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Decontamination of radioactively contaminated surfaces — Testing of decontamination agents for textiles

Décontamination des surfaces contaminées par la radioactivité — Essai des agents de décontamination pour les textiles

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 85 *Nuclear energy, nuclear technologies, and radiological protection*, Subcommittee SC 2, *Radiological protection*.

This second edition cancels and replaces the first edition (ISO 9271:1992), which has been technically revised.

The main changes are as follows:

— the scope was rephrased and specified;

— opening to further applications;

— adding of symbols of the used measurands;

— improvement of structure;

— improvement in readability;

— adaption to current standards;

— adding a new form in the Annex with description the properties of the agents to be tested.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Wherever radioactivity is used, there is a risk that textiles can become contaminated through contact with radioactivity in solution or airborne radioactivity.

It is normally necessary to remove this contamination to reduce the risk to staff from accidental intake of the radioactivity on the surface. The ease of decontaminating textiles is therefore an important parameter to consider when selecting materials to use, e.g., for facilities in the nuclear industry, in radionuclide laboratories or nuclear medicine facilities.

This document defines a quantitative method under objective conditions for testing the ease of decontamination of textile fabric. The method enables the comparison of different textile materials to support decisions on textiles for use in different applications.

For the test, radioactive solutions are deposited onto a sample of the material being studied. The solutions contain radionuclides commonly found in nuclear industry (^{60}Co, ^{137}Cs or ^{134}Cs) and are in aqueous form. The textiles are then cleaned with detergents or cleansing agent, to be tested, and the residual activity on the textiles is measured to give a quantitative measure of the ease of decontamination.

Information obtained from the test method will enable the optimization of the choice of decontamination agents for textiles. This should result in lower demands for materials and water in laundry systems, with consequent savings in the cost of radioactive waste processing operations such as filtration, evaporation, solidification and disposal.

If the customer desires that suitability of their decontamination agents is to be tested with other radiochemicals containing alpha- and beta- emitting radionuclides, then other procedures and measurement techniques (like liquid-scintillation counting) are to be used, which are not described in this document.

Comparative tests can be carried out with all possible combinations of textile materials and radionuclides in homogeneous solutions. Inorganic or organic solutions can be used and they should be based on a solvent which evaporates at room temperature. An assessment of the results of a series of comparative tests is made on the basis of the mean residual pulse rates.

In order to permit the general qualification of a decontamination agent as a single product, this document specifies a test and assessment method based on ^{60}Co and ^{137}Cs or ^{134}Cs applied to internationally standardized cotton fabric. These two radionuclides were selected because they are the most important sources of contamination in the nuclear industry. The cotton fabric selected is the only reference material available in this field. The assessment of the result of a single test is made using an assessment table of final residual pulse rates based on inter-laboratory experiments.

Decontamination of radioactively contaminated surfaces — Testing of decontamination agents for textiles

1 Scope

This document applies to the testing of the decontamination of textiles, which are contaminated by radioactive materials.

The test method describes the technique to assess the efficiency of decontamination agents (see ISO 7503-1 and ISO 7503-3).

This document applies to the testing of detergents, which may be used in aqueous solutions for the purpose of cleaning radioactively contaminated textiles.

The radionuclides used in this test are those commonly found in the nuclear industry (^{60}Co and ^{137}Cs or ^{134}Cs) in aqueous form. The test can also be adapted for use with other radionuclides and other chemical forms, depending on the customer requirements, if the solutions are chemically stable and do not damage the test specimen.

The test method is not suitable if the radionuclide emits low energy gamma rays, like ^{55}Fe, or low energy beta or alpha particles that are readily attenuated in the textile fabrics, or if the nuclide has a chemical or isotopic interaction with the detergent used in the method (e.g. tritium which could be in several chemical forms).

The test method does not apply to the testing of the ability of detergents to remove non-radioactive dirt.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2174, *Surface active agents — Preparation of water with known calcium hardness*

ISO 2267, *Surface active agents — Evaluation of certain effects of laundering — Methods of preparation and use of unsoiled cotton control cloth*

ISO 3819, *Laboratory glassware — Beakers*

ISO 6330, *Textiles — Domestic washing and drying procedures for textile testing*

ISO 11074, *Soil quality — Vocabulary*

ISO 80000-10, *Quantities and units — Part 10: Atomic and nuclear physics*

ISO/IEC Guide 98-3, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

ISO/IEC Guide 99, *International vocabulary of metrology — Basic and general concepts and associated terms (VIM)*

3 Terms, definitions and symbols

For the purposes of this document, the terms and definitions given in ISO 11074, ISO 80000-10, ISO/IEC Guide 98-3, ISO/IEC Guide 99 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1 Terms and definitions

3.1.1
contamination
radioactive substances deposited on textiles

3.1.2
contaminated textile specimen
pieces of textile reference materials which are contaminated in a specified manner and which are used to determine the efficiency of decontamination agents

3.1.3
decontamination
complete or partial removal of radioactive *contamination* (3.1.1) by a deliberate physical, chemical, or biological process

[SOURCE: ISO 12749-3:2015, 3.7.11.2]

Note 1 to entry: It is preferred that decontamination does not significantly change the characteristics of the surface.

3.1.4
specific pulse rate
I_s
pulse rate caused in the measuring apparatus under given geometrical conditions by 1 ml of a contaminant solution

Note 1 to entry: It is expressed in pulses per minute standardized on 1 ml of the contaminant solution. Pulse rates are derived from count rates applying dead time and background corrections.

3.1.5
residual pulse rate
I_r
pulse rate caused in the measuring apparatus under given geometrical conditions by the residual radionuclide on the tested side of the specimen after *decontamination* (3.1.3)

Note 1 to entry: I_r is expressed in pulses per minute.

3.1.6
mean residual pulse rate
$\overline{I_r}$
arithmetic mean of the residual pulse rate values obtained for the five test specimens contaminated by the same radionuclide

Note 1 to entry: It is expressed in pulses per minute.

3.1.7
standardized mean residual pulse rate
corrected value of the *mean residual pulse rate* (3.1.6)

Note 1 to entry: The correction factor is obtained by dividing a reference value of the specific pulse rate by the pulse rate of a contaminant solution used in the test.

Note 2 to entry: It is expressed in pulses per minute.

Note 3 to entry: The purpose of the correction factor is to compensate for variations in specific pulse rates of contaminant solutions used in different test laboratories.

3.1.8
final residual pulse rate
$I_{r,fin}$
arithmetic mean of the *standardized mean residual pulse rate* (3.1.7) obtained for ^{60}Co and ^{134}Cs or ^{137}Cs

Note 1 to entry: It is expressed in pulses per minute.

Note 2 to entry: is the pulse rate caused in the measuring apparatus under given geometrical conditions by the residual radionuclide on the tested side of the specimen after *decontamination* (3.1.3).

3.2 Symbols

For the purposes of this document, the following symbols apply.

