IS 9623 (2008): Selection, use and maintenance of respiratory protective devices - Code of practice [CHD 8: Occupational Safety, Health and Chemical Hazards]

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श्वसन संरक्षी उपकरणों का चयन, उपयोग और रख-रखाव — रीति संहिता

(पहला पुनरीक्षण)

Indian Standard

SELECTION, USE AND MAINTENANCE OF RESPIRATORY PROTECTIVE DEVICES — CODE OF PRACTICE

(First Revision)

ICS 13.340.30

BUREAU OF INDIAN STANDARDS
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NEW DELHI 110002

April 2008

Price Group 11

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Occupational Safety and Health and Chemical Hazards Sectional Committee had been approved by the Chemical Division Council.

This standard is intended to be a guide for the use of respiratory protective devices in industries. It is stressed that where there is a risk arising from employees inhaling air-borne contaminants which may cause injury, efforts should be made to remove the risk by improving the environment of the plant and the methods of operation. Nevertheless, the use of respiratory protective devices becomes necessary in some operations and in these situations such devices should be readily available for immediate use. Certain toxic substances can also be absorbed through skin. Where such hazards exist, respiratory protection alone is not sufficient and whole body should be protected through a positive pressure-tight suit including boots and gloves.

This standard was first published in 1980 taking assistance from AS CZ 11-1968 'Respiratory protective devices', BS 4275 : 1968 'Recommendation for the selection, use and maintenance of respiratory protective equipment' and ANSI Z 88-2-1969 'Practices for respiratory protections'. The concerned technical committee felt the need to revise this standard based on the experiences gained and the technological developments in the last two and a half decades in this area. During this revision, the standard has been made compatible with IS 8347 : 2007 'Respiratory protective devices — Definitions, classification and nomenclature of components *(first revision)*' and also considering the present Indian Standards on RPD which are developed aligning with the relevant EN standard. Further, apart from modifications in most of the clauses, following new aspects have been incorporated in this revision:

a) Hazard identification, evaluation and control,
b) Biological effects of respiratory hazards,
c) Respiratory protection programme,
d) Periodic evaluation and audit of the programme, and
e) Nominal protection factor.

This revision also provides the requirements of air quality for supplied air respirators, examples for selection of respirators through use of protection factor required medical fitness to use respirators, sample programme for respiratory protection programme and its checklist as annexes (*see* Annexes A, B, C, G and H) for benefit of the users.

The composition of the Committee responsible for the formulation of this standard is given at Annex J.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

SELECTION, USE AND MAINTENANCE OF RESPIRATORY PROTECTIVE DEVICES — CODE OF PRACTICE

(First Revision)

1 SCOPE

This standard describes various types of respiratory protective devices, discusses the factors affecting the choice of such devices, provides information and guidance on the selection, use and maintenance of respirators and contains recommendations for establishing respirator protection programmes at the workplace.

The standard, however, does not cover in its purview underwater breathing devices, the use of respirators in aircrafts, the use of respirators under military combat conditions and the use of life support respirators for medical or resuscitation purposes.

2 REFERENCES

The following standards contain provisions which, through reference in this text constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreement based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
8347 : 2007	Respiratory protective devices — Definitions, classification and nomenclature of components (*first revision*)
9473 : 2002	Respiratory protective devices — Filtering half masks to protect against particles (*first revision*)
10245	Breathing apparatus:
(Part 1) : 1996	Closed circuit breathing apparatus (compressed oxygen cylinder) — Specification (*first revision*)
(Part 2) : 1994	Open circuit breathing apparatus (*first revision*)
(Part 3) : 1999	Fresh air hose and compressed air line breathing apparatus
(Part 4) : 1982	Escape breathing apparatus (short duration self-contained type)
14166 : 1994	Respiratory protective devices — Full face masks
14746 : 1999	Respiratory protective devices: Half masks and quarter masks
15322 : 2003	Particle filters used in respiratory protective equipment
15323 : 2003	Gas filters and combined filters used in respiratory protective equipment

3 TERMINOLOGY

For the purpose of this standard, the definitions given in IS 8347 shall apply.

4 HAZARD IDENTIFICATION, EVALUATION AND CONTROL

4.1 Purpose

Identification of the type, nature and level of the hazard is necessary as it helps to determine the need for respiratory protection and the type of respirators required therewith.

4.2 Hazard Identification

4.2.1 The type and nature of the airborne contaminants shall be identified from the substances used, the processes and their products.

4.2.2 Material Safety Data Sheets (MSDS) shall be obtained from the manufacturers for all substances used and likewise information should be compiled for all products and by-products of process operations.

4.2.3 The atmosphere of any confined space shall be tested for oxygen deficiency, explosive atmospheres, and presence of toxic airborne contaminants before allowing entry of any person.

4.3 Hazard Evaluation

4.3.1 The level of exposure of workers to inhalation hazards shall be determined by measuring the concentrations of air contaminants or oxygen using appropriate sampling instruments and analytical methods.

4.3.2 Appropriate sampling strategies shall be followed to determine the full time weighted average (TWA) concentration, and where appropriate, the short term concentration to which the workers may be exposed. The results shall be compared with the relevant permissible exposure levels specified in the *Factories Act* and/or *Mines Act*, 1952.

4.4 Hazard Control

The main objective is to reduce or minimize workplace concentration of contaminants (dusts, mists, smoke, vapour or gases). This shall be accomplished, as far as possible, by adopting appropriate engineering control measures. Subject to effective engineering control being not feasible, suitable performing respirators shall be used.

5 RESPIRATORY HAZARDS AND THEIR BIOLOGICAL EFFECTS

5.1 Oxygen Deficiency

5.1.1 *Occurrence*

Oxygen deficiency is likely to be encountered in confined or unventilated cellars, wells, mines, ship holds, tanks, bins, vaults, burning buildings, and enclosures containing inert atmospheres.

5.1.2 *Effect*

There is normally 21 percent by volume of oxygen in the air, but a human being can get along on 17 percent, although this will cause his breathing to be laboured. At about 16 percent a candle or oil flame will be extinguished, whereas at 13 percent an acetylene flame goes out and most men cannot work. Below 13 percent concentration, dizziness and headaches occur. Eight to 10 percent concentration usually results in unconsciousness or death.

NOTE — The adverse effect of oxygen deficiency increases with decreasing atmospheric pressure or increased altitude.

5.2 Gaseous and Vapour Contaminants

5.2.1 *Asphyxiants*

They interfere with utilization of oxygen in the body.

5.2.1.1 *Simple asphyxiants*

These are physiologically inert substances that dilute oxygen in the air, for example, nitrogen, hydrogen, helium, methane and carbon dioxide.

5.2.1.2 *Chemical asphyxiants*

In low concentrations, these interfere with the supply or utilization of oxygen in the body by chemically reacting with blood, for example, carbon monoxide, hydrogen cyanide, cyanogens and nitriles.

5.2.2 *Irritants*

These are corrosive in action. They may cause irritation and inflammation of parts of the respiratory system (also skin and eyes) and pulmonary odema, for example, ammonia, hydrogen chloride, formaldehyde, sulphur dioxide, chlorine, ozone, nitrogen dioxide, phosgene and arsenic trichloride.

5.2.3 *Anaesthetics*

They cause loss of feeling and sensation and may lead to unconsciousness and death, for example, nitrous oxide, halogenated hydrocarbons and ethers. Some anaesthetics damage body organs, for example, carbon tetrachloride affects liver and kidneys, and chloroform affects liver and heart.

5.2.4 *Systemic Poisons*

These damage organs and systems in the body, for example, mercury (nervous system and various organs), phosphorus (bone), hydrogen sulphide (respiratory paralysis) and arsine (red blood cells and liver).

5.3 Particulate Contaminants

5.3.1 *Relatively Inert*

They cause discomfort and minor irritation, but generally there is no injury at reasonable concentrations. Examples are marble and gypsum.

5.3.2 *Pulmonary Fibrosis Producing*

They produce nodulation and fibrosis in the lungs, possibly leading to complications, for example, quartz, cristobalite, tridymite, coal and asbestos.

5.3.3 *Cancer Producing*

These produce cancer in some individuals after 'latent' period of 20 to 40 years, for example, asbestos, chromates, and radioactive particulates.

5.3.4 *Chemical Irritants*

These produce irritation, inflammation, ulceration, etc, in upper respiratory tract, for example, acid mists and alkali mists.

5.3.5 *Systemic Poisons*

They produce pathologic reactions in various systems of the body, for example, lead, manganese and cadmium.

5.3.6 *Allergy Producing*

They produce reactions such as itching, sneezing and asthma, for example, pollens, isocyanates, gums and spices.

5.3.7 *Febrile Reaction Producing*

These produce chills followed by fever, for example, fumes of zinc and copper.

5.4 Combinations of Gas, Vapour and Particulate Contaminants

Combinations of contaminants may occur simultaneously in the atmosphere. Contaminants may be entirely different substances (dust or gases from

blasting) or the particulate and vapour forms of the same substance. Synergistic effects may occur. Such effects may require extraordinary protective measures.

5.5 Conditions immediately dangerous to life or health may result from most of the above hazards with the probable exception of nuisance or low toxicity dusts.

6 RESPIRATORY PROTECTION REQUIREMENTS

6.1 Purpose

The purpose of respiratory protection is to ensure that the workers are adequately protected from inhaling excessive airborne contaminants or air, which is oxygen deficient. Workers should not be exposed to airborne contaminants in excess of their permissible exposure levels, where possible.

6.2 Indications

Appropriate respiratory protection shall be used by workers when exposed to oxygen deficient atmospheres or to airborne concentrations of contaminants in excess of or likely to exceed the permissible exposure levels. Where the airborne contaminants exceed half the permissible exposure levels, the use of appropriate respirators is advisable.

6.3 Respirator Standards

The respirator shall meet the relevant Indian Standards.

6.4 Employer Responsibility

Where respirator protection is required, suitable performing respirators shall be provided and maintained by the employer or by the occupier. The employer or the occupier shall be responsible for the establishment and maintenance of a respiratory protection program. They shall also be responsible for ensuring that the workers are properly trained in the use and care of the respirators.

6.5 Employee Responsibility

The workers shall use and maintain the respirators provided in accordance with instructions and training received.

7 RESPIRATORY PROTECTION PROGRAMME

7.1 Purpose

Providing respirators are only one of the components of the overall employer responsibility, and by itself may not ensure effective protection against inhalation hazards. The amount of contaminant that penetrates into the respirator depends on:

a) the efficiency of the filtering medium,

b) leakage through the seal between the facepiece and the face, and

c) leakage through the exhalation valve.

For respirators to be effective, they shall be of the correct type to protect against the hazard, be properly fitted to the workers faces, be worn all the time in the presence of the hazard and be properly maintained. The purpose of the respiratory program is to ensure that where respirators are used, they should provide adequate and effective protection against inhalation hazards.

7.2 Program Administration

7.2.1 The respiratory program shall be established by the employer or by the occupier and an individual designated to administer the program. The individual selected to administer or coordinate the program should be well versed in the area of respiratory protection and ideally be trained in Occupational Health or Safety. Overall he shall be responsible for the effective implementation of the program and shall have the full support of the management.

7.2.2 *Written Standard Operating Procedures*

Written standard operating procedures shall be established and implemented. There should be procedures for routine use of respirators as well as for emergency and rescue use. Suitable individuals should be responsible to the overall coordinator and be given responsibility of implementing some of the component activities of the program, where appropriate.

7.2.3 *Records*

Records of workplace monitoring, respirator issuance, fit testing, training, periodic inspections and maintenance of respirators shall be maintained.

