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Challenges and Innovations in Tunnelling

HYPERBARIC INTERVENTIONS & CHALLENGES

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Tunnelling Association of Canada
Association Canadienne Des Tunnels



A LILLTE ABOUT ME.. 😊

❑ I'm currently Manager, Dive and Tunneling Services with ASI Marine (ASI Group)

- I am an Australian who came to Canada 19 years ago
- I'm married to a Canadian and have two wonderful boys who love to play hockey and eat Vegemite
- I enjoy all sports; however, Rugby is my passion with hockey coming a close second... Go Habs...
- I joined the Royal Australian Navy in 1982 and started my diving career as a Ships Diver 1984
- 1985 I became a Navy Clearance Diver
- I left the Navy in 1996 as a Petty Officer CD and moved right into the Commercial Diving Industry
- I joined ASI in 2001 as a project manager for their diving division
- In 2011/12 ASI was approached by McNally/Kiewit/Aecon (JV) to consult and produce a 'Hyperbaric Intervention Procedure' for the Spadina Subway Extension line. This was my segway into the tunneling industry... "Wow what the hell did I get myself into"
- Over the last four years I have consulted, project managed and supervised over 600 hyperbaric interventions as well as created a new service division at ASI Marine for Hyperbaric Tunneling Support



HYPERBARIC INTERVENTIONS & CHALLENGES



 **ASI Marine**

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Tunnelling Association of Canada (TAC) – Ontario Chapter

Challenges and Innovations in Tunnelling

HYPERBARIC INTERVENTION

hyperbaric

(hy·per·bar·ic)

definition –

of or involving a gas at a pressure greater than normal.

intervention

(in·ter·ven·tion)

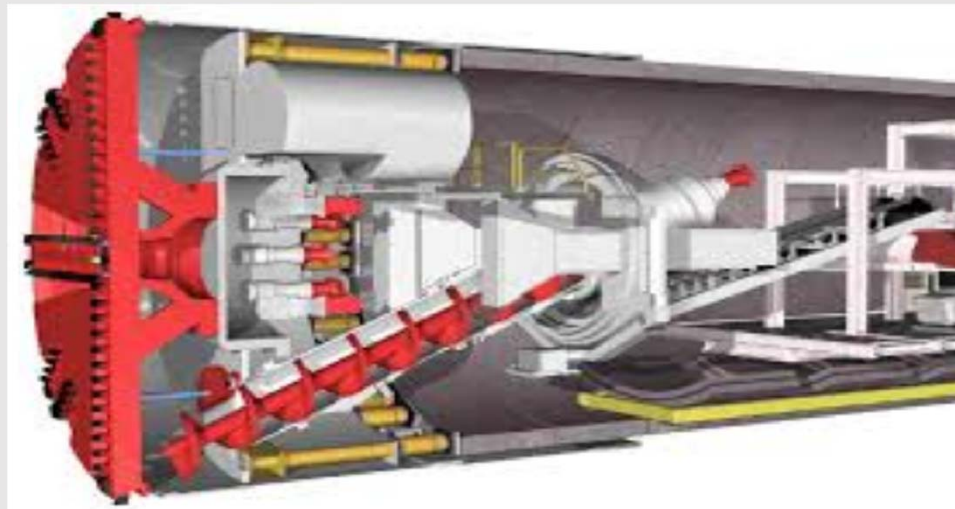
definition –

the act of intervening, interference so as to modify a process or situation.



COMPRESSED AIR WORK EPB - TBM

- ❑ Compressed-air work has been used to prevent the flooding of shafts and tunnels under construction since the 1850's
- ❑ Since the introduction of the Tunnel Boring Machine (TBM) very little digging under pressure has been needed; however, the soft ground TBM, Earth Pressure Balance Machine (EPB) requires workers on occasion to operate in a compressed air environment for inspections, repairs and tooling changes
- ❑ When compressed-air workers enter the pressurized working chamber to conduct such inspections, repairs and tooling changes, they are performing a **“Hyperbaric Intervention”**



COMPRESSED AIR WORK & COMMERCIAL DIVING

- ❑ Standard working pressures for air breathing in a pressurized environment range between 0.2 bar and 3.5 bar of pressure (3psi to 50psi) or (33fsw to 117fsw)
- ❑ As EPB machines dig deeper, pressures >3.5 bar (50psi) are being reached. These extreme pressures of 6, 9 and even 12 bar are outside of the reasonable range of air breathing, requiring offshore mixed gas deep diving technologies and procedures to perform any TBM work
- ❑ This adaptation of offshore diving technologies and procedures for the greater pressure environments have filtered down to the lesser pressure as standard practice for compressed air work on EPB machines