A	Activity of the radionuclide [Bq]
A_S	Specific activity of the radionuclide [Bq·g^{-1}]
A_E	Activity of the radionuclide in the contaminant solution [Bq]
D_{min}	Distance between the centre point of the contaminated area and the edge of the sensitive detector cross-section [mm]
h	Distance of the contaminated test surface from the detector surface [mm]
m	Mass [g]
M	Molar mass [kg·mol^{-1}]
r	Final volume of contaminant solution [ml]
s	Activity concentration of stock solution [MBq·ml^{-1}]
q	Carrier concentration [mol·l^{-1}]
τ	Carrier concentration of the initial radionuclide solution [mol·l^{-1}]
t	Time [s]
$t_{1/2}$	Half-life [years]
u	Carrier concentration, in moles per litre [mol·l^{-1}]
V	Volume [l]

4 Principle

A specimen of the textile material is contaminated using a solution containing ^{60}Co and ^{137}Cs or ^{134}Cs. The emission from the specimen is measured using a detector. The specimen made from textile reference material is decontaminated using a solution of the decontamination agent under test. The emission is measured again and the result is compared to the result of the first measurement to quantify the ease of decontamination.

Separate contaminant solutions containing ^{60}Co and ^{137}Cs or ^{134}Cs (carrier concentration: 10^{-5} mol·l^{-1}; pH 4) are prepared. 100 µl samples of these solutions are counted using a large area radiation detector. The specific pulse rates of contaminant solutions are calculated using the results from the count.

Specimens of the material under test are first treated with the contaminant solutions over a defined area and subsequently decontaminated with demineralized water. The residual pulse rate, I_r, is determined by measuring the contaminated samples.

The standardized mean residual pulse rates $\overline{I_{r,n}}$ for each radionuclide are calculated. The arithmetic mean of the respective values for ^{60}Co and ^{137}Cs or ^{134}Cs (final residual pulse rate, $I_{r,fin}$) is used to assess the ease of decontamination by means of a classification which has been compiled empirically.

5 Apparatus

In addition to ordinary laboratory apparatus, the following equipment shall be used for testing the ease of decontamination of textiles.

5.1 Beakers

Two beakers, of the low-form type, having a capacity of 2 000 ml and in accordance with requirements given in ISO 3819.

5.2 Radiation detector

A detector and associated electronics are required for determining the pulse rate. Suitable detectors are solid scintillation (e.g. NaI(Tl), $LaBr_3$(Ce), $CeBr_3$) and semi-conductor types selective for gamma-ray (see Reference [8]).

NOTE The sensitivity and the efficiency depend on the size of the scintillator crystal or the semi-conductor detector

The minimum size of the sensitive area of the detector shall be a circle having a diameter of 30 mm, but in practice, the geometrical requirement specified normally necessitates the use of a larger sensitive area.

To comply with geometrical requirements, the ratio $\frac{D_{min} - 12{,}5}{h}$ shall not be less than 3,

where

D_{min} is the smallest distance, in millimetres, from the centre point of the contaminated area, as projected onto the detector cross-section, to the edge of the sensitive detection area

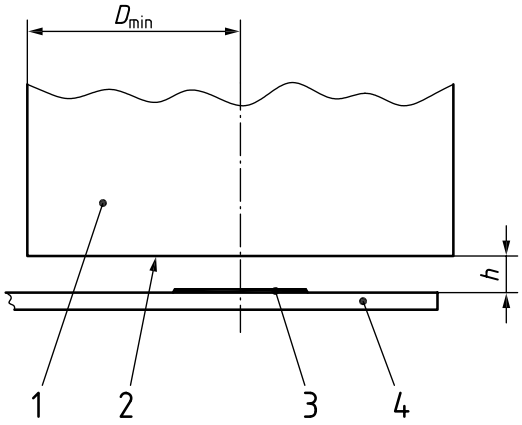
h is the distance, in millimetres, of the contaminated test surface from the detector surface (see Figure 1).

If the geometrical requirement $\frac{D_{min} - 12{,}5}{h} \geq 3$ is not met, a detector having a circular sensitive area of not less than 30 mm in diameter may be used, provided that

a) for the determination of the specific pulse rate (see 8.1), the 100 µl of contaminant solution is applied to the centre of the textile specimen

b) the net pulse rate of 100 µl of contaminant solution measured under these geometrical conditions is not less than 200 000 pulses per minute (see 6.1.1, 8.1 and Annex C).

The geometrical requirements for a radiation detector are illustrated in Figure 1.



Key

1	detector	h	distance, in millimetres
2	sensitive area of detector	D_{min}	smallest distance, in millimetres
3	contaminated area		
4	test specimen		

Figure 1 — Geometrical requirements for a radiation detector (cross-section)

5.3 Pipettes

Two pipettes with disposable tips, having a capacity of 100 µl.

5.4 Two polytetrafluoroethylene (PTFE) or quartz ampoules

Two polytetrafluoroethylene (PTFE) ampoules for preparation of the contamination solution

or

two quartz ampoules for the activation of the inactive stock solution in the neutron reactor are required.

5.5 Thermostat

A thermostat for setting and maintaining the test temperature at 60 °C.

5.6 Storage bottles

Two polytetrafluoroethylene (PTFE) bottles for storage the radioactive stock solution are required.

NOTE Other fluorinated materials of similar chemical resistance are possible alternatives to polytetrafluoroethylene (PTFE), such as polytetrafluoroethylene/perfluoropropylene (PTFE/PFP), perfluoro alkoxyl alkane (PFA) and poly(vinylidene fluoride) (PVDF).

5.7 Drying cabinet

Drying cabinet for drying the textile specimens in their respective holders.

5.8 Mounting

Ten holders for test specimens (5 for each radionuclide), made of poly(methyl methacrylate) (PMMA), serving as positioning aids for the contamination step (see Annex A).

5.9 Cage-stirrer apparatus

A cage-stirrer apparatus for six test specimens shall be used in accordance with Annex B. The apparatus shall be equipped with a motor allowing the stirrer to be rotated at 100 r/min.

6 Contamination and decontamination agents

6.1 Contaminant solutions

6.1.1 Composition of contaminant solutions

The test specimens shall be contaminated by the radionuclides ^{60}Co and ^{137}Cs or ^{134}Cs, contained in separate solutions.

The use of other radionuclides in aqueous solutions which may be more suitable in terms of type and chemical behaviour for the envisaged purpose of the textile fabrics can be adopted, subject to consultation with the testing laboratory.

However, the contaminant solutions shall be chemically stable and shall not degrade the test specimens. The decontaminated samples shall be stable in order to allow the residual contamination to be measured. Special measurement techniques may be required in the case of radionuclides the emissions of which are subject to absorption.

The activity concentration of the contaminant solution shall be such that an evaporated 100 µl sample produces a pulse rate of not less than 200 000 pulses per minute in the detector, after correction for dead time and background.

NOTE An activity concentration of 0,2 $MBq \cdot ml^{-1}$ is usually sufficient to fulfil the requirement.

The radionuclides shall be used with a carrier concentration of $(1,0 \pm 0,1) \cdot 10^{-5}$ $mol \cdot l^{-1}$ in a solution of nitric acid with a pH-value of 4,0 ± 0,2. To make sure that the activity concentration does not change the pH-value of the contaminant solution is checked monthly or before use. This shall be done using a sample of each contaminant solution.

6.1.2 Preparation of the contaminant solutions

6.1.2.1 Apart from Co^{2+} and Cs^{+} ions and the corresponding nitrate ions, the radionuclide stock solutions shall not contain any constituents, which remain in the residue when the solutions have been evaporated as described in 6.1.2.6.

