item and their parameters		
a.	**The compressor system should have-**			
b.	**Vertical Air Receiver**			
c.	**Air Treatment Module**			
d.	**System Controls**			
e.	**Accessories**			
1.12	**VACUUM SYSTEMS (Package unit)**	Make /Model/Country of origin		
		* NIT approving authority need to indicate the technical specification of respective item and their parameters		
a.	**Vacuum Pump Module**			

b.	**Vacuum Receiver**			
c.	**System Controls**			
d.	**Bacterial Filters**			
e.	**Accessories**			
1.13	**AREA VALVE SERVICE UNIT with Inbuilt Area Alarm**	Make /Model/Country of origin		
		* NIT approving authority need to indicate the technical specification of respective item and their parameters		
	Area Valve Box or Zonal Valve Box.			
1.14	**AGSS (Anesthetic Gas Scavenging System) Plant -**	Make /Model/Country of origin		
		* NIT approving authority need to indicate the technical specification of respective item and their parameters		
1.15 (a)	**Ward Vacuum Units (other than ICU area)**	Make /Model/Country of origin		
		It must consists of the following:-		
		1 no of Suction Regulator and 1no of 1000 ml polysulfone /polycarbonate collection jar.		
		Suction regulator (Digital/Analogue): Suction regulator should be supplied with a safety jar, including and antibacterial filter and an anti-overflow safety device. Should have wide membrane continuous suction controller.		
		Should have vacuum levels: 0-750 mm Hg or more		
		Should have vacuum gauge fitted with a protective bumper device.		
		Should have on/off knob allowing for the quick restoration of a readjusted vacuum level.		
		Must have central adjustment knob with a color coded for 0 to 750 mm Hg or more. Should have Polysulfone/ polycarbonate 100cc safety jar, autoclavable at 121° C at 5mins, unbreakable, fitted with an anti-overflow safety device and equipped with antibacterial filter. It should be totally transparent, to ensure perfect sucked liquid visibility.		
		Low flow ward vacuum unit - Should have vacuum levels: 0-150 mm of Hg +/-10%		

1.15 (b)	**Ward Vacuum Units (for ICU area)**	Make /Model/Country of origin		
		* NIT approving authority need to indicate the technical specification of respective item and their parameters		
1.16	**Theatre Vacuum unit for OT**	Make /Model/Country of origin		
		* NIT approving authority need to indicate the technical specification of respective item and their parameters		
	Theater Suction Trolley			
1.17	**GAS OUTLETS**	Make /Model/Country of origin		
		* NIT approving authority need to indicate the technical specification of respective item and their parameters		
1.18	**AREA VALVE SERVICE UNIT**	Make /Model/Country of origin		
		* NIT approving authority need to indicate the technical specification of respective item and their parameters		
1.19	**ALARM SYSTEM (Touch Screen)**	Make /Model/Country of origin		
a.	**Master Alarm (Digital)**	* NIT approving authority need to indicate the technical specification of respective item and their parameters		
b.	**Medical Gas Area Alarm**	Make /Model/Country of origin		
		* NIT approving authority need to indicate the technical specification of respective item and their parameters		
1.20	**Medical Gas Shut of Valves or Line Ball Valves or Isolation Valves**	Make /Model/Country of origin		
		* NIT approving authority need to indicate the technical specification of respective item and their parameters		
1.21	**Supply of O_2 Cylinders – Class D Type**	Make /Model/Country of origin		
		* NIT approving authority need to indicate the technical specification of respective item and their parameters		
1.22	**Supply of CO_2 Cylinders – Class D Type**	Make /Model/Country of origin		
		* NIT approving authority need to indicate the technical specification of respective item and their parameters		
1.23	**Supply of N_2O Cylinders – Class D Type**	Make /Model/Country of origin		
		* NIT approving authority need to indicate the technical specification of respective item and their parameters		

1.24	**Horizontal/ Vertical Bed Head Panel**	Make /Model/Country of origin		
		* NIT approving authority need to indicate the technical specification of respective item and their parameters		
1.25	**High pressure tubes for O_2, N_2O, Compressed Air,& Vacuum**	Make /Model/Country of origin		
		* NIT approving authority need to indicate the technical specification of respective item and their parameters		

