



GUIDELINES ON OCCUPATIONAL SAFETY AND HEALTH IN TUNNEL CONSTRUCTION

**INDUSTRIAL HEALTH DIVISION
DEPARTMENT OF OCCUPATIONAL SAFETY AND HEALTH
MINISTRY OF HUMAN RESOURCES
MALAYSIA**

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A. GENERAL GUIDELINES

1. NOTIFICATION TO THE DEPARTMENT OF OCCUPATIONAL SAFETY AND HEALTH

- 1.1 Before commencement of work at the work site, the contractor must notify the nearest Department of Occupational Safety and Health office through form JKJ 103 within seven days from the commencement of operations.
- 1.2 The following details should be submitted together with the application form:-
 - (i) organisation chart of the contractor's company;
 - (ii) projected work schedule;
 - (iii) detailed layout plans, sectional plans, and construction drawing of the tunnel;
 - (iv) details pertaining to the staff strength of the safety and technical personnel directly responsible for the site;
 - (v) list of machinery to be used;
 - (vi) ventilation design;
 - (vii) safe work procedures for all types of work involved;
 - (viii) medical facilities for workers working in the compression and decompression chambers;
 - (ix) details of air monitoring methods in working chamber, man-locks and medical locks and particulars pertaining to the appointed medical practitioner (Appendix 1 must be completed and submitted if work is carried out in compressed air); and
 - (x) emergency plan.
- 1.3 The contractor shall comply with the Factories and Machinery Act, 1967, the Occupational Safety and Health Act, 1994 and all the regulations made under them which are applicable to any aspect of tunnel construction.

2. SITE MANAGEMENT

- 2.1 The contractor must appoint a Safety and Health Officer (SHO) who should have overall responsibility for carrying out programmes on safety and health related to all operations and activities at the site.

- 2.2 Beside other duties prescribed under the Occupational Safety and Health (Safety and Health Officer) Regulations 1997 I the SHO should identify and set up appropriate permit-to-work systems to ensure that the necessary precautions are taken before risky work or work in a risky environment commences.
- 2.3 All hot work to be carried out underground should be approved by the SHO.
- 2.4 There should be established a proper system to control ingress and egress of personnel to and from tunnels under construction.

3. TRAINING

- 3.1 No workers should be deployed to work underground unless they have undergone a safety and health orientation programme to acquaint them with all the hazards associated with all the operations.
- 3.2 Any persons who are to be employed in a compressed air environment must undergo a specific orientation programme and must be given written information on the hazards associated with such work and the necessary precautions to be taken.
- 3.3. Special training should be conducted for man-lock and medical lock attendants.
- 3.4 Any persons handling medical equipment underground and at the shafts should undergo a safety and health orientation programme to ensure safety in the use of such equipment.
- 3.5 For a tunnelling operation where 25 or more employees have to work underground at anyone time, at least one rescue crew of 5 employees per shift must be trained in rescue procedures and resuscitation, the use, care and limitations of oxygen breathing apparatus, and the use and maintenance of fire fighting equipment.
- 3.6 For a tunnelling operation where less than 25 employees worker underground, not less than 5 employees must have such training in rescue work.
- 3.7 Suitable self-contained breathing apparatus should be made available at compressed air worksites. Any person working at these sites must be trained on the proper use of the breathing apparatus.

4. SAFETY MEASURES

- 4.1 Where workers are liable to be injured by falling or sliding material from the roof, face or wall of the tunnel, suitable measures such as shoring, spray-creating, use of rock bolts or other appropriate measures should be taken to ensure the safety of the workers.
- 4.2 All shores, segments, rock bolts, sets including horse-shoe shaped or arched or ribbed steel sets, should be designed and installed appropriately to ensure the stability of the excavated areas.

- 4.3 The roof, face and walls of the work area in a tunnel should be examined and tested at the start of each shift and at regular intervals thereafter to ensure that they are safe for the workers.
- 4.4 The stability of temporary supports such as shores, rock bolts etc. should be checked regularly.
- 4.5 The bolts should be tested at regular intervals determined by rock conditions and the distance from vibration sources.
- 4.6 All work areas should be adequately illuminated and the illumination level should not be less than 100 lux.
- 4.7 Emergency generators should be provided to ensure adequate illumination of the tunnel and other related workplaces in the event of a power failure. The generator should be located on the ground level.
- 4.8 Air that has passed through underground oil or fuel storage areas should not be used to ventilate working areas.
- 4.9 All mobile equipment used within a tunnel should be fitted with a dead man's or fail-safe handle.
- 4.10 Supply lines (to pneumatic tools) 20 mm (0.8") in diameter and above should be fitted with safety chains, and hoses of 50 mm (2") diameter and above should incorporate a safety wire secured at each connection. Water traps should be provided.

5. SHAFTS AND HOIST

- 5.1 Shafts should be properly lined. All openings at the top of shafts or other openings to a tunnel must be above the highest foreseeable water level. Surrounding protective banks must be constructed and maintained at a safe level and protected against being washed out.
- 5.2 Shafts of small diameter which workers are required to enter should be provided with steel casing, concrete pipe, timber shoring or other material of adequate strength to support surrounding earth.
- 5.3 The casing and bracing should be provided for the full depth of the shaft or at least 1.52 m (5 ft) into solid rock, and should extend at least 300 mm (1 ft) above ground level or to a sufficient height to prevent flood water from entering.
- 5.4 For any shaft over 20 m (65 ft) deep, a hoist should be used for the transport of men and materials. Reinforced concrete rafts or beams, spanning any sensitive area, should be provided if the ground resistance is locally inadequate.

