

**TCVN 6100: 1996  
ISO 5923: 1984**

**FIRE PROTECTION  
FIRE EXTINGUISHING MEDIA- CARBON DIOXIDE**

**(This English version is for reference only)**

**HA NOI – 2008**



## **Foreword**

TCVN 6100: 1996 was identical to ISO 5923:1984.

TCVN 6100: 1996 was prepared by Technical Committee TCVN/TC 21 *Equipment for fire protection and fire fighting*, proposed by Directorate for Standards, Metrology and Quality, and approved by Ministry of Science and Technology.

This standard was transferred in 2008 from Vietnam Standard into Vietnam National Standard under the same identifier number, as stipulated in Section 1, Article 69 of the Law on Standards and Technical Regulations and in Point a, Section 1, Article 6 of Decree No 127/2007/ND-CP of the Government dated 01 August 2007 detailing the implementation of a number of articles of the Law on Standards and Technical Regulation.



## Fire protection. Fire extinguishing media - Carbon dioxide

### 1. Scope

This standard specifies requirements for carbon dioxide for use as a fire extinguishing medium.

### 2. Normative references

ISO 2591-1, Test sieving;

ISO 4705, Refillable seamless steel gas cylinders

### 3. Definition

For the purposes of this International Standard, the following definition applies.

**carbon dioxide:** The chemical compound CO<sub>2</sub> used as a fire extinguishing medium.

### 4. Requirements

Carbon dioxide shall comply with the requirements of table 1, when tested by the appropriate method of test specified in clause 6.

Table 1- Requirements <sup>1)</sup>

| Property   | Requirement |
|--|-------------|
| Purity, % (V/V) min.   | 99.5        |
| Water content, % (m/m) max.  | 0.015       |
| Oil content, ppm by mass, max.   | 5           |
| Total sulfur compounds content, expressed as sulfur, ppm by mass, max. | 1.0         |

<sup>1)</sup> Carbon dioxide obtained by converting dry ice to liquid will not usually comply with these requirements unless it has been properly processed to remove excess water and oil.

## **5. Sampling**

### **5.1. General**

Samples of carbon dioxide needed to perform all the tests required by this International Standard shall be taken from the same manufacturing lot, using identical sampling procedures.

NOTE: Attention is drawn to the need to design equipment for handling carbon dioxide such that it is either capable of withstanding the pressures involved or protected from them.

### **5.2. Sampling equipment**

Rigid metal connections or flexible reinforced nylon hose should be used throughout the sampling equipment and shall be kept as short as possible. All components shall have a design pressure of not less than 137 bar.

### **5.3 Procedure**

#### **5.3.1 General**

Two methods of sampling are specified:

- a) direct sampling, in which the sample is passed to an evaporator and then directly to the analytical apparatus;
- b) sampling in cylinders, in which case the sample is transferred in a cylinder to a laboratory.

Other methods may be used provided that they are shown to give equally representative samples on analysis (see annexes A, B and C).

#### **5.3.2 Direct sampling**

Connect the sampling valve by means of suitable connections (see 5.2) to an evaporating device and then via a T-piece (the free leg of which is connected to the dip-tube of a Drechsel bottle containing 50 mm of mercury covered by a layer of water on the carbon dioxide side) to the analytical apparatus. Thoroughly flush the connections, valves and the evaporating device with carbon dioxide before starting to take the sample.

#### **5.3.3 Sampling in cylinders**

Use a cylinder of water capacity 1,4 kg or 2,0 kg, complying with the requirements of ISO 4705, and with a valve at each end.

An internal copper dip-tube of diameter at least 5 mm and of length equal to one-third of the length of the cylinder shall be brazed to the base of one valve, which shall be clearly identified. The cylinder shall be coated internally with tin (containing 1% (m/m) of lead) applied by hot dipping the cylinder after the walls have been descaled.

First clean the sampling cylinder by removing both valves and washing the inside of the cylinder with carbon tetrachloride. Purge with a current of dry filtered air. Wash with methanol and repeat the purging. Degrease the valves using carbon tetrachloride, then refit them. The methanol and carbon tetrachloride used shall comply with the requirements specified in annex B, clause B.2.

