

Safety Standards

of the
Nuclear Safety Standards Commission (KTA)

KTA 1507 (06/98)

**Monitoring the Discharge of Radioactive Substances
from Research Reactors**

(Überwachung der Ableitungen radioaktiver Stoffe
bei Forschungsreaktoren)

If there is any doubt regarding the information contained in this translation, the German wording shall apply.

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KTA SAFETY STANDARD

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Monitoring the Discharge of Radioactive Substances from Research Reactors

KTA 1507

The following safety standard was prepared on behalf of the Kerntechnischer Ausschuss (KTA) under the responsibility of the Normenausschuss Kerntechnik (NKe). The NKe intends an identical publication of this safety standard as DIN 25 417.

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PLEASE NOTE: Only the original German version of this safety standard represents the joint resolution of the 50-member Nuclear Safety Standards Commission (Kerntechnischer Ausschuss, KTA). The German version was made public in Bundesanzeiger No. 172a on September 15, 1998. Copies may be ordered through the Carl Heymanns Verlag KG, Luxemburger Str. 449, 50939 Koeln, Germany (Telefax +49-221-94373603).

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Comments by the editor:

Taking into account the meaning and usage of auxiliary verbs in the German language, in this translation the following agreements are effective:

shall	indicates a mandatory requirement,
shall basically	is used in the case of mandatory requirements to which specific exceptions (and only those!) are permitted. It is a requirement of the KTA that these exceptions - other than those in the case of shall normally - are specified in the text of the safety standard,
shall normally	indicates a requirement to which exceptions are allowed. However, the exceptions used shall be substantiated during the licensing procedure,
should	indicates a recommendation or an example of good practice,
may	indicates an acceptable or permissible method within the scope of this safety standard.

Fundamentals

(1) The safety standards of the Nuclear Safety Standards Commission (KTA) have the task of specifying those safety related requirements which shall be met with regard to precautions to be taken in accordance with the state of science and technology against the damage arising from the construction and operation of the facility (Sec. 7 para. 2 sub-para. 3 Atomic Energy Act), in order to attain the protection goals specified in the Atomic Energy Act and Radiological Protection Ordinance (StrlSchV).

(2) The stationary and mobile radiation protection instrumentation serves, among others, the dual purpose of protecting the persons inside and outside of the plant from ionizing radiation and of verifying the specified normal functioning of the equipment for retaining solid, liquid and gaseous radioactive substances inside the proper enclosures, for the controlled conduction of radioactive substances within the plant as well as for monitoring the discharge of radioactive substances. The KTA safety standards series 1500 specifies detailed requirements regarding this radiation protection instrumentation.

(3) Safety standard KTA 1507 contains the requirements that apply to the technical equipment and the supplementary administrative measures that are considered necessary for monitoring the discharge of radioactive substances with air and water in research reactors during specified normal operation and in the case of design basis accidents.

(4) In accordance with fulfilling the requirements of Sec. 46 para. 1 StrlSchV, namely, that (one) any uncontrolled discharge must be avoided, that (two) the discharged activity must as low as possible and that (three) all discharges must be monitored and reported – according to kind and amount of activity – to the competent authority at least once a year, it is necessary that equipment for monitoring the discharge of radioactive substances be installed and operated. In accordance with Sec. 72 StrlSchV, this monitoring equipment shall correspond to the state of science and technology.

(5) Monitoring the discharge of radioactive substances shall fulfill the following tasks:

- permit a detailed assessment of the discharged radioactive substances as a basis for evaluating the radiological effects,
- automatically initiate alarm signals in case specified limit values are exceeded,
- contribute to the fulfillment of the requirements in accordance with Sec. 46 para. 1 no. 3 StrlSchV.

(6) In addition to meeting the requirements of this safety standard, the Federal Act on Regulation of the Water Household (WHG) and the individual water act of the respective State (*Bundesland*) shall also be fulfilled.

(7) When discharging waste water into a public sewage system, the individual requirements and restrictions specified in communal law shall be taken into account.

1 Scope

(1) This safety standard shall apply to the equipment used for monitoring the discharge of gaseous, aerosolbound and liquid radioactive substances during specified normal operation and in the case of design basis accidents from stationary research reactors with a power larger than 50 kW including those plant components which are included in the nuclear licensing procedure.

Note:

Examples for such plant components are the neutron conductors, the cold and hot neutron sources and the irradiation facilities.

(2) In the case of research reactors with a power less than or equal to 50 kW and of zero power reactors, e.g. training re-

actors and critical assemblies, this safety standard should be applied only to an extent that is reasonable under consideration of all circumstances of the individual case.

(3) In as far as liquid radioactive substances are transferred to authorized third parties, e.g. central decontamination facilities or State collection facilities, the monitoring of these substances is not subject to the requirements of this safety standard.

Note:

Secs. 77 and 78 StrlSchV specifically pertain to the transfer of radioactive substances.

2 Definitions

2.1 Bleed water

Bleed water is that part of the circulating coolant that is discharged from the secondary and tertiary coolant circuits in order to keep the amount of substances contained in the coolant within permitted limits.

2.2 Discharge of radioactive substances

The discharge of radioactive substances is the intentional release of liquid, aerosolbound or gaseous radioactive substances from the facility along pre-determined ways.

2.3 Discrimination of a measuring device

Discrimination of a measuring device is the ratio of a measurement display observed on the measuring device to the actual value causing the display.

2.4 Specified normal operation

Specified normal operation entails

- operating processes for which the plant, assuming the able function of all systems (fault free condition), is intended and suited (normal operation);
- operating processes which occur in the event of a plant component or system malfunction (fault condition), insofar as safety related reasons do not stand against continued operation (abnormal operation);
- maintenance procedures (inspection, servicing, repair).

2.5 Detailed assessment of radioactive substances

Detailed assessment of radioactive substances is a specific kind of monitoring and entails identifying the discharged radionuclides or radionuclide groups and determining their activity over the length of a specified time period.

2.6 Cesium 137 equivalent

Cesium 137 equivalent is the activity concentration in units of Becquerel per cubic meter that is derived by multiplying the measured gamma count rate of the specimen under examination with the ratio of activity concentration to gamma count rate of a standard solution of Cesium 137 that is determined under similar geometric conditions.

2.7 Double determination

Double determination is an activity measurement on equal parts of a representative sample after having performed the identical preparatory procedural steps on these parts (e.g., concentration by evaporation, radio-chemical separation).

2.8 Decision limit

Cf. Section 2.20.2

2.9 Research reactor

A research reactor is a nuclear reactor which is operated exclusively for at least one of the following purposes:

- utilization of the radiation produced by nuclear fission,
- data measurement regarding nuclear physics,
- data measurement regarding reactor physics.

2.10 Overall loss factor (aerosols)

The overall loss factor comprises the pipe factor, the error due to a possibly non-isokinetic sampling, the error in determining a representative partial air stream with a sampling rake and the influence from retention in the collecting and measuring equipment.

2.11 Calibration of a measurement assembly for radiation monitoring

Calibration of a measurement assembly for radiation monitoring is the determination of the functional relationship between measurement display and actual value of the measurement parameter.

2.12 Coolant circuit

Coolant circuit is a cooling system in which a coolant is circulated repeatedly for the purpose of transporting heat.

2.13 Coolant circuit, closed

A closed coolant circuit is a cooling system in which there exists no connection between its coolant and the medium to which it transfers the heat.

2.14 Coolant circuit, open

An open coolant circuit is a cooling system in which there is a connection between its coolant and the medium to which it transfers the heat.

2.15 Coolant circuit, primary

Primary coolant circuit is a coolant circuit in which the heat from the reactor core is transferred by the coolant to a heat exchanger. The coolant is in direct contact with the fuel elements.

2.16 Cooling system, secondary

Secondary cooling system is a cooling system with which the heat that is transported within the primary coolant circuit to the heat exchanger is removed from the heat exchanger.

2.17 Measurement range factor

Measurement range factor is the ratio of the maximum value on the display scale of one measurement range to the maximum value of the next more sensitive measurement range.

2.18 Measurement medium

Measurement medium is a sample taken from the monitored medium that – possibly after an engineering procedural treatment such as heating, filtration, dilution – flows through the measurement volume (i.e., that region for which the discrimination of the corresponding measuring device had been determined during calibration).

2.19 Mixed sample

Mixed sample is a mixed of individual samples or cumulative samples, or of parts of these samples, taken over a specified time period.

2.20 Detection limit and decision limit of a measurement arrangement or measurement method for a specific nuclide or nuclide mixture**2.20.1 Detection limit**

The detection limit for a specific nuclide or nuclide mixture is that value of a measurement parameter which shall be calculated from certain characteristic statistical values in accordance with the equations specified under Section 2.20.3. It serves the purpose of proving whether or not the measurement system is suited for the measurement purpose. For this purpose, the calculated detection limit is compared with a predetermined detection limit specified on the basis of scientific, regulatory or other reasons.

Note:

Measurement parameters are, e.g., activity, activity concentration, time integral of the activity concentration.

2.20.2 Decision limit

The decision limit for a specific nuclide or nuclide mixture is the value of a measurement parameter calculated from certain characteristic statistical values in accordance with the equations specified under Section 2.20.3. It serves the purpose of deciding whether the examined medium contributed to a particular activity measurement or whether no more than the zero effect was measured.

2.20.3 Definition of the response limit and decision limit:

Detection limit $G_N = f \cdot k_N \cdot S$

Decision limit $G_E = f \cdot k_E \cdot S$

Herein, the following applies:

- a) in case of an integral digital measurement:

$$S = \sqrt{\frac{R_o}{t_o} \left(1 + \frac{t_o}{t_m} \right)}$$

- b) in case of integral analog measurement:

$$S = \sqrt{\frac{R_o}{2\tau}}$$

- c) in case of gamma spectrometry:

$$S = \sqrt{\frac{2b \cdot \bar{R}_o(E_\gamma)}{t_m}}$$

- d) in case of alpha-spectrometry:

$$S = \sqrt{\frac{\Sigma R_o(E_\alpha)}{t_o} \left(1 + \frac{t_o}{t_m} \right)}$$

with the following nomenclature:

G_N detection limit e.g. Bq

G_E decision limit e.g. Bq

f calibration factor e.g. Bq · s

k_N factor of statistical certainty for the detection limit

k_E factor of statistical certainty for the decision limit

Note:

Numerical values for these characteristic statistical parameters are specified in Section 6.1.3.

R_o Zero effect count rate s^{-1}

$\bar{R}_o(E_\gamma)$ Mean zero effect count rate per channel or eV at the energy E_γ s^{-1}

b Base width of a gamma peak (peak base width); $b = 1.7 h$ where h = half-value width of a gamma peak Number of channels or eV

$\Sigma R_o(E_\alpha)$	Zero effect count rate in the range of the examined alpha peak	s^{-1}
t_o	Zero effect measurement time	s
t_m	Measurement time of the sample or of the measurement medium	s
τ	Time constant	s

In the case of alpha-spectrometric measurements the response and decision limits are calculated on the assumption that the sum of the contents of the channels under a certain alpha-peak is considered as being equal to an integral digital measurement with a single-channel analyzer.

Note:

The equations specified are approximations designed for practical use. They apply in the case of a not too small zero-effect count rate (larger than 20). Details are specified in DIN 25 482.

2.21 Representative sample (for discharges)

A representative sample is a sample the examination of which allows determining the radioactive substances discharged according to type and activity.

2.22 Pipe factor

Pipe factor is the ratio of the activity concentration of a nuclide or nuclide group at the entry port of a sampling probe to the activity concentration at the collection point of the sampling or measurement device for monitoring gaseous or aerosolbound radioactive substances in a stationary condition.

