Safety Standards

of the
Nuclear Safety Standards Commission (KTA)

KTA 1503.1 (2022-11)

Monitoring the Discharge of Radioactive Gases and Airborne Radioactive Particulates
Part 1: Monitoring the Discharge of Radioactive Matter with the Stack Exhaust Air During Specified Normal Operation

(Überwachung der Ableitung gasförmiger und an Schwebstoffen gebundener radioaktiver Stoffe
Teil 1: Überwachung der Ableitung radioaktiver Stoffe mit der Kaminfortluft bei bestimmungsgemäßem Betrieb)

The previous versions of this safety standard were issued in 1979-02, 1993-06, 2002-06, 2013-11 and 2016-11

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KTA SAFETY STANDARD

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Previous versions of this safety standard:

1979-02 (BAnz No. 133 of July 20, 1979)
1993-06 (BAnz No. 211a of November 9, 1993)
2002-06 (BAnz No. 172a of September 13, 2002)
2013-11 (BAnz AT 17.01.2014 B3)
2016-11 (BAnz AT 10.03.2017 B5)

Contents

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, 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.

Basic Principles

(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 damage arising from the construction and operation of the plant (Sec. 7, para. (2), subpara. (3) Atomic Energy Act - AtG) in order to attain the protective goals specified in the AtG, the Radiation Protection Act (StrlSchG) and the Radiation Protection Ordinance (StrlSchV) as well as further detailed in the Safety Requirements for Nuclear Power Plants (SiAnf) and the Interpretations of the SiAnf.

(2) The stationary and the mobile radiation protection instrumentation serves, among others, in protecting the persons inside and outside of the facility from ionizing radiation, and in ascertaining the specified normal functioning order of the equipment

a) for keeping solid, liquid and gaseous radioactive substances within the provided enclosures,

b) for handling and the controlled conducting of radioactive substances within the facility, and

c) for monitoring the discharge of radioactive substances.

Concrete safety related requirements with regard to this instrumentation are specified in the safety standards of the series KTA 1500.

(3) The parts of safety standard KTA 1503 comprise the requirements regarding the technical equipment and additional organizational measures considered necessary with respect to monitoring emissions. These parts are, specifically:

Part 1: Monitoring the discharge of radioactive substances with the stack exhaust air during specified normal operation,

Part 2: Monitoring the discharge of radioactive substances with the stack exhaust air during design-basis accidents,

Part 3: Monitoring the non-stack discharge of radioactive substances.

(4) Monitoring the discharge of radioactive substances contributes to fulfilling the requirements specified under Sec. 8 StrlSchG, and Secs 99, 102 and 103 StrlSchV, in accordance of which it is required

a) that any exposure or contamination of man and environment must be minimized even to levels below the respective limit values specified in StrlSchG by taking into consideration the state of the art and by taking into account all circumstances of the individual situations (Sec. 8, para. (2) StrlSchG),

b) that no radioactive substances are discharged uncontrolled into the environment (Sec. 99, para. (4), StrlSchV), and

c) that discharges are monitored and reported to the proper authority at least once a year specifying their kind and activity (Sec. 103, para. (1) StrlSchV).

The monitoring equipment must fulfill the requirements under Sec. 90 StrlSchV.

(5) Monitoring the discharge of radioactive substances with the vent stack exhaust air during specified normal operation shall serve in

a) creating a detailed assessment of the radioactive substances discharged with the stack exhaust air as the basis for assessing the radiological effects, and

b) automatically initiating alarm signals,

(6) The equipment required for fulfilling these tasks are subdivided as

a) stationary measuring and sampling equipment, and

b) mobile measurement equipment deployed for determining the activity of the accumulated samples (cf. Table 3-4).

1 Scope

This safety standard shall apply to the equipment for monitoring the discharge of gaseous radioactive substances and radioactive substances bound to aerosols with the vent stack exhaust air during specified normal operation from nuclear power plants with light water reactors.

2 Definitions

(1) Discharge rate

Discharge rate is the quotient of the discharged activity and the time span in which this discharge occurred.

(2) Discharge of radioactive substances

Discharge of radioactive substances is the intentional discharge of liquid or gaseous radioactive substances or of radionuclides bound to aerosols from the power plant along paths provided for this purpose.

(3) Aerosol monitor

An aerosol monitor is a monitoring equipment that is used for measuring the cumulative beta or cumulative gamma activity concentration of radionuclides that are bound to aerosols in the air.

(4) Discrimination of a measurement equipment

The discrimination of a measurement equipment is the ratio of the displayed value of a measurement parameter to the correct value of this measurement parameter.

(5) Specified normal operation

Specified normal operation encompasses

a) Operating processes for which the plant, assuming the able function of all systems (fault free condition), is intended and suited (normal operation);

b) Operating processes which occur in the event of a component or system malfunction (fault condition) as far as safety related reasons do not oppose continued operation (abnormal operation);

c) Maintenance procedures (inspection, servicing, repair).

(6) Detailed assessment of radioactive substances

The detailed assessment is a special form of monitoring consisting of identifying, and determining the activity of, the radionuclides or radionuclide groups discharged over a given time span. For detailed assessment measured value is used. The measurement uncertainty is indicated separately.

(7) Decision threshold

A decision threshold is a calculated value of a measurement parameter (e.g., activity, activity concentration, specific activity) for comparison with a measured value in order to decide whether this measurement parameter has contributed to the measurement or has had a zero effect.

Note:

(1) Decision thresholds are determined in accordance with DIN EN ISO 11929-1.

(2) Application examples are given in report KTA-GS 82.

(8) Cumulative beta activity

The cumulative beta activity is the activity determined by an integral measurement of the beta particles emitted by a radioactive substance and setting this value into relation to the reference nuclide used for calibrating the measurement equipment.

(9) Cumulative gamma activity

The cumulative gamma activity is the activity determined by an integral measurement if the gamma radiation of a radioactive substance and setting this value into relation to the reference nuclide used for calibrating the measurement equipment.

(10) Overall loss factor
(sampling airborne radioactive substances)

The overall loss factor is a correction factor to be applied when determining the discharge of airborne radioactive substances. It is, essentially, comprised of factors related to changes of the activity concentrations of airborne radioactive substances caused by

a) determination of the partial air stream with a sampling rake,
b) a non-isokinetic sampling,
c) the transport through the sampling pipe (pipe factor), and
d) the transport in the sampling and measurement equipment.

(11) Calibration of a measurement equipment for radiation monitoring

The calibration of the measurement equipment for radiation monitoring is the determination of the relationship between the value defined by specific norms (e.g., activity of the calibration source) and the displayed value (e.g., count rate) of the measurement parameter.

(12) Measurement equipment

Measurement equipment includes the entirety of all measuring and auxiliary devices required for determining a measurement parameter, for passing on and adjusting a measurement signal and for displaying the measured value as an image of the measurement parameter.

(13) Measurement medium

The measurement medium is that sample extracted from the monitored medium that flows through the measurement volume (i.e., that region for which the discrimination of the respective measurement equipment was determined during calibration) possibly after an engineering procedural treatment such as heating, filtration, dilution.

(14) Mixture sample

A mixture sample is a mixture of individual samples or cumulative samples, or of parts of these samples, that were extracted within a specified time span.

(15) Detection limit

The detection limit is a calculated value for a measurement parameter (e.g., activity, activity concentration, specific activity) meant to be compared to a predetermined reference value to help decide whether or not the measurement procedure is suitable for a particular measurement task.

Note:

(1) Detection limits are determined in accordance with DIN EN ISO 11929-1.

(2) Application examples are given in report KTA-GS 82.

(16) Representative sample
(exhaust air)

A representative sample is a particular sample, the examination of which allows determining the radioactive substances discharged with the vent stack exhaust air according to their kind and activity.

(17) Pipe factor

The pipe factor is the ratio of the activity concentration of a radionuclide or radionuclide group at the entry port of a sampling probe and the activity concentration at the connection point of the sampling or measurement equipment for monitoring the activity concentration of gaseous or radionuclides bound to aerosols, this ratio being determined in a stationary condition.

(18) Cumulative sample

A cumulative sample is a sample accumulated by continuous or quasi-continuous sampling within a specified time span.

(19) Aerosols

Aerosols are solid or liquid particles suspended in air or in a gas.

(20) Monitoring

Monitoring is a collective term for the various types of a controlled determination of physical parameters; monitoring includes comparing the results with previously specified values.

