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Hygrothermal performance of building materials and products — Determination of hygroscopic sorption properties

Performance hygrothermique des matériaux et produits pour le bâtiment — Détermination des propriétés de sorption hygroscopique

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 734 10 79
E-mail copyright@iso.ch
Web www.iso.ch

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 12571 was prepared by the European Committee for Standardization (CEN) in collaboration with ISO Technical Committee TC 163, *Thermal insulation*, Subcommittee SC 1, *Test and measurement methods*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Throughout the text of this standard, read "...this European Standard..." to mean "...this International Standard...".

Annexes A to D of this International Standard are for information only.

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Foreword

The text of EN ISO 12571:2000 has been prepared by Technical Committee CEN/TC 89 "Thermal performance of buildings and building components", the secretariat of which is held by SIS, in collaboration with Technical Committee ISO/TC 163 "Thermal insulation".

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2000, and conflicting national standards shall be withdrawn at the latest by December 2001**.**

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

This standard is one of a series of standards, which specify test methods for the thermal and moisture related properties of building materials and products.

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1 Scope

This standard specifies two alternative methods for determining hygroscopic sorption properties of porous building materials and products:

a) using desiccators and weighing cups (desiccator method);
b) using a climatic chamber (climatic chamber method).

The desiccator method is the reference method.

The standard does not specify the method for sampling.

The methods specified in this standard can be used to determine the moisture content of a sample in equilibrium with air at a specific temperature and humidity.

2 Normative reference

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references, latest edition of the publication referred to applies.

EN ISO 9346	Thermal insulation - Mass transfer - Physical quantities and definitions (ISO 9346)
EN ISO 12570	Hygrothermal performance of building materials and products - Determination of moisture content by drying at elevated temperature (ISO 12570)

3 Definitions, symbols and units

3.1 Definitions

For the purposes of this standard, the definitions given in EN ISO 9346 and the following apply:

3.1.1 hygroscopic sorption
exchange of water vapour between ambient air and a porous material until the point of equilibrium is reached

3.1.2 moisture content mass by mass
mass of evaporable water divided by mass of dry material

3.1.3 moisture content volume by volume
volume of evaporable water divided by volume of dry material

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3.1.4 moisture content mass by volume
mass of evaporable water divided by volume of dry material

NOTE The mass of water is determined by weighing the specimen before and after drying at the appropriate drying temperature until constant mass is reached.

3.1.5 sorption curve
curve that establishes a relationship between the moisture content of a material at equilibrium with the environment and the relative humidity of the ambient air, at a specified temperature

3.1.6 adsorption curve
sorption curve established at a series of increasing equilibrium relative humidities

3.1.7 desorption curve
sorption curve established at a series of decreasing equilibrium relative humidities

3.2 Symbols and units

Symbol	Quantity	Unit
m	mass of test specimen	kg
m_0	mass of dried test specimen	kg
u	moisture content mass by mass	kg/kg
ψ	moisture content volume by volume	m^3/m^3
w	moisture content mass by volume	kg/m^3

4 Principle

4.1 Adsorption curve

The specimen is dried to constant mass. Whilst maintaining a constant temperature, the specimen is placed consecutively in a series of test environments, with relative humidity increasing in stages. The moisture content is determined when equilibrium with each environment is reached. Equilibrium with the environment is established by weighing the specimen until constant mass is reached. A minimum of four test atmospheres shall be selected in the humidity range under consideration.

After establishing the moisture content at each relative humidity the adsorption curve can be drawn.

4.2 Desorption curve

The starting point for desorption is a relative humidity of at least 95 %. This might be the last point of the adsorption curve or might be reached by adsorption from a dried test specimen. Whilst maintaining a constant temperature, the specimen is placed consecutively in a series of test environments, with relative humidity decreasing in stages. The moisture content is determined when equilibrium with each environment is reached. Equilibrium with the environment is established by weighing the specimen until constant mass is reached. A minimum of four test atmospheres shall be selected in the humidity range under consideration. Finally, the specimen is dried to constant mass.

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After establishing the moisture content at each relative humidity the desorption curve can be drawn.

NOTE A defined starting point for desorption has been chosen for better reproducibility.

5 Apparatus

5.1 Desiccator method

The test apparatus shall include:

a) weighing cups which do not absorb water and with tight-fitting lids;

b) balance, capable of weighing to an accuracy of ± 0,01 % of the mass of the test specimen;

NOTE If larger weighing cups are used, the weighing accuracy can be determined with respect to the total mass and the required accuracy of the test results.

c) drying oven, in accordance with EN ISO 12570;

d) desiccator, capable of maintaining the relative humidity within ± 2 % relative humidity;

e) constant-temperature chamber, capable of maintaining the specified test temperature to an accuracy of ± 0,5 K.

