

Safety Standards

of the

Nuclear Safety Standards Commission (KTA)

KTA 1503.2 (6/99)

**Monitoring the Discharge of Gaseous and Aerosol-bound
Radioactive Substances;**

**Part 2: Monitoring the Stack Discharge of Radioactive
Substances During design basis accidents**

(Überwachung der Ableitung gasförmiger und aerosolgebun-
dener radioaktiver Stoffe;

Teil 2: Überwachung der Ableitung radioaktiver Stoffe mit der
Kaminfortluft bei Störfällen)

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

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KTA SAFETY STANDARD

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**Monitoring the Discharge of
Gaseous and Aerosol-bound Radioactive Substances;
Part 2: Monitoring the Stack Discharge of Radioactive
Substances During design basis accidents**

KTA 1503.2

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PLEASE NOTE: Only the original German version of this safety standard represents the joint resolution of the 50-member Nuclear Safety Standards Commission (Kerntechnischer Ausschuss, KTA). The German version was made public in Bundesanzeiger BAnz No. 243b of December 23, 1999. Copies may be ordered through the Carl Heymanns Verlag KG, Luxemburger Str. 449, 50939 Koeln, Germany (Telefax +49-(0)221-94373603).

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Comments by the editor:

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

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

Fundamentals

(1) The safety standards of the Nuclear Safety Standards Commission (KTA) have the task of specifying those safety related requirements which shall be met with regard to precautions to be taken in accordance with the state of science and technology against the hazards arising from the construction and operation of the facility (Section 7 para. 2 no. 3 Atomic Energy Act), in order to attain the protective goals specified in the Atomic Energy Act and the Radiological Protection Ordinance (StrlSchV) and which are further detailed in "Safety Criteria for Nuclear Power Plants" and in "Guidelines for the Assessment of the Design of Nuclear Power Plants with Pressurized Water Reactors against Incidents pursuant to Section 28 para. 3 of the Radiological Protection Ordinance (StrlSchV) - Incident Guidelines".

(2) The permanently installed and mobile radiation protection instrumentation, among other equipment, serves to protect the persons inside and outside of the facility from ionizing radiation, to ascertain the specified normal functioning of the equipment for keeping solid, liquid and gaseous radioactive substances within the intended enclosure, for the handling and controlled conduction of the radioactive substances within the facility and for Monitoring the discharge of radioactive substances. The safety standards in the KTA 1500 series formulate specific safety related requirements for this instrumentation.

(3) Safety standard KTA 1503 contains the requirements for the technical equipment and additional organizational measures considered necessary with respect to Monitoring the emission of gaseous and aerosol-bound radioactive substances. It is comprised of the following parts:

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

Part 2: Monitoring the stack discharge of radioactive substances during design basis accidents,

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

(4) As specified under Sec. 46 para. 1 StrlSchV, it must be ascertained that any uncontrolled discharge is prevented, that the discharged radioactivity is as low as possible, that the discharge is monitored and, specified by type and radioactivity, is reported to the proper authority in no longer than yearly intervals. In accordance with these requirements, equipment for monitoring the discharge of radioactive substances shall be installed and operated. This monitoring equipment shall, in accordance with Sec. 72 StrlSchV, correspond to the state of the art in science and technology.

(5) In the case of design basis accidents and other accidents Sec. 36 StrlSchV requires the immediate introduction of all necessary actions to minimize the dangers to life, health and material goods. In accordance with the requirements under Sec. 38 StrlSchV the necessary auxiliary means shall be kept available with regard to damage control in case of design basis accidents and other accidents. The Monitoring carried out with the accident instrumentation for measuring the radioactive substances discharged with the stack air from nuclear power plants serves, among others, as the basis for taking these measures and for their type, extent and duration.

This Monitoring serves the following purposes:

- a) providing data regarding type and activity of the radioactive substances discharged during a design basis accident,
- b) providing information helping in deciding on the required protection measures,
- c) contribute toward meeting the requirements specified under Sec. 28 para.1 item 2, Secs. 36, 38, 46 para. 1, Sec. 72 para. 1 and Sec. 73 StrlSchV.

(6) Essential to the design of the instrumentation is the amount of information it must deliver during design basis accidents and the conditions for which the required measurement devices must be designed. With respect to specified normal operation this means an expansion of the requirements regarding measurement ranges and influencing parameters.

(7) By monitoring the activity of the discharged radioactive substances (emission monitoring) in connection with meteorological measurements and atmospheric dispersion calculations on the one hand and by direct measurements in the environment (pollution monitoring) on the other, it is possible to identify the radiological effects of the facility on the environment. Whereas, during specified normal operation the essential data will result from emission monitoring – the pollution measurements values will stay within the tolerance limits of natural radiation –, these pollution measurements will increase in importance during design basis accidents since they will enable establishing the radiological effects. In extreme cases, it is practically the only measurement method that will help to determine the effects on the environment since release of activity could occur along other paths than those intended for the discharge of radioactive substances.

(8) The concept on which this safety standard is based should normally ensure that, during design basis accidents, this emission monitoring can be reliably performed as long as emission monitoring still delivers valid results.

1 Scope

(1) This safety standard shall apply to the equipment for Monitoring the discharge of gaseous and aerosol-bound radioactive substances with the stack air from nuclear power plants with light water reactors during and after design basis accidents.

(2) In specifying the requirements for the instrumentation only those design basis accidents are considered where the gaseous and aerosol-bound radioactive substances would actually be discharged with the stack air. In the case of external events where monitoring of the emission of radioactive substances cannot be ensured, backup measurements shall be used that are carried out within the framework of environmental Monitoring (emission monitoring).

(3) Measurement systems for those events that require plant-internal accident management measures are not within the scope of this safety standard.