Support the cylinder vertically with its dip-tube valve upper-most. Before taking the sample, thoroughly flush the cylinder with a small quantity of liquid carbon dioxide, first through the top valve and then through the bottom valve. Repeat this flushing procedure, and leave the cylinder connected to the liquid carbon dioxide source via its lower valve. Then, with the upper valve closed, open the lower valve to admit liquid carbon dioxide to the cylinder. Partly open the upper (dip-tube) valve and continue filling until carbon dioxide snow is discharged from this valve. Close both valves. Open the top valve several times for brief intervals until only carbon dioxide gas is discharged from it. The free end of the dip-tube inside the cylinder will then be just above the liquid carbon dioxide level in the cylinder.

Samples shall be analysed as soon as reasonably practicable after collection. To withdraw the sample for analysis, support the sampling cylinder vertically with the dip-tube valve at the top. Connect the bottom valve of the sampling cylinder (liquid carbon dioxide) to an evaporating device and thence via a T-piece, the free leg of which is connected to a tube as described in 5.3.2, to the analytical apparatus. Thoroughly flush the connections, valves and the evaporating device with carbon dioxide before starting the analysis.

When sampling for the determination of water content, heat the connections to above the dew-point to prevent condensation during purging.

## **6. Methods of test**

### **6.1. Safety warning**

Attention is drawn to the need to design equipment for handling carbon dioxide such that it is either capable of withstanding the pressures involved or protected from them.

### **6.2. Purity**

Determine the purity by gas-liquid chromatography, using generally accepted laboratory techniques, or use a volumetric analyser.

The method used shall be capable of determining the purity with an accuracy of at least 0,1%.

The sample shall not constitute more than 10 % of the original quantity of carbon dioxide contained in the sample container.

**6.3. Water content**

Determine the water content by the method specified in annex A or by any other method giving equivalent results.

**6.4. Oil content**

Determine the oil content by the method specified in annex B or by any other method giving equivalent results.

**6.5. Total sulfur compounds content**

Determine the total sulfur compounds content by the method specified in annex C or by any other method giving equivalent results.

**7 . Packaging and labelling**

**7.1** Carbon dioxide shall be shipped and stored in containers that will not alter the medium or be detrimentally affected by it.

NOTE: The containers may need to comply with corresponding regulations.

**7.2** Containers shall be marked with the following information:

- a) supplier's name and address;
- b) "Carbon dioxide";
- c) package identification number;
- d) the number of the Standard;
- e) recommended storage precautions.



## Annex A

(normative)

### Determination of water content

#### A.1 Principle

Gravimetric determination of the water content by passing a sample of the gas over phosphorus pentoxide.

#### A.2 Apparatus and material

**A.2.1** Two absorption tubes, U-shape, the length of the limbs being 100 mm and the diameter of the tubes being 12 mm, fitted with side arms and ground-glass drilled stoppers. The tubes shall be filled with the desiccant (A.2.5) which shall be held in position by small pads of cotton wool.

**A.2.2** Flow meter (if desired), float type, suitable for measuring a carbon dioxide flow of 200 ml/min to 2000 ml/min.

**A.2.3** Gas meter, calibrated for 1l or 2,5l per revolution.

**A.2.4** Test sieves, of aperture sizes 425  $\mu\text{m}$  and 600  $\mu\text{m}$ , complying with the requirements of ISO 3310/1.

#### A.2.5 Desiccant

Sift powdered glass or clean, dry, washed sand and retain the portion that passes through a test sieve of aperture size 600  $\mu\text{m}$  but is retained on a test sieve of aperture size 425  $\mu\text{m}$ .

In general, follow the requirements of ISO 2591.

Quickly transfer to a stoppered container (a large weighing bottle or small stoppered jar is suitable) a volume of fresh phosphorus pentoxide and add about half as much by volume of the prepared powdered glass or sand. Vigorously shake the container to mix the components and fill the U-tubes (A.2. 1) as quickly as possible with the mixture.

