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Measurement of radioactivity — Gamma ray and beta emitting radionuclides — Test method to assess the ease of decontamination of surface materials

Mesurage de la radioactivité — Radionucléides émetteurs gamma et bêta — Méthode d'essai pour évaluer l'aptitude à la décontamination des matériaux de surface

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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).

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For an explanation on 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 the following URL: 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 8690:1988), which has been technically revised. The main changes compared to the previous edition are as follows:

- title was changed and adapted to measurement of radioactivity (or gamma ray and beta emitting radionuclides);
- opening to further applications;
- adding of symbols of the used measurands;
- improvement in readability;
- adaption to current standards;
- insert preparation of contaminant solution using neutron activation;
- adding a new annex with calculations using neutron activation.

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 surfaces can become contaminated through contact with radioactivity in solution or airborne radioactivity. It is normally necessary to remove this surface contamination to reduce the risk to staff from accidental ingestion of the radioactivity on the surface. The ease of decontaminating surface materials 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 surface materials. The method enables the comparison of different surface materials to support decisions on materials to use for different applications.

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

The results of the tests on different materials therefore help the user select the best surface material for the application being considered.

Measurement of radioactivity — Gamma ray and beta emitting radionuclides — Test method to assess the ease of decontamination of surface materials

1 Scope

This document applies to the testing of surfaces that may become contaminated by radioactive materials.

The ease of decontamination is a property of a surface and an important criterion for selecting surface materials used in the nuclear industry, interim storage or disposal facilities from which contamination can be removed easily and rapidly without damaging the surface. The test described in this document is a rapid laboratory-based method to compare the ease of decontamination of different surface materials.

The results from the test can be one parameter to take into account when selecting surface coatings such as varnish or impervious layers such as ceramics and other surfaces. The radionuclides used in this test are those commonly found in the nuclear industry (^{137}Cs, ^{134}Cs and ^{60}Co) in aqueous form. The test can also be adopted for use with other radionuclides and other chemical forms, depending on the customer requirements, if the solutions are chemically stable and do not corrode the test specimen.

The test does not measure the ease of decontamination of the surface materials in practical use, as this depends on the radionuclide(s) present, their chemical form, the duration of exposure to the contaminant and the environmental conditions amongst other factors.

The test method is not intended to describe general decontamination procedures or to assess the efficiency of decontamination procedures (see ISO 7503 series).

The test method is not suitable for use of radiochemicals if the radionuclide emit low energy gamma rays or beta particles that are readily attenuated in the surface.

2 Normatives references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 15, *Rolling bearings — Radial bearings — Boundary dimensions, general plan*

ISO 273, *Fasteners — Clearance holes for bolts and screws*

ISO 2009, *Slotted countersunk flat head screws — Product grade A*

ISO 2010, *Slotted raised countersunk head screws — Product grade A*

ISO 3819, *Laboratory glassware — Beakers*

ISO 4762, *Hexagon socket head cap screws*

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

3.1 Terms and definitions

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

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

- ISO Online browsing platform: available at https://www.iso.org/obp
- IEC Electropedia: available at http://www.electropedia.org/

3.1.1
surface contamination
radioactive substances deposited on defined surfaces

[SOURCE: ISO 7503-1:2016, 3.1.2]

3.1.2
decontamination
complete or partial removal of radioactive contamination 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.

3.1.3
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.

3.1.4
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* (3.1.2)

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

3.1.5
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.

3.1.6
standardized mean residual pulse rate

$\overline{I}_{r,n}$

corrected value of the *mean residual pulse rate* (3.1.5)

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.

3.1.7
final residual pulse rate

arithmetic mean of the standardized *mean residual pulse rate* $\overline{I}_{r,n}$ (3.1.6) obtained for ^{60}Co and ^{134}Cs or ^{137}Cs

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

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
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)
r	Final volume of contaminant solution (ml)
s	Activity concentration of stock solution (MBq ml^{-1})
q	Carrier concentration (mol l^{-1})
V	Volume (l)
m	Mass (g)
M	Molar mass (kg·mol^{-1})
H	Abundance
σ	Cross l (cm^{-2})
ø	Neutron flux ($\text{cm}^{-2}\text{·s}^{-1}$)
N_{L}	Avogadro constant
τ	Carrier concentration of the radionuclide-initial solution (mol l^{-1})

t	Time (s)
$t_{1/2}$	Half-life (years)
u	Carrier concentration, in moles per litre (mol l^{-1})

4 Principle

A specimen of the 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 surface is decontaminated using demineralized water. 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 value: 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.

Contamination of test material specimens was accomplished by treating a defined area with the contaminant solutions. Subsequent decontamination was achieved 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) is used to assess the ease of decontamination by means of a classification that has been empirically compiled.

5 Apparatus

In addition to ordinary laboratory apparatus, the following equipment is required for testing the ease of decontamination of surfaces.

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 include gas-filled proportional counter, scintillation and semi-conductor types.

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

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

where

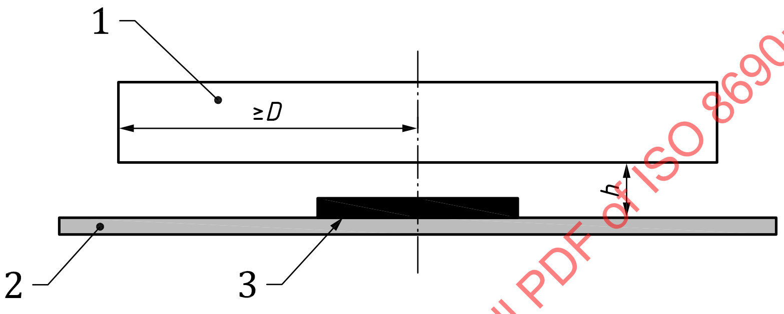
D_min	is the smallest distance, in millimetres, from the centre point of the contaminated area, as projected onto the detector cross-section, to the edge of the sensitive detection area;
h	is the distance, in millimetres, of the contaminated test surface from the detector surface (see Figure 1).

If the geometrical requirement $\frac{D_{\mathrm{min}} - 12,5}{h} \geq 3$ isn′t met, a detector having a circular sensitive area 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 evenly distributed as a series of individual droplets over a circular area 25 mm in diameter, i.e. the area over which the test specimens are contaminated;

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 8.1).

CAUTION — For the apparatus described in 5.3 to 5.6, separate equipment shall be used for the two or three radionuclides to prevent cross-contamination.



Key

1	detector
2	test specimen
3	contamination

Figure 1 — Geometrical requirements (cross-section)

5.3 Pipettes

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

Two pipettes with disposable tips, having a capacity of 1 000 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 Storage bottles

Two polytetrafluoroethylene (PTFE) bottles for storage of 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).

5.6 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).

Each holder shall contain a flat silicone rubber ring (45 mm × 25 mm × 2 mm) made of unfilled material having a Shore A hardness value of not more than 60.

NOTE 1 Unfilled, unpigmented, fluorinated silicone rubber has been found particularly suitable for this purpose.

Before using for the first time, the rubber rings shall be cleaned using the organic solvent mixture (see 7.3) used for cleaning the test specimens. The rings should only be reused after careful decontamination.

NOTE 2 Ten holders, five for each radionuclide, reduce the time needed to carry out the test and help to prevent cross-contamination.

5.7 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 surface material, can be adopted, subject to consultation with the testing laboratory.

However, the contaminant solutions shall be chemically stable and shall not corrode 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 where the emissions 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/ml is usually sufficient to fulfil the requirement.

The radionuclides shall be used with a carrier concentration of $(1 \pm 0{,}1)\cdot 10^{-5}$ mol·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 constituents that remain in the residue when the solutions are 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 ^{134}Cs or ^{137}Cs and ^{60}Co 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 $(1 \pm 0{,}1)\cdot 10^{-5}$ mol·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·l^{-1}] per 90 ml of final volume of contaminant solution.