Notes:

(1) Monitoring is performed, e.g.,

a) by continuous measurements, or
b) by analyses of samples (e.g. in a laboratory), or
c) by a combination of selective measurement values

and is always carried out in conjunction with a comparison of the results with previously specified values of the physical parameters (e.g., licensed limit values, operational values).

(2) To verify compliance with licensed limit values the upper limit of the probabilistically symmetric coverage interval is applied.

(21) Coverage interval

The coverage interval contains the area of potential true values of the measurand based on available information with a specified probability.

Note:

The limits of the probabilistically symmetric coverage interval are determined in accordance with DIN EN ISO 11929-1.

3 Measurement Objects and Measurement Procedures

3.1 General Requirements

(1) The kind and activity of the discharged radioactive substances shall be determined in accordance with the requirements under this safety standard.

(2) With regard to the physical properties as well as the sampling and measurement procedures and radiological significance of the discharged radioactive substances, it is necessary to distinguish between:

a) Radioactive noble gases,
b) Radioactive substances bound to aerosols,
c) Radioactive gaseous iodine,
d) Tritium,
e) Radioactive strontium,
f) Alpha emitters,
g) Carbon-14.

(3) The discharge of radioactive substances shall normally be monitored within a partial air stream of the exhaust air. The volumetric flow of these partial air streams shall be continuously monitored.

(4) The volumetric flow of the exhaust air shall be continuously measured and recorded. The measurement range shall extend at least from 25 % to 110 % of the nominal volumetric flow of the exhaust air. The absolute value of the measurement uncertainty of the volumetric flow during specified normal operation shall not exceed a value corresponding to 5 % of the nominal volumetric flow.

(5) Regarding the continuous measurement of radioactive substances bound to aerosols and of radioactive gaseous iodine, any deviation of the volumetric flow of the partial air stream exceeding 20 % of its nominal flow shall automatically issue an alarm in the control room.

(6) Regarding the detailed assessment of radioactive substances bound to aerosols, of radioactive iodine, tritium, radioactive strontium, Carbon-14 and of alpha emitters, the integral volumetric flow shall be measured. Any deviation of the volumetric flow of the partial air stream exceeding 20 % of its nominal flow shall automatically issue an alarm in the control room; if piston pumps are used, this alarm is not required.

Note:

An overview of the measurements to be performed is presented in **Table 3-4**. An example for the monitoring equipment is illustrated in **Figure 3-1** to help in visualizing the requirements of this safety standard.

(7) Suitable measurement equipment shall be provided for the determination of the activity of cumulative samples listed in **Table 3-4**. The requirements for this measurement equipment are specified under Sections 5 and 6.

(8) The laboratories contracted by the operating utility shall be suitably certified as being qualified in accordance with the Verification of the Licencee's Monitoring Guideline.

(9) The radioactivity concentration of the radionuclides determined in the detailed assessment measurements of the samples shall be corrected to the middle of the individual collection periods with the associated half-life values of the radionuclides.

3.2 Radioactive Noble Gases

3.2.1 Continuous measurement

(1) The discharge of radioactive noble gases with the exhaust air shall be monitored by a continuous measurement of the activity concentration and the volumetric flow of the exhaust air. The activity concentration shall be determined using two separate measurement equipment units, and shall be monitored with regard to threshold values. At least one unit of this measurement equipment shall enable monitoring the cumulative beta activity concentration of the noble gases.

(2) In order to prevent a distortion of the measured values, a high-efficiency particulate air filter of at least Filter Class E12 in accordance with DIN EN 1822-1 shall be installed in-line before the measurement equipment.

(3) The detection limit of the measurement equipment for measuring the activity concentration shall not exceed 1×10^4 Bq/m³ for Xenon-133 for a measurement duration of ten minutes.

(4) Taking the volumetric flow of the exhaust air into consideration, the measurement range of the measurement equipment shall enable monitoring discharge rates from 4×10^9 Bq/h through 4×10^{13} Bq/h relative to the nominal volumetric flow of the exhaust air.

3.2.2 Detailed assessment

(1) The radioactive noble gases discharged with the exhaust air shall be subjected to a detailed assessment. This detailed assessment shall be based on gamma-spectrometric measurements. The radionuclides listed in **Table 3-1** shall be taken into account.

Radionuclides	
Argon-41	Xenon-131 m
Krypton-85	Xenon-133
Krypton-85 m	Xenon-133 m
Krypton-87	Xenon-135
Krypton-88	Xenon-135 m
Krypton-89	Xenon-137
	Xenon-138

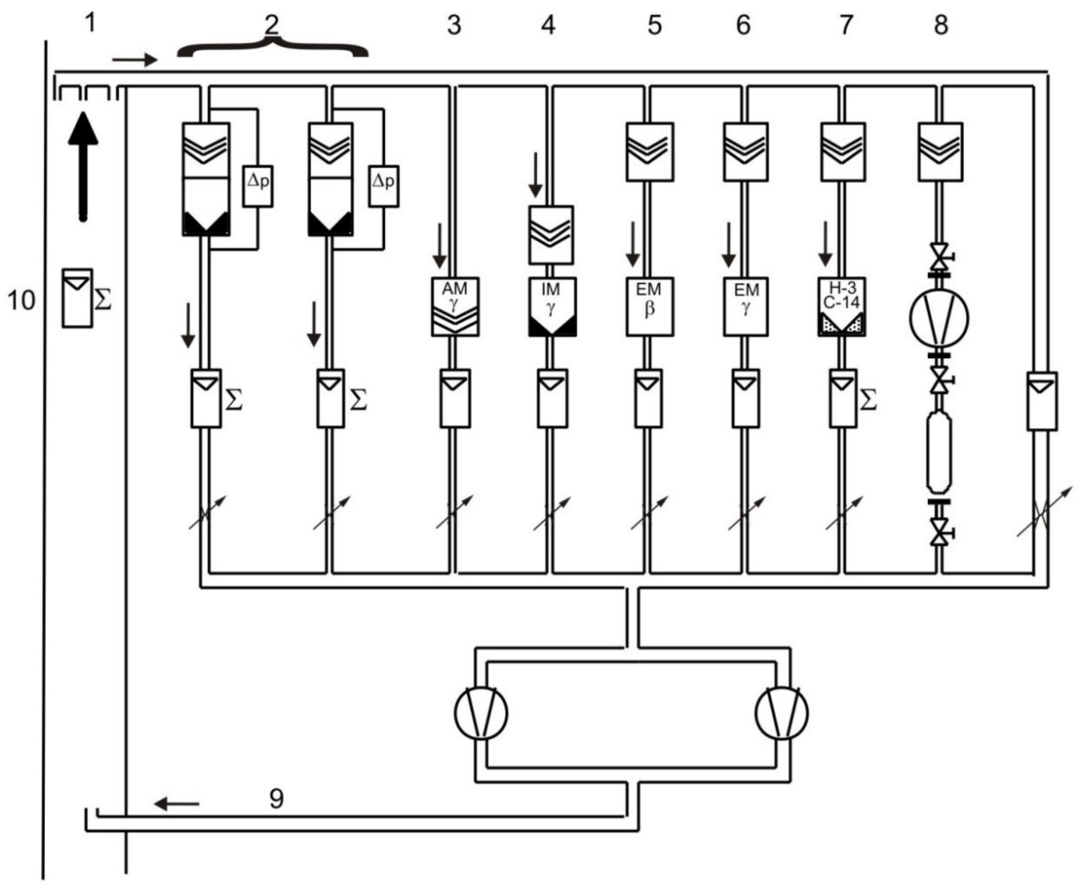
Table 3-1: Radionuclides to be taken into account in the detailed assessment of radioactive noble gases

(2) The measurement equipment for the nuclide specific detailed assessment of radioactive noble gases shall be designed such that, with a measurement medium of otherwise activity-free air, a activity concentration of 5×10^2 Bq/m³ for the reference nuclide Xenon-133 and 1×10^4 Bq/m³ for Krypton-85 can be determined within a maximum measurement duration of 24 hours.

(3) For those radionuclides listed in **Table 3-1** not detected by the individual measurements, the decision threshold achieved in the exhaust air for the particular measurement with the corresponding measurement equipment shall be recorded.

(4) Any other radionuclides detected in the stack exhaust air in the course of determining the noble gas fraction shall be individually specified in the report form (cf. **Figure 7-1a**) under the title “Other radioactive noble gases” even if they are not noble gases.

