Safety Standards

of the
Nuclear Safety Standards Commission (KTA)

KTA 1502 (11/2005)

Monitoring Radioactivity in the Inner Atmosphere of Nuclear Power Plants

(Überwachung der Radioaktivität in der Raumluft von Kernkraftwerken)

The previous version of this safety standard
was issued as KTA 1502.1 in 06/1986

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

Editor:
KTA-Geschaeftsstelle c/o Bundesamt fuer Strahlenschutz (BfS)
Willy-Brandt-Str. 5 • 38226 Salzgitter • Germany
Telephone +49(0)1888-333-(0) • Telefax +49(0)1888-333-1625

KTA SAFETY STANDARD

November 2005	**Monitoring Radioactivity in the Inner Atmosphere of Nuclear Power Plants**	KTA 1502

Previous version of this safety standard: KTA 1502.1 06/86 (BAnz No. 162a of September 3, 1986)

Contents

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. 101a of May 31, 2006. Copies may be ordered through the Carl Heymanns Verlag KG, Luxemburger Str. 449, 50939 Koeln, Germany (Telefax +49-221-94373603).

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

KTA-Geschaeftsstelle c/o BfS, Willy-Brandt-Str. 5, 38226 Salzgitter, Germany

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.

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 damage arising from the construction and operation of the plant (Sec. 7 para. 2 subpara. 3 Atomic Energy Act) in order to attain the protective goals specified in the Atomic Energy Act and the Radiological Protection Ordinance (StrlSchV) and further detailed in the "Safety Criteria for Nuclear Power Plants" and in the "Guidelines for the Assessment of the Design of PWR Nuclear Power Plants against Incidents pursuant to Sec. 28, para. 3 StrlSchV - Incident Guidelines" (the version released Oct. 18, 1983).

(2) The radiation monitoring and monitoring of airborne radioactive substances is carried out with the objective, among others, of protecting the persons inside and outside of the plant from ionizing radiation and of controlling the specified normal activity flow of solid, liquid and gaseous radioactive substances inside the plant and of monitoring the discharge of radioactive substances.

(3) Monitoring the concentration of radioactive substances in the inner atmosphere during specified normal operation contributes to fulfilling Secs. 5 and 6 StrlSchV by

a) automatically actuating signals upon exceeding alarm thresholds that are provided for detecting an increased concentration of radioactive substances in the inner atmosphere and for initiating the required measures,
b) identifying the individual compartment groups where an increased concentration of radioactive substances can lead to an increased discharge with the stack exhaust air,
c) indicating leaking systems or components that contain radioactive substances (leakage monitoring of plant components and component parts) by detecting an increased concentration of airborne radioactive substances,
d) detecting increased concentrations of airborne radioactive substances with special regard to human safety.

(4) The equipment and devices required for these tasks can be organized according to the following aspects:

a) stationary measuring or sampling equipment, in particular, for monitoring the concentration of airborne radioactive substances in the exhaust air collecting ducts,
b) mobile measurement and sampling equipment for monitoring the concentration of airborne radioactive substances in the inner atmosphere of the compartments, especially, with regard to the radiation protection monitoring of work places.

(5) Compartments or groups of compartments are monitored with regard to leakage from components and pipe lines carrying radioactive media as well as to the release of radioactive substances into the inner atmosphere by taking air specimens from the exhaust air collecting ducts or directly from the inner atmosphere. This task is performed, primarily, by stationary measuring equipment. With regard to the release of radioactive substances through the exhaust air stack, monitoring the exhaust air ducts simplifies identifying the sources. Monitoring the concentration of airborne radioactive substances in compartments and groups of compartments indicates the average concentration of radioactive substance in the inner atmosphere and, thus, serves decision-making regarding the accessibility of the compartments by personnel and regarding the deployment of additional mobile measuring equipment. It also serves in the detection of any increase of airborne radioactive substances in the inner atmosphere enabling the initiation of necessary measures in the case of aerosols escaping from systems and components and the automatic actuation of alarm signals whenever alarm thresholds are exceeded. It is generally not possible with this kind of monitoring to determine the concentration of airborne radioactive substances at work places with, possibly, locally increased concentrations which, however, is required with regard to radiological protection.

