

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

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

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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

KTA 1503.1

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PLEASE NOTE: Only the original German version of this safety standard represents the joint resolution of the 35-member Nuclear Safety Standards Commission (Kerntechnischer Ausschuss, KTA). The German version was made public in the Federal Gazette (Bundesanzeiger) on July 25, 2023. Copies of the German versions of the KTA safety standards may be mail-ordered through the Wolters Kluwer Deutschland GmbH (info@wolterskluwer.de). Downloads of the English translations are available at the KTA website (<http://www.kta-gs.de>).

All questions regarding this English translation should please be directed to the KTA office:

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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, 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 part KTA 1503.2

(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 of 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.