(5) The continuous measurement for the detailed assessment of radioactive noble gases shall basically rely on the spectra measured throughout the entire day. The evaluation results of the measured spectra determined in hourly intervals (or in other time intervals less than or equal to 24 hours) shall be included in the detailed assessment only if these specific measurements identify radioactive noble gases which cannot be verified in the day spectrum, e.g., due to only a short-term increase of the activity discharge. If the detection limit for this procedure is less than 1×10^4 Bq/m³, then the contribution of Krypton-85 to the overall discharge shall be determined, e.g., by sampling from the exhaust air and additional measurements.



1 Sampling rake
2 Sampling equipment for the detailed assessment of the activity discharge of radioactive substances and iodine compounds bound to aerosols
3 Aerosol monitor
4 Iodine monitor
5 Noble gas monitor (cumulative beta activity measurement)
6 Noble gas monitor and nuclide specific measurement equipment for the detailed assessment of the activity discharge of radioactive noble gases
7 Sampling equipment for the detailed assessment of the activity discharge of H-3 and C-14 compounds
8 Discontinuous sampling
9 Return pipe line
10 Volumetric flow measurement in the stack

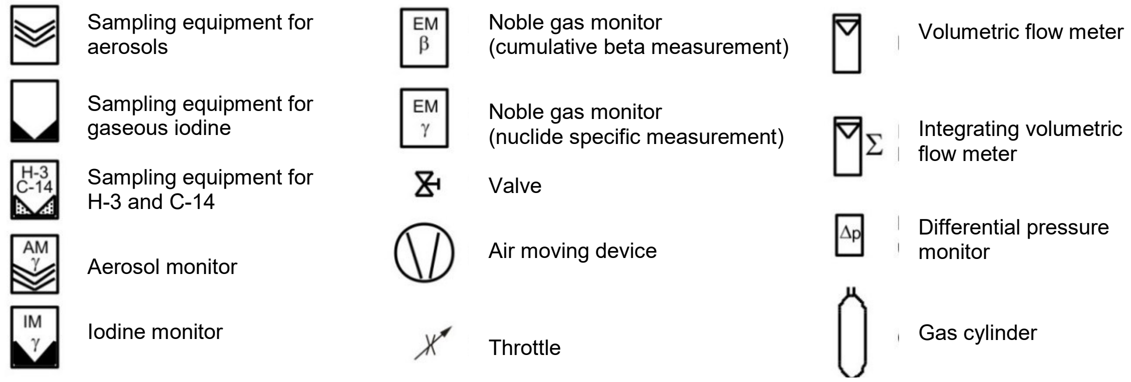


Figure 3-1 Example of the monitoring equipment

(6) If the detailed assessment of the discharged radioactive noble gases is not performed on the basis of the prioritized continuous nuclide specific measurement, then it shall be based on the overall discharge rate determined from the beta measurement taking the ratio of the individual nuclides within the nuclide composition into account. In this case the equipment for determining the discharge rate of radioactive noble gases as specified under Section 3.2.1 para.(1) shall be designed and constructed as a doubly redundant beta measurement equipment. The non-continuous determination of the nuclide composition shall be performed by extracting a representative sample once a week. The samples shall be analyzed without delay. If the measurement detects Xenon-133 with a activity concentration larger than 5×10^2 Bq/m³ but no Krypton-85, a second measurement of the sample shall be performed after a decay time of at least two days to determine the activity concentration of Krypton-85.

(7) In case of a failure of the measurement equipment for the continuous nuclide specific detailed assessment of radioactive noble gases, then this assessment shall be based on the overall discharge rate determined from the beta measurement taking the ratio of the individual nuclides within the nuclide composition into account. The nuclide composition shall be determined by extracting a representative sample at least once a week; the measurement and evaluation of these samples shall be performed as specified under para. (6).

(8) If the nuclide composition is determined non-continuously, then representative samples – in addition to the weekly samples – shall be taken and analyzed without delay whenever an upper threshold value responds from

a) the monitoring of noble gases or
b) the monitoring of radioactive substances bound to aerosols or
c) the monitoring of iodine.

(9) As long as one of the upper threshold values are pending, the nuclide composition shall, as far as possible, be determined in hourly intervals.

(10) In case of a non-continuous sampling, the nuclide composition shall be considered as constant in the time interval between two consecutive samplings.

3.3 Radioactive Substances Bound to Aerosols

3.3.1 Continuous measurement

(1) The discharge of radioactive substances bound to aerosols with the exhaust air shall be monitored by a continuous measurement. For this purpose, the radioactive substances bound to aerosols shall be continuously deposited from a partial air stream on a high-efficiency particulate air filter of at least Filter Class E12 in accordance with DIN EN 1822-1 with the activity on the filter being continuously measured during this process.

(2) The measurement equipment shall be designed such that, given a previously uncharged (fresh) high-efficiency particulate air filter, a short-term (one hour maximum) activity concentration of Cesium-137 with a time integral of 4 (Bq/m³)h will, within a maximum time of one hour, cause the detection limit for the alarm display of the measured value "Activity on the Filter" or "Increasing Activity on the Filter" to be exceeded.

Note:

The herein specified requirements for the detection limit apply to the plant-independent verification of the equipment characteristics.

(3) The measurement range of the measurement equipment shall be such that it will be possible to determine discharge rates from 4×10^6 Bq/h through 4×10^9 Bq/h relative to the nominal volumetric flow of the exhaust air.

(4) The activity on the filter shall be monitored for a value at which a discharge of 2×10^8 Bq inside one hour can still be detected with a maximum standard deviation of 10 %. The filter shall be exchanged when this value is exceeded and the discharged amount cannot anymore be determined with the maximum permissible standard deviation of 10 %. Regardless of this condition, the filter shall be exchanged at least every 14 days.

(5) In the case of measurement equipment with filters that are continuously or intermittently in motion, an alarm threshold shall be set to such a value that a discharge rate of at least 2×10^8 Bq/h relative to the nominal volumetric flow of the exhaust air can still be detected.

(6) Cesium-137 shall be used as reference nuclide for the requirements specified under paras. (2) through (5).

3.3.2 Detailed assessment

(1) The radioactive substances bound to aerosols discharged with the exhaust air shall be subjected to a detailed assessment. For this purpose, the radioactive substances bound to aerosols shall be continuously accumulated on two separate high-efficiency particulate air filters of at least Filter Class E12 in accordance with DIN EN 1822-1.

(2) The accumulation time span shall not exceed one week.

(3) Within two days after their removal, the high-efficiency particulate air filters shall be analyzed by a gamma spectrometric measurement. The radioactive decay between accumulation and measurement shall be taken into account. The detailed assessment shall take the radionuclides listed in **Table 3-2** into account.

(4) The high-efficiency particulate air filters shall be measured without delay whenever one of the upper threshold values of the exhaust air monitoring is reached. If automatically starting accumulators are additionally installed, the filters of these accumulators may be measured instead.

Radionuclides	
Chromium-51	Silver-110 m
Manganese-54	Antimony-124
Cobalt-57	Iodine-131
Cobalt-58	Cesium-134
Cobalt-60	Cesium-137
Zinc-65	Barium-140
Zirconium-95	Lanthanum-140
Niobium-95	Cerium-141
Ruthenium-103	Cerium-144
Ruthenium-106	

Table 3-2: Radionuclides to be taken into account in the detailed assessment of radioactive substances bound to aerosols

(5) The detection limit of the measurement equipment for determining the activity concentration in the exhaust air shall not exceed a value of 3×10^{-2} Bq/m³ for Cesium-137 and 1×10^{-2} Bq/m³ for Cobalt-60. For those radionuclides listed in **Table 3-2** not detected by the individual measurements, the

decision threshold and detection limit achieved in the exhaust air for the particular measurement with the corresponding measurement equipment shall be recorded.

(6) Additionally detected radionuclides with half-lives exceeding eight days shall individually be listed in the report form, (cf. **Figure 7-1b**) under the heading "Other gamma radiating radionuclides".

Note:

The detailed assessment of the discharged Iodine-131 is determined as specified under Section 3.4.2, of radioactive strontium as specified under Section 3.6 and of alpha emitters as specified under Section 3.7.

3.4 Radioactive Gaseous Iodine

3.4.1 Continuous measurement

(1) The discharge of radioactive gaseous iodine with the exhaust air shall be monitored by a continuous measurement. For this purpose, the iodine shall be continuously deposited from a partial air stream on an iodine filter which shall be continuously measured for the activity of the deposited Iodine-131.