All reagents used shall be of analytical grade (pro analysis) or better.

6.1.2.2 With the help of the data available for the activity concentrations of the ^{60}Co and ^{137}Cs or ^{134}Cs stock solutions, the quantities of these solutions to be used for preparing the desired quantities of contaminant solutions can be calculated. Formulae for the preparation of the contaminant solutions are given in Annex C.

6.1.2.3 The next step is to calculate from these input quantities the carrier quantities transferred with the radionuclides, and from these in turn calculate the quantities of cobalt(II) nitrate $[Co(NO_3)_2]$ or caesium nitrate $(CsNO_3)$ solutions respectively, which need to be added to establish a carrier concentration of $(1,0 \pm 0,1) \cdot 10^{-5}$ $[mol \cdot l^{-1}]$ in the individual solutions.

6.1.2.4 Place these quantities of carrier solutions in polytetrafluoroethylene vessels of sufficient size to allow dilution of the solutions to their final volumes. In order to enhance the displacement of chloride ions which may be present in the radionuclide stock solutions, add 5 ml of nitric acid solution (high purity grade) $[HNO_3 = 1\ mol \cdot l^{-1}]$ per 90 ml of final volume of contaminant solution.

6.1.2.5 Finally, add the calculated quantities of ^{60}Co and ^{137}Cs or ^{134}Cs stock solutions to the carrier solution.

6.1.2.6 In a fume hood, evaporate the mixtures to dryness using infrared lamps (or sufficient heat equipment) until fume evolution stops.

6.1.2.7 Then heat the vessels for another 2 h with the infrared lamps being moved to double the initial distance.

6.1.2.8 After cooling, top the vessels up to the respective final volume by adding nitric acid with a pH-value of 4.

NOTE Nitric acid with a pH value 4 is produced by diluting 7 µl of nitric acid (ρ = 1,4 g·ml^{-1}) to 1 l water using double distilled water.

6.1.2.9 Check the specific pulse rates of the thoroughly homogenized solutions in accordance with 8.1 and the pH value.

6.1.3 Storage of the contaminant solution

In order to avoid wall effects, which may alter the concentration, the individual solutions shall be kept in well-sealed polytetrafluoroethylene containers, which, in turn, are enclosed in glass containers of the smallest possible size to reduce the risk of evaporation.

A solution prepared in accordance with this procedure can be used as long as its pH-value lies within the specified range and the activity concentration has not changed by more than 5 % compared to its initial value (decay corrections being applied).

6.2 Decontamination agents

For the purpose of the test, the decontamination agents shall be used in solutions with a concentration of 7,5 g·l^{-1}. If the producer recommends a lower concentration for optimum performance a test at this lower concentration may be carried out, either

a) as an additional test, or

b) instead of the test under standard concentration conditions.

In case b), an assessment in accordance with Table 1 (see Clause 9) may be carried out, but the deviation shall be stated in the test report, e.g.

“Reported results are not fully comparable with standard test results, due to the deviating test concentration of the decontamination agent being, for example, 3 g·l^{-1} instead of 7,5 g·l^{-1}“.

If the producer recommends a higher concentration for optimum performance, an additional test with the recommended concentration may be carried out.

Deionized water with a maximum conductivity of 3 µS/cm shall be used as the solvent. The solutions shall be prepared not more than 1 h before each application.

7 Contaminated textile specimen

7.1 Reference materials

Standard cotton fabric conforming to the specifications in ISO 2267 shall be used as reference material. This fabric shall be pretreated in a washing machine of rotating drum type in the following manner.

Programme: hot wash three times at 60 °C (coloured wash) without pre-wash: followed by a complete rinsing programme

Wash load: 1 m^2 standard cotton fabric (no additional load)

Detergent: 80 g ECE[1)] reference detergent described in accordance with ISO 6330, free of optical brighteners

Water hardness: 2,5 $mmol \cdot l^{-1}$ in accordance with ISO 2174.

Pressing: Ironing between pieces of fabric which are free of optical brighteners (to be tested using an UV-lamp)

If requested, the use of other textile specimen materials is permissible subject to agreement. These other materials include textiles impregnated with defined quantities of dirt and textiles which have been subjected to pretreatment not complying with the specifications of this document. In this case, an assessment in accordance with Table 1 is not permissible, and other assessment tables shall be established.

7.2 Number and dimensions of contaminated textile specimens

Twelve square-shaped pieces of pretreated reference material shall be used.

The contaminated textile specimens should measure (50 ± 2) mm × (50 ± 2) mm.

8 Procedure

8.1 Determining the specific pulse rate of each contaminant solution

Dispense a 100 µl aliquot of the contaminant solution on the centre of each of three textile specimens, measuring 50 mm × 50 mm, in accordance with the procedure laid down in 8.3. The positioning aid (see 5.8) or a similar device may be used. After the solution has been allowed to dry (infrared lamps) at a maximum temperature of 45 °C, the textile specimens are removed from their frames. The pulse rate is measured on the textile specimens with a radiation detector. The detector (as specified in 5.2) is placed in the same measurement geometry (particularly with regard to the distance of the contaminated textile specimen from the detector) that is to be used for the test specimens (see 8.5). It is to be ensured that the measurement geometry (particularly with regard to the distance of the contaminated textile specimen from the detector) is the same as it was planned for the measurement on the test specimens (see 8.3).

The measuring period shall be 1 min for each sheet. Apply corrections for background and dead time losses.

Multiply the arithmetic mean of the three results by a factor of 10 so that the result is expressed in terms of pulses per minute standardized on one millilitre of the contaminant solution.

Carry out the determination separately for both contaminant solutions.

8.2 Preparation of the textile specimens

The textile specimens shall be cut to size parallel to the warp or the weft of the fabric, taking care not to stretch the material.

Care should be taken to protect the material against soiling, for example by wearing polyethylene gloves or by using tweezers.

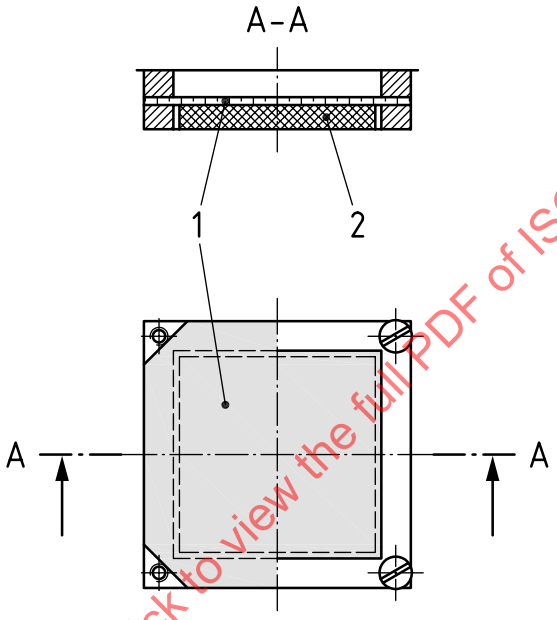
1) ECE: European Colour fastness Establishment.

8.3 Contamination

8.3.1 Preparation

For each radionuclide solution, six textile specimens shall be clamped in their respective steel specimen holders. In order to prevent sagging of the textile fabric, the plastic support block (5.8) shall be inserted into the lower part of the holder (see Figure 2). Care should be taken to avoid creasing of the fabric when screwing the holder tight.

