WHO technical consultation on oxygen scale-up
## Agenda

**Friday, 13 November, 2020**

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<tr>
<th>Time</th>
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| 16:00–16:10 | Welcome remarks  
  - Review of agenda  
  - Participant attendance  
  - Summary of Session 2 | Janet Diaz  
  Lead, Clinical Management for COVID-19  
  WHO Health Emergency Programme |
| 16:10–16:30 | Overview of Oxygen Sources at scale  
  ➔ Review of PSA and Cryogenic Liquid  
  ➔ Outline of VSA  
  Medical Oxygen distribution networks, including piping and high-pressure gas cylinders:  
  - Configurations with PSA plants  
  - Configurations with liquid  
  High-level considerations for piped network design:  
  - Technical  
  - Operational | Alejandra Velez  
  Focal point, Oxygen scale-up,  
  WHO Health Emergency Programme |
 Edgardo Diaz (co-chair) |
| 17:25–17:30 | Wrap-up and next steps | Janet Diaz |
Summary of key discussion take-aways from Session 2: PSA technical and operational challenges

✓ PSA systems are an assembly of original equipment manufacturer (OEM) components.

✓ The booster compressor is a critical component which was reported as “bottle neck”:
  o Why important? Allow redundancy by filling cylinder ramp as back-up source, and filling of supply cylinders both inter and intra facility.
  o Why is it a bottle neck?: require careful care, few qualified manufacturers worldwide; high cost of acquisition and maintenance, longer lead time than other OEM components, thus delays PSA installation

✓ Plant configuration is context related and requires strategic planning, including:
  o Conducting needs assessment and evaluating adsorption capacity are key to optimise the operation.
  o Establishing/strengthening relationships with suppliers to ensure product suitability, long-term service agreements, regional presence, etc.
  o Budgeting for HR, power supply, ancillary equipment, and maintenance.
  o Planning for security of supply (redundancy) such as backup ramp or tank,
Summary of key discussion take-aways from Session 2: PSA technical and operational challenges

- **Output oxygen purity** is not routinely checked; lack of guidance on impurities and/or contaminants.

- **Piping**: improves overall clinical care and reduces the dependency on booster compressors (topic of this meeting)

- **Training of technical and clinical staff** is a KEY to improve access and availability at the end of the value chain (not covered in detail, for later meeting).

- There is a gap with regards publicly available operational guidance for PSA generation plants.
The aim of this technical consultation is to achieve the following core objectives across four teleworking sessions:

**Needs assessment:** taking stock of existing guidance to forecast oxygen needs; identification of shared challenges; formalizing baseline assumptions and framework methodologies that apply for a high-level oxygen needs estimation for LMICs.

**Technical guidance:** finalizing operational elements and inputs for WHO consideration in producing interim guidance documents for oxygen production from PSA oxygen generator plants and subsequent distribution (e.g. cylinder manifolds, oxygen piping) at the facility level. *(2 of 2 sessions)*

**Global scale-up mapping:** establishing live mapping updates and/or networking resources to leverage previous accomplishments, to foster collaborations, and to avoid duplication of activities.

Identification of other work areas could result in the addition of further working sessions.
Solutions for oxygen supply will often be a mix of available sources: PSA oxygen generation plants are a suitable option for surge, and there is a need for operational guidance.

### PSA O₂ Generation Plants

**Description**
- Various own/operate models.
- Often situated onsite.
- Continuous and reliable electrical source during plant and booster operations.
- Detailed technical and financial planning for long-term operations and maintenance (~20 years).
- Need > 4 technicians for 24/7 operation.

**Requirements**
- Different sizes and configurations: single and duplex 2–200+ Nm³/hr
- Produced mainly for heavy industry; serves medical sector where GMP allows

**Additional Considerations**
- Scaling-up medical needs.
- Continuous supply at all atmospheric pressures.
- Supply can be piped bedside and/or plant can fill cylinders to be used bedside or transported elsewhere.

### Cryogenic Liquid Production

**Description**
- Third party responsible for production and supply chain.
- Plants must be offsite. Bulk liquid tanks with passive vaporization for onsite storage (specialized materials).
- CAPEX and OPEX are very high, borne by third party.
- Scaling-up medical needs.