COMPRESSED AIR WORK & COMMERCIAL DIVING

- ❑ One of the driving factors promoting the implementation of diving technologies and procedures for compressed air work is the modern day requirement and better respect for Health and Safety, Risk Mitigation and Liability
- ❑ Around the world successful and safe **'Hyperbaric Interventions'** are being conducted all over the world. Here in Canada, North America, South and Central America, Europe, the Middle East, Asia and Australia.
- ❑ Matching industrial requirements with adapted international rules, expertise and services for both regular air and deep mix gas/saturation work along with specialized equipment and trained personnel are the future challenges





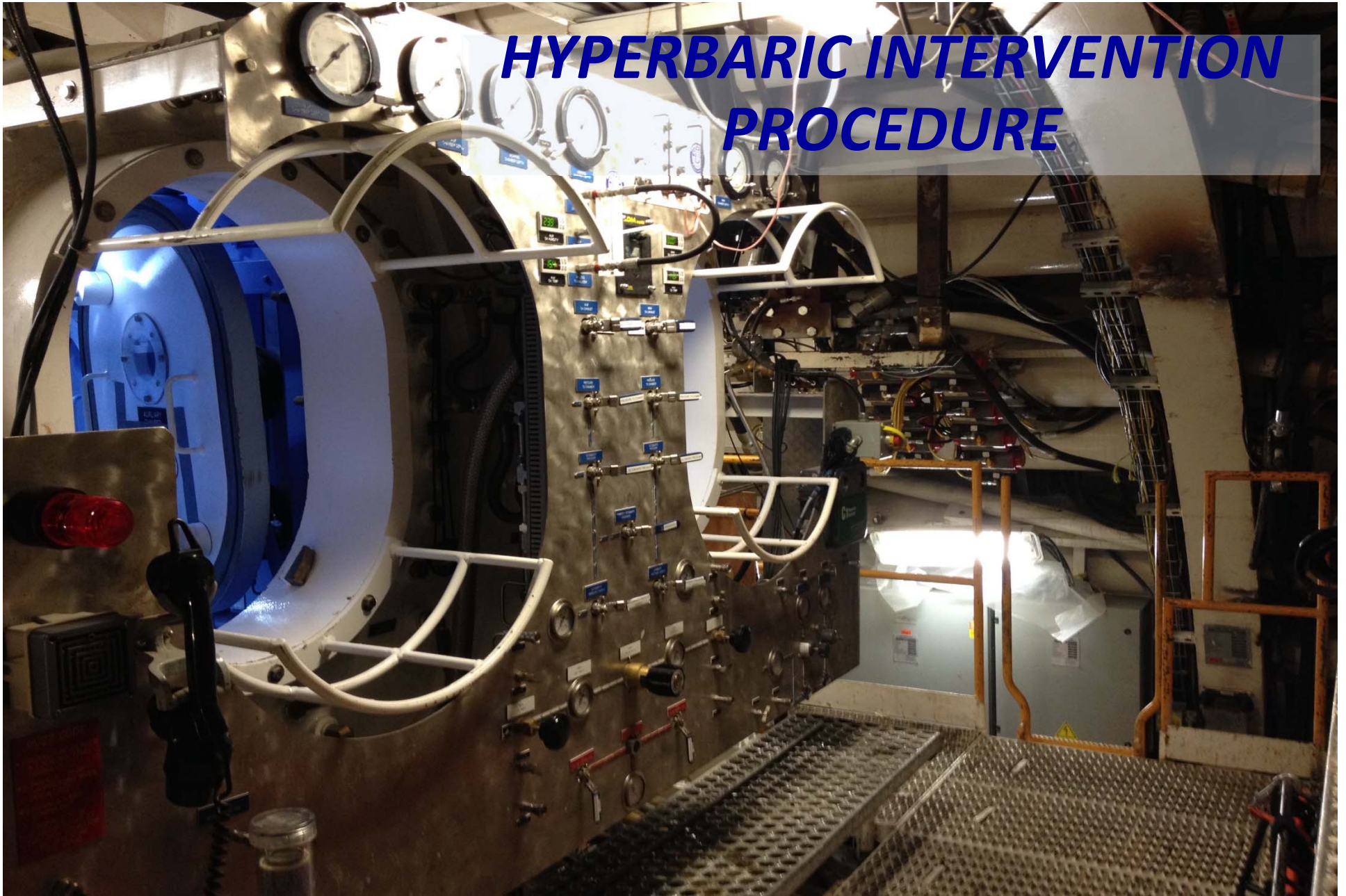
STANDARDS AND REGULATIONS

‘Hyperbaric Interventions in Canada’ *are planned and conducted in accordance with the following Standards and Regulations*