The corners of the textile specimens shall be cut off slightly, in order to prevent their coming into contact with the screws (see Figure 2).



Key

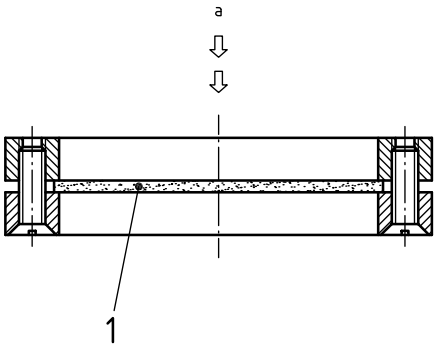
1 textile specimen
2 support block

Figure 2 — Use of specimen holder

Once the textile specimens are clamped into the holder, the plastic support block shall be removed and the holder shall be inverted for contamination.

8.3.2 Procedure

Apply by using a pipette, 100 µl of the contamination agents drop by drop to the centre of the textile specimens (see Figure 3 showing a diagonal cut of the holder).



Key

1 textile specimen

a Put the contamination agents from this side.

Figure 3 — Position of specimen holder during contamination

The textile specimens, still in their respective holders, shall then be dried in a drying cabinet at 40 °C ± 5 °C for 2 h. In this way, five textile specimens shall be contaminated with each contaminant solution. Avoid any contamination on the sixth mounted textile specimen, which are used for background measurements (see 8.5).

8.4 Decontamination

8.4.1 Preparation

For the purpose of decontamination, six textile specimens, five of which are contaminated and one of which is not, are necessary.

The specimen holders containing the textile specimens shall be fastened to the windows of the cage-stirrer apparatus (see 5.9). Stainless steel coil springs or disposable rubber bands may be used to fasten the holders onto the cage-stirrer. Care should be taken to ensure that the side of the fabric on which the contaminant solution was applied faces the inside of the cage.

8.4.2 Procedure

Decontamination shall be carried out at a speed of 100 r·min^{-1} in 900 ml of the decontamination agent (see 6.1) maintained at a temperature of 60 °C ± 2 °C. If the producer recommends a lower temperature for optimum performance, a test at this lower temperature may be carried out, either

a) as an additional test; or

b) instead of the test under standard temperature conditions.

In case b), an assessment in accordance with Table 1 may be carried out, but it shall be stated in the test report, e.g.

“Reported results are not fully comparable with standard test results, due to the deviating test temperature (for example 30 °C instead of 60 °C)”.

Care shall be taken that the cage-stirrer is positioned vertically and centrally, and that it touches the bottom of the glass beaker. The stirrer shall first be run for 10 min in one direction, and then for an additional 10 min in the other direction.

The specimens shall then be rinsed at the same rotational frequency in 900 ml of deionized water for 5 min at room temperature with the stirrer running in one direction. The deionized water shall be replaced and the rinsing repeated with the stirrer running in the opposite direction. The contaminated

textile specimens shall be removed from the cage stirrer and dried in their respective holders starting at 100 °C ± 5 °C for 30 min.

NOTE It is recommended to reduce the drying temperature during the drying process, or to set to variable temperature drying.

8.5 Determining the residual pulse rate, I_r

After cooling to room temperature, the contamination carriers shall be removed from their holders and their residual pulse rates determined.

Immediately before the measurement of the residual pulse rates, I_r, of the test specimens, measure the background pulse rate with an uncontaminated test specimen present.

The pulse rate of the decontaminated test specimens is measured using the equipment specified in 5.2. The measurement geometry, i.e. the distance and relative position of the test specimen and detector, shall be the same for all measurements (see 8.1). Care should be taken to ensure that the side of the contaminated textile specimen on which the contamination was applied faces the detector.

Each measurement shall be performed once, the background being deducted. Dead time losses shall be taken into account. Counting shall proceed for 5 000 counts above background or 10 min, whichever is the shorter time.

9 Calculation of results and assessment of ease of decontamination

After decontamination, the arithmetic mean of the residual pulse rates $\overline{I_r}$ (of the five test specimens of each group) is calculated separately for ^{60}Co and ^{137}Cs or ^{134}Cs. The results shall be expressed in pulses per minute and shall be used to calculate standardized mean residual pulse rates $\overline{I_{r,n}}$ according to the following formula.

$$\text{Standardized mean residual pulse rate } \overline{I_{r,n}} = \text{mean residual pulse rate } \overline{I_r} \cdot \frac{3 \cdot 10^6}{I_s}$$

This calculation shall be carried out separately for ^{60}Co ($\overline{I_{r,n}}(\text{Co})$) and ^{137}Cs or ^{134}Cs $\overline{I_{r,n}}(\text{Cs})$).

NOTE 1 The value of $3 \cdot 10^6$ pulses per minute standardized on 1 ml of a contaminant solution is the reference value of the specific pulse rate I_s of the contaminant solutions on which the table for assessing the ease of contamination is based.

Calculate the final result (i.e. the final residual pulse rate, $I_{r,fin}$) as the arithmetic mean of the standardized mean residual pulse rates for ^{60}Co ($\overline{I_{r,n}}(\text{Co})$) and ^{137}Cs or ^{134}Cs ($\overline{I_{r,n}}(\text{Cs})$).

The ease of decontamination shall be classified using the Table 1 if the contamination was carried out using the radionuclides ^{60}Co and ^{137}Cs or ^{134}Cs and not deviating from the decontamination process as described in 8.4 (e.g., using other decontaminant means or wiping off by removing of the adherent contamination mechanically).

Table 1 — Assessment of the ease of decontamination

Final residual pulse rate $I_{r,fin}$ pulses/min	Ease of decontamination
$I_{r,fin} < 3\,000$	Excellent
$3\,000 \leq I_{r,fin} < 15\,000$	Good
$15\,000 \leq I_{r,fin} < 60\,000$	Fair
$60\,000 \leq I_{r,fin}$	Poor

NOTE 2 Additional tests with other radionuclides or chemical forms can be carried out according to customer requirements.

The test methodology can be adapted to other radionuclides in different chemical forms, which match more closely to the chemical properties of the intended use, depending on customer requirements. However, the classification in Table 1 shall not be used. Another assessment table shall be established.

In practical applications, it can be important to consider other factors, such as chemical, mechanical and radiation resistance and long-term stability in the selection of the materials to be used. It should be recognized that further decontamination tests under simulated service conditions may be needed.

10 Test report

A test report shall be drawn up and contain the following information:

— a reference to this document, i.e. ISO 9271:2023;

— identification of the sample; manufacturer specification;

— application of the substrate, coating material or surface material;

— size of the test specimen;

— conditioning of the test specimen before testing;

— used equipment (measurement device, detector, contaminant);

— tester's description of the test specimen;

— test results (standardized mean residual pulse rates and Co/Cs-final residual pulse rate);

— assessment of ease of decontamination;

— statements of any deviations from ISO 9271 standard test results or assessment tables.

When assessing the suitability of a decontamination agent, in addition to the decontamination efficiency, other properties have to be taken into account depending on the technical conditions prevailing in the waste treatment plant and the solidification plant (see D.2).