If it is prepared in this way, it should be easy to fill the tube with the desiccant. If it is not easy, it is probable that the phosphorus pentoxide was moist before addition of the powdered glass or sand.

Prepare the desiccant in small quantities, as required.

#### A.3 Sampling

Take the sample in a cylinder by the method described in 5.3.3. About 120g of carbon dioxide is required for each determination.

#### A.4 Determination

## TCVN 6100:1996

After the evaporating device, connect the exit side of the T-piece to the absorption tubes (A.2.1), the flow meter (A.2.2), and the gas meter (A.2.3) in series, in that order.

Carefully open the regulating valve and absorption tube taps and allow the gas to flow at a flow rate of about 500 ml/min for 10 min; the carbon dioxide displaces the air in the absorption tubes. Close all taps, disconnect the absorption tubes and wipe the tubes surfaces with a dry, soft cloth. Place the absorption tubes in the balance case, leave for 20 min, then weigh them to the nearest 0,5 mg.

Reconnect the absorption tubes. Note the reading of the gas meter then allow the gas to pass at a steady rate of 500 ml/min to 1000 ml/min for 1h.

Close the taps and reducing valve. Note the gas meter reading.

Place the absorption tubes in the balance case, leave for 20 min, then weigh them to the nearest 0,5 mg.

### A.5 Expression of results

The water content, expressed as a percentage by mass, is given by the formula:

$$\frac{54,29(m_2 - m_1)}{V}$$

where:

$m_1$  is the initial mass, in grams, of the absorption tubes;

$m_2$  is the final mass, in grams, of the absorption tubes;

$V$  is the volume, in litres, at 20 °C and 760 mmHg<sup>1)</sup>, of gas passed, read from the gas meter.

## Annex B

(normative)

### Determination of oil content

#### B.1 Principle

Vaporization of a liquid sample and removal of any oil by passing the gas through carbon tetrachloride. Removal of residual oil in the cylinder by washing with more carbon tetrachloride and combination of the two carbon tetrachloride solutions. Spectrometric measurement of the oil content at 3 460 nm (the C-H stretching frequency) by means of an infra-red spectrometer.

#### B.2 Reagents

All reagents shall be of recognized analytical grade.

##### B.2.1 Carbon tetrachloride, distilled.

The reagent shall not show an infra-red absorption peak at 3460 nm.

##### B.2.2 Standard oil solution.

Dissolve 0,0200g of liquid paraffin in carbon tetrachloride, transfer quantitatively to a 100 ml one mark volumetric flask and dilute to the mark with carbon tetrachloride.

1 ml of this solution contains 200 µg of oil.

#### B.3 Apparatus

**B.3.1** Two bubblers, as shown in Figure 1.

**B.3.2** Drechsel bottle, of capacity 250 ml.

**B.3.3** Flow meter, float type, suitable for measuring a carbon dioxide flow of 200 ml/min to 2000 ml/min.

**B.3.4** Gas meter, calibrated for 1l or 2,5l per revolution.

**B.3.5** Infra-red spectrometer and accessories, suitable for making measurements at 3 460 nm.

#### B.4 Sampling

Take the sample by the method described in 5.3.3. About 700g to 1000g is required for each determination.

NOTE: A set of cylinders should preferably be retained for sampling for the determination of oil content and should not be used for other purposes.