6. COMMUNICATION AND ELECTRICAL FACILITIES

- 6.1 Effective and reliable means of communication such as bells, whistles or telephones should be maintained at all times at the following locations:-
- (i) The working chamber at the face of excavation and at intervals of 300 m (1000 ft);
 - (ii) The working chamber side of the man-lock near the door;
 - (iii) The interior of each chamber of the man-lock;
 - (iv) The lock attendant's station;
 - (v) The compressor plant; and
 - (vi) The first aid station.
- 6.2 Any code of signals used should be conspicuously posted near entrances to the workplaces and such other locations as may be necessary to bring them to the attention of all employees concerned.
- 6.3 Voltage levels to be used:-
- (i) For lighting and hand-held tools.
50 Hz 240 volts CTE (centre-tapped-earthed) system should be used. Portable electric hand tool, inspection lamp and lighting used in underground work areas or where compressed air work is carried out should be operated at a voltage not exceeding 50 volts between any conductor and the earth; and
 - (ii) All earthing requirements should comply with BS 7671.
- 6.4. Protection of electrical circuits:-
- (i) Current-operated earth leakage circuit breakers are to be installed in all distribution boards and their final sub-circuits. The sensitivity of such earth leakage circuit breakers should be in accordance with the following table:-

No.	Apparatus	Sensitivity of Current-Operated Earth Leakage Circuit Breaker
1	Portable/Hand-Held Tool	30 mA
2	Portable Lighting and Inspection Lamps	30 mA
3	Fixed Lighting	100 mA
4	Mobile Equipment and Apparatus	100 mA

- (ii) Moulded-Case Circuit Breakers and Miniature Circuit Breakers of the appropriate rating are recommended for use in all distribution boards. Semi-enclosed fuse units are prohibited.
- 6.5 Where compressed air work is carried out, dry-type transformers should be used. PCB type insulating medium should not be used.
- 6.6 Lighting:-
- (i) General lighting for normal work is to be powered by AC supply from a reliable power producer;
 - (ii) Emergency standby lighting of reduced level is to be powered by standby generators in the events of power failure and must be located on the ground level; and
 - (iii) Emergency exit light is to be powered by a battery pack of the nickel cadmium 8 type or others of a similar safe design. Such battery pack should be of sufficient capacity to sustain the exit light for at least 2 hours after failure of (i) and (ii) to guide the workers from the work areas.
- 6.7 Any exposed live high voltage conductor should not be present in any tunnel. When work is carried out in the vicinity of exposed live high voltage conductors, the following minimum clearances from such conductors to ground level or to areas which are accessible to workmen shall be:-
- | | | |
|------------------------|-----------------------|----------------------------------|
| 2.6 metres for 6.6 kV* | 2.8 metres for 22 kV* | * Voltage of the live conductor. |
|------------------------|-----------------------|----------------------------------|
- 6.8 All welding sets should be fitted with a voltage limiting device commonly known as a shock preventor. PCB type insulating medium should not be used.

7. RAIL HAULAGE

- 7.1 A minimum lateral clearance of 500 mm (20") should be maintained between any part of vehicle and any fixture or equipment after allowing for throw and swing.
- 7.2 The overhead clearance for locomotive drivers should not be less than 1.1 m (43") above the seat where the driver sits and not less than 2 m (6.5 ft) above the foot plate where the driver stands.
- 7.3 To provide protection for men on foot or those working adjacent to the track, high level platforms or timber recesses should be provided at suitable points.

8. DIESEL ENGINE

- 8.1 Diesel engines whether for haulage or other mobile equipment or for stationary plant should not be used unless adequate provision has been made for ventilation.

- 8.2 They should be so constructed that:-
- (i) no air enters the engines without first being cleaned;
 - (ii) no exhaust gases are emitted without first being cooled and diluted; and
 - (iii) no fumes or sparks are emitted by engines.

9. HYDRAULIC PLANT

- 9.1 Hydraulic oil whose flash point exceeds working temperatures likely to be encountered should be used under ground.
- 9.2 Only high temperature hose and coupling should be used and the lines should be properly protected.
- 9.3 Hydraulic lines working at temperatures exceeding 70°C should be protected by insulation or other screening against accidental human contact.

10. FIRE PROTECTION

- 10.1 Approved fire-resistant hydraulic fluids should be used in hydraulically actuated underground machinery and equipment.
- 10.2 Fully flameproof equipment should be used whenever there is danger of the presence of explosive gases.
- 10.3 The following should be provided in the medical lock:-
- (i) Wiring should be in conduits and lamp fitting should be of explosion proof type; and
 - (ii) No electric motor is to be used in the lock unless it is intrinsically safe.
- 10.4 Oil, grease or fuel stored underground should be kept tightly sealed in appropriate containers in a designated fire resistant area at a safe distance from explosives, magazines, electrical installations and shaft stations.
- 10.5 Gasoline or liquified petroleum gases or other highly flammable substances should not be stored or used underground unless the use of these has been approved by the SHO. They should be removed after use.
- 10.6 No oxy-acetylene should be used in a compressed air chamber. 10.7. All hoses, couplings, etc. should conform to BS 336: 1980.
- 10.8 Water for fire fighting should be available throughout the tunnel and the outlets should be located so as to be readily accessible.
- 10.9 Water supply should be sufficient in volume and pressure for the operation of fire hose and other equipment.

10.10 Fire service connections through air locks to be provided should include the following:-

- (i) One 75 mm Ø 21' (3" Ø) water supply pipe through lock with standard fire service 65 mm Ø 21' (2.5" Ø) instantaneous coupling -male coupling on the outside, female coupling on the inside;
- (ii) Water mains in the tunnels with fire service outlets at 61 m (200 ft) intervals, attached to one 30.5 m (100 ft) length of 40 mm Ø (1.6" Ø) hose or hose reels of sufficient length completed with suitable branch/nozzle;
- (iii) Airline connections through lock (three 12.7mm Ø [0.5" Ø] copper pipe) with suitable adaptors and extension tubes; and
- (iv) A fire alarm system connected to the surface site.

