Right to care

Treating Health Seriously

Gobabis Hospital

Namibia

FINAL REPORT

Engineer's Report: Medical Oxygen and Vacuum System

A report of the state of the Oxygen and Vacuum Systems at the Gobabis Hospital as at Wednesday 19 January 2022 with recommendations to improve the facility's ability to provide oxygen-based treatment for CoVid-19

3 FEBRUARY 2022

This report was prepared by

In Co-Operation with

TABLE OF CONTENTS

LIST OF TABLES

ABBREVIATIONS

Abbreviations Used in the Report	
ASU	Air Separation Unit
AFFL	Above Finished Floor Level
LOX	Liquid Oxygen
MA	Medical Air
MoHSS	Ministry of Health and Social Services
NRV	Non-Return Valve
PCC	Portable Oxygen Container
PSA	Pressure Swing Absorption (Unit)
TU	Terminal Units (i.e. gas delivery points wall-mounted at beds)
VAC	Vacuum
VIE	Vacuum Insulated Evaporator (LOX Tank)

VERSION CONTROL

Version	Date	Distribution
Draft	1 February 2022	Draft for internal review by Right to Care
Final	3 February 2022	Final Report

DISTRIBUTION LIST

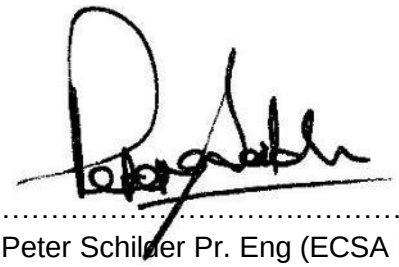
Type	Distribution List
Electronic Report	Mr. Theo Ligthelm, Right to Care Consultant

ENGINEER'S STATEMENT

This is to certify that this report is a true reflection of the installation found at the Gobabis Hospital during the time of the survey on Wednesday 19 January 2022.

It is expressly stated that our conclusion was reached based on good engineering judgement, our experience and what was shown to us by the delegation of hospital officials made available for the survey.

This document was issued without hand-written changes.



…….. 3 February 2022

Peter Schilder Pr. Eng (ECSA Reg 20080297) Date

DOCUMENT APPROVAL

The design and recommendations contained herein have been supported/approved by:

A. Right to Care Management

☐ Approved ☐ Approved with Changes ☐ Rejected

Name ……..…….. Capacity …….. Date……

B. USAID Regional Engineer

☐ Approved ☐ Approved with Changes ☐ Rejected

Name ……..…….. Capacity …….. Date……

C Ministry of Health and Social Services of Namibia (as the operator of the facility)

☐ Approved ☐ Approved with Changes ☐ Rejected

Name ……..…….. Capacity …….. Date……

D Department of Works (as the owner of the facility)

☐ Approved ☐ Approved with Changes ☐ Rejected

Name ……..…….. Capacity …….. Date……

1 EXECUTIVE SUMMARY

On Wednesday 19 January 2022, a delegation of engineering consultants visited the Gobabis Public Hospital in the Omaheke District of Namibia. The visit was in response to a request from the Ministry of Health and Social Services of Namibia (MoHSS) to identify and verify facility needs for an initial COVID-19 response and to improve care capacity during and post-COVID-19 waves.

The 172-bed hospital is currently supplied by one PSA oxygen generator with a calculated[1] maximum delivery of 65L per hour.

The visit confirmed that the hospital's oxygen supply and distribution system does not meet basic needs to treat the existing patient load at the facility. The management of the facility also indicated that there is no central vacuum system installed and is critical for providing successful oxygen therapy during respiratory related intervention for, *inter alia*, the treatment of COVID-19.

During the hospital site survey, the current installation was assessed and a needs analysis was performed with the hospital management.

1.1 Summary Recommendations for Oxygen System

We hereby make the following recommendations:

1. That all existing oxygen outlets be serviced and that the existing oxygen system be tested for leaks.
2. That additional oxygen points be installed to meet the basic operational requirements (as indicated by hospital management).
3. That the existing PSA oxygen generating unit is augmented with a second plant or under certain supply conditions, a Liquid Oxygen (LOX) Tank or VIE.
4. The PSA should be supplied electrically from the hospital electrical supply that is already supported by an emergency generator. It is unlikely that the existing hospital load and the new PSA (and envisaged vacuum pumps) could be supported from the existing 250kVA generator due to altitude and temperature derating. We recommend that a load calculation is performed before additional equipment is installed.
5. That the back-up cylinder bank is extended from a 3x2 to a 7x2 capacity, re-commissioned and calibrated to support the central system during excessive demand as well as primary supply failure.
6. That all alarms are repaired and reinstated.

