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Water conditioning equipment inside buildings — Devices using mercury low-pressure ultraviolet radiators — Requirements for performance, safety and testing

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ICS 91.140.60

British Standards

National foreword

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Water conditioning equipment inside buildings - Devices using mercury low-pressure ultraviolet radiators - Requirements for performance, safety and testing

Équipements de conditionnement de l'eau à l'intérieur des bâtiments - Dispositifs utilisant des radiateurs à mercure et basse pression de rayonnement UV - Exigences relatives aux performances, à la sécurité et aux essais

Anlagen zur Behandlung von Trinkwasser innerhalb von Gebäuden - Geräte mit Quecksilberdampf-Niederdruckstrahlern - Anforderungen an Ausführung, Sicherheit und Prüfung

This European Standard was approved by CEN on 10 May 2006.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

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Foreword

This document (EN 14897:2006) has been prepared by Technical Committee CEN/TC 164 “Water supply”, the secretariat of which is held by AFNOR.

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of an identical text or by endorsement, at the latest by December 2006, and conflicting national standards shall be withdrawn at the latest by December 2006.

With respect to potential adverse effects on the quality of water intended for human consumption/caused by the product covered by this standard, the following is pointed out to the user of the standard.

1) This standard provides no information as to whether the product may be used without restriction in any of the Member States.

2) It should be noted that, while awaiting the adoption of verifiable European criteria, existing national regulations concerning the use and/or characteristics of this product remain in force.

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

1 Scope

This document specifies definitions, principles of construction, requirements and methods for testing the performance of UV devices for drinking water installations inside buildings which are permanently connected to the mains supply at the point of entry into a building or within the water distribution system inside the building.

UV devices in the sense of this standard are UV bactericidal treatment devices or UV disinfection devices.

2 Normative references

The following referenced documents are indispensable for the application 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.

EN 1717, *Protection against pollution of potable water in water installations and general requirements of devices to prevent pollution by backflow*

3 Definitions

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

3.1
absorption
decrease of the incident irradiance of a light beam including transformation into other forms suffered by radiant energy passing through a material substance (e. g. heat)

3.2
irradiance
measure of the UV light flux divided by the area that intercepts the radiation, in W/m^2

NOTE The irradiance measured in UV disinfection devices by the UV device sensor is mainly influenced by the lamp output, the transmittance of the water, and scaling/fouling of the protective quartz sleeves and the position of the lamps in the radiation chamber.

3.3
disinfection
action of killing or inactivating all types of pathogenic bacteria to a specified degree of at least 99,999 % and all types of pathogenic viruses to a degree of at least 99,99 % using a UV disinfection device

3.4
bactericidal treatment
action of inactivating or killing bacteria present in water to an unspecified degree using a UV bactericidal treatment device

3.5
fluence
dose
product of irradiance in W/m^2 and exposure time in s, in J/m^2

NOTE Fluence is the correct term from a strictly scientific point of view.

3.6
germicidal fluence
fluence weighted with the germicidal UV sensitivity, in J/m^2

4

3.7
reduction equivalent fluence (REF)
average germicidal fluence measured by the biodosimeter in accordance with 5.3 in the radiation chamber, in J/m^2

3.8
radiation chamber
part of the device that comprises the radiation zone and the connecting pipes

3.9
radiation zone
part of the radiation chamber whose volume is used for the calculation of the fluence

3.10
exposure time
time interval during which a specific volume of water within the radiation zone is exposed to the radiation, in s

3.11
microbiological dosimeter;
biodosimeter
test organism used to determine the equivalent fluence, whose UV inactivation behaviour has been determined in a standard collimated beam apparatus (see Annex B), e. g. *Bacillus subtilis* spores

3.12
minimum irradiance
value determined in the type test that ensures the required reduction equivalent fluence at a defined water flow rate and at a defined UV transmittance value, in W/m^2

3.13
flow rate (Q)
volume of water per unit time flowing through the UV device, in l/min or m^3/h

3.14
maximum flow rate (Q_{max})
highest flow at which, at a defined UV transmittance of the water and a defined irradiance, the required reduction equivalent fluence can be guaranteed, in l/min or m^3/h

3.15
permissible operation range
those limit values for the operation parameters (irradiance at the sensor or UV transmittance of the water) and flow rate where adequate bactericidal treatment or disinfection is assured

3.16
sensor
system for the measurement of the irradiance in UV disinfection devices

3.16.1
reference sensor
sensor used to countercheck the signal of the device sensor where national regulations apply.

NOTE The reference sensor should comply to national standards where existent, e.g. [1], [2].

3.16.2
selectivity
percentage of the sensor signal that is produced by radiation with a wavelength of 254 nm

3.16.3
device sensor
calibrated sensor monitoring device used for continuous measurement of the irradiance

3.17
attenuation
absorption and diffraction of radiation passing through an optical medium in a specific direction

3.18
lamp service life
service life of a UV radiator after which the irradiance that is necessary to guarantee the minimum fluence can no longer be reached under the mode of operation given by the manufacturer, and the lamp has to be replaced, in h

3.19
UV lamp
radiator which produces UV light

3.20
UV device
general expression for products using UV light to irradiate water flow through, with the purpose of inactivating microrganisms being present in the water

3.21
UV disinfection device
device designed to disinfect water

3.22
UV bactericidal treatment device
device designed for bactericidal water treatment

3.23
turbidity
reduction of optical transmittance of a liquid caused by the presence of undissolved matter

3.24
UV transmittance (% T_{100})
spectral transmission rate at a wavelength of 254 nm at an optical path length in the medium of 100 mm, in %

NOTE In general, the UV transmittance includes the influence of attenuation and absorption of the through passing medium. The UV transmittance is measured in the unfiltered sample in quartz cuvettes of at least 40 mm at a wavelength of 254 nm in a spectrophotometer and is given in %.

3.25
UV radiation (UV)
electromagnetic radiation according to Table 1

Table 1 — UV radiation

Type	Wavelength nm
UV-C	> 100 ≤ 280
UV-B	> 280 ≤ 315
UV-A	> 315 ≤ 400
NOTE For bactericidal and disinfection purposes, part of the UV-C range is used.	

4 Requirements

4.1 General

The treatment of water with the UV device shall yield a reduction equivalent fluence of at least 400 J/m^2 (40 mJ/cm^2), at a wavelength of 254 nm in the defined operational range.

4.2 Radiation chamber

The radiation chamber is made of corrosion resistant and UV resistant materials. Materials and substances used shall be suitable for contact with drinking water.

NOTE Product intended for use in water supply systems should comply, when existing, with national regulations and testing arrangements that ensure fitness for contact with drinking water. The Member states, relevant regulators and the EC Commission agreed on the principles of a future unique European Acceptance Scheme (EAS), which would provide a common testing and approval arrangement at European level. If and when the EAS is adopted, European Product Standards will be amended by the addition of an Annex Z/EAS under Mandate M/136, which will contain formal references to the testing, certification and product marking requirements of the EAS.