(2) The measurement equipment shall be designed such that, given a previously uncharged (fresh) iodine filter, a short-term (one hour maximum) activity concentration of Iodine-131 with a time integral of 2 (Bq/m³)h will, within a maximum time of one hour, cause the detection limit for the alarm display of the measured value "Activity on the Filter" or "Increasing Activity on the Filter" to be exceeded.

Note:

The herein specified requirements for the detection limit apply to the plant-independent verification of the equipment characteristics.

(3) The measurement range of the measurement equipment shall be such that it will be possible to determine discharge rates of Iodine-131 from 4×10^5 Bq/h through 4×10^8 Bq/h taking the volumetric flow of the exhaust air into account.

(4) The activity on the filter shall be monitored with respect to a value at which a discharge of 4×10^7 Bq inside one hour can still be detected with a maximum standard deviation of 10 %. The filter shall be exchanged when this value is exceeded and the discharge cannot anymore be determined with the maximum permissible standard deviation of 10 %.

(5) The separation efficiency and loading capacity of the filters, both for elementary iodine as well as for organically bound iodine, shall be taken into account when choosing the sorption material. The iodine sorption material shall have a low rate of adsorption for noble gases.

Note:

In determining the separation efficiencies, the reference medium is, usually, the organic compound form of methyl-iodide.

(6) In order to prevent any distortion of the measurement, a high-efficiency particulate air filter of at least Filter Class E12 in accordance with DIN EN 1822-1 shall be installed inline before the iodine filter.

3.4.2 Detailed assessment

(1) The Iodine-131 discharged with the exhaust air shall be subjected to a detailed assessment. For this purpose, the elemental iodine and the organically bound radioactive iodine in the exhaust air shall be continuously accumulated on two separate iodine filters.

(2) The separation efficiency and loading capacity of the filters shall be known both for elemental iodine as well as for organically bound iodine and shall be taken into account when choosing the filters.

(3) In order to prevent any distortion of a measured value, a high-efficiency particulate air filter of at least Filter Class E12 in accordance with DIN EN 1822-1 shall be installed inline before the iodine filters; this filter may be identical to the high-efficiency particulate air filter specified under Section 3.3.2 para. (1).

(4) The accumulation period shall not exceed one week; the radioactive decay between accumulation and measurement shall be taken into account.

(5) The activity of Iodine-131 on the iodine filter and on the high-efficiency particulate air filter specified under para. (3) shall be determined by measurements in a gamma ray spectrometer within one day after removing the filters. The filters shall be analyzed without delay if one of the upper threshold values for monitoring the exhaust air is reached. If automatically starting accumulators are additionally installed, the filters of these accumulators may be measured instead.

(6) The detection limit for measuring the activity concentration of gaseous Iodine-131 in the exhaust air shall not exceed a value of 2×10^{-2} Bq/m³.

(7) Additionally iodine isotopes detected in the vent stack exhaust air in addition to Iodine-131 shall be reported individually in the report form (cf. **Figure 7-1b**) under "Other gaseous iodine isotopes" or "Other iodine isotopes bound to aerosols".

3.5 Tritium

(1) Tritium discharged with the exhaust air in the chemical compound form of water shall be monitored. For this purpose, samples shall be continuously accumulated.

(2) The activity of the tritium in the samples shall be determined in quarter annual intervals. It may be determined on the basis of the individual samples accumulated as specified under para. (1) or on the basis of a representative mixture sample.

(3) The activity of tritium discharged with the exhaust air shall be subjected to a detailed assessment. It shall be possible to detect a activity concentration of 1×10^2 Bq/m³ for tritium in the exhaust air.

(4) If the type of sampling requires that the temperature and humidity of the exhaust air are taken into account, then these measurement values shall continuously be determined.

3.6 Radioactive Strontium

(1) With regard to monitoring the discharge of radioactive strontium with the exhaust air, strontium shall be continuously deposited from a partial air stream of the exhaust air on a high-efficiency particulate air filter of at least Filter Class E12 in accordance with DIN EN 1822-1. This filter may be identical to the high-efficiency particulate air filter specified under Section 3.3.2 para. (1).

(2) The activity of the Strontium-89 and Strontium-90 shall be determined in quarter annual intervals on mixture samples that may be prepared from the high-efficiency particulate air filters exposed in the respective time span. In case of Strontium-89, the radioactive decay between accumulation and measurement shall be taken into account.

(3) The activity of strontium discharged with the exhaust air shall be subjected to a detailed assessment. It shall be possible to detect a activity concentration of 1×10^{-3} Bq/m³ for Strontium-89 and Strontium-90 in the exhaust air.

3.7 Alpha Emitters

(1) With regard to monitoring the discharge of alpha emitting radioactive substances (alpha emitters) with the exhaust air, alpha emitters bound to aerosols shall be continuously deposited from a partial air stream of the exhaust air on a high-efficiency particulate air filter of at least Filter Class E12 in accordance with DIN EN 1822-1. This filter may be identical to the high-efficiency particulate air filter specified under Section 3.3.2 para. (1).

(2) The nuclide specific analysis for alpha emitters shall be carried out in quarter annual intervals on mixture samples that may be prepared from the high-efficiency particulate air filters exposed in the respective time span.

(3) The activity of alpha emitters discharged with the exhaust air shall be subjected to a detailed assessment. The detailed assessment of the activity of alpha emitter shall take the radionuclides listed in **Table 3-3** into account. The detection limit of the measurement equipment for determining the activity concentration shall not exceed 5×10^{-3} Bq/m³ for Americium-241 in the exhaust air. For those radionuclides listed in **Table 3-3** not detected by the individual measurements, the decision threshold and detection limit achieved in the exhaust air for the particular measurement equipment with the particular measurement equipment shall be recorded. In the detailed assessment it is permissible to group together the nuclide pair Plutonium-238 and Americium-241 as well as the nuclide pair Plutonium-239 and Plutonium-240.

(4) Additionally detected alpha emitters shall individually be listed in the report form, (cf. **Figure 7-1b**) under the heading "Other alpha emitting radionuclides".

Radionuclides	
Plutonium 238	Americium 241
Plutonium 239	Curium 242
Plutonium 240	Curium 244

Table 3-3: Radionuclides to be considered in the detailed assessment of alpha emitters

3.8 Carbon-14

(1) The discharge of Carbon-14 with the exhaust air in the chemical compound form of carbon dioxide shall be monitored. For this purpose, samples shall be continuously accumulated from the exhaust air and analyzed in at least quarter annual intervals.

(2) The activity discharge of Carbon-14 with the exhaust air in the radiologically relevant chemical compound form of carbon dioxide shall be subjected to a detailed assessment. It shall be possible to detect a quarter annual discharge of at least 1×10^9 Bq.

(3) The annual activity discharge of Carbon-14 shall be determined. This may be determined analytically.

Measurement Task	*Measurement Procedure*	*Redundancy*	*Measurement or Sampling Equipment*	*Measurement Range (at nominal volumetric flow)*	*Detection Limit*	*Remarks*
Noble Gases						
a) continuous measurement	a1) integral continuous or: a2) integral continuous	yes yes	β- and γ-detector 2 × β-detectors	4×10^{9} Bq/h to 4×10^{13} Bq/h	1×10^{4} Bq/m³ for Xe-133	cf. Section 3.2.1 para. (3)
b) detailed assessment	nuclide specific continuous or:	no	γ-detector		5×10^{2} Bq/m³ for Xe-133	permissible as redundancy for the β-detector under a1) cf. Sec. 3.2.2 para. (2)
	nuclide specific non-continuous	no	accumulator		1×10^{4} Bq/m³ for Kr-85	permissible only in combination with a2) cf. Sec. 3.2.2 para. (2)
	in combination with integral continuous		β-detector			same measurement equipment as under a) “continuous measurement”
Radioactive substances bound to aerosols						
a) continuous measurement	integral continuous	no	γ- or β-detector	4×10^{6} Bq/h to 4×10^{9} Bq/h	4 (Bq/m³)h for Cs-137	cf. Sec. 3.3.1 para. (2)
b) detailed assessment	non-continuous	yes	accumulating filter		3×10^{-2} Bq/m³ for Cs-137 1×10^{-2} Bq/m³ for Co-60	cf. Sec. 3.3.2 para. (5)
Iodine						
a) continuous measurement	nuclide specific for Iodine-131	no	γ-detector	4×10^{5} Bq/h to 4×10^{8} Bq/h	2 (Bq/m³)h	cf. Sec. 3.4.1 para. (2)
b) detailed assessment	non-continuous	yes	accumulating filter		2×10^{-2} Bq/m³	cf. Sec. 3.4.2 para. (6)
Tritium						
detailed assessment	non-continuous	no	accumulator		1×10^{2} Bq/m³	cf. Sec. 3.5 para. (3)
Strontium						
detailed assessment	non-continuous	yes	accumulating filter		1×10^{-3} Bq/m³	the radioactive Strontium isotopes on the high-particulate air filter shall be analyzed, cf. Sec. 3.6 para. (3)
Alpha Emitters						
detailed assessment	non-continuous	yes	accumulating filter		5×10^{-3} Bq/m³	the alpha emitters on the high-particulate air filter shall be analyzed, cf. Sec. 3.7 para. (3)
Carbon 14						
as CO_2	non-continuous	no	accumulator		1×10^{9} Bq quarter annually	cf. Sec. 3.8 para. (2)
total	non-continuous	no	accumulator		5×10^{9} Bq annually	cf. Sec. 3.8 para. (3)

