PERSONAL PROTECTIVE EQUIPMENT
(Part-II : Respiratory Equipment)

Prepared by:

Committee on “Personal Protective Equipment”

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Preamble

Indian petroleum industry is the energy lifeline of the nation and its continuous performance is essential for sovereignty and prosperity of the country. As the industry essentially deals with inherently inflammable substances throughout its value chain – upstream, midstream and downstream – Safety is of paramount importance to this industry as only safe performance at all times can ensure optimum ROI of these national assets and resources including sustainability.

While statutory organizations were in place all along to oversee safety aspects of Indian petroleum industry, Oil Industry Safety Directorate (OISD) was set up in 1986 Ministry of Petroleum and Natural Gas, Government of India as a knowledge centre for formulation of constantly updated world-scale standards for design, layout and operation of various equipment, facility and activities involved in this industry. Moreover, OISD was also given responsibility of monitoring implementation status of these standards through safety audits.

In more than 25 years of its existence, OISD has developed a rigorous, multi-layer, iterative and participative process of development of standards – starting with research by in-house experts and iterating through seeking & validating inputs from all stake-holders – operators, designers, national level knowledge authorities and public at large – with a feedback loop of constant updation based on ground level experience obtained through audits, incident analysis and environment scanning.

The participative process followed in standard formulation has resulted in excellent level of compliance by the industry culminating in a safer environment in the industry. OISD – except in the Upstream Petroleum Sector – is still a regulatory (and not a statutory) body but that has not affected implementation of the OISD standards. It also goes to prove the old adage that self-regulation is the best regulation. The quality and relevance of OISD standards had been further endorsed by their adoption in various statutory rules of the land.

Petroleum industry in India is significantly globalized at present in terms of technology content requiring its operation to keep pace with the relevant world scale standards & practices. This matches the OISD philosophy of continuous improvement keeping pace with the global developments in its target environment. To this end, OISD keeps track of changes through participation as member in large number of International and national level Knowledge Organizations – both in the field of standard development and implementation & monitoring in addition to updation of internal knowledge base through continuous research and application surveillance, thereby ensuring that this OISD Standard, along with all other extant ones, remains relevant, updated and effective on a real time basis in the applicable areas.

Together we strive to achieve NIL incidents in the entire Hydrocarbon Value Chain. This, besides other issues, calls for total engagement from all levels of the stake holder organizations, which we, at OISD, fervently look forward to.

Jai Hind!!!

Executive Director

Oil Industry Safety Directorate
FOREWORD

The Oil Industry in India is over 100 years old. For historical reasons, the industry has adopted different international standards and codes of practice in the various organisations. With a view to standardise the practices in the oil industry (and particularly in areas of safety), the Ministry of Petroleum and Natural Gas constituted in 1986 a Safety Council assisted by the Oil Industry Safety Directorate (OISD) to formulate and implement a series of self-regulatory measures aimed at removing obsolescence, standardising and upgrading existing standards to ensure safer operations. Accordingly, OISD constituted a number of functional committees comprising experts nominated from industry to draw up standards and guidelines on various subjects.

The present standard on Personal Protective Equipment (in two parts) was prepared by the Functional Committee on Personal Protective Equipment based on industry experience and on various national and international standards and codes of practice. It is meant to serve as a user’s guide and is, in no way, a substitute for existing standards and manufacturer’s recommendations. It is hoped that this standard will help industry personnel select the appropriate PPE and use as also maintain them in the right way.

1. Part-I : Non-respiratory PPE
2. Part-II : Respiratory PPE

Suggestions for improving the standard are invited from users after it is put into practice. These may be addressed to:

The Member Co-ordinator
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These documents are intended only to supplement and not to replace the prevailing statutory requirements.
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In addition to the above, several other experts from industry contributed in the preparation, review and finalisation of this document.
# PERSONAL PROTECTIVE EQUIPMENT

## PART - II

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PERSONAL PROTECTIVE EQUIPMENT
PART – II

11.0 INTRODUCTION

The cardinal principal in controlling an unsafe condition is to remove the hazard. This can be achieved through better design, change of process or guarding by mechanical means.

In spite of care taken to design safety into all systems and operations in the oil industry, the risk of failure of engineering controls, materials, equipment and even that of safety devices cannot be fully eliminated. There are also some operations and situations like welding, cutting etc., where engineering controls are not feasible and use of personal protective equipment is made regularly. The use of personal protective equipment can, in such situations, do one or more of the following:

- Reduce risk of dangerous occurrences (e.g. safety belts).
- Provide a physical barrier between the user and hazard (e.g. apron, face shield).
- Render a hostile environment friendly albeit for limited period of time (e.g. breathing apparatus).

It is of course of primary importance that personal protective equipments are carefully selected and maintained. Improper selection, use and maintenance of personal protective equipment can only endanger the life of the user. The limitations of each equipment should be clearly understood and personnel should also be thoroughly trained in the right use of personal protective equipment.

Keeping this in mind, these standard guidelines are prepared for selection, use and maintenance of PPE. This standard has been divided in two parts for convenience of users i.e.

1. Part-I : Non Respiratory Personal Protective Equipment
2. Part-II : Respiratory Personal Protective Equipment

12.0 SCOPE

This part of the standard is intended to be a guide for the use of respiratory protective equipment in oil and gas industries. It describes various types of respiratory personal protective equipment, discusses the factors affecting the selection of such devices and includes guidelines for their use and maintenance. It also highlights the limitations of these equipments.

13.0 DEFINITIONS

13.1.1 Atmospheres or Conditions Immediately Dangerous to Life

These are the conditions which pose an immediate threat to health and life because of the presence of a toxic substance or because of oxygen deficiency or high temperature and include conditions which pose an immediate threat of severe exposure to contaminants such as radioactive material which are likely to have adverse delayed effects on health.

13.1.2 Atmospheres or Conditions Not Immediately Dangerous to Life or Health

These are the conditions which may produce discomfort immediately or chronic type of poisoning or affect after repeated exposures or acute diverse physiological symptoms after prolonged exposure.

13.1.3 Inhaled Air – The atmosphere breathed-in by the wearer.
13.1.4 Exhaled Air – The atmosphere breathed-out by the wearer.

13.1.5 Working Duration – The maximum period of time for which the apparatus should be used.

13.1.6 Effective Duration – The period of time for which the apparatus can be expected to function satisfactorily. This time will be equal to the working duration plus a reserve period of at least 10 minutes for apparatus of less than 45 minutes working duration and 15 minutes for working durations between 45 and 75 minutes. For apparatus with a working duration of more than 75 minutes, the reserve period shall be at least 20% of the working duration or 30 minutes, whichever is less.

13.1.7 Nominal Working Duration – The period of time in minutes arrived at by dividing the fully charged capacity of the cylinder in litres by 32 (that is, assuming an air flow of 32 lpm), less the reserve period in minutes.

Note – An air flow of 32 lpm is appropriate to the work rate of a man walking at a steady speed of 6.5 km/h. In practice, the time, for which protection is afforded, may be longer or shorter than the nominal working duration and will depend upon the work rate and physical characteristics of the wearer. In addition, the duration will be reduced if the apparatus is used for working in environment where the pressure is above atmospheric pressure.

13.1.8 Nominal Effective Duration – The nominal working duration plus a reserve period of at least 10 minutes.

Note – For marine use, the storage capacity of the cylinder or cylinders attached to the apparatus and carried by the wearer shall be at least 1200 litres of free air.

13.2 Breathing Apparatus

There are two main types of breathing apparatus:

13.2.1 Self-Contained Breathing Apparatus – This enables the wearer to breathe independently of the surrounding atmosphere, using a supply of air or oxygen from a cylinder or other container which is an integral part of the apparatus. There are two types of self-contained breathing apparatus:

i) Open Circuit type Breathing Apparatus Compressed air or oxygen, carried in cylinders, is led through a demand valve and a breathing tube to a face piece. Exhaled air passes through a non return valve to the atmosphere.

ii) Closed Circuit Type Breathing Apparatus – Exhaled air passes from mouth piece or face through a breathing tube into a purifier containing chemicals which absorbs the exhaled carbon dioxide. Oxygen is fed into the breathing circuit from a cylinder of compressed oxygen, from a liquid oxygen/air container or from chemical compounds contained in a canister. The oxygen and purified gases are mixed and fed to the wearer. The wearer inhales from a breathing bag & excess air, if any, is released through a relief valve.