The mechanical design and the construction shall comply with the relevant requirements for the pressure present. Direct or indirect leaking of radiation from the radiation chamber to the environment with a wavelength below 400 nm shall be avoided.

Radiation chambers shall be constructed in a way that they are easily serviceable.

For UV disinfection devices, the radiation chamber shall be provided with a sensor for a representative irradiation measurement. The location of the sensor shall be designed so that the irradiation measurement is not disturbed by gas bubbles or sediment deposits.

4.3 Low-pressure mercury UV lamps

In order not to produce ozone, only lamps with a radiation range above 240 nm shall be used. At the line of 254 nm shall be 85 % of the total radiation intensity in the UV C range at the mercury resonance.

Lamp(s) shall be marked with a designation of type. Only those lamps used for the type test shall be used in the UV device. The UV lamp(s) shall be approved for the device by the manufacturer or be equivalent to the approved type used at the type test.

4.4 Electrical

4.4.1 General

For the electrotechnical design of UV devices, the relevant EC Directives and CE marking requirements shall be accomodated. Compliance with these EC Directives is a requirement of this standard.(see [3])

4.4.2 UV disinfection devices

4.4.2.1 Controller

The UV disinfection device shall be equipped with a controller, which provides the following functions:

— when switching on the device, the signal for the waterflow shall be delayed until the minimum irradiance is reached;

— operation and failure of the electrical function of each lamp shall be indicated;

— operation beyond the permissible limits of operation shall be indicated and a signal shall be provided which allows the waterflow to be stopped;

— general malfunction signal shall be provided;

— when shutting down the device or in case of a breakdown of the electric power supply, a signal shall be provided which allows the stop of waterflow.

The following functions shall be displayed:

— device in function;

— failure signal for each lamp;

— irradiance, in W/m^2;

— service time of the UV lamps;

— flow-related alarm point(s).

4.4.2.2 Sensor

For the measurement of the irradiation, a sensor shall be provided to ensure disinfection under consideration of possible changes in water UV transmittance and lamp performance. Requirements for the device sensor are given in Annex A. Where national regulations apply, a sensor and monitoring window may have to fulfil certain requirements.

NOTE An example for a monitoring window is shown in Annex C.

4.4.3 UV bactericidal treatment devices

The UV bactericidal treatment devices shall be equipped with a controller, which provides the following functions:

— operation and failure of the electrical function of the lamp(s) shall be indicated;

— general malfunction signal shall be provided.

The following functions shall be displayed:

— device in function;

— service time of the UV lamps.

4.5 Performance

The UV device shall apply a reduction equivalent fluence of at least 400 J/m^2 at the end of the lamp service life for the specified flow rates and UV transmittance values.

The performance is evaluated with a type test for which the manufacturer shall provide information in accordance with Annex D.

4.6 Labelling

The information to be given on a nameplate, which shall be permanently fixed to the UV device and be legible when installed, shall be in accordance with Annex E.

4.7 Manual

The manual shall describe operation, control, cleaning and service measures.

The manual shall also contain at least the following information:

— operating diagram: transmittance vs. maximum admissible flow;

— water resulting from sampling (rinsing) shall be adequately disposed of to the provisions of EN 1717;

— replacement intervals for UV lamp(s), sensor (only for UV disinfection devices).

5 Testing

5.1 General

The manufacturer shall provide the details and documentation described in Annex D. The device to be tested is checked for conformity to the documentation.

The purpose of the type test is to verify that the UV fluence delivered by the device under test meets a reduction equivalent fluence of 400 J/m^2 at the end of the lamp life, at the specified flow rates and transmittance values.

Parameters to be changed during the test are the flow rate of the water and the UV transmittance of the water for the test of UV bactericidal treatment devices and the flow rate, the transmittance and the lamp-output, for the test of UV disinfection devices.

For the type test of UV disinfection devices the UV device shall be equipped with a sensor or with a specified monitoring window and a specified sensor if national regulation for these apply. The testing in the test rig comprises of five steps:

— checking the compliance of the device to be tested with the specifications;

— data collection during the test (flow rate, water temperature, electrical power consumption, ...);

— radiation physics tests, i.e. determination of the irradiance (only for UV disinfection devices)

— microbiological test with the biodosimeter;

— evaluation of the UV device and specification of the operating range.

The manufacturer shall provide data (flow rate versus UV transmittance), that give the testing points at which the UV fluence (400 J/m^2) is reached at the end of the lamp service time and the percentage of UV output at the end of lamp service life (e.g. 70 %). The permissible operational range is determined by measurements of at least three test points which should cover the whole operational range.

The UV device to be tested shall have new lamps that have been in service for 100 h. The manufacturer shall provide an appropriate method to vary the output of the UV lamps.

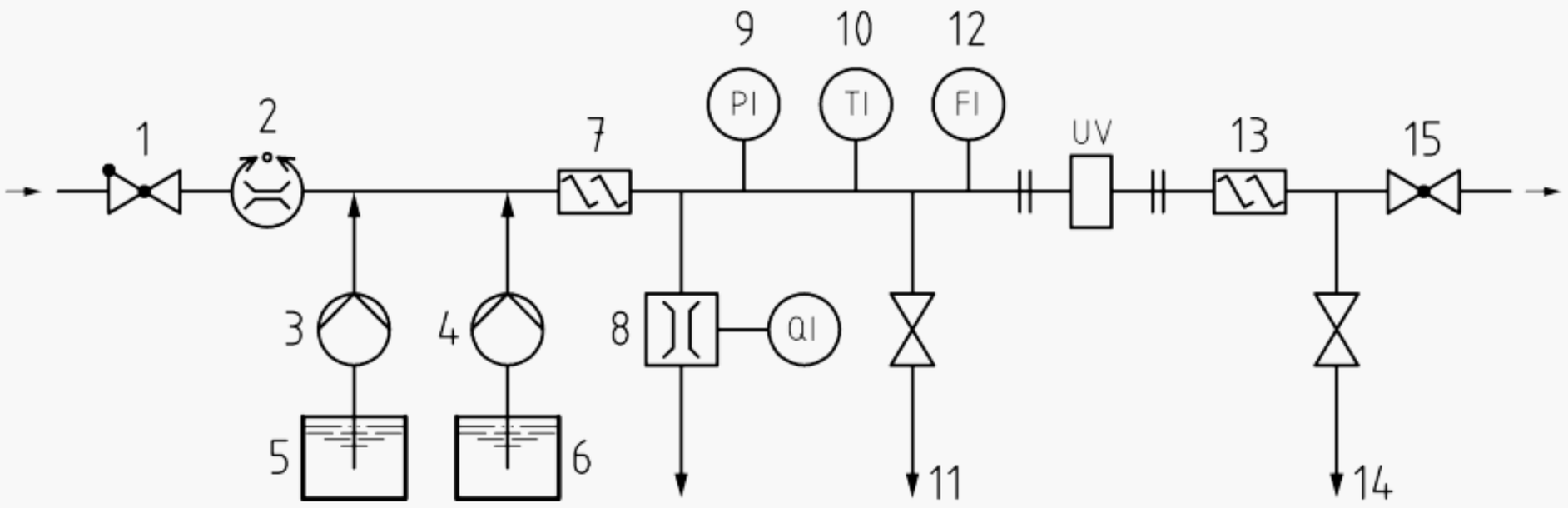
5.2 Test rig and installation

The test rig (see Figure 1) consists of a water supply with test water, wastewater removal, electrical equipment (voltage regulator), dosing device for the biodosimeter and the transmittance reducing solution, and static mixers.