Table 3-4: Monitoring of the discharge of radioactive substances with the exhaust air

4 Sampling

(1) The sampling location and sampling procedure shall be chosen such that the extracted samples are representative for the respective activity discharge to be monitored. The number of sampling points is dependent on the degree of intermixing of the exhaust air at the sampling location.

Note:
Details regarding the required number and the arrangement of the sampling probes are specified in DIN ISO 2889.

(2) The volumetric flow of the partial air stream extracted from the exhaust air should not be smaller than one thousands of the nominal volumetric flow of the exhaust air.

Note:

Details regarding the choice of the partial air stream are specified in DIN ISO 2889.

(3) The sampling pipe lines shall be designed, routed and from such materials that only the smallest amount possible of radioactive substances bound to aerosols and gaseous radioactive iodine compounds are retained.

Note:

Details regarding the design are specified in DIN ISO 2889.

(4) The selection and storage of sorption materials for the filters shall take aging effects into account. The specified temperature range shall be maintained.

(5) The design of the components for aerosol and iodine filters shall take the following points into consideration:

a) Gas leak tightness shall be ensured during operation. This is considered as being accomplished if the volumetric flow of leakage air at a pressure difference of about 100 hPa is not larger than 1 % of the volumetric flow for the sampling at a pressure difference of about 100 hPa.

b) Any damage to the filter in the region of the filter gasket shall be avoided.

c) The flow of bypass air around the accumulating medium (filter) shall normally be smaller than 1 % of the volumetric flow for the sampling.

d) The filters shall be easy to exchange.

e) The mechanical parts shall be resistant to corrosion.

f) Those parts of the filter mounting that contact the measurement medium shall be easy to decontaminate.

(6) If the sampling is performed non-continuously, the point in time and the duration of sampling shall be chosen such that the extracted samples are representative for the radioactive substances discharged between two consecutive samplings.

(7) The sampling equipment for the continuous accumulation of radioactive substances bound to aerosols shall be designed such that the fraction of aerosol particles with aerodynamically equivalent diameters in the range between 0.1 µm and 20 µm relevant for determining the activity discharge will reach the high-efficiency particulate air filter. The overall loss factor for radioactive substances bound to aerosols shall be determined for the sampling equipment. In this context, suitable methods are, e.g.:

a) The overall loss factor for radioactive substances bound to aerosols shall be determined using test aerosol particles whose particle size distribution in the specific material amount (number and mass of the test aerosol particles) has a median value for the aerodynamically equivalent diameter of about 1 µm with a standard geometric deviation between 2 and 3. These test aerosol particles shall be injected into the exhaust air duct and the overall loss factor determined from the injected quantity and the quantity found on the accumulating medium (filter).

b) The overall loss factor for radioactive substances bound to aerosols may be determined alone on the basis of the pipe factor for the particle size distribution specified under item a). The pipe factor may also be determined without injecting test aerosol particles by using the plant specific aerosols in the vent stack and at the sampling point. In this case, the other influence parameters required for determining the overall loss factor shall be determined by special measurements or by calculations.

c) The overall loss factor for radioactive substances bound to aerosols shall be determined by comparing the activity concentration measured directly in the exhaust air stack with the measured activity concentration values determined from the sampling and measurement equipment.

(8) The overall loss factor shall be determined during commissioning of the sampling equipment, and after any changes that could significantly influence the overall loss factor as well as every five years. Its value should not be larger than 2 but may not be larger than 3.

(9) The overall loss factor shall be taken into account in the detailed assessment of the discharged radioactive substances bound to aerosols.

Notes:

(1) In addition to the gamma radiating radionuclides, the radioactive substances bound to aerosols include the strontium isotopes Sr-89 and Sr-90 and the alpha emitting radionuclides.

(2) The overall loss factor is taken into account in the detailed assessment for the calculation of the activity discharge, of the detection limit and of the decision threshold.

(10) The sampling equipment including the filters shall be designed and installed such that no temperatures below the dew point can occur.

5 Design and Construction of the Monitoring Equipment

Note:

The requirements of Section 5 apply to both stationary and mobile measurement equipment unless indicated otherwise.

5.1 Design and Installation

5.1.1 General requirements

(1) All components of the monitoring equipment (e.g., sampling equipment, measuring sensors, measuring transducers) shall be designed such that they can be operated as specified under this safety standard at the ambient conditions and the measurement media conditions occurring at their location of installation or deployment.

(2) The measurement and sampling equipment shall be installed or housed such that

a) nominal operating ranges specified in the individual equipment specifications are maintained, and

b) tests and inspections, maintenance and repair can be easily performed.

5.1.2 Requirements for stationary monitoring equipment

(1) Upon variation of any one influencing physical parameter within the nominal operating ranges listed in **Table 5-1**, the measured value shall not vary by more than ± 30 % of the one determined at the reference value of this influencing physical parameter. In the course of this variation, all other influencing physical parameters – with the exception of the atmospheric pressure and the pressure of the measurement medium –

shall, as far as possible, remain unchanged close to the reference values of the calibration. In this context, the pressure difference between measurement medium and ambient atmosphere shall normally not exceed 200 hPa.

(2) The reference values listed in **Table 5-1** shall be applied for the corresponding influencing physical parameters. Reference value for the filter loading shall be the uncharged (fresh) condition. The reference value for the background radiation shall be specified by the manufacturer of the monitoring equipment.

(3) In case of a failure of the air conditioning in the measurement rooms, the calibration value shall not vary by more than ± 30 % within the first hour after failure of the air conditioning taking the ambient conditions to be expected into account.

(4) With regard to the immunity of the measurement equipment to electromagnetic influences (e.g., electrostatic discharges, electromagnetic fields, interference voltages) the Act on the Electromagnetic Compatibility of Devices (EMVG) shall be observed.

(5) The measuring devices of the continuously operated monitoring equipment shall normally, as far as possible, be installed or housed in central measurement rooms

(6) If an operating medium (e.g. counter gas) is required, the supply of the operating medium shall be ensured and the supply shall be monitored with regard to a possible failure.

(7) All electrical power loads shall be connected to the emergency power supply system. Redundant electrical power loads shall be connected to redundant bus bars.

(8) Monitoring equipment that are operated continuously shall be designed and constructed to be self-monitoring; it shall be ensured that the switch-over to the emergency power supply does not interrupt the measuring and the processing of measured values in any way that would cause stored data to get lost (e.g., measured quantities needed for an integration).

(9) After a power interruption, all radiation and activity monitoring equipment including their peripheral devices must restart automatically.

(10) In case measurement equipment are installed on or inside a bypass, the volumetric flow in the respective bypass shall be monitored.

(11) The measurement equipment for the integral determination of noble gases, the ventilators for the extraction of a partial air stream from the exhaust air as well as the filters for the detailed assessment of the discharged radioactive substances bound to aerosols and of radioactive iodine shall all be provided as doubly redundant units.

(12) The detection limits shall be determined at an ambient dose rate of 0.25 µGy/h (Cesium-137).

N o t e :

The determination of the detection limits for nuclear radiation measurements are specified in DIN EN ISO 11929-1.

5.2 Statistical Certainty

(1) The value of the factor $k_{1-\alpha}$ in accordance with DIN EN ISO 11929-1 shall be set equal to 1.645.

(2) The value of the factor $k_{1-\beta}$ in accordance with DIN EN ISO 11929-1 shall be set equal to 1.645.