10.11 Dry chemical fire extinguishers should not be used in tunnels.

10.12 Fire Fighting Procedures and Fire Drill.

The contractor should:-

- (i) Display at a prominent position on the construction site the procedure to be followed in the event of an outbreak of fire and such procedures should be approved by the Director of Fire and Rescue Department;
- (ii) Ensure that every person employed in compressed air is familiar with the procedures referred to in sub-paragraph (i); and
- (iii) Hold a fire drill on the construction site not less than once every month during the duration of the construction work.

11. FLOODING

- 11.1 Where the driving of more than one tunnel takes places from a shaft, there should be provision for the installation of water tight bulkhead doors. (Strict procedures to be adopted to prevent trapping of men in isolated sections).
- 11.2 In areas where there is potential inundation, especially in the case of a descending tunnel, there should be provision for air tight steel curtains in the top half of the tunnel at appropriate intervals to ensure the retention of pockets of air within which men can survive until lost air pressure is restored or men rescued.

12. WELFARE

- 12.1 Adequate and suitable facilities should be provided and maintained for the use of persons employed in compressed air who are required to remain on the construction site for one hour after decompression from pressure exceeding 1 bar .
- 12.2 Where meals are taken in the working chamber or medical lock, cupboard space should be provided for food and drinks. All drinks should be kept in covered containers.

- 12.3 Every man-lock, medical lock and equipment therein should be maintained in a clean state.
- 12.4 First aid facilities should be provided and readily available at the construction site and at all man-lock attendant stations.

B. CONVENTIONAL TUNNELLING – HEALTH GUIDELINES

13. PERMISSIBLE EXPOSURE LIMITS

- 13.1 The exposure to airborne contaminants of an employee working in a tunnel or shaft should not exceed the exposure limits specified in Appendix 2.
- 13.2 Employees should be removed from any area in which there is an airborne contaminant at a concentration which exceeds the exposure limit for that contaminant.
- 13.3 Portable instruments should be provided to test the atmosphere quantitatively for carbon monoxide, hydrogen sulphide, nitrogen dioxide, flammable or toxic gases, dust or other toxic contaminants that occur in the tunnel or shaft. Tests should be conducted before each shift and once in every shift or more frequently where necessary to ensure that the required quality of air is maintained. A record of all tests should be maintained and be kept available for inspection.

14. VENTILATION

- 14.1 Tunnels should be mechanically ventilated in all work areas. The direction of airflow should be reversible.
- 14.2 The supply of fresh air should not be less than 5.7 m³/min. for each employee underground or the number of air changes every hour is not less than twenty.
- 14.3 The average linear velocity of the airflow in the tunnel bore should not be less than 9 m/min. in those tunnels where blasting or rock drilling is conducted or where there are other conditions that are likely to produce dusts, fumes, vapours, or gases in harmful quantities.
- 14.4 The atmosphere in all underground work areas should contain at least 20% oxygen by volume.
- 14.5 Where there is a possibility of oxygen deficiency, a test for oxygen deficiency should be conducted before each shift and at least once in 4 hours in all work areas in the tunnel or shaft. A record of all tests should be maintained and kept available for inspection.

C. COMPRESSED AIR WORK – SAFETY GUIDELINES

15. COMPETENT PERSONS FOR AIR SUPPLY PLANT

- 15.1 The contractor should appoint a suitably qualified or experienced person to be in charge of the air supply plant at a construction site.
- 15.2 A person appointed in clause 15.1 should at all times be:-
 - (i) in charge of the air supply plant, and
 - (ii) in attendance at the construction site, when any person is employed in compressed air at the construction site.
- 15.3 There should be also an experienced, competent and reliable person on duty at the, air control valves as a gauge tender who will regulate the pressure in the working areas.
- 15.4 In tunnelling operations, one gauge tender may take charge of the air control valves of not more than 2 headings provided the gauge and controls are in one location.
- 15.5 There should be a gauge tender for each caisson.

16. AIR SUPPLY PLANT

- 16.1 The air supply plant for the production and supply of compressed air to any man-lock, working chamber and medical lock should be of suitable design.
- 16.2 The air-intakes for all air compressors should be located as far as practicable at a place where fumes, exhaust gases and other air contaminants will be at a minimum. Gauges indicating the pressure, in the working chamber should be installed in the compressor building, the lock attendant station and at the contractor's site office.
- 16.3 All high and low pressure air supply lines should be equipped with check valves. Low pressure air should be regulated automatically and there must be provided manually operated valves for emergency conditions.

17. LOW AIR COMPRESSOR

- 17.1 The low air compressor plant should be of sufficient capacity to ensure that the work is carried out safely and should be provided with a margin of safety to cater to emergencies.
- 17.2 Low air compressor units should have at least 2 independent and separate sources of power supply and each should be capable of operating the entire low air plant and its ancillary systems.

- 17.3 Switching from one independent source of power supply to the other should be done periodically to ensure the workability of the apparatus in an emergency.
- 17.4 The air mains supplying the working chamber and air locks should be properly protected and, where failure could result in danger to the workings, should be duplicated.
- 17.5 Duplicate low pressure air feed lines and regulating valves should be provided between the source of air supply and a point beyond the lock with one of the lines extending to within 30 m (100 ft) of the working face.

18. BULKHEADS AND AIR LOCKS

- 18.1 All bulkheads and air-tight diaphragms retaining compressed air within a tunnel or shaft should be capable of carrying the full thrust of the compressed air at its maximum pressure.
- 18.2 If the bulkhead is across a tunnel, its anchorage into the tunnel walls should be fully adequate to support the total load and any air lock or other sealed aperture should be properly anchored into the bulkhead.
- 18.3 Tests should be conducted on air locks at working pressure before being put to use.
- 18.4 Bulkheads should be tested in situ at working pressure.
- 18.5 If the diaphragm takes the form of a horizontal air deck across a shaft, it should anchor sufficient mass to resist the thrusts by gravitational force alone and should not rely on the tensile strength of cast iron or concrete.
- 18.6 The deck should be designed to take all dead loads when the shaft is under pressure.
- 18.7 Air lock construction should conform with the following:-
 - (i) should have adequate strength to withstand any air pressure, internal or external, to which the structure may be subjected in use and in an emergency;
 - (ii) lock doors are to be of steel;
 - (iii) should be of adequate dimensions for the full number of men likely to use the lock at any time;
 - (iv) anchorage of the lock against the thrusts imposed by air pressures on the ends of the lock should be designed to carry all loads safely;
 - (v) air tightness for the lock itself and satisfactory devices should be provided for sealing the doors even at low pressures. The inner walls of the locks to be suitably treated to eliminate the escape of air; and
 - (vi) incombustible materials to be used as extensively as possible.