Note:

Plant-internal accident management measures may require the specification of other requirements than those specified in this safety standard.

2 Definitions

2.1 Discharge rate

Discharge rate is the quotient found by taking the amount of activity discharged in a certain time period and dividing it by this same time period.

2.2 Discharge of radioactive substances

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

2.3 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 plant 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).

2.4 Iodine fractions

An iodine fraction is that part of the iodine that on account of its physical and chemical characteristics can be selectively collected in special filter and absorption materials. Currently known are the following fractions: elementary iodine, aerosol bound iodine and organically bound iodine. Elementary iodine and organically bound iodine are collectively described as gaseous iodine.

2.5 Measurement-range factor

Measurement-range factor is the ratio between the end value on the scale of one measurement range and the end value on the scale of the next more sensitive measurement range.

2.6 Measurement system

Measurement system is the entirety of all measurement devices and auxiliary devices that are required to establish a measured quantity, to transmit and adjust a measurement signal and to display a measured value as the image of a measured quantity.

2.7 Measurement medium

Measurement medium is the sample extracted from the monitored medium that then flows through the measurement volume (i.e. that region for which the discrimination of the measurement device has been determined during calibration) - possibly after having been put through a process-oriented treatment, e.g. warming up, filtering, dilution.

2.8 Detection limit and decision limit of a measurement system for a specific nuclide and nuclide mixture

Note:

Definitions: cf. KTA 1503.1

2.9 Design basis accident

A design basis accident is a chain of events which interferes with the operation of the plant or with the activity in such a way that operation or the activity must be interrupted for reasons of safety, and for which the plant must be designed or for which protective measures must be provided with regard to the activities.

2.10 Monitoring

Monitoring is a collective term standing for any kind of controlled measurement of physical values including their comparison with predetermined specified values.

Note:

Monitoring is carried out, e.g., by

- a) continuous measurement or
- b) discontinuous evaluation of samples (e.g. in the laboratory) or
- c) correlation of measured values

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

3 Measurement Items and Measurement Procedures

3.1 General Requirements

(1) During and after design basis accidents the discharged radioactive substances shall be determined in accordance with the requirements of this safety standard. With respect to the measurement procedures and to the radiological importance of the discharged materials, the following groups shall be distinguished between:

- a) radioactive noble gases,
- b) radioactive aerosols and radioactive gaseous iodine
- c) iodine 131 (aerosol-bound and gaseous).

(2) The equipment for monitoring the discharge of radioactive substances with the stack air during specified normal operation in accordance with KTA 1503.1 may also be used for monitoring the discharge during and after design basis accidents. In this case, this equipment shall then be additionally subject to the requirements under this safety standard.

(3) Measurement systems dedicated to the accident survey display may be employed as measurement system for the wide range display equipment, provided they meet the additional requirements for the wide range display equipment.

(4) The continuous or discontinuous extraction of samples for monitoring the discharge of radioactive substances should be performed inside the exhaust air or on a partial stream of the exhaust air. Measurements of the absorbed gamma ray dose rate may also be performed within or on the main stream of the exhaust air.

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

(6) The volumetric flows of each of the partial streams of the exhaust air shall be monitored; a reduction of the volumetric flows of the partial streams below a certain limit value shall be indicated in that area of the control room dedicated to emission monitoring.

(7) In the case of fire with smoke removal through the exhaust stack, the discharge of radioactive noble gases shall be determined with a continuously measuring ionization chamber as specified under Section 3.2.1.1 para. 1 item b. It is sufficient in this case to monitor the radioactive aerosols and radioactive gaseous iodine by collection in a filter and its later evaluation in the laboratory.

(8) The laboratory shall be equipped with suitable procedures and measurement systems that take into consideration the maximum expected sample activity for the evaluation of gaseous samples and of the aerosol and iodine filter samples.

Note:

Table 3-1 presents a survey of the required measurements.

3.2 Radioactive Noble Gases

3.2.1 Accident Survey Display Equipment

3.2.1.1 Continuous Measurement

(1) The discharge of radioactive noble gases with the exhaust air shall be continuously monitored by measuring the activity concentration and the volumetric stream. The activity concentration shall be determined by the following two measurements:

- a) measurement of the activity concentration of radioactive noble gases (beta ray activity) and
- b) measurement of the absorbed gamma ray dose rate.

The range of activity concentrations to be determined are 1×10^6 to 1×10^{11} Bq/m³ in the case of measurements under item a and 1×10^7 to 1×10^{11} Bq/m³ in the case of measurements under item b.

In calibrating for measurements under item a it shall be presumed that the nuclide xenon 133 is present. For measurements under item b the presumption is that each individual decay releases one gamma quantum with an energy of 300 keV. Measurements with the measurement goal under item a may also be performed by the measurement system as specified under Section 3.2.1.2 para. 4, provided that equipment covers the measurement range as required here.

(2) In the case of measurements under para. 1 item a a Class S high-efficiency particulate air filter in accordance with DIN 24 184 as well as a filter with a minimum retention rate of 90% for elementary iodine shall be placed in line before the measurement system in order to reduce contamination.

3.2.1.2 Nuclide Specific Measurement

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

(2) With the beginning of a design basis accident and a discontinuous determination of the nuclide composition of the radioactive noble gases, a representative sample shall basically be taken in hourly intervals for as long as it must be expected that a design basis accident related discharge exceeding a licensed limit value of specified normal operation could occur; these samples shall be evaluated without delay. A prolongation of the interval between extractions of samples and their nuclide specific evaluation beyond one hour is permissible in those cases where measured values of the noble gas measurement point specified under Section 3.2.1.1 para. 1 item a indicates that no essential changes have occurred.