******

CHAPTER 18

INDIAN/INTERNATIONAL STANDARD APPLICABLE FOR THE WORK OF MGPS SYSTEM

Indian Standard	International Standard	
IS/ISO 7396 :Part 1	ISO 7396-1:2016	Medical Gas Pipelines Systems : Part 1 Pipelines Systems for Compressed Medical Gases and Vacuum
IS/ISO 7396 :Part 2	ISO 7396-2:2007	Medical Gas Pipeline Systems : Part 2 Anaesthetic Gas Scavenging Disposal Systems
NIL	ISO 3746:2010	Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Survey method using an enveloping measurement surface over a reflecting plane
NIL	ISO 5359:2014	Anaesthetic and respiratory equipment — Low-pressure hose assemblies for use with medical gases
NIL	ISO 8573-1:2010	Compressed air — Part 1: Contaminants and purity classes
IS/ISO 9170 :Part 1	ISO 9170-1:2008	Terminal units for medical gas pipeline systems — Part 1: Terminal units for use with compressed medical gases and vacuum
IS/ISO 9170 :Part 2	ISO 9170-2:2008	Terminal Units for Medical Gas Pipeline Systems, Part 2 Terminal Units for Anaesthetic Gas Scavenging Systems
IS/ISO 10524 :Part 1	ISO 10524-1:	Pressure Regulators For Use with Medical Gases Part 1 Pressure Regulators and Pressure Regulators with Flow-Metering Devices
IS/ISO 10524 :Part 2	ISO 10524-2:2005	Pressure regulators for use with medical gases — Part 2: Manifold and line pressure regulators
IS/ISO 10524 :Part 3	ISO 10524-3:	Pressure Regulators for Use with Medical Gases Part 3 Pressure Regulators Integrated with Cylinder Valves
IS/ISO 10524 :Part 4	ISO 10524-4	Pressure Regulators for Use with Medical Gases Part 4 Low-pressure Regulators
NIL	ISO 11197:2004	Medical supply units
NIL	ISO 14644-1:1999	Cleanrooms and associated controlled environments — Part 1: Classification of air cleanliness
NIL	ISO 14971:2007	Medical devices — Application of risk management to medical devices
IS/ISO 15001	ISO 15001:2010	Anaesthetic and respiratory equipment — Compatibility with oxygen
IS/ISO 15002	ISO 15002:2018	Flow-Metering Devices for Connection to Terminal Units of Medical Gas Pipeline Systems
NIL	ISO 17672:2010	Brazing — Filler metals
NIL	ISO 18082:2014	Anaesthetic and respiratory equipment — Dimensions of non-interchangeable screw threaded (NIST) low-pressure connectors for medical gases
NIL	ISO 21969:2009	High-pressure flexible connections for use with medical gas systems

NIL	ISO 29463-1:2011	High-efficiency filters and filter media for removing particles in air — Part 1: Classification, performance testing and marking
NIL	ISO 80601-2-69:2014	Medical electrical equipment — Part 2-69: Particular requirements for basic safety and essential performance of oxygen concentrator equipment
IS 11478:2018	IEC 60601-1-8:2006	Medical electrical equipment — Part 1-8: General requirements for basic safety and essential performance — Collateral standard: General requirements, tests and guidance for alarm systems in medical electrical equipment and medical electrical systems
IS 2825:1969	EN 286-1:1998	Simple unfired pressure vessels designed to contain air or nitrogen — Part 1: Pressure vessels for general purposes
IS/ISO 15223 :Part 1	ISO 15223-1:2016	Medical Devices - Symbols to be used with Medical Device Labels, Labelling and Information to be Supplied Part 1 General Requirements
NIL	EN 1254-1:1998	Copper and copper alloys - Plumbing fittings - Fittings with ends for capillary soldering or capillary brazing to copper tubes
NIL	EN 1254-4:1998	Copper and copper alloys - Plumbing fittings - Fittings combining other end connections with capillary or compression ends
NIL	EN 13348:2008	Copper and copper alloys — Seamless, round copper tubes for medical gases or vacuum
IS/ISO 10079 :Part 2	ISO 10079-2:2014	Medical Suction Equipment Part 2 Manually Powered Suction Equipment
IS/ISO 10079 :Part 3	ISO 10079-3:2014	Medical Suction Equipment Part 3 Suction Equipment from a Vacuum or Pressure source
IS 8382:1977		Pressure Regulators, Pre-set Used with Medical Gas Cylinders
IS 5355		Oxygen flowmeter (dry bobbin type for Therapy purposes)
IS 6207		Trolleys for Oxygen Cylinders
IS 3624		Pressure and Vacuum Gauges
IS 2379:1990		Colour code for identification of pipe lines

******

CHAPTER 19

CODES & GUIDELINES FOR MEP AND OTHER HOSPITAL SERVICES IN HOSPITALS

19.1 ASHRAE 170-2017 covers patient care areas of Healthcare facilities in new buildings, additions to existing buildings, and alterations to existing buildings. It provides a guideline for Healthcare facility safety and dictates the air changes per hour required in Healthcare settings, pressure relationship requirements, exhaust requirements, filtration and air distribution requirements, humidity and temperature requirements, etc.

19.2 ASHRAE 189.3 Construction, and Operation of Sustainable High-Performance Healthcare Facilities.

19.3 Bio-Medical Waste Management Rules, 2016,for Treatment and Disposal of Hospital generated waste.

19.4 FGI Guidelines 2018, Guidelines for Design and Construction of Healthcare Facilities, provides minimum design requirements for Hospitals and its environment.

19.5 IS/ISO 7396 for Medical Gases Pipeline Systems.

19.6 ISO 13485, Quality Management System, Medical Devices, Key Standard for installation and servicing of medical devices and related engineering services

19.7 ISO 20017, RFID Standard for Healthcare.

19.8 NABH, Hospital Accreditation Standards.

19.9 NABL, Hospital Laboratories Accreditation Standards.

19.10 NBC 2016 provides Guidance for all services. Its part 4 provides specific Fire & Life Safety guidance and part 9 provides Plumbing & Drainage Guidelines.