The UV device is installed in the test rig and put into operation as specified by manufacturer or supplier. The UV device shall be attached to the water supply with respect to the length, configuration and nominal diameter of the inlet and outlet pipe defined by the manufacturer for the UV device.

The test water shall have a UV transmittance of at least 80 % to allow the regulation of the test conditions.

Calibrated registering measuring instrumentation for: flow rate, pressure, water temperature, UV transmittance and electrical parameters (current voltage) are required.



Key

1 Water inlet with check valve
2 Flow adjustment valve
3 Dosing pump, sodium thiosulfate
4 Dosing pump, biodosimeter
5 Sodium thiosulfate solution
6 Biodosimeter
7 Static mixer before UV device
8 Measurement UV transmittance device in the flow
9 Pressure measurement device
10 Temperature measurement device
11 Sampling point before UV device
12 Flowmeter
13 Static mixer after UV device
14 Sampling point after UV device
15 Stopvalve

Figure 1 — Test rig (schematic)

5.3 Biodosimetric measurements

As soon as stable operating conditions for the test rig and the UV device at a test point are reached, the biodosimeter is added to the inlet flow. Optimum mixing is achieved by the static mixer (concentration of the biodosimeter after mixing about $10^6 l^{-1}$ to $10^7 l^{-1}$).

Take the samples after UV irradiation and also after a static mixer. During the test, there shall be continuous flow through the sampling ports.

For each test point and measuring cycle, five samples shall be taken before and after UV irradiation respectively.

The determination of the concentration of the biodosimeter as number of colony forming units (CFU) is done in triplicate using a decimal dilution series. Use the pour plate method with plate count agar. Incubate for (48 ± 4) h at (37 ± 1) °C. Use three agar plates (diameter 90 mm) of the dilution step that results in 20 to 200 colonies per plate. The arithmetic average of the three counts is multiplied by the dilution factor and converted into the decadic logarithm. This results in five lg-concentration before and five lg-concentration after UV irradiation, of which the arithmetic average is calculated (lg N_0: before irradiation, lg N_1: after irradiation). The standard deviation s of the five parallel samples shall not exceed ± 0,2. Otherwise the test conditions are not stable (hydraulics, dosing, mixing). By calculating lg(N/N_0), the reduction at the test point is determined. In

Table 2 an example for the calculation is given. The conversion of the reduction to the reduction equivalent fluence is attained using the equation in B2.

Table 2 — Example for the evaluation of a biodosimetric measurement

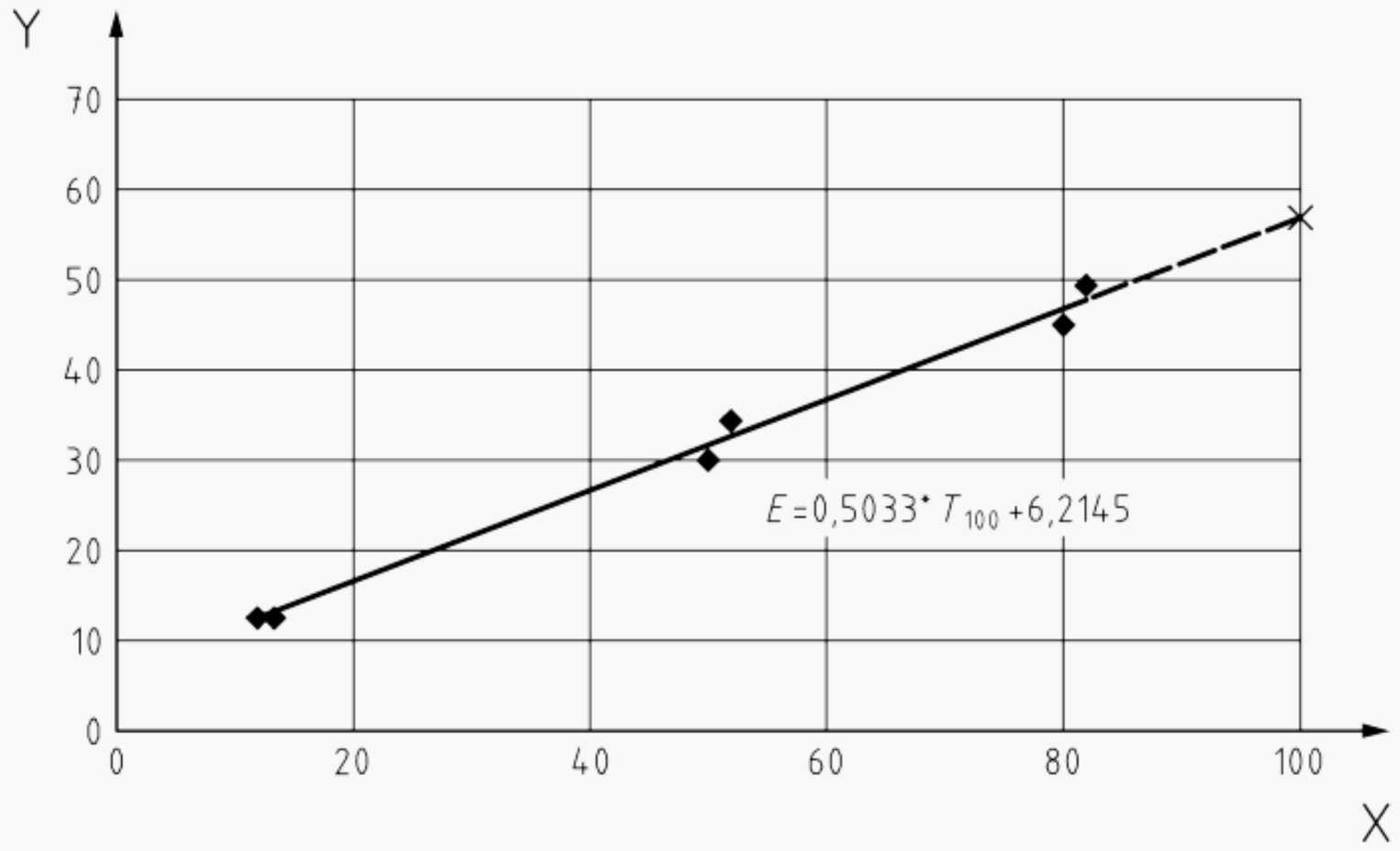
Before UV	Factor of dilution	Colony counts in single petri dishes CFU			Colony counts per litre CFU / l	lg colony counts per litre	lg arithmetic average before UV
		1	2	3			
Sample 1	10^{5}	80	96	104	$9{,}33 \times 10^{6}$	6,97	6,98 ± 0,12
Sample 2	10^{5}	105	100	82	$9{,}57 \times 10^{6}$	6,98	
Sample 3	10^{5}	59	67	54	$6{,}00 \times 10^{6}$	6,78	
Sample 4	10^{5}	119	116	143	$1{,}26 \times 10^{7}$	7,10	
Sample 5	10^{5}	88	113	90	$1{,}16 \times 10^{7}$	7,06	
After UV	Factor of dilution	Colony counts in single petri dishes CFU			Colony counts per litre CFU / l	lg colony counts per litre	lg arithmetic average after UV
		1	2	3			
Sample 1	10^{3}	52	37	50	$4{,}63 \times 10^{4}$	4,67	4,68 ± 0,11
Sample 2	10^{3}	33	53	30	$3{,}87 \times 10^{4}$	4,59	
Sample 3	10^{3}	46	55	68	$5{,}63 \times 10^{4}$	4,75	
Sample 4	10^{3}	69	74	53	$6{,}53 \times 10^{4}$	4,81	
Sample 5	10^{3}	43	34	31	$3{,}6 \times 10^{4}$	4,56	
Reduction: lg artihmetic average after UV – lg arithmetic average before UV						-2,30	