13.2.2 Airline Breathing Apparatus – There are two types of air-line breathing apparatus, which are distinguished by different methods of air supply.

i) Fresh Air Use (short distance) apparatus – This consists of a mouth piece or a face piece with a valve system, connected by an air hose to uncontaminated air which is drawn through the hose by the breathing action of the wearer. The air supply may be assisted by a hand or mechanically operated blower or bellows.

ii) Compressed Air-Line apparatus – This consists of a face piece, airhood or similar device connected by an air-line through a regulating valve to a source of compressed air.

iii) Air Hood or Blouse – This consists of a hood of rigid or flexible material completely covering the head, neck and portions of the shoulders or upper part of the body.
iv) Escape Gas Mask – An equipment consisting of a half mask face piece or mouth piece, canister and associated connections designed for escape only from atmospheres containing harmful contaminants.

13.3. Breathing Bag – A device to provide an adequate reserve of air or oxygen for inhalation.

13.4 Breathing Tube – A flexible, corrugated, nonkinking tube through which air or oxygen is carried to the face piece, helmet or hood.

13.5 Cartridge – A filter kept in a container which removes or renders innocuous limited concentrations of certain gases or vapours.

13.6 Contaminant, Atmospheric – any substance, either gaseous or particulate, which is not a constituent of the normal atmosphere.

13.7 Detachable Coupling – A device by means of which the wearer, without using hand tools, may quickly detach the respirator from the air supply source.

13.8 Disinfection – The treatment of respirators for removal of pathogenic organisms, by use of chemical substances or other means.

13.9 Dusts – Solid particles dispersed in a gaseous medium as a result of the disintegration of matter. The particle size of dusts which remain suspended for a very long time is between 0.5 to 10 microns.

13.10 Dust, Toxic – Dust which may be harmful to the respiratory system or to the other parts of the body after passing from the respiratory tract into the blood stream.

13.11 Eye Piece of Respirator – A gas tight, transparent visor in a full face or a hood through which the wearer can see.

13.12 Face Piece of Respirator – That portion of the respirator which covers the wearer’s nose and mouth in a half mask face piece; or nose, mouth and eyes in full mask face piece. It is designed to give a gas tight or dust-tight fit with the face and includes head bands, exhalation and inhalation valve(s) and connections for air-purifying device or respirable air source or both.

13.13 Filter – A fibrous medium (canned or uncanned) used in respirator for removal of solid or liquid particles from the air stream entering the respirator enclosure.

13.14 Fog – A mist of sufficient concentration to perceptibly obscure vision.

13.15 Fumes – Solid condensation particles with particle size generally less than 1 micron.

13.16 Harness – A device for carrying and holding the apparatus on wearer’s body.

13.17 Harness, Head – A device to hold the face piece securely in place on the wearer’s face.

13.18 Hood – A device for carrying and holding the apparatus on wearer’s body.

13.19 Hose Mask with or without Blower – A respirator through which uncontaminated air from a source, remote from the work place, is supplied to the wearer through an air hose at or near atmospheric pressure.

13.20 Indicator, Window – A device fixed on a gas mask canister, which visually indicates the useful life of the canister against a single chemical or against more chemicals by suitable colour change.

13.21 Irrespirable – Unfit for breathing.

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13.22 Lens, Corrective – A lens ground to the wearer’s individual corrective prescription.

13.23 Mists – Droplets of liquid dispersed in a gaseous medium. The droplets may carry substances in solution or particles in suspension of vapour. They may also be produced by the atomization of a liquid. The particle size of the mists is generally less that 1 micron.

13.24 Particulate – The generic name of dusts, mists, smokes and fumes.

13.25 Pneumoconiosis Producing Dusts – Dusts which on inhalation, get deposited and retained in the lungs and produce pulmonary diseases described as ‘Pneumoconiosis’ as a result of prolonged exposure.

13.26 Resistance – Restriction to the free flow of air, through a canister, cartridge, particulate filter or orifice of a respirator and is generally expressed in terms of millimeter of water column.

13.27 Respirable Size Particles – The range of size of particles in microns which can easily enter the human respiratory system and to the lungs and get deposited if not filtered or otherwise removed. The ciliary action is not effective against these particles.

13.28 Respirator – The generic name for a personal protective device which removes airborne contaminants from inhaled air by mechanical filtration, chemical reaction, absorption or adsorption.

13.28.1 Respirator, Air-Purifying – In these respirators, the inhaled air is drawn through a medium that removes the airborne contaminants by filtration, chemical reaction, absorption or adsorption.

13.28.2 Respirator, Canister – A respirator having a filter in the form of a canister which provides protection against limited concentrations of certain gases and vapours with or without particulate matter for a limited time.

13.28.3 Respirator, Chemical Cartridge – A respirator having a filter in the form of a replaceable cartridge, which provides protection against very low concentrations of specific toxic gases and vapours. The Cartridge affords protection only for a limited time by removing toxic contaminants by chemical reaction, absorption or adsorption.

13.28.4 Respirator, Particulate Matter – A respirator which mechanically removes particulate matter (dusts, mists, fumes and smokes) from the inhaled air by filtration.

13.28.5 Respirator, Compressed Air-Line – A respirator through which compressed air from a source, remote from the work place, is supplied to the wearer by means of an air-line.

13.28.6 Respirator with Hood – A respirator which completely covers the head, neck and portions of shoulders and through which compressed air from a source remote from the work place, is supplied to the wearer by means of an air-line. The wearer is always under a positive pressure of fresh air supply.

13.29 Types of Gas Mask

13.29.1 Front-Mounted or Back-Mounted Gas Mask – An equipment consisting of full face piece, breathing tube, canister, canister harness and associated connections, designed for entry into or escape from atmospheres containing harmful contaminants. The Canister may be worn at the front or back.

13.29.2 Chin-Type Gas Mask – An equipment consisting of a full face piece, canister and associated connections, designed for entry or escape from atmospheres containing harmful contaminants. The canister is usually attached to the face piece.

13.30 Respirator Container – A container which provides storage of one or more respirators to prevent contamination with moisture, dust, gas & against physical & mechanical damage during transit and storage.

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13.31 Smog – A combination or mixture of fog and smoke which prevails particularly in winter season during climatic inversion phase & remains suspended in air like mantle.

13.32 Smokes – Particles dispersed in a gaseous medium. Smokes settle slowly under gravity and are characterised by their mode of formation which may include combustion, destructive distillation, volatisation, condensation, chemical & photochemical reactions. The usual particle size of smokes is between 0.3 to 0.5 micron.

13.33 Sorbent – A material which removes toxic gases and vapours from air inhaled through a canister or cartridge by chemical or physical process.

13.34 Spray – Mechanically produced liquid particles with sizes generally in the visible or microscopic range.

13.35 Threshold Limit Value (TLV) – Air borne concentration of toxic substances and represents conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without any adverse effect.

13.36 Toxic Gases, Vapours and Dusts – Gases or vapours or dusts capable of producing injury once they reach a susceptible site in or on the body.

13.37 Valve (Air or Oxygen) A device fixed on a self-contained breathing apparatus which controls the direction of air or oxygen flow or the rate and pressure at which air or oxygen is delivered or both.

13.38 Value, Demand – A device installed on self contained breathing apparatus for controlled release of air or oxygen. It is actuated by negative pressure created by the action of inhalation by the wearer.

13.39 Valve, Exhalation – A one-way valve that allows exhaled air to leave a respirator and prevents ingress of outside air.

13.40 Valve, Inhalation – A device that allows respirable air to entre the face piece and prevents exhaled air from leaving the face through the intake opening.

13.41 Valve, Pressure Relief – A device for developing over-pressure lifts so as to allows excess air or oxygen to escape.

13.42 Valve, Regulator – A device which controls the rate and pressure of flow.

13.43 Vapour – The gaseous from of substances which changes into solid or liquid state either by increasing the pressure or decreasing the temperature alone.

14.0 HAZARD / ENVIRONMENT CLASSIFICATION FOR SELECTION OF RESPIRATORY PROTECTIVE DEVICES

14.1 Respiratory protective devices are of various types and work on different principles. It is therefore essential that a protective device is selected after careful consideration of the hazards involved so that it would give the desired protection.

14.2 In practice, the work environment may be either ventilated or un-ventilated and therefore constitute a hazard due to toxic contaminants or due to oxygen deficiency. An outline for selecting Respiratory Protection is shown in Table 14.1.
### Outline for Selecting Respiratory Protection on the Basis of Hazard/Environment

**HAZARD**

- **Oxygen Deficiency**
  - Positive Pressure or High Altitude
  - Toxic Contaminant

- **Positive Pressure Combination**
  - Gas Mask for Contaminant Escape
  - Positive Pressure Combination for Airline and Particulars

- **Gas or Vapor**
  - Chemical Cartridge Respirator with Appropriate Filter
  - Chemical Cartridge Respirator

- **Dust Mist or Fume**
  - Airline Respirator
  - Hose Mask with or without Chemical Cartridge

- **Oxygen Deficiency**
  - Gas Mask
  - Hose Mask with or without Chemical Cartridge

### Description of Respiratory Hazards According to Bio-Logical Effects

#### 15.0 OXYGEN DEFICIENCY

Oxygen deficiency is likely to be encountered in confined spaces or unventilated vessels, tanks & enclosures inert atmosphere.