7.3 Program Components

An effective respiratory protection program should incorporate the following:

a) Selection of suitable types of respirators,

b) Medical screening to determine workers fitness to use respirators,

c) Fit testing during issuance of respirators to ensure proper facial fit,

d) Training workers in the proper use and care of respirators,

e) Supervision of proper usage of respirators,

f) Inspection and maintenance of respirators,

g) Regular monitoring of worker exposure to the contaminant, and

h) Periodic evaluation and audit.

8 TYPES OF RESPIRATORY PROTECTIVE DEVICES, THEIR CAPABILITY AND LIMITATIONS

8.1 Respiratory protective devices are classified under two distinct types, namely, filtering device type and breathing apparatus type. The detailed classification of respiratory protective devices is shown in Fig. 1, 2, and 3.

8.1.1 *Filtering Device*

8.1.1.1 The contaminated inhaled air passes through filter(s) that reduce harmful airborne contaminants to below permissible exposure levels. The nature of the filter depends upon the composition and physical state of the contaminant. Such devices do not provide protection in oxygen deficient atmospheres or an atmosphere where the level of the harmful contaminant is excessive such as a level posing immediate danger to life and health (IDLH). There are also some gases or vapours which cannot be removed by any available filter(s).

8.1.1.2 Filtering devices do not protect against: (a) oxygen deficient atmospheres, (b) skin irritation, and (c) absorption through the skin or airborne contaminants. The maximum contaminant concentration against which an air purifying respirator will protect is determined by the designed efficiency and capacity of the chemical filter or filter. For gases and vapours and for particles having a TLV of less than 0.1 mg/m^2 the maximum concentration for which the air purifying unit is designed is specified on the label. Respirators will not provide the maximum design protection specified unless the facepiece is carefully fitted to the wearer's face to prevent inward leakage. The period for which protection is afforded depends on: (a) the type of filter, (b) concentration of contaminant, and (c) the wearer's respiratory rate.

A proper type of filter should be selected for the particular atmosphere and conditions. Filtering devices generally cause discomfort objectionable to breathing. Respirator facepiece present special problems to individuals required to wear prescription lenses.

8.1.2 *Breathing Apparatus*

8.1.2.1 Respirable air is provided from a source independent of the working environment. It is delivered

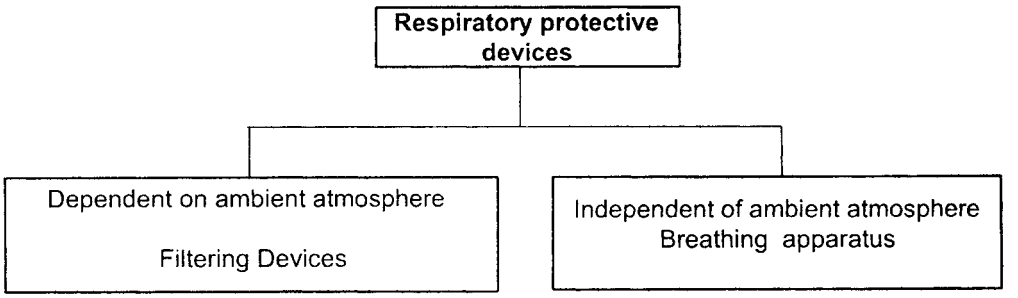

FIG. 1 CLASSIFICATION OF RESPIRATORY PROTECTIVE DEVICES

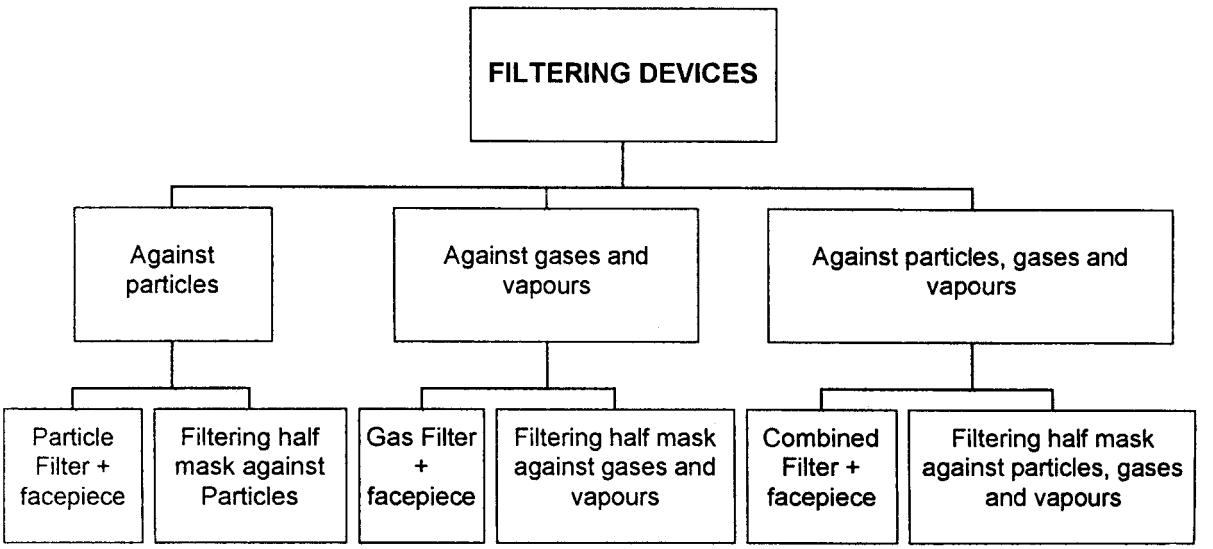

FIG. 2 FILTERING DEVICES

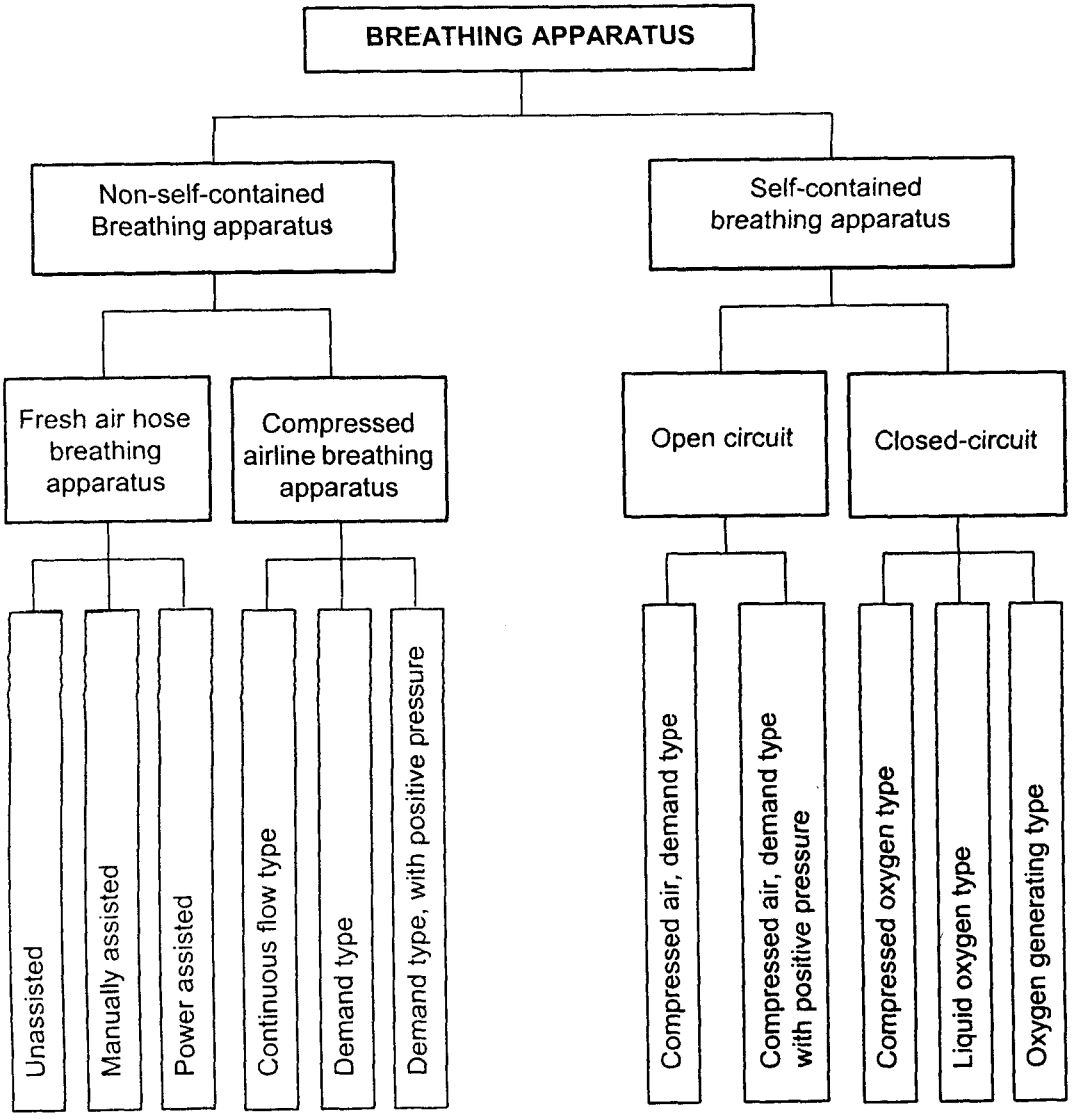

FIG. 3 BREATHING APPARATUS

to the person through an airline, or from an apparatus carried by the person.

Atmosphere-supplying respirators provide protection against oxygen deficiency and most toxic atmospheres. The breathing atmosphere is independent of ambient atmospheric conditions. Except for the supplied-air suit, no protection is provided against skin irritation by materials such as ammonia and hydrogen chloride, or against absorption of materials, such as hydrogen cyanide, tritium, or organic phosphate pesticides through the skin. Facepieces present special problems to individuals required to wear prescription lenses.

8.1.2.2 There are two types of supplied air respirators:

a) *Non-SCBA or airline respirators* — Breathable air is supplied via a fresh air hose, or from a compressor/compressed air cylinder [*see* IS 10245 (Part 3)]. The quality of compressed air shall meet the specifications in Annex A. The hose is attached to the user by a belt or other suitable means and can be detached rapidly and easily in an emergency. A flow control valve or orifice is provided to regulate the rate of airflow to the user. Exhaled air passes to the ambient atmosphere through a valve or opening in the respirator inlet covering (half or full facepiece, helmet or hood).

The respirable air supply is not limited to the quantity the individual can carry, and the devices are light weight and simple. The wearer is restricted in movement by the hose

or airline and shall return to a respirable atmosphere by retracing his route of entry. The hose or airline is subject to being severed or pinched off.

The demand type produces a negative pressure in the facepiece on inhalation whereas continuous flow and pressure-demand types maintain a positive pressure in the facepiece at all times and are less apt to permit inward leakage of contaminants. Air-line respirators provide no protection if the air supply fails.

Airline respirators are classified into three types:

1) *Continuous-flow type (positive pressure)* — A volume of air more than required for breathing by the wearer is supplied continuously to the respirator inlet covering in positive pressure. At least 115 litres of air per minute for tight fitting facepieces and 170 l/min for loose fitting facepieces, helmets and hoods is required to ensure positive pressure during the users' inhalation cycle.
2) *Demand type (negative pressure)* — The demand valve permits flow of air only during inhalation when a negative pressure exists in the space between the inlet covering of a tight-fitting respirator and the face of the user. The demand valve shuts off completely during exhalation.
3) *Pressure demand (positive pressure)* — A positive pressure is normally maintained in the tight fitting respirator. Air flows when pressure inside the facepiece is reduced below a pre-set (positive) value because of leakage or inhalation.

b) *Self-Contained Breathing Apparatus (SCBA)* — The wearer carries the breathing air source. Commonly a full-facepiece is used, although half facepiece and hoods are available. The SCBA allows mobility. The service life depends on the amount of oxygen carried and whether oxygen in the exhaled breath is recirculated. It should be used in atmospheres with unknown air contaminants, IDLH levels or oxygen deficient atmospheres.