(3) The activity discharge of individual noble gas nuclides determined from the discontinuous measurement of the nuclide composition shall be based on the activity concentration determined with the measurement system specified under Section 3.2.1.1 para. 1 item a. In case this measurement system fails, the basis used shall be the absorbed gamma ray dose rate determined with the measurement system specified under Section 3.2.1.1 para. 1 item b.

(4) In case equipment is available with which a continuous determination of the nuclide composition of the noble gases discharged with the exhaust air is possible, then, instead of the procedures under paras. 2 and 3, this equipment should be used within its measurement range for determining the activity discharge of the individual noble gas nuclides.

3.2.2 Wide Range Display

3.2.2.1 Continuous Measurement

The discharge of radioactive noble gases with the exhaust air shall be continuously monitored by measuring the activity concentration and the volumetric stream. The activity concentration shall be determined by one of the following measurements:

- measurement of the activity concentration of radioactive noble gases (beta activity) or
- measurement of the absorbed gamma ray dose rate.

It shall be possible to monitor activity concentrations from 1×10^{10} to 1×10^{13} Bq/m³,

In calibrating for measurements under item a it shall be presumed that the nuclide xenon 133 is present. For measurements under item b the presumption is that each individual decay releases one gamma quantum with an energy of 300 keV.

3.2.2.2 Nuclide Specific Measurement

(1) The nuclide composition of the noble gases discharged with the stack air shall be determined by measurements in a gamma ray spectrometer.

(2) In case of a discontinuous determination of the nuclide composition, a representative sample shall basically be taken in hourly intervals; these samples shall be evaluated without delay. A prolongation of the interval between extractions of samples and their nuclide specific evaluation beyond one hour is permissible in those cases where measured values of the noble gas measurement point specified under Section 3.2.1.1 indicates that no essential changes have occurred.

(3) The activity discharge of individual noble gas nuclides determined from the discontinuous measurement of the nuclide composition shall be based on the activity concentration determined with the measurement system specified under Section 3.2.1.1 para. 1 item a or on the absorbed gamma ray dose rate determined with the measurement system specified under Section 3.2.1.1 para. 1 item b.

Note:

The requirements of Section 3.2 are summarized in **Table 3-2**.

3.3 Radioactive Aerosols and Radioactive Gaseous Iodine

3.3.1 Continuous Measurement

3.3.1.1 General Requirements

(1) The discharge of radioactive aerosols and of radioactive gaseous iodine with the exhaust air shall be monitored by continuous measurements. To this end, the radioactive aerosols and the radioactive gaseous iodine shall be continuously collected from a partial stream on a Class S high particulate air filter in accordance with DIN 24 184 and on a filter for gaseous iodine. The measurements shall include:

- the entire activity accumulated on the filters or its change with time and
- the entire iodine 131 activity accumulated on the filters or its change with time.

(2) The continuous sample extraction and measurement required under para. 1 shall be considered as being continuous even if, during a cycle period of no more than 10 minutes, the sample extraction is interrupted and the filter loading is determined automatically for this period of interruption. However, the actual time of sample extraction shall be equal to at least 50% of the cycle period.

(3) The volumetric partial stream for sample extraction radioactive aerosols and radioactive gaseous iodine shall be kept constant ($\pm 20\%$) and shall be continuously monitored with respect to this requirement.

3.3.1.2 Accident Monitoring Display

One measurement device (with characteristics as specified under Section 3.3.1.1) shall be available that is in a position to determine an overall exhaust air activity concentration for aerosols and gaseous iodine in the range from 1×10^2 to 1×10^6 Bq/m³ and an activity concentration of iodine 131 from 2×10^1 to 2×10^5 Bq/m³.

3.3.1.3 Wide Range Display

One measurement device (with characteristics as specified under Section 3.3.1.1) shall be available that is in a position to determine an overall exhaust air activity concentration for aerosols and gaseous iodine in the range from 1×10^5 to 2×10^8 Bq/m³ and an activity concentration of iodine 131 from 2×10^4 to 2×10^7 Bq/m³.

3.3.2 Nuclide Specific Measurement

(1) In order to determine the nuclide composition of radioactive aerosols and radioactive gaseous iodine these shall be continuously collected on a Class S high particulate air filter in accordance with DIN 24 184 and on a filter for gaseous iodine. In the measurement range of the accident survey display, this collecting device shall be installed redundantly.

(2) If the continuous measurement indicates that it could be possible that a discharge of radioactive aerosols or of iodine 131 exceeds a licensed limit value, the activity of the individual nuclides both on the high particulate air filter and on the filter for gaseous iodine shall be determined without delay in a gamma ray spectrometer. However, only the filters from one sampling location are required to be evaluated in the laboratory.

(3) Subsequently, the activity determination shall basically be performed in hourly intervals. A prolongation of the interval between activity determinations beyond one hour is permissible in those cases where measured values of the continuous measurement points specified under Section 3.3.1.2 or 3.3.1.3 indicate that no essential changes have occurred.

(4) During sample extraction the volumetric partial stream shall be measured and any change in the partial stream of more than 20% of its nominal value shall be automatically displayed.

(5) The analyses associated with the activity determination of the discharged alpha emitters and the strontium isotopes may be carried out on collective samples after the end of the design basis accident.

(6) When they are evaluated the high particulate air filters shall basically be apportioned and the evidential pieces kept for one year. In those cases where this requirement does not seem practicable, the high particulate air filters of the redundant sampling locations shall be kept as evidential pieces.

Note:

The requirements of Section 3.3 are summarized in **Table 3-3**.

