# AIR PURIFYING RESPIRATORY PROTECTIVE DEVICES FOR RESCUE TEAMS

## CFASDM 001 : 2013

**ORIGINAL STANDARD IN JAPANESE, VER. 1, 2013-04-01**

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**DELIBERATED BY**

**THE COUNCIL OF FIRE APPLIANCES STANDARD**

**FOR DISASTER MANAGEMENT**

# FOREWORD

This standard has been established by the Council of Fire Appliances Standard for Disaster Management (CFASDM) for which the Fire Equipment and Safety Center of Japan (FESC) acts as the Secretariat regarding the performance and testing methods for highly advanced fire equipments used by the rescue teams of fire departments at the time of special types of disasters, such as terrorism, as well as large-scale disasters, such as volcanic eruptions.

This standard has been established with reference to the relevant NIOSH (National Institute for Occupational Safety and Health) standards, EN (European standards), JIS and Ministry of Health and Welfare standards and others. Whenever these reference standards are revised, this standard will accordingly be reviewed and revised if necessary.

It must be reminded that parts of this standard may infringe a patent with technical properties, patent on application after its laid-open disclosure, utility model patent or application for the registration of a utility model after its laid-open disclosure. Neither the Council of Fire Appliances Standard for Disaster Management nor the Fire Equipment and Safety Center of Japan shall be held responsible for the non-confirmation of such patent with technical properties, patent on application after its laid-open disclosure, utility model patent or application for the registration of a utility model after its laid-open disclosure.

# CONTENTS

# Air Purifying Respiratory Protective Devices for Rescue Teams

## 1. Scope

This standard stipulates the minimum requirements regarding the structure-related demands and performance-related demands for the direct connection type full face respirator (hereinafter referred to as the "respirator") among the air purifying respiratory protective devices used by rescue teams at the time of a special kind of disaster or a large-scale disaster.

**Note :** The respirator stipulated in this standard does not assume its use in such situation as exposure to radiation, fierce fire, ignition by a chemical substance or high risk of explosion.

## 2. Normative references

The standard listed below shall form part of this standard when cited in this standard. When a cited standard is accompanied by the year of effectuation, the version established in that year alone shall form part of the provisions of this standard and the provisions of subsequent revisions and supplementary provisions shall not form part of this standard.

JIS T 8001: 1992 Glossary of terms for respiratory protective devices

## 3. Definitions

The principal terms used in this standard are defined as follows in addition to those definitions given in JIS T 8001.

a) **Direct connection type full face respirator :** A type of respirator where the filter is directly attached to a full facepiece

b) **Peak value of exhalation resistance :** The pressure difference between inside the respirator and the outside atmosphere repeats the similar waveform shown in Fig. 1 when breathing is continual with the respirator worn or when the breathing simulator attached to the respirator is in operation. The peak value of exhalation resistance means the plus-side maximum value of every wave.

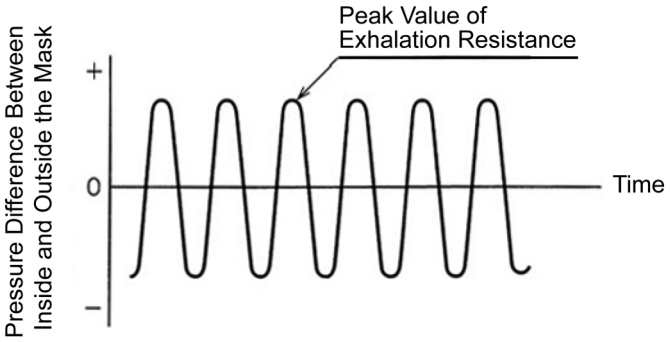



**Fig. 1 Peak value of exhalation resistance**

**c)** **Maximum allowable penetration:** The maximum concentration when the effuluent concentration of the test gas is not judged to be breakthrough when the test gas is fed through the filter.

**d)** **Permeation:** The phenomenon where a chemical substance in contact with a material surface is absorbed, diffused inside at the molecular level and departs through the rear surface.

**e)** **Head plate:** A component of the head harness which is placed on the head of wearer to prevent the head harness from sliding.

## 4. Classification

The respirators and the filters are classified into the following types.

**a)** **Types of respirators:** There are two types of respirators in relation to the purpose of use: Respirator for multiple gases and Respirator for volcanic eruption.

**b)** **Types of filters:** There are two types of filters in relation to the purpose of use: Filter for multiple gases and Filter for volcanic eruption. Each type is further classified into two categories in relation to the service time: Long-life type (Code: L) and Short-life type (Code: S).