2.23 Cumulative sample

Cumulative sample is a sample accumulated by continuous sampling over a specified time period.

2.24 Design basis accident

Design basis accident is a chain of events which, upon its occurrence, would require interruption of plant operation or task activity for reasons of safety, and which shall be considered in the plant design or for which protective measures are provided with regard to the task activity.

2.25 Monitoring

Monitoring is a collective term for all the different types of a controlled determination of physical parameters and includes the comparison with specified values.

Note:

Monitoring includes

- continuous measurements or
- intermittent analyses of samples (e.g. in the laboratory) or
- a combination of measurement values

always in connection with a comparison to specified values of the physical parameters (e.g., licensed limit values, operational values).

3 Monitoring of Radioactive Substances Discharged with Vent Air During Specified Normal Operation

3.1 General Requirements

(1) The radioactive substances discharged during specified normal operation shall be determined according to kind and activity in accordance with the requirements of Section 3. With regard to the measurement procedures, it shall be differentiated between the following nuclides and nuclide groups:

- radioactive noble gases,

- radioactive aerosols,
- radioactive gaseous iodine,
- tritium,
- radioactive strontium,
- alpha emitters,
- carbon 14.

(2) With regard to monitoring the discharge of radioactive substances, the continuous or non-continuous sampling and the measurements shall normally be performed in a partial exhaust air stream. The volumetric flow of all partial streams shall be continuously monitored.

(3) The volumetric flow of the exhaust air shall be measured and recorded continuously; the measurement error of the volumetric flow shall be specified.

(4) Regarding the continuous measurement of radioactive aerosols and radioactive gaseous iodine, any deviation of the volumetric flow in the partial stream by more than 20% from its nominal value shall be automatically annunciated.

(5) Regarding the detailed assessment of radioactive aerosols, radioactive iodine, tritium, radioactive strontium, carbon 14 and alpha emitters, the flow rate shall be measured and any deviation of the volumetric flow in the partial stream by more than 20% from its nominal value shall be automatically annunciated.

3.2 Radioactive Noble Gases

3.2.1 Continuous Measurement

(1) The discharge rate of the radioactive noble gases discharged with the exhaust air shall be continuously determined by beta-measurements and shall be monitored with respect to a limit value. This requires at least one continuous measurement and recording of the activity concentration in connection with the continuous measurement and recording of the volumetric flow of the exhaust air.

(2) In order to prevent any falsification of the measurement values by aerosol contamination, a Class S high-efficiency particulate air filter in accordance with DIN 24 184 shall be installed in line ahead of the measuring points.

(3) The detection limit of the measurement assembly for measuring the activity concentration shall not exceed 1×10^4 Bq/m³ with respect to xenon 133 and a measurement duration of ten minutes.

(4) The measurement range of the measurement assembly for measuring the activity concentration is determined from the detection limit and the licensed annual limit. The measurement range of the measurement assembly shall allow determining discharge rates up to one tenth of the licensed annual limit value averaged over 24 h under consideration of the volumetric flow of the stack exhaust air.

(5) If the activity measuring point is not designed as being redundant, the discharged radioactive noble gases shall be estimated for the duration of any failure period of this measurement point; the estimation shall be based on some other permanently installed instrumentation and a known exhaust air volumetric flow. The duration of failure shall not exceed a time period of 3 days.

3.2.2 Detailed Assessment

(1) A detailed assessment shall be performed for the radioactive noble gases discharged with the exhaust air. This requires a beta measurement to determine the overall discharge rate and taking into consideration the proportion of each individual nuclide in the nuclide composition.

(2) The non-continuous determination of the nuclide composition shall be performed on a representative sample taken in three months intervals. The samples shall be measured without delay. In this context, the nuclides listed in **Table 3-1** shall at least be taken into account.

Nuclide			
Argon	41	Xenon	131 m
Krypton	85	Xenon	133
Krypton	85 m	Xenon	133 m
Krypton	87	Xenon	135
Krypton	88	Xenon	135 m
		Xenon	138

Table 3-1: Nuclides to be considered in the detailed assessment of radioactive noble gases discharged with the exhaust air

(3) The detection limit for the determination of the individual nuclides shall not exceed 1×10^3 Bq/m³ with respect to xenon 133. The values to be specified for any undetected nuclides listed in **Table 3-1** shall be the detection limits achieved in the individual measurement with the measurement assembly.

(4) The time duration of the measurement for the detailed assessment shall correspond to the time required to achieve the detection limit specified in para. 3.

(5) If the measurement specified under para. 2 detects xenon 133 with an activity concentration exceeding 1×10^3 Bq/m³, however no krypton 85, then a second measurement with regard to the activity concentration of krypton 85 shall be performed after a decay period of no less than two days.

(6) In addition to the sampling in quarterly intervals, further representative samples shall be taken and analyzed without delay if the limit value specified under Section 3.2.1 para. 1 is reached and registers for a duration exceeding 30 minutes. For as long as this limit value continues to be registered, a sample shall be taken at least every 24 hours and the nuclide composition determined without delay.

(7) In the case of non-continuous sampling, the nuclide composition shall be considered as being unchanged in the period between two consecutive samplings.

(8) Alternatively to the requirements under paras. 2 through 7, the discharged radioactive noble gases may also be determined by continuous nuclide specific measurements. The detailed assessment shall be based on the nuclide spectra to be determined daily. When evaluating the daily nuclide spectra, the detection limit of the measurement assembly shall not exceed a value of 1×10^3 Bq/m³ for xenon 133.

(9) Additional radionuclides verified in the stack exhaust air shall be recorded in the report form (cf. **Figure 8-1**) in the line "Other nuclides".

3.3 Radioactive Aerosols

3.3.1 Continuous Measurement

(1) The radioactive aerosols discharged with the exhaust air shall be monitored continuously. For this purpose, the radioactive aerosols shall be continuously accumulated on a Class S high-efficiency particulate air filter in accordance with DIN 24 184 from a partial stream, and shall be measured during the accumulation process.

(2) The measurement assembly shall be designed such that, given a previously uncontaminated high-efficiency particulate air filter and a short-time activity concentration with a

time integral of 4 (Bq/m³) · h for cesium 137, the display of the measurement parameter "activity on the filter" will exceed the decision limit within one hour at the most.

(3) The high-efficiency particulate air filter shall be monitored for a maximum activity value beyond which the filter must be exchanged. Even at this level of filter contamination it shall still be possible at a nominal volumetric flow of the exhaust air to detect a discharge of 5×10^7 Bq with sufficient accuracy ($\pm 20\%$) within less than one hour.

(4) If the activity measuring point is not designed as being redundant, the radioactive aerosols discharged during a failure of the instrumentation for monitoring the discharge of radioactive aerosols shall be estimated on the basis of the known exhaust air volumetric flow by means of some other permanently installed instrumentation, e.g. the one used for monitoring the room atmosphere. The failure duration shall not exceed a time period of three days.

(5) A fulfillment of the requirement for a continuous monitoring may be dispensed with, provided,

- the radioactive aerosols are retained by filtering the entire exhaust air through Class S high-efficiency particulate air filters in accordance with DIN 24 184 and the functioning of the retaining equipment is monitored or
- a continuous measurement of radioactive gaseous iodine is performed as specified under Section 3.4.1.

3.3.2 Detailed Assessment

(1) A detailed assessment shall be performed for the radioactive aerosols discharged with the exhaust air. To this end, radioactive aerosols shall be continuously collected by deposition on a Class S high-efficiency particulate air filters in accordance with DIN 24 184.

(2) The collection period shall not exceed one week; the time elapsed between start of collection and start of measurement shall be accounted for applying a decay correction.

(3) The high-efficiency particulate air filters shall be evaluated by gamma spectrometric measurements within one week of the removal of the filter. In the detailed assessment, the radionuclides listed in **Table 3-2** shall be taken into account.

(4) The high-efficiency particulate air filter under para. 1 shall be measured without delay whenever the limit value specified under Section 3.2.1 para. 1 is reached and registers for more than 30 minutes.

(5) The detection limit of the measurement assembly for determining the activity concentration shall not exceed 2×10^{-2} Bq/m³ with respect to cobalt 60. The values to be specified for any undetected nuclides listed in **Table 3-2** shall be the decision limits achieved in the individual measurement with the measurement assembly.

Nuclide			
Chromium	51	Silver	110 m
Manganese	54	Antimony	124
Cobalt	58	Antimony	125
Iron	59	Iodine	131
Cobalt	60	Cesium	134
Zinc	65	Cesium	137
Zirconium	95	Barium	140
Niobium	95	Lanthanum	140
Ruthenium	103	Cerium	141
Ruthenium	106	Cerium	144

Table 3-2: Nuclides to be considered in the detailed assessment of radioactive aerosols discharged with the exhaust air

(6) The measurement duration for the detailed assessment shall correspond at least to the measurement duration required for reaching the detection limit specified under para. 5.

(7) Additionally verified radionuclides with a half-life longer than eight days shall be recorded in the report form (cf. **Figure 8-1**) in the line "Other nuclides".

3.4 Radioactive Gaseous Iodine

3.4.1 Continuous Measurement

(1) The radioactive iodine discharged with the exhaust air shall be continuously monitored. For this purpose, the radioactive iodine shall be continuously accumulated on an iodine filter from a partial stream, and shall be measured for the activity of iodine 131 (reference nuclide) deposited during the accumulation process.

(2) The measurement assembly shall be designed such that, given a previously uncontaminated high-efficiency particulate air filter and a short-time activity concentration with a time integral of $2 \text{ (Bq/m}^3) \cdot \text{h}$ for iodine 131, the display of the measurement parameter "activity on the filter" will exceed the decision limit within one hour at the most.

(3) The activity on the iodine filter shall be monitored for a maximum activity value beyond which the filter must be exchanged. Even at this level of filter contamination it shall still be possible at a nominal volumetric flow of the exhaust air to detect a discharge of $1 \times 10^6 \text{ Bq}$ with sufficient accuracy ($\pm 20\%$) within less than one hour.

(4) In order to prevent any falsification of the measurement values by aerosol contamination, a Class S high-efficiency particulate air filter in accordance with DIN 24 184 shall be installed in line ahead of the iodine filter.

(5) Separation efficiency and loading capacity of the filters shall be specified and taken into account when choosing the filters both for elementary iodine and for organically bound iodine. The iodine sorbents used shall be characterized by a low adsorption for noble gases.

Note:

The separation efficiency with respect to organically bound iodine is usually determined on the reference basis of methyl iodide.

(6) The fulfillment of the requirement for continuous monitoring specified under para. 1 may be dispensed with, provided, the radioactive iodine of the entire exhaust air is retained in iodine filters and the functioning of the retaining equipment is monitored.

(7) If a continuous measurement of the discharged iodine 131 with the measuring system specified under paras. 1 through 5 cannot be performed on account of the low level of the licensed values, then the use of a plant specific monitoring procedure is permissible.

3.4.2 Detailed Assessment

(1) A detailed assessment of the radioactive iodine discharged with the exhaust air shall be performed. To this end the radioactive gaseous iodine shall be collected by a continuous deposition on filters.

(2) Separation efficiency and loading capacity of the filters shall be specified and taken into account when choosing the filters both for elementary iodine and for organically bound iodine.

(3) In order to prevent falsification of the measurement results by aerosol contamination a Class S high-efficiency particulate air filter in accordance with DIN 24 184 shall be installed ahead of the iodine filter; this may be the same filter as that specified in Section 3.3.2.