4 Sampling

4.1 Radiation Protection and Sampling Locations

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

(2) The sampling locations that require access of personnel shall be chosen or shielded such that the local dose rates at these locations shall not exceed the design reference value of 10 mSv/h, assuming an activity concentration of 1×10^{13} Bq/m³ xenon 133-equivalency of radioactive noble gases in the exhaust air.

Note:

The reference values specified in this section are oriented on the objective of safety standard KTA 1301.1 "Radiation Protection Considerations for Plant Personnel in the Design and Operation of Nuclear Power Plants; Part 1: Design" and take Accident Protection Regulation VBG 30 "Nuclear Power Plants" into consideration.

4.2 Sample Extraction Equipment and Procedures

(1) The sample extraction procedure should be chosen such that the samples taken are representative of the emission during a design basis accident. The aim should be that the exhaust air is homogeneously mixed in the vicinity of the point where the samples are extracted.

(2) The sample line for aerosols and iodine shall be constructed from a material that has a low retention capability for aerosols and iodine. Horizontal sections and extreme bends in the sample extraction lines shall be avoided as far as possible; if bends cannot be avoided they should have a bending radius larger than 5 times the pipe diameter. The inside of pipe transitions shall be designed to avoid any disturbance of the flow characteristics, and the design shall, likewise, take account for smooth inside surfaces. Corrugated tubes or components with corrugated inner surfaces shall not be used.

(3) In choosing the adsorption materials of the filters, aging effects shall be taken into consideration. The specified temperature range shall be adhered to.

Nuclide Group	Accident Survey Display	Wide Range Display
Radioactive noble gases	a) Continuous measurement of the activity concentration (beta ray activity) b) Continuous measurement of the absorbed gamma ray dose rate c) Determination of the activity of the individual nuclides (by gamma ray spectrometry)	d) Continuous measurement of the activity concentration (beta ray activity) or e) Continuous measurement of the absorbed gamma ray dose rate f) Determination of the activity of the individual nuclides (by gamma ray spectrometry)
Radioactive aerosols and radioactive gaseous iodine	a) Continuous measurement of the overall activity accumulation on the filters or its change with time b) Continuous measurement of the overall iodine 131 activity on the filters or its change with time c) Determination of the activity of the individual nuclides (by gamma ray spectrometry) of the charged filters	d) Continuous measurement of the overall activity accumulation on the filters or its change with time e) Continuous measurement of the overall iodine 131 activity on the filters or its change with time f) Determination of the activity of the individual nuclides (by gamma spectrometry) of the charged filters

Table 3-1: Correlation of the continuous measurements and the nuclide specific measurements to the accident survey display and the wide range display

	Accident Survey Display	Wide Range Display
Measured value	a) Activity concentration (beta ray activity) b) Absorbed gamma ray dose rate c) fractional contribution of individual nuclides to overall activity	d) Activity concentration (beta ray activity) or e) Absorbed gamma ray dose rate f) Fractional contribution of individual nuclides to overall activity
Measurement range	re a): 1×10^6 to 1×10^{11} Bq/m ³ re b): 1×10^7 to 1×10^{11} Bq/m ³ re c): If a nuclide specific continuous measurement is available this should be used within its measurement range ¹⁾	re d) or e): 1×10^{10} to 1×10^{13} Bq/m ³ re f): not specified ²⁾
Redundancy	re a) and b): The single measurement equipment provided for a) and b) each are redundant to each other re c): not required	re d) or e): not required re f): not required
Exhaust air	re a): Volumetric stream shall be measured and automatically recorded re b): Volumetric stream shall be measured and automatically recorded	re d): Volumetric stream shall be measured and automatically recorded re e): Volumetric stream shall be measured and automatically recorded
Partial stream	re a): Monitoring of partial stream re b): not required, provided the measurement is performed within or on the exhaust air stream re c): Monitoring of partial stream	re d): Monitoring of partial stream re e): Monitoring of partial stream not required, provided the measurement is performed within or on the exhaust air stream re f): Monitoring of partial stream
Sample extraction	re a): Continuous flow of partial stream of exhaust air through the measurement chamber ³⁾ re b): Sample extraction not required, provided the measurement is performed within or on the exhaust air stream re c): In case of discontinuous sample extraction: gas samples should be extracted in hourly intervals as long as it must be expected that the discharge of radioactive noble gases exceeds the licensed limit value and essential variations are seen in the measured value of the measurement equipment under item a.	re d): Continuous flow of partial stream of exhaust air through the measurement chamber ³⁾ re e): Sample extraction not required, provided the measurement is performed within or on the exhaust air stream re f): Gas samples should be extracted in hourly intervals as long as essential variations are seen in the measured value of the measurement equipment under items d) or e).
Performance of Measurements	re a): Continuous measurement of the beta particle activity in the measurement chamber re b): Continuous measurement of the absorbed gamma ray dose rate within or on a exhaust air stream re c): In case of discontinuous sample extraction: gamma spectrometric evaluation of the gas sample without delay after extracting the sample.	re d): Continuous measurement of the beta ray activity in the measurement chamber re e): Continuous measurement of the absorbed gamma ray dose rate within or on a exhaust air stream re f): Gamma spectrometric evaluation of the gas sample without delay after extracting the sample.
<p>¹⁾ In case of a discontinuous evaluation of the nuclide composition, the activity discharge of the individual noble gas nuclides shall be based on the beta ray activity concentration determined with the measurement equipment under item a. In the case of failure of this equipment the basis used shall be the absorbed gamma ray dose rate determined with the measurement equipment under item b.</p> <p>²⁾ In case of a discontinuous evaluation of the nuclide composition, the activity discharge of the individual noble gas nuclides shall be based on the beta ray activity concentration determined with the measurement equipment under item d or on the absorbed gamma ray dose rate determined with the measurement equipment under item e.</p> <p>³⁾ A Class S high-efficiency particulate air filter in accordance with DIN 24 184 as well as a filter with a minimum retention rate of 90% for elementary iodine shall be placed in line before the measurement chamber in order to reduce contamination.</p>		