(3) The value of the factor $k_{1-\gamma}$ in accordance with DIN EN ISO 11929-1 shall be set equal to 1.645.

5.3 Threshold Values of the Stationary Measurement Equipment

(1) If it is necessary to readjust devices during operation, built-in adjustment controls shall be provided. All adjustment controls on electronic devices of the monitoring equipment shall be arranged or secured in such a way that a readjustment by non-authorized personnel can, to a large extent, be precluded. A misadjustment by the equipment itself shall be impossible.

(2) Equipment failure and the exceeding of threshold values shall be optically displayed and acoustically annunciated and recorded in the control room. Collective alarms are permissible, provided, the measurement location originating the alarm is displayed in the control room or in a control room annex. The acoustic alarms may be cancelled individually or collectively before remedying the cause of the alarm.

(3) The optical alarms in the control room indicating that a failure has occurred or that an upper threshold value has been exceeded shall also indicate the alarm condition (e.g., registered, or acknowledged).

5.4 Displaying and Recording the Measured Values of Stationary Measurement Equipment

(1) In case of an analog display, the measurement equipment shall normally have only one display range for each measurement parameter. If more than one display range is necessary, it is required

a) that, in the case of multiple linear display ranges, the sequential measurement ranges overlap each other by at least 10 % and the full-scale values do not differ by more than the factor of 10; and

b) that, in the case of multiple logarithmic display ranges, sequential measurement ranges overlap each other by at least one decade.

(2) The measured value should be displayed on the associated measurement equipment. In the control room the following values shall be displayed and automatically recorded:

a)	Exhaust air:	Volumetric flow,
b)	Radioactive noble gases:	cumulative beta activity concentration; discharge rate (Bq/h),
c)	Radioactive substances bound to aerosols:	filter loading (activity); in case of measurement equipment with a built-in filter: activity change per unit time,
d)	Gaseous radioactive iodine:	filter loading (activity); activity concentration; discharge rate (Bq/h).

(3) The recorded data shall remain directly visible and well legible for a time span of at least 3 hours.

5.5 Testability

The monitoring equipment shall be designed and constructed such that a verification of the perfect functioning order of individual devices is possible within the framework of the initial tests specified under Section 6.2.2 and of the inservice inspections specified under Section 6.2.3, and for tests of the mobile measurement equipment specified under Section 6.3. It shall be possible to perform functional tests even during full power operation of the nuclear power plant.

Influencing Physical Parameters	*Nominal Operating Ranges*	*Reference Values*
Operating voltage		
alternating current voltage supply	85 to 110 % of the nominal value of the operating voltage	Manufacturer specification
direct current voltage supply	specified voltage range of the direct current voltage grid	Manufacturer specification
Ambient temperature	15 °C to 40 °C	20 °C
Ambient air pressure	900 hPa to 1100 hPa	Manufacturer specification
Relative humidity of ambient air	10 % to 95 %, non-dewing	60 %
Temperature of the measurement medium	15 °C to 40 °C	20 °C
Pressure of the measurement medium[1)]	700 hPa to 1100 hPa	Manufacturer specification
Relative humidity of the measurement medium	10 % to 95 %, non-dewing	60 %

[1)] The pressure difference between measurement medium and ambient atmosphere shall not be larger than 200 hPa.

Table 5-1: Nominal operating ranges and reference values of the influencing physical parameters

6 Maintenance of the Monitoring Equipment

N o t e :

The requirements of Section 6 apply to both stationary and mobile measurement equipment unless indicated otherwise.

6.1 Servicing and Repair

6.1.1 Execution

Servicing and repair of the monitoring equipment shall be performed in accordance with the respective operating and repair instructions and by qualified persons.

6.1.2 Documentation

(1) All servicing and repair tasks performed shall be documented.

(2) In the case of stationary sampling and measurement equipment, this documentation shall contain the following information:

a) Unambiguous identification of the monitoring equipment involved,

b) Type of the servicing or repair task performed,

c) Type and number of exchanged parts,

d) Reasons for exchanging the parts,

e) Regarding the newly installed parts:
date and detailed identification of the test certificates and of the verifications required under this safety standard,

f) Data regarding the outage times,

g) Date of the servicing or repair task,

h) Name and signatures of the qualified persons.

6.2 Tests and Inspections of Stationary Measurement Equipment

6.2.1 Test and inspections to be performed

The monitoring equipment shall be subjected to the following tests and inspections:

a) Prior to their deployment in a nuclear power plant:
   - aa) Certification of suitability, and
   - ab) Calibration,

b) Prior to their first deployment in a particular nuclear power plant:
   - ba) Check of suitability,
   - bb) Factory test,
   - bc) Check of calibration with solid calibration sources, and
   - bd) Commissioning tests and inspections,

c) During deployment in the nuclear power plant
   - ca) regular inservice inspections, and
   - cb) tests and inspections after servicing and repair tasks.

6.2.2 Initial tests and inspections

6.2.2.1 Verification of suitability

(1) Prior to their initial deployment in a nuclear power plant, it shall be verified that the monitoring equipment fulfill their tasks and meet the specified requirements.

N o t e :

Requirements regarding verifying the suitability of stationary measurement equipment for monitoring activity are dealt with in safety standard KTA 1505.

(2) The verification of suitability comprises a (plant independent) verification of the equipment characteristics and a plant-dependent suitability check.

(3) The plant-dependent suitability check shall be performed by the proper authority or an authorized expert appointed by the proper authority.

6.2.2.2 Calibration and check of the calibration

(1) Prior to their first deployment, suitable calibration factors shall have been established for the monitoring equipment including the volumetric flow measurement equipment. It is permissible to determine the calibration factors on type-identical measurement equipment. The calibration shall be performed at the reference values specified in **Table 5-1**.

(2) The measurement equipment for monitoring the overall beta activity of the radioactive noble gases shall be calibrated using Xenon-133 and Krypton-85. The energy dependence of the discrimination of the measurement equipment for determining the beta radiation of the radioactive noble gases shall be determined using at least three representative beta emitters with a maximum beta energy within the range from 150 keV to 2500 keV. The energy dependency of the response characteristics of the measurement equipment for determining the gamma radiation of radioactive noble gases shall be known for gamma radiation in the energy range from 60 keV to 2500 keV.

(3) The measurement equipment for the gamma-spectrometric measurements specified under Section 3.2.2 shall be calibrated using Xenon-133 and Krypton-85.

(4) The measurement equipment for the monitoring of the beta radiation of the radioactive substances bound to aerosols shall be calibrated with Technetium-99 or Cobalt-60 as well as with Chlorine-36 or Cesium-137, and for the monitoring of gamma radiation with Barium-133 and Cesium-137. The energy dependence of the discrimination for beta radiation shall be known in the energy range from 150 keV to 2500 keV, and for gamma radiation in the energy range from 100 keV to 1700 keV. In order to reduce the probability of detecting falsifying nuclides and background radiation, the lower threshold for gamma radiation in the measurement equipment for monitoring radioactive substances bound to aerosols may be raised to a maximum level of 250 keV.

(5) The measurement equipment for monitoring iodine shall be calibrated with Iodine-131.

(6) The measurement equipment for monitoring water-bound tritium shall be calibrated with tritiated water.

(7) The measurement equipment for monitoring alpha emitters shall be calibrated with Americium-241.

(8) During the initial calibration, a set of solid calibration sources shall be specified that are suited to check one display value in one of the lower and one display value in one of the upper decades of the measurement range. For this purpose, the following solid calibration sources shall be provided:

a) For monitoring noble gases:
Cobalt-60, Technetium-99 or Cesium-137 for the measurement equipment for beta emitters, Barium-133 or Cobalt-57 for the gamma radiation measurement equipment, and Americium-241 and Europium-152 for the continuous gamma-spectrometric measurement equipment;

b) For monitoring radioactive substances bound to aerosols: Cobalt-60 or Technetium-99 for the beta radiation measurement equipment and Barium-133 or Cobalt-57 for the gamma radiation measurement equipment;

c) For the iodine monitoring: Barium-133.

(9) Following initial calibration of the monitoring equipment, a solid calibration source shall be applied in a defined and reproducible geometry to determine a display value which will later make it possible to check the calibration and to connect further type-identical equipment.

6.2.2.3 Factory test

(1) A factory test shall be performed to verify that the monitoring equipment was properly manufactured and is in perfect functioning order. In case the monitoring equipment is comprised of components from different manufacturers, the proper manufacturing and perfect functioning order of these components shall be verified by factory tests performed at the respective manufacturing plant.