(4) The collection period shall not exceed one week; the time elapsed between start of collection and start of measurement shall be accounted for applying a decay correction.

(5) The activity of iodine 131 in the high-efficiency particulate air filter under para. 3 and in the iodine filter shall be determined by gamma spectrometric measurements within one day from the time the samples were taken.

(6) The high-efficiency particulate air filter and the iodine filter shall be measured without delay whenever the limit value specified under Section 3.2.1 para. 1 is reached and registers for more than 30 minutes.

(7) With regard to the detailed assessment of radioactive iodine, the detection limit for iodine 131 (key nuclide) of the measuring system shall not exceed a value of $2 \times 10^{-2} \text{ Bq/m}^3$.

(8) With regard to the detailed assessment measurement, the measurement time shall be at least long enough to achieve the detection limit specified in para. 7.

(9) The detailed assessment of the activity of discharged radioactive iodine shall, preferably, be performed as specified under paras. 1 through 8. Alternatively, it may be performed as specified under paras. 10 through 14, provided, (one) that the activity concentration of iodine 131 in the primary coolant circuit is less than $1 \times 10^5 \text{ Bq/m}^3$ and (two) that the emissions, e.g. from experiments, not accounted for by this procedure are verified as being negligibly small.

(10) With regard to the determining the discharge of iodine, representative water samples shall be taken in weekly intervals from the primary coolant circuit.

(11) The activity of iodine 131 in the representative water samples shall be determined by gamma spectrometric measurements within one week from the time the samples were taken. A decay correction shall be applied.

(12) The detailed assessment of the radioactive iodine discharged with the stack exhaust air shall basically be performed by multiplying the measured activity concentration of radioactive iodine in the primary coolant circuit with one-tenth (plant specific to research reactors) of the quantity of primary coolant evaporated over the period of the detailed assessment. A detailed assessment of the radioactive iodine discharged with the exhaust air based on an experimentally determined coefficient with regard to the transfer of radioactive iodine from the primary coolant circuit to the exhaust air is permissible.

(13) Representative samples of the water from the primary coolant circuit shall be taken and measured without delay if the limit value under Section 3.2.1 para. 1 is reached and registers for more than 30 minutes.

(14) The detection limit of the measuring system for the measurement required under para. 11 shall not exceed a value of $4 \times 10^3 \text{ Bq/m}^3$ for iodine 131 (key nuclide) when performing the measurement on a sample of demineralized water.

3.5 Tritium

3.5.1 Light Water Reactors

(1) The discharge of tritium in the chemical form of water with exhaust air shall be monitored. This requires that tritium samples are collected continuously.

(2) The samples shall be evaluated for tritium in three months intervals. This may be performed either by evaluating the individual samples under para. 1 or by evaluating a representative mixed sample.

- (3) The evaluating procedure shall be able to detect a tritium concentration of 1×10^3 Bq/m³ in the exhaust air.
- (4) If the type of sampling requires that the temperature and humidity of the exhaust air must be taken into account then these parameters shall be determined in monthly intervals.
- (5) If molecular sieves are used to collect tritium then a possible residual activity shall be taken into account to prevent a falsification of the measurement results. Once used molecular sieves should not be used a second time. However, if their reuse is intended, then, prior to their deployment, the used molecular sieves shall be subjected to a four hour long rinsing process in a stream of inert gas at a temperature of 400 °C in order to remove any residual water.
- (6) Alternatively to the requirements under paras. 1 through 5, the procedure described under paras. 7 through 9 may also be used.
- (7) With regard to the detailed assessment of the activity discharge of tritium, the activity concentration of tritium in the pool water shall be measured once a year.
- (8) The activity discharge of tritium shall be obtained from the product of the activity concentration of tritium determined in the sample and the amount of pool water evaporated per annum.
- (9) The detection limit for the measurement of the activity concentration of tritium in the pool water shall not exceed a value of 4×10^4 Bq/m³.
- (10) If a light water reactor is equipped with an additional heavy water tank the tritium inventory which exceeds 1×10^{14} Bq, then the requirements under Section 3.5.2 shall be fulfilled.

3.5.2 Heavy Water Reactors

- (1) The discharge of tritium with the exhaust air shall be monitored continuously with respect to a limit value and shall be subjected to a detailed assessment.
- (2) With respect to the nominal volumetric flow of the exhaust air, the measurement range of the measurement assembly shall permit the monitoring of discharge rates between 5×10^7 Bq/h and 5×10^{11} Bq/h.
- (3) The detection limit of the measurement assembly shall not exceed a value of 2×10^3 Bq/m³.
- (4) In order to prevent a falsification of the measurement due to aerosol contamination, a Class S high-efficiency particulate air filter in accordance with DIN 24 184 shall be installed ahead of the measurement system.
- (5) The volumetric flows of measurement air and counter gas shall be kept constant, with a permissible deviation of $\pm 15\%$, and each shall be monitored by flow rate meters with respect to an upper and a lower limit value.

3.6 Radioactive Strontium

- (1) The radioactive strontium discharged with the exhaust air shall be monitored by continuously accumulating strontium on a Class S high-efficiency particulate air filter in accordance with DIN 24 184 from a partial exhaust air stream. This high-efficiency particulate air filter may be identical to the one under Section 3.3.2.
- (2) An evaluation for strontium 89 and strontium 90 shall be performed in three months intervals on mixed samples that may be created from the high-efficiency particulate air filters exposed in that particular time period. In the case of strontium 89, the time elapsed between start of collection and start of measurement shall be accounted for applying a decay correction.

- (3) A detailed assessment shall be performed with regard to the activity of radioactive strontium discharged with the exhaust air. In this respect, the detection limit for discharged strontium 89 and strontium 90 shall not exceed a value of 1×10^{-3} Bq/m³.
- (4) The fulfillment of the requirement for the detailed assessment under paras. 1 through 3 may be dispensed with, provided, the activity concentration of lanthanum 140 (key nuclide) from the detailed assessment of radioactive aerosols under Section 3.3.2 does not exceed a value of 2×10^2 Bq/m³ and the discharge of strontium 89 and strontium 90 from carrying out experiments is verified as being negligibly small.

3.7 Alpha Emitters

- (1) The alpha emitting radioactive materials (alpha emitters) discharged with the exhaust air shall be monitored by continuously accumulating strontium on a Class S high-efficiency particulate air filter in accordance with DIN 24 184 from a partial exhaust air stream. This high-efficiency particulate air filter may be identical to the one under Section 3.3.2.
- (2) The nuclide specific evaluation for alpha emitters shall be performed in three months intervals on mixed samples that may be created from the high-efficiency particulate air filters exposed in that particular time period.
- (3) A detailed assessment shall be performed for alpha emitters discharged with the exhaust air. In this assessment the radionuclides listed in Table 3-3 shall be taken into account. The detection limit of the measurement assembly shall not exceed a value of 5×10^{-3} Bq/m³ with respect to americium 241. For those radionuclides listed in **Table 3-3** which were not detected, the decision limits achieved in the individual measurement with this measurement assembly shall be specified. The measurement time for this detailed assessment shall at least correspond to the measurement time required to achieve the required detection limit for americium 241. In the detailed assessment the nuclide pairs plutonium 238 and americium 241 as well as plutonium 239 and americium 240 may be summed up together.

Nuclide			
Uranium	234 ¹⁾	Americium	241
Plutonium	238	Curium	242
Plutonium	239	Curium	244
Plutonium	240		

¹⁾ In place of curium 242 and curium 244, for research reactors with highly enriched nuclear fuel

Table 3-3: Nuclides to be considered in the detailed assessment of alpha emitters discharged with the exhaust air

- (4) Additionally verified radionuclides shall be recorded in the report form (cf. Figure 8-1) in the line "Other nuclides".
- (5) The fulfillment of the requirement for the detailed assessment under paras. 1 through 3 may be dispensed with, provided, the overall alpha activity concentration in the primary coolant circuit does not exceed a value of 1×10^3 Bq/m³ and the discharge of alpha emitters from carrying out experiments is verified as being negligibly small. The overall alpha activity concentration shall be determined in three months intervals from representative mixed samples.

3.8 Carbon 14

- (1) The discharge of carbon 14 in the chemical form of carbon dioxide with the exhaust air shall be monitored. This requires that carbon 14 samples are collected continuously. The

evaluation for carbon 14 shall be performed in three months intervals by evaluating representative mixed or cumulative samples. The evaluating procedure shall be able to detect a carbon 14 activity concentration of 5 Bq/m³ in the exhaust air.

(2) The fulfillment of the requirement under para. 1 for monitoring may be dispensed with, provided, the activity concentration of carbon 14 is assessed in detail by another determination procedure, e.g. one that is based on calculating the production rate of carbon 14.

3.9 Sampling

(1) The sampling location and sampling procedure shall be chosen such that the samples taken are representative for emission monitoring. The objective must be that the exhaust air is homogeneously mixed in the region where samples are taken.

(2) The volumetric flow rate of the partial exhaust air stream shall normally not be less than one thousandths of the nominal volumetric flow rate of the exhaust air.

Note:

Details regarding sampling are specified in DIN 25 423.

(3) With regard to the continuous sampling of iodine and aerosols, the sampling line shall be of a material that has a low adsorption capability for iodine and aerosols. Short lines shall be used. Horizontal sections and tight bends of the sampling lines shall, if possible, be avoided; if bends cannot be avoided, their bending radius should be larger than five times the pipe diameter. The inside surface of pipe transitions shall be designed such that disturbances of flow characteristics are prevented; likewise, care shall be taken that smooth inner surfaces are achieved. Corrugated pipes or components with a corrugated inside surface shall not be used.

(4) Ageing effects shall be taken into account in the choice and storage of the adsorption material for filters. The temperature range shall be specified and met as specified.

(5) With regard to the filter mounting, care shall be taken that

- a) during operation the leak-tightness is such that the volumetric flow of leakage air is negligibly small comparative to that of the partial stream for sampling,
- b) any damage to the filter in the region of the filter gasket is prevented,
- c) any bypass flow around the filter is avoided,
- d) it is ensured that the change of filter can be performed easily and to a large extent without contamination,
- e) it is corrosion resistant and easy to decontaminate.

(6) If sampling is non-continuous, timing and duration of the sampling shall be selected such that the samples are representative of the amounts of radioactive substances discharged between two samplings.

(7) The sampling system for continuous sampling of radioactive aerosols shall be designed such that during specified normal operation the entire spectrum of particles with aerodynamically equivalent diameters in the range from 0.1 to 20 µm is monitored. The overall loss factor of the as-built sampling system shall be determined by one of the following methods:

- a) The overall loss factor of activity bound to aerosol particles is determined with test aerosol particles whose particle size distribution has a median value of the aerodynamically equivalent diameter of about 1 µm and a geometric standard deviation between 2 and 3. These test particles shall be fed into the exhaust air duct and the overall loss factor determined from the amount supplied and the amount found on the collecting medium. The overall loss factor may, alternatively, be determined by feeding the test aerosols into one of the sampling probes and calculating the pipe factor. In this case, the other parameters required

for determining the overall loss factor shall be determined by separate measurements or calculations.

- b) The overall loss factor for activity bound to aerosol particles shall be determined by comparing the activity concentrations measured directly in the exhaust air stack and the activity concentration determined from the measurement values of the collecting and measurement systems.

- c) The overall loss factor shall be determined upon commissioning of the sampling system as well as after every change to the sampling systems that could essentially influence the overall loss factor.

(8) The overall loss factor determined as specified under paragraph 7 shall be taken into consideration in the detailed assessment of the discharge of radioactive aerosols.

(9) The sampling system shall be designed and located such that the ambient temperature can never drop below the dew point.

