Case Study:

Custom Refuge Chamber Strengthens Safety on Small TBM

Custom refuge chamber designed for 4.4m diameter tunnel boring machine with limited gantry space.

mineARC SYSTEMS

Ensuring a Site is Emergency Ready

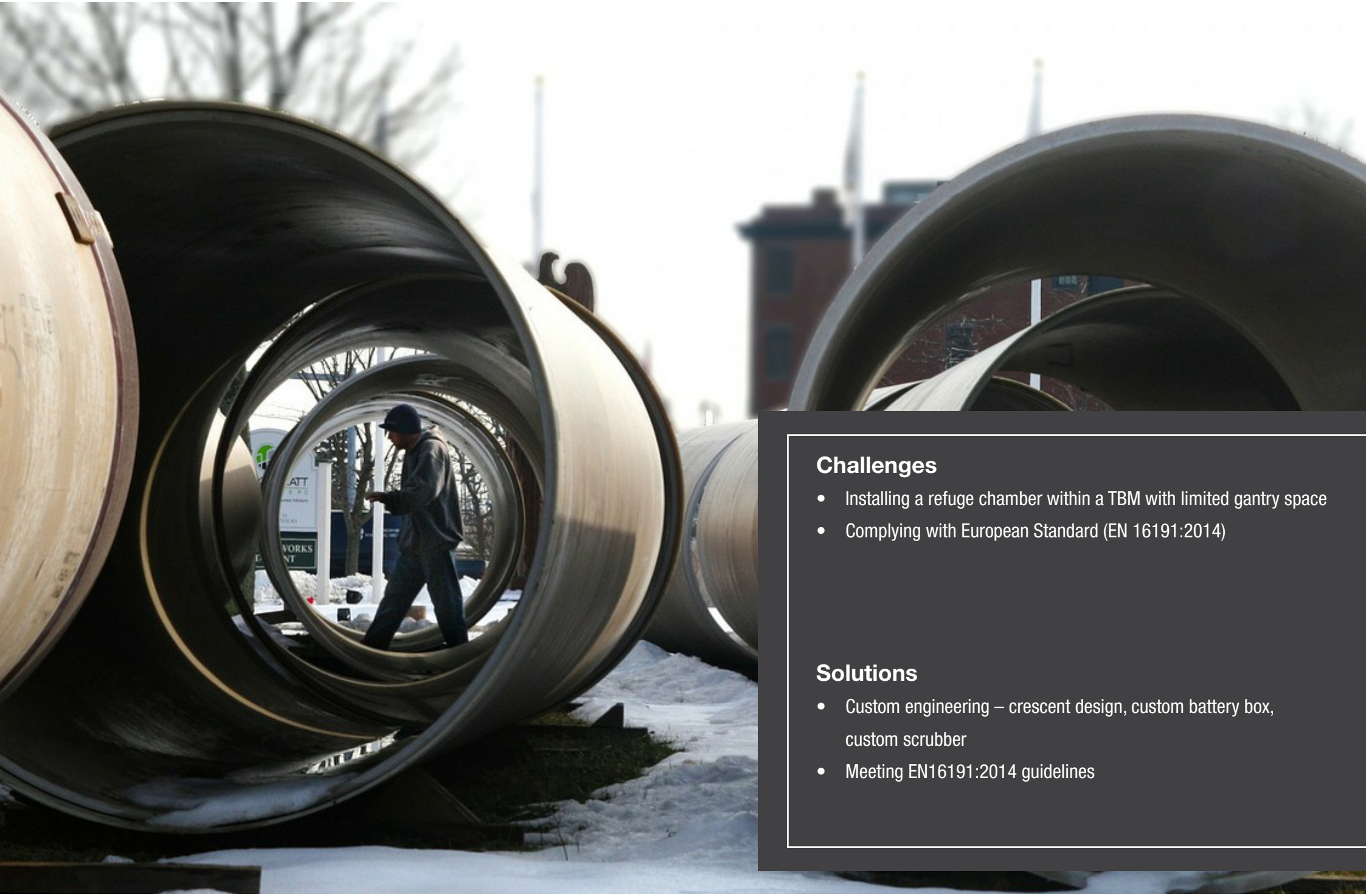
A tunnel project in the Middle East, vital to the enhancement of the country's underground drainage network maintains high safety standards with two custom refuge chambers. The project aims to provide a sustainable solution to storm water run-off and discharge of surface. The $251 million project is the second phase of development, which includes the construction of a rainwater discharge tunnel, pumping station, and rainwater treatment facility.