5.2 Climatic chamber method

The test apparatus shall include:

a) weighing cups which do not absorb water;

b) balance, capable of weighing to an accuracy of ± 0,01 % of the mass of the test specimen;

NOTE If larger weighing cups are used, the weighing accuracy can be determined with respect to the total mass and the required accuracy of the test results.

c) drying oven, in accordance with EN ISO 12570;

d) climatic chamber capable of maintaining the relative humidity within ± 5 % relative humidity and the temperature within ± 2 K over the whole test area.

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6 Test specimens

6.1 Specification of the test specimens

A test specimen shall be representative of the product and have a mass of at least 10 g. Specimens of materials with a dry density less than 300 kg/m^3 shall have an area of at least 100 mm × 100 mm.

If it can be demonstrated from other references that the result will not be affected, a test specimen can be cut or crushed into smaller pieces to reduce the time to reach equilibrium with the environment.

6.2 Number of test specimens

A minimum of three specimens shall be tested. The procedure in clause 7 shall be applied to each specimen.

7 Procedure

7.1 Test conditions

Reference sorption curves shall be established at a temperature of (23 ± 0,5) °C. If agreed between the parties, sorption curves can be established at other temperatures for specific applications.

7.2 Desiccator method

7.2.1 General

Make up the appropriate saturated aqueous solution to achieve the necessary relative humidity in the desiccator.

NOTE Annex A gives the relative air humidities of various saturated solutions in equilibrium, and annex B describes the preparation of various solutions.

Place the desiccator in the constant-temperature chamber.

7.2.2 Adsorption curve

Weigh the weighing cup and lid when empty and dry.

Put the test specimen into the weighing cup without the lid and dry it until constant mass in the drying oven at the temperature specified in EN ISO 12570.

Constant mass is reached if the change of mass between three consecutive weighings, each made at least 24 h apart, is less than 0,1 % of the total mass.

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Put the test specimen in the weighing cup, with the lid beside it, into the desiccator containing the salt solution needed to give the appropriate relative humidity.

Periodically weigh the specimen until it is in equilibrium with the environment (constant mass). Immediately after removing the lid of the desiccator, put on the lid of the weighing cup, and move the weighing cup to the balance. After weighing the cup, return it to the desiccator with the lid beside it.

NOTE 1 Annex C gives an example of a detailed weighing procedure.

Repeat the procedure for increasing humidities. A minimum of four approximately evenly spaced humidities in increasing order shall be selected in the range of 30 % to 95 % relative humidity.

NOTE 2 It is possible that mould and mildew grow on specimens of wood based materials in atmospheres with relative humidities over 80 %. This might invalidate the test and can be prevented by adding a few drops of an appropriate fungicide to the solution.

7.2.3 Desorption curve

The starting point for desorption is a relative humidity of at least 95 %. This might be the last point of the adsorption curve or might be reached by adsorption from dried test specimen.

Put the test specimen in the weighing cup, with the lid beside it, into the desiccator containing the solution needed to give the appropriate relative humidity.

Periodically weigh the specimen until it is in equilibrium with the environment (constant mass). Immediately after removing the lid of the desiccator, put on the lid of the weighing cup, and move the weighing cup to the balance. After weighing the cup, return it to the desiccator with the lid beside it. Constant mass is reached if the change of mass between three consecutive weighings, each made at least 24 h apart, is less than 0,1 % of the total mass.

NOTE Annex C gives an example of a detailed weighing procedure.

Repeat the procedure for decreasing humidities. A minimum of four approximately evenly spaced humidities in decreasing order shall be selected in the range of 95 % to 30 % relative humidity.

7.3 Climatic chamber method

7.3.1 Adsorption curve

Put the test specimen, if necessary in the weighing cup, in the drying oven and dry it until constant mass at the temperature specified in EN ISO 12570. Constant mass is reached if the change of mass between three consecutive weighings, each made at least 24 h apart, is less than 0,1 % of the total mass.

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Put the test specimen in the climatic chamber. At first the humidity in the climatic chamber is the lowest of the range of values chosen for the test (see below).

Periodically weigh the specimen in the climatic chamber until it is in equilibrium with the environment (constant mass).

Repeat the procedure for increasing humidities. A minimum of four approximately evenly spaced humidities in increasing order shall be selected in the range of 30 % to 95 % relative humidity.

7.3.2 Desorption curve

The starting point for desorption is at a relative humidity of at least 95 %. This might be the last point of the adsorption curve or might be reached by adsorption from dried test specimen.