5.4 Performance test procedure

5.4.1 UV disinfection devices

Install the UV device in the test rig let water flow through the UV device at the lowest flow rate to be tested for 10 min before turning on the lamps of the UV disinfection device. Turn on the UV lamp(s) and do not proceed until a stable irradiance reading is achieved.

In the first part of the test, the transmittance of the test water is varied within the operational range specified by the manufacturer that corresponds to the flow rates. The relationship of the UV transmittance of water and the irradiance measured by the sensor shall be determined. The output of the lamps is reduced by a method specified by the manufacturer, so that it is decreased to the value at the end of the lamp service time (e.g. by 30 %). The transmittance variation is done twice with three values at least. Using these six values, a graph is established as shown below.



Key

Y Irradiance E (W/m²)

X UV transmittance T_{100} (%)

Figure 2 — Irradiance measured by device sensor vs. UV transmittance

From the graph the irradiance settings for the biodosimetry are derived. The following table gives an example.

Table 3 — Irradiance value settings derived from measurements during transmittance variation (example)

Irradiances E_1, E_2, E_3 at which biodosimetric measurements take place W/m²	Maximum flow rate Q Specified by manufacturer m³/h	UV transmittance T_{100} Specified by manufacturer %/10 cm
11	3	10
31	9	50
46	12	80

The single steps to establish the transmittance-irradiance dependency are:

— UV transmittance of the test water is adjusted with a transmittance reducing substance [e.g. sodium thiosulfate solution ($Na_2S_2O_3$)].

— Adjust the UV transmittance that appertains to the highest flow rate to be tested and measure the irradiance E_1.

— Adjust the UV transmittance that appertains to the medium flow rate to be tested and measure the irradiance E_2.

— Adjust the UV transmittance that appertains to the lowest flow rate to be tested and measure the irradiance E_3.

The water flow rate may be kept low for these measurements (e.g. lowest flow rate to be tested), as the flow rate does not influence the measurement results.

Biodosimetric measurements

The UV device under test is then challenged with the biodosimeter in the test rig varying the flow rates and the irradiances first at full output of the lamp(s) and reduced UV transmittance of the test water, and second at reduced output of the lamp(s) and test water with high UV transmittance.

All measurements are repeated once with at least three test points each, divided by a shut-off of the device (shut-off of the lamp and cut-off of the water flow for 15 min).

Adjust the following test points by varying the transmittance, add biodosimeter, take samples and evaluate as described above:

test point 1: highest flow rate to be tested, full lamp output, adjustment of the irradiance E_1 by reduction of the UV transmittance.

test point 2: medium flow rate to be tested, full lamp output, adjustment of the irradiance E_2 by reduction of the UV transmittance.

test point 3: lowest flow rate to be tested full lamp output, adjustment of the irradiance E_3 by reduction of the UV transmittance.

The following test points shall be adjusted by using test water with a UV transmittance of 80 % to 90 % and variation of the output of the UV lamp:

test point 1*: highest flow rate to be tested, adjustment of the irradiance E_1 by reduction of the output of the UV lamp.

test point 2*: medium flow rate to be tested, adjustment of the irradiance E_2 by reduction of the output of the UV lamp.

test point 3*: lowest flow rate to be tested, adjustment of the irradiance E_3 by reduction of the output of the UV lamp.