---

<sup>1)</sup> 1 mmHg = 133,322Pa

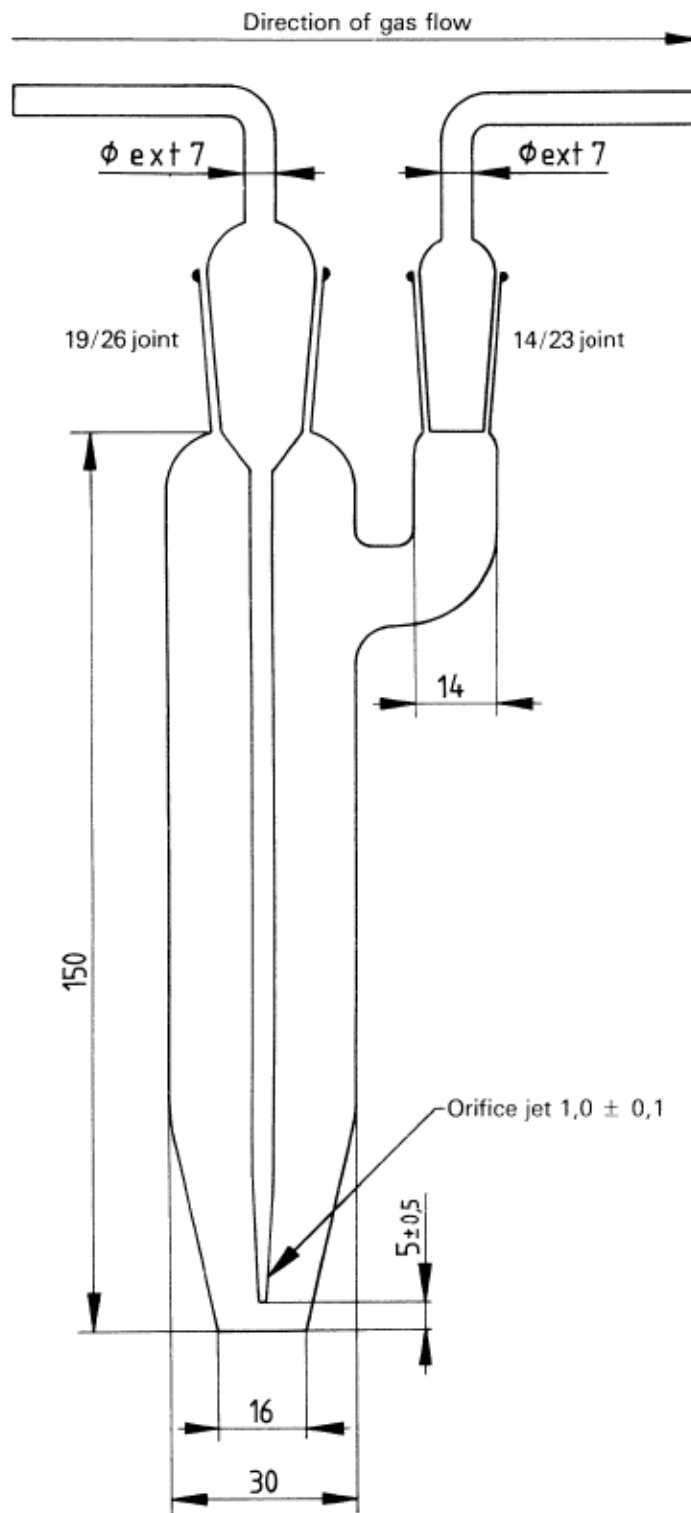


Figure B.1 – Bubbler for the determination of oil content

## **B.5 Procedure**

### **B.5.1 Preparation of test solution**

Place 100 ml of the carbon tetrachloride (B.2.1) in the Drechsel bottle (B.3.2) and 25 ml in each bubbler (B.3.1). Support the weighed sampling cylinder with the dip-tube valve at the top, connect the bottom valve of the weighed cylinder to the T-piece of the evaporating device and then to the Drechsel bottle, the two bubblers, the flow meter and the gas meter in series, in that order, using short rubber connections.

No carbon dioxide shall be allowed to pass to the atmosphere through the outlet of the T-piece.

Weigh the cylinder, totally expand the contents of the cylinder through the absorption train at a flow rate of about 1000 ml/min, and read the volume of gas passed (this serves as a check on the amount of carbon dioxide used for the test).

#### **NOTE**

- 1) Some evaporation of the carbon tetrachloride will take place. If this is excessive, stop the flow of gas and refill the absorption bottles, noting the volume of carbon tetrachloride.
- 2) In view of the toxic nature of carbon tetrachloride, the effluent gas from this determination should be discharged to the outside air.