Put the test specimen, if necessary on the weighing cup, in the climatic chamber.

Periodically weigh the specimen in the climatic chamber until it is in equilibrium with the environment (constant mass). Constant mass is reached if the change of mass between three consecutive weighings, each made 24 h apart, is less than 0,1 % of the total mass.

Repeat the procedure for decreasing humidities. A minimum of four approximately evenly spaced humidities in decreasing order shall be selected in the range of 95 % to 30 % relative humidity.

8 Calculation and expression of results

The moisture content, u, is calculated as follows for each specimen:

$$u = \frac{m - m_0}{m_0} \qquad (1)$$

For the adsorption curve or for the desorption curve, take the mean of the calculated moisture contents for the various specimens at each relative humidity.

After calculation of the mean moisture content of the various test specimens at each relative humidity the adsorption and desorption curves can be drawn by joining the data points with straight lines.

NOTE More accurate curve fitting techniques can be used to fit functional relations to the data - see the references in annex D for further information.

EN ISO 12570 gives methods for converting the values of u calculated from equation (1) into the moisture content volume by volume ψ or moisture content mass by volume w.

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9 Accuracy of measurement

9.1 Error in moisture content

The error in the moisture content, for a balance conforming with 5.1 b), can be estimated by using equation (2):

$$\frac{\Delta u}{u} = \pm 0{,}0002 \frac{m_0}{m - m_0} \qquad (2)$$

9.2 Control of environmental conditions

9.2.1 Desiccator method

The relative humidity within the weighing cup is determined by the saturated solution used in the desiccator.

NOTE The relative humidity and the accuracy for various saturated solutions is given in annex A.

The temperature in the constant-temperature chamber shall be carefully monitored with calibrated instruments.

9.2.2 Climatic chamber method

The temperature and the relative humidity in the whole testing area of the climatic chamber shall be carefully monitored with shielded calibrated instruments such as a wet and dry bulb psychrometer or a chilled mirror dewpoint meter.

10 Test report

The test report shall include the following:

a) reference to this standard;

b) product identification:
- product name, factory, manufacturer or supplier;
- type of product;
- production code number;
- the form in which the product arrived at the laboratory;
- other information if necessary; e.g. thickness, dry density;

c) test procedure:
- date of the start and duration of the test;
- the method of sampling;
- the method and temperature of drying;
- any factors which may have influenced the results;
- the test method used (dessicator or the climatic chamber);
- the test temperature;

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d) results:

- table of the measured values (relative humidity, u and optionally ψ and w, if needed) and mean value at given temperature;
- graph showing sorption curves.

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Annex A (informative)

Relative air humidities above saturated solutions in equilibrium

Table A.1 gives the relative air humidities of 28 saturated solutions in equilibrium with the atmosphere of the chamber at temperature intervals of 5 K, together with the range of uncertainty at each temperature. The values for 23 °C are obtained by linear interpolation.

Table A.1 - Relative air humidities above saturated solutions in equilibrium

Temperature °C	**Relative humidity**, %					
	Caesium Fluoride CsF	Lithium bromide LiBr	Zinc bromide $ZnBr_2$	Potassium hydroxide KOH	Sodium hydroxide NaOH	Lithium chloride LiCl
0		7,75 ± 0,83				11,23 ± 0,54
5	5,52 ± 1,9	7,43 ± 0,76	8,86 ± 0,89	14,34 ± 1,70		11,26 ± 0,47
10	4,89 ± 1,6	7,14 ± 0,69	8,49 ± 0,74	12,34 ± 1,40		11,29 ± 0,41
15	4,33 ± 1,4	6,86 ± 0,63	8,19 ± 0,61	10,68 ± 1,10	9,57 ± 2,8	11,30 ± 0,35
20	3,83 ± 1,1	6,61 ± 0,58	7,94 ± 0,49	09,32 ± 0,90	8,91 ± 2,4	11,31 ± 0,31
23	3,57 ± 1,0	6,47 ± 0,55	7,83 ± 0,43	08,67 ± 0,78	8,51 ± 2,2	11,30 ± 0,28
25	3,39 ± 0,94	6,37 ± 0,52	7,75 ± 0,39	08,23 ± 0,72	8,24 ± 2,1	11,30 ± 0,27
30	3,01 ± 0,77	6,16 ± 0,47	7,62 ± 0,31	07,38 ± 0,56	7,58 ± 1,7	11,28 ± 0,24
35	2,69 ± 0,63	5,97 ± 0,43	7,55 ± 0,25	06,73 ± 0,44	6,92 ± 1,5	11,25 ± 0,22
40	2,44 ± 0,52	5,80 ± 0,39	7,54 ± 0,20	06,26 ± 0,35	6,26 ± 1,2	11,21 ± 0,21
45	2,24 ± 0,44	5,65 ± 0,35	7,59 ± 0,17	05,94 ± 0,29	5,60 ± 1,0	11,16 ± 0,21
50	2,11 ± 0,40	5,53 ± 0,31	7,70 ± 0,16	05,72 ± 0,27	4,94 ± 0,85	11,10 ± 0,22
55	2,04 ± 0,38	5,42 ± 0,28	7,87 ± 0,17	05,58 ± 0,28	4,27 ± 0,73	11,03 ± 0,23
60	2,03 ± 0,40	5,33 ± 0,25	8,09 ± 0,19	05,49 ± 0,32	3,61 ± 0,65	10,95 ± 0,26