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

6.1.2.6 Evaporate the mixtures to dryness using infrared lamps 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 Preparation of contaminant solution using neutron activation

Stable $Co(NO_3)_2$ or $CsNO_3$ solutions are used as stock solutions.

Chloride solutions are inappropriate, because the activation of chlorine produces unwanted radionuclides such as ^{35}S, ^{36}Cl and ^{38}Cl.

The specific activity of the ^{60}Co- and ^{134}Cs-solution produced by neutron activation can be calculated from concentration of the Co- and Cs-stock solutions. The ideal carrier concentration should be $1{,}0 \cdot 10^{-5}$ mol·l^{-1}.

By means of concentration of the inactive Co- and Cs-stock solutions the amount of these solutions can be calculated, which are required for the desired volumes of the contaminant solutions with the carrier concentration of $1{,}0 \cdot 10^{-5}$ mol·l^{-1}.

Co- and Cs-stock solutions are loaded in a polytetrafluoroethylene (PTFE) or quartz ampoule and dried by maximum 40 °C. Subsequently the ampules are sealed and activated in the reactor.

The irradiation time can be calculated using the formulae in Annex D. The irradiation time depends on the radionuclide, the neutron flux, and the starting stock solution concentration.

After activation the ampoules are unsealed and the activated material are transferred to sealable bottles for storage using nitric acid (pH = 4) solution. Continue rinsing until the desired volume of stock solution is achieved.

For opening ampoules following operation, it is recommended that the ampoule is positioned in the centre of a closable polyethylene tube (PE) and broken carefully in a vice. To be sure that all the activated contents were transferred, the complete content of the tube is washed over with nitric acid (pH = 4) into the storage bottle.

6.1.4 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 Decontaminant solution

Decontaminant solutions used for examinations should be demineralized water with a maximum electrolytic conductivity of 3 $\mu S \cdot cm^{-1}$.

7 Test specimens

7.1 Preparation and preliminary testing

7.1.1 Resistance to cleaning solution

For the purposes of the preliminary testing, a test specimen having at least one flat surface of adequate size (see 7.3) and which can consist of any suitable material — such as non-metallic or metallic materials, coating systems, floor coverings — shall be used. The test specimens shall have sufficient resistance to the cleaning solution (e.g. alkaline detergents). This shall be checked using the following procedure:

a) soak a small piece of cotton wool in the cleaning liquid, place it on the surface of a specimen and cover with a Petri dish;

b) after 10 min contact, remove the cotton wool and rinse the specimen using demineralized water;

c) then dry the specimen for 1 h at (40 ± 5) °C;

d) examine the specimen visually.

Specimens which show more than a slight change in colour and luster are unsuitable for testing.

7.1.2 Test specimens of non-metallic materials

The non-metallic test materials— such as high polymers, glass, ceramic materials — shall have the same surfaces and the same quality like in actual usage.

If the backing of the test specimen is porous or is an uncoated metal, the back and edges shall be coated in a readily decontaminable material (e.g. by using an epoxy, polyurethane or chlorinated rubber coating).

For preparing test specimens with coatings, a representative sample shall be taken from the coating material to be investigated and prepared for testing in accordance with the relevant standard methods.

The coating materials shall be applied to the carriers or the backings in the manner customary in actual usage and shall be suitably post-treated; any additional treatment, such as additional thermal ageing, is not permissible.

NOTE It is recommended to avoid electrostatic interaction between the solution and the material, e.g. by discharging the material.

The date of preparation of the test specimens shall be recorded.

7.1.3 Test specimens of metallic materials

Test specimens of metal or with metallic surfaces shall be pretreated in a manner typical of actual usage. For coating of the reverse and edges, the back and edges of the specimen shall be treated as for non-metallic material (7.1.2).

The surface roughness (average roughness value) shall be stated by the manufacturer and shall be mentioned in the description of the sample material.

7.2 Number and dimensions

For the purposes of the test, 25 nominally identical test specimens shall be prepared and of these at least two groups of five shall be tested in two parallel tests.

NOTE 1 Remaining test specimens are used for the preliminary tests in accordance with 7.1 and as reference specimens following the test.

The test specimens should measure 50 mm × 50 mm (with a tolerance of −2 mm and +10 mm for each side).

The thickness of the test specimen should be between 1 mm and 10 mm. One corner shall be marked as the reference corner by means of a cross of fine scratches on the back of each test specimen.

Other test specimen dimensions and other conditions for preparation are subject to arrangement and shall be stated in the test report.

NOTE 2 Test specimens of dimensions not greater than 51 mm × 51 mm × 3,5 mm can be stored and transported conveniently using slide storage containers; this helps to avoid contact between the surfaces to be tested.

7.3 Conditioning and cleaning

The test specimens shall be kept in open containers at the testing laboratory in a clean and non-corrosive atmosphere at (23 ± 2) °C (see ISO 291) for not less than 14 days. This requirement does not apply to test specimens with ceramic or glass surfaces.

To clean the surface, wipe the test specimens using a soft cellulose tissue. First wipe the surface to be tested using a tissue heavily soaked in the cleaning mixture, which should be composed of benzine (boiling range from 60 °C to 80 °C) and isopropanol (minimum content 99 %) in a mixing ratio of 1:1 by volume. Repeat the wiping using an "almost dry" tissue. Repeat the wiping operation a third time using a tissue heavily soaked in pure water.

In each case, carry out the wiping operation five times in a single direction over the sample using a different portion of the tissue for each stroke. The tissue shall only be used for one wiping operation (i.e. five strokes).

Finally, rinse the test specimens with pure water using a squeeze bottle to remove all fibers and particles from the surface to be tested. Dry the test specimens in a vertical position (in an environment free of airborne contaminants) for 1 h at (40 ± 5) °C.

Test specimens coated with organic surface materials can, in addition, be tested without any prior cleaning when subject to special requirements. In such cases, the preparation of the test specimens shall be carried out in accordance with the manufacturer's instructions. If the cleaning stage is omitted, this shall be noted in the test report.

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 sheets of window glass, measuring 50 mm × 50 mm, in accordance with the procedure laid down in 8.2. The positioning aid (see 5.6) or a similar device may be used. Evaporate the drops to dryness under infrared lamps at a maximum temperature of 45 °C. Place the detector (as specified in 5.2) in the same measurement geometry (particularly with the regard to the distance of the contaminated glass surface from the detector) that is to be used for the test specimens (see 8.3). Measure the pulse rate detected on the three glass sheets.

It is to be ensured that the measurement geometry (particularly with regard to the distance of the contaminated glass surface from the detector) is the same as it was planned for the measurement on the test specimens (see 8.3).

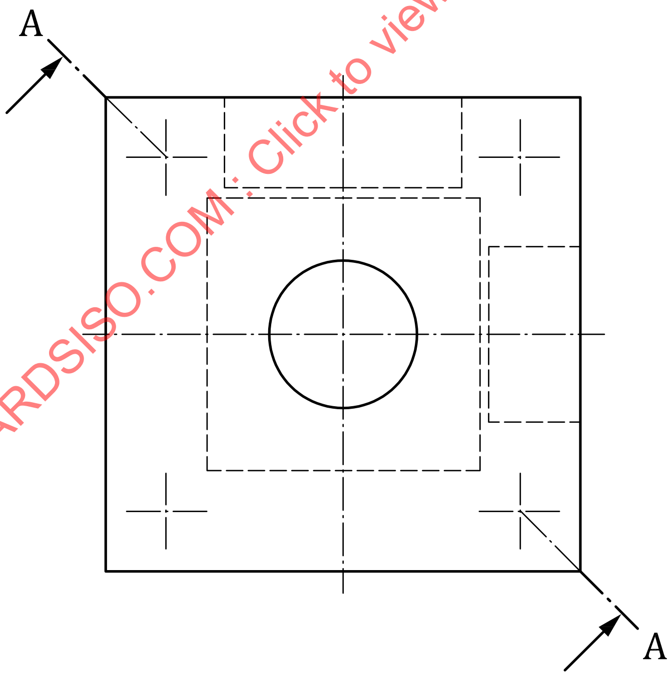
The measuring period shall be 1 min for each sheet. Apply corrections for background and dead time losses.