## 5. Structure

The structure of the respirator must meet the following requirements.

**a)** The respirator easy to handle, shall not be damaged easily and shall not give the wearer abnormal oppressive pain.

**b)** The respirator shall have a structure which enables the wearer to easily check the state of fitness between the wearer's face and the facepiece at any time by closing either the inhalation port or exhalation port.

**c)** Any replacement of the filter, head harness, inhalation valve or exhalation value shall not impair the performance and wearing ability of the respirator.

**d)** When a hazardous material is unavoidably used, the respirator shall have a structure which prevents any harm to the human body by means of covering, filtration or other methods.

**e)** The respirator shall have a structure which does not significantly impair the field of vision of the wearer.

**f)** A full facepiece with a nose cup shall have a structure whereby the nose cup easily fits to the wearer's face.

**g)** An eyepiece shall be firmly attached to maintain the gas-tightness of the facepiece and shall not cause any gas-tightness defect when tested by the method stipulated in **7.1.1**.

**h)** The inhalation valve shall sensitively react to normal breathing.

**i)** The exhalation valve shall meet the following requirements.

**1)** The exhalation valve shall sensitively react to normal breathing without fail regardless of the moisture situation of the valve and the valve seat.

**2)** When the internal and external pressures are balanced, the exhalation valve shall be in the closed position regardless of the facepiece direction.

**3)** The exhalation valve shall be protected by a cover or other to prevent damage by an external force.

**j)** The head harness shall meet the following requirements.

**1)** The length of the head harness shall be adjustable and its replacement shall be possible.

**2)** The head harness shall have a structure which ensures adequate tension and the application of a uniform pressure to the parts in contact with the face when the respirator is worn.

**3)** The head harness and its attaching sections shall have sufficient strength to resist rupture or detachment when tested by the method stipulated in **7.1.2**.

**k)** The structure of the filter shall meet the following requirements.

**1)** When the filter is shaken violently, the gas capacity shall remain unchanged and channeling shall not occur.

**2)** The filter shall have a structure which prevents both direct contact with the skin and inhalation of an absorbing agent or its powder.

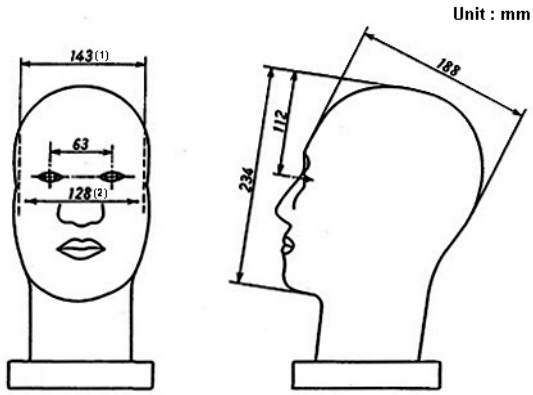
**3)** The inner surface of the filter shall be corrosion-resistant in correspondence with the corrosiveness of the absorbent used or shall have sufficient corrosion-resistance treatment.

## 6. Performance

The performance shall meet the following requirements.

### 6.1 Gas-tightness

The facepiece and the filter shall not give any air leakage when tested by the method specified in **7.2.1**. In the case of the facepiece, however, the gas-tightness at the contact area between the facepiece and the dummy head for testing (hereinafter referred to as "dummy head"; see **Fig. 2**) shall be excluded from this requirement.




Notes
1) Distance between the antilobia
2) Width of the zygomatic arch

**Fig. 2 Dummy head for test**

### 6.2 Operative gas-tightness of exhalation valve

The exhalation valve shall immediately show the inside pressure reduction when tested by the method stipulated in 7.2.2. In addition, the time required for returning the normal pressure after pressure reduction shall be 15 s or longer.

### 6.3 Breathing resistance of respirator

The breathing resistance of the respirator shall be equal to or lower than the value shown in **Table 1** when tested by the method stipulated in **7.2.3**.

**Table 1 Air flow resistance of respirator**

Unit: Pa

| Item | Breathing resistance of respirator |
|---|---|
| Inhalation resistance | 350 |
| Exhalation resistance | 80 |
| Peak value of exhalation resistance | 190 |

### 6.4 Flow resistance of filter

The flow resistance of the filter shall be 300 Pa or less when tested by the method stipulated in **7.2.4**.

