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Granular carbon dioxide (CO_2) absorbent material for life support, diving, hyper- and hypobaric applications – Specification

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Contents

Summary of pages

This document comprises a front cover, an inside front cover, pages i to ii, pages 1 to 14, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 July 2015. It was prepared by Subcommittee PH/4/7, *Underwater breathing apparatus*, under the authority of Technical Committee PH/4, *Respiratory protection*. A list of organizations represented on this committee can be obtained on request to its secretary.

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its requirements are expressed in sentences in which the principal auxiliary verb is "shall".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Requirements in this standard are drafted in accordance with *Rules for the structure and drafting of UK standards*, subclause **J.1.1**, which states, "Requirements should be expressed using wording such as: 'When tested as described in Annex A, the product shall ...'". This means that only those products that are capable of passing the specified test will be deemed to conform to this standard.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

Introduction

Granular and pelleted carbon dioxide (CO_2) absorbents are used in a variety of life-support, diving, hyper- and hypobaric applications. The type and characteristics of absorbents vary dependent upon the intended use, differences in manufacturing techniques and chemical composition.

This standard provides requirements and test methods for carbon dioxide absorbents, and designations for such absorbents. This allows users to select appropriate materials for their intended application.

1 Scope

This British Standard gives requirements and test methods for granular and pelleted carbon dioxide absorbent materials.

NOTE For the purposes of this standard, the term "granular" includes both granular and pelleted material.

It is applicable to granular carbon dioxide absorbents intended for use in life-support applications including re-breathing apparatus on the surface and underwater, hyperbaric, and hypobaric applications.

It excludes granular and pelleted carbon dioxide absorbents intended for use in applications in medical anaesthesiology, materials that also generate oxygen, and monolithic pre-formed materials or those embedded within a polymer matrix.

2 Normative references

BS ISO 3310-1, *Test sieves – Technical requirements and testing Part 1: Test sieves of metal wire cloth*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this British Standard, the following terms and definitions apply.

3.1.1 activity time

time (in minutes) that a carbon dioxide absorbent material can maintain an effluent carbon dioxide level less than a given value

3.1.2 granule/granular material

granular or pelleted material

3.1.3 friability

propensity to form dust

3.1.4 indicator

material that changes colour as an absorbent is used

3.2 Abbreviations

S-H	Small soda lime, high-activity
S-L	Small soda lime, low-activity
L-H	Large soda lime, high-activity
L-L	Large soda lime, low-activity

Li-S Lithium hydroxide, small

Li-L Lithium hydroxide, large

4 Requirements

4.1 Absorbent designations

The absorbent shall be a granular material of one of the following designations:

a) For soda lime based materials:

S-H, S-L, L-H or L-L

b) For lithium hydroxide based materials:

Li-S or Li-L

*NOTE Requirements for associated granule sizes and dust-loads are given in **4.4**, and requirements for friability are given in **4.5**.*

4.2 Carbon dioxide absorbent activity

The carbon dioxide absorbent material shall have an absorbent activity in accordance with Table 1 when tested in accordance with **5.1.**

Table 1 **Carbon dioxide absorbent activity**

Carbon dioxide absorbent material	Absorbent activity
S-H and L-H	≥ 90 min
S-L and L-L	≥ 60 min
Li-S and Li-L	≥ 125 min

4.3 Volatile (water) content

The absorbent material shall have the following volatile content, when tested in accordance with **5.2**:

S-H, L-H, S-L and L-L, between 14% and 22%.

Li-S and Li-L, < 1.0%.

4.4 Carbon dioxide absorbent granule size and dust load

The granule sizes and dust loads of the absorbent material shall be in accordance with Table 2, when tested in accordance with **5.3**.