3.10 Non-centrally Monitored Emission

3.10.1 General Requirements

In research reactors radioactive substances may be produced in rooms and parts of the facility or may be transported to locations that are not connected to the central exhaust air stack. The path of discharge of these radioactive substances ("non-centrally monitored emissions") shall be properly documented with respect to the individual facility or task.

3.10.2 Monitoring

The discharge of radioactive substances from the facilities or during the tasks specified under Section 3.10.1 shall be monitored. Therefore, representative monthly samples shall be taken from suitable locations and at times that are representative for the individual operating period; these samples shall be evaluated with regard to their nuclide specific activity. The annual activity discharge shall be estimated on the basis of this evaluation and shall be documented in the annual report.

Note:

The essential requirements of Section 3 are collated in **Table 3-4**.

4 Monitoring of Radioactive Substances Discharged with Vent Air During Design Basis Accidents

4.1 General Requirements

(1) During and after design basis accidents the discharged radioactive substances shall be determined according to type and activity in accordance with the requirements of this section. With regard to the measurement procedures and the radiological relevance of the discharged radioactive substances, the following nuclides and nuclide groups shall be discerned between:

- a) radioactive noble gasses,
- b) radioactive aerosols,
- c) radioactive gaseous iodine,
- d) tritium.

(2) Provided, design basis accident analyses verify that the design basis accident related activity discharge of all or individual nuclides or nuclide groups specified under para. 1

- a) cannot lead to values exceeding the licensed annual values and
- b) is monitored by the measurement systems for specified normal operation in accordance with the requirements regarding measurement system for monitoring radioactive substances discharged with exhaust air during design basis accidents,

then, additional measurement systems for the individual nuclide groups may be dispensed with.

(3) The continuous or non-continuous sampling and measurements necessary for monitoring the discharge of radioactive substances shall normally be performed in a partial exhaust air stream.

(4) The volumetric flow of the exhaust air shall be continuously measured and recorded.

(5) The volumetric flows of the partial exhaust air streams shall be monitored; should the volumetric flows of the partial streams drop below a certain limit value this shall cause a control room alarm in the Section dedicated to emission monitoring.

(6) In the case of fire and the ensuing smoke removal through the exhaust air stack and in case of a simultaneous unavailability of the measurement systems for monitoring radioactive substances discharged with stack exhaust air, e.g. due to clogging of the pre-filters or filters, the radioactivity discharged in this time period shall be estimated on the basis of measurements with different instrumentation.

(7) With respect to the evaluation of gaseous samples, of the aerosol filters and of the iodine filters, suitable procedures and measurement systems shall be available in the laboratory that take into consideration the maximum expected activity of the samples.

4.2 Radioactive Noble Gases

4.2.1 Continuous Measurement

(1) The discharge rate of radioactive noble gases discharged with exhaust air shall be determined on a continuous basis by measuring the activity concentration and the volumetric flow of the exhaust air.

(2) The activity concentration of the radioactive noble gases shall be determined from an overall beta measurement.

(3) With respect to the measurement of the activity concentration, one filter with a minimum retention capability of 90% for elementary iodine and a Class S high-efficiency particulate air filter in accordance with DIN 24 184 shall be installed inline ahead of the measurement chamber.

(4) The detection limit of the measurement assembly for measuring the activity concentration shall not be larger than one thousandths of the licensed annual value averaged over 24 hours.

(5) Design basis accident analyses shall be performed in order to specify the end points of the measurement range. The resulting maximum activity concentration of radioactive noble gases in the exhaust air multiplied by a safety margin of 10 shall normally still lie within the measurement range of the measurement assembly.

(6) The activity measuring point specified under Section 3.2.2 for specified normal operation may be used as the measurement system under para. 2, provided, these are redundantly available and they fulfil the requirements under Section 4.

4.2.2 Detailed Assessment

(1) The nuclide composition of the radioactive noble gases discharged with exhaust air shall be determined by gamma spectrometric measurements.

(2) In case the nuclide composition of radioactive noble gases is determined non-continuously, then, from the onset of a design basis accident, representative samples shall basically be taken in hourly intervals for as long as an accident related release exceeding the licensed limit value for specified normal operation must be reckoned with; these samples shall be evaluated without delay. It is permissible to take the samples

and perform the nuclide specific measurements in time intervals longer than one hour, provided, the measurement value of the noble gas measuring point specified under Section 4.2.1 indicates that no essential changes have occurred.

(3) In the case of a non-continuous determination of the nuclide composition, the discharged radioactive noble gas nuclides shall be determined based on the activity concentration determined using the measurement system specified under Section 4.2.1 para. 2.

(4) The nuclide composition of radioactive noble gases may also be determined by continuous nuclide specific measurements.

4.3 Radioactive Aerosols

(1) For as long as a design basis accident related discharge of radioactive aerosols exceeding the licensed limit value for specified normal operation must be reckoned with, the activity of the individual nuclides of the radioactive aerosols discharged with exhaust air shall be determined, if possible, in hourly intervals by gamma spectrometric measurements.

(2) With respect to the determination of the nuclide composition of the radioactive aerosols, these shall be continuously collected on a Class S high-efficiency particulate air filter in accordance with DIN 24 184. This collection point may be identical to the collection point specified under Section 3.3.3 for the detailed assessment of radioactive aerosols during specified normal operation, provided, it fulfills the requirements under Section 4.

(3) During the collection of radioactive aerosols the flow rate shall be measured and an alarm automatically given whenever the partial stream volumetric flow deviates by more than 20% from its nominal value.

(4) The high-efficiency particulate air filter under para. 2 shall normally be evaluated, if possible, without delay; the analyses for determining the alpha emitters and the strontium isotopes discharged with the exhaust air may be performed on cumulative samples at the end of the design basis accident.

4.4 Radioactive Gaseous Iodine

(1) For as long as a design basis accident related discharge of radioactive iodine exceeding the licensed limit value for specified normal operation must be reckoned with, the activity of the individual nuclides of the radioactive iodine discharged with exhaust air shall be determined, if possible, in hourly intervals by gamma spectrometric measurements.

(2) With respect to determining the nuclide composition of radioactive iodine, it shall be continuously collected on an iodine filter. This collection point may be identical to the collection point required under Section 3.4.3 for the detailed assessment of radioactive iodine during specified normal operation, provided, it also fulfills the requirements under Section 4.

(3) In order to prevent any falsification of the measurement values by aerosol contamination, a Class S high-efficiency particulate air filter in accordance with DIN 24 184 shall be installed inline ahead of the iodine filter; this high-efficiency particulate air filter may be identical to the one required under Section 4.3 para. 2.

(4) During the collection of radioactive iodine the flow rate shall be measured and an alarm automatically given whenever the volumetric flow deviates by more than 20% from its nominal value.

4.5 Tritium

(1) A monitoring for tritium shall be performed in heavy water reactors and in light water reactors equipped with additional heavy water tanks the tritium inventory of which could exceed a value of 1×10^{14} Bq.

(2) The activity discharge rate of tritium with exhaust air shall be monitored by continuous measurements.

(3) In order to prevent any falsification of the measurement values by aerosol contamination, a Class S high-efficiency particulate air filter in accordance with DIN 24 184 shall be installed inline ahead of the measurement system.

(4) The volumetric flow of both the measurement air and the counter gas shall be held constant within a deviation range of

$\pm 15\%$ and shall each be monitored by a flow rate meter for the particular upper and lower limit value.

(5) The detection limit of the measurement assembly for measuring the discharge rate shall not be larger than one thousands of the licensed annual value averaged over 24 hours.

(6) Design basis accident analyses shall be performed in order to specify the end points of the measurement range. It shall normally be possible to monitor the resulting maximum discharge rate of tritium multiplied by a safety margin of 10.

(7) The measurement assembly for specified normal operation required under Section 3.5.2 may be used for the monitoring of tritium during design basis accidents, provided, it also fulfills the requirements under Section 4.

Measurement Task	Measurement or Sampling System	Measurement Range (Bq/h)	Detection Limit	Reference Nuclide	Remarks
Noble gasses Continuous measurement	β -detector	1)	$1 \cdot 10^4$ Bq/m ³	Xe 133	Limit value is oriented on the value of the licensed discharge If Xe 133, but no Kr 85, is verified, then a second measurement for Kr 85 shall be performed no less than two days later
	Detailed assessment		γ - detector	$1 \cdot 10^3$ Bq/m ³	
Aerosols Continuous measurement	β - or γ - detector		4 (Bq/m ³) h	Cs 137	The continuous measurement may be dispensed with, provided, a continuous measurement for radioactive iodine is performed or the radioactive aerosols are retained by filtering the entire exhaust air and the proper functioning of the retaining equipment is monitored.
	Detailed assessment	Filter collector	$2 \cdot 10^{-2}$ Bq/m ³	Co 60	
Iodine Continuous measurement	γ - detector		2 (Bq/m ³) h	I 131	The continuous measurement may be dispensed with, provided, radioactive gaseous iodine is retained by filtering the entire exhaust air and the proper functioning of the retaining equipment is monitored.
	Detailed assessment	Filter collector	$2 \cdot 10^{-2}$ Bq/m ³	I 131	
		Water sample		$4 \cdot 10^3$ Bq/m ³	I 131
Tritium Light water RR Detailed assessment	Collector		$1 \cdot 10^3$ Bq/m ³	H 3	Alternative measurement in the primary coolant circuit
	Water sample		$4 \cdot 10^4$ Bq/m ³	H 3	
Heavy water RR Continuous measurement	Tritium measurement location	$5 \cdot 10^7$ to $5 \cdot 10^{11}$	$2 \cdot 10^3$ Bq/m ³	H 3	measurement values from the continuous measurement shall be used
	Detailed assessment				
Strontium Detailed assessment	Filter collector		$1 \cdot 10^{-3}$ Bq/m ³		The detailed assessment may be dispensed with, provided, the activity concentration of La 140 (reference nuclide) in the detailed assessment of radioactive aerosols does not exceed 2×10^{-2} Bq/m ³ and, provided, and the discharge from carrying out experiments is verified as being negligibly small.
Alpha emitters Detailed assessment	Filter collector		$5 \cdot 10^{-3}$ Bq/m ³	Am 241	cf. KTA 1503.1
	Water sample		$1 \cdot 10^3$ Bq/m ³	Am 241	The detailed assessment may be dispensed with, provided, the overall activity concentration of alpha emitters in the primary coolant circuit does not exceed 1×10^{-3} Bq/m ³ and, provided, and the discharge from carrying out experiments is verified as being negligibly small.
Carbon 14 Detailed assessment	Collector		5 Bq/m ³		Collection of carbon dioxide. Other determination procedures are permissible.

¹⁾ upper limit of measuring range is at least one tenth of annual license value averaged over 24 h.

Table 3-4: Monitoring of the discharge of radioactive substances with exhaust air during specified normal operation

4.6 Sampling

4.6.1 Radiation Protection and Sampling Locations

(1) The sampling, sample transport and nuclide specific measurement shall be designed such that the corresponding radiation exposure per individual person and sampling shall not exceed a design guide value of 1 mSv.

(2) Sampling locations that must be personally attended to shall be chosen and shielded such that the corresponding local dose rates at these locations shall, as a result of the design basis analyses, not exceed a design guide value of 10 mSv/h.

(3) The sampling locations shall be chosen such that sampling shall be possible during a design bases accident. In this respect, a longer sampling tube is permissible than the one of the measurement systems for monitoring the radioactive substances discharged with exhaust air during specified normal operation.