There is normally 21% by volume of oxygen in the air but a human being can get along on 17% although this will cause his breathing to be laboured.

As a general rule, entry inside vessels is permitted only if oxygen content is not less than 19.5% unless provided with proper Breathing Protection.

At about 16%, candle or oil flame extinguishes. Below 13% concentration, dizziness occurs & leads to unconsciousness or death.

#### 15.2 PARTICULARS CONTAMINANTS

Generally they cause discomfort or minor irritation. Particles are produced by mechanical means, by disintegration processes such as grinding, crushing, drilling, blasting and spraying or by dusting etc.

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Particulates are classified as dust, fume, fog, mist, smoke etc. Generally these hazards are at mechanical shops, tank cleaning & catalyst loading / unloading areas.

Particulate of asbestos known to have resulted in cancer.

15.3 IRRITANTS : CHEMICAL/VAPOUR

They may cause irritation and inflammation of the parts of respiratory system.

Example : Ammonia, Sulphur Dioxide, Chlorine etc.

15.4 ASPHYXIANTS

They interfere with utilisation of oxygen in the body and affect blood or vital organs.

Example : Carbon Monoxide, Hydrogen Sulphide etc.

15.5 ANAESTHETICS

They cause loss of feeling and sensation and may lead to unconsciousness & death.

Example : Nitrous oxide, Halogenated hydrocarbon etc.

15.6 TOXIC CHEMICALS

Poisonous chemicals which damage organs and system in human body are called toxic chemicals.

Example : Mercury (nervous system and various organs), Hydrogen sulphide (respiratory paralysis) Arsenic (Red blood cells and liver), Tetraethyl lead (nervous system) etc.

16.0 DESCRIPTION OF GAS AND VAPOUR CONTAMINANTS / HAZARDS

Gases likely to be encountered in the oil industry may be explosive, anaesthetic, asphyxiants, toxic or irritant. Therefore, care should be taken to ensure that equipment handling gases is kept in good condition and that any defects and leaks are reported immediately.

16.1 PETROLEUM VAPOURS

Vapours liberated by light petroleum fractions are anaesthetics and mucous membrane irritants. Although they are relatively of low toxicity, it is hazardous when it builds up to harmful concentration in the atmosphere, particularly in confined spaces such as in tanks, drains & trenches.

16.2 FUEL GAS

Fuel gas may contain considerable quantity of hydrogen sulphide and full precautions must be taken to guard against hydrogen sulphide poisoning wherever fuel gas is encountered.

16.3 HYDROGEN SULPHIDE

Hydrogen Sulphide is an extremely toxic chemical and dangerous even in very low concentrations. It is found in untreated fuel gas, may be found in vapour space of crude and bitumen tanks, reactors, hydrogen plant, platformer units etc. A colourless gas with offensive odour of rotten eggs, rapidly destroys sense of smell at higher concentrations. Wherever the presence of this gas is suspected, a respirator or airline mask should be used be used and a test for H2S carried out.

(TLV = 10 ppm for 8 hrs exposure - maximum allowable concentration).

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16.4 INERT GAS

Where vessels have been purged with inert gas, there is a danger of oxygen deficiency.

16.5 CARBON MONOXIDE

Carbon monoxide is a very dangerous gas with no odour. It may be encountered in stack gas of cat cracker units & CO-boilers.

It combines with blood cells, poisoning the nervous system.
In areas where carbon monoxide is suspected, a proper gas mask should be used.

16.6 SULPHUR DIOXIDE

At the sulphur recovery and kerosene treatment units (Edeleanu Process) the presence of SO2 is possible. It causes irritation of the eye, nose, throat and lungs.

At low concentrations, it is not highly dangerous, yet it should not be breathed for any length of time. A correct respirator should be used.

16.7 AMMONIA

A low irritant, causes irritation of the breathing membranes and eye surface. Ammonia is used in boiler house and atmospheric distillation pipe stills and as an acid neutralising agent in column overhead vapours. It’s TLV is 25 ppm.

16.8 CHLORINE

Chlorine is an extremely powerful vesicant and respiratory irritant. The liquid and high concentration of gas will cause severe burns and blisters to the exposed skin areas. If inhaled, it will cause harm to lung tissues.

Chlorine cylinders are used at chlorination plant in the refinery. While working in chlorine contaminated areas, impervious clothing and either an air hose mask or self contained breathing apparatus should be used. It’s TLV is 1 ppm.

16.9 TETRA ETHYL LEAD (TEL)

TEL is extremely toxic and poisonous if it enters the body as it can be readily absorbed into the bloodstream and nervous system through the skin.

The presence of TEL is also seen in the sludge of gasolene tanks (containing TEL). TEL injection facility is another location in the Oil Industry where TEL vapours are present.

Only employees, medically examined and declared fit, should handle TEL with proper clothing and respiratory protection.

Maximum allowable concentration – 100 microgrammes of lead per cubic meter.

16.10 BENZENE

Benzene is a carcinogen. It mainly enters the body through inhalation, ingestion, skin and eye contact.

Benzene exerts active narcotic action common to many other hydrocarbons. Acute exposures to benzene can result in central nervous system depression, he-adache, dizziness, nausea & convulsions. In case of exposure to 20,000 ppm or 64 gm/m³ there is likelihood of death due to ventricular fibrillation within 5 minutes.

Biological monitoring of all workers, subject to benzene exposure, should be done for its content in urine sample. This will ascer-tain that no worker absorbs an unacce-ptable amount of benzene (TLV-1 ppm).

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16.11 Other dust/vapours handled in a Refinery/ oil installation which needs breathing protection or which are respiratory hazards are:
+ Acid fumes
+ Various catalysts
+ Amine additives, carbon dioxide
+ Phenol
+ Coke Dust

17.0 CLASSIFICATION OF RESPIRATORY PROTECTIVE DEVICES

When it is not possible or feasible to render an environment free from any form of air contaminants, then it is necessary to protect the individual worker with the proper type of respiratory protection.

Respiratory protection should not, however, be considered a substitute for engineering control procedures to eliminate health hazards.

Respiratory devices normally should be restricted to intermittent exposure or to exposures that are impractical to control by other methods.

Respiratory Protective devices have several drawbacks:
- They do nothing to reduce or eliminate the hazard.
- Their failure may result in immediate exposure to the hazard.
- Such devices may become ineffective without the knowledge of the wearer.

Classification of Respiratory Protective Equipment is given in table 17.1.

17.1 In general, respiratory Protective Equipment fall in two basic categories i.e. Air purifying Equipment (Item 17.2) and Air Supplying Equipment

<table>
<thead>
<tr>
<th>CLASSIFICATION OF RESPIRATORY PROTECTIVE EQUIPMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>RESPIRATORY PROTECTIVE EQUIPMENT</td>
</tr>
<tr>
<td>AIR PURIFYING EQUIPMENT</td>
</tr>
<tr>
<td>AIR SUPPLYING EQUIPMENT</td>
</tr>
<tr>
<td>MECHANICAL FILTER RESPIRATOR</td>
</tr>
<tr>
<td>BREATHING APPARATUS</td>
</tr>
<tr>
<td>CHEMICAL CARTRIDGE</td>
</tr>
<tr>
<td>CANISTER RESPIRATOR</td>
</tr>
<tr>
<td>AIRLINE SELF CONTAINED RESPIRATOR</td>
</tr>
<tr>
<td>HOSE MASK WITH BLOWER TYPE RESPIRATOR</td>
</tr>
<tr>
<td>CONTINUOUS FLOW RESPIRATOR</td>
</tr>
<tr>
<td>DEMAND TYPE RESPIRATOR</td>
</tr>
<tr>
<td>PRESSURE DEMAND</td>
</tr>
<tr>
<td>OPEN CIRCUIT</td>
</tr>
<tr>
<td>CLOSE CIRCUIT</td>
</tr>
<tr>
<td>DEMAND TYPE</td>
</tr>
<tr>
<td>PRESSURE OXYGEN GENERATING TYPE COMPRESSED</td>
</tr>
<tr>
<td>OXYGEN TYPE</td>
</tr>
</tbody>
</table>

Equipment (Item 18.0).

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17.2 AIR PURIFYING EQUIPMENT

As the name suggests, these equipments purify the intake air. They are further classified as:

17.2.1 Mechanical Filter respirators

This type offers protection against air-borne particulate matter including dust, metal fumes such as silica dust, catalyst dust, asbestos dust, coke dust etc. The device consists essentially of soft, resilient face piece of either half mask or full face design. Directly attached to the face piece, is a mechanical filter made up of fibrous material to remove harmful particles by trapping them during inhalation of air.