Reweigh the sampling cylinder, taking care to use the same valve fittings as at the first weighing. Remove the valve not attached to the dip-tube and wash the inside of the cylinder with 25 ml of the carbon tetrachloride. Wash the interior of the evaporating device and valves with carbon tetrachloride and combine this solution with the cylinder washings and the contents of the bubblers. Make up the combined solutions to some suitable, definite volume.

### **B.5.2 Preparation of blank test solution**

Evaporate a volume of carbon tetrachloride, equal to the total volume (including any additions) of carbon tetrachloride used in the absorption train plus washings, to the volume of the combined solution (see B.5.1) and subsequently treat it in the same way as the test solution.

### **B.5.3 Spectrometric measurements**

Following the manufacturer's instructions for the operation of the instrument, determine the absorbances of the test solution and of the blank test solution at the wavelength of maximum absorption (approximately 3 460 nm). From the calibration graph (B.5.4), deduce the masses of oil corresponding to the measured absorbances.

### **B.5.4 Preparation of the calibration graph**

Prepare suitable dilutions of the standard oil solution (B.2.2) to cover the range within which the mass of oil in the sample is expected to be found. Measure the absorbance of each of these solutions as described in B.5.3. Prepare a calibration graph by plotting the masses of oil against the corresponding absorbances.

### **B.6 Expression of results**

The oil content, expressed in parts per million by mass, is given by the formula:

$$\frac{m_3 - m_4}{m_5}$$

where

$m_3$  is the mass, in micrograms, of oil in test solution;

$m_4$  is the mass, in micrograms, of oil in the blank test solution;

$m_5$  is the mass, in grams, of sample taken.

NOTE: The mass,  $m_5$ , can be checked by calculation from the mass of 1l of carbon dioxide at 20 °C and 1013 mbar (760 mmHg), which is 1,84g.

## Annex C

(normative)

### Determination of total sulfur compounds content

#### C.1. Principle

Reduction of any sulfur compounds present by passing equal volumes of the sample and purified hydrogen over silica wool at 900 °C. Removal of the hydrogen sulfide thus produced by passing the gases through neutral cadmium chloride solution ( $\text{CdCl}_2$ ). Determination of sulfur by adding a known amount of iodine solution and determining the excess iodine by titration with standard volumetric sodium thiosulfate solution.

#### C.2. Reagents

All reagents shall be of recognized analytical grade and the water used shall be distilled water or water of equivalent purity.

**C.2.1.** Hydrogen, gas produced electrolytically.

**C.2.2.** Hydrochloric acid, concentrated,  $d = 1,18\text{g/ml}$ .

**C.2.3.** Soda lime, in lumps which pass a test sieve of aperture size 2 mm but which are retained on a test sieve of aperture size 1,8 mm.

NOTE- The soda lime should not have been used in other determinations where oxygen has been used, as explosions may occur.

**C.2.4.** Cadmium chloride, 50 g/l neutral solution.

Dissolve 5g of cadmium chloride in 100 ml of water and add, drop by drop, approximately 1mol/l sodium hydroxide solution until the first cloudiness appears.

**C.2.5.** Sodium thiosulfate, standard volumetric solution,  $C(\text{Na}_2\text{S}_2\text{O}_3) = 0,02\text{ mol/l}$  solution<sup>1)</sup>.

**C.2.6** Iodine, standard volumetric solution,  $c(I_2) = 0,01\text{ mol/l}$  solution<sup>1)</sup>

**C.2.7** Starch indicator solution. Make a paste of 1g of soluble starch with a little water, pour the paste, with constant stirring, into 100 ml of boiling water and boil for 1min. Allow to cool.

#### C.3 Apparatus

Note: The apparatus is shown diagrammatically in figure C.1.

---

<sup>1)</sup> Hitherto expressed as “0,02 N standard volumetric solution”.

**C.3.1.** Flow meter, float type, suitable for measuring a hydrogen flow of 200 ml/min to 2000 ml/min.

**C.3.2.** Flow meter, float type, suitable for measuring a carbon dioxide flow of 200 ml/min to 2000 ml/min.

**C.3.3.** Two furnace tubes, made of transparent silica, each 500 mm long, of internal diameter 16 mm, with one end reduced to 3 mm internal diameter.