A test report should include the information and data specified in Annex D. The format in which the information is presented in Annex D may be used as an example for the test report.

Annex A
(informative)

Clamp specimen holder

The clamp specimen holder is shown in Figures A.1 and A.2.

The top and bottom parts are screwed together with four M3 × 8 countersunk screws complying with ISO 2009.

The surface texture specifications comply with ISO 21920-1. Material: acid-resistant stainless steel.

Dimensions in millimetres

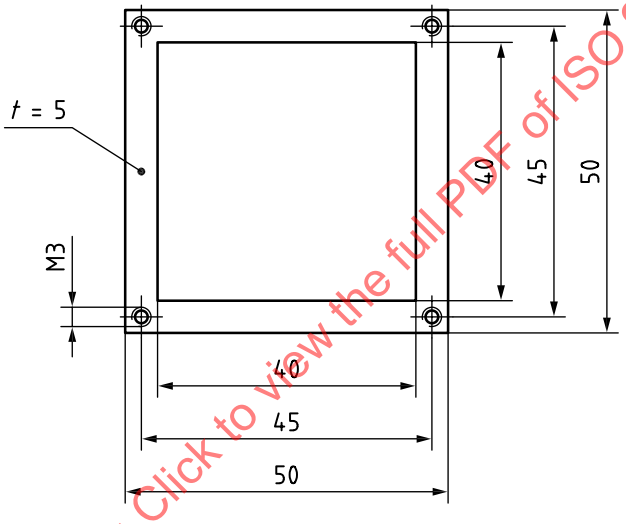


Figure A.1 — Clamp specimen holder — Bottom part

Dimensions in millimetres

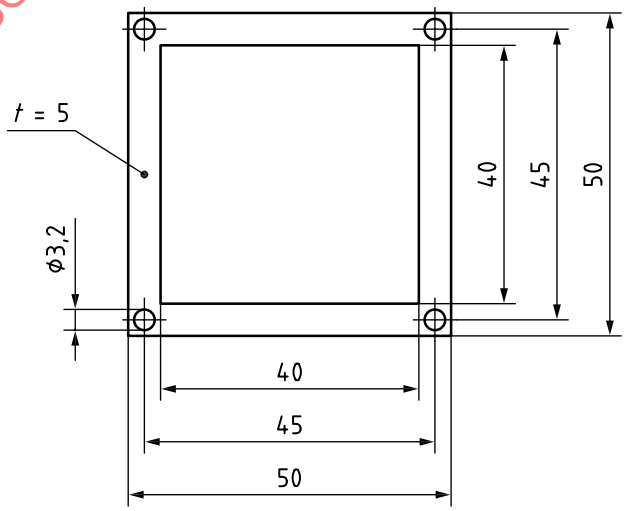


Figure A.2 — Clamp specimen holder — Top part

Annex B
(normative)

Cage-stirrer apparatus for decontamination

A general view of the cage-stirrer apparatus is shown in Figure B.1. Figures B.2 to B.9 illustrate the components of the cage-stirrer.