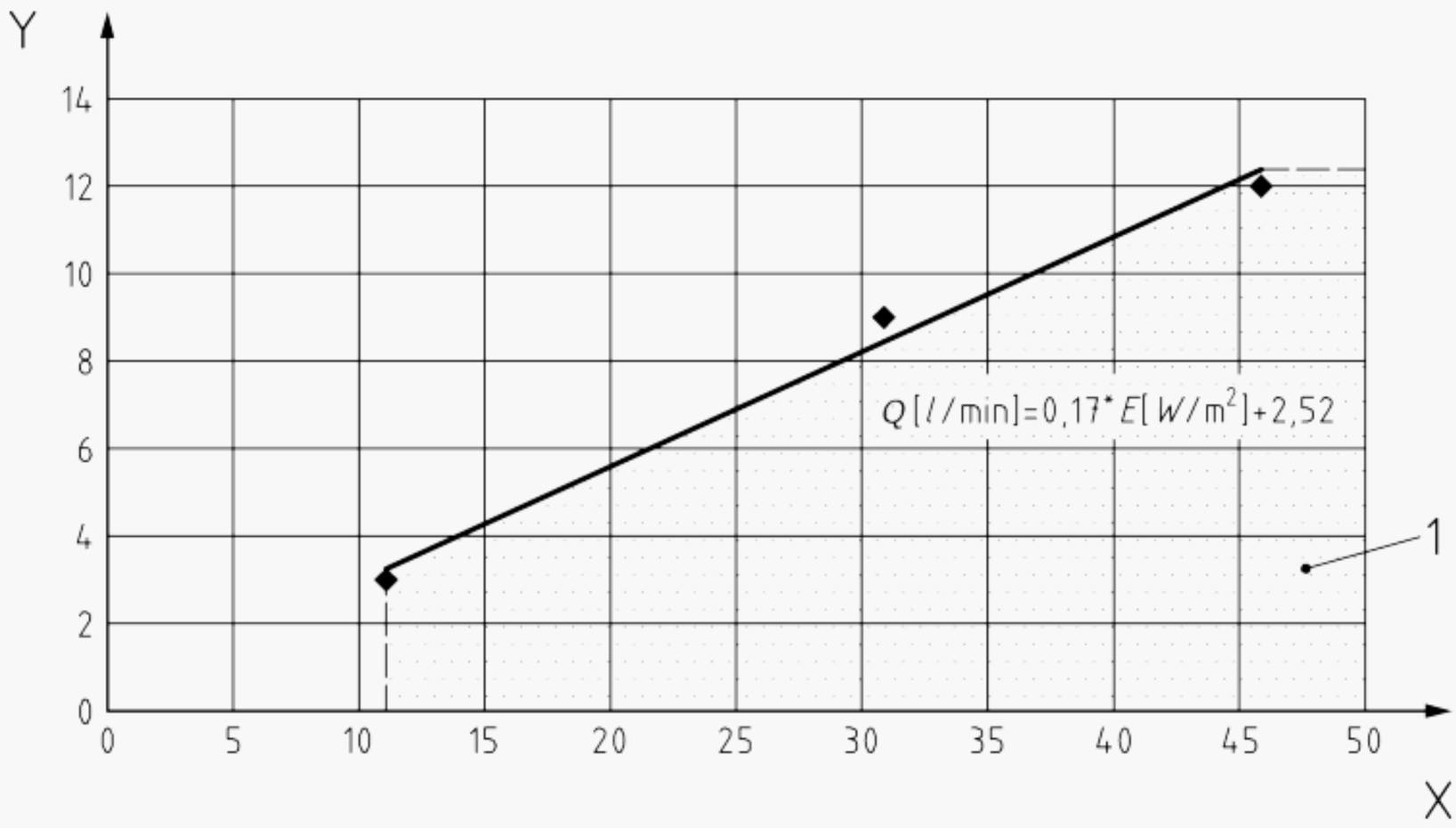
5.4.2 Processing of the data

From the UV fluence response, which has been determined in the laboratory collimated beam device and the samples taken, reduction equivalent fluence values shall be calculated. All values shall be higher than or equal to 400 J/m².The data shall be used to set up the operational diagram of flow rate in m³/h or l/min vs irradiance in W/m².

Table 4 — Results of biodosimetric measurements (example)

Test settings	Test point 1 transmittance variation Irradiance E_1 at flow rate q_1	Test point 1* lamp output variation Irradiance E_1 at flow rate q_1	Test point 2 transmittance variation Irradiance E_2 at flow rate q_2	Test point 2* lamp output variation Irradiance E_2 at flow rate q_2	Test point 3 transmittance variation Irradiance E_3 at flow rate q_3	Test point 3* lamp output variation Irradiance E_3 at flow rate q_3
REF for first run J/m²	405	420	401	425	408	402
REF for second run J/m²	417	403	413	416	410	424

Calculate a regression graph (linear or non-linear) from irradiance E vs flow rate Q. Calculate the correlation coefficient R^2 from the three test points. If R^2 is higher than 0,95 use linear regression. If R^2 is less than 0,95, calculate the regression graph using a non-linear function, e.g. square function. From the correlation function calculate a table with flow rate and corresponding irradiance values for the whole permissible operational range.



Key

Y Flow rate Q (l/min)

X Irradiance E (W/m²)

1 Permissible operation range for UV disinfection device

Figure 3 — Representation of the permissible operating range: minimum irradiance and maximum flow rate (example)

Table 5 — Parameters of permissible operating range of UV disinfection devices tested (example)

Minimum irradiance (alarm point) measured with device sensor E W/m^2	Maximum flow rate Q_{max} l/min
…	…
19,2	5,8
22,6	6,4
26,1	7,0
29,5	7,5
31,6	7,9
35,1	8,5
...	...

5.4.3 UV bactericidal treatment devices

Install the UV device in the test rig. Let water flow through the UV device at the lowest flow rate to be tested for 10 min before turning on the lamps of the UV disinfection device. Turn on the UV lamp(s) and do not proceed until a stable burning behaviour of the UV lamps can be expected.

The output of the lamp(s) is reduced by a method specified by the manufacturer, so that it is decreased to the value at the end of the lamp service time (e.g. by 30 %). The transmittance of the test water is varied within the operational range specified by the manufacturer that corresponds to the flow rates.

Biodosimetric measurements

The UV device under test is then challenged with the biodosimeter in the test rig varying the flow rates and the transmittance values.

All measurements are repeated once with at least three test points each, divided by a shut-off of the device (shut-off of the lamp and cut-off of the water flow for 15 min).

Adjust the following test points and add biodosimeter, take samples and evaluate as described above:

test point 1: highest flow rate to be tested, reduction of the UV transmittance to the corresponding (highest) transmittance.

test point 2: medium flow rate to be tested, reduction of the UV transmittance to the corresponding (intermediate) transmittance.

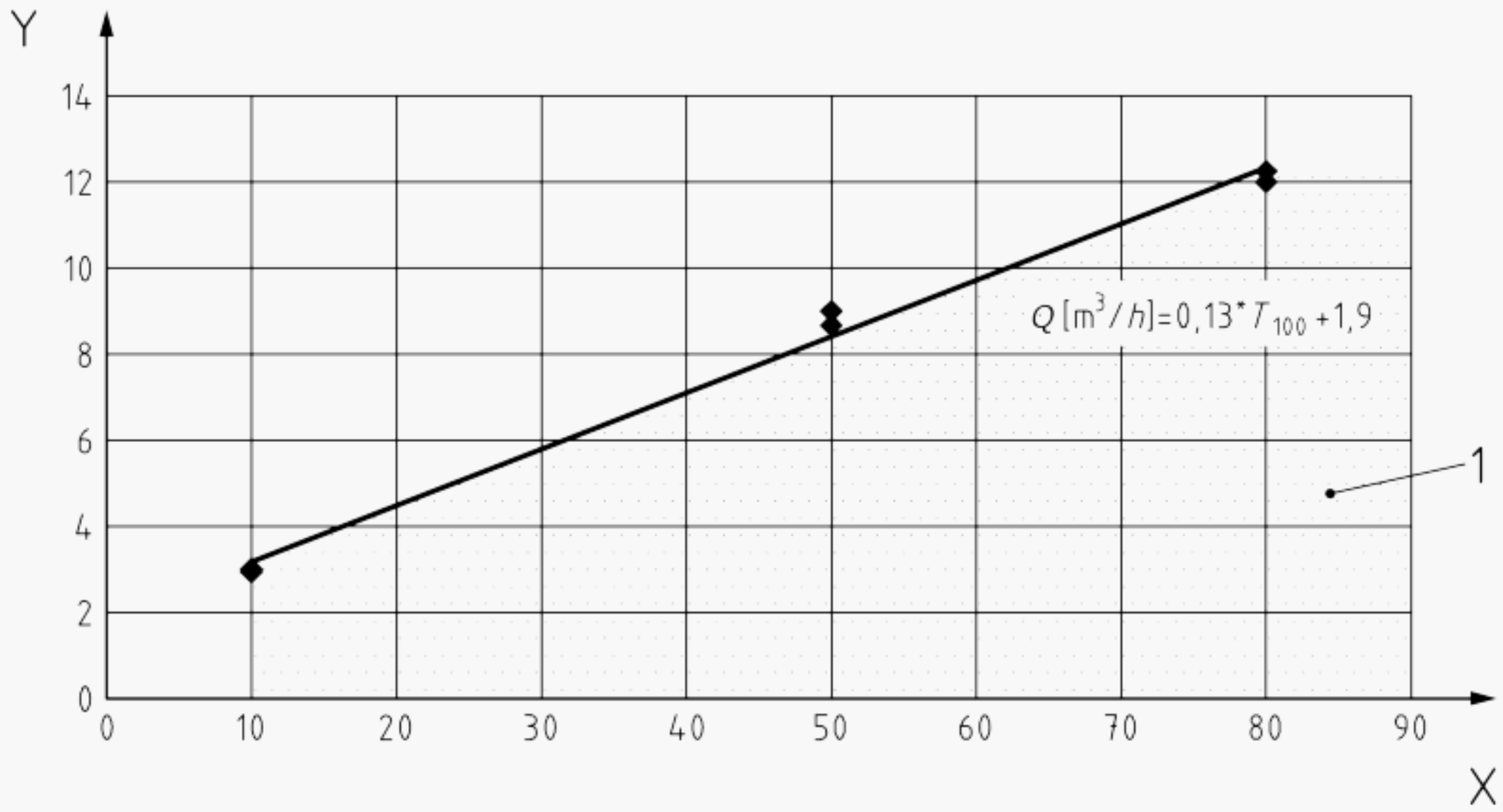
test point 3: lowest flow rate to be tested full lamp output, reduction of the UV transmittance to the corresponding lowest transmittance.