### 6.5 Gas capacity of filter

The gas capacity of the filter shall be that the breakthrough time for the long-life type filter and the short-life type filter are equal to or longer than 60 min and 30 min respectively against any type of test gas when tested by the method stipulated in **7.2.5**.

### 6.6 Permeation resistance of facepiece

The face blank and eyepiece of the facepiece of the respirator for multiple gases shall not cause obvious discolouration of the detector paper when tested by the method stipulated in **7.2.6**.

### 6.7 Particle collection efficiency of filter

The particle collection efficiency of the filter shall meet the following requirements.

**a) Particle collection efficiency of filter for multiple gases**

The DOP particle collection efficiency of a filter for multiple gases shall be 99.97% or higher when tested by the method stipulated in **7.2.7**.

**b) Particle collection efficiency of filter for volcanic eruption**

The NaCl particle collection efficiency of a filter for volcanic eruption shall be 95% or higher when tested by the method stipulated in **7.2.7**.

### 6.8 Rising value of $CO_2$ concentration in inhaled air

The rising value of the $CO_2$ concentration in the inhaled air shall be 1.0% or less when the facepiece is tested by the method stipulated in **7.2.8**.

## 7. Tests

The tests shall be structural tests and performance tests.

### 7.1 Structural Tests

The following structural tests shall be conducted.

#### 7.1.1 Impact test on eyepiece

After alternatively placing the eyepiece attached to the facepiece in thermostatic chambers of -10 °C and 40 °C five times each for 30 min each time, the facepiece shall be attached to a dummy head with the central part of the eyepiece in a level position. A steel ball of 22 mm in diameter and about 45 g in mass shall then be freely dropped on to the central surface of the eyepiece from a height of 1.3 m and any occurrence of a gas-tightness defect due to damage to the eyepiece, etc. shall be checked by the method stipulated in **7.2.1**. In this case, the steel ball may be dropped through a pipe (with an inner diameter of approximately double the diameter of the steel ball in question) which allows the free fall of the steel ball.

### 7.1.2 Strength test of head harness and its attaching part

Each head harness attaching part shall be subject to a tensile load of 50 N with the head harness and facepiece acting as the two ends to check any occurrence of rupture or detachment. However, when an end of the head harness is attached to the head plate or any other part, such part shall act as one end for testing purposes.

## 7.2 Performance tests

The following performance tests shall be conducted.

### 7.2.1 Gas-tightness test

The respirator shall undergo the gas-tightness test in the following manner.

**a)** In the case of a facepiece of a respirator of which the structure allows replacement of the filter, it shall be attached to a dummy head with the exhalation valve seat and inhalation port closed and gas pressure shall be applied inside the facepiece to check any occurrence of air leakage. The detection of air leakage shall use one of the following methods. However, this requirement shall not apply when a different method approved by a test institution is used.

**1)** Air containing ammonia with a pressure of 1.0 kPa shall be fed inside the facepiece attached to the dummy head while the subject areas for the gas-tightness check shall be covered by a cloth immersed in an alcohol solution of phenolphthalein to observe any change of the colour of the cloth to red after 5 s.

**2)** Air or another gas with a pressure of 1.0 kPa shall be fed inside the facepiece attached to the dummy head while soap water or similar is applied to the subject areas for the gas-tightness check to observe any occurrence of soap water bubbles for 30 s.

**3)** The facepiece attached to the dummy head shall be submerged under water (in a manner where the front of the facepiece is looking upward with the depth from the water surface to the eyepiece of 20 - 25 mm) and air or another gas with a pressure of 1.2 kPa shall be fed inside to observe any occurrence of air bubbles in the water for 30 s.

**b)** In the case of a filter of the respirator of which the structure allows replacement of the said filter, gas pressure shall be applied inside the filter with all openings closed to check any occurrence of leakage. In this case, an externally attached filter can be tested with the said filter being detached from the facepiece. The detection of air leakage shall use one of the following methods. However, this requirement shall not apply when a different method approved by a test institution is used.

**1)** Air or another gas with a pressure of 1.5 kPa shall be fed inside the filter while soap water or similar shall be applied to the subject areas for the gas-tightness check to observe any occurrence of soap bubbles for 30 s.

**2)** The filter shall be submerged under water (in a manner where the outside air side of the filter is looking upward with the depth from the water surface to the uppermost part of the submerged filter of 20 - 25 mm) and air or another gas with a pressure of 1.7 kPa shall be fed inside the filter to observe any occurrence of air bubbles in the water for 30 s.