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.

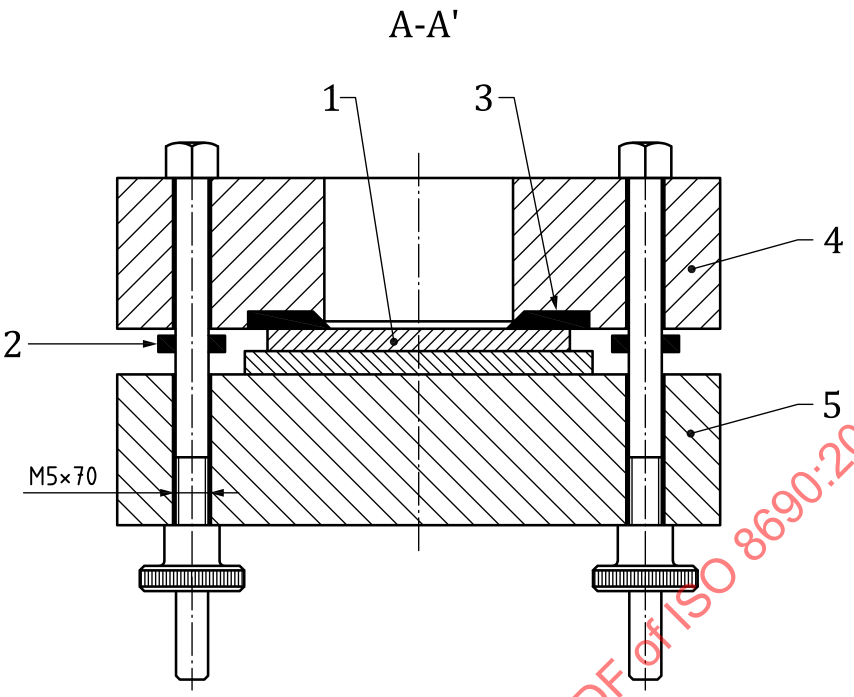
Carry out the determination separately for both contaminant solutions.

8.2 Contamination

Contamination shall be performed using the assembly shown in Figure 2.



a) Holder for contamination of test specimen; position of the profile A-A in b) is enlarged and turned 45° (see also Figures A.1 and A.2)



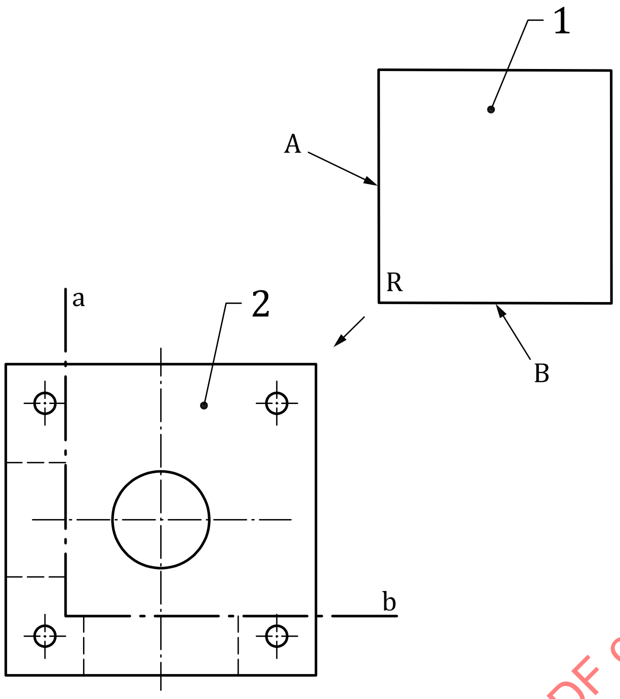
b) Holder for contamination of test specimen; drawn in profile (insertion of test specimen, see also Figures A.1 and A.2)

Key

1	test sample
2	ring from silicon rubber to fix the screw (8 mm × 4 mm × 5 mm)
3	flat ring from silicon rubber in contact with the testing surface (45 mm ×25 mm × 2 mm)
4	part U
5	part L
[a]A	enlarged and turned 45°

Figure 2 — Holder for contamination of test specimen

Insert a test specimen into the positioning aid (5.6) with its reference corner R as shown in Figure 3. Bring edges A and B of the test specimen into close contact with lines a and b of the positioning aid, the contact B-b having priority. Then press the test specimen against upper part U containing the silicone rubber ring by fastening the screws until the test specimen is in contact with upper part U along all its edges.



Key

1	test sample (front)
2	part U (top view)
R	edge, of the form where the right angle is to it next

Figure 3 — Holder for contamination of test specimen; individual view (insertion of test specimen)

Contaminate the test specimens by applying 1 ml of the contaminant solution to the middle of the circle visible through the upper part U. Keep the holder in a horizontal position. If, in the case of highly hydrophobic surface materials, the contaminant does not immediately cover the test circle, the holder may be tilted to ensure that the liquid spreads sufficiently.

Place a small Petri dish over the test circle on top of part U to prevent evaporation of the contaminant solution.

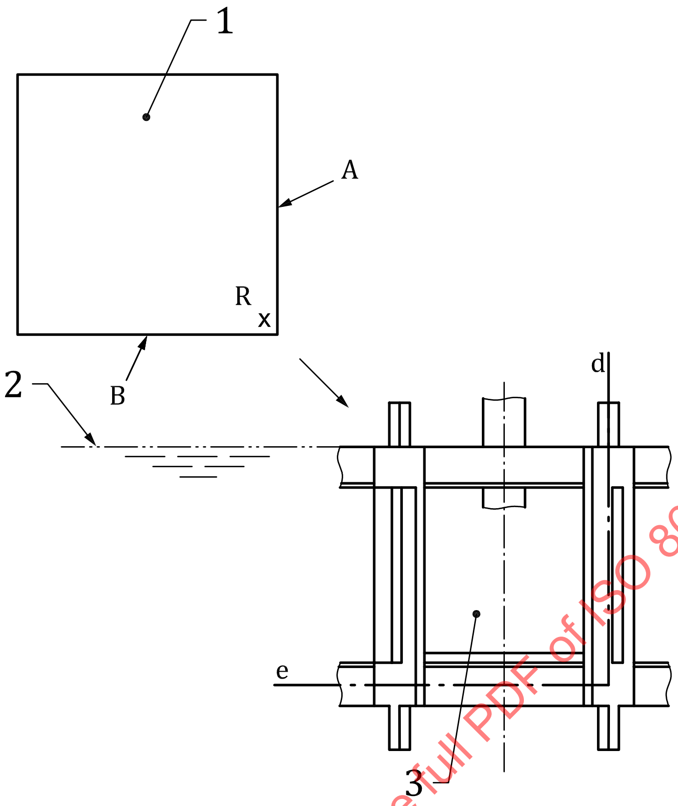
After (120 ± 5) min, using a pipette (5.4) suck the contaminant solution off as completely as possible. For this purpose, it is necessary to tilt the holder. Then invert the holder. After removing the nuts, lift the lower part L and then the test specimen vertically so that distribution of contaminant solution to uncontaminated parts of the test specimen is prevented.

In order to avoid the effects of evaporation, fix the test specimen immediately to the stirring cage and start the decontamination as soon as a set of specimens is fixed. The whole procedure of removing the specimens from their holders and fixing them to the cage shall not take more than 12 min.