MAINTENANCE AND INSPECTION

a. The face piece should be inspected for any defect every time before use.
b. Ensure that there are no holes in the filter.
c. Ensure that head bands are in good condition and mechanical filter not plugged prior to use.

LIMITATIONS AND CAUTION

Mechanical filters do not provide protection against harmful concentration of gases or oxygen dieficiency.

Filter may be replaceable or be a permanent part of the respirator, hence these should be cleaned /replaced as per manufacturer’s instructions.

17.2.2 CHEMICAL CARTRIDGE RESPIRATOR

It is a completely assembled device with either a full mask/half face mask/face piece or mouth piece and one or more cartridges designed to provide respiratory protection against low concentrations of certain gases and organic vapours (0.05 % to 0.1% by volume depending upon the contaminant, with or without particulate contaminants), which are not immediately dangerous to life & health.

The cartridges contain chemicals which absorb certain gases and organic vapours to purify the inhaled air. Chemical Cartridge respirators are further classified according to the specific gases or vapours they are designed to protect against. Combination of a mechanical filter along with a chemical cartridge filter for dual exposure is also used.

MAINTENANCE AND INSPECTION

(i) The face piece should be inspected for any defect in the exhalation and inhalation valves.
(ii) The head bands should be in good condition.
(iii) The cartridges should be checked to ensure that they are tightly screwed into the holders.
(iv) Face piece should be kept clean & dry.
(v) When combination respirator of mechanical and chemical cartridges is used, the mechanical replaceable filters are preferred as mechanical filters normally plug up before the chemical cartridge is exhausted.

When a flexible breathing tube is a part of the chemical cartridge respirator, it shall not restrict free movement of head, disturb face piece fit or otherwise interfere with wearer’s activity. It shall not shut off air flow because of kinking or chin or arm pressure.

(vii) Face Piece Fit Tests

Before using face piece in the field, tighten straps of face piece and adjust mask so that it fits on the face snugly.

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Test the mask by crimping the hose at a point nearest to the cartridge to shut off air supply and inhale. If there is no leak in mask, face piece should contract tight against the face and the wearer should experience breathing difficulty.

Note: Ensure that the cartridge respirator meets and is certified for the performance and design requirements of IS-8522.

LIMITATIONS AND CAUTIONS

+ This equipment should not be used where gases or fumes may be present in high concentrations.
+ It should not be used in closed vessels where there is an oxygen deficiency.
+ It should not be used as a substitute for a canister mask.
+ It is necessary that concentration of the contaminant is known and sufficient oxygen is present when these equipments are used.
+ These devices should never be used in dangerous atmosphere.
+ If any gas or fume is smelt through the cartridge; it should be changed at once.
+ Keep the cartridges dry. If they become saturated or wets they should not be used again.

17.3 CANISTER GAS MASK

The action of a canister gas mask is one of absorbing at a low rate gases which may be mixed with air by drawing the air through a canister filled with a chemical. The efficiency of the chemical in the canister is dependent on the amount of gases which may be present. Large amounts or high concentrations of gases over-load the absorbing chemical and some of the gases pass through. Therefore, this equipment should be used only in low concentrations of gases. The canister does not supply oxygen. It only removes a definite limited quantity of the gas for which it is designed. For these reasons, the canister masks are not approved for use in closed vessels. Exception to this is the use of canisters in cleaning tanks, where tests have indicated a gas concentration of less than 2% (v/v).

17.3.1 CLASSIFICATION

Canister type respirators are classified according to:
(a) their construction
(b) the specific gas(es) or vapour(s) they are designed to protect against, and
(c) the concentration(s) of gas(es) or vapour(s) they are designed to protect against.

The maximum gas/vapour concentration, (percent by volume), against which these devices may afford protection is given in Table 17.2.
### Table 17.2
MAXIMUM VOLUME CONCENTRATIONS OF CONTAMINANTS FOR WHICH THE CANISTER SHOULD PROVIDE PROTECTION

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Contaminant</th>
<th>Front or Back Mounted Gas Mask</th>
<th>Chin-Type Gas Mask</th>
<th>Escape Gas Mask</th>
</tr>
</thead>
<tbody>
<tr>
<td>i.</td>
<td>Acid gases</td>
<td>2.0 (Notes 1 &amp; 2)</td>
<td>0.5 (Notes 1 &amp; 2)</td>
<td>0.1 (Notes 1 to 4)</td>
</tr>
<tr>
<td>ii.</td>
<td>Ammonia</td>
<td>3.0 (Note 1)</td>
<td>0.5</td>
<td>0.5 (Note 3)</td>
</tr>
<tr>
<td>iii.</td>
<td>Carbon Monoxide</td>
<td>2.0 (Note 1)</td>
<td>(Not recommended)</td>
<td>1.0</td>
</tr>
<tr>
<td>iv.</td>
<td>Organic Vapours</td>
<td>2.0 (Notes 1 &amp; 2)</td>
<td>0.5 (Notes 1 &amp; 2)</td>
<td>0.5 (Notes 1 to 3)</td>
</tr>
</tbody>
</table>

**Notes:**

1. Approval may be for acid gases organic vapours as a class or for specific acid gases or organic vapours. Approval may also be granted for combination or all of these materials.

2. Not for use against acid gases or organic vapours with poor warning properties or which generate high heat of reaction with sorbent material of canister.

3. Eye protection may be required in certain concentrations of acid gases, ammonia and organic vapours.

4. Suggested maximum concentrations of use are lower than this for some acid gases and organic vapours.

**17.3.2 OPERATION**

When first using this equipment, study instructions from the manufacturer. It is necessary that employees, who may be required to use gas masks in emergencies, should learn about the use of gas masks, practise and be thoroughly trained and be ready to use them.

Before using the canister gas mask, be certain that you are using the right type of canister, as canisters are made specifically for different gases e.g. Type N canister provides protection against ACID GASES, AMMONIA, CARBON MONOXIDE, ORGANIC VAPOURS & PARTICULATES.

Do not remove top and bottom seals until ready for use.

When attaching new canisters, make sure that the connections are tight. On canisters with windows for protection against Carbon Monoxide, discard the canister when the indicator section changes colour when compared to the colour of the reference section. The reference section does not change colour. When the canister is used for protection against other gases, discard the canister.

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regardless of the colour of the window indicator, when warned by odour or irritation that the gases are passing through the canister.

17.3.3 CORRECT WAY TO USE A CANISTER GAS MARK

- Remove the seal from bottom of the canister and plastic cap from top.
- Connect the facepiece to the canister. Make sure that the connections are tight.
- Buckle on canister harness in front/back.
- Place the face mask on your face, chin first and pull the head harness over your head.
- Tighten lower straps first. This brings facepiece snugly around chin.
- Next, tighten centre adjusting straps. This makes facepiece fit with the contours of face and cheeks.
- Tighten straps to make mask fit on forehead. If properly adjusted, mask should fit on face snugly.
- Test the mask. Crimp hose at a point nearest to the canister to shut off air supply and inhale. If there is no leak in hose and masks, facepiece should contract tight against face and the wearer should experience breathing difficulty.
- You are now ready to go into the gas-eous area. If odour of gas is detected, leave the area immediately and re-check the mask. If any defect is found, use another mask and return this mask for inspection and replacement.
- When use of mask is finished, it is important that time card be marked, showing number of minutes canister was in service.

MAINTENANCE AND INSPECTION

Masks should be carefully inspected before each use. The face piece should be checked for any defect, such as loose or cracked lens, defect in exhalation valve or head straps broken or missing. The hose should be checked to ensure that it is securely fastened to the facepiece and canister and that there are no breaks in it. The canister should be checked, to see that it has enough residual life for the job at hand. Keep the mask clean and in good condition.

LIMITATIONS AND CAUTIONS

Canisters are designed for specific contami-nants and it is, therefore, necessary to ensure that only the appropriate type of canister is used for any given situation.

The canisters must be replaced under normal use once every 6 months or after 100 hours of use whichever is earlier, whether used or not from the date the seal is broken. They must gas masks shall not be used in any enclosed area, such as closed vessels, condenser box, excavation or manhole, unless gas tests indicate that the concentration of gas present is below 5% of the lower explosive limit in case of hydrocarbons, or 2% by volume in case of other gases. Care must be taken in using such equipment to assure that the capacity of canister is not exceeded.

This may occur in such work as repairing leaks in gas lines even when working in the open. If there is any doubt, use a fresh air hose mask. Do not use gas mask facepiece which have been used by others until they have been sterilised.