**c)** In the case of a respirator of which the structure does not allow replacement of the filter, the exhalation valve and inlet of the filter shall be closed and gas pressure shall be applied after removal of the inhalation valve to observe any occurrence of air leakage. The detection of air leakage shall use one of the following methods. However, this requirement shall not apply when a different method approved by a test institution is used.

**1)** Air or another gas with a pressure of 1.5 kPa shall be fed inside the respirator attached to a dummy head while soap water or similar shall be applied to the subject areas for the gas-tightness check to observe any occurrence of soap bubbles for 30 s.

**2)** The respirator attached to the dummy head shall be submerged under water (in a manner where the front of the facepiece is looking upward with the depth from the water surface to the uppermost part of the submerged respirator of 20 - 25 mm) and air or another gas with a pressure of 1.7 kPa shall be fed inside to observe any occurrence of air bubbles in the water for 30 s.

### 7.2.2 Operative gas-tightness test on exhalation valve

The exhalation valve shall be mounted to a gas-tightness tester to which an exhalation valve seat is attached and air shall be sucked at a flow rate of 1 L/min to check the state of inside pressure reduction due to the closure of the exhalation valve. This shall be followed by reducing of the inside pressure by 1.5 kPa below the outside pressure and left uncontrolled to measure the period required by the inside pressure to return to the normal pressure level. In this case, the inner volume of the gas-tightness tester shall be 50 ± 5 $cm^3$.

### 7.2.3 Breathing resistance test on respirator

The respirator shall undergo the breathing resistance test in the following manner.

**a) Measuring of inhalation resistance and exhalation resistance**

The respirator shall be mounted to a dummy head or similar and the contact area between the facepiece and the dummy head or similar shall be sealed by paste or similar to prevent air leakage. Inhalation and exhalation shall then be conducted at a rate of 40 L/min to measure the

pressure difference between the inside and outside of the facepiece (in the case of a full facepiece with a nose cup, the pressure difference between inside the nose cup and outside the facepiece; the same shall apply hereinafter).

**b) Measuring of peak value of exhalation resistance**

The respirator shall be mounted to a dummy head or similar and the contact area between the facepiece and the dummy head or similar shall be sealed by paste or similar to prevent air leakage. A breathing simulator shall be attached to the said dummy head or similar. Reciprocal air flow operation shall then be conducted at (2.0 ± 0.1 L/time) × (15 ± 1 times/min) and the pressure difference between the inside and outside of the facepiece shall be measured for a one min period from 30 after the commencement of the air flow operation by a precision differential pressure meter (95% class, including a recorder with a response time of 0.4 s or less). Finally, the mean value of the peak values during this one minute period shall be calculated.

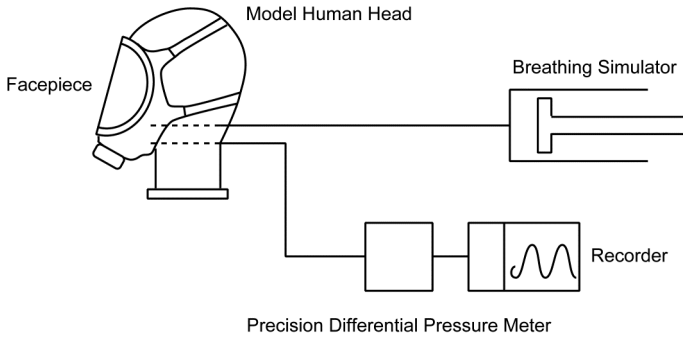



**Fig. 3 Example of testing system to measure the peak value of exhalation resistance**

### 7.2.4 Flow resistance test on filter

Using individual filters as specimens, air shall be fed from the filter's inlet at 40 L/min (in the case of the respirator with one filter) or 20 L/min (in the case of the respirator with two filters) between influent and effluent of the filter shall be measured.

### 7.2.5 Gas capacity test on filter

Using the same number of filters (one filter or a pair of filters) to be attached to the facepiece as specimens, air containing the test gas of which the concentration is shown in **Table 2** shall be fed depending on the purpose of use of the filter. The temperature and relative humidity of the mixture of test gas and air shall be 20 ± 2 °C and 50 ± 5 % respectively and the flow rate shall be 30 L/min. The level of concentration of the test gas contained in air which has passed through the specimen shall be measured using a method capable of measuring the maximum allowable permeation in a stable manner and the period required for breakthrough shall be obtained.