(4) The exhaust air channels leading out of the area protected against external events shall be equipped with connecting possibilities for the removal of samples.

4.6.2 Sampling Equipment and Procedures

(1) Sampling location and sampling procedure shall normally be chosen such that the samples taken are representative for emission during a design basis accident. The objective must be that the exhaust air is homogeneously mixed in the region where samples are taken.

(2) The sampling lines for iodine and aerosols shall be of a material that has a low adsorption capability for iodine and aerosols. Horizontal sections and tight bends of the sampling lines shall, if possible, be avoided; if bends cannot be avoided, their bending radius should be larger than five times the pipe diameter. The inside of pipe transitions shall be designed such that disturbances of the flow characteristics are prevented; likewise, care shall be taken that smooth inner surfaces are achieved. Corrugated pipes or components with a corrugated inner surface shall not be used.

(3) Ageing effects shall be taken into account in the choice of the adsorption material for filters. The temperature range shall be met as specified.

(4) Separation efficiency and loading capacity of the filters shall be taken into account when choosing the filters both for elementary iodine and for organically bound iodine. The iodine sorbents used shall be characterized by a low adsorption capability for noble gases.

(5) The components of the aerosol and iodine filters shall be designed and arranged such that

- a) leak tightness is ensured during operation and the volumetric flow of leakage air is negligibly small comparative to that of the partial stream for sampling,
- b) any damage to the filter in the region of the filter gasket and any bypass flow around the filter are avoided,
- c) it is ensured that the exchange of filter can be easily performed,
- d) all mechanical parts are corrosion resistant,
- e) the arrangement can be flushed, e.g., for the removal of noble gases.

(6) The sampling system shall be designed or located such that the ambient temperature will not drop below the dew point.

(7) In the case of non-continuous sampling, the nuclide composition shall be considered as being constant in the period between two consecutive samplings.

5 Monitoring of Radioactive Substances Discharged with Water

5.1 Radioactively Contaminated Waste Water

5.1.1 General Requirements

(1) Radioactive waste water produced during reactor operation shall be collected in a discharge tank prior to discharge.

(2) If the nuclear operating license for the reactor includes the handling of unsealed radioactive substances, e.g. in radiochemistry laboratories, the reactor operator shall be responsible for monitoring this radioactive waste water. In this case, the procedure specified under para. 1 shall be followed.

5.1.2 Sampling

Prior to its discharge, a sample which shall be representative of the entire contents of the discharge tank shall be taken. This requires that prior to sampling the entire contents of the tank is homogenized, e.g., by pumping into a second tank, by circulating or by mixing with an agitator. The duration of homogenization should be adapted to the size of the tank and should last at least 30 minutes. Prior to sampling, the sampling line shall be flushed with the homogenized water. One liter of the sample shall be used for the decision-making measurement and shall be stored as evidential sample for the duration of one year (one-liter sample). Mixed samples for the detailed assessment may be taken in proportion to the discharge from the other parts of the sample. From the moment of sampling until the end of the discharge procedure, no water shall flow into the discharge tank.

5.1.3 Decision-making Measurement

(1) In order to make a decision with respect to a discharge from the discharge tank, an integral measurement of gamma radiation in the energy range above 0.1 MeV shall be performed. If it must be presumed that, due to the handling of unsealed radioactive substances specified under Section 5.1.1 para. 2, pure beta emitters or alpha emitters are present in the waste water, an integral measurement of beta emission in the energy range above 0.1 MeV or an integral measurement of alpha emission in the energy range above 4 MeV shall be performed. These measurements shall be performed as double determinations. Integral pulse rates shall be specified as a cesium 137 equivalent for gamma emitters, as a strontium 90/yttrium 90 equivalent for beta emitters, and as an americium 241 equivalent for alpha emitters.

(2) An additional double determination of the activity concentration of tritium shall be performed in the case of heavy water reactors and of light water reactors equipped with additional heavy water tanks the tritium inventory of which could exceed a value of 1×10^{14} Bq.

(3) The integral measurements specified under para. 1 shall be performed in such a way that activity concentrations can be determined which lie in a range between 1×10^4 and 1×10^7 Bq/m³ (cesium 137 equivalent) in the case of gamma radiation, between 1×10^3 and 1×10^5 Bq/m³ (strontium 90/yttrium 90 equivalent) in the case of beta emission, and between 1×10^3 and 1×10^6 Bq/m³ (americium 241 equivalent) in the case of gamma radiation. The measurement of the activity concentration of tritium specified under para. 2 shall cover a range between 4×10^4 and 4×10^9 Bq/m³.

Note:

The terms 'strontium 90/yttrium 90 equivalent' and 'americium 241 equivalent' are used analogously to the term 'cesium 137 equivalent' defined under Section 2.6.

5.1.4 Discharging

(1) The water from the discharge tank shall be pumped off only if the activity concentration of the water does not exceed a value of 5×10^6 Bq/m³ (cesium 137 equivalent) and the licensed discharge values or the discharge values specified by the authorities are not exceeded and if written confirmation has been received from a radiological protection officer or from a person authorized by that officer.

(2) During the discharging procedure the activity concentration of the waste water shall be continuously monitored by measurement system for the integral measurement of gamma radiation. Both, exceeding the activity concentration of 5×10^6 Bq/m³ (cesium 137 equivalent) as well as a failure of the measurement system shall be displayed and recorded in the control room. The discharging procedure shall be interrupted in these cases.

(3) The measurement range of the measurement system for the integral measurement of gamma radiation under para. 2 shall extend at least from 1×10^5 to 1×10^7 Bq/m³ (cesium 137 equivalent).

(4) Taking a measurement duration of one hour, the detection limit of the measurement system for the integral measurement of gamma radiation specified under para. 2 shall not exceed the lower limit of the measurement range specified under para. 3.

5.1.5 Detailed Assessment

5.1.5.1 Gamma Sources

(1) With regard to the detailed assessment and, provided, the procedure under para. 2 is not used, a part of the sample taken prior to discharging shall be subjected to a gamma-spectroscopic analysis within the week following the discharge. This shall take at least the nuclides listed in **Table 5-1** into consideration. The detection limit of the measurement assembly for determining the activity concentration when measuring a demineralized water sample shall not exceed a value of 1×10^3 Bq/m³ for cobalt 60. The measurement time for the detailed assessment shall correspond at least to the measurement time required for achieving the detection limit for cobalt 60. Within the framework of gamma spectrometric analyses it shall be checked whether other radionuclides not listed in **Table 5-1** also occur. If they are verified they shall also be included in the detailed assessment.

(2) In case a mixed sample created specified under Section 5.1.2 is used for the detailed assessment, then the choice of the collection and evaluation time period shall take the required detection limits, the half-lives of the expected nuclides and the licensed discharge limit values into account.

5.1.5.2 Radioactive Strontium

Mass proportional three-month mixed samples shall be prepared and analyzed for strontium 89 and strontium 90 within one month after their preparation. The detection limit of the procedure for determining the activity concentration shall not exceed the value of 5×10^2 Bq/m³.

5.1.5.3 Alpha Emitters

Mass proportional twelve-month mixed samples shall be prepared and analyzed for alpha emitters (overall activity) within three months after their preparation. The detection limit of the procedure for determining the overall alpha activity concentration shall not exceed the value of 2×10^2 Bq/m³. If the analysis of a sample results in a value for the overall alpha activity concentration exceeding 1×10^3 Bq/m³ then this sample shall be analyzed with respect to its content of indi-

vidual alpha emitters. This shall take the nuclides listed in **Table 5-2** into account. The detection limit of the procedure for determining the activity concentration shall not exceed the value of 50 Bq/m³ with respect to americium 241. In the detailed assessment, the nuclides plutonium 239 and plutonium 240 may be summed up together.

(2) Additional radionuclides verified in the waste water shall be recorded in the report form (cf. **Figure 8-1**) in the line "Other nuclides".

Nuclide			
Chromium	51	Silver	110m
Manganese	54	Antimony	124
Cobalt	58	Antimony	125
Iron	59	Iodine	131
Cobalt	60	Cesium	134
Zinc	65	Cesium	137
Zirconium	95	Barium	140
Niobium	95	Lanthanum	140
Ruthenium	103	Cerium	141
Ruthenium	106	Cerium	144

Table 5-1: Nuclides to be considered in the detailed assessment of radioactive substances discharged with water: Gamma sources

Nuclide			
Uranium	234	¹⁾	Americium 241
Plutonium	238		Curium 242
Plutonium	239		Curium 244
Plutonium	240		

¹⁾ in place of Curium 242 and Curium 244, in the case of research reactors with highly enriched nuclear fuel

Table 5-2: Nuclides to be considered in the detailed assessment of radioactive substances discharged with water: Alpha emitters

5.1.5.4 Tritium

(1) Mass proportional twelve-month mixed samples shall be prepared and analyzed for their content of tritium within three months after their preparation.

(2) In the case of heavy water reactors and light water reactors equipped with additional heavy water tanks the tritium inventory of which could exceed a value of 1×10^{14} Bq, mass proportional monthly mixed samples shall be prepared and analyzed for their content of tritium within the following week after their preparation.

(3) The detection limit of the procedure for determining the activity concentration shall not exceed a value of 4×10^4 Bq/m³.

5.1.5.5 Other Radionuclides

If it cannot be excluded that, due to a nuclear operating license specified under Section 5.1.1 para. 2, radionuclides can get into the discharge tank that cannot be determined by the measurement procedures specified for detailed assessment in the previous sections, then special methods for the detailed assessment of these radionuclides shall be specified in the operating manual.

5.1.5.6 Consideration of the Time Period of Collection

The time elapsed between start of collection and start of measurement shall be accounted for applying a decay correction.

5.2 Cooling Water**5.2.1** Open Secondary Cooling Systems

(1) Open secondary cooling systems shall basically be subjected to a continuous monitoring in the secondary coolant circuit or in the bleed water by measurement systems for the integral measurement of gamma radiation. The requirement for continuous monitoring of the secondary cooling system is dispensable, provided, it is ensured for all operating conditions of the reactor that the pressure in the secondary cooling system is higher than that in the primary cooling system or, if this condition cannot be met during plant outage, that operating instruction specify that the primary cooling system or the secondary cooling system must be isolated during plant outage.

(2) If the equipment for continuous monitoring specified under para. 1 is not available in the secondary cooling system, then, after those time periods when the definite pressure drop between primary coolant circuit and secondary coolant circuit was not upheld, a representative sample shall be removed from the secondary cooling system at a location close to the heat exchangers; its gamma count rate shall be determined as a cesium 137 equivalent by measuring the gamma radiation in the energy range above 0.1 MeV; this shall be carried out prior to a return to service of the secondary cooling system.

(3) The measurement range of the measurement system for continuous monitoring specified under para. 1 shall extend at least from 4×10^4 to 1×10^7 Bq/m³ (cesium 137 equivalent).

(4) Taking a measurement duration of ten minutes, the detection limit of the measurement system for continuous monitoring specified under para. 1 shall not be larger than the lower limit of the measurement range specified under para. 3.

(5) The limit value of the monitoring equipment specified under para. 1 shall be set at 4×10^5 Bq/m³. Any exceeding of this limit value shall cause an automatic alarm and shall be recorded.

(6) Prior to emptying the cooling system or to a non-continuous bleed-off procedure, a representative sample shall be taken from the secondary cooling system and shall be evaluated as specified in para. 7.

(7) A sample shall be taken from the secondary cooling system or from the bleed-off water in monthly intervals; its gamma count rate shall be determined within the following week by measuring the gamma radiation in the energy range above 0.1 MeV as a cesium 137 equivalent.