Table 2 **Carbon dioxide absorbent granule size**

Granule size	Limits (weight %)	
	Small-granule	Large-granule
Retained on 5.60 mm sieve	–	1.0 max
Retained on 4.75 mm sieve	–	7.0 max
Retained on 2.80 mm sieve	1.0 max	–
Retained on 2.00 mm sieve	30.0 max	76.0 min

Table 2 **Carbon dioxide absorbent granule size**

Granule size	Limits (weight %)	
	Small-granule	Large-granule
Retained on 1.40 mm sieve	48.0 min	–
Retained on 0.60 mm sieve	20.0 max	15.0 max
Passing 0.60 mm sieve (dust)	0.50 max	0.50 max

4.5 Friability

The absorbent material friability shall be in accordance with Table 3, when tested in accordance with **5.4**.

NOTE Table 3 allows for higher dust level as this is created during the friability test.

Table 3 **Friability for carbon dioxide absorbent materials**

Granule size	Limits (weight %)	
	Small-granule	Large-granule
Retained on 5.60 mm sieve	–	1.0 max
Retained on 4.75 mm sieve	–	7.0 max
Retained on 2.80 mm sieve	1.0 max	–
Retained on 2.00 mm sieve	30.0 max	76.0 min
Retained on 1.40 mm sieve	48.0 min	–
Retained on 0.60 mm sieve	20.0 max	15.0 max
Passing 0.60 mm (dust)	1.0 max	1.0 max

4.6 Flow resistance

The absorbent material shall have the following flow resistance when tested in accordance with **5.5**:

S-H, S-L and Li-S: ≤ 1.4 mbar.

L-H, L-L and Li-L, ≤ 1.2 mbar.

4.7 Indicators

The absorbent material shall contain no indicators, when tested in accordance with **5.6**.

5 Testing

WARNING.
Carbon dioxide absorbents consisting of (or containing) lithium hydroxide are harmful by inhalation and corrosive to skin and eyes.

5.1 Carbon dioxide absorbent activity

5.1.1 Principle

To pass a known concentration of carbon dioxide through a predetermined sample size to determine the time to achieve 0.50% v/v carbon dioxide at the outlet.

5.1.2 Apparatus

5.1.2.1 *absorbent test rig,* in accordance with Figure 1.

5.1.2.2 *activity tube*, in accordance with Figure 2.

5.1.2.3 *snow storm filler*, in accordance with Figure 3 and Figure 4.

5.1.2.4 *carbon dioxide analysers*, capable of measuring an inlet carbon dioxide concentration of 5% v/v ±0.05% and an effluent concentration of 0.5% v/v ±0.01%.

5.1.3 Preparation and preservation of test samples and test pieces

Assemble a test rig as shown in Figure 1.

Locate the activity tube, as shown in Figure 2, into the base of a snow storm filler as detailed in Figure 3 and Figure 4.

Pour the absorbent at an even rate into the snow storm filler till the activity tube is filled to the 105 ml calibration mark. The mass (g) of absorbent added to the tube shall be recorded.

5.1.4 Procedure

The test shall be repeated a minimum of three times, with the activity being the shortest recorded time. The tests to determine the activity at atmospheric pressure shall be conducted at (20 ±1) °C and in accordance with the following procedure:

Insert the activity tube into the test rig; the tube shall be vertical, with the test gas flowing top to bottom. Pass a flow of (3.0 ±0.1) l/min of homogenous (5.0 ±0.05%) v/v carbon dioxide in nitrogen (or air) test gas mixture, maintained at (20 ±1) °C, through the humidifiers and activity tube.

A sample of both inlet and effluent gas exiting the activity tube shall be drawn off and passed into a suitably ranged closed-loop carbon dioxide analysers, at a sufficient rate to provide accurate analysis.

The sample gas shall pass through a drying agent that will not absorb carbon dioxide (e.g. $MgClO_4$) before passing into the gas analyser.

The output signal from the inlet sample analyser and effluent sample analyser shall be recorded.

5.1.5 Expression of results

Record the time taken for the effluent gas to reach a level of 0.50% v/v carbon dioxide.