1.2 Summary Recommendations for Vacuum Systems

We hereby make the following recommendations for the vacuum system:

1. That a new central vacuum system, complete with new TUs, pipe reticulation, vacuum pumps, filters, accumulator and alarm system be designed and installed to meet existing need.
2. That the vacuum plant be electrically connected to the local electrical supply that is already backed up by an emergency generator.

[1] Capacity was calculated from the compressor size used in the existing installation.

1.3 Process

The following process is envisaged:

1. That the design according to this document is approved by:
    a. Right to Care Management
    b. USAID Regional Engineer
    c. Ministry of Health and Social Services of Namibia (as the operator of the facility)
    d. Department of Works (as the owner of the facility)
2. Once approved or approved with modifications, a final document is issued.
3. That a tender is issued to prospecting contractors to bid for the design, construction, servicing and testing of the existing and new oxygen and vacuum installation. The approved document will serve as the design brief.
4. That a tender issued to capable suppliers for the supply and installation of a PSA unit.
5. That a tender issued to capable suppliers for the supply and installation of a Vacuum plant.
6. A tender for the civil works will be issued under separate cover.
7. Tender adjudication and awarding of projects.
8. Construction/Installation
9. Acceptance testing by Right to Care Engineers
10. Hand-over to MoHSS.

2 SITE VISIT

The existing installation was inspected on Wednesday 19 January 2022. The inspection was undertaken by Dr. Chuka Onaga (Right to Care Deputy Chief of Party), Mr Theo Ligthelm (Right to Care Team Lead), Mr Molefe Sematlane (Right to Care Civil Engineer) and Peter Schilder (Right to Care Mechanical Engineer). The group was assisted by the hospital CEO, the nursing services manager and the maintenance technician.

3 DESCRIPTION OF EXISTING OXYGEN INSTALLATION

3.1 Existing Oxygen Supply System and Reticulation

Oxygen is reticulated to select areas in the hospital via a central pipe distribution system.

The primary source of oxygen is a PSA unit with a calculated capacity of around 65L/min. At the time of the survey, oxygen was supplied at a rate of 32L/min at a purity of 94.9%. Even with almost no demand form the hospital, the PSA was producing at 50% of capacity. Refer to Photograph 13 and 17 in Addendum 1.

The central oxygen installation includes secondary supply sources consisting of 1 back-up cylinder bank with an automatic change-over. Please refer to Table 1.

Table 1: Summary of Secondary Oxygen Supplies.

Location	Bank Size	Appendix 1 Reference
Services Area	3x2 cylinders	Photograph 1,3
Total Cylinders	6 cylinders	

During the survey, the cylinder bank did not have any cylinders connected in a way that it would serve as a secondary supply to the central system.

The following was noted during the survey:

1) It was noted that even with no patients receiving oxygen and one patient in theatre, the existing PSA was delivering oxygen at around 50% of its calculated capacity. The existing PSA therefore has limited capacity to meet additional demand.
2) The overall quality of the original oxygen reticulation was very high however, it appears that the pipework was bastardised inside the cylinder back-up chamber. Refer to photograph 17.
3) The oxygen cylinder bank will require repairs i.e. the pig-tails needs to be repaired and annealed, the pig tail non-returns need to be serviced/replaced and the alarm system needs to be repaired and recommissioned.
4) A small Nitrous Oxide and Medical Air cylinder bank is also installed at the hospital and appears to be functional however, the demand for nitrous oxide and medical air is almost nil.
5) The existing PSA power supply is fed from a local changeover switch located outside the PSA enclosure. The wiring is not considered safe. Refer to photograph 14.

3.2 Existing and Envisaged Number of Oxygen Terminal Units (TUs)

The hospital currently has 17 oxygen TUs installed in theatre, casualty (serving as a temporary theatre), selected wards and critical care areas. Please refer to Addendum 2 for the location detail of these outlets.

Should the envisaged 10 bed ICU be constructed, an additional 10 outlets will increase the total number of TUs to 27. It is understood that these additional TUs will be installed as part of the existing construction projects.

During the survey, the hospital management indicated that an additional 50 outlets are required to meet the hospital's basic needs. The total envisaged number of oxygen outlets are summarised in Table 2:

Table 2: Summary of Existing and Envisioned Oxygen Outlets

Location	Nr. O_2 TUs
Current number of outlets	17
Outlets due to envisaged projects	10
Additional operational requirement	50
Total Oxygen Outlets	**77**

4 OVERALL DESIGN PHILOSOPHY

This is a medium sized facility with an existing central piped system reticulated into selected parts of the building. A PSA oxygen generation unit is currently installed as the primary source of oxygen.