5.4.4 Processing of the data

From the UV fluence response which has been determined in the laboratory collimated beam device and the samples taken six reduction equivalent fluences are calculated for each flow rate/transmittance tested. All values shall be higher than or equal to 400 J/m². The data shall be used to set up the operational diagram of flow rate in m³/h or l/min vs transmittance in %.

Calculate a regression graph (linear or non-linear) for transmittance T_{100} vs flow rate Q using the six values. Calculate the correlation coefficient R^2 from the six test points. If R^2 is higher than 0,95 use the linear

regression. If R^2 is less than 0,95, calculate the regression graph using a non-linear function, e.g. square function. From the correlation function calculate a table with transmittance and corresponding maximum permissible flow rate for the whole permissible operational range.



Key

Y Flow rate Q_{max} (l/min)

X Transmittance T_{100} (%)

1 Permissible operation range for UV bactericidal treatment device

Figure 4 — Representation of the permissible operating range: minimum UV transmittance and maximum flow rate (example)

Table 6 — Parameters of permissible operating range of UV devices tested (example)

Maximum flow rate Q_{max} l/min	UV transmittance T_{100} %/10 cm
…	…
4,8	22
5,4	27
6,1	32
6,7	37
7,0	39
7,6	44
...	...

Annex A
(normative)

Requirements for the device sensor

A.1 Calibration

The device sensor shall be calibrated in W/m^2.

A.2 Selectivity

The radiation of a wavelength above 254 nm shall contribute not more than 5 % to the signal output of the device sensor. The selectivity shall be proved by a diagram provided by the manufacturer.

A.3 Measuring range linearity

For radiation with a wavelength of 254 nm the measuring range of the device sensor for the irradiance shall be at least 0,1 W/m^2 to 250 W/m^2. The signal has to be linear over the whole measuring range. The linearity shall be proved by the manufacturer.

A.4 Measuring range and resolution

The measuring range of the device sensor shall include the permissible operational range of the irradiance.

The range from E_1 to E_2 shall be readable in steps of 3 % of the range. This gives the following specifications for the readability A in W/m^2 of the measuring system:

$$0{,}03\,(E_2 - E_1) \geq A \leq 0{,}03\,E_1 \qquad \text{(A.1)}$$

where

E_1 is the lowest irradiance of the operating range, in W/m²;

E_2 is the highest irradiance of the operating range, in W/m²;

A is the smallest difference of irradiance still readable on display of the device sensor, in W/m².

EXAMPLE 1 E_1 = 5 W/m², E_2 = 100 W/m²

E_2 - E_1 = 95 W/m²

95 · 0,03 = 2,85 W/m²

5 · 0,03 = 0,15 W/m². The readability is to be 0,15 W/m².

EXAMPLE 2 E_1 = 30 W/m², E_2 = 70 W/m²

E_2 - E_1 = 40 W/m²

40 × 0,03 = 1,2 W/m²

30 × 0,03 = 0,9 W/m². The readability is to be 0,9 W/m².

The display shall be stabilised (attenuator) by appropriate means.

A.5 Temperature drift

The temperature drift of the device sensor shall be taken into account.