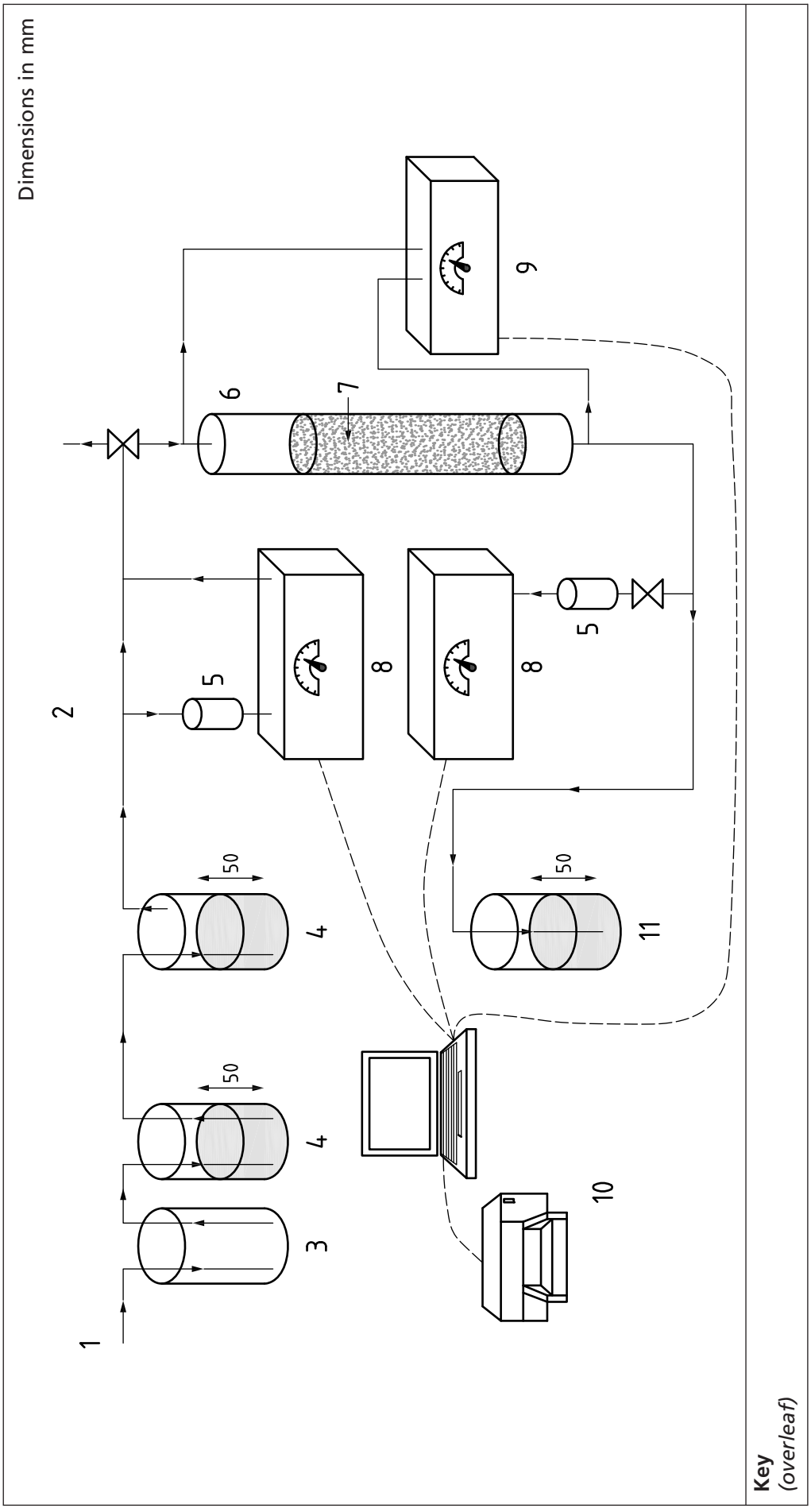


Figure 1 **Schematic carbon dioxide absorbent test rig**

Figure 1 **Schematic