(8) If the conditions of para. 1 sentence 2 do not apply, then in the case of failure of the measurement system for continuous monitoring specified under para. 1, a daily sample shall be taken from the secondary cooling system or the bleed-off water; its gamma count rate shall be determined within the next 24 hours by measuring the gamma radiation in the energy range above 0.1 MeV as a cesium 137 equivalent.

(9) The measurement range of the integral gamma measurement system for the evaluation of the samples taken as specified under paras. 2, 6, 7 and 8 shall extend at least from 4×10^3 to 1×10^7 Bq/m³ (cesium 137 equivalent).

(10) If the evaluation verifies that a sample taken as specified under para. 2 has an activity concentration of more than 1×10^4 Bq/m³ (cesium 137 equivalent) then the secondary cooling system shall not be returned to service.

(11) The reactor shall be shut down without delay, either, if the activity concentration at the measurement system for continuous

monitoring specified under para.1 exceeds a value of 4×10^5 Bq/m³ (cesium 137 equivalent) or if the evaluation of one of the samples taken as specified under paras. 6, 7 and 8 is verified as having an activity concentration exceeding a value of 1×10^4 Bq/m³ (cesium 137 equivalent).

5.2.2 Closed Secondary Cooling Systems (Intermediate Coolant Circuits)

(1) Intermediate coolant circuits shall preferably be monitored by measurement systems for the continuous integral measurement of gamma radiation.

(2) If the equipment for continuous monitoring specified under para. 1 is not available, a sample shall be taken from each intermediate coolant circuit in weekly intervals; their gamma count rate shall be determined within the following week by measuring the gamma radiation in the energy range above 0.1 MeV as a cesium 137 equivalent.

(3) If the equipment for continuous monitoring specified under para. 1 is available, a sample shall be taken from each intermediate cooling system only in three month intervals; their gamma count rate shall be determined within the following week by measuring the gamma radiation in the energy range above 0.1 MeV as a cesium 137 equivalent.

(4) The measurement range of the measurement system for continuous monitoring specified under para. 1 shall extend at least from 4×10^4 to 1×10^7 Bq/m³ (cesium 137 equivalent).

(5) Taking a measurement duration of ten minutes, the detection limit of the measurement system for continuous monitoring specified under para. 1 shall not exceed the lower limit of the measurement range specified under para. 4.

(6) The limit value of the monitoring equipment specified under para. 1 shall be set at 4×10^5 Bq/m³. An exceeding of this limit value shall cause an automatic alarm and shall be recorded.

(7) The measurement range of the integral gamma measurement system for the evaluation of the samples specified under paras. 2 and 3 shall extend at least from 4×10^4 to 1×10^7 Bq/m³ (cesium 137 equivalent).

(8) The corresponding intermediate coolant circuit should be shut down, either, if the activity concentration at the measurement system for continuous monitoring specified under para.1 exceeds a value of 4×10^5 Bq/m³ (cesium 137 equivalent) or if the evaluation of one of the samples taken as specified under paras. 2 and 3 is verified as having an activity concentration exceeding a value of 1×10^4 Bq/m³ (cesium 137 equivalent). Otherwise, a sample shall be taken without delay from the corresponding tertiary cooling system; its gamma count rate shall be determined within a short time period by using the integral gamma measurement system specified under para. 7 and measuring the gamma radiation in the energy range above 0.1 MeV as a cesium 137 equivalent.

(9) Provided, the activity concentration verified for the sample taken as specified under para. 8 sentence 2 does not exceed 1×10^4 Bq/m³ (cesium 137 equivalent) and, provided, the activity concentration in the corresponding secondary coolant circuit does not exceed 4×10^5 Bq/m³, then further samples shall be taken in weekly intervals from the tertiary cooling system; their gamma count rate shall be determined within 24 hours by using the integral gamma measurement system specified under para. 7 and measuring the gamma radiation in the energy range above 0.1 MeV as a cesium 137 equivalent. In case the activity concentration in the corresponding secondary coolant circuit is larger than 4×10^5 Bq/m³, then further samples shall be taken from the tertiary cooling system in daily intervals and shall be evaluated without delay.

(10) If the evaluation of one of the samples taken as specified under paras. 8 and 9 verifies an activity concentration exceeding 1×10^4 (cesium 137 equivalent) in the tertiary cooling system, then the corresponding intermediate coolant circuit shall be shut down without delay.

Note 1:

To help in visualizing the requirements of this safety standard, **Figure 5-1** presents a schematic of the systems required to be monitored together with the corresponding measurement systems and sampling locations. The requirements with respect to the measurement systems are collated in **Tables 5-3** and **5-4**.

Note 2:

The requirements of this Section and of Section 6 with respect to the stationary measurement systems take into account that the discharge of radioactive substances occurs in a controlled way both during specified normal operation and during design basis accidents. In the case of a failure of vessels, components and their connecting pipe lines, the released water will be retained in the tub-like rooms or will be led by the drainage system into sumps, collecting tubs or vessels where it is collected; even during a design basis accident the radioactive substances will, therefore, be discharged via planned paths that are monitored by the monitoring equipment for specified normal operation.

6 Design and Construction of Monitoring Equipment

6.1 General Requirements for Stationary Monitoring Equipment

6.1.1 Design and Location

(1) The individual monitoring equipment shall be designed for the ambient conditions, measurement medium conditions as well as operating voltages as specified in **Table 6-1**.

(2) The measurement value shall vary by no more than $\pm 30\%$ with respect to the measurement value obtained at the time of calibration specified under Section 7.2.3.3 when any one of the influence parameters varies within the nominal operating ranges specified in **Table 6-1** and the other influence parameters remain essentially constant at the reference values of the calibration. However, when monitoring gaseous and aerosolbound radioactive substances, the difference between the pressure at the sampling location and at the measuring volume shall normally not exceed 200 mbar.

(3) With respect to the influence parameters listed in **Table 6-1** the likewise listed reference values shall be used. With respect to filter loading, the uncontaminated condition shall be the reference value. With respect to back ground radiation, the reference value shall be specified by the manufacturer of the monitoring equipment.

Section	Measurement	Measurement Procedure	Minimum Measurement Range Bq/m ³	Detection limit Bq/m ³	Limit Value Bq/m ³	Reference Nuclide
5.1.3	Decision-making measurement	γ -measurement	$1 \cdot 10^4$ to $1 \cdot 10^7$	¹⁾	$5 \cdot 10^6$	Cs-137
		β -measurement	$1 \cdot 10^3$ to $1 \cdot 10^6$	¹⁾	²⁾	Sr-90/Y-90
		α -measurement	$1 \cdot 10^3$ to $1 \cdot 10^6$	¹⁾	²⁾	Am-241
5.1.4	Continuous monitoring of discharge	γ -measurement	$1 \cdot 10^5$ to $1 \cdot 10^7$	¹⁾	$5 \cdot 10^6$	Cs-137
5.1.5	Detailed assessment	γ -measurement		$1 \cdot 10^3$		Co-60
		β -measurement		$5 \cdot 10^2$		Sr-90/Y-90
		α -measurement		$2 \cdot 10^2$		Am-241
		Tritium-measurement		$4 \cdot 10^4$		H-3
¹⁾ In the case of measurement systems for the continuous and non-continuous measurements, the detection limits as specified under Section 2.20 shall not be larger than the lower limit values of the minimum measurement ranges specified in Tables 5-3 and 5-4 .						
²⁾ The limit value is oriented on the licensed value for activity discharges or will be specified by the proper authority.						

Table 5-3: Monitoring of radioactively contaminated waste water (Discharge tank)

Section	Measurement	Measurement Procedure	Minimum Measurement Range Bq/m ³	Detection limit Bq/m ³	Limit Value Bq/m ³	Reference Nuclide
5.2	continuous monitoring	γ -measurement	$4 \cdot 10^4$ to $1 \cdot 10^7$	¹⁾	$4 \cdot 10^5$	Cs-137
5.2	measurement of coolant samples	γ -measurement	$4 \cdot 10^3$ to $1 \cdot 10^7$	¹⁾	$1 \cdot 10^4$	Cs-137
¹⁾ cf. Table 5-3						

Table 5-4: Monitoring of the cooling water

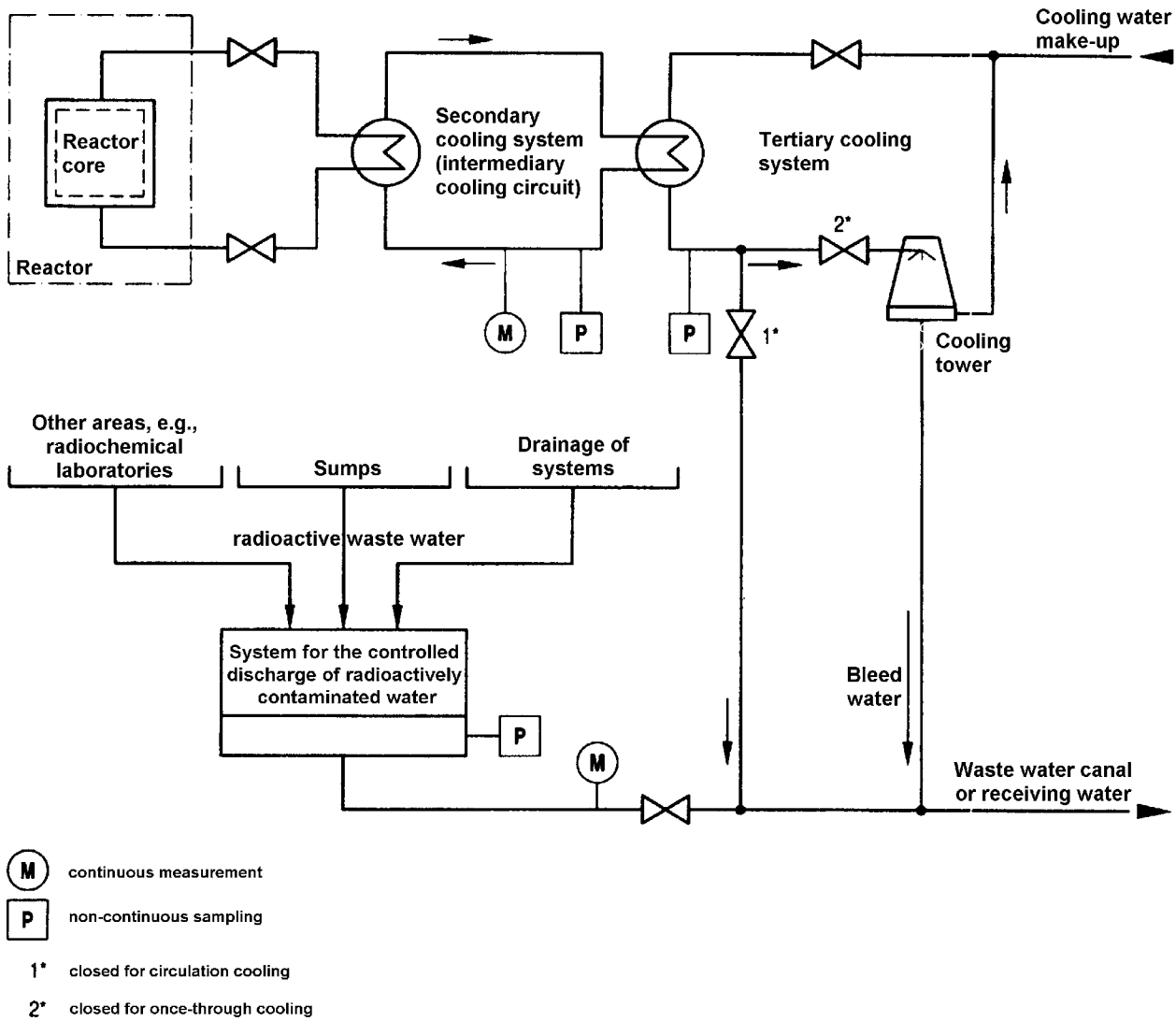


Figure 5-1: Monitoring of radioactive substances discharged with water; example shown is a closed secondary coolant circuit

Influence Parameter	Nominal Operating Range	Reference Value
Operating voltage	- a/c supply voltage	Manufacturer specification
	- d/c supply voltage	
Ambient temperature in °C	15 to 40	20
Pressure of the ambient air in mbar	900 to 1100	1013
Relative humidity of ambient air in %	10 to 95, non-dewing	60
Temperature of the sampling medium in °C	10 to 40	20
Pressure of the sampling medium ¹⁾ in mbar ²⁾	700 to 1100	1013
relative humidity of the sampling medium in % ²⁾	10 to 95, non-dewing	60

¹⁾ Difference between the pressure at the sampling location and in the measurement volume shall not exceed 200 mbar
²⁾ Monitoring equipment to determine the discharge of gaseous or aerosolbound substances

Table 6-1: Nominal Operating ranges and reference value of influence parameters

(4) In the case of a failure of the ventilation in the instrument rooms, the calibration value shall be met within $\pm 30\%$ under consideration of the expected ambient conditions in the first hour after ventilation failure.