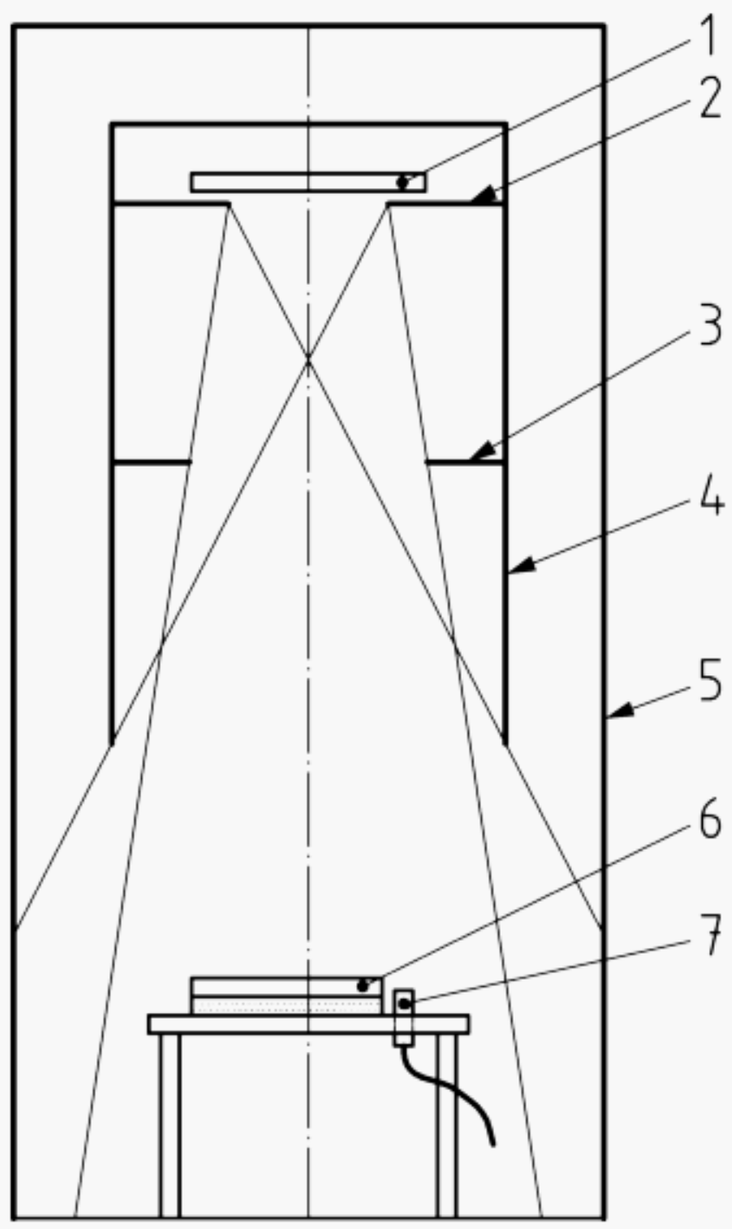
A.6 Stability over time

The stability of the characteristics of the device sensor shall be assured for at least one year. Afterwards, the sensor shall be replaced by a new one.

Annex B
(normative)

Biodosimeter calibration

The UV fluence response of the biodosimeter shall be determined in a calibrated collimated beam apparatus (Figure B.1), with at least eight fluences in the range of 100 J/m^2 to 800 J/m^2. An example for the cultivation of the biodosimeter is given in [4].



Key
1 Low pressure Hg-radiator
2 Apparatus for reducing the efficient radiator length
3 Shutter for setting the radiation time
4 Lamp cover
5 Unit cover with door
6 Petri dish with biodosimeter suspension
7 Reference sensor

Figure B.1 — Collimated beam apparatus for biodosimeter calibration

Adjust a graph to the data obtained by linear regression to the linear part of these eight points, and include zero (i.e. nine points) using the following equation:

$$\lg \frac{N}{N_0} = -k \times H_0 + d \qquad \text{(B.1)}$$

where

$\frac{N}{N_0}$ is the survival rate;

k is the slope of the UV sensitivity, in m^2/J;

H_0 is the fluence, in J/m^2;

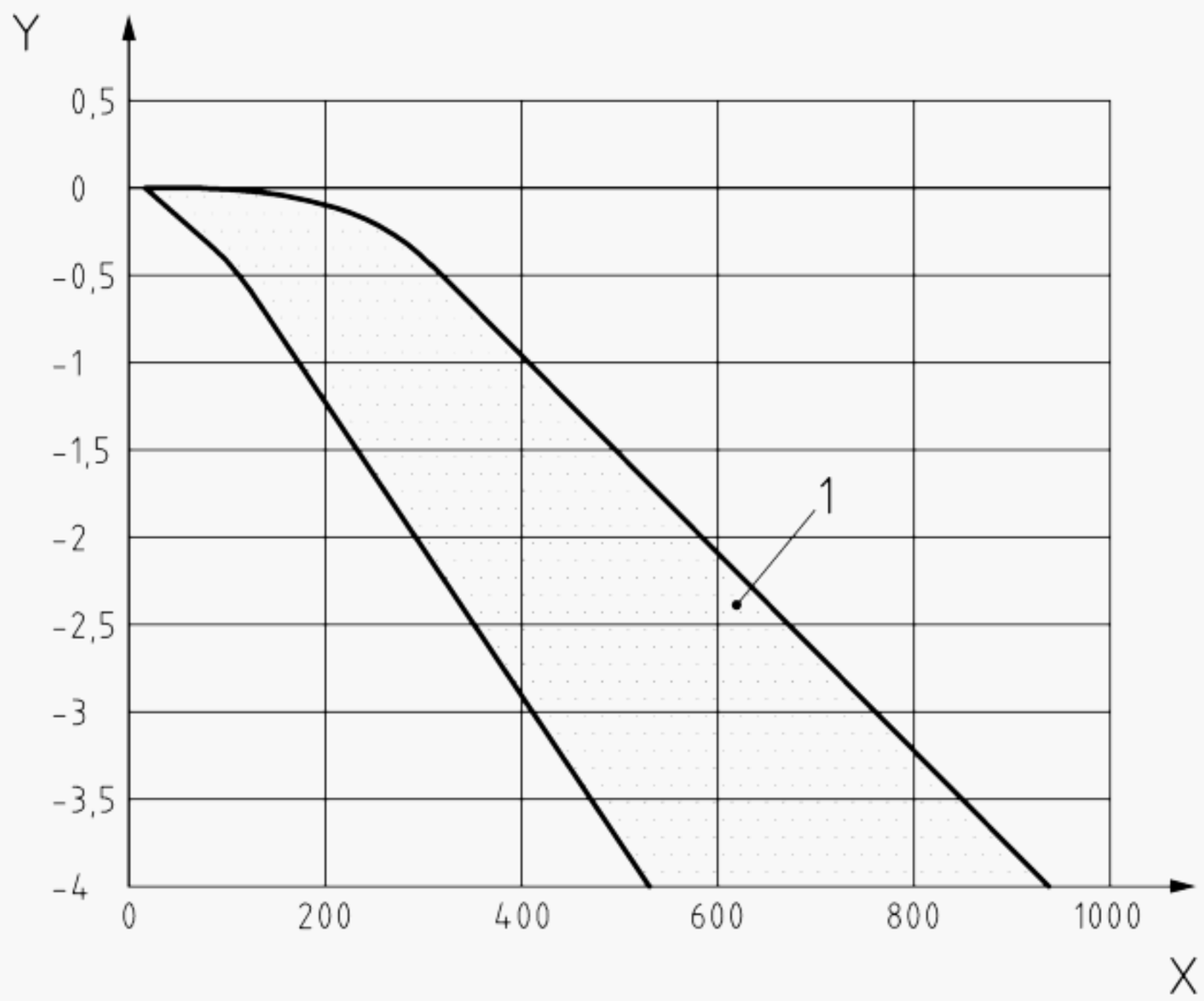
d is the distance between the intercept of the graph with the ordinate and zero.

The constants k and d shall be determined by linear regression and shall be in the following range:

k = 0,0056 m^2/J up to 0,0085 m^2/J;

d = 0,49 up to 0,91.

The permissible range for the UV sensitivity of the biodosimeter is shown in Figure B.2.



Key

Y Decadic logarithm of survival rate lg (N/N_0)

X Fluence H_0 (J/m^2)

1 Permissible range

Figure B.2 — Permissible range for the inactivation graph of the biodosimeter

During the type test the reduction equivalent fluence applied is calculated according to the following equation:

$$REF = -\frac{1}{k} \times \lg\left[1 - \left(1 - \frac{N}{N_0}\right)^{10^{-d}}\right] \qquad \text{(B.2)}$$

where

$\frac{N}{N_0}$ is the inactivation of the biodosimeter rate caused by the UV device;

k is the slope of the UV sensitivity, in m^2/J.