- ❑ CSA Standard Z275.3-09 Occupational Safety Code for Work in Compressed Air Environments
- ❑ CSA Standard Z275.4-14 Competency Standard for Diving and Hyperbaric Chamber Operations
- ❑ CSA Standard Z180-1 Compressed Breathing Air Systems
- ❑ AMSE PVHO-I Safety Standard for Pressure Vessels for Human Occupancy
- ❑ ITA – International Tunneling and Underground Space Association. Working Group No. 5 Health and Safety in Works “Guidelines for Good Working Practice in High Pressure Compressed Air”.
- ❑ DCIEM Diving Manual – Decompression Procedure and Tables
- ❑ US Navy Diving Manual Revision 6 – Standard Decompression Tables
- ❑ Local/Governing Provincial Regulations for e.g. *Ontario MOL Compressed Air Regulation O-Reg. 213/91*



HYPERBARIC INTERVENTION PROCEDURE



HYPERBARIC INTERVENTION PROCEDURE

'Hyperbaric Interventions' are planned and conducted in accordance with a written *Hyperbaric Intervention Operations and Procedure Manual*.

☐ Responsibility

- Project Manager
- Project Safety Manager and Hyperbaric Consultant
- Appointed Hyperbaric Physician
- Project Superintendent
- Air lock and medical lock attendants
- Hyperbaric/compressed air worker and mechanics

☐ Operating Requirements

- Duty to provide safety
- Training of compressed air workers
- Hyperbaric equipment maintenance
- Maximum pressure
- Working chamber protection
- Communications
- Posted instructions



HYPERBARIC INTERVENTION PROCEDURE

'Hyperbaric Interventions' are planned and conducted in accordance with a written Hyperbaric Intervention Operations and Procedure Manual.

□ Compression and Decompression of Workers

- Pressure Limits and work procedures
- Maximum working pressure and working period
- Decompression Obligation
- Multiple exposures
- Decompression tables
- Oxygen breathing
- Management pre-intervention procedure
- Pre-intervention safety meeting
- Air lock preparation and control station
- Medical lock
- Medical fitness exam
- Medical requirements
- Compression procedure
- Decompression procedure
- Rules when using oxygen decompression



HYPERBARIC INTERVENTION PROCEDURE

'Hyperbaric Interventions' are planned and conducted in accordance with a written Hyperbaric Intervention Operations and Procedure Manual.

❑ Air Locks and Medical Lock

- Use of air lock and medical lock
- Size and capacity
- Certification and equipment
- Oxygen masks and oxygen breathing system
- Timekeeping and recording
- Communications
- Lighting, heating, ventilation
- Lock attendants

❑ Regulation of Pressure in Working Areas

- Air compressor and alternate source of power
- Pressure monitoring
- Regulation of Air Quality in working chamber
- Ventilation and flow monitoring
- Supply lines and air tools
- Fire prevention and safety



TBM AIR LOCK & SUPPORT PERSONNEL



HYPERBARIC INTERVENTION EQUIPMENT

TBM Compressor Plant & Filtration



Medical Lock Compressor



HYPERBARIC INTERVENTION EQUIPMENT

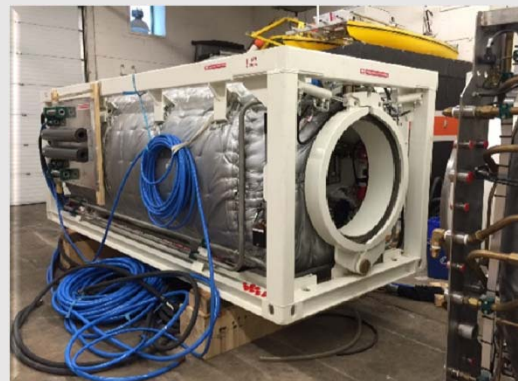
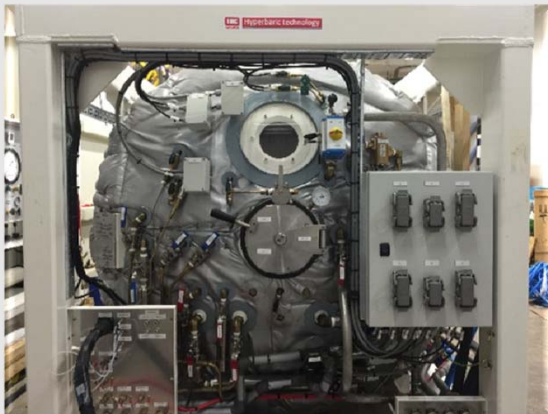
Transfer Lock on MSV