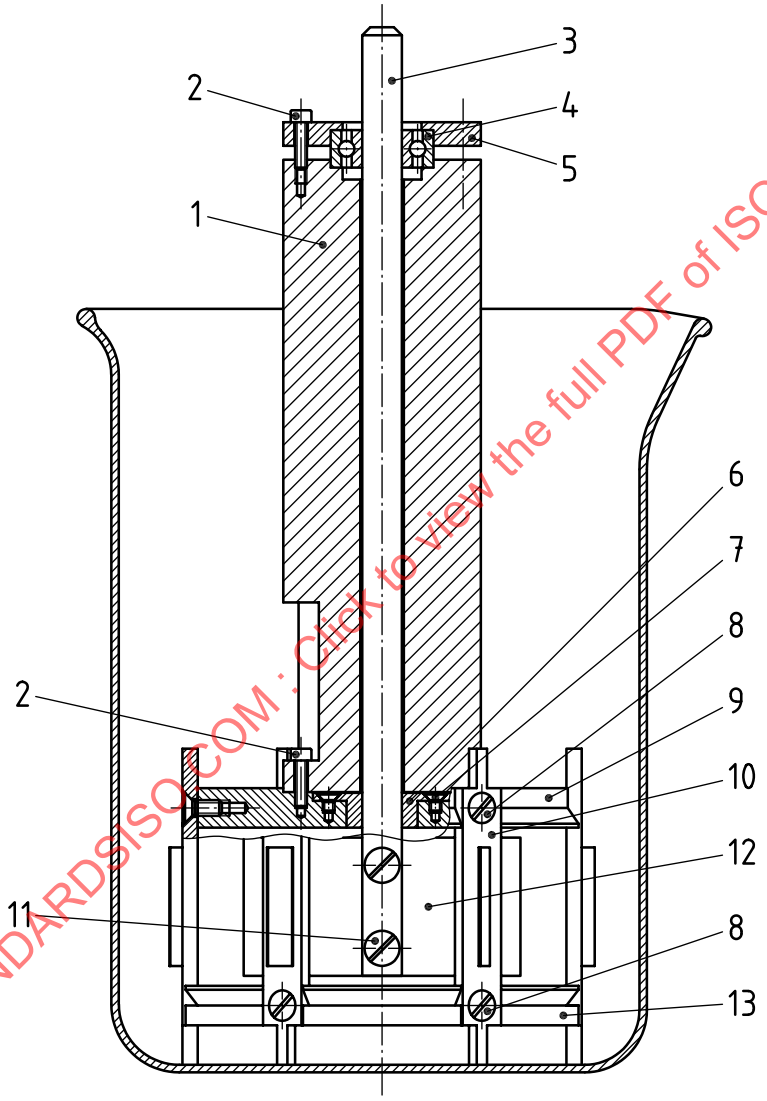


Figure B.1 — General set-up of cage-stirrer apparatus

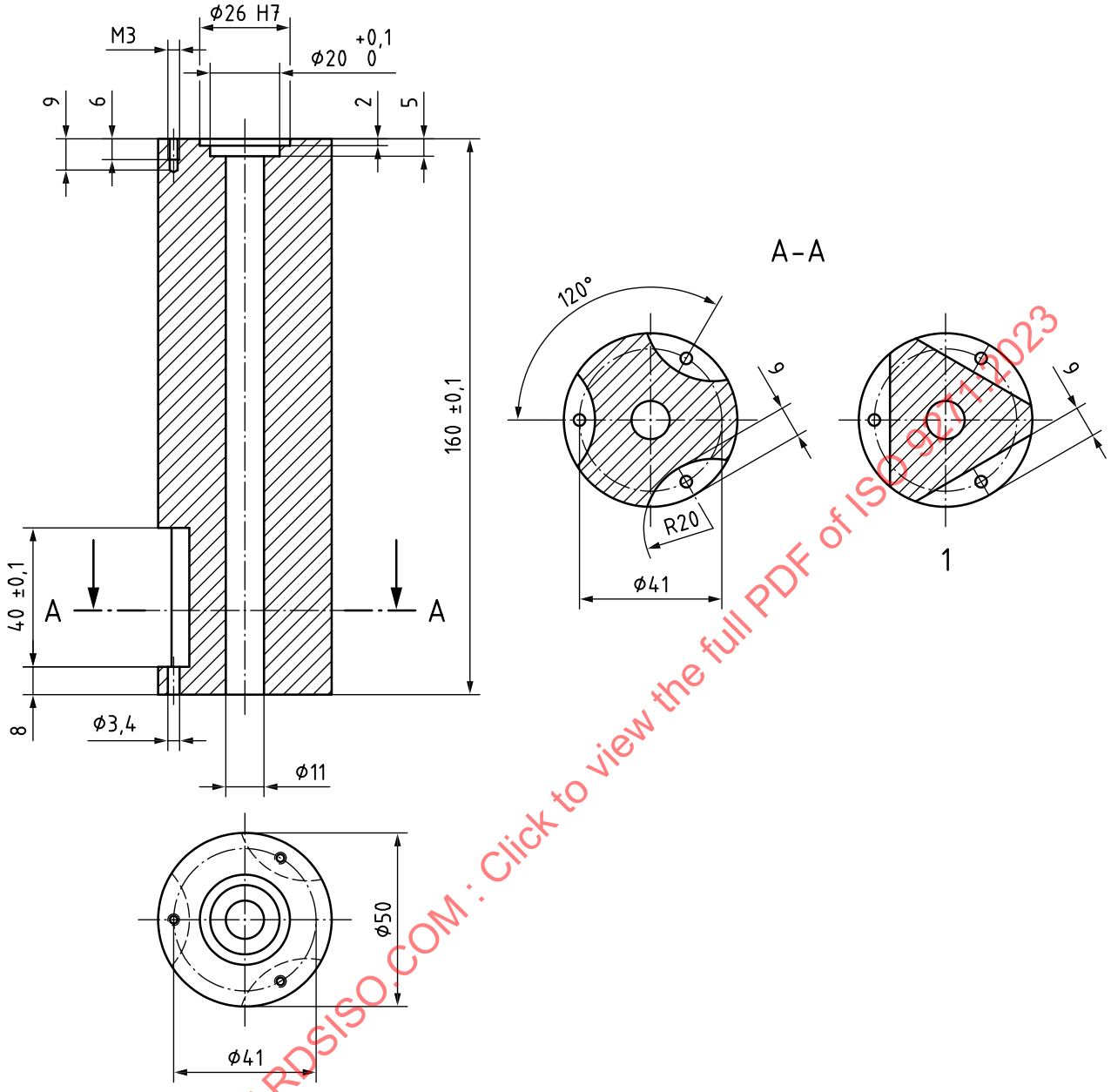
Table B.1 — Parts list to Figure B.1

Reference Number on Figure B.1	Number of items	Description	Material	Figure
1	1	Stirrer support	Acrylic glass	B.2
NOTE Non-metric equivalents for the screws can be used.				

Table B.1 *(continued)*

Reference Number on Figure B.1	Number of items	Description	Material	Figure
2	6	Hexagon socket head cap screws, M3 × 12, in accordance with ISO 4762[5]	Acid-resistant stainless steel	—
3	1	Stirrer axle	Acid-resistant stainless steel	B.3
4	1	Radial deep-groove ball bearing with washers in accordance with ISO 15[1] (Dimensions: d = 10, D = 26, B = 8) DIN 625 000-6-2Z		—
5	1	Mounting support for ball bearing	Acrylic glass	B.4
6	1	Bearing of stirrer shaft Bores: ø 3,4 Clearance in accordance with ISO 273[2] Countersunk in accordance with ISO 2009[3]	Polytetrafluoroethylene (PTFE)	B.5
7	2	Slotted countersunk head screws, M3 × 5, in accordance with ISO 2009[3]	Acid-resistant stainless steel	—
8	12	Slotted countersunk head screws, M4 × 10, in accordance with ISO 2009[3]	Acid-resistant stainless steel	—
9	1	Upper hexagonal disc	Acrylic glass	B.6
10	6	Connecting part Bores: ø 4,5 Clearance in accordance with ISO 273[2] Countersunk in accordance with ISO 2009[3]	Acid-resistant stainless steel	B.7
11	2	Slotted raised countersunk head screws, M3 × 10, in accordance with ISO 2010[4]	Acid-resistant stainless steel	—
12	1	Stirrer blade	Acid-resistant stainless steel	B.8
13	1	Lower hexagonal disc	Acrylic glass	B.9
NOTE Non-metric equivalents for the screws can be used.				