Table 3-2: Measurements with respect to radioactive noble gases

	Accident Survey Display and Wide Range Display	
	Continuous Measurements (Measurements specified in Table 3-1 items a, b, d and e)	Nuclide Specific Measurements (Measurements specified in Table 3-1 items c and f)
Measured value	Radioactivity collected on the filters or its chronological development	Radioactivity of the individual nuclides collected on the filters
Measurement range	It shall be possible to determine the following activity concentrations: Accident survey display measurement as under item a: From 1×10^2 to 1×10^6 Bq/m ³ measurement as under item b: from 2×10^1 to 2×10^5 Bq/m ³ Wide range display measurement as under item d: from 1×10^5 to 2×10^8 Bq/m ³ measurement as under item e: from 2×10^4 to 2×10^7 Bq/m ³	not specified
Redundancy	not required	The sample extraction equipment shall be (twice) redundant in the measurement range of the accident survey display
Exhaust air	Measurement and recording of the volumetric flow	Measurement and recording of the volumetric flow
Partial stream	Volumetric flow shall be kept constant and shall be monitored	Volumetric flow shall be kept constant and shall be monitored
Sample extraction	Continuous loading of the Class S high-efficiency particulate air filter and of the filter for gaseous iodine	If it cannot be precluded that a discharge of radioactive aerosols or of iodine 131 will exceed a license value then the continuous charging of one collecting device (or of two collecting devices in the measurement range of the accident survey display) shall be determined with a Class S high-efficiency particulate air filter and a filter for gaseous iodine over sequential collecting periods of one hour as long as essential changes occur in the measurement values of the corresponding continuous measurements.
Performing the measurements	Continuous measurement of the overall radioactivity on the filters and the overall radioactivity of all iodine 131 fractions on the filters.	Evaluation of the filters of the collecting devices (or, within the measurement range of the accident survey display, of one collecting device) in a gamma ray spectrometer as soon as possible after the end of the collecting period ¹⁾
<p>1) It is permissible to forestall the evaluation of the high-efficiency particulate air filter with respect to alpha particle emitters and strontium isotopes based on cumulative samples until after the end of the design basis accident.</p>		

Table 3-3: Measurements with respect to radioactive aerosols and radioactive gaseous iodine

(4) In choosing the adsorption materials, the separation efficiency and loading capacity of the filters both for elementary and for organically bound iodine shall be taken into account. The iodine absorbers used shall have a low adsorption effectiveness for noble gases.

(5) The components of aerosol and iodine filters and their arrangement shall be designed such that

- a) during operation gas tightness is ensured and the volumetric leakage air stream will not exceed 5% of the volumetric partial stream for sample extraction ,
- b) any damage to the filter in the region of the filter gasket is avoided and a bypass stream around the filter can be precluded,

- c) an easy exchange of the filter is ensured,
- d) all mechanical parts are corrosion resistant,
- e) the arrangement can be flushed, e.g., to remove noble gases.

(6) The sample extraction system shall be designed or located such that the ambient temperature will not drop below the dew point. The design requirements for the sample extraction medium (exhaust air) are specified in **Table 5-2**. It is permissible to use other values as design requirements, provided these are certified by design basis accident analyses.

(7) In the case of discontinuous sample extraction, the nuclide composition shall be considered unchanged in the time period between successive sample extractions.

5 Design of the Monitoring Equipment

5.1 General Design and Location

(1) All components of the measurement equipment, e.g. the sample extraction system, sensor, measuring transducer, shall be designed such that they can withstand the ambient and medium conditions at their points of installation and can be operated in accordance with this safety standard during those plant-internal design basis accidents when their able function is required.

(2) The measurement and sample extraction equipment shall be installed or located such that

- a) the nominal operating conditions are met as listed in the individual equipment specifications,
- b) easy inspection, servicing and repair are possible.

(3) The measured value shall not change by more than $\pm 30\%$ with respect to one of the measured values achieved during the calibration as specified under Section 6.2.2.2 when varying one of the influence parameters within the nominal operating ranges specified in **Table 5-1** while all other influence parameters remain as close to the reference values of calibration as possible.

(4) In the case of mutually redundant measurement equipment including sample extraction equipment it shall be ensured that a failure due to fire is limited to one of the redundancies or that the remaining equipment can fulfill the necessary safety function.

(5) If it cannot be precluded that one of the components of measurement equipment mentioned in para. 1 will fail due to the influence of design basis accidents, e.g. fire, then it shall be ensured that the monitoring can immediately be replaced, e.g. by a discontinuous sample extraction. In this case the corresponding sampling location shall be provided for, e.g., in the intake structure or in the base of the stack.

(6) It shall be ensured that during smoke removal in the course of a fire, an early exchange of the filters can be performed whenever necessary.

(7) With regard to resistance to design basis accidents of the measurement equipment and, specifically, their resistance to, e.g., electrostatic discharges, electromagnetic fields, interference voltages, the Electromagnetic Compatibility of Equipment Act (EMVG) shall be observed.

(8) During required operation, the local dose rate shall be measured in rooms where continuously operated measurement equipment are located. The procedures shall be specified in the operating manual.

(9) Detectors, measurement transducers and data storage shall be connected to a non-interruptible emergency power supply. Other components of the Monitoring equipment, e.g. heat tracing of the sample extraction systems, pumps for transporting the measurement medium, shall be connected to the emergency power supply, however, a short-time power loss is permissible, e.g. during the startup of the emergency Diesel unit. It shall be ensured that these components will automatically restart when power is again available.