Use is permissible in atmospheres immediately dangerous to life or health. The period over which the device will provide protection is limited by the amount of air or oxygen in the apparatus, the ambient atmospheric pressure (service life is cut in half by a doubling of the atmospheric pressure) and work load. A warning device shall be provided to indicate to the wearer when the service life has been reduced to a low level. Some apparatuses have a short service life (few minutes) and are suitable only for escape (self-rescue) from an irrespirable atmosphere. Main limitations of these respirators are their weight or bulk or both, limited service life, and the training required for their maintenance and safe use.

There are two types of SCBA:

1) *Open-circuit SCBA* — Compressed breathing air is carried in cylinders and is released through a pressure demand valve and breathing tube to facepiece or head covering from which exhaled air passes through a non-return valve to the atmosphere [*see* IS 10245 (Part 2)]. The duration of use for commercially available units typically ranges from 30 min to an hour. The demand type produces a negative pressure in the facepiece on inhalation whereas the pressure-demand type maintains a positive pressure in the facepiece and is less apt to permit inward leakage of contaminants.
2) *Closed-circuit SCBA* — The exhaled breath contains about 70 percent oxygen. In this type all or part of the exhaled air is cleaned and recycled after removal of carbon dioxide and moisture. Make up oxygen is provided from cylinder(s) of compressed oxygen or liquid oxygen [*see* IS 10245 (Part 1)], or from oxygen-generating chemicals. The duration of use for commercially available units typically ranges from 30 min to 4 h. The closed circuit operation conserves oxygen and permits longer service life.

NOTE — Self-contained breathing apparatus can only be used with full face masks or mouthpieces, since half masks or hoods do not have a sufficiently tight connection with the human air passage.

SCBA's for escape is a smaller and lighter version that provides breathing air for a shorter period of time for escape from IDLH or oxygen deficient atmosphere [*see* IS 10245 (Part 4)]. The facepiece or head covering is designed to facilitate quick donning. With a compressed air source, the service life for a continuous flow hood type escape SCBA is typically

5 to 8 min and that for a pressure demand full facepiece escape SCBA is 5 to 15 min and 30 to 90 min with a oxygen generating source. These respirators are not designed for use in routine work or for rescue purposes.

8.2 Types of Respirator Inlet Coverings

It refers to a facepiece (half or full mask) (*see* IS 14166 and IS 14746) or a head covering (helmet or hood) worn by a user. It serves as a barrier against the contaminated separate atmosphere and as a framework to which air purifying filters or supplied airline may be attached. There are two types of respirator inlet coverings (*see* Fig. 4). The tight fitting type is designed to provide a tight facial seal on the user. The loose fitting type is designed to cover the entire head. Tight fitting type inlets can be used for all respirators (both filtering device and breathing apparatus). Loose fitting facepieces or hoods and helmets are used in continuous flow respirators such as Powered Air Purifying Respirators (PAPR) or airline respirators. Hoods and helmets protect the head against flying particles in jobs such as sand blasting. Helmets provide additional protection against falling objects.

8.3 Types of Filtration Media

Air contaminants are in particulate (solid or liquid) or gaseous chemicals (gas or vapour molecules). Airborne particles are removed from the air by filtering mechanisms when the contaminated air passes through the particulate filters. Gaseous chemicals are removed usually through sorption mechanisms when the contaminated air passes through the sorbent filters.

8.3.1 *Particulate Filters*

Air purifying particulate filters are classified as P1, P2 and P3 according to their filtering efficiency as per IS 15322 and IS 9473. Filter efficiency is commonly tested using a 0.3-micron NaCl or Paraffin oil aerosol. The 0.3-micron size is the most penetrating size for particulate filters. Therefore, respirators will filter all other particle sizes at least as well as the certified efficiency level. The service life is generally limited by considerations of hygiene, damage and breathing resistance. Atmospheric contaminants such as oil mist may cause reduction in filter efficiency. In oily environments, the use of oil resistant filters may be considered. Particulate filters alone shall not be used against gas or vapour hazards. The service life depends on breathing resistance which increases when particulate starts loading on the filter.

8.3.2 *Chemical Filters*

The sorbent chemical filtering device respirators remove gaseous and vapour contaminants. They have a limited service life which varies with the volume, type, packing density of sorbent, used such as activated charcoal and the conditions under which it is used, such as the concentration of the contaminant in the

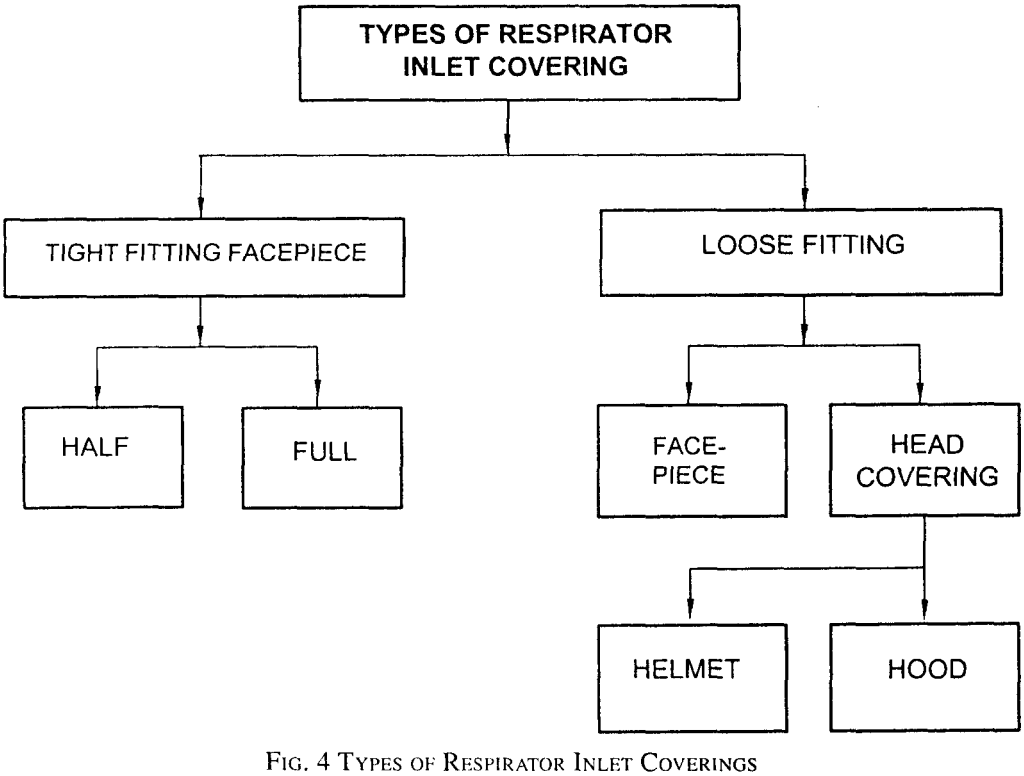

FIG. 4 TYPES OF RESPIRATOR INLET COVERINGS

atmosphere, the humidity and the breathing rate of the user (work load). The selection of filter depends on the type of contaminant, the permitted maximum use concentration and the length of service life. Sorbent filters are designed to provide protection for a specific chemical such as ammonia or a class of chemical hazard such as organic vapours (*see* IS 15323). Some of the commercially available sorbent filters are used for protection against organic vapours, acid gases, ammonia, formaldehyde, etc. It is important that the filter(s) should be selected for the specific chemical hazard. For example, sulphur dioxide filters will protect against atmospheric sulphur dioxide but may not be suitable for protection against organic vapours. Sorbent filters are not suitable for protection against airborne particles.

High and medium capacity filters contain more volume of sorbent than that of low capacity filters and hence can be used at higher contamination levels or for a longer service life. Medium and high capacity (front or back mounted) fitters are used with a PAPR.

The capacity of a sorbent filter is defined as the product of its maximum use or tested concentration (C_{MAX}) and its breakthrough time (T_{bt}):

$$\text{Filters capacity (mg.h/m}^3\text{)} = [C_{MAX}\,(\text{mg/m}^3)] \times [T_{bt}\,(\text{h})]$$

A sorbent filter cannot be used in contaminated atmosphere above its maximum use concentration or IDLH level. When it is used at contaminated atmosphere below the maximum use concentration, its service life is longer than the maximum use breakthrough time. The new service life can be calculated as follows:

$$\text{Service life (h)} = \text{Filters capacity/Exposure concentration}$$

8.3.3 *Combination Particulate and Gaseous Filter Media*

A combination particulate filter and chemical filters (*see* IS 15323) shall be used to remove the presence of both particulates and gaseous contaminants. It can be a sorbent filter with a particulate filter attached on the inlet side or an integral combined filter. Integral combined filters are sorbent filters built in with a particulate filter in one unit. Particulate filter with adequate filtration efficiency and sorbent filters for the specific chemical shall be selected. In operations such as spray painting, a combination filter consisting of a particulate filter and an organic vapour sorbent filters shall be used. A prefilter may also be added on the inlet side to prevent the relatively large paint droplets from clogging the particulate filter quickly. Integral combined filters designed for specific combined exposures applications such as spray painting and pesticide applications are also available.

8.4 Selection of Respiratory Protective Devices Using Nominal Protection Factors

8.4.1 *Introduction*

The performance of respiratory protective devices can be expressed in terms of the contaminant concentration inside the facepiece cavity (C_1) and the contaminant concentration outside the facepiece (C_0). The relationship between C_1 and C_0 can be expressed as penetration (C_1/C_0), efficiency ($C_0 - C_1)/C_0$ or protection factor (C_0/C_1). The protection factor is related to the penetration (p %) and efficiency (e %) as follows:

$$\text{Protection factor} = (C_0/C_1) = \frac{100}{p(\%)} = \frac{100}{100 - e(\%)}$$

In general, the C_1 term of the protection factor considers total leakage into the facepiece. When various sources of leakage into the device are controlled or when different techniques are used to determine both C_0 and C_1 the resulting ratio expressions are given distinct designations such as fit factor or laboratory protection factor. All measures of performance dealing with a ratio of inside the outside facepiece concentration are based upon the above equation, with the difference being the limitations and conditions imposed on the concentration measurements, particularly C_1.

8.4.2 *Protection Factor*

Protection factors can be defined in many ways as given in **8.4.2.1** to **8.4.2.7** below.

8.4.2.1 *Assigned protection factor*

The 'Assigned Protection Factor' is a measure of the minimum anticipated workplace level of respiratory protection that would be provided by a properly functioning device, to a large percentage of properly fitted and trained users. The maximum use concentration for a device is generally determined by multiplying a contaminant's occupational exposure limit (or TLV) by the protection factor assigned to the device. The Assigned Protection Factor should be based on Workplace Protection Factor measurements made in a representative number of wearers. In the absence of Workplace Protection Factor measurements, it may be necessary to utilize measurements of Laboratory Protection Factors. However, it is not appropriate to rely upon measurements of Laboratory Protection Factors in this way, unless there is a demonstrated correlation between the Laboratory Protection Factor and the Workplace Protection Factor.