carbon dioxide absorbent test rig**

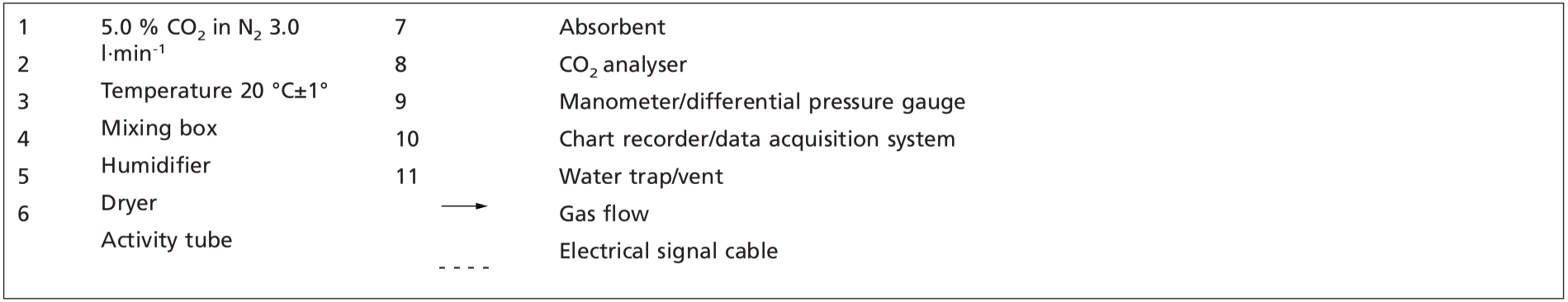
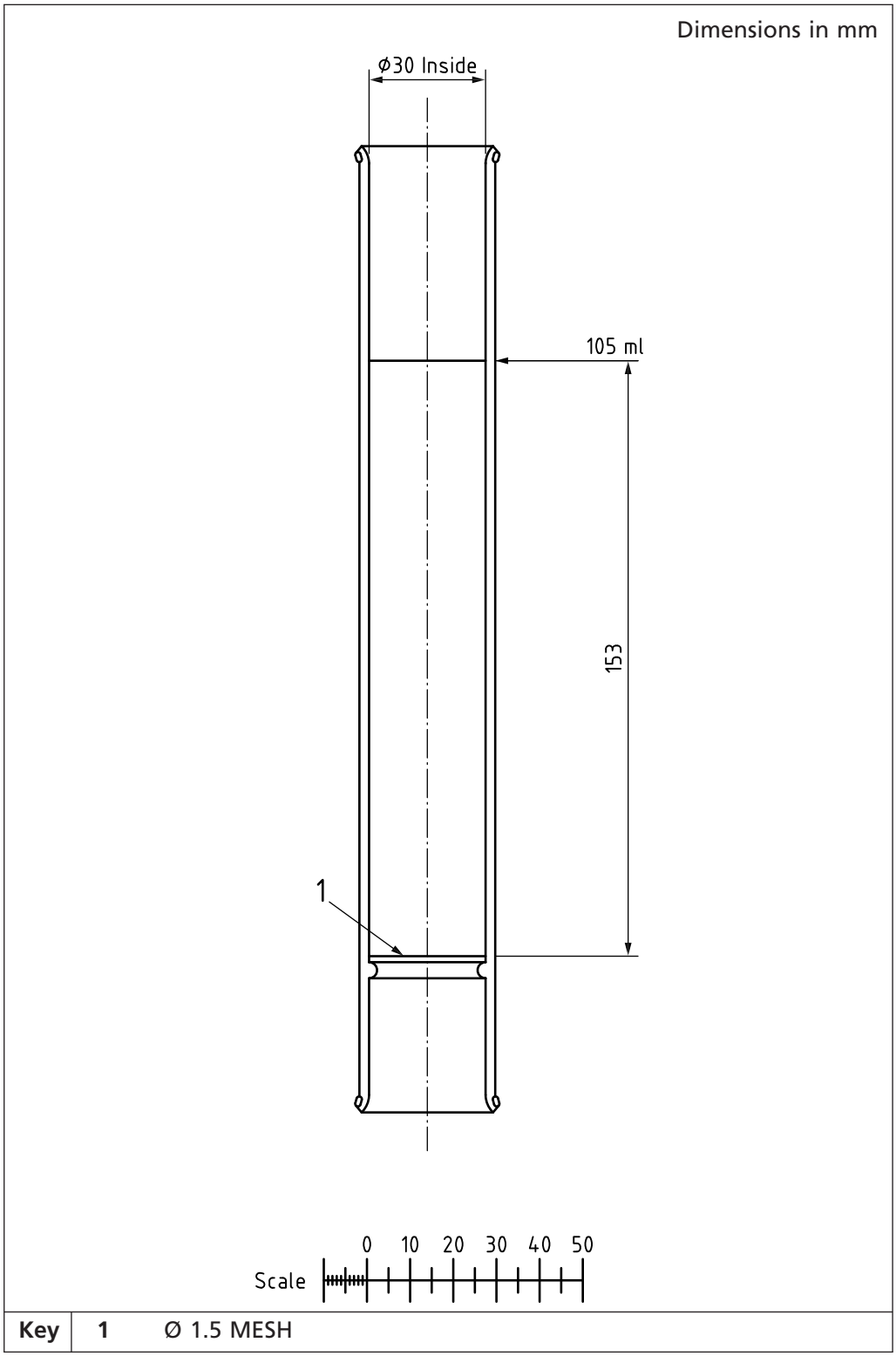