As the proposed intervention is to alleviate the chronic oxygen and vacuum shortage and to increase the oxygen therapy capability if the facility, the existing system will be firmed up rather than replacing it with a properly designed system. A new vacuum system will need to be created.

All additions should comply with the standards and norms set out in this document as far as practically possible however, the end result it will not necessarily comply with all stated standards.

5 OXYGEN SYSTEM DESIGN BRIEF

Based on the design philosophy above, the oxygen system upgrade design brief is as follows:

5.1 Primary Supply

Liquid oxygen would be the default primary supply source for this installation as it is on the main oxygen supply route into Namibia however, due to the associated liquid oxygen cost, the existing undersized PSA unit should be replaced with a PSA unit that can supply the entire envisaged demand.

The primary supply should deliver a total flow of 460L/min plus 10% = 500L/min. As a new PSA would supply the entire envisaged demand, the existing PSA may be used as a standby or may be relocated to another facility.

Should affordable medical grade liquid oxygen become available in Namibia, a VIE should be considered as primary source of oxygen. The plinth that will be constructed for the PSA should be able to accommodate a VIE in future. Based on the diversified demand and a 1-week refilling interval, a 5t LOX tank should be considered. The associated losses at 2% per day will require a minimum demand of 50L per minute to curb loss to atmosphere.

5.2 Secondary Supply

The secondary supply shall be the automatic change-over oxygen cylinder back-up banks.

It is recommended that the existing cylinder bank (Refer to Table 1) is increased to a 7x2 bank to ensure a supply of 4 hours at the diversified flow rate of 460L/min.

5.3 Reserve Supply

Based on HTM02-1 Table 4, the reserve supply can be determined by risk assessment. In line with HTM02-1 Table 2 with duplex supplies from two separate plinths and locations, no reserve supply is required as the installation would be served by “other dual supply to a pipeline distribution system”.

No permanently connected reserve supply is required however, a plug-in point should be provided at each cylinder back-up bank to enable a Portable Cryogenic Container (PCC) to be connected during time of extreme oxygen demand, such as during a CoVid wave or future pandemic.

5.4 Terminal Units (TUs)

The number of TUs shall not be according to HTM02-1 (Table 11) but according to the needs analysis identified by hospital management. The 60 additional oxygen TUs and distribution thereof will be according to Addendum 2.

Additional TUs, shall be installed in a commercially available TU wall-mount enclosure at 1400 AFFL centred on the bed position. Oxygen TUs will be on the left and vacuum TUs on the right. TU separation shall be 150mm between centres.

All existing TUs shall be serviced and tested for correct operation.

5.5 Valve Boxes (AVSUs)

Each ward shall be fitted with isolation valves inside a valve box according to HTM02-1, Section 3.

5.6 Piping Installation

The sizing of the pipe system will be according to HTM02-1. The contractor will check the pressure drop against the diversified flow calculation per ward, contained in Addendum 3. An overall pressure drop will be limited to 5%, therefore on a 400kPa system, limited to 20kPa from source to point of consumption.

Where piping is found to be adequate, the existing piping shall be retained. Where piping is found to be incorrectly sized, an additional pipe of adequate size shall be installed to create a ring feed into the hospital.

All pipes shall be pressure tested according to HTM02-1

6 VACUUM SYSTEM

The vacuum installation and requirements were assessed as part of the oxygen survey.

6.1 Existing Vacuum Supply System and Reticulation

It was found that there is no central vacuum system in the facility. All suctioning is performed with portable electric suction pumps.

7 VACUUM SYSTEM DESIGN BRIEF

Based on the required number of vacuum terminal units (wall outlet points) as tabled in Addendum 2, the following system components are recommended for this hospital:

7.1 Primary Supply

It is proposed that three new vacuum pumps each with a capacity of 1 410L/min plus 10% = 1 550L/min with associated filters, control panel, alarm system and accumulator, is installed inside the existing vacuum pump room and connected to the hospital electrical supply.

7.2 Vacuum Reticulation

A new vacuum system should be designed to service all wards. Refer to Addendum 5 for a proposed lay-out.

The sizing of the pipe system will be according to HTM02-1. The contractor will check the pressure drop against the diversified flow calculation per ward contained in Addendum 4. An overall pressure drop will be limited to 5% of nominal vacuum from source to point of consumption.

All pipes shall be pressure tested according to HTM02-1

7.3 Terminal Units

The distribution of vacuum TUs will be per Addendum 2.

7.4 Valve Boxes (AVSUs)

Each ward shall be fitted with isolation valves inside a valve box according to HTM02-1, Section 3.