8.4.2.2 *Effective protection factor*

The 'Effective Protection Factor' is a measure of the overall protection achieved in the workplace, taking into account time periods when RPD's are not worn. It is defined exactly as the Workplace Protection Factor, with the exception that C_1 is collected even when the device is not worn. Again, both C_0 and C_1 are TWA samples collected simultaneously.

8.4.2.3 *Fit factor*

The 'Fit Factor' is a quantitative measure of the fit of a particular facepiece to a particular individual. It is defined under the conditions of quantitative fit testing as the concentration in the test chamber C_0 divided by concentration inside the facepiece C_1 which is attributable only to faceseal leakage. This can be assumed only if other sources of leakage including filter penetration and exhalation valve leakage are negligible.

8.4.2.4 *Laboratory protection factor*

The 'Laboratory Protection Factor' is a surrogate measure of the Workplace Protection Factor of a device. It differs from the Workplace Protection Factor only in that it is measured in a laboratory simulation of a workplace setting rather than actually measured in the workplace. The definition of and restrictions on C_0 and C_1 are as described for Workplace Protection Factor with the exception that the tests are conducted in the laboratory under situation which attempt to stimulate actual workplace activities and conditions. For Laboratory Protection Factor testing to estimate Workplace Protection Factors reliably a relationship must be demonstrated between the two tests. No such relationship has been identified in the literature and until such a relationship can be shown experimentally the Laboratory Protection Factor is of questionable use in determining the predicting Workplace Protection Factor.

8.4.2.5 *Programme protection factor*

The 'Programme Protection Factor' is a measure of the respiratory protection provided to a worker by an established programme. It is defined as the TWA estimated contaminant concentration which the user would inhale if he were not wearing the respiratory protective device C_0 divided by the TWA estimated contaminant concentration inside the facepiece measured while the device is used in the context of the existing programme C_1. In terms of worker health, the Programme Protection Factor is the most significant form of the protection factor. It is a measure of the effectiveness of the complete programme. The Programme Protection Factor is a function of the wearer, the fit of the device, selection, the design, training, maintenance, storage, supervision, program administration and monitoring and any other variable that affects programme effectiveness. If any of these programme elements are deficient, the Programme Protection Factor will be adversely affected.

8.4.2.6 *Workplace protection factor*

The 'Workplace Protection Factor' is a measure of the actual protection provided in the workplace under the conditions of that workplace by a properly functioning device when correctly worn and used. It is defined as the estimated contaminant concentration which the user would inhale if he were not wearing the respiratory protective device C_0 divided by the estimated contaminant concentration inside the facepiece C_1. The sampling restrictions placed on C_0 and C_1 are that both be time-weighted average (TWA) samples taken simultaneously, only while the device is properly worn and used during normal working activities. In practice, the Workplace Protection Factor would be determined by measuring the concentration inside and outside the facepiece during the activities of a normal workday.

It has been the practice, in the absence of Workplace Protection Factor or Laboratory Protection Factor data, to assign protection factors on measurements of respiratory protective device fit factors. The practice however is not considered to be appropriate unless a reliable correlation between the Workplace Protection Factors and the fit factors can be demonstrated.

The specific protection factors defined above accommodate the majority of conditions in which the protection of a respiratory protective device needs to be specified. In summary, the Workplace Protection Factor is a measure of the protection provided by a device during a work shift when it is worn for only some fraction of the total work shift periods, the fit factor is a quantitative estimate of the fit of a particular device to a particular individual; the Programme Protection Factor describes the protection provided by an established respiratory protection programme and the assigned level of protection provided by a device to a large percentage of the user population.

As described above the Programme Protection Factor is the only meaningful value in the workplace, but for the purpose of this standard the Nominal Protection Factor will be used.

8.4.2.7 *Nominal protection factor*

The Nominal Protection Factor is calculated from the permitted total inward leakage values derived from criteria specified in standards. Normally, the Nominal Protection Factor can provide only very rough guidance for the performance (protection) of an apparatus on a person. In order to use the Nominal Protection Factor many parameters have to be accommodated. Using

Nominal Protection Factors for the selection of respiratory protective devices is one of several possible approaches and should never be a substitute for careful checks by the user which are designed to ensure the suitability of the chosen device for the intended use. Claims relating to performance which are based upon Nominal Protection Factors may be misleading and shall be used with caution.

As an aid to the selection of respiratory protective equipment, the term 'Nominal Protection Factor' has been introduced into these guidelines for each type of equipment. The NPF is derived from the maximum permitted leakage (%) of the whole device stated in certain standards or some of the inward leakage figures from the relevant standards for different components.

Nominal Protection Factor is defined as:

$$NPF = \frac{1}{PIL} \times 100\ \%$$

where

PIL = permitted total inward leakage (%).

Example 1: *Complete Equipment*

Filtering half mask *FFP*1

Permitted total inward leakage = 22 %

$$\text{Nominal Protection Factor} = \frac{1}{\text{Permitted total inward leakage}} = \frac{1}{22} \times 100 = 4.5$$

Example 2: *Multicomponent Equipment*

Particle filter *P*1 and half mask

Permitted inward leakage through the filter	20 %
Permitted inward leakage at the faceseal and exhalation valve	2 %
	22 %

$$\text{Nominal Protection Factor} = \frac{1}{22} \times 100 = 4.5$$

8.4.3 *The Protection Factor Needed*

The selection of the most suitable type of equipment for particular circumstances requires understanding of the hazard against which protection is required as well as understanding of the limits of protection of the equipment available.

It is necessary to know both the concentration and occupational exposure limits of harmful contaminants that are likely to be encountered in air.

Example 3

How to estimate the protection factor required?

Contaminant : harmful airborne dust

Concentration : the time-weighted average is 20 mg/m^3

The occupational exposure limit : 0.2 mg/m^3

The required minimum protection factor is:

$$\frac{20}{0.2} = 100$$

From the list (*see* Table 1) of respiratory protection devices can be seen the types of equipment which may meet this requirement if used correctly.

Example 4

The maximum allowed concentration of contaminant with *P*2 filter and full face mask:

Contaminant : Chlorine

Occupational exposure limit : 1 ppm

Full face mask gives a nominal protection factor 2 000

*P*2 + full face mask gives a nominal protection factor 2 000

2 000 × 1 ppm = 2 000 ppm = 0.2 % chlorine

It should be borne in mind that the performance predicted by the Nominal Protection Factor is determined from criteria in Indian Standards and can only be expected of a respiratory protection device that is correctly worn and which has been properly maintained. When a facepiece is available in more than one size it is important the best fitting size for the individual is worn. Facial hair, when present between the face and facepiece, will substantially increase the leakage with consequent decrease in protection.

8.4.4 *Actual Protection Achieved by RPD's in Use*

Nominal Protection Factors compare only the test requirements for performance under laboratory conditions, provided by the different types and classes of RPD. The actual protection provided by a given device depends on the airflow, fitting of the facepiece and many other personal and environmental factors.

Inward leakage of ambient atmosphere may occur at the faceseal when the pressure within the facepiece falls below atmospheric pressure during inhalation. Inward leakage caused by exhalation valves should be small under normal conditions but can be drastic in certain cases. In the case of particle filters, there will generally be a measurable penetration through the filter itself. An inward leakage may occur at the neck cord of a hood type compressed airline device or at the waist

Table 1 Nominal Protection Factors
(*Clause* 8.4.3)

Device	Marking	Nominal Protection Factor[1)]
(1)	(2)	(3)
Particulate Filtering Devices:		
a) Filtering half mask	FFP1	4
	FFP2	12
	FFP3	50
b) Filter with quarter mask or half mask	P1	4
	P2	12
	P3	50
c) Filter with full face mask	P1	5
	P2	20
	P3	1 000
Gas Filtering Devices:		
a) Filter with quarter or half mask		20
b) Filter with full face mask		2 000
Fresh Air Hose Breathing Apparatus:		
a) With half mask		50
b) With hood (only powered)		1 000
c) With full face mask		2 000
d) With mouthpiece assembly		1 000
		In assisted type apparatus the inward leakage is the same as that of the facepiece
		In unassisted type the inward leakage depends on air supply
Compressed Airline Breathing Apparatus:		
a) With half mask		20
b) With hood		1 000
c) With full face mask		2 000
d) With mouthpiece assembly		10 000
		In continuous flow devices the inward leakage depends on air supply and work raise and is less than that of the facepiece
Self-Contained Open-Circuit Component Air Breathing Apparatus:		
a) With full face mask		2 000
b) With mouthpiece assembly		10 000
c) With positive pressure		50 000
Self-Contained Closed-Circuits Oxygen Breathing Apparatus:		
a) With full face mask		2 000[2)]
b) With mouthpiece assembly		10 000[2)]
c) With positive pressure		50 000[2)]
		The recirculation of the gas can reduce the protection factor

[1)] The nominal protection factors given are only for guidance.
[2)] In closed circuit breathing apparatus the exhaled breath is recirculated to remove carbon dioxide. Any other contaminant present is also recirculated and may reduce the effective protection given by the device.

band and wrists of a blouse type compressed airline device.

Nominal Protection Factors can only be used for comparing different types of devices. To determine the actual protection, every person who is likely to use the device would have to be tested because the protection is specific to the wearer in given circumstances and is subject to changes. However, every person who will use a device should be checked as appropriate to ensure a satisfactory faceseal as recommended by the manufacturer.

8.4.5 *Selection of Respiratory Protective Devices*

In order to achieve the Nominal Protection Factor, all factors mentioned in the description of different devices should be considered and their influences on real protection under working conditions given by a specific device evaluated.

It is especially important that all persons requiring respiratory protective devices are adequately trained and educated in the use of the device. The user should know the function, capabilities and limitations of the device.

The user shall be so trained that he knows how to put the device on so that it fits properly. Checking the operation and facepiece fit before entering a hazardous atmosphere should also be included in the training. The user should be aware that the protection will be reduced substantially if the device is not working all the time.

9 SELECTION OF RESPIRATORS

9.1 Factors in Selection

When selecting a suitable respirator for a particular situation many factors have to be evaluated. It is critical to ensure that only the correct type of respiratory protective devices are used, and where there is any doubt, expert advice should be sought. Few examples for selection of respirators are given in Annex B.

The selection of respiratory protective devices depends on the following factors:

a) Hazard related factors are used to identify respirators that can provide adequate protection based on the nature of harmful contaminant and its atmospheric concentration.

b) Task related factors are used to identify respirators which are suitable for the work activities or workplace environments.

c) Operator related factors are used to identify respirators that fit and are acceptable to the users. Tight fitting respirators shall pass recommended methods of test for facial fit.

9.2 Hazard Related Selection Factors

These include the nature; permissible exposure levels and atmospheric level of the harmful contaminant define the extent and nature of protection needed for the selection of the correct respirators for applications.

a) *Oxygen Deficient, Unknown Hazard, Unknown Concentration or Concentration Above IDLH* — Use SCBA or full-face airline respirator (Positive Pressure) with escape SCBA or helmet/hood continuous flow airline respirator with escape SCBA.

b) *Required Minimum Protection Factor (Min PF_{req})* — The minimum respiratory protection required is defined as the ratio of the atmospheric contaminant concentration to its PEL:

$$Min\ PF_{req} = \frac{\text{Atmospheric contaminant concentration}}{\text{Permissible exposure level}}$$

The required minimum protection factor for any given situation is that factor necessary to reduce the exposure of the user to below PEL. The choice of a suitable respirator is made from the respirators with APF's larger than the required minimum protection factor. If the $Min\ PF_{req}$ is > 1 000, a SCBA should be selected and if the $Min\ PF_{req}$ is < 10, an air purifying half facepiece should suffice if the contaminant is not an eye irritant.

c) *Inadequate Warning Properties* — The presence or breakthrough of harmful gases in the breathing air can be detected if they have a noticeable odour or they cause local irritation on the eyes or upper respiratory tract. This has often served as a warning against dangerous situations. Gases without adequate warning properties may lead to situations in which the users fail to replace the sorbent filters that have exceeded their service life. In this case, supplied breathing apparatuses are preferred. For contaminants, with short term PEL, air-purifying respirators shall only be used if the filters have a reliable end of service life indicators or the factory has a practical filters change schedule based on real life filters service data in place.