(5) With regard to failure resistance of measuring equipment to electromagnetic disturbances - such as electrostatic discharges, electromagnetic fields, interference voltages - the Act on the Electromagnetic Compatibility of Equipment (EMVG) shall be taken into consideration.

(6) The design of all on-site stationary measuring equipment and parts of measuring equipment dealing with the monitoring of watery substances shall correspond to the protection type IP 54 in accordance with DIN VDE 0470 Part 1 (foreign particle and water protection).

(7) The measurement and sampling equipment shall be installed and located such that

- they are sufficiently protected against any influences that could prevent their proper operation,
- the nominal operating ranges specified in the respective instrument specifications are met,
- inspection, servicing and repair are easily performed,
- authorized personnel can easily access this equipment during specified normal operation.

(8) The electronics for the measuring device of the continuously operated monitoring equipment should be installed or located in central instrument rooms.

(9) Measuring containers and sampling containers shall be easy to dismantle and decontaminate. It shall be possible to flush measuring containers and sampling containers that are used in monitoring watery substances without having to disassemble them.

(10) It shall be ensured that with regard to monitoring watery substances the lower energy threshold is set such that all radionuclides with a gamma energy above 0.1 MeV are registered.

6.1.2 Fail-safe Operation

(1) If a measuring point requires special operating media, e.g. counter gas, then the supply of operating media shall be ensured and monitored.

(2) Electric loads shall be connected to the emergency power system. Redundant electric loads shall be connected to redundant power busses, provided, this is necessary for the operation of the redundant systems.

(3) Monitoring equipment required to operate continuously shall be designed to be self-monitoring; it shall be ensured that the switch-over to emergency power occurs such that neither the measurement nor the measurement value processing are interrupted in a way that stored data, e.g. measurement values required for integration, are lost.

(4) All radiation and activity monitoring systems including their peripheral equipment that are not connected to a continuous power supply shall restart automatically after an interruption in power supply.

(5) The volumetric flow through bypasses shall be monitored wherever measuring equipment is connected to or located in the bypass. The volumetric flow of the measuring media shall be monitored wherever the measuring equipment is directly connected to a system.

6.1.3 Factors of Statistical Certainty

(1) The factor of statistical certainty for the response limit, k_E , has a value of $k_E = 1.645$ in the case of non-collecting,

continuous measurements and a value of $k_E = 3.0$ in the case of collecting, continuously measuring devices (aerosol and iodine monitor) and in the case of measurements for detailed assessments as well as of decision-making measurements.

(2) The factor of statistical certainty for the detection limit, k_N , has a value of $k_N = k_E + 1.645$ in the case of all measurements specified under para. 1.

6.1.4 Limit Values

(1) If the equipment requires adjustments during operation then built-in adjustment devices shall be provided. All adjustment devices on electronic instrumentation of the monitoring equipment shall be arranged or secured in such a way that it is largely impossible for unauthorized persons to adjust the settings. A self-adjustment of the settings shall not be possible.

(2) Lower limit values indicating failure of the instrument or an exceeding of the upper limit value shall be optically displayed and acoustically annunciated and recorded in the control room or, if at times the control room is not manned, e.g. during reactor shut down, they shall be displayed at another location that is always manned at these times. Group alarms are permissible. However, the measuring point causing the alarm should be displayed in the control room, in the control room annex or at another location manned at all times. The acoustic alarms may be canceled individually or altogether before a repair of the failure cause has been carried out.

(3) The optical alarms in the control room indicating the failure or an exceeding of an upper limit value shall also indicate the alarm condition.

6.1.5 Measurement Display and Recording

(1) The measuring device shall normally have only one display range. In case multiple display ranges are required, these shall overlap

- in the case of linear display ranges, by at least 10% of the measuring range whereby the measuring range factor shall not exceed a value of 10,
- in the case of logarithmic display ranges, by at least one decade.

(2) The measurement values shall normally be displayed at the measuring devices. The measurement values listed in the following table shall be displayed and recorded in the control room:

1	exhaust air	volumetric flow
2	radioactive noble gases	activity concentration
3	radioactive aerosols	filter contamination (activity)
4	radioactive gaseous iodine	filter contamination (activity)
5	tritium	activity concentration
6	cooling water	activity concentration ¹⁾
¹⁾ may also be displayed and registered at a different location		

(3) With regard to the display of measurement values it shall be ensured that the numerical values of the response limits derivable from the detection limits specified under this safety standard are clearly visible, e.g. that they lie at least 2 to 3 mm above the median value of background radiation. To this end it is permissible to apply suitable measures such as, e.g., a background compensation.

(4) The recordings on the recording paper shall be directly visible for at least three hours and shall be well legible.

(5) It is permissible to display the measurement values specified under para. 2 on a CRT-monitor in the control room, provided, that this monitor is predominately used for the display of these measurement values, that a copy of the monitor display can be printed at all times and that the measurement values are permanently stored. A second monitor shall be available as a redundancy measure. The display on the monitor shall meet the requirements specified under para. 1.

6.1.6 Testability

The monitoring equipment shall be designed and manufactured such that the proper functioning of the individual instruments and devices can be ascertained within the framework of the initial test under Section 7.2.3 and of the inservice inspections under Section 7.2.4.

6.2 Special Requirements for Stationary Measuring equipment for the Monitoring of Discharged Radioactive Substances During Design Basis Accidents

6.2.1 Failure Resistance to Design Basis Accidents

(1) All components of the measuring equipment - e.g. sampling system, measuring sensor and measuring transducer - shall be designed such that they are failure resistant and can be properly operated under the ambient conditions and measuring medium conditions expected at their location of installation during those design basis accidents and consequential situations where proper functioning of this measuring equipment is required.

(2) The ambient conditions and measuring medium conditions expected at the respective locations of installation shall be derived from the design basis accident analyses.

(3) The measuring equipment for monitoring the radioactive substances discharged during design basis accidents shall be designed such that they will stay in functioning order under design basis accident conditions for a duration that lasts from the beginning of the design basis accident to that time when the equipment is either not required anymore, can be exchanged or repaired. The required minimum time to remain in functioning order shall be derived from the design basis accident analyses.

(4) The measurement uncertainty and the temporal behavior of the measuring equipment shall stay within specified tolerance limits under conditions of design basis accidents. These tolerance limits shall be specified within the framework of system design. The tolerance limits may be dependant of the design basis accident sequence. In order to cover this requirement, multiple channels with overlapping measurement ranges may be used.

6.2.2 Power Supply

The measuring sensors and transducers shall normally be supplied from a continuous power supply. Other components of the monitoring equipment – e.g. heater tracers of the sampling system, pumps for transporting the measurement media – shall be connected to the emergency power system; a short loss of power is permissible, e.g. during run-up of the emergency diesel generator.

7 Maintenance of Stationary Monitoring Equipment

7.1 Servicing and Repair

7.1.1 Performance

Servicing and repair of the monitoring equipment shall be performed in accordance with the corresponding operating and repair instructions and by competent personnel.

7.1.2 Record Keeping

All servicing and repair tasks shall be documented. The individual records shall contain at least the following information:

- unambiguous identification of the monitoring equipment,
- type of the servicing or repair task performed,
- type and number of the exchanged parts,
- in the case of new parts installed: date and detailed description of the test certificates and of the test certification by tests required under this safety standard,
- indication of the outage times,
- date of the servicing or repair task,
- name and signature of the authorized personnel.

7.2 Tests

7.2.1 Testing Schedule

Type, extent and intervals of the tests required under Section 7.2.4 shall be specified in the testing schedule.

7.2.2 Test Certification

All test performed shall be documented by test certificates. The test certificates shall be stored for a period of ten years. These shall contain at least the following information:

- date of the test,
- test object,
- type of test,
- test documents,
- test results,
- in case of faults: imposed deadline for removal of the faults or of exchanging the test object,
- name and signature of the tester.

7.2.3 Initial Testing

7.2.3.1 General Requirements

The monitoring equipment or its components shall be subjected to the following tests:

- qualification test,
- calibration,
- factory test,
- commissioning test.

7.2.3.2 Qualification Test

(1) Prior to the initial application in a research reactor, it shall be verified that the monitoring equipment will fulfil its tasks and will meet the specified requirements. The long-term behavior of the monitoring equipment under a cyclic change of ambient conditions shall normally also be tested within the framework of these tests.

(2) The qualification test shall be assessed by authorized experts. It is permissible to verify qualification entirely or partly on the basis of proving a successful service under comparable operating conditions.

7.2.3.3 Calibration and Check of Calibration

(1) The monitoring equipment shall be calibrated prior to its deployment. This calibration may also be performed on a type-identical device.

(2) The measuring equipment for monitoring noble gasses shall be calibrated with argon 41. The discrimination of the

equipment must be known for the radiation of the nuclides xenon 133 and krypton 85.

(3) The measuring equipment for monitoring beta-emitting aerosols shall be calibrated both with technetium 99 or cobalt 60 as well as with chlorine 36 or cesium 137, and gamma-emitting aerosols with barium 133 and cesium 137. The energy dependency of the discrimination shall be known for beta radiation in the energy range from 150 to 2500 keV and for gamma radiation in the energy range from 100 to 1700 keV. It is permissible to set the lower threshold for gamma radiation of the measuring equipment for aerosol monitoring at a maximum of 250 keV in order to reduce the probability of detecting interfering nuclides or background radiation.

(4) The measuring equipment for iodine monitoring shall be calibrated with iodine 131.

(5) The measuring equipment for water bound tritium shall be calibrated with water containing tritium.

(6) The measuring equipment for monitoring water shall be calibrated with cesium 137. The discrimination shall be known for gamma radiation in the energy range from 100 to 1700 keV.

(7) During initial calibration a set of calibration sources shall be specified which can be used to check a display value in one of the lower decades and also a display value in one of the upper decades of the measuring range. To this end the following calibration sources shall be available:

- a) with regard to noble gas monitoring - cobalt 60 or technetium 99 for the measuring points for beta radiation and barium 133 or cobalt 57 for the measuring points for gamma radiation,
- b) with regard to aerosol monitoring - cobalt 60 or technetium 99 for the measuring points for beta radiation and barium 133 or cobalt 57 for the measuring points for gamma radiation,
- c) with regard to iodine monitoring - barium 133,
- d) with regard to water monitoring - cesium 137 and one calibration source to check the lower threshold, e.g., barium 133 or cobalt 57.