8.3 Decontamination

For decontamination, fix five of the test specimens to the windows of the cage-stirrer (5.7) using thin rubber bands or coil springs (made of acid-resistant steel).

In order to ensure that the contaminated area of a test specimen is positioned in the middle of a cage window, the reference corner of the test specimen shall cover the lower corner at the right-hand size of the cage window. Bring edges A and B of the test specimen into close contact with the positioning aid lines d and e, the contact B-e having priority (see Figure 4).



Key

1	test sample (back)
2	minimum water level during the decontamination
3	cage stirrer window
R	edge of the form placed next to the right angle formed by d and e

Figure 4 — Cage stirrer for decontamination (insertion of test specimen)

A sheet of acid-resistant steel shall be used to close the sixth window. Steel sheets of this type shall also be used to support very thin test specimens, which otherwise would not have a sufficiently flat surface.

lmmerse the cage in (900 ± 20) ml of demineralized water (6.2) in such a way that the cage touches the bottom of the beaker (5.1). If beakers other than those specified in 5.1 are used, they shall be filled to the minimum level indicated in Figure 4. The initial temperature of the water shall be (23 ± 2) °C.

Run the stirrer for 2,5 min at a speed of (100 ± 5) r/min. Replace the beaker with another beaker containing water and run the stirrer for a further 10 s. Remove the test specimens from the cage and then dry them at (40 ± 5) °C in a drying cabinet.

NOTE If a check on recontamination from the decontaminant solution is deemed to be necessary, the steel sheet closing the sixth window may be replaced by an uncontaminated test specimen.

8.4 Determining the residual pulse rate

After drying, measure the pulse rate of the decontaminated test specimens 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).

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.

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 [$\overline{I_{r,n}}$ (Co)] and ^{137}Cs or ^{134}Cs [$\overline{I_{r,n}}$ (Cs)].

NOTE 1 The value of $3\cdot10^6$ 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) as the arithmetic mean of the standardized mean residual pulse rates for ^{60}Co [$\overline{I_{r,n}}$ (Co)] and ^{137}Cs or ^{134}Cs [$\overline{I_{r,n}}$ (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 no deviation from the decontamination process as described in 8.3 (e.g. using other decontaminant means or wiping off by removing mechanically of the adhere contamination).

Table 1 — Assessment of the ease of decontamination

Final residual pulse rate (FRPR) pulses/min	**Ease of decontamination**
FRPR < 3 000	Excellent
3 000 < FRPR < 15 000	Good
15 000 < FRPR < 60 000	Fair
60 000 < FRPR	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 are closer match to the chemical properties to the intended use, depending on customer requirements. However, the classification in Table 1 shall not be used. It is important to ensure that the contaminant solutions are chemically stable and do not cause corrosion of the test specimen. The chemical stability of the decontaminated test specimen is required for the measurement of the residual. The test is not suitable for use if the radionuclide emits low energy gamma rays or beta particles that are readily attenuated in the surface.

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:

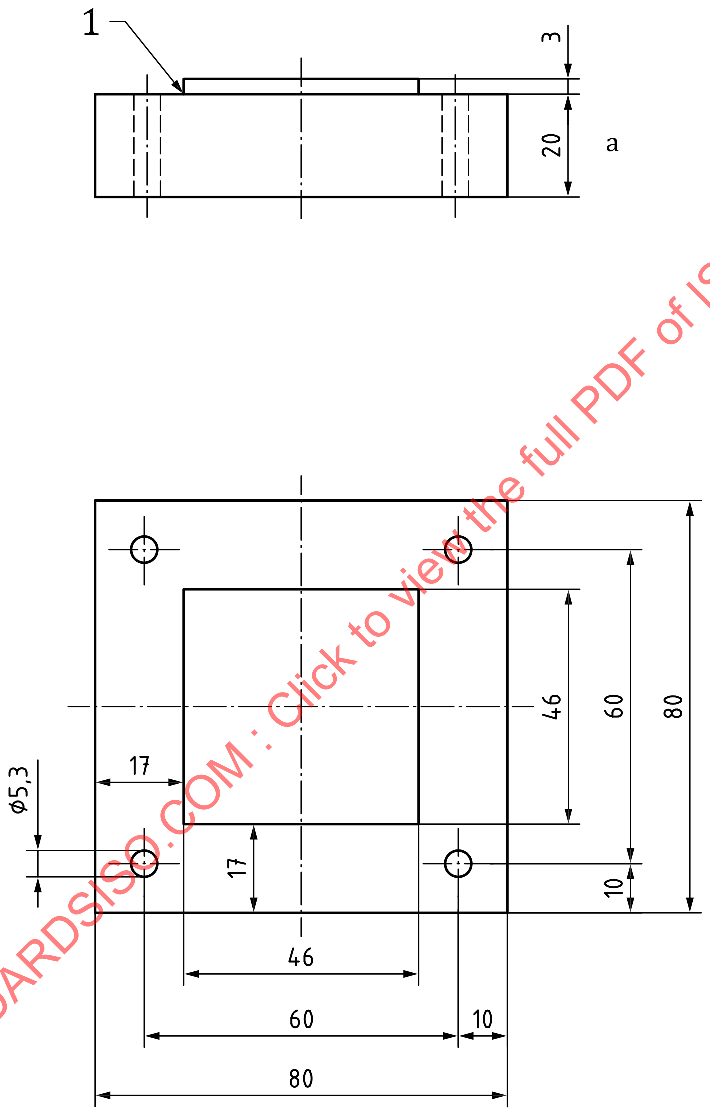
- a reference to this document, i.e. ISO 8690:2020;
- identification of the sample; manufacturer specification;
- application of the substrate, coating material or surface material;
- size of the test specimen;
- conditioning of the test specimen before testing;
- used equipment (measurement device, 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.

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

Annex A
(informative)