An individual with a “punctured ear drum” ray not be adequately protected from gas by using a gas mask. Under certain conditions, it may be possible for gas to be drawn through the punctured ear drum into the lungs. To prevent this, ear protection like ear plugs must be worn.
Because of the nature of this equipment, it is always preferable to use Fresh Air Hose Mask, in closed vessels, manhole etc. and emergency leaks of hydrocarbons or chlorine etc. where the concentration of the contaminant cannot be estimated. When canister is used in situations of leak, life of canister is very short viz. in a 1/2% (5000 ppm) concentration life would be between 1 and 2 hours.

Get complete instructions from the manufacturer of canister including shelf life and train the people thoroughly in its use.

![Diagram of Universal gas mask canister]

**Fig. 17.1 : Universal gas mask canister**

17.3.4 **COLOURS**

Each respirator canister or cartridge or their labels shall have a distinctive colour as indi-cated in Table 17.3.
### Table 17.3
**COLOURS ASSIGNED TO CANISTERS OR CARTRIDGES**

<table>
<thead>
<tr>
<th>Atmospheric Contaminant(s) to be protected against</th>
<th>Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acid Gases</td>
<td>White</td>
</tr>
<tr>
<td>Organic Vapours</td>
<td>Black</td>
</tr>
<tr>
<td>Ammonia gas</td>
<td>Green</td>
</tr>
<tr>
<td>Carbon monoxide gas</td>
<td>Blue</td>
</tr>
<tr>
<td>Acid gases and organic vapours</td>
<td>Yellow</td>
</tr>
<tr>
<td>Acid gases, ammonia and organic vapours</td>
<td>Red</td>
</tr>
<tr>
<td>Other vapours and gases not listed above</td>
<td>Olive</td>
</tr>
<tr>
<td>Radioactive materials (except tritium and noble gases)</td>
<td>Purple</td>
</tr>
<tr>
<td>Dusts, fumes and mists (other than radioactive materils)</td>
<td>Orange</td>
</tr>
</tbody>
</table>

**Notes:**

1. A purple colour stripe shall be used to identify radioactive materials in combination with any vapour or gas.
2. An orange colour stripe shall be used to identify dusts, fumes and mists in combination with any vapour or gas.
3. As colour coding of canisters may be different in case of imported canisters, caution must be exercised in their use.

Where labels only are coloured to confirm with this standard, the canister or cartridge body shall be grey or a metal canister or cartridge body may be left in its natural metallic colour.

The colour coating or coloured material used shall offer a high degree of resistance to changes such as chipping, scaling, peeling, blistering and fading and to the effects of ordinary atmospheres to which they may be exposed under normal conditions of storage and use.

### 17.3.5 MARKING

On each air-purifying respirator canister and cartridge, the following shall appear in bold letters:

- **CANISTER FOR ___________________________**
  - (Name of atmospheric contaminant)

  or

- **CARTRIDGE FOR ___________________________**
  - (Name of atmospheric contaminant)
In addition to, either or both of statements, the following information shall appear beneath the appropriate phrase on the canister or cartridge label.

(i) For respiratory protection in atmospheres containing not more than (concentration) by volume of ____________________________

(Name of atmospheric contaminant)

(ii) For respiratory protection in atmospheres containing ____________________________

(Type of particulate contaminant)

(iii) Do not use in atmospheres containing less than 16 % oxygen by volume.

Note: As the chemical contained in the canister may lose its effectiveness over a period of time, the expiry date of the canister must be marked clearly on the canister.

18.0 AIR SUPPLYING EQUIPMENT
(Supplied Air Respirator)

The important advantages of air supplying respirators are simplicity of design, broad application and good protection when properly selected, adequately supplied with respirable air and used in the manner or for the purposes for which they are designed and approved. They are applicable without any regard to the kind or physical state of contaminant.

Service life and resistance to inhalation are not dependent upon plugging of particulate filters or capacity of chemical absorbents.

Hose-type air supplying respirators make air available to the wearer through a hose connected to supply of respirable air. They may be divided into two groups:

i) Air Line Respirator

ii) Self-Contained Breathing Apparatus

18.1 Air Line Respirator or Hose Mask Respirator can be of following types:

i) Hose Mask with blower/without blower

ii) Continuous flow Respirator

iii) Demand Type Respirator

iv) Pressure Demand Type Respirator

18.1.1 (i) Hose Masks with Blower/Without Blower

There are two types of hose masks the hose mask with blower (Type A) and the hose mask without blower (Type B).

The hose mask with blower (Type A) as shown in Fig. 18.1 is approved for respiratory protection in any atmosphere, regardless of the type of concentration of the contaminant, provided that enough respirable air is supplied to the wearer by means of the blower.

It consists of full face piece connected by a flexible breathing tube or tubes and a large diameter (approximately 1 in. inside diameter) hose to a hand or motor-operated blower, which must be operated in respirable air. Two hose lines, each up to 30 m in length, may be served by hand-operated blower or by a motor operated blower. The hose is attached to the wearer by a sturdy body harness to which a life line may be secured. The respirator is designed for use with the blower in continuous operation and with a man in constant attendance at the blower (Refer Fig. 18.1 showing its typical use). In the event that the blower cases to operate, the wearer can still inhale respirable air through the hose with no more effort than when wearing a gas mask.
Check valves in the facepiece and breathing tube assembly prevent exhaled air from entering the hose and cause it to leave the facepiece through the exhalation valve. Each hose mask has a serviceable trunk for storage and transportation.

Fig. 18.1: (Type A) Hose mask with hand operated blower
The Type B Hose Mask without Blower is approved for respiratory protection in any atmosphere from which the wearer can escape without the aid of the respirator. It consists of a full facepiece connected by a flexible breathing tube or tubes, to a large diameter (approximately 25 mm inside diameter) hose, on the inlet end of which is a filter screen and a means of anchoring it in respirable air. The wearer obtains respirable air by means of his own respiratory effort. Check valves in the facepiece and breathing tube assembly prevent exhaled air from entering the hose and cause it to leave the facepiece through exhalation valve. The hose is attached to the wearer by a body harness. A maximum of 15 m of hose may be used with this respirator.

The choice of the proper respirator for any situation requires consideration & integration of pertinent factors, which include contami-nation of the air, the place and the kind of work to be done.

18.2 : Typical use of hose mask with blower

FRESH AIR HOSE MASK

Where to use :

Fresh air hose mask shall be used in following cases :

i) When it is necessary to enter any enclosed area where tests indicate presence of Hydrogen Sulphide (H₂S), Carbon Monoxide (CO) or combustible gas even in low concentrations.

ii) Where, in emergencies, it is necessary to enter an enclosed vessel which has not been properly prepared for.

iii) Where canisters cannot be used because the concentration exceeds the limit for canister (5% of L.E.L. in case of Hydrocarbon gases and 2% Vol. in case of other gases).

iv) In entering areas where there is heavy smoke.

v) Where there is an oxygen deficiency.

Use :

i) The face piece should be adjusted and tested.

ii) See that the hose and the life line are not entangled.

iii) The blower MUST be placed where there is plenty of fresh, uncontaminated air.

iv) Where a hand driven blower is used, the crank must be turned continuously from the time the man puts on the face piece until he returns to fresh air & removes the face piece completely.

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v) Two persons must be deputed to perform the cranking operation alternately & as standby. Standby should be alert throughout to notice the changing working conditions, if any.

vi) A lifeline must be attached to the hose mask harness.

vii) Ensure that the hose is not run over by moving vehicles or men at work site.

MAINTENANCE AND INSPECTION

The facepiece and the hose should be carefully inspected to assure that there are no defects and that all joints are tight. The blower should be checked and tested to see that it is operating properly. The lifeline should be inspected to assure that it is in good condition and securely attached to the hose mask harness. After using the equipment, clean the exterior of “hose” and the “life line”. When not in use, protect the ends of the hoses by covering them with pieces of cloth.

LIMITATIONS AND CAUTIONS

i) Do not use more than 30 m of hose on each blower connection.

ii) Do not place the blower where the air may be contaminated, like in the vicinity of sewer manholes or catch basins. Keep it to the windward side of any possible contaminating source.

iii) Always have a man present to assist in any emergency which might arise.

iv) Depute men who are experienced in this type of work.

v) Be certain that the gas or vapour is not of a type which may be harmful to the skin, for example, a high concentration of ammonia.

vi) In case of hydrocarbon gas if concentration is above 50% of the Lower Explosive Limit (a reading of 0.5 on the combustible gas indicator), NO ENTRY IS PERMITTED EVEN WITH FRESH AIR HOSE MASK.