D. COMPRESSED AIR WORK – HEALTH GUIDELINES

19. AIR SUPPLY

- 19.1 The supply of compressed air to a working chamber should be sufficient to provide, at the pressure in the working chamber, not less than 0.3m³/min./person in the working chamber.
- 19.2 A reserve compressed air supply should be available for all man-locks and medical locks.
- 19.3 Where compressed air work is carried out, the air in any working chamber, man-lock, medical lock should be of the quality specified in Appendix 3.
- 19.4 Where compressed air is used, the temperature in any working chamber, man-lock or medical lock should not exceed 29°C.
- 19.5 A wet and dry bulb thermometer, in good working order, should be provided in every working chamber and the Jock attendant in charges should record the readings of the thermometer at the end of each shift in the Lock Attendant's Register (Appendix 4).

20. GENERAL MEASURES

- 20.1 Identification badges (yellow badges: an example IS shown in page 12) should be given to all employees, indicating that the wearer is a compressed air worker. A permanent record should be kept of all identification badges issued. The badge which should be worn at all times -off the job, as well as on the job -should contain the following information:
 - (i) employee's name;
 - (ii) address of the medical lock; and
 - (iii) the telephone number of the appointed medical practitioner for the compressed air project.It should also contain instructions that, in case of sudden illness or emergency of unknown or doubtful cause, the wearer should be rushed to the medical lock.
- 20.2 When no lock attendant is inside a man-lock or working chamber, the arrangements should be such as to enable any person employed in compressed air inside the man-lock or working chamber to control the doors of the man-lock or working chamber in order to leave or enter the working chamber in the case of emergency.
- 20.3 No person should consume alcohol whilst he is employed in compressed air.
- 20.4 No person under the influence of alcohol should undergo compression in any lock other than in a medical lock.

20.5 No person should smoke whilst he is employed in compressed air.

20.6 No person should will fully

(i) obstruct; or

(ii) delay; or

(iii) refuse

to follow any instruction given by a lock attendant or medical lock attendant in the course of his duties.

AN EXAMPLE OF THE IDENTIFICATION BADGE

Colour : YELLOW
Size : 35 mm x 40 mm
Material : Plastics (or hard board) with lamination and 5 mm hole for string.

FRONT

COMPRESSED AIR WORKER
Name:
<i>In case of sudden illness or emergency of unknown or doubtful cause, the wearer of this badge should be rushed to</i>
MEDICAL LOCK
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX (..... site address.....) Tel : xx-xxxxxxx
xxxxxxxxxxx SDN. BHD.

REVERSE

PEKERJA UDARA TERMAMPAT
Nama:
<i>Sekiranya berlaku sakit atau kecemasan tiba-tiba yang puncanya diragui atau tidak diketahui, pemakai lencana ini hendaklah dikejarkan ke</i>
SENDAT PERUBATAN
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX (.....alamat.....) T el: xx-xxxxxxx
xxxxxxxxxxxxxxxx SDN. BHD.

21. MAN-LOCKS

- 21.1 Every man-lock should be of adequate internal dimensions and capacity for the purposes for which it is used.
- 21.2 Where working pressure is greater than 1 bar, the Contractor should provide a three compartment man-lock of acceptable design for the unrestricted transfer of men to and from the working chamber.
- 21.3 When the pressure in a man-lock exceeds 1 bar, the man-lock should have a space of not less than 1.2m³ per person and a sitting space of not less than 0.6 m in width (with back support) per person.
- 21.4 Every man-lock should have an independent supply of fresh air which can be used for ventilation.
- 21.5 Every man-lock should be provided with suitable equipment including -
- (i) valves or taps controlling the flow of air into and from the man-lock so as to enable careful compression and accurate decompression to be carried out;
 - (ii) a clock or clocks so positioned that the lock attendant and any person in the man-lock can readily ascertain the time;
 - (iii) pressure gauges which will readily indicate-
 - (a) to the lock attendant the pressure in the man-lock and in each working chamber to which the man-lock affords direct or indirect access;
 - (b) to persons in the man-lock the pressure in the man-lock; and
 - (iv) a pressure recording gauge accurate to within 0.05 bar if the working pressure exceeds 1 bar.
- 21.6 A notice which can be easily read and understood by the workers, indicating -
- (i) the precautions to be taken by persons during their compression or decompression and after decompression; and
 - (ii) the maximum number of persons who may normally be accommodated in the man-lock.
- should be affixed in each man-lock.
- 21.7 All furniture and equipment in a man-lock should be incombustible or of fire-proof material.
- 21.8 When the pressure in a working chamber exceeds 1 bar, the man-lock should be used solely for the compression or decompression of persons.
- 21.9 No person should be employed in compressed air unless -
- (i) he has had previous experience of such work; or
 - (ii) if he has not had such experience, he is accompanied by a person experienced in such work.

22. COMPRESSION AND DECOMPRESSION

- 22.1 Compression of all persons in the man-lock should be carried out according to the compression procedures in Appendix 5.
- 22.2 Decompression of all persons to normal conditions should be in accordance with a decompression procedure and should be carried out under supervision of the appointed Medical Practitioner.
- 22.3 Where a person in a man-lock collapses or is taken ill during decompression, the lock attendant in charge should raise the pressure in the working chamber and should report the matter immediately to the medical lock attendant on duty. The lock attendant should then follow the instruction of the medical lock attendant or the appointed medical practitioner on duty.