(6) The concentration of airborne radioactive substances in the inner atmosphere at the work places is monitored, primarily, by mobile measuring or sampling equipment. In individual cases, however, this monitoring can be carried out by suitably located stationary measuring equipment, e.g., which is located at the work place of the person to be monitored, provided, it is ensured that this equipment delivers measurement results that are representative for the inner atmosphere at the work place. Mobile measurement and sampling equipment are also used, e.g., for leakage detection and for the collection of data required for the planning of work procedures.

1 Scope

This safety standard applies to nuclear power plants with light water reactors during specified normal operation.

Note:
Although designed with special regard to specified normal operation, the stationary measuring or sampling equipment designed pursuant to this safety standard will also be able to provide information regarding the matters specified under Basic Principles para. 3 items a through d during design basis accidents, at least in their initial phases.

If, during a design basis accident, it becomes impossible to perform onsite measurements with mobile measuring or sampling equipment, suitable specimens may, if necessary, be analyzed and evaluated in the laboratory.

2 Definitions

(1) Exhaust air duct

An exhaust air duct is a ventilation duct that guides the exhaust air out of the compartment.

(2) Exhaust air collecting duct

An exhaust air collecting duct is a ventilation duct that guides the exhaust air from one or more compartments to the exhaust stack.

(3) Measuring equipment

Measuring equipment means the entirety of all measuring devices and auxiliary devices that are required for measuring a measurement parameter, for transferring and adapting a measurement signal and for passing on a measured value as image of the measurement parameter.

(4) Monitoring the inner atmosphere

Monitoring the inner atmosphere means monitoring the radioactive substances in the inner atmosphere.

(5) Sampling device

A sampling device is the equipment for the removal and storage of radioactive substances from gaseous or liquid media for a later evaluation in the laboratory.

(6) Monitoring

Monitoring is the collective term used for all kinds of controlled data acquisition of physical parameters and includes the comparison of these data with specified values.

Note:
Monitoring is carried out, e.g., in the form of

a) continuous measurements or
b) analysis of test specimens (e.g., in the laboratory) or
c) combination of measured values

always in conjunction with a comparison with the values specified for the physical parameters (e.g., licensed values, operational values).

3 Compartments and Compartment Groups to be Monitored

3.1 General Requirements

The concentration of airborne radioactive substances in the inner atmosphere shall be monitored in those compartments and compartment groups where radioactive substances can be released. The monitoring shall be carried out in the following ways:

a) by the use of stationary, continuously measuring equipment for specimens collected from representative locations in the inner atmosphere, in the air conditioning ducts, in the exhaust air duct of the compartment, or in the exhaust air collecting duct of the compartment group.

   Note:

   The requirements regarding the equipment and devices dedicated to monitoring the concentration of airborne radioactive substances in the inner atmosphere depend on the possibilities for the release of radioactive substances (radioactive noble gases, aerosol-bound radioactive substances, radioactive iodine) into the inner atmosphere and also on the design of the air conditioning facilities (e.g., recirculated air filtration, air exchange rate).

   Generally, already during the design of the nuclear power plants, various compartments are combined as compartment groups with regard to air conditioning. With this in mind, Section 3.2 specifies examples for the compartment groups that shall be monitored using stationary measuring equipment.

   By monitoring the concentration of airborne radioactive substances in the air of the exhaust air collecting duct of a compartment group, it is possible to detect an increase in air contamination of the associated compartment group at an early time.

b) by the use of mobile measuring or sampling equipment

   ba) at the work place with special regard to human protection, if the possibility for a relevant incorporation pursuant to the Radiological Protection Ordinance exists,

   bb) when the need arises to localize a leakage.

c) by sampling specimens at the sampling nozzles specified under Section 4.1.1.2.