8 APPLICABLLE STANDARDS AND NORMS

The installation shall be according to the following standards as far as practical.

1. Reticulation: ISO7396-1: Medical Gas Pipeline Systems
2. Design: Health Technical Memorandum 02-01: Medical gas pipeline systems.
3. PSA: WHO Technical Specifications for Pressure Swing Adsorption (PSA) Oxygen Plants dated 8 June 2020

9 CONCLUSION

The oxygen and vacuum system of a hospital is a life critical resource and is one of the fundamental systems that is required in a building to make it a healthcare facility.

Providing oxygen therapy is a fundamental treatment mechanism in many clinical interventions. A hospital's ability to provide a secure source of oxygen and vacuum is often life-saving.

We are of the opinion that the above recommendations will dramatically increase the ability of the Gobabis hospital to provide positive clinical outcomes.

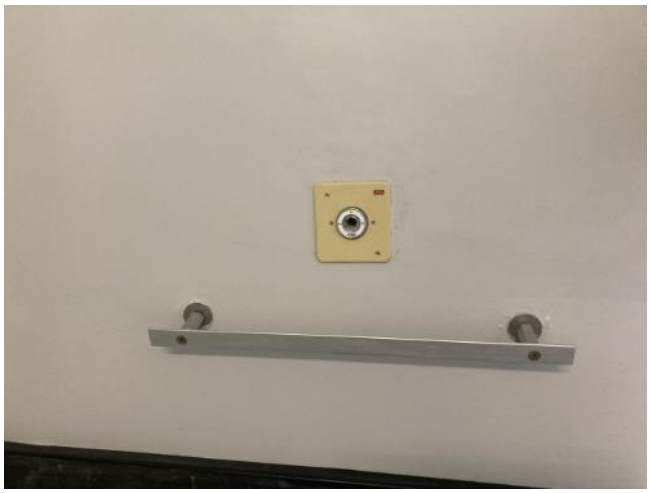
10 ADDENDUM 1 - Photographic Record

Photographic evidence is provided here for reference.

Photograph 01

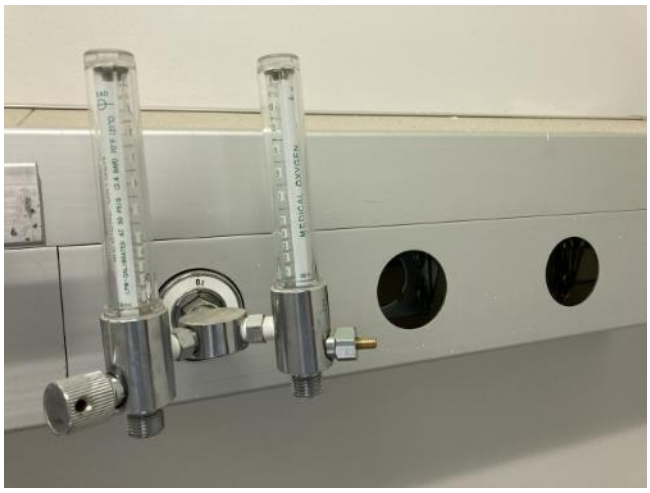
Photograph 02

Photograph 03



Photograph 04

Photograph 05



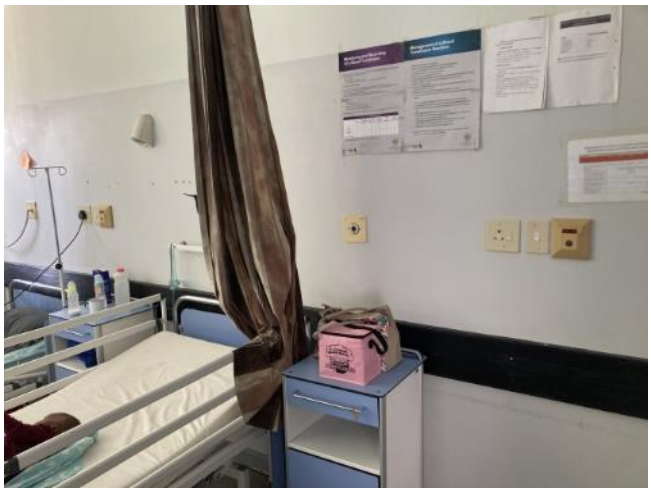
Photograph 06

Photographic Evidence (*Continued*)