(8) Subsequent to the initial calibration of the measuring device of the monitoring equipment a calibration source shall be used in a definite and reproducible geometry in order to determine a connection calibration value that can later be used (one) to check the calibration and (two) to connect additional type identical devices.

7.2.3.4 Factory Test

(1) In a factory test, the proper manufacture and perfect functioning order of the monitoring equipment shall be verified.

(2) If the monitoring equipment is comprised of components produced by various manufacturers, the proper manufacture and perfect functioning order of these components shall be confirmed by tests performed by the respective manufacturers.

(3) The factory test shall be performed as a production test and shall include at least:

- a) visual examination,
- b) test of the signal value as a function of the specified operating voltage fluctuation,
- c) test of the characteristic with a pulse or power generator with at least one test value per order of magnitude in the measurement range.

(4) The factory test shall be performed by the factory expert and, in substantiated cases, in the presence of experts authorized by the proper authority.

7.2.3.5 Commissioning Tests

(1) During the commissioning test after installation, the perfect construction and functioning of the monitoring equipment shall be verified. The tests shall address the following items:

- a) construction of the monitoring equipment,
- b) installation of the monitoring equipment,
- c) display (with a pulse or power generator with at least one test value per order of magnitude in the measurement range),
- d) calibration check (with a calibration source),
- e) limit value setting,
- f) connection to the emergency power supply,
- g) automatic restart after interruption of the power supply,
- h) through-flow monitoring,
- i) measured value processing (signals, alarms),
- j) supply of operating media.
- k) exhaust air volumetric flow measurement.

(2) The commissioning test shall be carried out by the operator and, to an extent specified by the competent authority, by or in the presence of authorized experts.

7.2.4 Inservice Inspections

7.2.4.1 General Requirements

(1) The monitoring equipment shall be subjected inservice inspections during operation.

Note:

These are regularly recurring tests and test after repairs.

(2) In the case of functional tests for which it is necessary to remove safety interlocks, the consent of the competent authority shall be obtained.

(3) The tests shall be possible without interaction in the circuits (e.g. soldering).

(4) The tests shall be carried out in accordance with test documents in which the test methods for each individual test are collated. These include the following data:

- a) test specification or test instruction,
- b) test object and test location,
- c) testing equipment to be used,
- d) test conditions,
- e) required values.

7.2.4.2 Regularly Recurring Tests

(1) Regularly recurring tests shall be used to verify the perfect functioning of the monitoring equipment. They shall be based on the tests and test frequencies specified in **Table 7-1**.

(2) For the verification of the calibration specified under line no. 1 of **Table 7-1**, a definite and reproducible geometry of the detector and calibration source shall be specified in accordance with Section 7.2.3.3 and the required display value shall be determined.

(3) The tests shall be carried out by the operator or by experts authorized by the competent authority.

7.2.4.3 Tests after Repairs

After a successful repair the perfect functioning shall be verified by a commissioning test as specified under Section 7.2.3.5 and to an extent corresponding to the extent of the repair.

7.3 Removal of Defects

Any defects determined in the course of tests shall be removed without delay within the time periods specified in the test certification.

1	2	3	4	5
No.	Test Object	Testing Method	Test Frequency ¹⁾	
			by operator	by authorized expert ²⁾
1	Monitoring equipment	a) visual inspection	during plant walk-through	annually
		b) checking the calibration with calibration source	quarterly	annually
		c) counter tube: checking of the plateau	–	annually
2	Test and servicing records	Visual inspection	–	annually
3	Electronic components	feed-in of standard signals into the transmitters (at least one value per decade of the measuring range) ³⁾ comparison of all displays and recordings	annually	annually
4	Signal processing	Operational availability: visual inspection	during plant walk-through	annually
		Failure signals: by interrupting power supply or by interrupting the connection between signal sensor and transducer	quarterly	annually
		Hazard alarms: using radiation source, or electrically	quarterly	annually
5	Through-flow monitoring and operating medium supply without automatic Function check	Visual inspection	during plant walk-through	annually
	with automatic Function check	Comparison of the required value with the actual value	quarterly	annually
6	Exhaust air volumetric flow	Comparison of the required value with the actual value at nominal volumetric flow	annually	annually
7	Sampling System	Visual inspection, check of the automatic switching of ventilators or blowers	annually	annually
<p>¹⁾ When a test under column 5 is performed, any simultaneous test to be performed under column 4 may be dispensed with.</p> <p>²⁾ This is the expert authorized by the competent authority.</p> <p>³⁾ The testing method of feeding standard signals into the transmitter with at least one value per decade is not necessary in the case of digital measuring equipment, provided, the code has been tested and is self monitoring. In this case it is sufficient to feed-in one signal in the uppermost decade if the processing electronics does not perform any switching in the entire measurement range. This too may be dispensed with, provided, one of the signals from the check of calibration falls into the upper decade of the measuring range.</p>				

Table 7-1: Regularly recurring tests (inservice inspections)

8 Measurement Results

8.1 Documentation

8.1.1 Flow Diagram

(1) The sampling and monitoring equipment installed to monitor the discharged gaseous, aerosolbound and liquid radioactive substances shall be shown on clearly understandable flow charts. The different types of sampling and measurements shall be characterized by different symbols.

(2) In the descriptions - e.g. in the form of tables - corresponding to the various flow charts, the required measurement objective and the execution of the measurement shall be specified for each sampling and monitoring equipment. With respect to the sampling, the reason, type, location and frequency as well as the required measurements shall be indicated. With respect to the monitoring equipment, the measurement objectives and the related technical requirements such as type of measurement, measurement arrangement including shielding, calibration, measurement ranges, detection limit and measurement uncertainty, shall be indicated. With respect to the measurement laboratory, the measurement tasks and the related technical requirements shall, likewise, be indicated.

8.1.2 Extent

The documentation shall be organized such that a complete verification of the discharge of radioactive substances is possible. This includes records on:

- a) activity measurements
(individual nuclide concentrations and discharge rates),
- b) taking of samples
(continuous, non-continuous, date and time, duration),
- c) exhaust air
(amount, date and time, duration),
- d) water
(types of water, quantity, date and time, duration),
- e) responsible persons and executors.

8.1.3 Evidential Samples

Type, quantity and period of retention for evidential samples shall be agreed upon with the supervisory authority.

8.2 Report to the Authorities

8.2.1 Contents

Reports to the proper supervisory authority regarding the discharge of gaseous, aerosolbound or liquid radioactive substances shall include:

- a) quantity of exhaust air,
- b) quantity of waste water,
- c) licensed values,
- d) nuclide-specific activity discharged

and the lowest and highest detection limits achieved by the various measuring equipment in the reporting period.

8.2.2 Detailed Assessment

The nuclide specific verification of the activity discharged and its comparison with the licensed values shall be carried out at least once every calendar year. Nuclides with concentrations below the relevant detection limit required by this safety standard shall not be considered in the detailed assessment.

8.2.3 Report Forms

(1) Report forms in accordance with **Figures 8-1** and **8-2** shall normally be used for the regular reports.

(2) Only such values shall be listed in the column "Discharged Activity" that result from measurement values of an activity concentration exceeding the detection limit.

Discharge of gaseous and aerosolbound radioactive substances (KTA 1507)					
Reactor:	Year:		Exhaust Air Volume in m ³ :		
Nuclide	Detection Limit in Bq/m ³		Discharged Activity in Bq	Licensed Value in Bq/a	Remarks
	min.	max.			
Noble gasses:					
Ar 41					
Kr 85					
Kr 85m					
Kr 87					
Kr 88					
Xe 131m					
Xe 133					
Xe 133m					
Xe 135					
Xe 135m					
Xe 138					
Other nuclides					
Sum of noble gasses ¹⁾					
Overall beta activity ²⁾					
Iodine:					
I 131 gaseous					
I 131 aerosolbound					
Sum of iodine 131					
Other nuclides					
Aerosols:					
Cr 51					
Mn 54					
Co 58					
Fe 59					
Co 60					
Zn 65					
Zr 95					
Nb 95					
Ru 103					
Ru 106					
Ag 110m					
Sb 124					
Sb 125					
Cs 134					
Cs 137					
Ba 140					
La 140					
Ce 141					
Ce 144					
Other nuclides					
Sum					
Sr 89					
Sr 90					
Tritium					
Overall activity concentration of alpha emitters (in primary coolant circuit)					
U 234					
Pu 238					
Pu 239					
Pu 240					
Am 241					
Cm 242					
Cm 244					
Other nuclides					
Sum					
Carbon 14					
¹⁾ in case of a continuous nuclide specific measurement for the detailed assessment.					
²⁾ in case of a non-continuous nuclide specific measurement for the detailed assessment..					

Figure 8-1: Example of a report form for activity discharged with exhaust air

Discharge of radioactive substances with water (KTA 1507)			Sheet	of	
Reactor:		Year:			
Water discharge:		m ³		Type of water:	
Nuclide	Detection Limit in Bq/m ³		Discharged Activity in Bq	Licensed Value in Bq/a	Remarks
	min.	max.			
Cr 51					
Mn 54					
Co 58					
Fe 59					
Co 60					
Zn 65					
Zr 95					
Nb 95					
Ru 103					
Ru 106					
Ag 110m					
Sb 124					
Sb 125					
I 131					
Cs 134					
Cs 137					
Ba 140					
La 140					
Ce 141					
Ce 144					
Other nuclides					
Sr 89					
Sr 90					
Sum					
Tritium					
Overall activity of alpha emitters					
U 234					
238					
Pu 239					
Pu 240					
Am241					
Cm 242					
Cm 244					
Other nuclides					
Sum					

Figure 8-2: Example of a report form for activity discharged with water

Annex

Regulations Referred to in this Safety Standard

(The references exclusively refer to the version given in this annex. Quotations of regulations referred to therein refer to the version available when the individual reference below was established or issued.)

Atomic Energy Act		Act on the Peaceful Utilization of Atomic Energy and the Protection against its Hazards (Atomic Energy Act) of December 23, 1959 (BGBl I, Page 814) as Amended and Promulgated on July 15, 1985 (BGBl I, Page 1565) last amended by the Act of April 6, 1998 (BGBl I Page 694)
StrlSchV		Ordinance on the protection against damage and injuries caused by ionizing radiation (Radiation Protection Ordinance - StrlSchV) in the version published on June 30, 1989 (BGBl I, 1989, p. 1321), corrected October 16, 1989 (BGBl I, 1989, p. 1926) last amended by ordinance of August 18, 1997 (BGBl I, Page 2113)
WHG		Act on the Regulation of Water Resources (Water Resources Act - WHG) of July 27, 1957 (BGBl I, Page 1110, corrected Page 1386) last amendments by ordinance of August 18, 1997 (BGBl I, Page 2113) in the version promulgated on November 12, 1996 (BGBl I, Page 1695) last amended by ordinance of April 30, 1998 (BGBl I, Page 823)
EMVG		Act on the Electromagnetic Compatibility of Equipment (EMVG) of November 9, 1992 (BGBl I, Page 1864) in the final version promulgated on August 30, 1995 (BGBl I, Page 1118)
DIN 24 184	(12/90)	Type testing of high efficiency particulate air filters; using paraffin oil mist as test aerosol
DIN VDE 0470-1	(11/92)	Degrees of protection provided by enclosures (IP Code); [IEC 60529:1989]; German edition EN 60529:1991