23. WORK IN PRESSURES EXCEEDING 1 BAR

- 23.1 Generally, no person should be employed in compressed air at a pressure exceeding 1 bar on more than 3 occasions in any 24-hour period.
- 23.2 Paragraph 23.1 will not apply:-
 - (i) in the case of an emergency where the employer authorises that any person may be so employed on more than 3 occasions in any 24-hour period, in which case the employer should keep a record signed by him of such employment and particulars of the emergency.
 - (ii) to a person who is a supervisor or is engaged on maintenance work provided that –
 - (a) such person should not be so employed on more than 5 occasions in any 24-hour period;
 - (b) such employment is not for more than half an hour on any 1 occasion;
 - (c) there is an interval of not less than 1 1/2 hours between each such employment; and
 - (d) the maximum pressure at which such person is so employed does not exceed 2 bars.
- 23.3 A person who is employed in compressed air at a pressure exceeding 1 bar should spend not less than 12 consecutive hours at atmospheric pressure in any 24-hour period.
- 23.4 Except in the case of an emergency, no person should be employed in compressed air at a pressure exceeding 3.4 bars without permission from the appointed Medical Practitioner.

- 23.5 When the working pressure exceeds 1 bar, the duration of the shift work in compressed air for a new starter (including those who have not been employed in compressed air for more than 14 days previously) should be gradually increased from 4 hours on the first day by one hour each day until the full shift time is reached.

24. MEDICAL LOCKS

- 24.1 Where persons are employed in compressed air in a working chamber, a suitably constructed medical lock should be provided and maintained.
- 24.2 Where more than 100 persons are so employed, a medical lock should be provided for every 100 persons or part thereof.
- 24.3 Every medical lock should be situated as near as possible to the man-lock.
- 24.4 Every medical lock should -
- (i) have not less than 1.8 m clear headroom at its highest point;
 - (ii) have 2 compartments so that it can be entered while under pressure;
 - (iii) have efficient means of verbal communication, and means of giving non-verbal signals, between persons inside and outside the medical lock and between persons in compartments of the medical lock;
 - (iv) have one or more windows through which any person in either compartment of the medical lock can be observed from the outside;
 - (v) be adequately ventilated;
 - (vi) be protected from the weather and the sun;
 - (vii) have adequate lighting.
- 24.5 Every medical lock should be provided with suitable equipment including:-
- (i) a pressure recording gauge, which should be accurate to within 0.05 bar;
 - (ii) if a circular recording chart is used it should rotate at a speed of not less than once in 4 hours;
 - (iii) a couch not less than 1.8 meters in length.
- 24.6 A medical lock should not be used for any purpose other than a therapeutic purpose, but it may be used:
- (i) for training and testing of persons without previous experience of compressed air work; or
 - (ii) in case of an emergency.
- 24.7 A medical lock should, at all times, be kept ready for immediate use.

- 24.8 External lighting should be used; however, if internal wiring is necessary, then such wiring should be of mineral insulated copper cable protected by stainless-steel) tubing complying with British Standard 6207 or equivalent standards.
- 24.9 All spark-or arc-creating devices such as switches, standard light bulbs, and standard electrical outlets should not be used within a medical lock.
- 24.10 A medical lock is an air receiver. It should be tested and registered by Department of Occupational Safety and Health.
- 24.11 A medical lock should be capable of withstanding a pressure of not less than 100 kNm² above the maximum pressure used or likely to be used in the chamber at any time.

25. MAN-LOCK AND MEDICAL LOCK ATTENDANTS

- 25.1 Every man-lock or medical lock should be under the charge of a lock attendant or medical lock attendant respectively.
- 25.2 There should be not less than 3 man-lock or medical lock attendants available for duty in respect of each man-lock or medical lock, respectively.
- 25.3 No man-lock or medical lock attendant should be on duty for more than 12 hours in any 1 shift.
- 25.4 All man-lock and medical lock attendants should:
 - (i) be medically fit;
 - (ii) be willing to go into compressed air at any working pressure;
 - (iii) be trained in first aid; and
 - (iv) have completed a suitable training course designed to familiarise them with the problems associated with compression, decompression and compressed air illness and with the keeping of records.
- 25.5 The man-lock attendant should be in attendance at the man-lock at all times when any person is employed in compressed air in the man-lock or in a working chamber to which the man-lock affords direct or indirect access.
- 25.6 The medical lock attendant should be in attendance at the medical lock:-
 - (i) whilst any person is employed in compressed air at a pressure exceeding 1 bar. ,
 - (ii) whilst any person is being treated in the medical-lock; and
 - (iii) for 24 hours after the last man-lock decompression from a pressure exceeding 1 bar has taken place.
- 25.7 A medical lock attendant should, when on duty, have immediate access to all records of pressures and other relevant information regarding conditions in the man-lock and working chamber.

26. DUTIES OF MAN-LOCK ATTENDANTS

- 26.1 The lock attendant in charge of a man-lock should :-
- (i) control the compression of all persons in the man-lock;
 - (ii) carry out the compression of all such persons according to the compression procedure in Appendix 5;
 - (iii) control the decompression of all persons who have been employed in compressed air; and ;
 - (iv) where a person has been employed in compressed air at a pressure exceeding 1 bar, carry out the decompression of the person according to a decompression procedure set up by the appointed Medical Practitioner.
- 26.2 Where any person is employed in compressed air in a working chamber, the lock attendant in charge should:-
- (i) record in the Lock Attendant's Register (Appendix 4) all the particulars specified therein in respect of that person; and
 - (ii) keep in his custody the Lock Attendant's Register and any man-lock decompression chart and give them to the medical practitioner.
- 26.3 Where a person is employed in compressed air at a pressure exceeding 1 bar on more than 1 occasion in any 12-hour period, the lock attendant in charge shall ensure that such person carries a properly completed Compressed Air Worker's Transfer Record (Appendix 6).
- 26.4 The employer should ensure that the lock attendant in charge of a man-lock complies with paragraphs 26.1 -26.3.