Holder for contamination of test specimen

Dimensions in millimetres



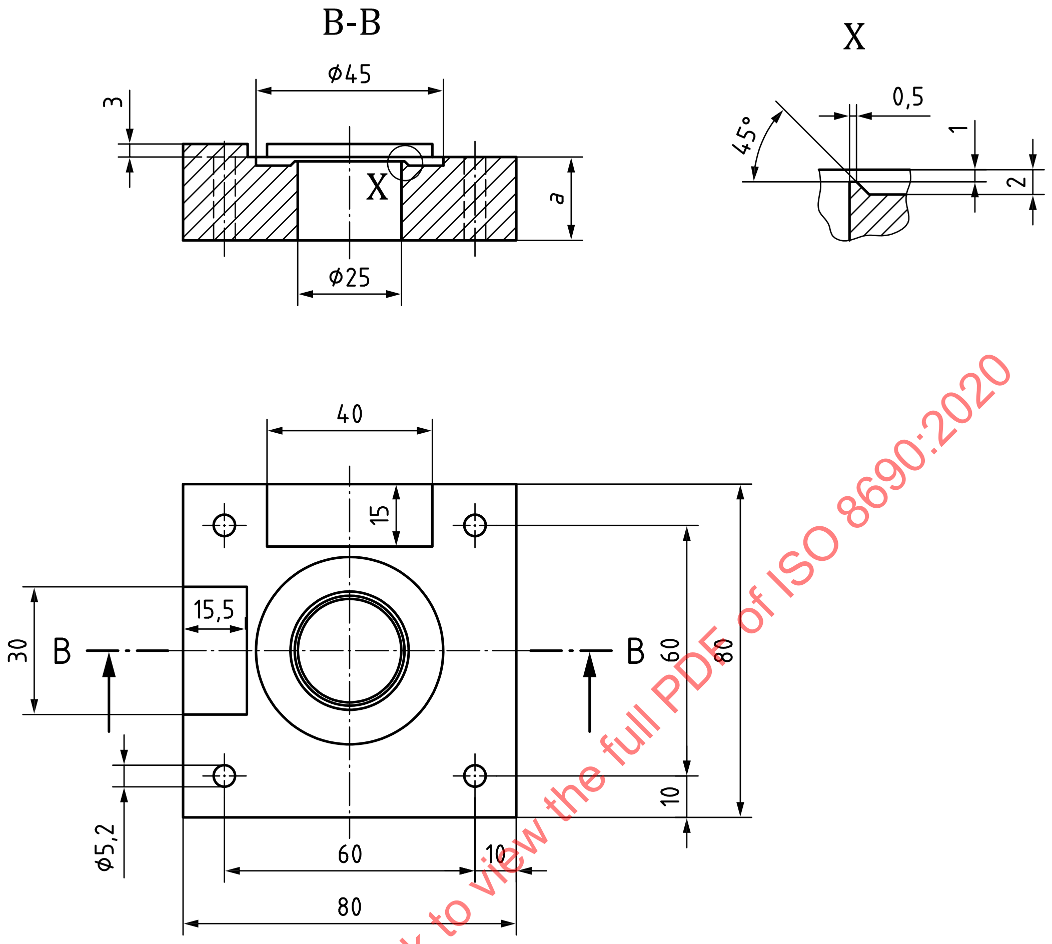
Key

1 with acrylic glass (persplex) glued on

[a] 18 mm or 20 mm.

Figure A.1 — Lower part, material: acrylic glass

Dimensions in millimetres

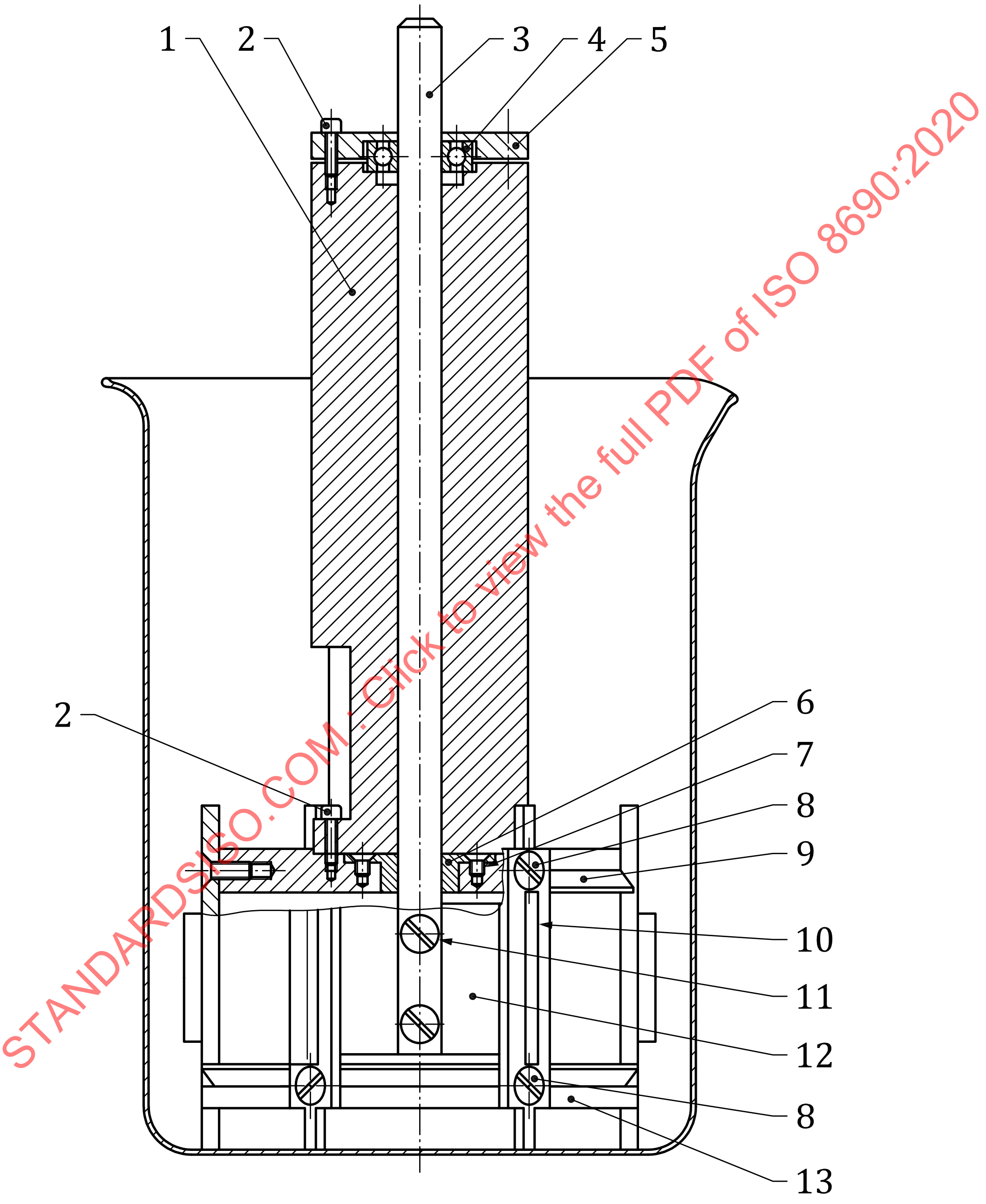


[a] 18 mm or 20 mm.

Figure A.2 — Upper part U

Annex B
(normative)

Cage-stirrer apparatus for decontamination



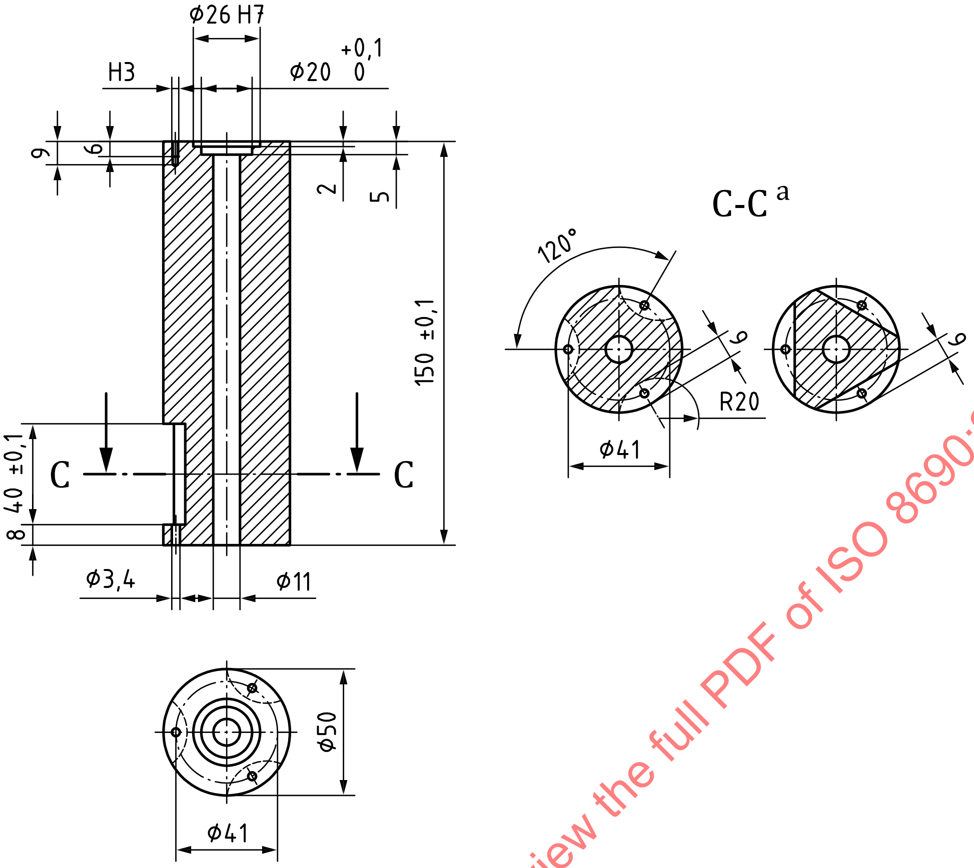
NOTE See Table B.1.