Figure 2 **Absorbent activity tube**



Key	1	Ø 1.5 MESH

Figure 3 **Snow storm filler for activity tube**

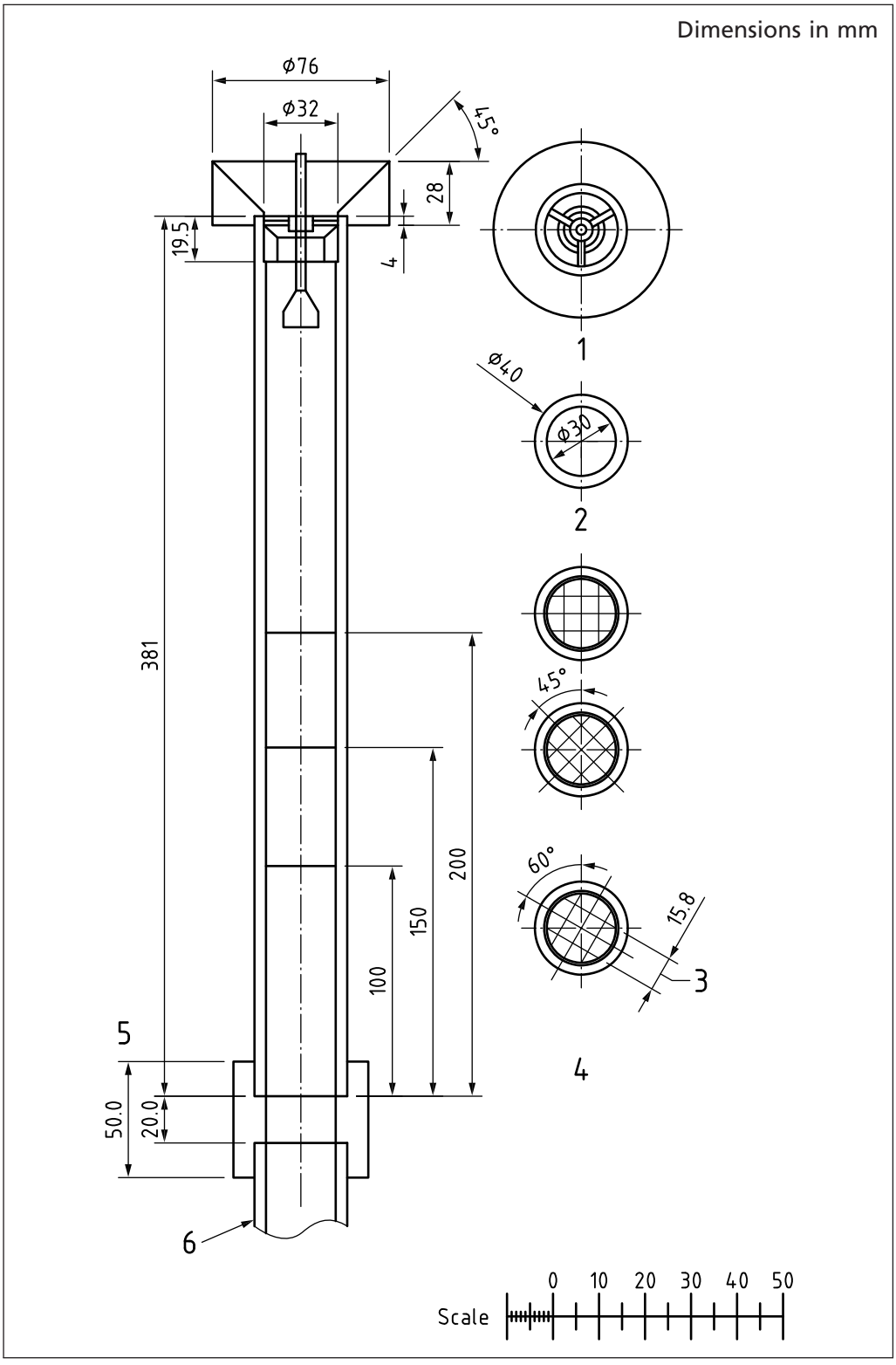


Figure 3
Key

1	View on top end
2	Typical section of tube
3	MESH (5/8′) Pitch Wire 32 swg. Typical in 3 positions
4	Dimension from bottom to the fill line on the sample tube should be 148.5 mm
5	Dimensions of collar
6	Activity tube