(2) The factory test shall be performed as a production test and shall comprise:

a) Visual inspection,

b) Test of the output value as a function of the specified fluctuation of the operating voltage,

c) Test of the response characteristic with a pulse or current generator and at least one test value for each decade of the measurement range,

d) Test of the overload resistance (by using electronic means or a solid radiation source),

e) Function test (using of a solid radiation source),

f) Test of the volumetric flow or integral volumetric flow measurement,

g) Leak-tightness test.

(3) The factory test shall be performed by plant experts and, in justified cases, in the presence of the proper authority or an authorized expert appointed by the proper authority.

6.2.2.4 Commissioning Tests

(1) The post-installation commissioning tests shall verify the proper design and function of the monitoring equipment. The following items shall be tested:

a) Design of the monitoring equipment,

b) Installation of the monitoring equipment,

c) Display (with at least one test value for each decade of the measurement range),

d) Check of the calibration (with a solid calibration source),

e) Connection to the emergency power system,

f) Volumetric flow monitoring,

g) Measurement value processing,

h) Supply of operating media,

i) Equipment failure alarms,

k) Threshold value settings and alarm signals,

l) Automatic restart after interruption of the power supply, and

m) Connection to the volumetric flow of the exhaust air.

(2) The commissioning test shall be carried out by the plant operator and, to an extent specified by the proper authority, by the proper authority or an authorized expert appointed by the proper authority or in their presence.

6.2.3 Inservice inspections

6.2.3.1 General requirements

(1) The testing schedule, the test instructions and test certificates shall be in accordance with safety standard KTA 1202.

(2) The inservice inspections shall be possible without manual changes of the circuitry (e.g., soldering).

6.2.3.2 Regular inservice inspections

(1) Regular inservice inspections shall be performed to verify the perfect functioning order of the monitoring equipment. The test procedures and test frequencies shall be as specified in **Table 6-1**.

(2) The verification of the calibration listed under Running Number 1 b) of **Table 6-1** shall be carried out in the defined geometry and with the solid calibration source specified during initial calibration of the measurement equipment (cf. Section 6.2.2.2 para. (9)). The required value of the display must be achieved with an accuracy that shall be specified in the testing manual.

(3) The regular inservice inspections shall be performed by the plant operator or by the proper authority or by an authorized expert appointed by the proper authority.

6.2.3.3 Post-repair testing

After completion of a repair task, the perfect functioning order shall be verified by a commissioning test as specified under Section 6.2.2.4 to an extent corresponding to the repair task.

6.2.3.4 Removal of defects

The time limits and, possibly, alternative measures for the removal of defects shall be specified in the operating manual. The defects including the measures taken for their removal shall be documented.

6.3 Tests of the Mobile Measurement Equipment

(1) It shall be verified that the measurement equipment fulfill their task and meet the requirements specified in the present safety standard.

(2) The measurement equipment shall be calibrated for their individual measurement task.

(3) Commissioning tests shall be performed to verify the proper design and perfect functioning order of the measurement equipment. In this context the following shall be tested:

a) Design of the measurement equipment,

b) Arrangement of the measurement equipment,

c) Functionality and performed calibration check,
and

d) Supply of operating media.

(4) The commissioning test shall be carried out by the plant operator and, to an extent specified by the proper authority, by the proper authority or an authorized expert appointed by the proper authority or in their presence.

(5) Regular inservice inspections shall be performed.

(6) The testing schedule, the test instructions and test certificates shall be as specified in safety standard KTA 1202.

(7) Regular inservice inspections shall be performed to verify that the measurement equipment is in perfect functioning order. The tests and test intervals shall be as listed under Running Numbers 2 and 8 of **Table 6-1**.

(8) After completion of a repair task, the perfect functioning order shall be verified by a commissioning test to an extent corresponding to the repair task.

7 Measurement Results

7.1 Documentation

7.1.1 Flow chart

(1) The sampling and monitoring equipment provided for measuring the discharge of gaseous radioactive substances and of radioactive substances bound to aerosols shall be clearly presented in a flow chart. Different symbols shall be used to identify the type of sampling and monitoring.

(2) In a description correlated to the flow chart (e.g., in the form of a table), the required measurement task and the measurement procedure shall be specified for each sampling and monitoring equipment. In case of sampling equipment, the task, type, location and frequency as well as the measurements to be performed shall be listed. In case of monitoring equipment, the measurement tasks and technical measurement requirements, in particular, the measurement procedure, the arrangement of the measurement equipment including radiation shielding, the calibration, the measurement ranges, detection limits and measurement uncertainties shall be listed. Likewise, the measurement tasks and technical measurement requirements of the measurement laboratory shall be described.

7.1.2 Extent

The documentation shall be structured such that a complete verification of the discharge of radioactive substances is possible. In this context, the documentation shall include records on

a) Activity measurements
(individual radionuclide concentrations and discharge rates),

b) Samplings
(continuous, non-continuous; point in time, time span),

c) Volumetric flow of exhaust air in the vent stack,
and

d) Responsible and performing persons.

7.2 Report to the Proper Authorities

7.2.1 Content

The reports to the proper supervisory authority about the discharge of gaseous radioactive substances bound to aerosols shall include:

a) Integral volume of exhaust air,

b) Licensed limit values,

c) Nuclide specific activity discharge and the respective measurement uncertainties,

d) The maximum decision thresholds and detection limits achieved with the deployed measurement equipment in the reporting period.

e) Overall loss factor.

7.2.2 Detailed assessment

The nuclide specific verification of the activity discharged in the exhaust air and the comparison with the licensed limit values shall be prepared quarter annually and for the time span since the beginning of the calendar year. Those nuclides with concentrations below the decision threshold do not need to be considered in the detailed assessment.

7.2.3 Report form

(1) The report form shown in **Figure 7-1a) and b)** shall normally be used for the regular reports.

(2) The column "Discharged Activity" shall list only those values that result from measured values of activity concentrations exceeding the decision thresholds. If no measurement values exceeding the decision thresholds are detected in the detailed assessment period, the corresponding fields in the report form shall be marked as “unk.” (unknown) for the resulting calculated value of the discharged activity.

(3) In the column „Discharged Activity and its uncertainty“ the summation of measurement uncertainties according to Gaussian error propagation shall be applied and list in the in the appropriate line.

<table>
<tr><th rowspan="2">Running Number</th><th rowspan="2">Test Objects</th><th rowspan="2">Test Procedures</th><th colspan="2">Test Frequencies</th></tr>
<tr><th>by the plant operator</th><th>by proper authority or by an expert authorized by the proper authority</th></tr>
<tr><td rowspan="3">1</td><td rowspan="3">Monitoring equipment</td><td>a) Visual inspection</td><td>during inspection rounds</td><td>annually</td></tr>
<tr><td>b) Verification of calibration with solid calibration source</td><td>quarter annually</td><td>annually</td></tr>
<tr><td>in case of counter tubes: verification of the plateau, as necessary</td><td>–</td><td>annually</td></tr>
<tr><td>2</td><td>Testing and maintenance records</td><td>Visual inspection</td><td>–</td><td>annually</td></tr>
<tr><td>3</td><td>Electronic modules</td><td>Insertion of suitable signals at inputs provided or simulation of signals directly into the measurement transducer input with at least one value in each decade of the measurement range 1) for the integral test of the measurement transducer.

For testing the measurement transducer output as well as devices such as displays, recorders, monitoring computers, at least one value shall be simulated for each decade of the measurement range; in the case of computer based measurement equipment, these values may be created by the software.