3.2 Monitoring with Stationary Measuring equipment

3.2.1 Nuclear power plants with pressurized water reactor

3.2.1.1 Compartment groups

Typical compartment groups (shown schematically in **Figure 3-1**) are

a) Compartment group 1 inside the containment

   The compartment group 1 inside the containment consists of the compartments directly enclosing the primary coolant circuit.

b) Compartment group 2 inside the containment

   The compartment group 2 inside the containment consists of the compartments containing radioactivity-retaining components that do not belong to the compartment groups 1 or 3.

c) Compartment group 3 inside the containment

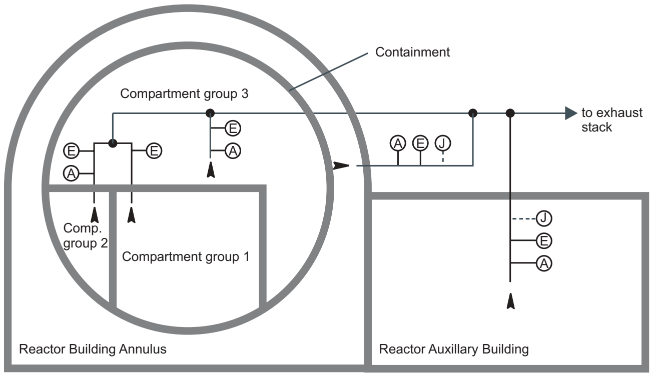
   The compartment group 3 inside the containment consists of the compartments containing the fuel pool and of all compartments inside the containment vessel not containing any primary-coolant-retaining components.

d) Compartment group Reactor Building Annulus

   The compartment group Reactor Building Annulus consist of the compartment between the containment and the outer concrete shell of the reactor building.

e) Compartment group Reactor Auxiliary Building

   The compartment group Reactor Auxiliary Building consists of those compartment outside of the reactor building that are within a controlled access area and that contain radioactivity-retaining systems and components or in which radioactive substances are handled.



Sampling location
Ⓔ for radioactive noble gases
Ⓐ for aerosol-bound radioactive substances
Ⓙ for radioactive iodine (cf. footnote 2 to Table 3-1)

Figure 3-1: Example for monitoring the inner atmosphere of nuclear power plants with pressurized water reactor

3.2.1.2 Measured Items

Monitoring with the stationary measuring equipment as specified under Section 3.1 item a) shall measure the radionuclide groups listed in **Table 3-1**.

Compartment group	Radionuclide groups whose concentration shall be monitored		
	Noble gases	Aerosols	Iodine
Compartment group 1 inside the containment	X	X [1)]	-
Compartment group 2 inside the containment	X	X	-
Compartment group 3 inside the containment	X	X	-
Compartment group Reactor Building Annulus	X	X	X [2)]
Compartment group Reactor Auxiliary Building	X	X	X [2)]

1) During air flushing operation. Monitoring may be performed by switching over to the measuring equipment of another compartment group.

2) If necessary, e.g., when switching-on stationary filter facilities.

Table 3-1: Radionuclide groups whose concentration shall be monitored in nuclear power reactors with pressurized water reactors

3.2.2 Nuclear power plant with boiling water reactor

3.2.2.1 Compartment groups

Typical compartment groups (shown schematically in **Figure 3-2**) are

a) Compartment group Containment

   The compartment Containment consists, essentially, of the compartments enclosing the reactor with the control rod drive system and the pressure suppression system.

b) Compartment group Reactor Building

The compartment group Reactor Building consists, essentially, of the compartments containing the fuel pool, the residual heat removal system and the air-conditioning systems.

c) Compartment group Reactor Auxiliary Building

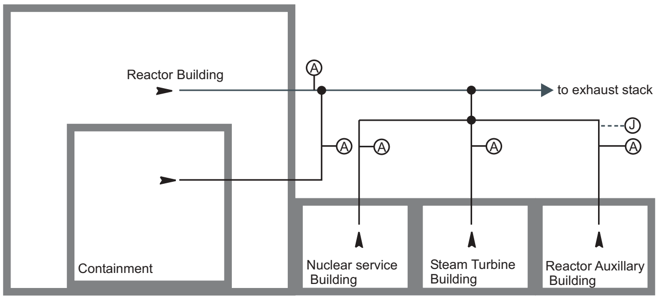
The compartment Reactor Auxiliary Building consists of the compartments containing the auxiliary plant components and facilities.

d) Compartment group Nuclear Services Building

The compartment group Nuclear Services Building consist of the compartments containing the storage facilities, laboratories and exhaust air facilities.

e) Compartment group Steam Turbine Building

The compartment group Steam Turbine Building consists of those compartments which house the primary coolant steam driven turbine and the associated systems carrying the primary coolant and the feedwater.