27. APPOINTMENT OF MEDICAL PRACTITIONERS

- 27.1 Where any construction work in compressed air is carried out, the employer should appoint a medical practitioner to supervise all medical matters which may arise in connection with the construction work.
- 27.2 The appointed medical practitioner should be:-
- (i) suitably qualified and conversant with the problems associated with work in compressed air and the medical aspects of such work;
 - (ii) conversant with the provisions of these guidelines,
 - (iii) medically fit;
 - (iv) willing go to into compressed air at any working pressure; and
 - (v) on call at all times when construction work in compressed air is in progress.

- 27.3 The appointed medical practitioner should:-
- (i) examine medically persons for fitness for employment in compressed air;
 - (ii) supervise medical lock attendants;
 - (iii) treat compressed air illness and other conditions; and
 - (iv) supervise the keeping of :-
 - (a) all compressed air workers' medical information, including the Compressed Air Workers' Medical Records (Appendix 7);
 - (b) the compressed air workers' Compressed Air Illness Notification Form (Appendix 8);
 - (c) the compressed air workers' individual records (Appendix 9); and
 - (d) ensure that all the above records are readily available for submission to the Department of Occupational Safety and Health when required.

28. MEDICAL SUPERVISION AND CERTIFICATION

- 28.1 No person should be employed in compressed air unless he has been examined by an appointed medical practitioner and certified by him to be fit for such employment.
- 28.2 In the case of a person who:-
- (i) is a new starter, the examination for certification of fitness should be carried out not more than 3 days prior to work in the compressed air;
 - (ii) is not a new starter and who continues to be employed in compressed air at a working pressure not exceeding 1 bar, the examination for certification of fitness should be carried out not less than once in every 3 months;
 - (iii) is not a new starter and who continues to be employed in compressed air at a working pressure exceeding 1 bar, the examination for certification of fitness should be carried out not less than once in every 4 weeks.
- 28.3 A person who is required to be employed in compressed air and who is suffering from a cold in the head, chest infection, sore throat or earache should report the matter to the appointed medical practitioner and the medical practitioner should recommend to the safety officer whether he is fit to work or not.
- 28.4 Any person suffering from a cold in the head, chest infection, sore throat, earache or any other illness or injury necessitating absence from work for more than 3 consecutive days should be re-examined by an appointed medical practitioner and certified by him to be fit for employment in compressed air before he resumes such employment.

- 29.1 Every person employed in compressed air at a pressure exceeding 1 bar should undergo a radiographic examination of his major joints within 4 weeks after starting such employment, unless the person has had such an examination during the 12 months immediately preceding such employment.
- 29.2 Every person who continues to be employed in compressed air at a pressure exceeding 1 bar should undergo such an examination at intervals of about but not more than 12 months.
- 29.3 These radiographic examinations should be arranged by the appointed medical practitioner with the approval of the contractor or employer and the cost of the examination should be borne by the contractor or employer.
- 29.4 The appointed medical practitioner should enter the particulars of such radiographic examinations in the Compressed Air Worker's Medical Record (Appendix 7)
- 29.5 Every person employed or proposed to be employed in compressed air should submit himself for the necessary medical examinations.

30. MAINTENANCE OF RECORDS

- 30.1 The employer should maintain a register of all persons employed in compressed air. Such a register should include the following particulars of the person's:
 - (i) name;
 - (ii) identity card or work permit number;
 - (iii) date of birth;
 - (iv) nationality;
 - (v) home address; and
 - (vi) occupation.
- 30.2 The contractor or employer should keep copies of the completed Appendices 4, 7 and 9 in his possession for 5 years.
- 30.3 The employer should make available a copy of all medical records of that particular person employed in compressed air on termination of his employment.

APPENDIX 1

DETAIL OF MONITORING

1. AIR MONITORING

(a) Particulars of person in charge of air monitoring (attach curriculum vitae)

(i) Name: _____

(ii) Qualifications: _____

(iii) Experience in conducting air monitoring: _____

(b) Air contaminant to be monitored:

No.	Name of Contaminant	Method of Sampling	Method of Sampling
1	Hydrogen Sulphide		
2	Carbon Monoxide		
3	Carbon Dioxide		
4	Oil Mist		
5	Other toxic impurities e.g dusts and fumes		

MAN AND MEDICAL LOCKS AND APPOINTED DOCTOR

1. LOCKS

(a) Details of Locks

Type of Lock	Number of Locks	Dimensions
Man-lock(s)	mØ xLength
Medical-lock(s)	mØ xLength

2. LOCK ATTENDANTS

(i) Details of Man-Lock Attendants

Name of man-lock attendant	
Training background	
Experience in handling man-locks	

(ii) Details of Medical-Lock Attendants

Name of medical-lock attendant	
Details of training	
Detail of experience in handling medical-locks	

2. MAXIMUM WORKING PRESSURE

Maximum working pressure for the following locks:-

- (i) man-lock kPa
- (ii) medical-lock kPa
- (iii) working chamber kPa

4. APPOINTED MEDICAL PRACTITIONER (S):

- (a) Name(s) : _____
- (b) Address of Practice : _____
- (c) Qualifications : _____

- (d) Training and-experience in compressed air illness problems:

APPENDIX 2

PERMISSIBLE EXPOSURE LIMIT

Substance	ppm ^b	Mg/m ^{3c}
GAS, VAPOUR, FUME AND MIST		
Acrylamide	-	0.3
Ammonia	25	17
Asphalt fumes	-	5
Benzene	10	32
Butane	800	1900
Calcium hydroxide	-	5
Calcium oxide	-	2
Carbon dioxide	5000	9000
Carbon monoxide	25	29
Carbon tetrachloride	5	31
Chlorine	0.5	1.5
Coal tar pitch	-	0.2
Gasoline	300	890
Hydrogen cyanide	4.7	5 ^d
Hydrogen sulphide	10	14
Lead	-	0.15
LPG(Liquefied Petroleum Gas)	1000	1800
Nitric oxide	25	31
Nitrogen dioxide	3	506
Nitroglycerin	0.05	0.46
Ozone	0.1	0.2
Phosgene	0.1	0.4
Sodium hydroxide	-	2
Sulphur dioxide	2	5.2
Sulphuric acid	-	1
Trinitrotoluene (TNT)	-	0.5
Welding fumes	-	5