Dimensions in millimetres

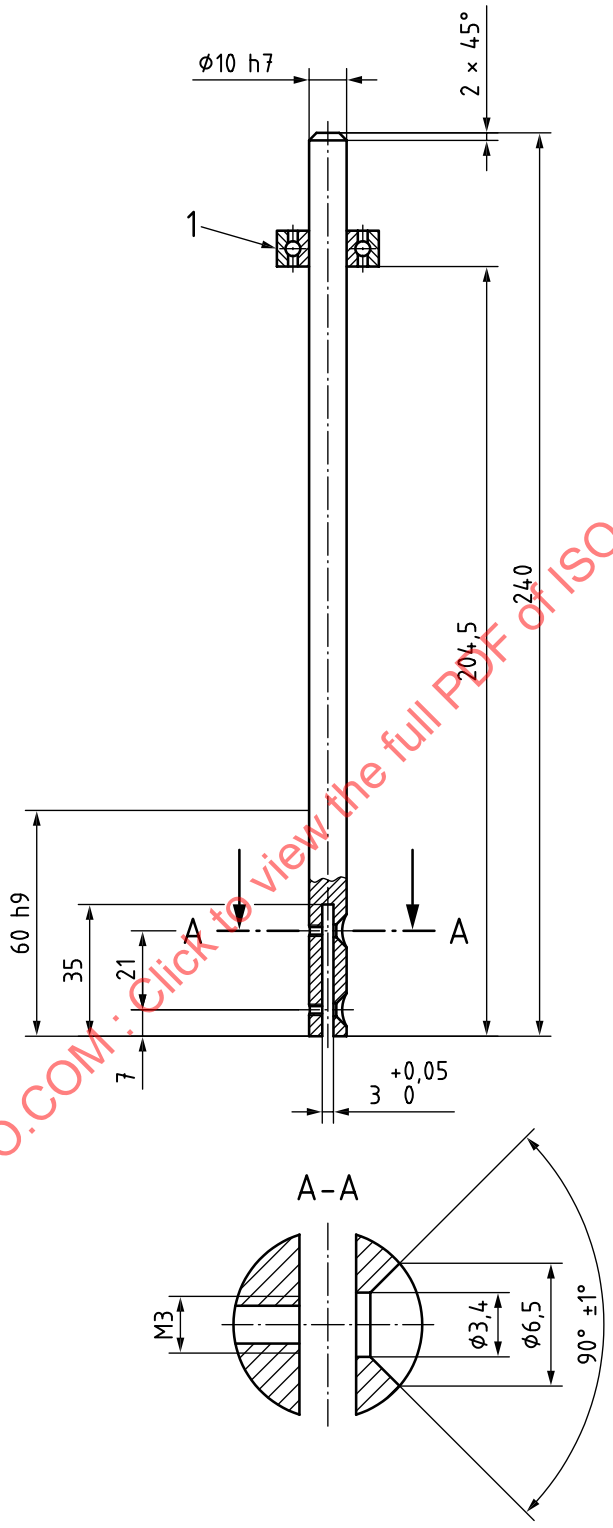


Key

1 alternative

Figure B.2 — Stirrer support column

Dimensions in millimetres



Key

1 grooved ball bearing fixed to the axle with ball bearing adhesive

Figure B.3 — Stirrer axle

Dimensions in millimetres

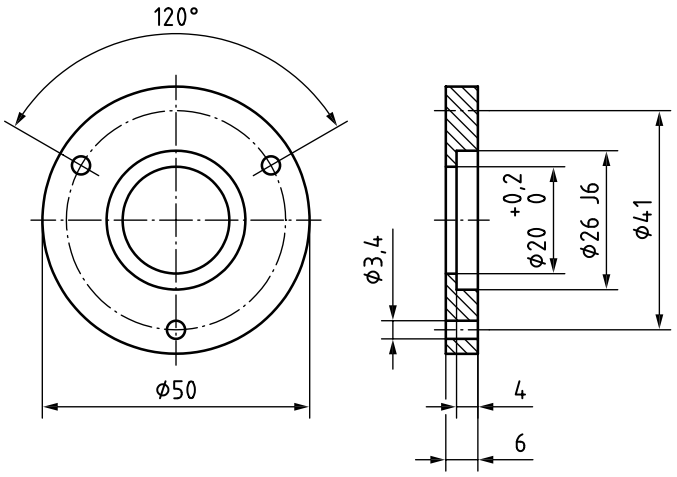


Figure B.4 — Mounding support for ball bearing

Dimensions in millimetres

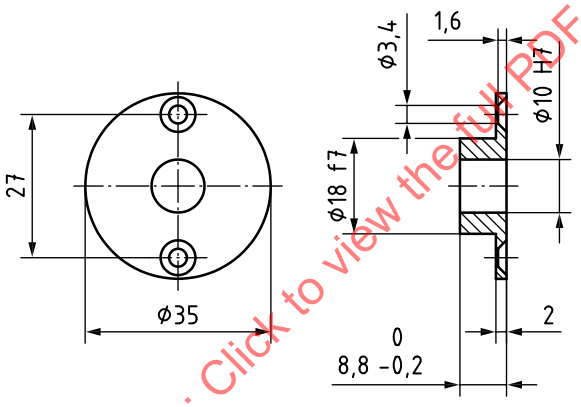
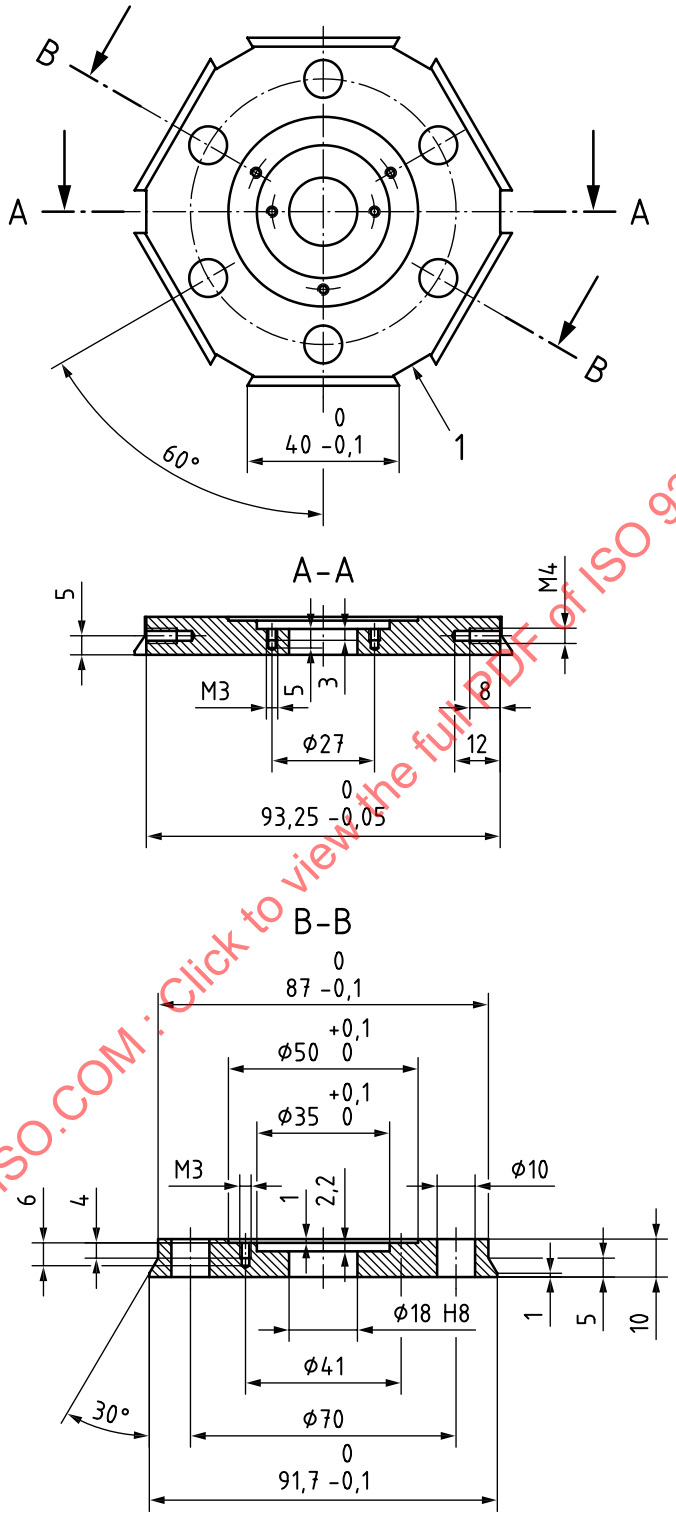