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

Table B.1 — Parts list to diagram B.1

Reference Number on Figure B.1	Number of items	Description	Material	Figure
1	1	Stirrer support	Acrylic glass	B.2
2	6	Hexagon socket head cap screws, M3 × 12, in accordance with ISO 4762	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 (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 Countersunk in accordance with ISO 2009	Polytetrafluoroethylene (PTFE)	B.5
7	2	Slotted countersunk head screws, M3 × 5, in accordance with ISO 2009	Acid-resistant stainless steel	—
8	12	Slotted countersunk head screws, M4 × 10, in accordance with ISO 2009	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 Countersunk in accordance with ISO 2009	Acid-resistant stainless steel	B.7
11	2	Slotted raised countersunk head screws, M3 × 10, in accordance with ISO 2010	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 may be used.				

Dimensions in millimetres



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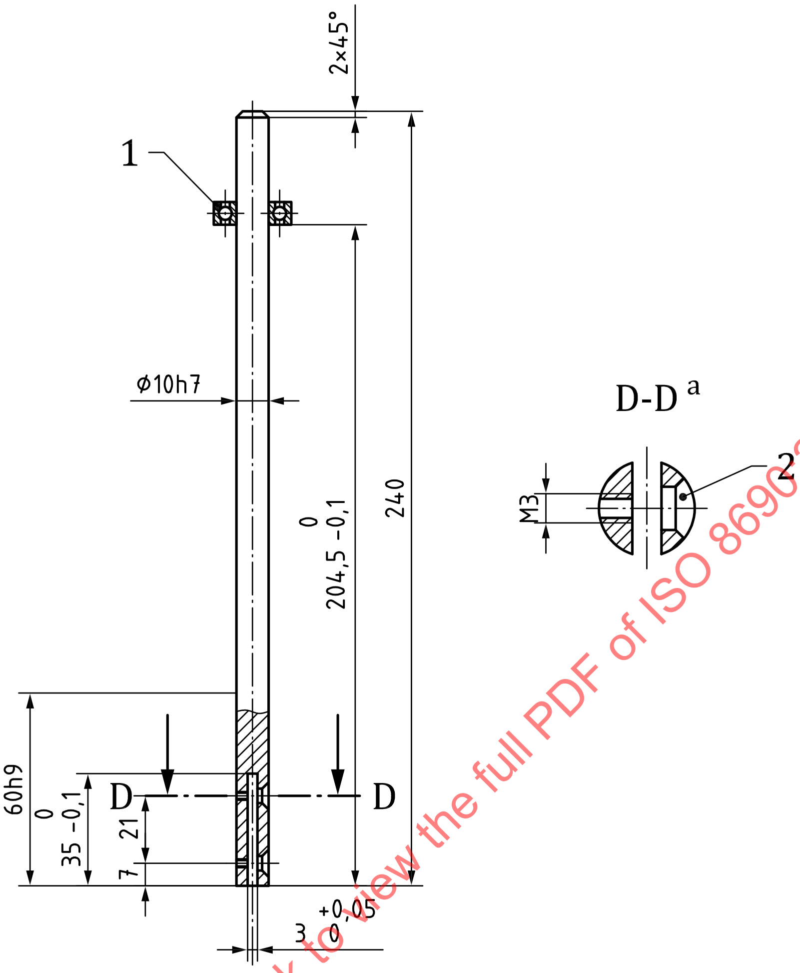
[a] Optional.

Figure B.2 — Stirrer support column



Key

1 grooved ball bearing with ball bearing glued to the axis

2 subsidence DIN 74 — A4

[a] Enlarged.

Figure B.3 — Stirrer axle

Dimensions in millimetres

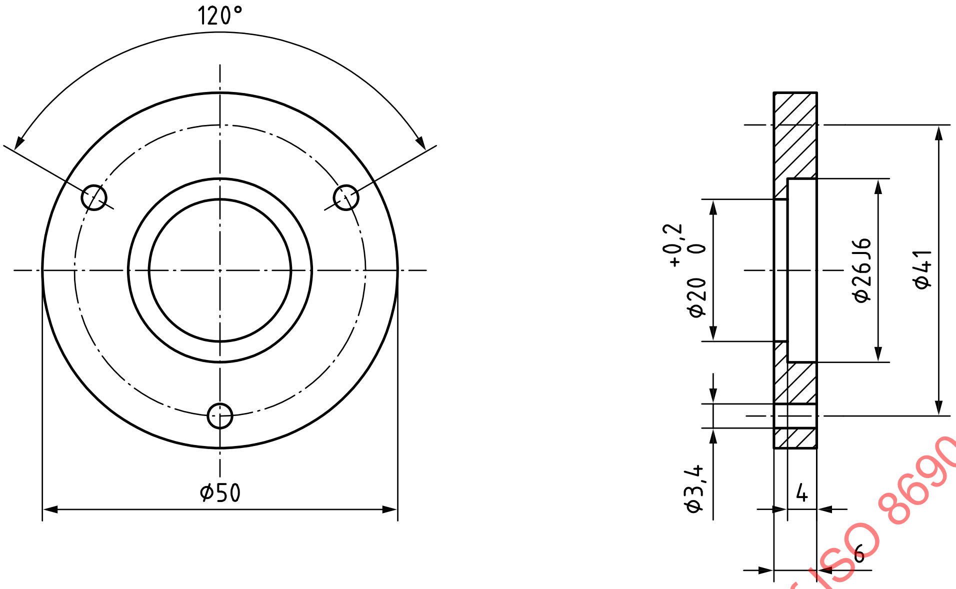
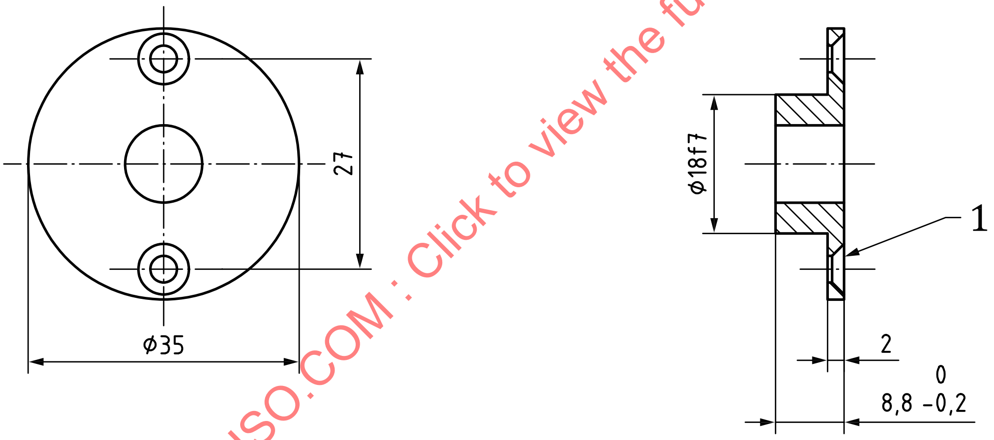