**Table 2 Conditions for gas capacity test on filter**

Unit : ppm

| Type of filter | Test gas | | Maximum allowable penetration |
|---|---|---|---|
| | Substance | Concentration | |
| For multiple gases | Chloropicrin | 1,000 | 5 |
| | Chlorine | 1,500 | Chlorine 1 ppm or hydrogen chloride 5 ppm* |
| | Cyclohexane | 2,600 | 10 |
| | Ammonia | 2,500 | 12.5 |
| | Sulphur dioxide | 1,500 | 5 |
| | Hydrogen cyanide | 940 | 4.7 |
| | Hydrogen sulphide | 1,000 | 5 |
| For Volcanic Eruption | Sulphur dioxide | 750 | 5 |
| | Hydrogen sulphide | 1,000 | 5 |

* The breakthrough is where either chlorine 1 ppm or hydrogen chloride 5 ppm is reached first.

### 7.2.6 Permeation resistance test on facepiece

The permeation resistance test on the facepiece shall be conducted in the following manner.

**a)** From the areas of the face blank and eyepiece of the facepiece which are in contact with atmospheric air when in actual use, test pieces of 15 mm x 15 mm in size shall be cut from the thinnest parts of those areas where test pieces of the said size can be cut.

**b)** Detector paper (designated by a test institution which is stipulated separately from this standard) of 10 mm x 10 mm in size shall be closely adhered to the back (face side of the facepiece) of each test piece. Each test piece shall be placed on a glass plate with the detector paper side facing down and the area between the edges of the test piece and glass plate shall be sealed with paraffin.

**c)** The test piece shall be placed in a level position and 0.02 mL of β-chloroethyl ethyl sulphide (CAS: 693-07-2) shall be dripped on to the surface of the test piece.

**d)** The specimen in the state described in **c)** shall be placed inside a thermostatic chamber of 30 ± 1 °C and any discolouration of the detector paper shall be examined 6 h later.

### 7.2.7 Particle collection efficiency test on filter

Using individual filters as specimens, test particles suspended in air shown in **Table 3** shall be fed to the specimen. Depending on the number of filters attached to the facepiece, the air flow rate shall be either 85 L/min (in the case of the respirator with one filter) or 42.5 L/min (in the case of the respirator with two filters) (if the number of filters to be attached to the facepiece exceeds two, the test conditions shall be modified in accordance with the principle adopted for the case of two filters).

During the period where the quantity of the test particles supplied to the specimen reaches the value shown in Table 3, the test particle concentrations before and after passing through the specimen shall be continually measured using a particulate concentration meter by the scattered light method and the lowest value of particle collection efficiency shall be obtained among the values calculated by the following equation.

$$E = \frac{C_1 - C_2}{C_1} \times 100$$

Where,

E : particle collection efficiency (%)

$C_1$ : test particle concentration before passing through the specimen ($mg/m^3$)

$C_2$ : test particle concentration after passing through the specimen ($mg/m^3$)

**Table 3 Test particles**

| Particles | | DOP | NaCl |
|---|---|---|---|
| Concentration ($mg/m^3$) | | ≦ 100 | ≦ 50 |
| Variation range to the mean value of concentration | | ≦15% | |
| Median of size distribution (μm) | | 0.15 ~ 0.25 | 0.06 ~ 0.1 |
| Geometric standard deviation of size distribution | | ≦ 1.6 | ≦ 1.8 |
| Quantity of particles supplied to filter (mg) | In the case of one filter being attached to the facepiece | 200 | 100 |
| | In the case of two filters being attached to the facepiece | 100 | 50 |

### 7.2.8 Test of rising $CO_2$ concentration in inhaled air

A breathing simulator shall be attached to a dummy head and shall operate under the conditions shown in **Table 4**. The $CO_2$ concentration in the inhaled air shall be measured in both cases of the respirator being either mounted or not mounted to a dummy head and the value of the $CO_2$ concentration rise in the inhaled air shall be calculated using the following equation.