18.1.2 CONTINUOUS FLOW RESPIRATORS

These are of two types:

In the first type a set amount of air is fed continuously to the facepiece. The amount is regulated by an air control valve or special air inlet design which is not susceptible to accidental changes of the setting even when jarred. This valve and a small filter may be placed in the air line between the short length of flexible tubing leading to the facepiece and the small diameter pressure hose from the air source. It can be clipped to the wearer’s belt or mounted on a belt permanently. A slight positive pressure on the inside of the mask is always maintained to prevent inward leakage of the contaminated out-side atmosphere. The continuous flow respirator, with either the half or full face-piece, is the most common type. It is best suited for use with air compressor systems.

It generally consists of a compressed air supply, a pressure release valve, a small diameter (approximately 3/8 to 1/2 in.) compressed air hose, a quick coupling, an air flow control device designed to permit regulation of the air flow and either a half or full facepiece. Like the hose masks, the air line respirator is provided with a low resistance exhalation valve. The pressure release valve setting depends upon supply system pressures, length of hose used and the required air flows. To a large extent, these requirements are closely related to performance and safety of the respirator.

The air line respirator (continuous flow type) may be used for protection in any atmosphere that is not immediately hazardous to life. It is particularly adapted to some types of jobs because it is light and may be worn for a long period of time without appreciable discomfort.

For example, it is often used for spray painting, insecticide applications, weld-ing, metalising and prolonged production work in hazardous areas. It should be kept in mind that these respirators depend upon a mechanical air supply which is not carried by the wearer of the respirator.
18.1.3 DEMAND TYPE/PRESSURE DEMAND TYPE RESPIRATOR

Basically both these types are same with slight variation. In “Demand Type” Respirator, equipped with a half or full mask facepiece, the demand valve permits flow of air only during inhalation. In “Pressure Demand Type” Respirator, equipped with a half or full mask facepiece, a positive pressure is maintained in the facepiece at all the times.

![Diagram of respiratory equipment]

**Fig. 18.3: Airline respirator - demand flow type**

When the air must be conserved as could be the case when the supply is from a cylinder of compressed air, the demand flow respirator is preferred (see Fig. 18.3). The demand flow type contains a deemand regulator at the lower end of the breathing tube. A demand regulator has a diaphragm actuated valve which opens upon inhalation, permitting air to be supplied & closes upon exhalation. This permits air to flow to the facepiece only when the wearer inhales.

It should be emphasised at this point that the demand flow types must always be used with a tight fitting facepiece, whereas the continuous flow type may be assembled with a half mask, full face piece or hood. Also, the demand type usually requires a pressure regulator when a high pressure air supply is used.

Since an air line respirators not to be used in lethal atmospheres, no life line is needed. If something does go wrong with the air supply, the mask can simply be removed and the wearer can move out of the contaminated air. Because of the trailing hose, the travel of the user is Limited to a specified area.

A variation of both the continuous flow and the demand types of air line respirator is a device which has a regular & an emergency source of air supply. The emergency source may consist of a small bottle of compressed air or oxygen, or a canister, attached so that in case either the supply of higher pressure air to the small supply hose is cut off or the hose is disconnected, the changeover to the bottle or canister is automatic and the wearer can take his time getting out of the contaminated atmosphere.

MAINTENANCE AND INSPECTION

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The afore-mentioned maintenance suggestions also apply to air-line respirators. In addition, they should be inspected weekly or monthly, depending on use. Regulators, relief valves, air control valves and demand (or pressure demand) regulators should be checked regularly for cleanliness and proper operation. Rubber and plastic parts should be checked for deterioration. The pressure regulator, filter, hose and facepieces should be checked for the same signs.

The air hose & attachments should be cleaned regularly to prevent accumulation of paint, oil, grease or solvents that could harm the rubber or attachments. Oil and grease should be removed with steam at no more than 5 psi of pressure. The steam nozzle should not be held too close to the air hose to prevent its “burning”. Goggles & rubber gloves should be worn by the person doing the cleaning.

LIMITATIONS AND CAUTIONS

(i) This equipment is suitable for respiratory protection against all atmospheric contaminants in concentrations not immediately harmful to life.

(ii) Pure compressed air, free from contaminants having the standard oxygen content in air (21% by volume) should be supplied to the wearer.

Common contaminants in compressed air include Carbon Monoxide, Oil Vapour, Water Vapour, Nitrogen Dioxide and particulates. Of these impurities, Carbon Monoxide (CO) is the most toxic. The removal of all the dangerous contaminants in a compressed air system can be effected by a multi-functional purification system.

Intake Air purity (BS 4275)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>5 PPM</td>
</tr>
<tr>
<td>CO₂</td>
<td>500 PPM</td>
</tr>
<tr>
<td>Oil</td>
<td>0.5 mg/cu.n1.</td>
</tr>
<tr>
<td>Water</td>
<td>0.03 mg/litre</td>
</tr>
<tr>
<td>Odour</td>
<td>Odour less</td>
</tr>
<tr>
<td>Oxygen</td>
<td>21%</td>
</tr>
</tbody>
</table>

The compressed air supply, whether it is obtained from a compressor directly or from a cylinder of compressed air, can be a source of contamination unless adequate precautions are taken. It is preferable to use equipment which does not need internal lubrication, rather than high pressure compressors as sources of respirable air. Water-lubricated compressors offered by several distributors are safe so far as production of carbon monoxide & oil mists or vapours is concerned. Diaphragm, graphite-mercury and graphite-vane non-lubricated types of compressors are available.

It is necessary to provide a trap and filter on the side of the compressor to remove oil, water, scale or other extraneous matter before it comes to the regulator or mask. The compressor intake must be kept away from all sources of contamination, including engine exhausts. If an internally lubricated compressor is used, it should be well maintained so as to keep it from overheating to the point of forming dangerous amounts of carbon monoxide. As an extra safeguard, the compressor should be equipped with a temperature—actuated alarm which can also be made to shut off the compressor, if it starts getting overheated.

18.2 MODIFICAMON OF AIRLINE RESPIRA-TORS OF CONTINUOUS FLOW TYPE

18.2.1 Abrasive Blasting Respirators

Abrasive blasting respirators are essentially modifications of air line respirators of the continuous flow type. Abrasive blasting respirators fall into general designs:

1. A full mask, tight fitting face piece connected to a supply of air (continuous or possibly demand flow), assembled with a hood and cap of flexible material for protecting the head and shoulders from abrasive rebound.
(2) A rigid, loose fitting helmet covering the head and neck with a loose fitting collar around the neck, the helmet being connected through a hose line to a continuous flow air supply (See Fig. 18.4). The helmet is fitted with a flexible collar or short cap for protection from abrasive rebound.

![Diagram of an abrasive blasting respirator-helmet type]

**Fig.18.4: Abrasive blasting respirator-helmet type**

The quantity of air supplied to an abrasive blasting respirator should be such that a slight positive pressure is maintained at all leakage points so that no contaminant can enter from the outside. Approximately 6 cubic feet per minute of free air (at ambient pressure) is the minimum requirement for continuous flow, helmet-type, abrasive blasting respirator. The minimum requirement for a demand respirator is 28 litres per minute of free air.

The manner in which the air enters the helmet is very important and care must be taken to avoid injection effects that will cause localised low pressure areas inside the helmet, resulting inflow of external contaminated atmosphere.

Within certain ranges, increase in air flow may increase contamination, the reasons being evident from the behaviour of nozzles. Considerable attention is also to be given to the noise caused by air rushing through the air supply line and the sound being amplified in the helmet.

### 18.2.2 SUPPLIED AIR HOODS

The supplied air hood is similar to the abrasive blasting respirator except that the hood is generally constructed of lighter material, such as duck, other sturdy cloth or plastic, with a large transparent area for viewing the work. In many instances, such as for paint spraying and use with radioactive materials, these hoods are made of inexpensive materials & are disposable. Many variations in design and materials are available for specific uses. Figure 18.5 illustrates one of such respirators that is commercially available.

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Various methods of air entry into the hoods are employed. These range from the splash of air on a diffusion plate near the back or top of the hood to the downward and upward flow of air from a number of small streams of air from orifices evenly distributed in the bottom and top of a circular plenum attached to the head frame. One type consists of a flexible vinyl hood without headgear or frame. Air from the supply source inflates the hood like a balloon, causing it to float around the wearer’s head. Drawstrings under the chin hold it in place to ensure a snug fit & there is a large window for viewing the work. This type could be used for paint spraying operations. The hood acts as a positive pressure chamber which is being continuously purged with fresh air at low velocity.

The requirement is 42 litres per minute of free air (at ambient pressure). Only well designed hoods will meet this requirement. Others may require more free air. The control valve is generally supported on the wearer’s belt at the lower end of the breathing tube in a position where the user is free to regulate the supply to his own requirements within certain limits. As in other types of supplied air respirators, it is desirable to include a device in the supplied air line to remove odours, mists & particulates which may arise from the compressor.