Figure B.4 — Mounting support for ball bearing

Dimensions in millimetres

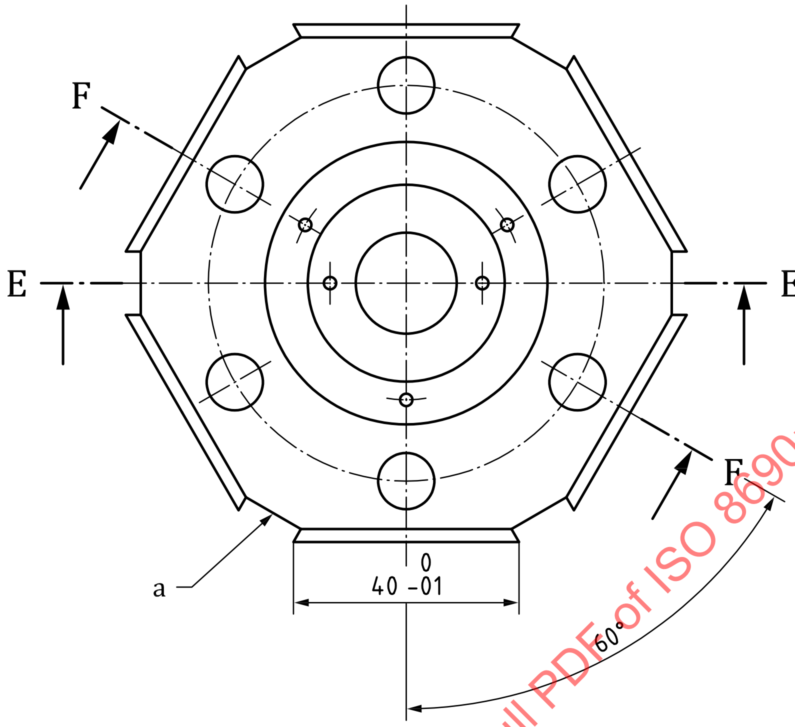


Key

1 subsidence DIN 74 — A3

Figure B.5 — Bearing of stirrer shaft

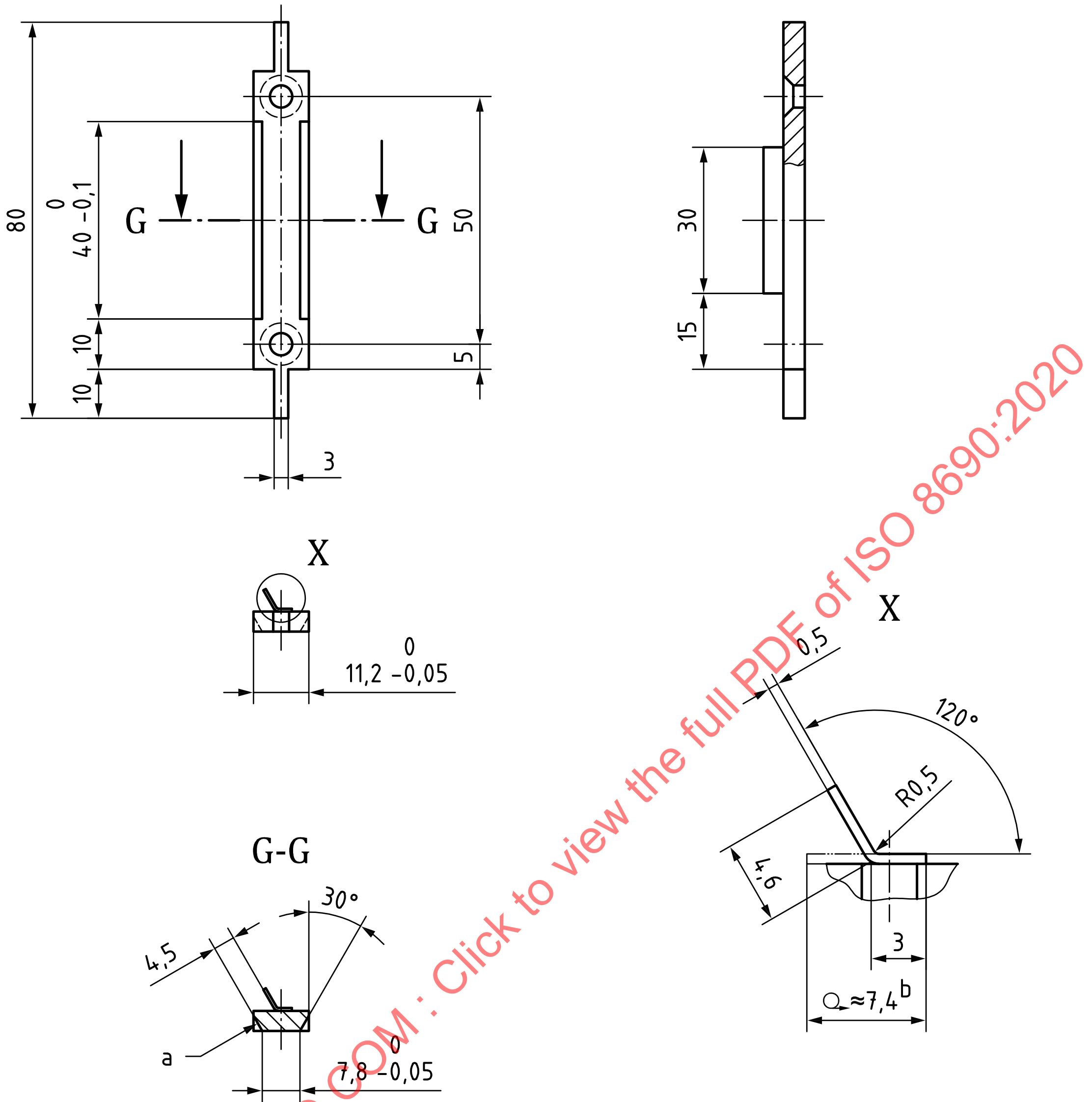
Dimensions in millimetres



[a] Pos. Nr 10 tight-fitting.