Figure 4 **Snow storm filler (throat detail)**

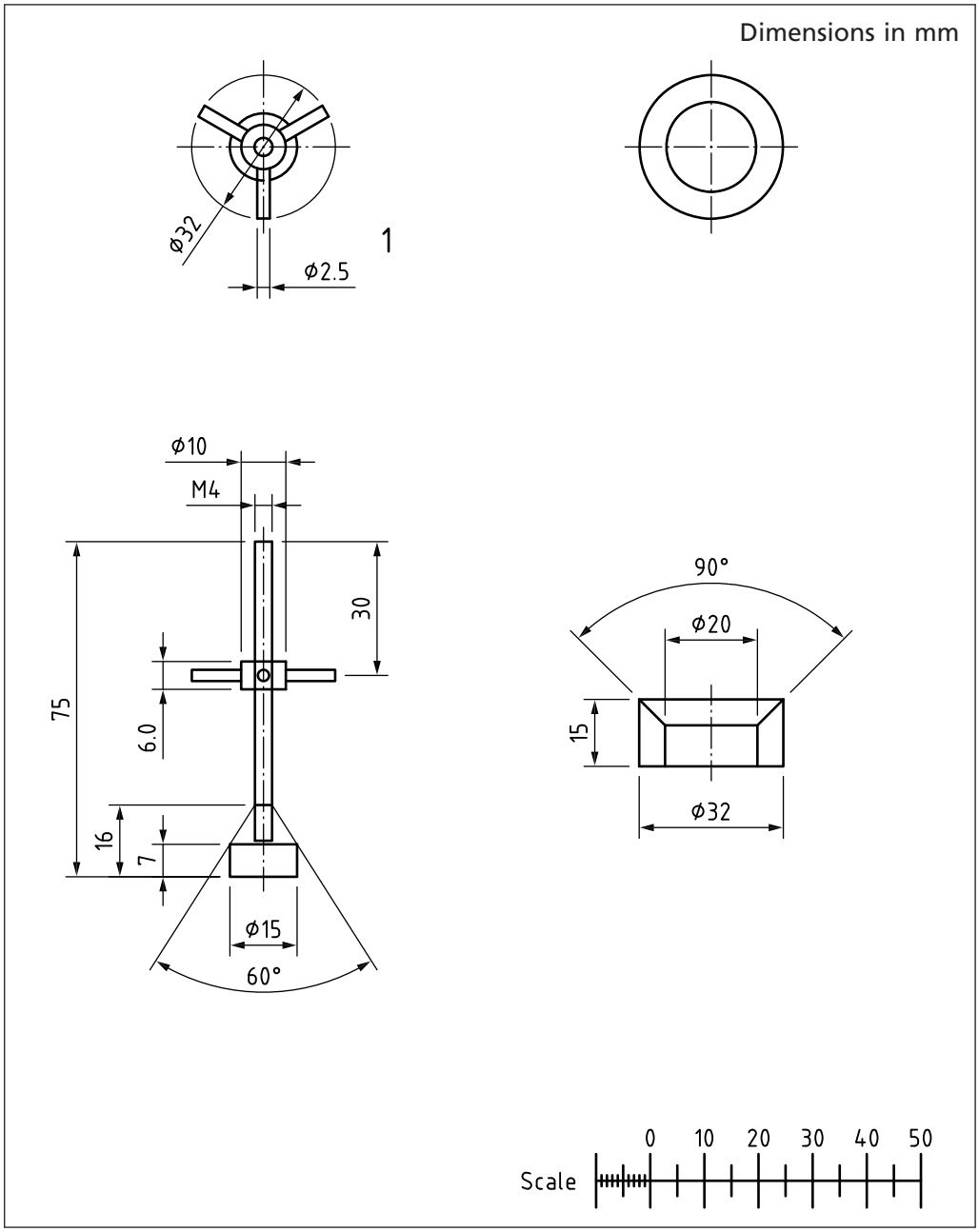


Figure 4
Key

1	Three support arms equi-spaced

5.2 Volatile (water) content

5.2.1 Volatile content method (a)

5.2.1.1 Principle

To drive off the volatile component by heating to a predetermined temperature until a constant weight is achieved.

5.2.1.2 Apparatus

5.2.1.2.1 *automatic volatile content infrared balance*

5.2.1.3 Preparation and preservation of test samples and test pieces

5.2.1.4 Procedure

Transfer approximately 10 g of absorbent onto an automatic volatile content infrared balance and record (if required) the mass (M_{A1}). Start the automatic drying cycle at a nominal temperature of 150 °C and record (if available) the percentage volatile reading when the absorbent is dry and/or the mass of the dried absorbent (M_{A2}).

5.2.1.5 Expression of results

If required, the percentage volatile content (volatile matter, %) can be calculated using Formula (1):

$$\frac{(M_{A1} - M_{A2})}{M_{A1}} 100 \qquad (1)$$

5.2.2 Volatile content method (b)

5.2.2.1 Apparatus

5.2.2.1.1 *dish,* squat form min. 100 mm diameter and 20 mm depth, able to withstand temperatures in excess of 150 °C