1) *Limitations of odour as warning for end of service filters life* — Odour indicates the presence of contaminant. Odour is often used to indicate that the cartridges have reached the end of their service life. However, the sense of smell may not be a reliable warning property in respiratory protection due to the following:

i) Considerable individual variations in smell perception. For example, hydrogen cyanide has a characteristic almond odour which is not detected by some people. Respirator users must be tested for their ability to detect the contaminant odour at low level when they are first fitted with respirators.

ii) The sense of smell may be considerably diminished by a cold or inflammed nasal passage. Users must be tested for their ability to detect the odour if there are reasons to believe that their sense of smell may be compromised.

iii) The odour of the harmful contaminant may be marked by the presence of other odours or smells. Breathing apparatuses are preferred in this situation. The sense of smell is not reliable.

iv) The sense of smell fails to detect high concentrations of some contaminants, such as hydrogen sulphide, if such concentrations have been built up gradually. Breathing apparatuses are preferred in this situation.

v) The odour of some contaminants,

such as toluene di-isocyanate (TDI) can only be detected at hazardous levels. Breathing apparatuses are preferred in this situation.

2) *Limitations of irritant action as warning for end of service cartridge life* — Irritants cause discomfort, burning sensation or irritation at the upper respiratory tract or eyes. Some contaminants, such as ammonia or hydrogen chloride, produce an intolerable sensation and no one would willingly remain in such an atmosphere. However, other contaminants such as solvent vapour that produce a milder irritation may cause the wearer to respirator beyond the service life of the filters. This may result in over exposure to the hazard.

d) *Irritants and Corrosives* — For chemicals that may irritate or damage the exposed eyes or skin, eye and skin protection should be provided in addition to respiratory protection. Full-facepicce, helmet or hood shall be used for eye protection and hood with protective clothing or full chemical suit for eye and skin protection.

e) *Physical Form of Hazards* — When a filtering device respirator is used, the correct type of filter(s) or chemical filter(s) or a combination of these shall be used. If the hazard is in the form of a gas or vapour, the appropriate sorbent Filters should be used. Particulate filters would not be protective against gas or vapour hazard.

9.3 Task Related Selection Factors

Certain respirators may interfere with the activities of a task or *vice versa*. Task related factors include working duration, activities of user, vision and communication requirement at work, extreme temperature, and the requirement for eye or head protection. These are summarized in Table 2.

9.4 Operator-Related Selection Factors

Facial characteristics may affect the facial seal and make it difficult to fit a respirator to the operator. In this situation, a loose fitting can be used. Facial characteristics affecting the use of a respirator are summarized in Table 3.

10 GUIDANCE ON USE OF RESPIRATOR

10.1 Fitness to Use Respirators

Respirators impose some level of physiological and psychological stress on the user. Although a majority of the workers may not have any difficulties using respirators, a few may have medical conditions that could limit the use of respirators. It is therefore advisable for persons who are required to wear respirators to undergo a medical assessment according to the details as given in Annex C to determine their fitness to wear respirators.

Table 2 Task Related Recommendations

(*Clause* 9.3)

Sl No.	Item	Recommendation
(1)	(2)	(3)
i)	Working Duration	*Service life*: Service life for SCBA is limited by the amount of breathing air carried and that for air purifying and PAPR respirators by the capacity of sorbent cartridges or canisters or the battery life. Extended use with particulate filter will result in an increase in breathing resistance caused by progressive blocking of filter. Compressors are preferred over compressed air cylinders to supply breathing air for the airline respirators. Air supplied from cylinders has limited service life.
ii)	Activity of User	*Unrestricted movement needed:* SCBA and Filtering device have the least interference on the users. Airline respirators restrict the movement of users. *Location of task*: Limited by the distance from compressed air source to location of work. Long airlines may be a source of danger to others working in the area and may themselves be damaged by accident. The use of cylinder air which can be moved close to the task location may alleviate these problems. *Heavy workload*: The weight size of SCBA or breathing resistance of air purifying respirators, especially those with a high efficiency filter, impose additional load to users. Airline or PAPR preferred.
iii)	Communication	Where communication is important, consideration should be given to selecting a facepiece with appropriate speech transmission facilities, otherwise the tendency will be for the user to remove the respirator to speak.
iv)	Temperature Extremes	*High temperature*: Use supplied air respirator having an adequate supply of cool breathing air to avoid heat stress, especially when heavy workload activities are involved. *High humidity*: In a high humidity atmosphere, fogging of full-facepiece. Supplied air or PAPR may be preferred.
v)	Eye or Head Protection	Full-facepiece, helmet or hood respirators protect the eyes and head from flying particles in blasting and splashes of corrosive chemicals. Welding eye protectors may interfere with full-facepiece, helmet or hood respirators.

Table 3 Limitations Related to Operators' Facial Characteristics
(*Clause* 9.4)

Sl No.	Characteristic	Recommendation
(1)	(2)	(3)
i)	Beards	Interferes with the fit of a half-mask or full respirator
ii)	Moustaches	Interferes with the fit of a half mask and if too long, interfere with the peripheral seal of a full facepiece respirator
iii)	Side burns	Interferes with the fit of a full face mask respirator if the side burns extend below a line drawn through the top of the tragion and the canthus of the eye
iv)	Long hair	Care should be taken to ensure that hair is not trapped beneath the fitting surface of a half mask or full face mask respirator
v)	Eye glasses	Use a full face respirator with special corrective lenses mounted inside
vi)	Facial deformities	Scars, deep skin creases, prominent cheek bones, severe acne and the lack of teeth or dentures can prevent a respirator from sealing properly

10.2 Fitness to Work with Specific Health Hazards

Workers exposed to certain specific contaminants (lead, cadmium, mercury, etc) are required to undergo pre-employment and periodical medical examinations. The results of the periodic medical surveillance (for example blood lead) may be useful as an indication of the effectiveness of respiratory protection.

10.3 The use and fit of a respiratory device require careful control and, where practicable, it should be issued on a personal basis.

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

10.5 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.

10.6 In areas where the wearer could be overcome 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.

10.7 Fitting of the facepiece is most important and subjects should be properly instructed when first issued with 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.

10.8 Respirator Fit Testing

10.8.1 *Purpose*

To select the right size and model of the respirator for the user to ensure that good facial seal integrity is achievable whenever the respirator is worn. It shall be done for all tight fitting air purifying and supplied air respirators, including SCBA. In order for the designed performance of the respirator to be achieved, the respirator must fit the user. After fit testing, if the respirator is issued at an individual, each respirator should bear an identifying mark, which may be the user's name, initial or badge number. This identification mark shall not affect the performance of the respirator.

10.8.2 *Methods*

A qualitative or quantitative respirator fit test method shall be used to determine the ability of each individual user to obtain a satisfactory fit with a respirator. A fit test must not be conducted if there is any hair growth between the face and the sealing surface of the respirator, such as stubble, moustache, beard, long side burns or the user is putting on prescriptive glasses with temple bars for tight fitting facepieces. Any safety equipment, such as goggles and safety glasses that is worn with the respirator in the normal course of work should also be worn during the fit testing. Prior to the commencement of the fit test, the user should conduct a fit check (if tight fitting facepieces are used) and also receive an explanation of the fit test procedures as given in Annex D.

If a situation is encountered where a fit with a respirator cannot be obtained, then the fit testing could be repeated using a different size or model. If this still fails, then transferring the worker to a job where respiratory protection is not required or providing the worker with a loose fitting respirator of sufficient protection shall be considered.

10.8.2.1 *Qualitative fit test methods (QLFT)*

For qualitative fit testing, banana oil (iso-amyl acetate) testing agent can be used only for those respirators that can filter organic vapours. Saccharain and Bitrex test agents are used for testing dust respirators not equipped with high efficiency filters. The latter is tested using an irritant smoke. Only validated test protocols as given

in **E-1** should be followed. QLFT methods have only been validated for a fit factor of 10 for a tight-fitting respirator operated in demand atmosphere-supplying or non-powered air-purifying respirator.

10.8.2.2 *Quantitative fit test methods (QNFT)*

This requires the use of special quantitative fit testing equipment and a trained operator. Only validated test protocols as given in **E-2** should be followed. The QNFT is validated for fit factor determination of all types of respiratory devices.

10.8.3 *Frequency*

a) Before the respirator is issued to assure that a suitable respirator has been selected.

b) At least once every 2 years or whenever there is any change in the user's facial characteristics or where medical examination indicates excessive exposure to a contaminant.

10.8.4 *Records of Fit Testing*

The following information should be recorded and maintained:

a) Name of person tested;
b) Type, size and model of the respirator selected;
c) Date of the fit test;
d) Person conducting the test;
e) Fit factor achieved and instrument calibration record, if quantitative fit test was conducted;
f) Success or failure of fit test and type of testing agent if qualitative fit test was conducted;
g) Success or failure of fit test and type of testing agent if qualitative fit test was conducted; and
h) List of personal protective equipment worn.

11 TRAINING

11.1 Purpose

Selecting the proper respirator for a given hazard is important, but equally important is using the device correctly. Proper usage can be ensured by training the respiratory program administrator & user in the selection, use and maintenance of respirators.

11.2 Content

a) *Program Administrator* — The administrator who oversees the requirement, issuance and proper usage of respirators in the company should have a comprehensive knowledge of respirators and respiratory protection practices. The training should include:
   1) Nature, extent and health effects of airborne contaminants in the workplace;
   2) Principles and criteria for selecting respirators;
   3) Fitting and issuance of respirators;
   4) Maintenance and storage of respirators;
   5) Company's respiratory protection program;
   6) Regulations concerning respirator usage;
   7) Limitations of respirator use in the situation used;
   8) Probable time over which it will provide protection; and
   9) Necessity for proper handling, maintenance and cleaning of the equipment.

b) *Respirator User* — Utmost importance of this training should be given to the user with easily understood explanations about the need and reasons for using a respirator. This is to motivate the user to accept the fact that protection is necessary and to instill the desire to wear and maintain a respirator properly.

   To ensure the proper and safe use of respirator, the minimum training of each respirator user shall include:

   1) The need for respiratory protection;
   2) The nature, extent and health effects of airborne contaminants in the workplace;
   3) Proper fit and use of respirators;
   4) Limitations with the type of respirators used; and
   5) Instruction for inspection, storage and maintenance of the respirator.

11.3 Training Frequency

The program administrator and users shall be trained upon initial assignments and be retrained once annually. More frequent training and drills may be required for users of emergency escape or SCBA, which are not routinely in use. Employees shall demonstrate their understanding and the skills in the correct use of respiratory protective devices.

11.4 Training Records

Every training conducted shall be documented to show the person trained, instructor's name and date of training. The respirator training and the documentation shall include the type, model and size of respirator for which each employee has been trained and fit tested.