(10) Redundant electric loads shall be connected to redundant busses if they are required for the operation of redundant systems.

(11) If a measurement point requires an operating medium, e.g. counter gas, the supply of this operating medium shall be designed to be fail-safe and shall be monitored with respect to possible failure.

(12) An equipment failure and the exceeding of the upper end scale values shall be optically displayed and acoustically announced in the control room and shall be automatically recorded.

(13) The optical signals in the control room with respect to equipment failure and to an upper measurement range value being exceeded shall indicate the alarm condition, e.g., new or acknowledged alarm.

(14) Pumps serving more than one measurement train shall be provided as (twice) redundant units.

(15) With regard to measuring radioactive aerosols and radioactive gaseous iodine, precautionary measures shall be taken by which fractions of the measurement signal caused by other radiation sources are reduced to such extent that the simulated activity concentration of the measured substance remains sufficiently small. **Table 5-3** lists the interference sources and the resulting maximum allowed simulated activity concentrations that shall be considered in the design of the measurement equipment.

(16) The effect of an increased dose rate on the measurement equipment shall not exceed the maximum allowed simulated activity concentration as listed in **Table 5-3**. The dose rate of the interference source shall be assumed as $10 \mu\text{Sv/h}$ from cesium 137 for the accident survey display and as 1 mSv/h from cesium 137 for the wide range display.

(17) If the actual effect of the interference source is not known at the time of measurement, it shall be conservatively assumed that the measurement signal is caused entirely by the substance to be measured. This overestimation may be corrected for, provided the actual effect of the interference source is known at the time of measurement and the corresponding simulated signal can be calculated.

(18) The influence of radioactive noble gases in the measurement volume on the measurement of radioactive aerosols and gaseous iodine and iodine 131 shall be stated in the equipment specification.

5.2 Statistical Safety and Detection

(1) The factor of statistical certainty for the response limit, k_E , has a value of $k_E = 1.645$ in the case of non-collecting, continuous measurements and a value of $k_E = 3.0$ in the case of collecting, continuously measuring devices (Sections 3.3.1.2 and 3.3.1.3) and in the case of measurements for detailed assessments as well as of decision-making measurements.

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

(3) The detection limit shall basically not be higher than the lower limit of the measurement ranges as specified under

Section 3. In the case of collecting, continuously measuring equipment, this requirement need be met only for the uncharged (fresh) filter.

5.3 Display and Automatic Recording of Measured Values

(1) The continuously measured values of the exhaust air, of the activity concentration and absorbed gamma ray dose rate of radioactive noble gases, of the activity accumulated on both filters or its change in time and the accumulated activity of iodine 131 on the two filters or its change in time as well as the values of the discharge rates if they are determined in the measuring device shall all be displayed and automatically recorded.

(2) The measured value should be displayed on the measuring equipment; it shall be displayed and automatically recorded in the control room. The measured values of the accident survey display and of the wide range display for the continuous measurements under Section 3.2.1.1 para. 1 items a) or b) and under Section 3.2.2.1 items a) or b) shall be

displayed and registered in the emergency control center or at a location that remains accessible during design basis accidents.

(3) In the case of an analog display the measurement devices for each measured value shall basically have only one display range. If more than one display range is necessary it is required,

- a) that, in the case of multiple linear display ranges, that the measurement ranges overlap each other by at least 10% and the measurement-range factor is not larger than 10,
- b) that, in the case of multiple logarithmic display ranges, that the measurement ranges overlap each other by at least one decade.

(4) If more than one measurement device is deployed in order to register the entire measurement range then the individual measurement ranges shall overlap each other by at least one decade.

(5) The automatically recorded data on the chart paper shall be directly visible and well legible for a time period of at least 3 hours.

(6) The measurement values may be displayed in the control room on CRT monitors, provided that one monitor is dedicated primarily to the presentation of these values, that a copy of the screen display can be printed out at all times and that the values are stored. A second monitor shall be available as a redundancy. The display on the monitor shall meet the requirements specified under para. 3.

6 Maintenance of Installed Monitoring Equipment

6.1 Servicing and Repair

6.1.1 Execution

Servicing and repair of the Monitoring equipment shall be carried out by qualified personnel and in accordance with the corresponding operating and maintenance instructions.

6.1.2 Documentation

All servicing and repair tasks shall be documented. The documentation shall contain the following information:

- a) unambiguous identification of the Monitoring equipment involved,
- b) type of the servicing or repair performed,
- c) type and number of parts exchanged,
- d) reasons for exchanging the parts,
- e) regarding exchanged parts: date and identification of the test certifications and of the test certificates required under this safety standard,
- f) information on the failure duration (outage),
- g) date of performing servicing or repair,
- h) name and signature of the qualified personnel.

6.2 Tests and Inspections

The Monitoring equipment shall be subjected to the following test and inspections:

- a) before their deployment in a nuclear power plant:
 - aa) certification of suitability,
 - ab) calibration,
- b) before their deployment in a specific nuclear power plant:
 - ba) verification of suitability,
 - bb) factory test,
 - bc) verification of the calibration with calibration sources,
 - bd) commissioning tests,

c) in the course of their deployment in the nuclear power plant:

- ca) regular in-service inspections,
- cb) tests and inspections after servicing and repair.

6.2.1 Check list

Type, extent and intervals of the tests and examinations shall be specified in documents that are in accordance with KTA 1202.

6.2.2 Initial Tests

6.2.2.1 Certification of Suitability

(1) Before their initial deployment in a nuclear power plant it shall be demonstrated that the Monitoring equipment fulfill their purpose and meet the specified requirements.