5.2.2.2 *fan stirred oven,* capable of maintaining a temperature of (150 ±10) °C

5.2.2.3 Procedure

Transfer approximately 100 g of absorbent to a previously weighed (M_{M1}) clean, dry dish and accurately weigh (M_{M2}).

Remove the lid and place the dish, with the lid alongside, in the fan stirred oven maintained at (150 ± 10) °C.

After 120 min. replace the lid and transfer the dish to a desiccator, containing fresh active desiccant. Allow to cool for 30 min.

Release the lid on the dish momentarily and re-weigh (M_{M3}).

5.2.2.4 Expression of results

The percentage volatile content (volatile matter, %) shall be calculated using Formula (2):

$$\frac{(M_{M2} - M_{M3})}{(M_{M2} - M_{M1})} 100 \qquad (2)$$

5.3 Carbon dioxide absorbent granule size and dust load

5.3.1 Principle

To determine the size distribution of the granular material using a nest of standard sieves.

5.3.2 Apparatus

5.3.2.1 *sieves*, clean, dry (see Table 4)

5.3.2.2 *mechanical sieve shaker*, of known frequency and amplitude

5.3.3 Preparation and preservation of test samples and test pieces

Perform a visual inspection of the sieves shown in Table 4, in accordance with BS ISO 3310-1, **5.2**, Test 1.