19.11 NEC 2011 provides Guidance for all Electrical Services and Lighting Services.

19.12 NFPA 92, A group of Standard on Smoke Control & Management Systems

19.13 NFPA 99, 2018,Healthcare Facilities Code provides comprehensive Guidance for mitigating the hazards of fire, explosion, and electricity.

19.14 NFPA 101, Life Safety Code provides building requirements necessary to protect Hospital Building Occupants from dangers caused by fire, smoke, and toxic fumes.

19.15 Occupational Safety and Health Administration (OSHA) standards for Use of construction materials in Hospital Engineering Services.

19.16 The regulations for Radiation safety of International Atomic Energy Agency and Atomic Energy Regulatory Body of India.

19.17 The Rights of Persons with Disabilities Act, 2016 provides for the design of products, environments and services to be usable by all people including Persons with Disabilities to the greatest extent possible.

19.18 Whole Building Design Guide, Hospitals, 2017, design Criteria for Public Hospital buildings in USA.

19.19 ANSI/TIA/EIA-569 Telecommunications Pathways and Spaces.

19.20 MIL-HDBK-419A Grounding, Bonding, and Shielding for Electronic Equipment and Facilities, Basics, Volume 1 of 2.

19.21 MIL-HDBK-419A Grounding, Bonding, and Shielding for Electronic Equipment and Facilities, Application, Volume 2 of 2.

19.22 CPWD General Specifications for Heating, Ventilation & Air-Conditioning (HVAC) 2017.

19.23 CPWD General Specifications for Electrical Works Part I Internal -2013.

19.24 CPWD General Specifications for Electrical Works Part IV Sub-Station -2013.

19.25 CPWD General Specifications for Electrical Works Part V Wet Riser & Sprinkler System -2013.

19.26 CPWD General Specifications for Electrical Works Part VI Fire Detection and Alarm System -2013.

19.27 CPWD Compendium of Norms for Designing of Hospitals and Medical Institutions

19.28 In addition, now Green Building Council Guidelines and Energy Audits and preliminary Audits of Gas Services are also applied at pre-construction stage.

NOTE: The up to date amendments in respect of above shall be applicable.

******

CHAPTER 20

LICENSES, PERMITS & STATUTORY OBLIGATIONS FOR HOSPITALS IN INDIA

a) Air (Prevention and Control of Pollution) Act, 1981 along with Rules, 1982
b) Atomic Energy Regulatory Board
c) Bio-Medical Waste Rules, 2016
d) Boilers Act 1923
e) Building Permit (Completion Certificate)
f) Child Labour (Prohibition and Regulation) Act 1986 along with Rules, 1988 and Children (Pledging of Labour) Act 1933.
g) Consumer Protection Act, 1986 along with Rules, 1987 amended in 1998
h) Delhi Nursing Home Registration Act 1953
i) Delhi Private Medical Establishment (Regulations) Act 1956
j) Drugs & Cosmetics Act, 1940
k) Explosive Act, 1884 along with The Explosive Substance Act 1908 and The Explosives Rules, 1983
l) Govt. Order No. 73231/SS B4/92/Home dated 29.09.1993 - Section 304 not applicable in Hospital deaths.
m) Indian Lifts and Escalators Act
n) National Building Code
o) National Electrical Code
p) National Commission Acts [Containing 4 Acts -Women Act ,1990 SafaiKaramcharies Act, 1993 and Allied Information]
q) National Environmental Tribunal Act, 1995
r) No Objection Certificate from the Chief Fire Officer
s) No Objection Certificate under Bio-medical Waste Rules, 1998
t) No Objection Certificate under Pollution Control Act
u) Pre-Natal Diagnostic Techniques (Regulation & Prevention of Misuse) Act, 1994 along with Rules, 1996
v) Radiation Protection Certificate in respect of All X-Ray Equipment from BARC
w) Radiation Protection Rules under BARC Act
x) The Blood Bank Permit under Drugs Act
y) The Excise Permit to store Spirit
z) The Permit to Operate Lifts under the Indian Lifts and Escalators Act

NOTE: The above is a indicative list only. The other/s as applicable as per requirement of hospital services/ local building byelaws/ statutory compliances are also to be followed.

******

EDITORIAL TEAM



Sh. Vimal Kumar
CE CSQ (E)



Sh. Saurabh Kumar
SE(E) TLQA



Sh. Rajiv Gupta
EE (E) TLQA



Sh. Bhagwan Ram
AE (E) TLQA



Sh. Sandeep Kumar Das
AE (E) TAS

Any Errors, Omissions or Suggestion for modification in this specification may be referred to Chief Engineer, CSQ(E), Nirman Bhawan, New Delhi.

Address:- Room No. 229 A, A-Wing, Nirman Bhawan,
New Delhi

Email Id:- delceecsq.cpwd@gov.in
Tel. No. 011-23061418



Published under the Authority of
Director General CPWD, Nirman Bhawan, New Delhi