12 SUPERVISION OF PROPER USAGE

Respirators provide protection they are designed to give only when they are worn properly at all times when exposed to a contaminated environment. Regular

inspections of workers usage of respirators should be made by the program administrator. During such inspection, checks should be made on donning and fit checking procedures and the proper installation of the respiratory components.

Appropriate signage shall be used to designate 'Respiratory Protection Required' areas where the use of respiratory protection is mandatory.

13 MAINTENANCE, INSPECTION AND STORAGE OF RESPIRATORS

13.1 Respirator maintenance, inspection and proper storage of respirators shall be an integral part of the overall respiratory protection program initiated at the workplace. Wearing a poorly maintained or malfunctioning respirator can lead to a false sense of security and can prove fatal. Emergency escape and rescue devices are particularly vulnerable to poor maintenance because they are used infrequently.

Respirators issued on individual basis should preferably be maintained and inspected by the user. For non-routine use or shared respirators, the responsibility should be assigned to a particular individual to ensure proper maintenance.

A program for the maintenance of respirators shall include the following:

a) Cleaning,
b) Inspection for defects,
c) Replacement of filters/cartridges,
d) Charging and replacement of batteries for PAPR,
e) Storage,
f) Record keeping, and
g) Assurance of breathing air quality.

13.2 Cleaning

13.2.1 Respirators issued shall be cleaned periodically and after each use. If shared, they shall also be cleaned before being worn by different individuals.

13.2.2 Users who maintain their own respirators should be trained in cleaning procedures. Alternatively, a centralized maintenance cleaning and storage station may be used if there are many routine respirator users.

The following procedure is recommended for cleaning and disinfecting respirators:

a) Remove any filters, cartridges or canisters.
b) Wash facepiece and breathing tube in cleaner-disinfectant or detergent solution. Use a hand brush to facilitate removal of dirt.
c) Rinse completely in clean, warm water.
d) Air dry in a clean area.
e) Clean other respirator parts as recommended by the manufacturer.
f) Inspect valves, head harness and other parts, and replace with new parts, if defective.
g) Insert filters cartridges, and canisters, new if necessary; make sure that the seal is tight.
h) Place respirator in a clean, dry plastic bag or other suitable container.

13.2.3 Strong cleaning and disinfecting agents can damage respirator parts. Temperatures above 85°C and vigorous mechanical agitation should not be used. Solvents which affect rubber parts should be used with caution.

13.2.4 Manufacturers' cleaning and disinfecting method may also be adhered to. Caution to be observed while using soaps and detergents as they may damage the respirator or cause irritation to the user. All respirators shall be thoroughly rinsed after cleaning with detergents.

13.3 Inspection

13.3.1 All respiratory protective equipment should be inspected:

a) prior to every use, and
b) during and after cleaning.

13.3.2 Cleaning the respirator entails usually disassembling. This presents a good opportunity to examine each respirator thoroughly. Respirators should be inspected after each cleaning operation to ensure proper reassembly.

13.3.3 In addition, equipment designated for emergency use shall be inspected at least once in a month to ensure that it is in working condition in accordance with the manufacturer's specifications.

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

13.3.5 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 and flexible and prevent them from taking a set during storage.

13.3.6 Replacement of damaged parts shall be done only by persons trained in proper respirator maintenance and assembly. Substitution of parts or filters from a different brand or type of respirator will

invalidate the original approval and may result in leakage of the respirator when worn. A list of recommendations of maintenance work is given in Annex F.

13.4 Replacement of Filters

13.4.1 The service life of the filter depends primarily on the filter/sorbent characteristics, contaminant concentration, breathing rate, relative humidity, temperature. Various types of sorbents are used in cartridges and canisters. The ability to affect removal of the contaminant depends largely on the sorbent, granular size, quantity and surface area. Many sorbents beds and designed to remove very specific contaminants.

13.4.2 Basically, the breathing resistance is considered high when the user feels or perceives an increase in the resistance to breathing. Damp atmospheres also increase breathing resistance. Water condensation on the filter may also occur due to a poorly designed inhalation valve or a valve that does not function effectively.

13.4.3 *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 adjustment 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. For PAPR's, subject to full charged batteries, if there is reduction in the air flow rate, it implies usually the filters are clogged. Cleaning clogged filters with compressed air is not advisable.

13.5 Storage

13.5.1 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. Routinely 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.

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

13.5.3 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.

13.6 Record Keeping

A record shall be kept stating the inspection dates and findings for all respirators maintained for emergency and routine use.

14 REGULAR MONITORING OF WORKER EXPOSURE

Concentration of atmospheric contaminants, which originally required the use of respirators, may vary due to changes effected in operations or processes, production time or volume, implementing engineering controls or deterioration in working conditions. To determine the need for continued respiratory protection or additional buffer protection, periodic monitoring of the air contaminant(s) levels should be carried out. The frequency would depend on the level of exposure. If the levels are exceeding permissible exposure limits, it should be carried at least twice in a year or else at least annually.

15 PERIODIC EVALUATION AND AUDIT

15.1 Frequency

The continued relevance and the effectiveness of the program should be evaluated periodically by the program coordinator. Such evaluations should be carried out at least annually.

15.2 Air Contaminant Levels

The results of periodic workplace monitoring of specific air contaminants should be evaluated to determine the need for continued respiratory protection or additional protection.

15.3 Engineering Control Measures

The feasibility of introducing engineering control measures or other innovative technologies which may remove the need for respiratory protection should also be evaluated periodically.

15.4 Operation Standards and Records

The program should be evaluated to ensure that it is in accordance with current applicable regulations and industry accepted standards and is implemented according to written procedures. A sample respirator protection program and a checklist are included in Annexes G and H.

Inspection of the use of respirators at the workplace shall determine whether correct respirators are used and worn properly. Examination of respirators in use and storage shall indicate how well they are maintained.

Users should be consulted periodically about their acceptance of respirators, including any discomfort, resistance to breathing, interference with job performance or any other feedback.

Records of respirator issuance, fit testing, and worker training and respirator maintenance should be reviewed.

15.5 Program Effectiveness

Where applicable, medical surveillance, including biological monitoring, shall be carried out periodically to determine if the respirator users are being adequately protected. This can construe as one indicator of the effectiveness of the program.

It is also desirable that an audit of the program be conducted by a knowledgeable person not directly associated with the program. The audit should cover all the components of the program including program administration, management commitment, emergency preparedness and program effectiveness.

16 SPECIAL PROBLEMS IN USE OF RESPIRATORS

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

16.2 Corrective Lens with Full Face Mask

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 face mask piece. As a temporary measure, glasses with short temple bars or without temple bars may be taped to the wearer's head. Wearing of contact lenses in contaminated atmospheres with a respirator should not be allowed.

16.3 Eyewear with Half Face Mask

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 minimize or avoid this problem.

16.4 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 or the lenses to reduce fogging. Otherwise, it would be impossible to wear a full facepiece in ordinary room temperatures without severe fogging. Antifog compounds can be used to coat the inside of the lense to prevent fogging at room temperatures and down to temperatures approaching 0°C. However, before 20°C antifog compounds will not prevent severe fogging.

16.4.1 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°C.

16.4.2 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 contained breathing apparatus or air line respirators at low temperatures. The dew point of the breathing gas should be appropriate to the ambient temperatures.

16.4.3 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.

16.5 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 minimized. This can be done by selecting and using respirators having minimum weight and breathing resistance. Supplied-air respirators and hood and suits having an adequate supply of cool breathing air are recommended.

16.6 Communication

16.6.1 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.

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

16.6.3 Various methods of electronically transmitting speech from the respirators are available. Respirator 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 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 centre of gravity and moment of inertia such that the mask may be dislodged from the face during wearer's activity in a toxic environment. Removal of speech transmission devices may allow contaminant leakage into the facepiece.

ANNEX A

[*Foreword,* and *Clause* 8.1.2.2(a)]

REQUIREMENTS FOR AIR QUALITY (COMPRESSORS OR CYLINDERS) FOR SUPPLIED AIR RESPIRATORS

A-1 AIR QUALITY

Air used to supply respirators shall:

a) contain not less than 17.00 percent oxygen and not more than 23.5 percent by volume of oxygen,
b) contain not more than 5 ppm of carbon monoxide,
c) contain not more than 500 ppm of carbon dioxide,
d) contain not more than 0.50 mg/m^3 of oil mist, and
e) have no objectionable or nauseous odour.

A-2 TEMPERATURE AND HUMIDITY

In addition, the air supplied shall be of a temperature not exceeding 29°C and a relative humidity not exceeding 85 percent.

A-3 AIR FLOW

The necessary capacity of any air supply for respiratory protection shall meet a minimum requirement of 170 l/min for each person measured at the respirator.

A-4 COMPRESSORS

A-4.1 Types

A breathing air type compressor shall be used. When other compressors are used, special measures have to be taken to ensure breathing air quality requirements as per **A-1** at all times. Wherever possible, oil free compressors should be used. A malfunctioning or over heated oil lubricated compressor may introduce harmful carbon monoxide into the breathing air. Compressors should be well maintained.

A-4.2 Location of Air Intake

The location of the air intake shall be carefully selected so as to avoid entry of contaminated air into the system. This is particularly applicable to portable air compressors, used for supplying breathing air. Exhaust gases from a combustion engine powered compressor or from other nearby sources may contaminate the air drawn into the system.

A-4.3 Filters

Suitable in-line air purifying sorbent beds and filters shall be installed to assure breathing air quality. The filters shall be changed at regular intervals in accordance with manufacturer's instructions.

A-4.4 Alarms

If oil lubricated or combustion engine powered compressors are used, they shall have a carbon monoxide alarm set at 10 ppm. Compressors should also have alarms to indicate compressor failure or over-heating.

A-4.5 Separate Air Supply

A separate installation for supplying breathing air is recommended. However, where air is used in the manufacturing process as well as in the supply of respirable air, particular care should be taken to avoid the risk of contamination and to ensure that the air quality is maintained at all times. In every instance, it should be ensured that any backpressures from operating plants using the air supply will not cause contamination of the air used for breathing.

A-5 CYLINDERS

Cylinders containing breathing air shall be tested regularly, properly labelled and maintained.

A-6 COUPLINGS

Breathing air couplings shall be incompatible with outlets for other gas systems to prevent connecting supplied air respirators with non-respirable sources.

A-7 TESTING

Regular testing of the air supplied to the respirator shall be undertaken to verify the quality of air and records detailing analysis maintained meticulously.

ANNEX B

(*Foreword,* and *Clause* 9.1)

RESPIRATOR SELECTION EXAMPLES

B-1 EXAMPLE 1

A painter carrying out brush painting is exposed to 700 ppm of turpentine. The PEL for turpentine is 100 ppm and the IDLH level is 1 500 ppm. It is an irritant and has good warning properties. The odour threshold is 50 to 200 ppm. It is a skin and irritant at 75 to 200 ppm.

The oxygen content in the atmosphere is normal and the atmospheric concentration of turpentine is below the IDLH level of 1 500 ppm.

The atmospheric concentration is higher than the permissible exposure level and the minimum required protection factor is :

$$Min\ PF_{req} : 700/100 = 7$$

Since the $Min\ PF_{req}$ is less than 10, respirator recommended in the selection chart is air-purifying respirator of half facepiece.

Since turpentine is an irritant and has good warning properties, eye protection is needed. Hence, air-purifying respirator of full facepiece should be chosen instead.

As turpentine is an organic vapour, organic vapour cartridges have certified maximum use concentration higher than 700 ppm shall be fitted to the full facepiece air-purifying respirator. The duration of cartridge use depends on the services life information from the manufacturer.