18.2.3 SUPPLIED AIR SUITS

Supplied air or air-inflated suits are forms of supplied air respiratory protective equipment which provide purified air not only for breathing purposes but also for insulating the whole body from the surrounding atmosphere, (see Fig. 18.6). This type of protection is needed only in the most extreme conditions where there is an exposure to substances that are irritating or corrosive to the skin and mucous membranes and are also toxic or hazardous to life. Examples of such conditions would be the escape of toxic and corrosive gases like chlorine and acid gas. One very specific use of a supplied air suit is in biological laboratories where the worker is isolated from large scale, dangerous cultures. The isolation of the man from the work rather than the isolation of the work from the man seems to be much more efficient in this instance. In any event, a complete suit of protective clothing plus some arrangement from supplied air must be used.

Fig. 18.5: One type of supplied air hood

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19.0 SELF-CONTAINED BREATHING APPARATUS

A self-contained breathing apparatus may be defined as a respirator in which the supply of air, oxygen or oxygen-generating material is carried by the wearer.

There are two main types of self contained breathing apparatus:

19.1 CLOSE CIRCUIT - Closed circuit breathing apparatus is one in which the exhaled air is re-breathed by the wearer after the carbon dioxide concentration has been effectively reduced and the oxygen concentration enriched. It is used either with a full face piece or with mouth piece and nose clip.

Closed circuit self contained breathing apparatus are of two types:

(i) COMPRESSED OR LIQUID OXYGEN TYPE High pressure oxygen from a gas cylinder passes through a high-pressure reducing valve and in some designs, through a low-pressure admission valve to a breathing bag or container. Liquid oxygen is converted to low pressure gaseous oxygen and delivered to the breathing bag. The wearer inhales from the bag through a corrugated tube connected to a mouthpiece or facepiece and a one-way check valve. Exhaled air passes through another check valve and tube into a container of carbon dioxide removing chemical and reenters the breathing bag. Make up oxygen enters the bag continuously or as the bag deflates to accentuate an admission valve sufficiently. A pressure relief system is provided and a manual bypass system and saliva trap may be provided depending upon the design. Refer Fig. 19.1
Fig. 19.1 : Self Contained Breathing Apparatus Compressed oxygen type

ii) OXYGEN GENERATING TYPE - Water vapour in the exhaled breath reacts with chemical in the cartridge to release oxygen to the breathing bag. The wearer inhales from the bag through a corrugated tube and one-way check valve at the facepiece. Exhaled air passes through a second check valve breathing tube assembly into the cartridge. The oxygen release rate is governed by the volume of exhaled air. Carbon dioxide is removed by the cartridge. Refer Fig. 19.2.

Fig. 19.2 : Oxygen-Generating Self Contained Breathing Apparatus
19.2 OPEN CIRCUIT

Open - Circuit breathing apparatus is one in which compressed air carried in cylinders is fed through a demand valve and breathing tube to a full face piece. Exhaled air passes through a non-return valve to the atmosphere.

Open circuit self contained breathing apparatus make use of compressed air or compressed oxygen or liquid air or liquid oxygen. Where oxygen (liquid or com-pressed) is used, such apparatus should not be used for atmospheres not compatible with oxygen. These are of two types:

i) DEMAND TYPE - These are equipped with a demand valve that is breathing on initiation of inhalation and permits the flow of breathing atmosphere to the face-piece. On exhalation, pressure in the facepiece becomes positive & the demand valve is deactivated.

The demand valve permits oxygen or air flow only during inhalation. Exhaled breath passes to ambient atmosphere through a valve(s) in the facepiece. A bypass system is provided in case of regulator failure except on escape-type units.

Note - Bypass systems are not necessary in compressed air breathing equipment under the following conditions:

(a) When pressure reducers are built in such a way that blockage of air supply is impossible.

(b) Where it is ensured that the lung demand valve still operates and intolerable pressure increase is avoided by an over-pressure valve. Should the lung demand valve also break down. The lung demand valve can be operated by a little push button.

ii) PRESSURE DEMAND TYPE - These are equipped with full face-piece only. Positive pressure is maintained in the facepiece at all times. The wearer usually has the option of selecting the demand or pressure demand mode of operation.

19.2.1 DESCRIPTION AND PRINCIPLES OF OPERATION

a. Demand Type Self-Contained Breathing Apparatus

The demand type self-contained breathing apparatus (see Fig 19.3) consists of a full facepiece connected to demand valve, which is connected, through a pressure reducing valve, to a cylinder of compressed air or oxygen. A pressure gauge is located near the demand valve to indicate the pressure of the gas in the gas cylinder.

When the wearer inhales, a slight negative pressure is created in the facepiece, breathing tube and demand valve. This negative pressure depresses a diaphragm in the demand valve & causes the gas inlet valve to open and remain open until the wearer exhales and a positive pressure is created in the above parts. The gas flows from the compressed gas cylinder only when the wearer inhales and the rate of flow is automatically adjusted by the wearer’s breathing characteristics.

Exhaled breath is not recirculated, but passes to the exterior of the facepiece through an exhalation valve. A bypass valve is provided, by means of which adjustable flow of gas can be delivered to the facepiece in the event of failure of any part of the pressure reducing valve or the demand valve. The apparatus is attached to the wearer’s body by means of suitable harness.

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19.2.2 STEPS FOR USE

Donning Operation

- Check the cylinder pressure.
- Connect the regulator to the cylinder.
- Keep the cylinder with valve facing up ward.
- Get proper hold on the cylinder.
- Ensure that the sliding side buckles are free.
- Lift the cylinder above your head, ensure the side sliding straps come above your back via hands.
- Fix the chest strap.
- Pull lower sliding buckle with jerk to adjust cylinder.
- Fix the waist strap.
- Ensure that the positive pressure control lever near regulator inlet knob is in "OFF" position.
- Open the regulator inlet knob. Ensure that the bypass knob is shut.
- Open cylinder valve fully.
- Check the regulator gauge reading.
- Fit the mask chin first, adjust chin straps, then the temple and forehead straps and make it air tight.
- Ensure air tightness by shutting hose end by palm and inhaling slowly. Mask should collapse on the face.
- If it is air tight, connect the hose to the regulator and breath on.
- Move the positive control lever to "ON" position (upward direction).

Redonning Operation

- Move the positive control lever near the regulator inlet knob to “OFF” position (Downwards).

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 disconnect the face mask hose connection from the regulator.
- Remove face piece by loosening the straps.
- Close the cylinder valve.
- Close the yellow knob on regulator.
- Remove the wrist strap.
- Loosen the side straps.
- Remove the chest straps.
- Slowly lift the cylinder from the back.
- Ensure that you enter the time and period of use in the record book.

**CAUTIONS**

- Inlet valve of the regulator must be opened first then only cylinder valve should be opened.
- Bypass (where provided) should always be shut for normal operation & be opened and adjusted to wearer's requirement, only if the regulator inlet fails during normal operation.
- It must be borne in mind that apparatus designed for air cannot be used with oxygen cylinder and vice versa.
- The wearer should keep a watch on the pressure gauge so that he can leave the area safely even if the alarm fails.
- When alarm within the regulator starts ringing, it is a warning that only 20 to 25% of air remains in the cylinder. Leave the contaminated area at once.

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# Respiratory Protective Equipment Inspection Report

## I. Breathing Apparatus Set

<table>
<thead>
<tr>
<th>SL. NO.</th>
<th>Locations</th>
<th>Box No.</th>
<th>Cylinder No.</th>
<th>Pressure of Cylinder</th>
<th>Mask Condition</th>
<th>Remarks</th>
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- Spare Cylinders (full) at Fire Station
- Spare Cylinders (empty) at Fire Station
- Spare Cylinders sent for filling

Notes:

Inspected by

Signature

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### RESPIRATORY PROTECTIVE EQUIPMENT INSPECTION REPORT
#### II. CANISTER GAS MASK

**Date:**

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<thead>
<tr>
<th>SL. NO.</th>
<th>LOCATIONS</th>
<th>BOX NO.</th>
<th>CYLINDER NO.</th>
<th>PRESSURE OF CYLINDER</th>
<th>MASK CONDITION</th>
<th>REMARKS</th>
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Inspected by

Signature

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20.0 GUIDELINES ON USE OF RESPI-RATORY PROTECTION DEVICES

Some broad guidelines on use of respiratory protection devices are given below:

20.1 The use and fitness of a respiratory device requires careful control & where practicable, it should be issued on a personal basis.

20.2 Standard procedures should be developed for respirator’s use. These should include all information and guidance necessary for their proper selection, use & care. Possible emergency and routine usage of respirators should be anticipated and planned.