(2) The certification of suitability is comprised of a (plant independent) certification of the equipment characteristics and of the plant specific verification of suitability.

(3) The equipment characteristics shall be certified either by presenting proof of service-life or by available test certificates or within the framework of type testing.

(4) Testing shall be performed by authorized experts.

Note :

This subject matter is being treated in safety standard KTA 1505 "Suitability Certification of Radiation Measurement Equipment" (in preparation).

6.2.2.2 Calibration and its Verification

(1) Suitable calibration factors shall be specified for the Monitoring equipment prior to their first deployment. The calibration factors may be determined on a type identical measurement equipment.

(2) Measurement equipment used for measuring the overall beta activity of radioactive noble gases shall be calibrated with xenon 133 and krypton 85; the measurement equipment used for measuring the absorbed gamma ray dose rate shall be calibrated with a calibration source of cesium 137 or cobalt 60.

(3) The energy dependency of the discrimination of the measurement equipment for determining the beta radiation of radioactive noble gases shall be determined with at least three representative beta particle emitters with a maximum beta energy in the range from 150 keV to 2500 keV. The energy dependency of the discrimination of the measurement equipment for determining the gamma radiation of radioactive noble gases shall be known for a gamma radiation in the energy range from 60 keV to 2500 keV.

(4) A measurement equipment for determining the gamma radiation of radioactive aerosols or of gaseous radioactive iodine shall be calibrated with barium 133 or iodine 131 or with cesium 137.

(5) The energy dependency of the discrimination of the measurement equipment in accordance with para. 4 shall be known for a gamma radiation in the energy range from 200 keV to 2500 keV.

(6) Measurement equipment for determining iodine 131 shall be calibrated with iodine 131.

(7) During initial calibration a set of calibration sources shall be specified with which the display values within the measurement range of the accident survey equipment can be verified.

(8) Following initial calibration of the Monitoring equipment a calibration source in a definite and reproducible geometry shall be used to determine a display value which can later be used to verify calibration and to connect type identical equipment.

Influence Parameters	Nominal Operating Range	Reference Value
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 grid	
Ambient temperature in °C	15 to 40	20
Ambient air pressure in mbar	900 to 1100	1013
Relative humidity of ambient air in %	10 to 95, non-dewing	60
Temperature of the measurement medium in °C	reference value \pm 10	1)
Pressure of the measurement medium ²⁾ in mbar	850 to 1250	1013
Relative humidity of the measurement medium in %	10 to 85	50
<p>1) Shall be specified by the manufacturer regarding the sample extraction and treatment concept such that the temperature is always higher than the dew point.</p> <p>2) Pressure difference between ambient atmosphere and measurement medium shall not be larger than 200 mbar.</p>		

Table 5-1: Nominal operating range and reference values of the influence parameters

Design Value	PWR	BWR
Temperature in °C	50	80
Relative humidity in %	85	100 ¹⁾
Pressure in mbar	850 to 1250	850 to 1250
1) additional fog droplet content of the exhaust air: 10 g/m ³		

Table 5-2: Design conditions at the point of sample extraction (exhaust air)

Measurement objective	Interference Source to be Assumed			
	Accident Survey Display		Wide Range Display	
	Radioactivity inside the reactor containment in accordance with the design basis accident "Leakage in the reactor coolant line"	Noble gas activity concentration in the sample extraction stream in accordance with the design basis accident "Leakage in the reactor coolant line"	The radioactivity to be assumed in the reactor containment shall be 100 times the values on which the accident survey display is based.	The noble gas activity concentration to be assumed shall be 100 times the values on which the accident survey display is based.
Aerosols and gaseous iodine	10 ³ Bq/m ³	10 ³ Bq/m ³	10 ⁵ Bq/m ³	10 ⁵ Bq/m ³
Iodine 131	10 ² Bq/m ³	10 ² Bq/m ³	10 ⁴ Bq/m ³	10 ⁴ Bq/m ³
Noble gas (beta particle activity)	10 ⁶ Bq/m ³ ¹⁾	—	10 ¹⁰ Bq/m ³ ¹⁾	—
Noble gas (absorbed gamma ray dose rate)	10 ⁷ Bq/m ³ ¹⁾	—	10 ¹⁰ Bq/m ³ ¹⁾	—
1) These values specify the lower limits of the required respective measurement ranges. The simulated activity concentrations under conditions of the assumed interference sources are lower.				

Table 5-3: Maximum values of the simulated activity concentration

6.2.2.3 Factory Test

(1) The factory test shall verify the correct manufacture and perfect functioning of the Monitoring equipment. In case the Monitoring equipment is comprised of components from different manufacturers then the correct manufacture and perfect functioning of these components shall be verified by factory tests at the individual manufacturer.

(2) The factory test shall be performed on individual pieces (production test) and shall comprise:

- a) visual inspection,
- b) test of the output value as 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 display range,
- d) test of the resistance to overmodulation (electronically or with a calibration source),
- e) functional test with a calibration source.

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

6.2.2.4 Commissioning Test

(1) The post-installation commissioning test shall demonstrate 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 a pulse or current generator and at least one test value for each decade of the measurement display range),
- d) calibration (with a calibration source),
- e) connection to the emergency power system,
- f) monitoring of flow velocity,
- g) measured value processing (alarms),
- h) supply of operating media,
- i) monitoring of equipment failure,
- k) limit value settings,
- l) automatic restart after interruption of the power supply.

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

6.2.3 Regular In-service Inspections

6.2.3.1 General Requirements

(1) The tests and inspections shall be performed on the basis of test and inspection documents in accordance with KTA 1202.

(2) The tests and inspections shall be possible without any change to the circuitry (e.g. soldering).