Photograph 07

Photograph 08

Photograph 09



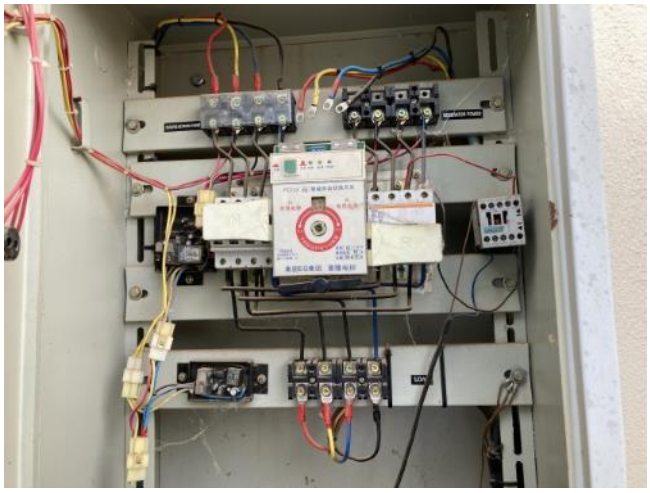
Photograph 10

Photograph 11

Photograph 12

Photographic Evidence (*Continued*)

Photograph 13



Photograph 14

Photograph 15

Photograph 16

Photograph 17

Photograph 18

11 ADDENDUM 2 - Number of Terminal Units

Detail of the existing and required number of Oxygen and Vacuum TU in the Gobabis Hospital.

		Oxygen		Vacuum	
Discipline	**Location**	**Exist.**	**Req.**	**Exist.**	**Req.**
Theatre	Theatre Suite	1	0	0	2
	Theatre Pre-Op	1	0	0	2
	Recovery	0	1	0	2
Temp. Theatre/Casualty	Theatre Suite	2	0	0	2
	Theatre Pre-Op/Recovery	3	0	0	3
TB Ward	Room A09 Male Ward	0	4	0	4
	Room A19 Female Ward	0	4	0	4
Paediatrics	Room B07 Female High Care	3	0	0	3
	Room B08 Peads High Care	2	0	0	3
	Room B09 Male High Care	3	0	0	3
	Room B04 Peads Acute Care	0	2	0	2
	Room B10 Medical Infected	0	4	0	0
	Room B12 Male Medical	0	4	0	0
	Room B13 Male Medical	0	4	0	0
	Room B23 Medical High Care	0	4	0	0
	Room B25 Female Medical	0	4	0	0
	Room B28 Female Medical	0	0	0	0
Maternity	Room C03	0	2	0	0
	Room C04 Antenatal	0	4	0	0
	Room C05 Nursery	0	3	0	3
	Room C07 Post Delivery	0	4	0	0
	Room C08 Private	0	2	0	0
	Room C10 Delivery Room	2	2	0	4
	Room C11 Labour	0	2	0	2
ICU	Planned ICU	0	10	0	10
		17	60	0	49
TOTAL (Number of TUs)		**77**		**49**	

12 ADDENDUM 3 - Oxygen & Vacuum Peak- and Diversified Flow Calculation

Detail of the flow and diversified flow calculation in L/min

		Design Flow			Diversif. Flow	
Discipline	**Location**	**O2**	**VAC**	**Beds**	**O2**	**VAC**
Theatre	Theatre Suite	100	40	1	100	80
	Theatre Pre-Op	10	40	1	10	40
	Recovery	10	40	1	10	40
Temporary Theatre/New Casualty	Theatre Suite	100	40	1	100	80
	Theatre Pre-Op/Recovery	10	40	2	16	50
TB Ward	Room A09 Male Ward	10	40	6	26.5	150
	Room A19 Female Ward	10	40	6		
Paediatrics	Room B07 Female High Care	10	40	6	86.5	550
	Room B08 Peads High Care	10	40	6		
	Room B09 Male High Care	10	40	6		
	Room B04 Peads Acute Care	10	40	4		
	Room B10 Medical Infected	10	40	6		
	Room B12 Male Medical	10	40	6		
	Room B13 Male Medical	10	40	6		
	Room B23 Medical High Care	10	40	6		
	Room B25 Female Medical	10	40	6		
	Room B28 Female Medical	10	40	0		
Maternity	Room C03	10	40	4	47.5	290
	Room C04 Antenatal	10	40	6		
	Room C05 Nursery	10	40	4		
	Room C07 Post Delivery	10	40	4		
	Room C08 Private	10	40	2		
	Room C10 Delivery Room	10	40	4		
	Room C11 Labour	10	40	2		
ICU	Planned ICU	10	40	10	64	130
TOTAL FLOW (L/min)					460.5	1410

13 ADDENDUM 4 - Hospital Extent (Google Maps)

14 ADDENDUM 5 - Proposed Oxygen & Vacuum Distribution Drawing