Temperature °C	**Relative humidity**, %					
	Calcium bromide $CaBr_2$	Lithium iodide LiI	Potassium acetate $KC_2H_3O_2$	Potassium fluoride KF	Magnesium chloride $MgCl_2$	Sodium iodide NaI
0					33,66 ± 0,33	
5		21,68 ± 0,30			33,60 ± 0,28	42,42 ± 0,99
10	21,62 ± 0,13	20,61 ± 0,25	23,38 ± 0,53		33,47 ± 0,24	41,83 ± 0,83
15	20,20 ± 0,12	19,57 ± 0,20	23,40 ± 0,32		33,30 ± 0,21	40,88 ± 0,70
20	18,50 ± 0,12	18,56 ± 0,16	23,11 ± 0,25		33,07 ± 0,18	39,65 ± 0,59
23	17,30 ± 0,12	17,96 ± 0,14	22,75 ± 0,30		32,90 ± 0,17	38,76 ± 0,52
25	16,50 ± 0,12	17,56 ± 0,13	22,51 ± 0,32	30,85 ± 1,30	32,78 ± 0,16	38,17 ± 0,50
30		16,57 ± 0,10	21,61 ± 0,53	27,27 ± 1,10	32,44 ± 0,14	36,51 ± 0,43
35		15,57 ± 0,08		24,59 ± 0,94	32,05 ± 0,13	34,73 ± 0,39
40		14,55 ± 0,06		22,68 ± 0,81	31,60 ± 0,13	32,88 ± 0,37
45		13,49 ± 0,05		21,46 ± 0,70	31,10 ± 0,13	31,02 ± 0,37
50		13,38 ± 0,05		20,80 ± 0,62	30,54 ± 0,14	29,21 ± 0,40
55		11,22 ± 0,05		20,60 ± 0,56	29,93 ± 0,16	27,50 ± 0,45
60		09,98 ±0,06		20,77 ± 0,53	29,26 ± 0,18	25,95 ± 0,52

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Table A.1 - Relative air humidities above saturated solutions in equilibrium (continued)

Temperature °C	Relative humidity, %					
	Potassium carbonate K_2CO_3	Magnesium nitrate $Mg(NO_3)_2$	Sodium Bromide NaBr	Cobalt chloride $CoCl_2$	Potassium iodide KI	Strontium chloride $SrCl_2$
0	43,13 ± 0,66	60,35 ± 0,55				
5	43,13 ± 0,50	58,86 ± 0,43	63,51 ± 0,72		73,30 ± 0,34	77,13 ± 0,12
10	43,14 ± 0,39	57,36 ± 0,33	62,15 ± 0,60		72,11 ± 0,31	75,66 ± 0,09
15	43,15 ± 0,33	55,87 ± 0,27	60,68 ± 0,51		70,98 ± 0,28	74,13 ± 0,06
20	43,16 ± 0,33	54,38 ± 0,23	59,14 ± 0,44		69,90 ± 0,26	72,52 ± 0,05
23	43,16 ± 0,36	53,49 ± 0,22	58,20 ± 0,42		69,28 ± 0,25	71,52 ± 0,05
25	43,16 ± 0,39	52,89 ± 0,22	57,57 ± 0,40	64,92 ± 3,5	68,86 ± 0,24	70,85 ± 0,04
30	43,17 ± 0,50	51,40 ± 0,24	56,03 ± 0,38	61,83 ± 2,8	67,89 ± 0,23	69,12 ± 0,03
35		49,91 ± 0,29	54,55 ± 0,38	58,63 ± 2,2	66,96 ± 0,23	
40		48,42 ± 0,37	53,17 ± 0,41	55,48 ± 1,8	66,09 ± 0,23	
45		46,93 ± 0,47	51,95 ± 0,47	52,56 ± 1,5	65,26 ± 0,24	
50		45,44 ± 0,60	50,93 ± 0,55	50,01 ± 1,4	64,49 ± 0,26	
55			50,15 ± 0,65	48,02 ± 1,4	63,78 ± 0,28	
60			49,66 ± 0,78	46,74 ± 1,5	63,11 ± 0,31	