Place a loose packing of silica wool not less than 200 mm long in the tube with a small plug of silica wool near the wide end to reduce radiation heating of the polyvinyl chloride connection.

**C.3.4.** Furnace and control: a twin-tube furnace, about 460 mm long, to operate at 900 °C, and fitted with a thermocouple and temperature indicator.

**C.3.5.** Soda lime tower, or suitable absorption tube.

**C.3.6** 'Y' tube.

**C.3.7** Bubbler, as shown in figure 1.

**C.3.8.** Burette, of capacity 10ml, complying with the requirements of ISO/R 385, class A.

**C.3.9** Pipette, of capacity 2ml, complying with the requirements of ISO 648, class A.

**C.3.10.** Test sieves, of aperture size 2mm and 1,8 mm, complying with the requirements of ISO 3310/1.

#### **C.4 Sampling**

Take the sample in a cylinder by the method described in 5.3.3. About 120 g is required for each determination.

Connect the outlet of the evaporating device to the apparatus shown in figure 2. All connections shall be as short as possible and shall be made of polyethylene or polyvinyl chloride.

#### **C.5. Procedure**

Place 25 ml of the neutral cadmium chloride solution (C.2.4) in the absorber and connect it to the apparatus. Pass the hydrogen (C.2.1) at a flow rate of 500 ml/min through the cold furnace tubes for about 5min to purge the system of air before heating is commenced. Then raise the temperature of the furnace to 900 °C.

Pass carbon dioxide and hydrogen into the system at an accurately known and steady flow rate (500 ml/min for each gas) for about 2h with the furnace maintained at 900 °C ± 10 °C.

Note the times at which the determination was begun and ended or expand a known mass of carbon dioxide through the apparatus.



Disconnect the bubbler and close the hydrogen cylinder. Remove the jet of the absorber and wash it with a small volume of water, adding the washings to the remainder of the cadmium chloride solution. By means of the pipette (C.3.9), add 2 ml of the standard volumetric iodine solution (C.2.6) to the bubbler, followed by 2 ml of the concentrated hydrochloric acid (C.2.2). Back titrate the excess iodine with standard volumetric sodium thiosulfate solution (C.2.5), using the starch solution (C.2.7) as indicator.

### C.6. Expression of results

The total sulfur compounds content, expressed as sulfur in parts per million by mass, is given by the formula:

$$\frac{320(2,00 - V)}{m_6}$$

where:

V is the volume, in millilitres, of sodium thiosulphate solution used;

$m_6$  is the mass, in grams, of sample taken.

NOTE- The mass,  $m_6$ , may be obtained by weighing or by calculation using the formula:

$$m_6 = 0,000184 \times A \times t$$

where:

A is the flow rate, in millilitres per minute, at 20 °C and 1013 mbar (760 mmHg), of the carbon dioxide;

t is the time of flow, in minutes.

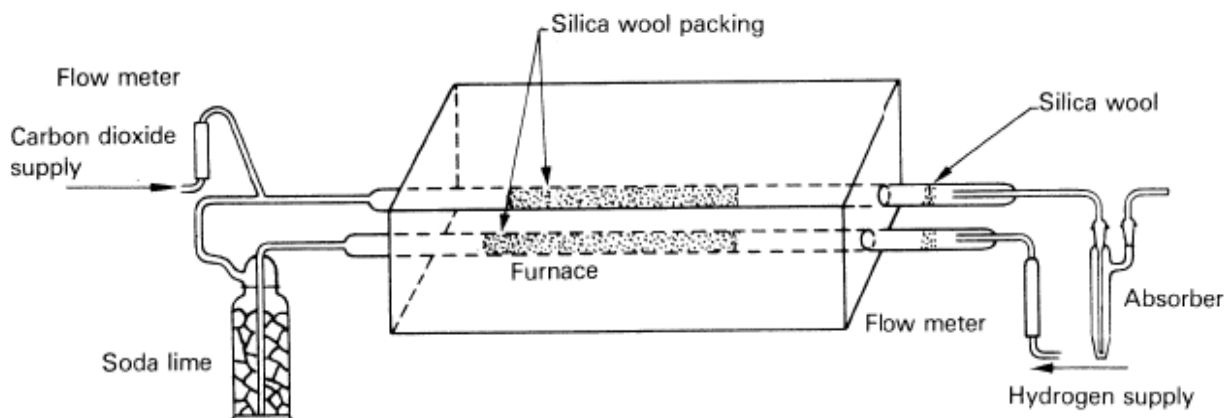


Figure C.1 – Apparatus for the determination of total sulfur compounds content

**Annex D**

(informative)