Table 4 **Nest of 250 mm diameter sieves**

Sieve aperture size (mm)	Small-granule	Large-granule
5.60	–	✓
4.75	–	✓
2.80	✓	–
2.00	✓	✓
1.40	✓	–
0.60	✓	✓
Receiver pan	✓	✓

Weigh and record each of the sieves and the receiving pan indicated in Table 4. Assemble the nest of clean dry sieves indicated in Table 4 in order of aperture size with the receiver pan at the base.

5.3.4 Procedure

Distribute (100 ±0.1) g of absorbent onto the top sieve. Record the amount of absorbent used. Attach the lid and shake the assembled sieves for 5 min. on a mechanical shaker.

Remove the nest of sieves from the shaker and weigh the amount of material retained on each sieve, and the dust passing into the receiver at the base of the nest. Any granules lodged in the meshes of a sieve shall be included as the material retained on the sieve.

5.3.5 Expression of results

Report the mass of material on each sieve, and the dust in the receiver, as a percentage of the total mass of absorbent retained in the nest of sieves.

5.4 Friability

5.4.1 Principle

To determine the change in size distribution of the granular material following an extended period of vibration on a nest of standard sieves.

5.4.2 Apparatus

5.4.2.1 *sieves*, clean, dry (see Table 4)

5.4.2.2 *mechanical sieve shaker*, of known frequency and amplitude

5.4.3 Preparation and preservation of test samples and test pieces

Perform a visual inspection of the sieves shown in Table 4, in accordance with BS ISO 3310-1, **5.2**, Test 1.

Weigh and record each of the sieves and the receiving pan indicated in Table 4. Assemble the nest of clean dry sieves indicated in Table 4 in order of aperture size with the receiver pan at the base.

5.4.4 Procedure

Distribute (100 ±0.1) g of absorbent on the top sieve. Record the amount of absorbent used. Attach the lid and shake the assembled sieves for 60 min. on a mechanical shaker.

Remove the nest of sieves from the shaker and weigh the amount of material retained on each sieve, and the dust passing into the receiver at the base of the nest. Any granules lodged in the meshes of a sieve shall be included as the material retained on the sieve.

5.4.5 Expression of results

Report the mass of material on each sieve, and the dust in the receiver, as a percentage of the total mass of absorbent retained in the nest of sieves.

5.5 Flow resistance

5.5.1 Principle

To determine the resistance to flow under standard flow conditions.

*NOTE The test should be conducted during the absorbent activity test (**5.1**).*

5.5.2 Apparatus

As defined for the activity test in **5.1**.

differential pressure monitor, a differential pressure monitor with a minimum accuracy of ±0.01 mbar

5.5.3 Procedure

The differential pressure monitor shall be connected to the top and the bottom of the activity tube in a manner which will not be affected venturi, pitot, or turbulence (identical connections, top and bottom of the tube can minimize these effects).

A baseline differential pressure shall be recorded with the activity test gas flowing and no absorbent in the activity tube.

During the full duration of the activity test the differential pressure across the activity tube shall be monitored and the maximum differential pressure recorded.

5.5.4 Expression of results

The maximum differential pressure minus the baseline differential pressure shall be reported.

5.6 Indicators

The presence of an indicator shall be identified by observing the absorbent during the absorbent activity test (**5.1**) and noting any colour change that occurs.

NOTE To prevent nugatory testing, the presence of an indicator may also be identified by placing a few granules on a white filter circle and wetting with a few drops of 10% ethanoic acid solution, when a colour change will indicate the presence of an indicator.

6 Marking

The external packaging of the absorbent material shall:

a) identify the manufacturer by name, trade name or other means of identification;

b) state the number and date of this British Standard [1)];

c) state the name, type and designation of material;

d) state a unique identifier, e.g. the batch or lot number, date of manufacture and expiry date;

e) include any relevant health and safety warnings such as irritant or corrosive; and

f) storage conditions.

7 Information supplied by the manufacturer

The information supplied by the manufacturer shall include:

a) the intended use, e.g. the type of life support system; and

b) relevant handling information.

NOTE This is covered in UK law by the need to provide a Material Safety Data Sheet (MSDS).

[1)] Marking BS 8618:2015 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is solely the claimant's responsibility. Such a declaration is not to be confused with third-party certification of conformity.

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