**Requirements**
- Goods and service contract.
- Product can be used via high-pressure gas cylinders or piped bedside from bulk tank.
VSA – O2 production akin to PSA with some nuanced differences

**Key advantages**
- Oil-free blower = ↓ in filtration requirements
- Slightly smaller footprint, one adsorption tower.
- Not operating under pressure:
  - Unaffected by altitude
  - Less sensitive to environmental wear & tear

**Careful considerations**
- Oil-free blower = 15% ↑ CAPEX (for <100 Nm3/hr range, typical for medical application)
- Production lag due to single adsorption tower
- Product 3.8 bar. **Additional** oil-free booster likely required if:
  - Need for direct bedside piping
  - Need for use for ventilatory support (NIV, IMV)
  - ↑ cost, challenges with elevation & environment.

**ACTION:**
Please share experiences about the use of VSA in LMICs. Do we need to explore this topic further?

Image source: PCI Gases
FOCUS DISTRIBUTION 1 of 2 - PSA oxygen generation plants system overview: supply (production and reserve) + distribution (piped network or trolleys) + delivery (regulation and conditioning)
FOCUS DISTRIBUTION 2 of 2 - Liquid oxygen system overview: supply (production and storage) + distribution (piped network or trolleys) + delivery (regulation and conditioning)
Piped distribution network design: High-level overview and key considerations

Key Considerations...

... In preliminary design
- Departments & wards services
- Total number of terminal units
- Total terminal units in use at any given time (concept of diversified flow)
- Test pressures and flows
- System level flows (aligning with source availability)

... For safe and optimal operations
- Back-up (twinning, rings, etc.)
- Isolation capabilities
- Sufficient AVSUs and LVAs and in the appropriate locations
- Alarm panels strategically located
- Operational plan

Twin line network

Same Project, 2 designs

Annular “Ring” network
Oxygen distribution: Technical queries for safe, reliable, lasting solutions

Oxygen output purity
As discussed over the past weeks, we call into question output quality with respect to impurities, and potential for broader system contamination (either cylinders, pipeline, or both). For now, what are our recommendations for mitigating this risk?

Manifold change-over
There are three types of changeover systems: automated, semi-automated, and manual. From your experience, can you speak to advantages, disadvantages, or preferences?

Piping Materials
Historically, copper has been the material of choice for medical oxygen piping. Do we consider:
- PU medical gas hose
- Polyamide
How does it impact in the quality of the design and the oxygen delivered?
Are other concerns (e.g. safety) documented?

Bulk tank troubleshooting
Have you experienced bulk tank vapourizers freezing up? Has this happened recently in surge? If yes, have you been able to mitigate, alongside the service provider, to ensure that needs will be continuously and safely met?

Piping Standards
Using standards to guide and ensure quality. How can these standards be adapted for the contexts in which we work?
- e.g. HTM-02-01 / NFPA 99 / ISO 7396-1 /AIGA / EIGA / CFR

Cylinder distribution inter facility
Does anyone have any experience to share to address or mitigate some of the following operational challenges?
- Maintaining adequate inventory of empty cylinders
- Optimizing fleets (full out, full on return)
- Understanding appropriate cylinder size according to medical application.

Environmental considerations
How does the environment (humidity, extreme temperatures, contamination) affect the pipeline design? How would this affect the electronic components (alarms and/or controls)?

Piping circuitry
Twinned and annular lines are different strategies, especially in critical care or isolation wards, to facilitate distribution security. There might be has added costs & increased maintenance needs.
Are there other approaches you’ve employed (e.g. local isolation or alternative back-up) to achieve the same result for supply stability?
Oxygen distribution: common operational challenges – closing remarks and next steps

ACTION:
Entities are encouraged to participate in the development of operational guidance for oxygen distribution.

The discussed and outlined challenges frame what will be a tremendously helpful global good.

Cylinders:
- Maintaining standards (vessel sizes, valve connections, appropriate regulators and flowmeters, etc.) in a geography
- Handling and safety – need for better guidance, perhaps for more comprehensive international standards.

Pipelines:
- Standards for pipelines for medical application
- Guidance for design, installation, validation, and verification of medical gas (oxygen) distribution networks.

General safety guidance for oxygen.
Greater need > larger solutions > greater, more centralized risks.

Purity: navigating requirements for medical oxygen; unclear guidance relating to different sources. What is acceptable? Why differences in pharmacopoeia?
Important information

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