TUP Transfer Under Pressure

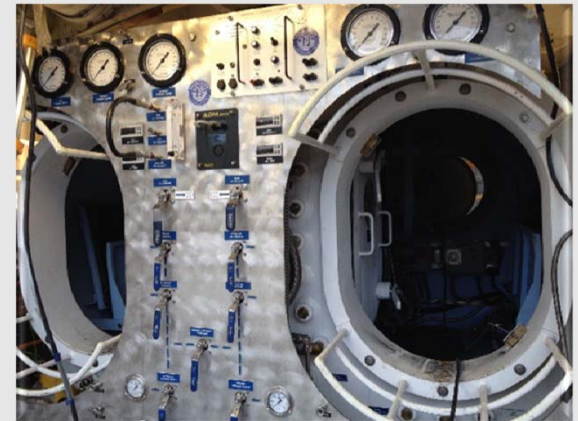


Transfer Lock in Tunnel



HYPERBARIC INTERVENTION EQUIPMENT

Typical Twin Air Lock on TBM



HYPERBARIC INTERVENTION EQUIPMENT

Treatment Medical Locks



TBM AIR LOCK SUPPORT PERSONNEL



HYPERBARIC WORKERS/MECHANICS

Inspections



Repairs and Tooling Changes



WORKER TRAINING AND AWARENESS

‘Hyperbaric Interventions’ are performed under pressure in accordance with commercial diving regulations and standards. Personnel working under pressure must be **‘medically fit to dive’** and competent

□ Training Requirements

- Undergo hyperbaric medical examination by qualified hyperbaric physician
- Hold current fit to div medical (2 years or 1 year if over 40)
- Attend formal classroom awareness training on tunneling Hyperbaric Operations
- Perform chamber and air-lock dives for real exposure and decompression experience. Familiarization with working components, valves, communications etc. on site specific chambers and air-locks
- Controlled pressurization to actual planned working pressure





HEADING AND PRESSURE MANAGEMENT

'Hyperbaric Interventions' are time critical and rely on stable pressure conditions in the working chamber/heading

☐ Ventilation Plan

- Heading pressure requirements
- Size and capacity of air supply compressors
- Redundant air supply compressor
- Use of flow meters
- Pneumatic control valves with redundancy
- Good air flow management
- Bentonite flooding – Cake
- Alternate face sealing



HEADING AND PRESSURE MANAGEMENT

'Hyperbaric Interventions' are time critical and rely on stable pressure conditions in the working chamber/heading

□ Heading Pressure Procedure

- Continuous pressure monitoring
- Manage air loss
- Adherence to protocol for excessive air loss
- Record keeping vent flow Vs. air loss
- Worker awareness
- Communication

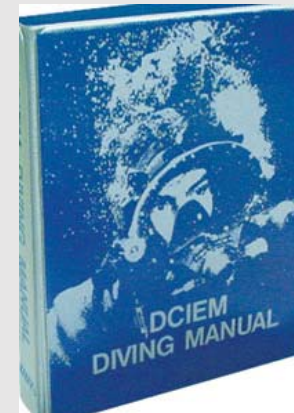
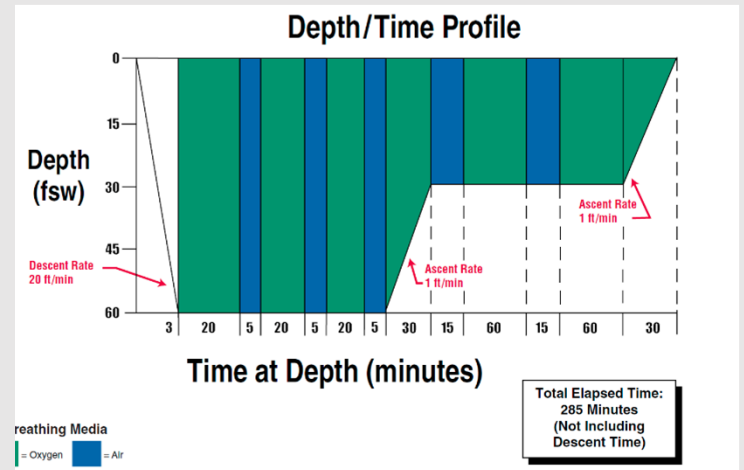


PLANNING WORKING UNDER PRESSURE

'Hyperbaric Interventions' are performed under pressure in accordance with commercial diving disciplines and standards and pre-set decompression tables

□ Decompression Procedure

- Pre-intervention planning based upon pressure, scope of work and allowable safe working time under pressure
- Plan the decompression schedule in writing, Air or Oxygen
- Record intervention times and pressures
- Adhere to decompression table rules and exceptions
- Workers to be aware of potential Decompression Sickness (DCS) signs and symptoms 24 hours post intervention
- Hyperbaric physician to be on site or on-call/stand-by



Time to Wake Up.!!!



QUESTIONS?