Temperature °C	Relative humidity, %					
	Sodium nitrate $NaNO_3$	Sodium chloride NaCl	Ammonium Chloride NH_4Cl	Potassium bromide KBr	Ammonium sulphate $(NH_4)_2SO_4$	Potassium chloride KCl
0		75,51 ± 0,34			82,77 ± 0,90	88,61 ± 0,53
5	78,57 ± 0,52	75,65 ± 0,27		85,09 ± 0,26	82,42 ± 0,68	87,67 ± 0,45
10	77,53 ± 0,45	75,67 ± 0,22	80,55 ± 0,96	83,75 ± 0,24	82,06 ± 0,51	86,77 ± 0,39
15	76,46 ± 0,39	75,61 ± 0,18	79,89 ± 0,59	82,52 ± 0,22	81,70 ± 0,38	85,92 ± 0,33
20	75,36 ± 0,35	75,47 ± 0,14	79,23 ± 0,44	81,67 ± 0,21	81,34 ± 0,31	85,11 ± 0,29
23	74,69 ± 0,33	75,36 ± 0,13	78,83 ± 0,42	81,20 ± 0,21	81,13 ± 0,29	84,65 ± 0,27
25	74,25 ± 0,32	75,29 ± 0,12	78,57 ± 0,40	80,89 ± 0,21	80,99 ± 0,28	84,34 ± 0,26
30	73,14 ± 0,31	75,09 ± 0,11	77,90 ± 0,57	80,27 ± 0,21	80,63 ± 0,30	83,62 ± 0,25
35	72,06 ± 0,32	74,87 ± 0,12		79,78 ± 0,22	80,27 ± 0,37	82,95 ± 0,25
40	71,00 ± 0,34	74,68 ± 0,13		79,43 ± 0,24	79,91 ± 0,49	82,32 ± 0,25
45	69,99 ± 0,37	74,52 ± 0,16		79,18 ± 0,26	79,56 ± 0,65	81,74 ± 0,28
50	69,04 ± 0,42	74,43 ± 0,19		79,02 ± 0,28	79,20 ± 0,87	81,20 ± 0,31
55	68,15 ± 0,49	74,41 ± 0,24		78,95 ± 0,32		80,70 ± 0,35
60	67,35 ± 0,57	74,50 ± 0,30		78,94 ± 0,35		80,25 ± 0,41

Temperature °C	Relative humidity, %			
	Strontium Nitrate $Sr(NO_3)_2$	Potassium Nitrate KNO_3	Potassium Sulphate K_2SO_4	Potassium Chromate K_2CrO_4
0		96,33 ± 2,9	98,77 ± 1,1	
5	92,38 ± 0,56	96,27 ± 2,1	98,48 ± 0,91	
10	90,55 ± 0,38	95,96 ± 1,4	98,18 ± 0,76	
15	88,72 ± 0,28	95,41 ± 0,96	97,89 ± 0,63	
20	86,89 ± 0,29	94,62 ± 0,66	97,59 ± 0,53	
23	85,79 ± 0,35	94,00 ± 0,60	97,42 ± 0,47	
25	85,06 ± 0,38	93,58 ± 0,55	97,30 ± 0,45	97,88 ± 0,49
30		92,31 ± 0,60	97,00 ± 0,40	97,08 ± 0,41
35		90,79 ± 0,83	96,71 ± 0,38	96,42 ± 0,37
40		89,03 ± 1,2	96,41 ± 0,38	95,89 ± 0,37
45		87,03 ± 1,8	96,12 ± 0,40	95,50 ± 0,40
50		84,78 ± 2,5	95,82 ± 0,45	95,25 ± 0,48
55				
60				

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Annex B (informative)

Preparation of saturated solutions

A mixture of distilled water and the quantity of substance necessary to produce a saturated solution according to table B.1, is heated to the given temperature (where the excess of substance is just dissolved) and is then cooled slowly to room temperature, stirring continuously.

Reagent grade chemicals should be used for preparation.

Saturated solutions can be corrosive and harmful to health, and care should be taken in their preparation and handling.

Solutions should be checked regularly to ensure that they retain a mixture of solid and liquid and have not become contaminated.

References to more detailed descriptions of the preparation of saturated solutions are given in annex D.

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