Figure B.5 — Bearing of stirrer shaft

Dimensions in millimetres

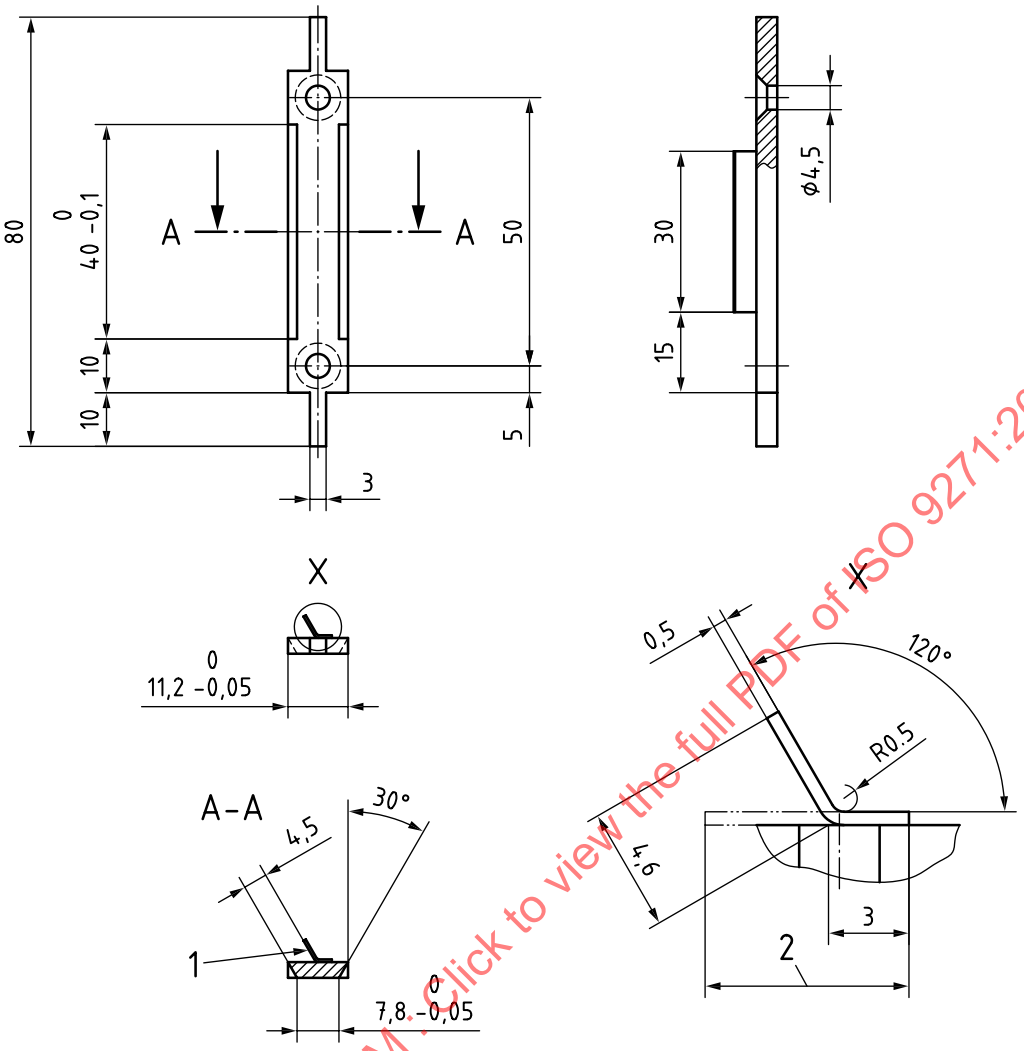


Key

1 connector part fitted

Figure B.6 — Upper hexagonal disc

Dimensions in millimetres



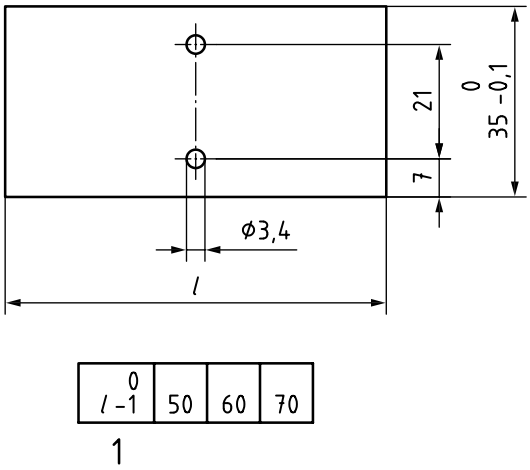
Key

1 spot welded

2 stretched length

Figure B.7 — Connecting part

Dimensions in millimetres



0 l -1	50	60	70

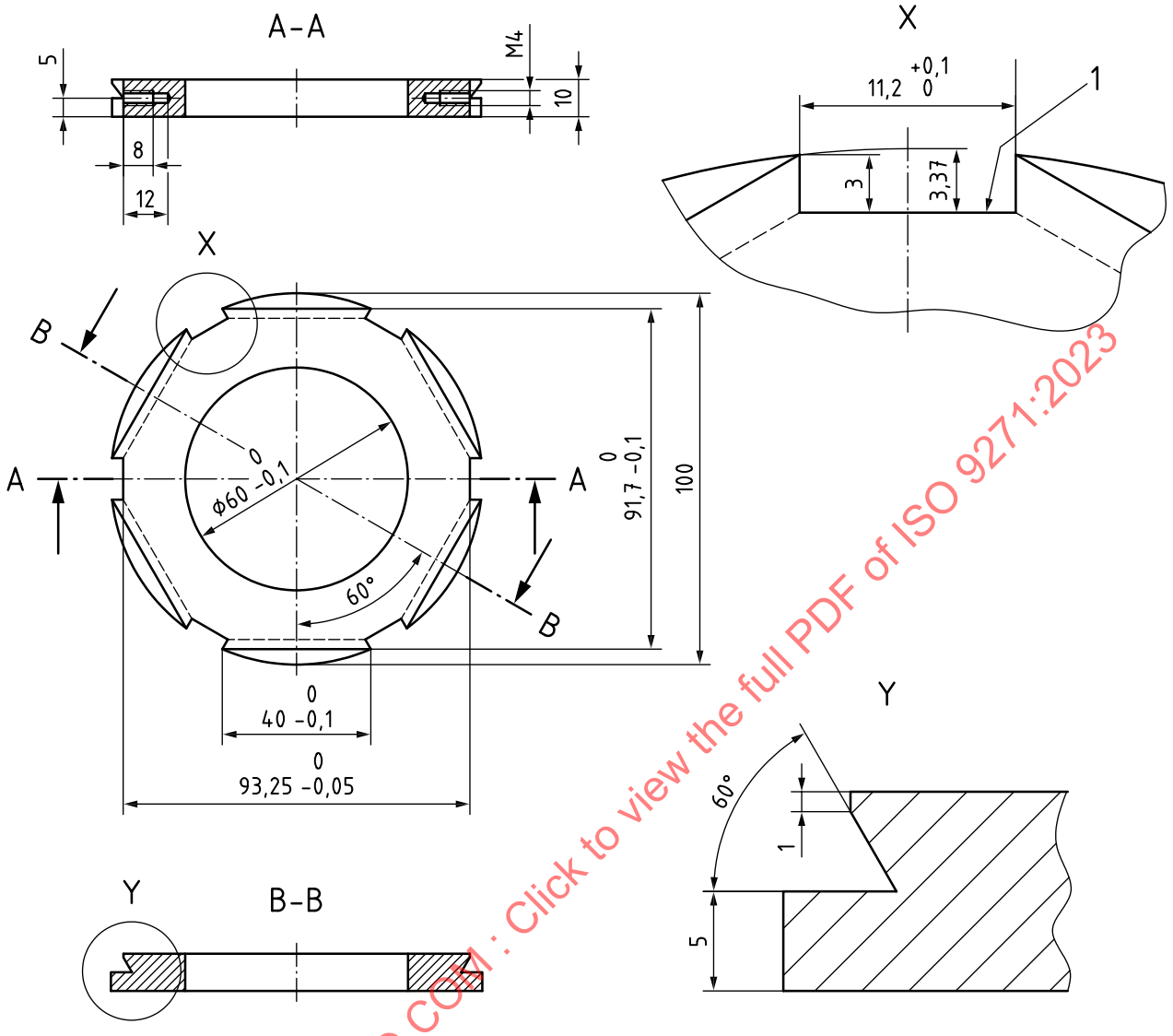
1

Key

1 thickness = 3

Figure B.8 — Stirrer blade

Dimensions in millimetres



Key

1 connector part fitted

Figure B.9 — Lower hexagonal disc