20.3 Written procedures should be prepared covering safe use of respirators in dangerous atmospheres that might be encountered in normal operations. Personnel shall be familiar with these procedures and the available respirators.

20.4 In areas where the wearer could be over-come by a toxic or oxygen deficient atmosphere due to failure of the respirator, at least one additional man should be present. Communications (visual, voice or signal line) should be maintained between both or all individuals present. Planning should be such that at least one individual will be unaffected by any likely incident and have the proper rescue equipment to be able to assist the operator in case of emergency.

20.5 Fitting of the facepiece is most important and users should be properly instructed when first issued with the equipment, making sure that all the inspired air is drawn through the device in the proper manner. A satisfactory fit of a full facepiece cannot be expected when spectacles are worn unless spectacles are specially made for the purpose.

To assure proper protection, the facepiece fit shall be checked by the wearer each time he puts on the respirator. This may be done by following the manufacturer’s facepiece fitting instructions. The following two simple field tests may also be used:

(i) Positive pressure test - Close the exhalation valve and exhale gently into the facepiece. The face tit is considered satisfactory if a slight positive pressure can be built up inside the facepiece without any evidence of outward leakage of the air at the seal. For most respirators, this method of leak testing requires that the wearer first removes the exhalation valve cover and then carefully replaces it after the test.

(ii) Negative pressure test - Close off the inlet opening of the canister or cartridge(s)! by covering with the palm of the hand(s) or by replacing the seal(s), inhale gently so that the facepiece collapses slightly and hold the breath for ten seconds. If the facepiece remains in its slightly collapsed condition and no inward leakage of air is detected, the tight-ness of the respirator is satisfactory.

21.0 TRAINING AND EDUCATION IN PROPER USE OF RESPIRATORS

A wearer should be trained in the correct way to use and adjust respiratory protective devices. Instructions should also cover the following:

i. How to recognise the need to wear a device
ii. The importance of wearing the device
iii. Principle on which the device operates and its essential parts
iv. The field of use and limitations of the device
v. The probable time period over which it will provide protection
vi. How to recognise faulty functioning of the device

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vii. What to do under emergency conditions which may be brought about by his work or by accident to his protective equipment

viii. The necessity for proper handling, maintenance and cleaning of the equipment

22.0 MAINTENANCE AND CARE OF RESPIRATORS

22.1 Respirators should be properly maintained to retain their original effectiveness. A programme for maintenance and care of respirators should be adjusted to the type of plant, working conditions & hazards involved and should include the following basic services:

i. Inspection for defects (including leak check)

ii. Cleaning and disinfection

iii. Repair

iv. Storage

22.2 INSPECTION

22.2.1 All respirators should be inspected as a routine before and after each use. A respirator that is not in routine use but is kept ready for emergency use should be inspected after each use and at least once a month to ensure that it is in satisfactory working condition.

22.2.2 Self-contained breathing apparatus should be inspected monthly. Air and oxygen cylinders should be fully charged according to manufacturer’s instructions. It should be ensured that the regulator and warning device function properly.

22.2.3 Respirator inspection should include a check of the tightness of connections and the condition of the facepiece, head harness, valves, connecting tube and canisters. Rubber parts should be inspected for pliability and signs of deterioration. Stretching and manipulating rubber parts with a massaging action will keep them pliable & flexible and prevent them from taking a set during storage.

22.2.4 A record of inspection dates and findings for respirators maintained for emergency use should be kept.

22.3 CLEANING AND DISINFECTION

i) Regularly used respirators should be collected, cleaned and disinfected as frequently as necessary to ensure that proper protection is provided for the wearer. Each worker should be briefed on the cleaning procedure and it should be ensured that he will always receive a clean & disinfected respirator. Such assurances are of greatest significance when respirators are not individually issued. Respirators maintained for emergency use should be cleaned and disinfected after each use.

ii) Strong cleaning and disinfecting agents can damage respirator parts. Temperature above 85 degree C & vigorous mechanical agitation should not be used. Solvents which affect rubber parts should not be used.

22.4 Repair - Replacement or repairs should be done by experienced persons with parts designed for the respirator. No attempt should be made to replace components or to make adjustments or repairs beyond the manufacturers recommendations. Reducing or admission valves or regulators should be returned to the manufacturer or to a trained technician for adjustment or repair.

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22.5 STORAGE

22.5.1 After inspection, cleaning and necessary repair, respirators should be stored to protect against dust, sunlight, heat, extreme cold, excessive moisture or damaging chemicals. Respirators placed at stations and work areas for emergency use should be stored in compartment built for the purpose, be quickly accessible at all times and be clearly marked. Regularly used respirators, such as dust respirators, may be placed in plastics bags. Respirators should not be stored in such places as lockers or tool boxes unless they are in carrying cases or cartons.

22.5.2 Respirators should be packed or stored so that the facepiece and exhalation valve will rest in a normal position and its function will not be impaired by the rubber parts setting in an abnormal position.

22.5.3 Instructions for proper storage of emergency respirators, such as gas masks and self-contained breathing apparatus are found in the “use and care” instructions, usually mounted inside the carrying case lid.

23.0 SPECIAL PROBLEMS IN USE OF RESPIRATORS

There are some special problems in the use of respirators which need careful consideration and these are mentioned below:

23.1 Corrective Lens with Full Facepiece
Providing respiratory protection for individuals wearing corrective glasses is a serious problem. A proper seal cannot be established if the temple bars of eye glasses extend through the sealing edge of the full facepiece. As a temporary measure, glasses with short temple bars or without temple bars may be taped to the wearer’s head. Wearing contact lenses in contaminated atmospheres with a respirator should not be allowed.

23.2 Eyewear with Half Mask Facepiece - If corrective spectacles or goggles are required, they should be worn so as not to affect the fit of the facepiece. Proper selection of equipment will minimise or avoid this problem.

23.3 Respirator Use in Low Temperatures - Major problems in the use of the full facepiece at low temperatures are poor visibility and freezing of exhalation valve. All full facepieces are designed so that the incoming fresh air sweeps over the inside of the lenses to reduce fogging. Otherwise, it would be impossible to wear a full face-piece in ordinary room temperatures with-out severe fogging. Antifog compounds can be used to coat the inside of the lens to prevent fogging at room temperatures & down to temperatures approaching 0 degree C. However, below 20 degree C antifog compounds will not prevent severe fogging.

23.3.1 Full facepieces are available with nose cups that direct moist exhaled air through the exhalation valve. A properly fitted nose cup should provide satisfactory or adequate visibility at temperatures down to 0 degree C.

23.3.2 At very low temperatures, the exhalation valve may collect moisture and freeze open, allowing the wearer to breathe contaminated air or freeze closed, preventing normal exhalation. Dry respirable air should be used with self-contained breathing apparatus or air line respirators at low temperatures. The dew point of the breathing air should be appropriate to the ambient temperatures.

23.3.3 High pressure connections on self-contained breathing apparatus may leak because of metal contraction at low temperatures. The connections should not be overtightened since they may break when temperature returns to normal.
23.4 **Respirator Use in High Temperatures** - A man working in areas of high ambient temperature is under stress. Any additional stress resulting from the use of respirators should, therefore, be minimised. This can be done by selecting and using respirators having minimum weight and breathing resistance. Supplied air respirators, hood and suits having an adequate supply of cool breathing air are recommended.

23.5 **Communication**

23.5.1 Although conventional respirators distort the human voice to some extent, the respirator exhalation valve usually provides a pathway for some speech transmission over short distance in relatively quiet areas. Talking can induce facepiece or component leakage and therefore, should be limited while wearing a respirator, especially those with half-mask facepiece.

23.5.2 Mechanical speech transmission devices called "speaking diaphragms" are available as an integral part of some respirators. These devices consist of a resonant cavity and diaphragm which amplify sound in the frequency range most important to speech effectively. The diaphragm acts as a barrier to the ambient atmosphere. It should be carefully handled and protected by a cover to prevent puncturing of diaphragm.

23.5.3 Various methods of electronically transmitting speech from the respirator are available. Respirators with electric or electronic speech transmission devices, having an integral or body attached battery power supply should be used with caution in explosive atmospheres. Sealed power sources should be checked for integrity of seals. Connecting cables from microphones inside the facepiece should have gas tight seals where they emerge from the facepiece. When the loudspeaker diaphragm is a part of the barrier between the respirator wearer and the ambient atmosphere, it should be frequently inspected for leakage and should be adequately protected from puncture or rupture. The assembly of an electronic or electrical speech transmission device into a respirator should be avoided if it results in a shift of centre of gravity such that the mask may get dislodged from the face during wearer’s activity in a toxic environment. Removal of speech transmission devices may allow contaminant leakage into the facepiece.
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