A leading Chinese manufacturer will provide the Tunnel Boring Machine (TBM) for this section of the drainage tunnel project.

Due to the terrain, phase two of the project will use an Earth Pressure Balance Machine (EPBM). EPB's are designed to operate in softer ground conditions which contain water under pressure. Geological conditions considered include stratum such as Rus Formation, Midra Shale, and Simsima Limestone as well as varying water table ranges due to the proximity of the tunnel to the shallow coastal waters off the Qatar peninsula.

The project is scheduled to be completed at the end of 2021 in preparation for the 2022 World Cup.

Pictured: Crescent Design Tunnelling Refuge Chamber by MineARC Systems



Challenges

- Installing a refuge chamber within a TBM with limited gantry space
- Complying with European Standard (EN 16191:2014)

Solutions

- Custom engineering – crescent design, custom battery box, custom scrubber
- Meeting EN16191:2014 guidelines

01.

Refuge Chambers for Limited Gantry Space

The TBM has a 4.4m diameter, with limited the space available on the gantry for a refuge chamber. Due to the nature of the tunnelling project, a larger TBM is not necessary; however, ensuring the safety of personnel on board is.

The project opted for the Crescent Design TunnelSAFE Refuge Chamber as it is moulded to the contours of the TBM's cylindrical shape to reduce wasted space between the chamber and the external wall.

Two chambers were designed to meet the maximum size restrictions: H x 2280mm, L x 9750mm. W x 735mm/ Ø3540mm (diameter). They were also required to sustain ten personnel for 24-hours. There are several considerations which need to be met when designing a limited size refuge chamber. These include ensuring sufficient breathable air, effective cooling, and backup power supply within the confined space.

The restricted structure required customised holding places for the life support equipment.

Pictured: Inside the custom, crescent shaped TunnelSAFE Refuge Chamber

The tunnel project complied with the European Standard (EN 16191:2014) Safety Requirements for Tunnelling Machinery. This compliance extends to any refuge chamber* on-site. Annex D of the EN 16191:2014 outlines the minimum requirements for a refuge chamber, from concept and design to instruction prerequisites. The limited available space on the TBM presented a challenge when meeting the needs of the standard, three critical areas requiring redesign were:

- **Chamber Floor Area:** The EN standard requires at least 0.75m2/person of floor area, minimum headroom of 1.6m and a minimum volume of 1.5m3/person, as well as an additional 2m3 for the storage of rescue equipment (e.g. stretchers, toilet) and water. A thorough risk assessment determined that a single 20 person chamber wouldn't meet EN floor space and volume requirements on one gantry. As a result, two ten-person chambers were situated on consecutive separate gantries, one after the other.

- **Backup Power Supply:** Tunnelling refuge chambers must provide a minimum 24hr capacity in standalone mode; this requires the use of an uninterrupted power supply. As a standard MineARC Refuge Chambers host the battery box at the rear of the chamber, this allows easy access for maintenance and protection against passing machinery and traffic. However, the positions and significantly smaller width meant access to the batteries via standard design measures could not be applied. Alternatively, an access door was positioned on the inner side of the chamber to ensure maintenance staff were able to perform a thorough service when required.

- **CO and CO2 Scrubber:** Breathable air involves the removal of hazardous gases such as carbon dioxide and carbon monoxide as well as a fresh supply of oxygen. A scrubber performs removal of these gases. A custom-framed Extra Low Voltage (ELV) style scrubber was installed within each crescent design refuge to ensure no additional floor space was taken, and the MARCISORB chemical cartridges could still be securely placed.