For example, commercially available chemical filters with maximum use concentration of 1 000 ppm and breakthrough time of 80 min are acceptable choices. Cartridge capacity is the product of the maximum concentration and the breakthrough time. In this case, chemical filter capacity = 1 000 × 80 ppm-min. Since service life = (total chemical filters capacity)/(exposure concentration), the anticipated service life for a chemical filter respirator will be: 1 000 × 80/700 = 114 min. Chemical filters should be replaced every 114 min or sooner if the odour of turpentine or eye irritation is apparent. The anticipated exposure level for the worker with a half mask chemical filter having NPF of 20 will be 700/20 = 35

B-2 EXAMPLE 2

A worker is painting in a storage tank (4 m diameter and 2 m height) with no forced ventilation. The completion time of this job is estimated to be 1 h. Xylene is the solvent for the paint used. The temperature inside the tank is 20°C.

The PEL of xylene is 100 ppm, and it's IDLH level is 1 000 ppm. It produces irritation to the eyes and nose at 200 ppm.

The storage tank is a poorly ventilated space, so the atmospheric concentration of xylene may increase quickly to levels in excess of the IDLH concentration. The vapour pressure at 20°C is 9 mmHg and the possible saturation vapour concentration may reach 12 000 ppm.

The oxygen content in the atmosphere is normal and the atmospheric concentration of xylene is higher than the IDLH level.

Airline hose will not interfere with the work activities in this small tank. Since xylene is an irritant, eye protection is required. So, airline full-facepiece respirator with escape SCBA is recommended. Nominal protection factor is 2 000. The anticipated exposure level for the worker is less than: 12 000/2 000 = 6 ppm.

B-3 EXAMPLE 3

Workers in a lead acid battery are exposed to 0.45 mg/m^3 of lead in the form of oxide dust. The PEL for lead is 0.15 mg/m^3 and the IDLH is 700 mg/m^3.

The oxygen content in the atmosphere is normal and the atmospheric concentration of lead is below the IDLH level of 700 mg/m^3.

Atmospheric concentration of lead is higher than the permissible exposure level and the minimum required protection factor for the application is:

$$Min\ PF_{req} = 0.45/0.15 = 3$$

Since the hazard is in the form of particulate and is not an irritant, the choice would be air-purifying half facepiece respirator with particulate filter of NPF 4. The anticipated exposure level for the worker will be 0.45/4 = 0.11.

ANNEX C

(*Foreword*, and *Clause* 10.1)

MEDICAL FITNESS TO USE RESPIRATORS

C-1 PHYSIOLOGICAL CONSIDERATIONS

Carrying heavy respirators, for examples SCBA and other equipment in addition to a heavy workload may impose stress on the cardiopulmonary system. Intense ambient heat (for example during fire fighting) could be an additional stress on the heart. Persons with severe lung diseases may experience difficulty with breathing against the additional resistance of a respirator.

C-2 PSYCHOLOGICAL CONSIDERATIONS

Full-face respirators especially with full body protection may give rise to feelings of anxiety and isolation in some people, making it difficult for them to perform their work satisfactorily.

C-3 TYPES OF EXAMINATIONS

A medical history and at least a limited physical examination by a physician are recommended. In particular, the cardiopulmonary system should be evaluated. The medical history can detect most problems that might require further evaluation. The physical examination can confirm any findings from the medical history and also detect certain medical conditions (for example hypertension) that may be symptomatic. A previous history of respirator usage should also be elicited.

Chest X-ray, spirometry and exercise stress tests with ECG monitoring may be considered in persons using SCBA, when extremely stressful work conditions are expected or when indicated by the history and physical examination.

The respirator user should be observed during a trial period to evaluate any potential anxiety or claustrophobic reaction during the use of the respirator during training.

C-4 FREQUENCY

The examination should be carried out prior to the issue of respirators and periodically. The periodic examinations (consisting of the clinical examination) may be conducted once every three years. For workers above 45 years of age and who are carrying out strenuous work with SCBA, annual examinations are recommended.

C-5 MEDICAL CONDITIONS THAT MAY LIMIT RESPIRATOR USAGE

There is a great variation in the type of respirators, work conditions and workers' health status. As such, these medical conditions may not be absolute contraindications but should be considered together with other relevant factors and the worker's particular situation. Many impaired workers would be able to work safely while wearing respirators if they could control their own workplace, including having sufficient time to rest. Some of these medical conditions are:

a) Moderate or severe pulmonary disease;
b) Angina pectoris, significant arrhythmias, recent myocardial infarction;
c) Symptomatic or uncontrolled hypertension;
d) Claustrophobia/anxiety reaction; and
e) History of spontaneous pneumothorax.

It should be noted that mild to moderate impairment of lung function would not preclude the using of respirators in most cases.

ANNEX D

(*Clause* 10.8.2)

RESPIRATOR FIT CHECK

D-1 GENERAL

Prior to fit testing, a positive and/or negative-pressure fit check should be conducted with all tight-fitting respirators to determine if the respirator is properly sealed to the face of the user. The fit checks can be performed by following the manufacturer's recommended procedure or by the set of instructions below. This check should be performed by the user each time the respirator is worn.

D-2 NEGATIVE-PRESSURE TEST

For respirator with valves, the user should close off the inlet opening of the filter(s) by covering it with the palm of the hands or by squeezing the breathing tube so that air cannot pass through. Then inhale gently so that the facepiece collapses slightly, and hold the breath for 10 s. The fit is considered satisfactory if the facepiece remains in its slightly collapsed condition and no inward leakage of air is detected.

For disposable respirators without valves, the user should cover the filter with both hands and inhale sharply. An unsatisfactory faceseal is indicated by the feel of an airstream channelling through the leak area.

D-3 POSITIVE-PRESSURE TEST

For respirators with valves, the user should close off the exhalation valve and exhale gently into the facepiece. The fit is considered satisfactory if a slight positive pressure can be build up inside the facepiece without the detection of any outward leakage of air at the seal.

For disposable respirators without valves, the user should cover the filter with both hands and exhale vigorously. An unsatisfactory faceseal is indicated by the feel of an airstream channelling through the leak area.

ANNEX E

(*Clauses* 10.8.2.1 *and* 10.8.2.2)

RESPIRATOR FIT TEST METHODS

E-1 QUALITATIVE FIT TEST

E-1.1 Banana Oil (Isoamyl Acetate) Test

Isoamyl acetate is a low toxicity, organic substance with a banana-like odour. It is only suitable for testing the face fit of respirators using organic vapour filtering medium. The prospective use should put on the respirator in an area away from the test enclosure so that there is no prior contamination of the filtering medium by 'pre-exposure' to isoamyl acetate. The chemical is applied to the test enclosure and the user should perform the following activities for 30 s each:

a) *Normal Breathing*

b) *Deep Breathing to Simulate Heavy Exertion* — This should not be done long enough to cause hyperventilation.

c) *Side-to-Side and Up-and-Down Head Movements* — These should approximate those that take place on the job.

d) *Talking* — This can be accomplished by reading a prepared text loudly, enough to be understood by someone standing nearby.

Other exercises may be added depending on the job of the user. For example, if the user is going to spend a significant time bent over some task, it may be desirable to include an exercise approximating this bending.

Break respirator seal and expose the user to the test agent to verify the user's sensitivity.

The major drawback of the isoamyl acetate test is that the odour threshold varies widely among individuals. Furthermore, the sense of smell is easily dulled and may deteriorate during the test so that the user can only detect high vapour concentration.

E-1.2 Saccharin Test

This test is suitable for respirators incorporating any particulate filter. It relies upon the user's ability to

detect saccharin aerosol by taste. Chemical cartridge or canister respirator shall be fitted with a particulate filtering medium before this test can be carried out. Individuals vary in their taste threshold; therefore a screening procedure is performed to establish suitability.

Prospective test subjects are screened with an aerosol produced from 0.83 percent by weight solution of sodium saccharin in water. The test subject stays inside the test enclosures without a respirator and is instructed to breathe through the mouth only. The solution is then puffed up to a maximum of 30 times, using a nebuliser through a hole in the enclosure material. The number of puffs required for the saccharin to be tasted is recorded. If the subject is unable to taste the saccharin after 30 puffs, a different method of fit testing should be used.

A period of several minutes should elapse after the sensitivity test before re-testing the subject wearing a respirator.

The test subject, having passed the sensitivity test, is then fitted with the appropriate respirator. The subject is placed in the test enclosure and an aerosol produced from an 0.83 percent by weight solution of sodium saccharin in water is puffed through the hole. Initially, the number of puffs is the same as the number taken to produce a response in the screening procedure. Half the number of squeezes is delivered every 30 s. The test subject should perform exercises such as those described in **E-1.1**. Note that sweet food and drinks should not be consumed 30 min prior to testing.

E-1.3 Irritant Smoke Test

It is only suitable for testing the facial fit of air supplied respirators or air purifying respirators incorporating a high efficiency particulate filter. The test substance is an irritant (stannic chloride or titanium tetrachloride), which is available commercially in sealed glass tubes. When the tube ends are broken and air is passed through them, usually with a squeeze bulb, a dense irritant smoke is emitted. In this test, irritant smoke is introduced around the seal of the respirator. No enclosure is to be used to prevent build up of irritant smoke around the user. If the user detects any of the irritant smoke, it implies a defective fit. An adjustment or replacement of respirator is necessary. The irritant smoke test should be performed with caution, as the aerosol is highly irritating to the eyes, skin and mucous membrane. The user usually reacts involuntarily to the leakage by coughing or sneezing.

E-2 QUANTITATIVE FIT TEST METHODS

Quantitative fit tests involve placing the user in an atmosphere containing an easily detectable non-toxic aerosol. The atmosphere inside the respirator is sampled through a probe in the respirator. The leakage is expressed as a concentration inside the facepiece as a percentage of the outside concentration. The numbers generated by quantitative fit tests do not reflect the protection factors likely to be achieved in the work-place. The advantage of the quantitative fit test is that it does not rely on a subjective response. However, these tests generally require equipment, which can be operated by only highly trained personnel. Each test respirator should be equipped with a sampling probe to allow removal of air sample from the facepiece. The test facepiece may not be worn in service since the test orifice negates the approval of the respirator. Aerosol tests generally use particulates much finer than those encountered in most industries and so require high efficiency particulate filter during the test. The most commonly available quantitative fit tests are described below.

E-2.1 Sodium Chloride Test

A liquid aerosol is generated continuously from a salt water solution using a nebulizer, then dried to produce discrete sub-micron particles, and dispersed into a test enclosure. A means is provided for sampling the atmosphere in the chamber or hood and inside the respirator. The amount of penetration is displayed electronically.

E-2.2 Oil Mist Test

This uses an air generated oil mist. It differs from the sodium chloride test only in that the aerosol particle is liquid. The aerosol is generated using a nozzle atomizer, but being oil, the mist does not dry into solid particles when injected into the diluting air stream.

E-2.3 Particle Counters

In this test, natural dusts in the atmospheres are used as the test aerosol.