During the type test, the UV sensitivity of the biodosimeter shall be checked with at least two samples of test water containing the biosdosimeter in order to verify the stability of the biodosimeter. Two samples shall be irradiated with 200 J/m^2, 400 J/m^2 and 600 J/m^2 respectively. The values of *k* and *d* shall be within the range of the standard inactivation graph given in Figure B.2. The inactivation graph and the results of the verification test shall be included in the test report.

Annex C
(informative)

Monitoring window

Requirements for a monitoring window to be provided with a UV disinfection device to be type tested. This monitoring window is normative in some European countries. The monitoring window basically consists of a tube with an internal diameter of 20 mm manufactured with a precision rating E_9, which is sealed by a quartz glass disc of a diameter of at least 23 mm and a thickness of at least 5 mm.

Dimensions in mm

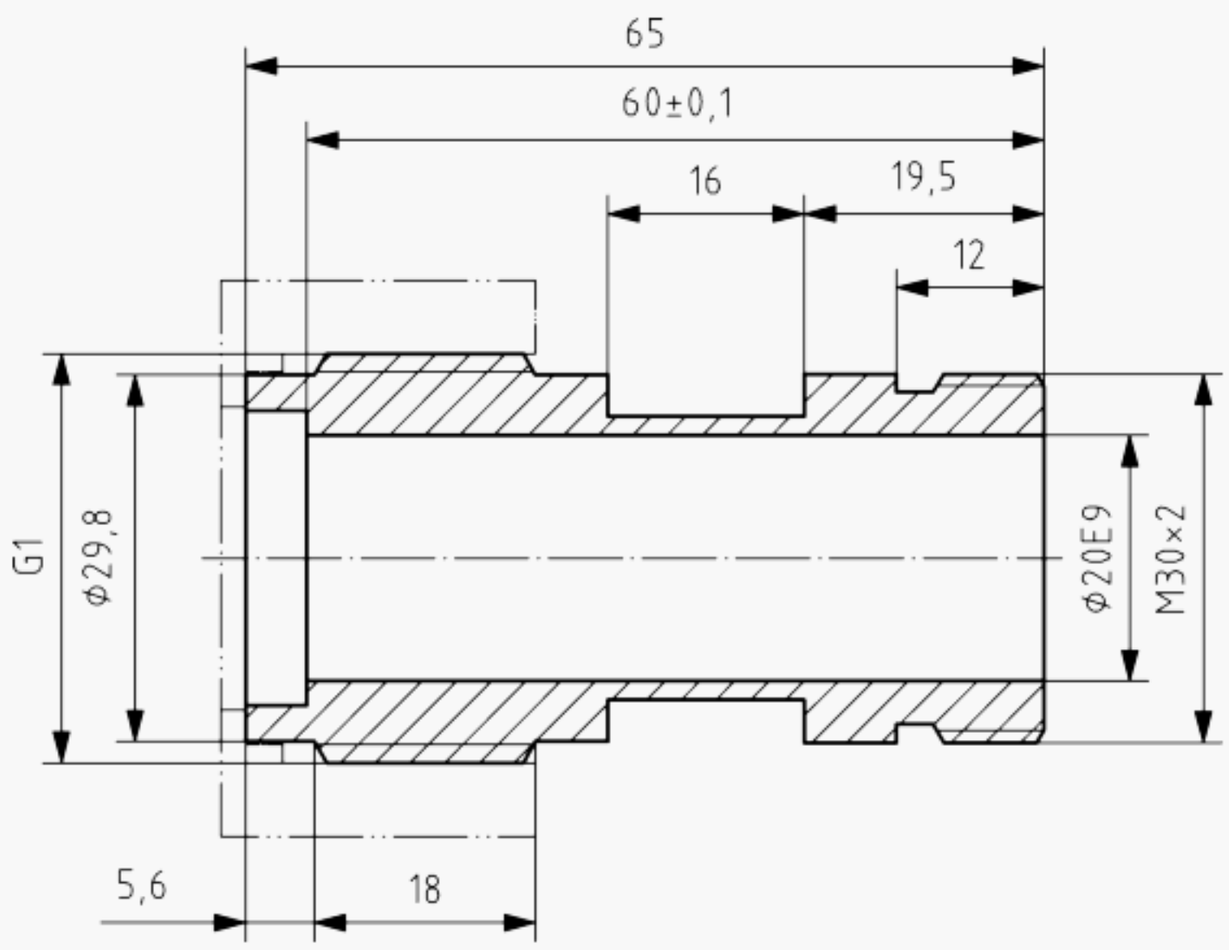


Figure C.1 — Dimensions of the monitoring window

Annex D
(normative)

Manufacturer's information for the type test

The manufacturer shall provide the following information and documentation prior to the type test:

— name of manufacturer;

— designation of product;

— type of device;

— specification of the materials used;

— number of UV radiators;

— UV radiator type: graph of the emission spectrum, e.g. the relative spectral radiation intensity in relation to the wavelength in the range of 200 nm to 400 nm;

— electrical power intake of the UV radiator (including regulator), in W;

— UV-C output of the UV radiator, in W;

— service life period of the UV radiator(s);

— protective quartz sleeve type (documentation of the manufacturer);

— permissible range of the water temperature;

— detailed drawing of the device with all accessories including dimensions;

— details of the form and length of the inlet and outlet pipe, if necessary;

— mass of the device, in kg;

— total energy demand of the device, in W;

— voltage, in V;

— frequency, in Hz;

— current uptake, in A;

— maximum operating pressure, in Pa;

— pressure loss at maximum flow (may be determined during the test), in Pa;

— manual;

— test points: flow rates and transmittance values to be tested.

Only for UV disinfection devices:

— type of device sensor;

— test report concerning the linearity and the temperature stability of the device sensor;

— information about the stability over time of the device sensor;

— detailed drawings of the device sensor.

Annex E
(normative)

Manufacturer's information for the UV device user

The radiation chamber shall be equipped with an identification plate containing the minimum information in accordance with Table E.1. This plate shall have been fixed on the radiation chamber before the type test (without the data being measured at the type test).

Table E.1 — Identification plate for the radiation chamber

Manufacturer	
Address of the manufacturer	
Type of device	
Year of production	
Rated voltage (V)	
Current intensity (A)	
Frequency (Hz)	
Max flow rate (m^3/h) and corresponding irradiance (W/m^2) for UV disinfection devices Max flow rate (m^3/h) and corresponding transmittance (%) for UV bactericidal treatment devices	

Bibliography

[1] ÖNORM M 5873-1, *Plants for disinfection of water using ultraviolet radiation — Requirements and testing — Part 1: Low pressure mercury lamp plants.*

[2] DVGW W 294, *UV systems for the disinfection in drinking water supplies — Requirements and testing.*

[3] 98/83/EC, *Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption.*

[4] Sommer, R.: Untersuchungen zur Trinkwasserdesinfektion durch UV Strahlung. Dissertation, Universität für Bodenkultur, Wien 1991, S. 64 - 65.

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