**General properties****D.1 Physical properties**

For information only, a number of the more important physical properties of carbon dioxide are given in table D.1.

**Table D.1 – Physical properties of carbon dioxide**

| Property   | Value    |
|--|----------|
| Relative molecular mass                                | 44       |
| Sublimation point at atmospheric pressure, °C          | -78,5    |
| Critical temperature, °C                               | 31       |
| Critical pressure, bar                                 | 73,8     |
| Critical volume, m <sup>3</sup> /kg                    | 0,002 15 |
| Critical density, kg/m <sup>3</sup>                    | 466,1    |
| Equilibrium vapour pressure at 20 °C, bar              | 57,3     |
| Vapour density at 20 °C and 1 bar, kg/m <sup>3</sup>   | 1,84     |
| Equilibrium liquid density at 20 °C, kg/m <sup>3</sup> | 774      |
| Triple point, °C                                       | -56,6    |
| bar  | 5,19     |

**D.2 Electrical conductivity**

Carbon dioxide complying with the requirements for purity specified in this International Standard has a very low electrical conductivity and can be used to extinguish fires involving live electrical equipment.

**D.3 Effects on materials**

Carbon dioxide is stable and inert to most common materials.

**D.4 Static electricity**

In some circumstances, the discharge of carbon dioxide can cause a built-up of static electricity. This can cause sparks which can be hazardous in an explosive atmosphere.

**D.5 Toxicology**

Information on the toxicology of carbon dioxide is given in annex G.

**Annex E**

(informative)

**Safety precautions for handling**

**E.1** Carbon dioxide is shipped from the manufacturer as a liquefied gas

- in bulk under pressure at low temperature;
- in cylinders under higher pressure at ambient temperatures.

All precautions pertaining to the safe handling and operation of containers, piping and equipment under pressure should be observed when filling fire fighting equipment with the medium.

**E.2** During the discharge of containers of carbon dioxide, low temperatures can arise through expansion of the liquid to gas and solid. This can present a hazard of frost burn. Gloves and eye protection should be worn when transferring carbon dioxide from one container to another.

**E.3** Transfer of carbon dioxide should be carried out in a well-ventilated area or in the open air.

**E.4** Carbon dioxide is much heavier than air and can collect in pits, cellars and low-lying areas. Care should be taken when entering such areas on sites where carbon dioxide has been used.

**Annex F**  
(informative)  
**Compatibility**

Carbon dioxide may be used simultaneously with other types of fire extinguishing media for fire fighting purposes, with no known indications that extinguishing efficiency is affected.

## **Annex G**

(informative)

### **Toxicology**

#### **G.1 General**

The principal action of carbon dioxide is to cause suffocation, although it is mildly toxic in its own right.

At concentrations of 3% to 4% (V/V) in air, the respiration rate is increased and headaches can be caused.

At concentrations of 9% (V/V), personnel can lose consciousness within minutes, this being preceded by disorientation, visual disturbance, ringing in the ears, tremors, etc.

At a concentration of about 20 % (V/V), death will follow in 20 min to 30 min.

#### **G.2 Precautions and treatment**

In practice, concentrations of 30 % (V/V) or more are employed for total flooding systems. Similarly, high concentrations could be encountered near to the nozzles of hand extinguishers or local application systems. Such concentrations are highly hazardous for persons and special precautions should be taken depending upon the specific conditions of use.

Persons suffering from exposure to carbon dioxide should immediately move or be moved to fresh air. Medical aid should always be sought in the event of such over-exposure.

---