Substance	ppm ^b	Concentration
Zinc chloride fume	-	1
Zinc oxide fume	-	5
DUST (OTHER THAN MINERAL DUST)		
Asbestos		
Amosite		1 fibre/ml
Chrysotile or other forms		1 fibre/ml
Fluorides		2.5 mg/m ³
MINERAL DUST		
Cement		10 mg/m ³
Nuisance particulates (e.g. calcium carbonate gypsum)		
Total dust		10 mg/m ³
Respirable dust		10 mg/m ³

Note:

- Permissible Exposure Limits refer to the time weighted average concentrations of airborne chemical substance for an 8-hour workday, to which workers can be repeatedly exposed without adverse health effects.
- Parts of vapour or gas per million parts of contaminated air by volume at 25°C and 760 mm Hg pressure.
- Approximate milligrams of substance per cubic metre of air.
- Capital letter C denotes ceiling limit which is the concentration that should not be exceeded even instantaneously.

APPENDIX 3

QUALITY OF COMPRESSED AIR IN WORKING CHAMBER

MAN-LOCK AND MEDICAL LOCK

Carbon monoxide	not more than 10 parts per million
Carbon dioxide	not more than 500 parts per million
Oil	not more than 1 mg/m ³
Odour and cleanliness	As far as is practicable, the air should be free from all odour and contamination by dust, dirt, and metallic particles and should not contain any other toxic substance.

APPENDIX 4

LOCK ATTENDANT'S REGISTER

Date : _____

Dry Bulb Temperature : _____ / _____ / _____

Wet Bulb Temperature : _____ / _____ / _____

Construction Site : _____

Name of Lock Attendant : _____

Name of Worker	NRIC/Work Permit Number	Date & Time of Last Decompression	Compression		Maximum Working Pressure	Time in Working Chamber		Decompression		
			Times of entry into working chamber	Working Pressure		Hour	Min	Time decompression commenced	Time decompression finished	Decompression time

The time recorded on this Form must be taken from the clock provided for the use of the man-lock attendant.
Record all times as a.m or p.m

APPENDIX 5

COMPRESSION PROCEDURE

1. Every employee going under air pressure for the first time should be instructed on the precautions to take during compression.
2. During the compression of employees, the pressure should not be increased to more than 0.2 bar within the first minute. The pressure should be held at 0.2 bar and again at 0.5 bar sufficiently long to determine if any employees are experiencing discomfort.
3. After the first minute the pressure should be raised uniformly and at a rate not to exceed 0.7 bar per minute.
4. If any employee complains of discomfort, the pressure should be held to determine if the symptoms are relieved. If, after 5 minutes the discomfort does not disappear, the man-lock attendant should gradually reduce the pressure until the employee signals that the discomfort has ceased. If he does not indicate that the discomfort has disappeared, the man-lock attendant should reduce the pressure to atmospheric and the employee should be released from the lock and required to report to the medical lock attendant.

APPENDIX 6

COMPRESSED AIR WORKER'S TRANSFER RECORD

Name of Lock Attendant : _____

NRIC/Work Permit No : _____

Date	Lock No. or Description		Pressure							Total decompression time in minutes	Lock Attendant's Signature
	When Entering	When leaving (if different)		Hour	Mins	Hours	Mins	Hours	Mins		

This record is to be retained by the person to whom it is issued. Entries are to be made by the man-lock attendant who shall also make the necessary entries in the Lock Attendant's Register (Appendix 4)

APPENDIX 7

COMPRESSED AIR WORKER'S MEDICAL RECORD

This Form should be completed by the appointed medical practitioner in respect of a compressed air worker within 8 weeks after starting to be employed in compressed air work.

Name of Worker :	Date of Birth :	Sex :	Race :	
NRIC No: _____				
Residential Address: _____ _____				
Name & Address of Employer: _____ _____				
Contact No: _____				
Date Employed: _____				
Previous Compressed Air Experience:				
Employer	Dates (From/To)	Maximum Working Pressure	Any Compressed Air Illness (Type I/II)	Radiographic examination results and dates

(1) MEDICAL HISTORY

Ever declared unfit for employment in compressed air? YES / NO

Currently on any drugs or medication? YES / NO

Operations : _____

Injuries : _____

Bronchitis	Yes/No	Asthma	Yes/No	Hay fever	Yes/No
Sinusitis	Yes/No	Ear trouble	Yes/No	Tuberculosis	Yes/No
Hernia	Yes/No	Fits	Yes/No	Psychiatric disorders	Yes/No
Heart trouble	Yes/No	Hypertension	Yes/No		
Peptic ulcer problem	Yes/No	Bone/joint disease	Yes/No	Diabetes	Yes/No