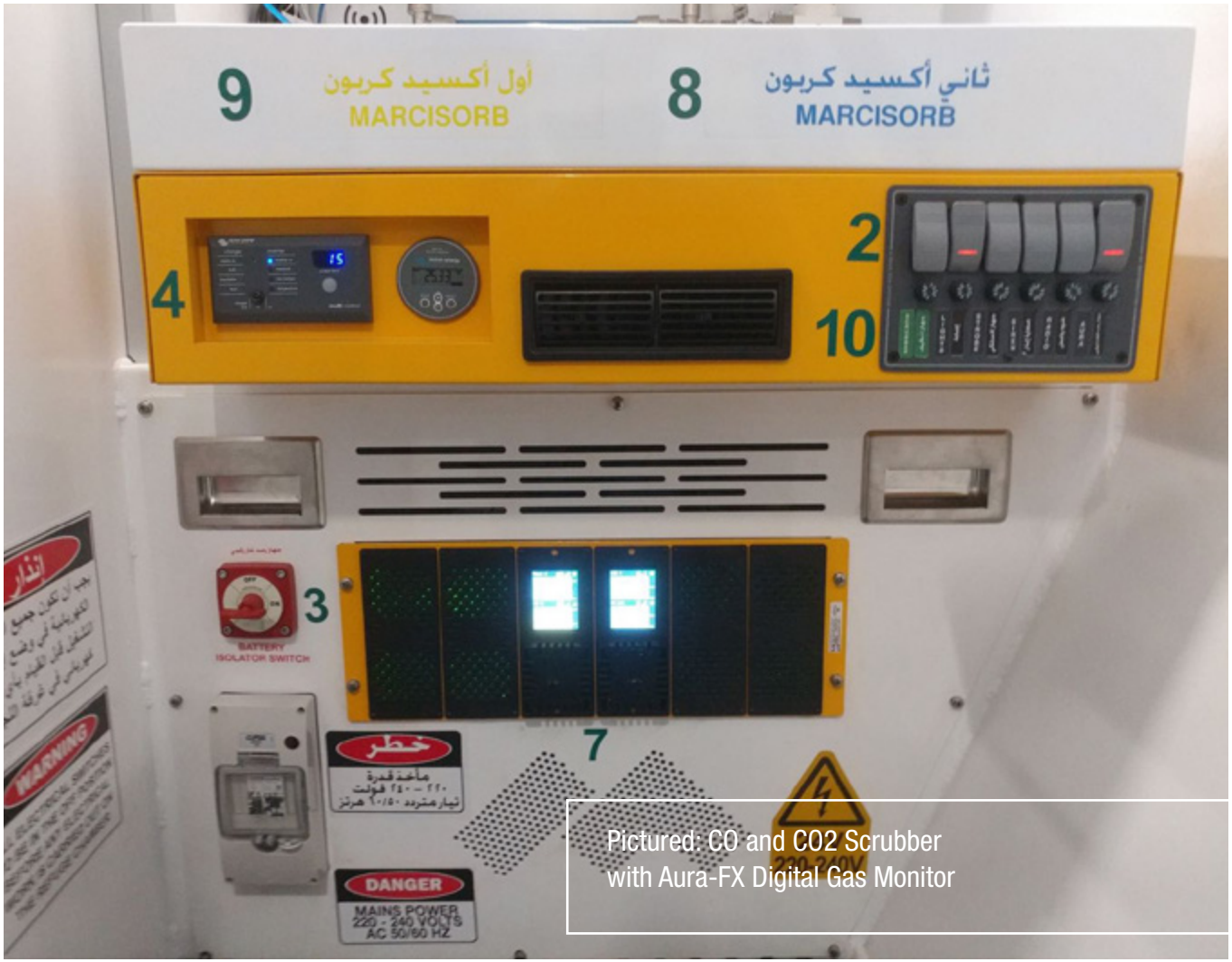
**MineARC's tunnel refuge chamber can also be built to meet the British Standard (BS 6164:2011) Code of Practice for Health and Safety in Tunnelling in the Construction Industry, and the ITA's "Guidelines for the Provision of Refuge Chambers Under Construction".*

02.

Meeting European Safety Guidelines

Underground construction and tunnel design have several known risks. Hazards common to such work include exposure to air contaminants, fire, and other emergencies. Mitigation against these dangers consists of the provision of refuge chambers to provide a safe ‘go-to’ area. All risks must be taken into account when managing safety underground.

As with tunnel design, refuge chambers can be customised to fit the applicable industry standards and requirements of the project. When a traditional option is not appropriate, thinking outside the box can result in better quality and better safety management. The company worked alongside MineARC to ensure the supplied shelters meet the needs of the project as well as provide exceptional safety measures.



Pictured: CO and CO2 Scrubber with Aura-FX Digital Gas Monitor

Tailored Industry Solutions

Refuge Chambers & Toilets

- TunnelSAFE Crescent Design

Life-Supporting Technology

- ELV Scrubber
- Positive Pressure Maintenance System (PPMS)
- Pressurised Access Safety System (PASS)
- GuardIAN Refuge Chamber Monitoring
- Compressed Air Management System (CAMS)
- Aura-FX Digital Gas Monitoring
- MARCISORB Chemical Cartridges

Training & Education

- Dual language signage and operation materials, English and Arabic
- Factory commissioning
- On-site operational training
- On-site certified refuge chamber servicing
- Operational guides
- e-learning access

For More Information

To learn more about how MineARC Systems can support your site, visit minearc.com

Contact Us

e: info@minearc.com.au

p: +61 8 9333 4966