Figure B.6 — Upper hexagonal disc

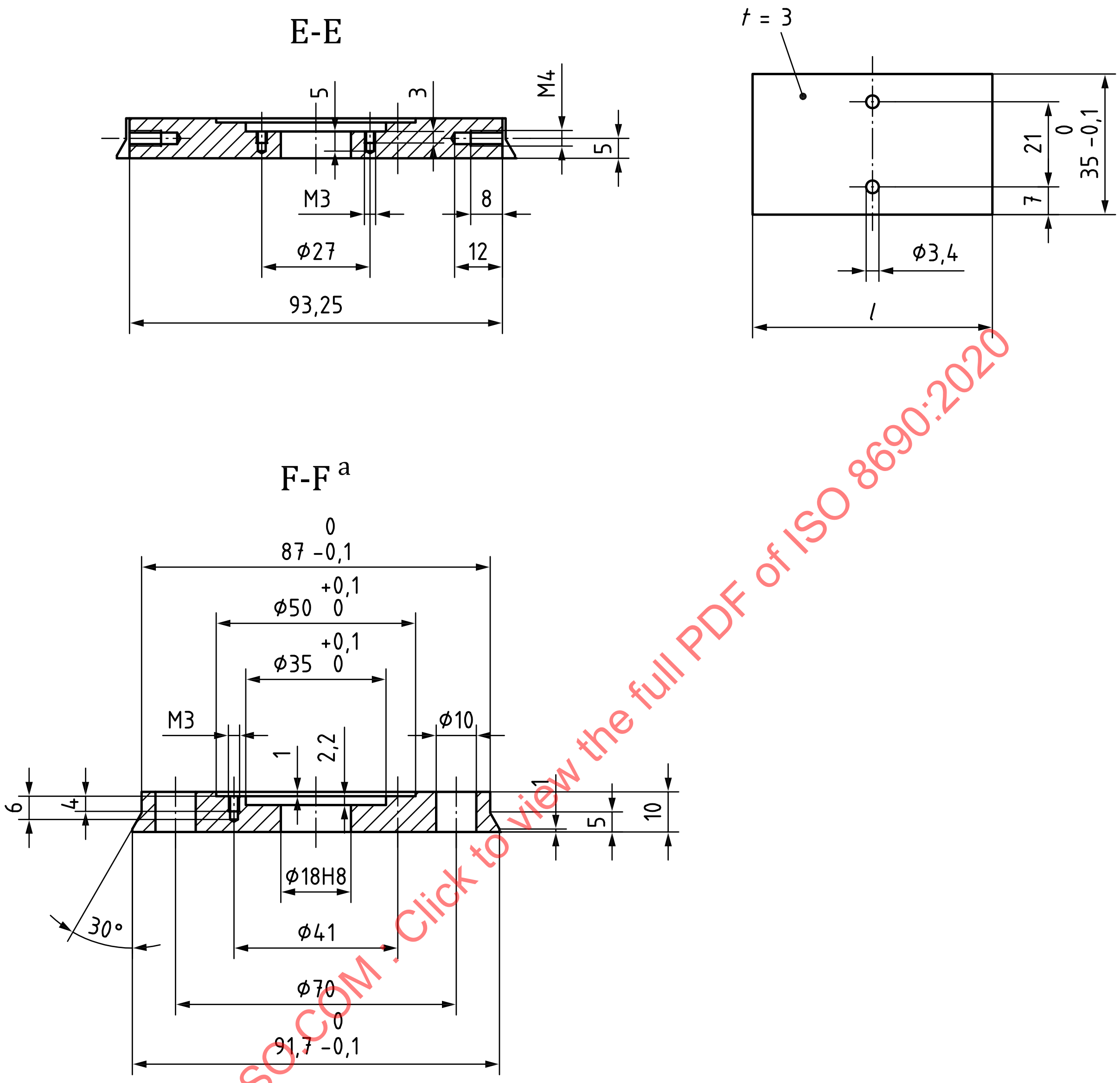
Dimensions in millimetres



[a] Spot-welded.

Figure B.7 — Connecting part

Dimensions in millimetres



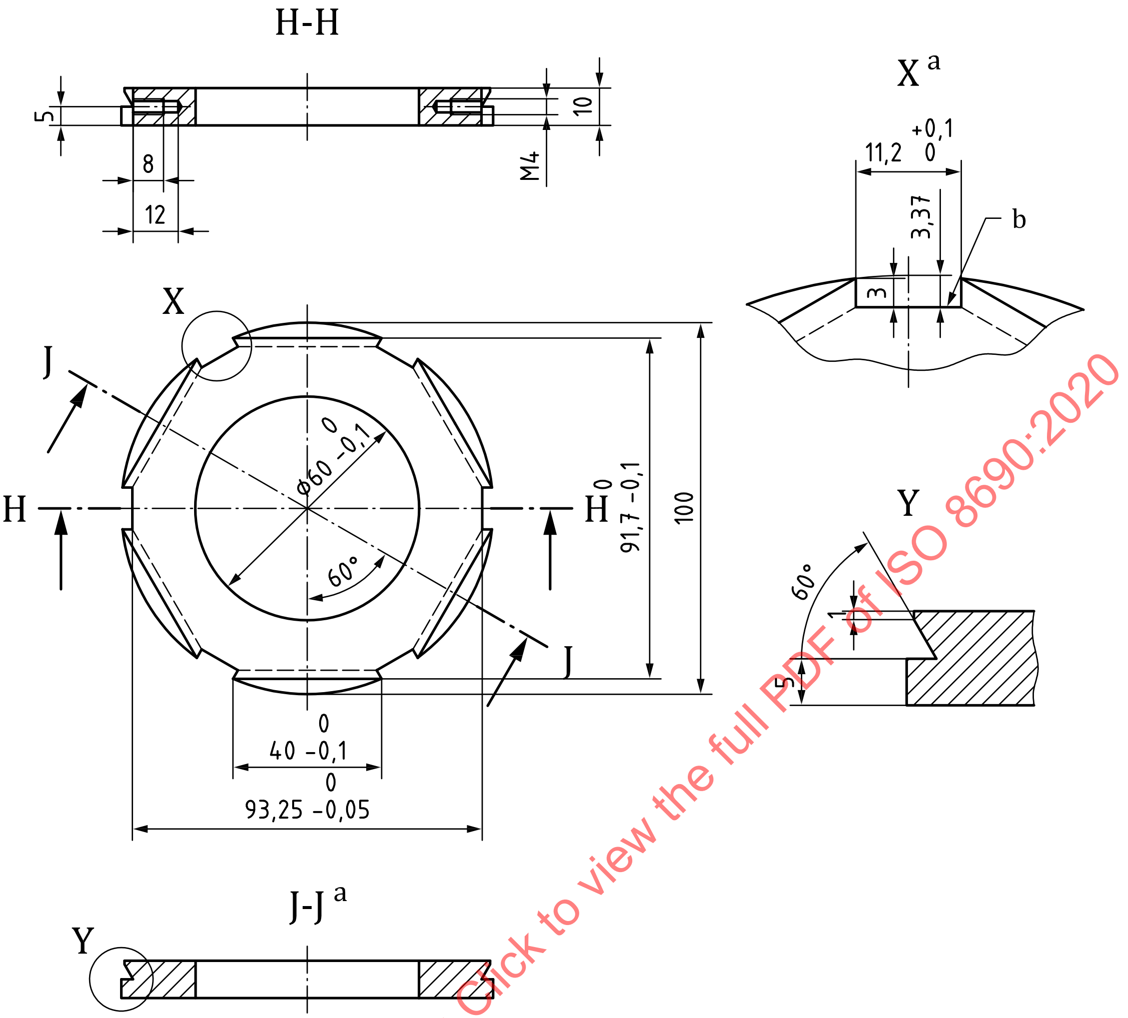
[a] Turned 30°.

Figure B.8 — Stirrer blade

Table B.2 — Dimension of the stirrer blade

$L^{0}_{-0,1}$	50 mm	60 mm	70 mm

Dimensions in millimetres



[a] 30° turned.

[b] Pos. Nr 10 spot-welded.

Figure B.9 — Lower hexagonal disc

Annex C
(informative)

Formulae for preparation of the ^{137}Cs and ^{60}Co contaminant solutions

C.1 General

The formulae given in this annex provide guidance for calculating the volumes of radioactive stock solution and standardized carrier solution necessary to prepare a radioactive contaminant solution of 0,2 MBq·ml^{-1} activity concentration and 10^{-5} molarity (instructions for adding nitric acid are not included.)

C.2 Desired final volume of contaminant solution

r ml is the volume of radionuclide stock solution required to yield an activity concentration of 0,2 MBq·ml^{-1} in the final volume of contaminant solution.

C.3 Total activity of the solution

C.3.1 Characterisation of the activity by use of the disintegration rate

If reliable data exist from the activity concentration of the initial solution, and the detection limit of the applied count meter is at least 0,17 pulse per disintegration, the value 0,2 MBq·ml^{-1} can be used as a reference value for the calculation of the activity concentration of the contaminant solution.

The product from the final activity of contaminant solution A_E and final volume of contaminant solution *r* yields in Mega Becquerel:

$$A_E = 0{,}2 \cdot \frac{\text{MBq}}{\text{ml}} r \cdot \text{ml} = 0{,}2\, r \cdot \text{MBq} \qquad \text{(C.1)}$$

C.3.2 Characterisation of the activity by use of the pulse rate

If the condition described under C.3.1 is not fulfilled or the amount of the activity should be limited, the value 2·10^6 pulses per minute and millilitre is taken as minimum value of the activity concentration of the contaminant solution.

The total pulse rate I_E, which is equal with the pulse rate of the final volume, is calculated by

$$I_E = 2 \cdot 10^6 \text{ pulses} \cdot (\text{min} \cdot \text{ml})^{-1}\, r \cdot \text{ml} = 2 \cdot 10^6 \text{ pulses} \cdot \text{min}^{-1} \cdot r \qquad \text{(C.2)}$$