(2) MEDICAL EXAMINATION

Height (Standing, without shoes) : _____ cm

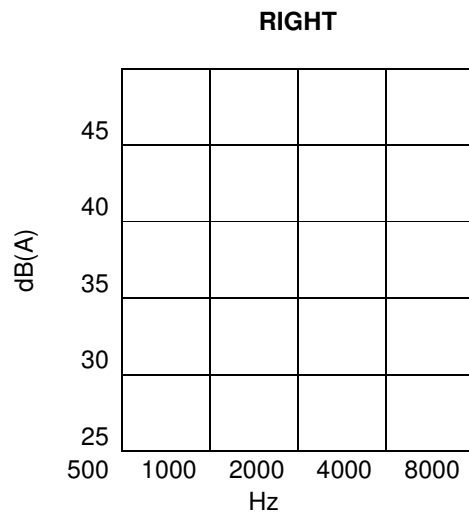
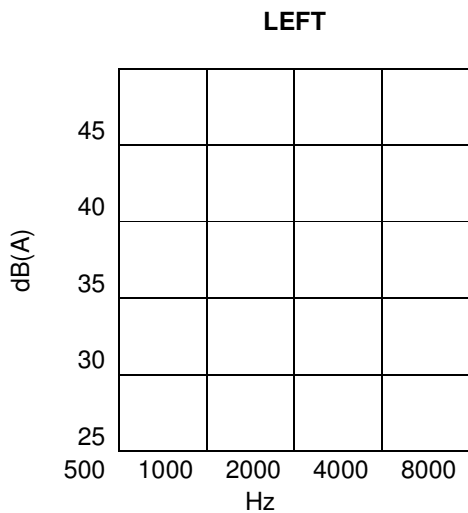
Weight (In light clothing, without shoes; using beam or lever scale) : _____ kg

Body fat: _____ %

Heart : _____ Pulse: _____ Blood Pressure : _____

Lungs : _____ Joints : _____

Ears: _____ Nose: _____ Sinuses : _____



Abdomen: _____ Nervous system : _____

Hb: _____ PBF: _____

ECG (if indicated) : _____

Sickle cell trait (if indicated) : _____

Urine: Glucose: _____ Blood: _____ Protein: _____

(3) RADIOGRAPHIC EXAMINATION

Chest X-ray : _____ Date of examination : _____

Normal/Abnormal *
If Abnormal, attach a copy of report.

Skeletal X-ray : _____ Date of examination : _____
(including shoulder, hip
and knee joints)

Normal/Abnormal *
If Abnormal, attach a copy of report.

(4) TEST IN LOCK : _____

(5) Fit for employment in compressed air : YES / NO

Remarks :

Doctor's name & signature

(6) ADD ANY FURTHER NOTES OR EXAMINATION RESULTS WITH DATES :

<u>Date</u>	<u>Examination (give details)</u>	<u>Remarks</u>
-------------	-----------------------------------	----------------

* Delete if not applicable.

APPENDIX 8

COMPRESSED AIR ILLNESS NOTIFICATION FORM

This form should be completed by the appointed medical practitioner in respect of a compressed air worker whom he believes to be suffering from compressed air illness and forwarded to the Director General of Occupational Safety and Health, Floor 22, Wisma KWSSG, Jalan Kampong Attap, 50534 Kuala Lumpur. This Form should accompany the Third Schedule of the Factories and Machinery Act 1967 (refer to Section 32).

Name of Employer: _____ Date Employed : _____
/ Contract No.

Full name of worker: _____ NRIC/
Work Permit No : _____

Occupation: _____ Activity : Manual/Supervisory/Sedentary

Maximum working pressure : _____

If multiple exposure, how many? _____

Total exposure time : _____

Was decompressed according to approved tables? YES / NO

New starter: YES / NO

"Cold" infection: Head or chest YES / NO

Onset of Symptoms after decompression : _____ minutes/hour (Date: _____)

TYPE I (BENDS)

Site of pain : _____

Any signs of symptoms other than pain (skin mottling or irritation) : 1

TYPE II (If Yes, tick in appropriate box for details)

Neurological:

- | | | |
|---|-------------------------------------|--------------------------------------|
| <input type="checkbox"/> Unconsciousness | <input type="checkbox"/> Drowsiness | <input type="checkbox"/> Headache |
| <input type="checkbox"/> Vertigo | <input type="checkbox"/> Tinnitus | <input type="checkbox"/> Convulsions |
| <input type="checkbox"/> Visual disorders | | |
| <input type="checkbox"/> Paralysis (Indicate site or level) : | _____ | |
| <input type="checkbox"/> Loss of sensation (Indicate site or level) : | _____ | |

APPENDIX 9

COMPRESSED AIR WORKER'S INDIVIDUAL RECORD

PART 1 : GENERAL

This form should be completed by the appointed medical practitioner in respect of a compressed air worker.

Period under consideration : _____ to _____

Name of worker : _____ NRIC/Work Permit No : _____

Name & Address of Employer : _____

Date employed : _____ Date left employment : _____
(if applicable)

Shift worker : YES / NO *

PART II : SUMMARY

Compressed Air Work Record during month considered :

Maximum Working Pressure : _____

Total number of decompressions from : _____

Number of direct (conventional) decompression from :

(a) WP < 1.9 bars : _____

(b) WP > 1.9 bars : _____

* Delete if not applicable
WP : Working Pressure

Bladder deficit

Bowel deficit

Cardio-Respiratory:

Yes / No

Substantial discomfort/Chest pain

Breathlessness

CO

Abdominal:

Yes / No

Pain (Indicate site) : _____

Diarrhoea

Systemic:

Yes / No

Fatigue / Malaise

Fever

Nausea / vomit

Other symptoms : _____

TREATMENT

Time commenced: _____ Time completed : _____

Pressure or relief: _____ Highest pressure used: _____

Method of decompression : _____ Number of decompressions : _____

Residual symptoms : _____

Fit for employment in compressed air again: Yes / No

Evidence of recurrence after leaving medical center: Yes / No

Signature of notifying doctor

For decompressions resulting in compressed air illness symptoms, give the following details :

Date	Maximum Working Pressure	Symptoms Type I / Type II	Number of Therapeutic Compressions Required

TYPE III : DETAILED RECORDS

Name of Worker : _____

NRIC/Work Permit No : _____

Date	Length of Shift	Maximum Working Pressure	Compressed Air Illness		Symptom Not Treated
			Type I	Type II	

APPENDIX 10

PRESSURE AND CONVERSION

1. All pressure quoted in this guidebook are gauge pressure.
2. The conversion factors are :

1 bar	=	105 N/m ²	1 bar	=	14.5 psi
1 m	=	3.281 ft	1 ft	=	0.3048 m
1mm	=	0.03937	1 in	=	25.4 mm