Comparison of all displays and recordings.</td><td>annually</td><td>annually</td></tr>
<tr><td rowspan="4">4</td><td rowspan="4">Alarm signals</td><td>a) Operational availability:
visual inspection</td><td>during inspection rounds</td><td>annually</td></tr>
<tr><td>b) Failure alarm signal:
by interrupting the voltage supply or interrupting the signal connection between measurement transducer and detector or by inserting a value below the failure threshold</td><td>quarter annually</td><td>annually</td></tr>
<tr><td>c) Hazard alarm:
by radiation source or electrically</td><td>quarter annually</td><td>annually</td></tr>
<tr><td>d) Volumetric flow monitoring:
by varying the volumetric flow to values outside of the alarm thresholds</td><td>annually</td><td>annually</td></tr>
<tr><td rowspan="3">5</td><td>Flow monitoring and supply of operating media</td><td></td><td></td><td></td></tr>
<tr><td>without automatic function control</td><td>Visual inspection</td><td>during inspection rounds</td><td>annually</td></tr>
<tr><td>with automatic function control</td><td>Comparison of the required value with the actual value</td><td>quarter annually</td><td>annually</td></tr>
<tr><td>6</td><td>Volumetric flow of exhaust air</td><td>Comparison of the required value with the actual value at nominal volumetric flow</td><td>annually</td><td>annually</td></tr>
<tr><td rowspan="2">7</td><td rowspan="2">Sampling equipment</td><td>a) Visual inspection, check of the switching of ventilators or blower</td><td>annually</td><td>annually</td></tr>
<tr><td>b) Determination of the overall loss factor</td><td>every 5 years</td><td>every 5 years</td></tr>
<tr><td rowspan="2">8</td><td rowspan="2">Mobile measurement equipment</td><td>a) Visual inspection</td><td>quarter annually</td><td>annually</td></tr>
<tr><td>b) Check of calibration</td><td>quarter annually</td><td>annually</td></tr>
<tr><td colspan="5">1) The test procedure of simulating of detector signals at the measurement transducer inputs for the integral test of measurement transducers and measurement circuits – with at least one value in each decade of the measurement range – is not required in the case of computer-based measurement equipment, provided, the software program is certified. In this case it is sufficient to insert one signal in the uppermost decade of the measurement range, provided, the pre-processing electronics do not perform any switching procedures throughout the entire measurement range. This too is not required if the verification of the calibration is carried out with one measurement value in the uppermost decade of the measurement range.</td></tr>
</table>

Table 6-1: Regular inservice inspections

NPP:	In the ..... quarter, 20.. Since the beginning of the year 20..					
Volume of exhaust air in m³			Overall loss factor			
Radionuclide	***Decision Threshold and Detection Limit [1] of the activity concentration in the exhaust air (Bq/m³)***		***Discharged activity [2] (Bq) and its uncertainty (Bq)***		***Licensed value of the activity discharge (Bq/a)***	***Remarks***
	DT max.	***DL max.***	***in quarter***	***since start of the year***		
Radioactive Noble Gases:						
Ar-41						
Kr-85						
Kr-85m						
Kr-87						
Kr-88						
Kr-89						
Xe-131m						
Xe-133						
Xe-133m						
Xe-135						
Xe-135m						
Xe-137						
Xe-138						
Other radioactive noble gases						
Sum radioactive noble gases [3]						
Sum radioactive noble gases (Cumulative beta activity) [4]						
H-3 as vaporous water						
C-14						
C-14 as CO_2						
C-14 (Sum of all gaseous compounds)						
Sum of gaseous radionuclides and compounds (except iodine)						
Iodine:						
I-131 gaseous, elemental						
I-131 gaseous, organically bound						
I-131 bound to aerosols [5]						
Sum I-131						
Other gaseous iodine isotopes						
Other iodine isotopes bound to aerosols						

[1] DT and LT are the maximum decision thresholds and detection limits achieved with a single measurement in the detailed assessment period.

[2] unk. = unknown, see also Section 7.2.3 para. (2)

[3] Sum of the activity discharge from the nuclide specific measurement

[4] Sum of the activity discharge from the integral measurement

[5] Contains correction regarding the overall loss factor (applies to strontium isotopes und alpha emitting radionuclides)

Figure 7-1a: Example for the report form of discharged activity, Part 1

NPP:	In the ..... quarter, 20.. Since the beginning of the year 20..					
Volume of exhaust air in m^3			Overall loss factor			
Radionuclides	***Decision Threshold and Detection Limit [1] of the activity concentration in the exhaust air (Bq/m³)***		***Discharged activity [2] (Bq) and its uncertainty (Bq)***		***Licensed value of the activity discharge (Bq/a)***	***Remarks***
	DT max.	***DL max.***	***in quarter***	***since start of the year***	***min.***	
Radionuclides Bound to Aerosols [5]:						
Cr-51						
Mn-54						
Co-57						
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 gamma radiating radionuclides						
Sr-89						
Sr-90						
Pu-238						
Pu-238 + Am-241						
Pu-239						
Pu-239 + Pu-240						
Pu-240						
Am-241						
Cm-242						
Cm-244						
Other alpha emitting radionuclides						
Sum of radionuclides bound to aerosols						

[1] DT and LT are the maximum decision thresholds and detection limits achieved with a single measurement in the detailed assessment period.

[2] unk. = unknown, see also Section 7.2.3 para. (2)

[3] Sum of the activity discharge from the nuclide specific measurement

[4] Sum of the activity discharge from the integral measurement

[5] Contains correction regarding the overall loss factor (applies to strontium isotopes und alpha emitting radionuclides)

Figure 7-1b: Example for the report form of discharged activity, Part 2

Appendix A

Regulations Referred to in this Safety Standard

Regulations referred to in this safety standard are only valid in the version cited below. Regulations which are referred to within these regulations are valid only in the version that was valid when the later regulations were established or issued.

AtG		Act on the Peaceful Utilization of Atomic Energy and the Protection against its Haz-ards (Atomic Energy Act) Atomic Energy Act in the version promulgated on July 15, 1985 (BGBl. I, p. 1565), most recently changed by article 1 of the act dated December 4, 2022 (BGBl. I, p. 2153)
StrlSchG		Act on the Protection against the Harmful Effect of Ionising Radiation (Radiation Protection Act - StrlSchG) Radiation Protection Act of June 27, 2017 (BGBl. I, p. 1966), most recently changed by the promulgation of January 3, 2022 (BGBl. I, p. 15)
EMVG		Act on the electromagnetic compatibility of operating components (EMVG) of September 26, 1998 (BGBl. I, No. 64, p. 2882), most recently changed by Article 51 of the act of June 23, 2021 (BGBl. I p. 1858)
StrlSchV		Ordinance on the Protection against the Harmful Effects of Ionising Radiation (Radiation Protection Ordinance - StrlSchV) Radiation Protection Ordinance of November 29, 2018 (BGBl. I, p. 2034, 2036), most recently changed by article 1 of the ordinance dated October, 2021 (BGBl. I p. 4645)
SiAnf	(2015-03)	Safety Requirements for Nuclear Power Plants (SiAnf) of November 22, 2012, amended version of March 3, 2015 (BAnz AT 30.03.2015 B2), most recently changed as promulgated by BMUV on February 25, 2022 (BAnz AT 15.03.2022 B3)
Interpret of SiAnf	(2015-03)	Interpretations of the safety requirements for nuclear power plants of November 22, 2012, of November 29, 2013 (BAnz AT 10.12.2013 B4), changed on March 3, 2015 (Banz AT of March 30, 2015 B3)
Self-Surveillance Control Guideline	(1996-02)	Control of the self-surveillance regarding radioactive emissions from nuclear power plants of February 5, 1996 (GMBl. 1996, No. 9/10, p. 247)
KTA 1202	(2017-11)	Requirements for the testing manual
KTA 1503.2	(2022-11)	Monitoring the Discharge of Radioactive Gases and Airborne Radioactive Particulates Part 2: Monitoring the Discharge of Radioactive Matter with the Vent Stack Exhaust Air During Design-Basis Accidents
KTA 1503.3	(2022-11)	Monitoring the Discharge of Radioactive Gases and Airborne Radioactive Particulates Part 3: Monitoring the Non-Stack Discharge of Radioactive Matter
KTA 1505	(2022-11)	Suitability verification of the stationary measurement equipment for radiation monitoring
DIN EN 1822-1	(2019-10)	High efficiency air filters (EPA, HEPA and ULPA) - Part 1: Classification, performance testing, marking; German version EN 1822-1:2019
DIN ISO 2889	(2012-07)	Sampling airborne radioactive materials from the stacks and ducts of nuclear facilities (ISO 2889:2010)
DIN EN ISO 11929-1	(2021-11)	Determination of the characteristic limits (decision threshold, detection limit and limits of the coverage interval) for measurements of ionizing radiation - Fundamentals and application - Part 1: Elementary applications (ISO 11929-1:2019); German version EN ISO 11929-1:2021
KTA-GS 82	(2016-11)	Determination of the characteristic limits (decision threshold, detection limit and limits of the confidence interval) for nuclear radiation measurements according to DIN ISO 11929 - Application examples for the KTA safety standard series 1500, Revision 1