In the case of the respirator with a nose cup, the contact area between the nose cup and dummy head may be sealed by paste or similar to eliminate any openings.

$$D = C_3 - C_4$$

Where,

D : value of $CO_2$ concentration rise in inhaled air due to the use of the respirator (%)

$C_3$ : $CO_2$ concentration in the inhaled air in the case where the respirator is mounted to the dummy head (%)

$C_4$ : $CO_2$ concentration in the inhaled air in the case where the respirator is not mounted to the dummy head (%)

**Table 4 Test conditions for $CO_2$ concentration rise in inhaled air due to use of the respirator**

| | |
|---|---|
| Ambient test temperature (°C) | 20 ± 5 |
| Breathing waveform | sine wave |
| Tidal volume (L) | 2.0 ± 0.1 |
| Number of ventilations per minute | 15 ± 1 |
| $CO_2$ concentration in inhaled air (%) | 5.0 ± 0.5 |

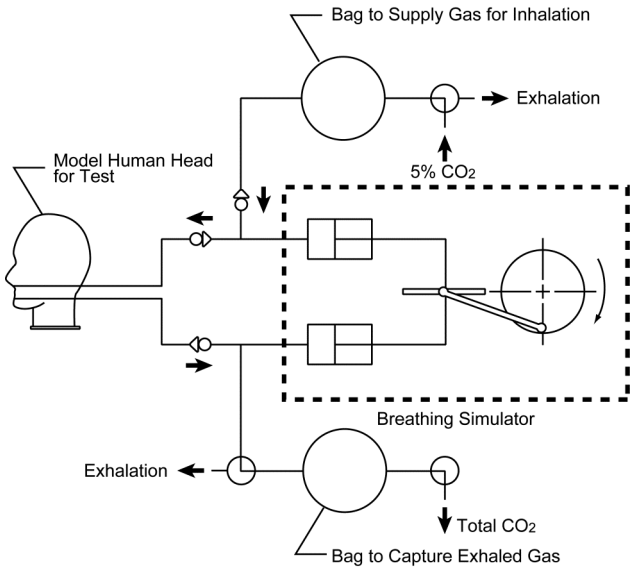



**Fig. 4 Example of test system for rising $CO_2$ concentration in inhaled air**

## 8. Inspection

The following items shall be inspected by means of sampling inspection and shall be complied with all of the requirements described in **5.** and **6.**.

**a)** Gas-tightness

**b)** Operative gas-tightness of exhalation valve

**c)** Inhalation resistance of respirator

**d)** Exhalation resistance of respirator

**e)** Peak value of exhalation resistance of respirator

**f)** Air flow resistance of filter

**g)** Gas capacity of filter

**1)** Substances for testing the filter for multiple gases

- Chloropicrin
- Hydrogen cyanide

- Ammonia

**2)** Substances for testing the filter for volcanic eruption
- Sulphur dioxide

**h)** Particle collection efficiency of filter

## 9. Marking

The following information shall be marked in Japanese on the container, facepiece and filter of the respirator. However, proper names may be indicated in the original language.

**a)** Container for respirator (in an easily visible place)

**1)** Product name or product number
Example : OOOO

**2)** Name of standard
Example : Air Purifying Respiratory Protective Device for Rescue Teams: Direct Connection Type Full Face Respirator

**3)** Model number (number given by a test institution which is stipulated separately from this standard; the same shall apply hereinafter)

**4)** Type based on the purpose of use

**5)** Category of effective operation duration or corresponding code

**6)** Name of manufacturer or its code

**b)** Facepiece

**1)** Product name or product number
Example : OOOO

**2)** Model number

**3)** Type by purpose of use

**4)** Name of manufacturer or its code

**5)** Date of manufacture or its code

**c)** Filter (including packaging material if items indicated on the filter cannot be checked because of the packaging material used for the filter)

**1)** Product name or product number
Example : OOOO

**2)** Model number

**3)** Type by purpose of use

**4)** Category by duration of use or its code

**5)** Name of manufacturer or its code

**6)** Date of manufacture or its code

**7)** Indication of the use of multiple filters (limited to those filters for which the simultaneous use of multiple filters is required)

## 10. Manuals

A facepiece and filter shall be accompanied by a manual which explains the following matters in Japanese. However, proper names may be indicated in the original language.

### 10.1 Manual for Facepiece

**a)** Model number

**b)** Environmental conditions in which the respirator can be used

**c)** Environmental conditions in which the respirator should not be used (place where the oxygen concentration may become less than 18% or place where the concentration of toxic gas may exceed the permissible level)

**d)** Types of filters which can be used and the selection method

**e)** Performance of the filters which can be used

**f)** Replacement criteria for filters

**g)** Checking, maintenance and storage methods and important notes

**h)** Disinfection method for the facepiece and important notes

### 10.2 Manual for Filter

**a)** Model number

**b)** Environmental conditions in which the respirator can be used

**c)** Environmental conditions in which the respirator should not be used (place where the oxygen concentration may become less than 18% or place where the concentration of toxic gas may exceed the permissible level)

**d)** Facepiece which can be used

**e)** Performance of filter

**f)** Replacement criteria for filter