ANNEX F

(*Clause* 13.3.6)

LIST OF RECOMMENDATIONS OF MAINTENANCE WORK

Sl No.	*Respirator Type*	*Item to Inspect*	*Recommendations*
1	**Disposable**	Physical damage, such as damaged filter	Replace with new respirator
		Loss of elasticity and damaged straps	do
		Metal nose clip for damaged	do
2	**Reusable air purifying respirator**	***Facepiece***	
		Excessive dirt accumulation	Clean facepiece
		Cracks, tears, distortion	Replace with new facepiece or respirator
		Cracked or badly scratched lens	Replace lens or replace with a new respirator
		Headstraps	
		Breaks, tears or loss of elasticity	Replace head harness
		Damaged buckles	Replace with new buckles
		Worn out head harness	Replace with new
		Inhalation and exhalation valves	
		Dirt on valve or valve seat	Clean
		Missing or damaged valve	Replace with new
		Improper insertion of valve body in facepiece	Reinsert the valve body. Replace with new valve body if proper fit is not obtained
		Filter elements	
		Correct filter for hazard	If wrong, change to right one
		Incorrect installation of filter	Reinstal filter
		Increased filter resistance	Replace with new filter
		Damaged filter holder	Replace with new holder
		End of service date for filter	Replace with a new filter
3	**Powered air purifying respirator**		
		Breathing tube for damage	Replace with new tube
		Missing or loose hose clamps	Replace with new hose clamps
		Battery pack cannot be fully charged	Replace with new battery pack
		Low flow rate obtained	Recharge battery or replace filter
4	**Supplied air respirator**		
		Facepiece, head harness, straps	Checks similar to PAPR
		Valves, breathing tubes	
		Loose fitting facepiece	
		Torn seams, cracked visor for helmet	Replace with new
		Supplied air system	
		Breathing air quality	Maintain or replace air filtration system
		Damaged or kinks in air hoses	Replace air hose
		Damaged hose fittings	Replace air hose
		Improper setting of warning devices and regulators	Check with manufacturer
5	**SCBA**	Consult manufacturer's literature for applicable inspection criteria	
		Recommended to be inspected once a month	

ANNEX G

(*Foreword*, and *Clause* 15.4)

SAMPLE RESPIRATORY PROTECTION PROGRAM

Form XYZ

Hazard (Type of Airborne Contaminant) Date_____

Tel No: _____ Factory_____

Address_____

Overall Program Administrator_____

Designation_____

Sl No.	*Activities*	*Intervals to be Carried Out*	*Person Incharge*	*Designation*
1	Monitor airborne contaminants levels at regular intervals	Initially and periodically thereafter		
2	Reduce airborne contaminant levels by *engineering measures (where feasible)*	Whenever contamination levels ≥ Permissible exposure limits		
3	Select suitable respirators specific for the hazard concerned	When necessary		
4	Arrange for medical examinations to ensure employees are medically fit to use respirators	At time of employment and once every three years (annually for SCBA users who are above 45 years old)		
5	Issue respirators	At time of employment and when necessary		
6	Arrange for fit test	At time of employment and once a year		
7	Train workers-proper use, fit checks, storage	At time of employment and once a year		
8	Clean & maintenance	Weekly		
9	Inpsect work areas to ensure compliance	Weekly		
10	Display signs to designate respiratory protection areas	Whenever necessary		
11	Medical surveillance and record keeping	Pre-employment and periodic		
12	Review the program	Annually or whenever a change in process		

ANNEX H

(*Foreword*, and *Clause* 15.4)

CHECKLIST FOR RESPIRATOR PROTECTION PROGRAM

In general, the program should be evaluated at least annually, with program adjustments, as appropriate, made to reflect the evaluation results.

I. *Program Administration*

a) Is there a written respiratory program?

b) Is program responsibility vested in one individual who is knowledgeable and who can coordinate all aspects of the program?

c) Can feasible engineering controls or work practices eliminate the need for respirators?

d) Does the program include the following activities?

- Monitoring of airborne contaminants levels
- Respirator selection
- Medical fitness to use respirators
- Issuance of respirators
- Fit testing and checking
- Inspection to check on proper usage
- Training
- Maintenance, storage, repair and inspection of respirators
- Respiratory protector signage
- Medical surveillance (where applicable)

e) Is the program reviewed regularly?

II. *Program Operation*

f) Monitoring of airborne contaminant levels

- Are work area conditions and worker exposures properly surveyed?

g) Respiratory Protection equipment selection

- Are respirators selected on the basis of hazards to which the workers are exposed?
- Are selections made by individuals knowledgeable of selection procedures?
- Are only certified respirators purchased and used? Do they provide adequate protection for the specific hazard and concentration of the contaminants?

h) Has a medical evaluation of the prospective user been made to determine physical and psychological ability to wear the selected respiratory protective equipment?

j) Where practical, have respirators been issued to the users for their exclusive use, and are there records covering issuance?

k) Respiratory protection equipment fitting

- Has fit testing been conducted on the respirator?
- Are users given an opportunity to try out several respirators to determine whether the respirator they wear subsequently is the best fitting one?
- Are users trained on fit checks whilst donning the respirators?

m) Respirator use in the work area

- Are respirators being worn correctly?
- Are workers wearing respirators all the time while in the work area?

n) Training

- Are users trained in proper respirator use, cleaning and inspection?

p) Maintenance of respiratory protective equipment

- Storage
- Are respirators stored in a manner so as to protect them from dust, sunlight, heat, excessive cold or moisture, or damaging chemicals?
- Inspection
- Are respirators inspected before and after each use and during cleaning?
- Is respiratory protective equipment designated as 'emergency use' inspected at least monthly (in addition after each use)?
- Has the respirator been modified in any way?
- Repair
- Are replacement parts used in repair those of the manufacturer of the respirator?

q) Special use conditions

- Is a procedure developed for respiratory protective equipment usage in atmosphere IDLH?
- Is a procedure developed for equipment usage for entry into confined spaces?

r) Signage

- Are there appropriate signage's on respiratory protection?

s) Medical surveillance

- Are the users on a regular medical surveillance program (where applicable)

ANNEX J

(Foreword)

COMMITTEE COMPOSITION

Occupational Safety and Health and Chemical Hazards Sectional Committee, CHD 8

Organization	*Representative(s)*
National Safety Council, Navi Mumbai	SHRI K. C. GUPTA (***Chairman***)
Airport Authority of India, New Delhi	SHRI A. N. KHERA SHRI M. DURAIRAJAN (*Alternate*)
Alkali Manufacturers' Association of India, Delhi	DR Y. R. SINGH
Atomic Energy Regulatory Board, Mumbai	SHRI P. K. GHOSH
Bhabha Atomic Research Centre, Mumbai	SHRI S. SOUNDARARAJAN SHRI S. D. BHARAMBE (*Alternate*)
Central Boiler Board, New Delhi	REPRESENTATIVE
Central Leather Research Institute, Chennai	SHRI G. SWAMINATHAN
Central Mining Research Institute, Dhanbad	SHRI J. K. PANDEY
Central Warehousing Corporation, New Delhi	SHRI F. C. CHADDA SHRI S. C. GUPTA (*Alternate*)
Century Rayon, Thane	SHRI H. G. UTTAMCHANDANI SHRI S. K. MISHRA (*Alternate*)
Confederation of Indian Industries, New Delhi	SHRI A. K. GHOSE SHRI ANIK AJMERA (*Alternate*)
Consumer Education & Research Centre, Ahmedabad	DR C. J. SHISHOO SHRI S. YELLORE (*Alternate*)
Department of Industrial Policy and Promotion, New Delhi	DR D. R. CHAWLA
Department of Space (ISRO), Sriharikota	SHRI K. VISHWANATHAN SHRI V. K. SRIVASTAVA (*Alternate*)
Directorate General Factory Advice Service and Labour Institute, Mumbai	DR A. K. MAJUMDAR SHRI H. VISHWANATHAN (*Alternate*)
Directorate General of Health Services, New Delhi	DR P. H. ANATHANARAYANAN DR A. N. SINHA (*Alternate*)
Directorate General of Mines Safety, Dhanbad	DIRECTOR OF MINES (MSE) DEPUTY DIRECTOR OF MINES SAFETY (HQ) (*Alternate*)
Directorate of Industrial Safety and Health, Mumbai	SHRI S. D. JAGTAP
Directorate of Standardization, Ministry of Defence, New Delhi	SHRI P. S. AHUJA LT-COL TEJINDER SINGH (*Alternate*)
Employees State Insurance Corporation, New Delhi	DR A. M. PATIL DR G. N. BANKAPUR (*Alternate*)
Hindustan Aeronautics Limited, Bangalore	SHRI S. V. SURESH
Hindustan Lever Limited, Mumbai	SHRI B. B. DAVE SHRI ADITYA JHAVAR (*Alternate*)
Indian Association of Occupational Health, Bangalore	REPRESENTATIVE
Indian Chemical Manufacturers Association, Mumbai	SHRI PRAKASH WAGLE SHRI A. A. PANJWANI (*Alternate*)
Indian Institute of Chemical Technology, Hyderabad	SHRI K. V. RAMANAYYA
Indian Institute of Safety and Environment, Chennai	DR M. RAJENDRAN DR G. VENKATARATHNAM (*Alternate*)
Indian Petrochemical Corporation Ltd, Vadodara	SHRI P. VIJAYRAGHAVAN SHRI M. R. PATEL (*Alternate*)
Indian Toxicological Research Centre, Lucknow	DR VIRENDRA MISHRA DR V. P. SHARMA (*Alternate*)

Organization	*Representative(s)*
Ministry of Defence (DGQA), New Delhi	SHRI M. S. SULTANIA SHRI SUJIT GHOSH (*Alternate*)
Ministry of Defence (R&D), Kanpur	DR A. K. SAXENA DR RAJINDRA SINGH (*Alternate*)
Ministry of Environment & Forests, New Delhi	REPRESENTATIVE
Ministry of Home Affairs, New Delhi	SHRI OM PRAKASH SHRI D. K. SHAMI (*Alternate*)
National Institute of Occupational Health, Ahmedabad	DR H. R. RAJMOHAN DR A. K. MUKHERJEE (*Alternate*)
National Safety Council, Navi Mumbai	SHRI P. M. RAO SHRI D. BISWAS (*Alternate*)
NOCIL, Mumbai	DR B. V. BAPAT SHRI V. R. NARLA (*Alternate*)
Office of the Development Commissioner (SSI), New Delhi	SHRI MATHURA PRASAD SHRIMATI SUNITA KUMAR (*Alternate*)
Oil Industry Safety Directorate (Ministry of Petroleum & Natural Gas), Delhi	SHRI SHASHI VARDHAN SHRI S. C. GUPTA (*Alternate*)
Ordnance Factory Board, Kolkata	DR D. S. S. GANGULY SHRI R. SRINIVASAN (*Alternate*)
Petroleum & Explosives Safety Organization, Nagpur	JOINT CHIEF CONTROLLER OF EXPLOSISES
Safety Appliances Manufacturers Association, Mumbai	SHRI M. KANT SHRI KIRIT MARU (*Alternate*)
SIEL Chemical Complex, New Delhi	SHRI N. S. BIRDIE SHRI RABINDRA NATH SAHU (*Alternate*)
Southern Petrochemical Industries Corporation Ltd, Chennai	SHRI V. JAYARAMAN SHRI S. MURUGANANDAM (*Alternate*)
Steel Authority of India Ltd, Ranchi	SHRI V. K. JAIN
Tata AIG Risk Management Services Ltd, Mumbai	SHRI URMISH D. SHAH
Tata Chemicals Ltd, Mithapur, Dist Jamnagar	SHRI SANJIV LAL SHRI M. C. AGRAWAL (*Alternate*)
BIS Directorate General	SHRI E. DEVENDAR, Scientist 'F' & Head (CHD) [Representing Director General (*Ex-officio*)]

Member Secretary
SHRI N. K. PAL
Scientist 'E' (CHD), BIS

Occupational Safety and Health Subcommittee, CHD 8 : 1

National Safety Council, Navi Mumbai	SHRI P. M. RAO (***Convener***)
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This Indian Standard has been developed from Doc : No. CHD 8 (1190).

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