(3) A coordination with the proper authority shall be established in the case of functional tests that require the removal of safety related interlocks.

6.2.3.2 Regular In-service Inspections

(1) Regular in-service inspections shall be performed to assure a fault-free functioning of the measuring equipment.

(2) The tests and test frequencies shall be as specified in **Table 6-1**.

(3) The verification of calibration under running number 1 b) of **Table 6-1** shall be carried out as specified under Section 6.2.2.2 with the calibration source and geometry defined during initial calibration of the measurement equipment. The required display value shall be achieved with an accuracy to be specified in the testing manual.

6.2.3.3 Testing after Repairs

After having performed a repair task, fault-free functioning shall be demonstrated by a commissioning test specified under Section 6.2.2.4 with the extent of this test corresponding to the repair task.

6.2.4 Removal of Defects

Any defects identified by the tests shall be removed without delay and within the time limits specified in the test records.

6.2.5 Test Records

All tests and inspections performed shall be documented by test records. The test records shall be kept in storage. They shall contain the following information:

- a) test object,
- b) type of test or inspection,
- c) test documents,
- d) test results,
- e) in case of defects: time period specified for the removal of defects or for the replacement of the test object,
- f) date of testing,
- g) name and signature of the tester.

7 Documentation of Measurement Results

7.1 Flow Chart

(1) The installed sample extraction and Monitoring equipment for monitoring the discharged gaseous and aerosol-bound radioactive substances shall be clearly presented in a flow chart. The different types of sample extractions and Monitoring measurements shall be identified by different symbols.

(2) The required objectives and means of measurement of each individual sample extraction and Monitoring equipment shall be described (e.g. in tabular form) with the descriptions correlated to the flow chart. With regard to sample extraction equipment, the objective, type, location and frequency as well as required measurements shall be specified. With regard to Monitoring equipment, the measurement objectives and technical measurement requirements, especially, the type of measurement, the measurement system including radiation shielding, calibration, measurement display ranges, detection limits and measurement tolerances shall be specified. With regard to the measurement laboratory, the measurement tasks and technical measurement requirements shall, likewise, be described.

7.2 Extent of Documentation

The documentation shall be structured such that

- a) the chronological development of the activity discharged through the stack
 - aa) prior to the occurrence of,
 - ab) during and
 - ac) after
 the design basis accident can be traced on the basis of continuous measurements and sample evaluations,
- b) the sample extraction

- ba) prior to the occurrence of,
 bb) during and
 bc) after

the design basis accident including point in time, duration and sample extraction type (continuous, discontinuous) and other boundary conditions occurring during sample extraction can be traced,

- c) the volumetric flow of the stack air
 ca) prior to the occurrence of,
 cb) during and
 cc) after

the design basis accident is described together with the automatically recorded physical state variables.

1	2	3	4	5
Running No.	Test Object	Testing Procedure	Test Frequency ¹⁾	
			by the plant operator	by the authorized expert ²⁾
1	Monitoring equipment	a) Visual inspection	during inspection rounds	annually
		b) Calibration check with a radiation source	quarter annually	annually
		c) In case of counter tubes: verification of the plateau	—	annually
2	Inspection and servicing records	Visual inspection	—	annually
3	Electronic modules	Insertion of standard signals into the transmitters (at least one value in each decade of the measurement range) ³⁾ Comparison of all displayed and automatically recorded display values	annually	annually
4	Alarm signals	a) Operational availability: visual inspection	during inspection rounds	annually
		b) Failure alarm: by interrupting the voltage supply or interrupting the signal connection between measurement transducer and detector	quarter annually	annually
		c) Maximum value of measurement range: with calibration source or electronically	quarter annually	annually
5	Flow monitoring and supply of operating media without automatic function control	Visual inspection	during inspection rounds	annually
	with automatic function control	Comparison of actual and required values	quarter annually	annually
6	Sample extraction system	Visual inspection and check of the ventilator or blower switching	annually	annually
<p>1) If a test as specified under column 5 is performed then a test specified for the same time period under column 4 need not be performed.</p> <p>2) These requirements pertain to the expert authorized by the proper authority.</p> <p>3) The testing procedure of inserting at least one standard signal into the transmitters for each decade of the measurement range is not required in the case of digital measurement devices, provided the software program is certified and itself of a self-monitoring nature. In this case it is sufficient to insert a single signal in the uppermost decade of the measurement range, provided the pre-processing electronics do not require any switching procedures over 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.</p>				

Table 6-1: Regular in-service inspections

Appendix

Regulations Referred to in this Safety Standard

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

Atomic Energy Act		Act on the Peaceful Utilization of Atomic Energy and the Protection against its Hazards (Atomic Energy Act) of December 23, 1959 (BGBl I, Page 814) as Amended and Promulgated on July 15, 1985 (BGBl I, Page 1565) last amended by the Act of April 6, 1998 (BGBl I Page 694)
StrlSchV		Ordinance on the protection against damage and injuries caused by ionizing radiation (Radiation Protection Ordinance - StrlSchV) in the version published on June 30, 1989 (BGBl I, 1989, p. 1321), corrected October 16, 1989 (BGBl I, 1989, p. 1926) last amended by ordinance of August 18, 1997 (BGBl I, Page 2113)
EMVG		Electromagnetic Compatibility of Devices Act (EMVG) of September 18, 1998 (BGBl. I, p. 2882)
KTA 1202	(6/84)	Requirements for the testing manual
KTA 1503.1	(6/93)	Monitoring the discharge of gaseous and aerosol-bound radioactive substances; Part 1: Monitoring the stack discharge of radioactive substances during specified normal operation
DIN 24 184	(12/90)	Type testing of high efficiency particulate air filters; Using paraffin oil mist as test aerosol