Sampling location

Ⓐ for aerosol-bound radioactive substances

Ⓙ for radioactive iodine (cf. footnote1 of table 3-2)

Figure 3-2: Example for monitoring the inner atmosphere of nuclear power plants with boiling water reactor

3.2.2.2 Measured Items

Monitoring with the stationary measuring equipment as specified under Section 3.1 item a) shall measure the radionuclide groups listed in **Table 3-2**.

Note:
In the case of boiling water reactors, it is not necessary to monitor the concentration of radioactive noble gases because the content of radioactive noble gases is very small due to the continuous deaeration of the coolant.

3.3 Monitoring with mobile measuring or sampling equipment

If monitoring with mobile measuring or sampling equipment as specified und Section 3.1 item b) is deemed necessary, the actual monitoring shall be performed under consideration of the expected air contamination due to radioactive noble gases, aerosol-bound radioactive substances or radioactive iodine.

Note:
Whenever the concentration of radioactive noble gases is monitored with mobile measuring or sampling equipment and the relationship between the occurrence of noble gases and iodine in the inner atmosphere is known, then a special monitoring of the concentration of radioactive iodine isotopes need only be carried out when an increase of the concentration of the radioactive noble gases has been observed.

Compartment Group	Radionuclide groups whose concentration shall be monitored	
	Aerosols	Iodine
Compartment group Containment	X [1)]	-
Compartment group Reactor Building	X	-
Compartment group Reactor Auxiliary Building	X	X [2)]
Compartment group Nuclear Services Building	X	-
Compartment group Steam Turbine Building	X	-

1) During air flushing operation. Monitoring may be performed by switching over to the measuring equipment of another compartment group.

2) If necessary, e.g., when switching-on stationary filter facilities.

Table 3-2: Radionuclide groups whose concentration shall be monitored in nuclear power reactors with boiling water reactors

4 Measurement Procedures

4.1 General Requirements

4.1.1 Sampling from air ducts

The sampling location and the sampling procedure shall be chosen such that the collected specimens are representative for compartment groups or work places that are to be monitored. The number of sampling probes shall depend on the degree of intermixture of the exhaust air at the sampling location.

Note:
Sampling is regulated in standard DIN 25423-2 “Sampling procedures for the monitoring of radioactivity in air - Part 2: Special requirements for sampling from air ducts and stacks“

4.1.1.1 Sampling pipe lines

Sampling pipe lines shall be designed, routed and manufactured from such materials that a least possible amount of aerosol-bound radioactive substances and compositions of gaseous radioactive iodine will be retained.

Note:
Design details are regulated in the standard series DIN 25423.

4.1.1.2 Sampling nozzles in the exhaust air collecting duct

With regard to the non-continuous sampling of air specimens, special sampling nozzles shall be installed in the exhaust air ducts or the exhaust air collecting ducts.

4.1.1.3 Sampling duration

The sampling duration for the continuous monitoring of aerosol-bound radioactive substances and of radioactive iodine shall normally not exceed two weeks. An earlier change of the filter shall be performed in case an amassing of dust has caused a flow rate reduction of more than 20 %, or in case the radioactivity from amassed airborne radioactive substances impairs proper performance of the measurement task.

4.1.1.4 Filter bracket and sampling device

Care shall be taken that the measurement is not falsified by a contamination of the sampling and collecting device and, especially, of the filter bracket. A filter change shall be easy to perform. The leakage air current shall remain negligible with regard to the partial air current for sampling.

4.1.2 Installation of the measuring equipment

The measuring equipment shall be installed such that they are sufficiently protected against any influence, e.g., background radiation at the location of the detector, that can impair their proper function. The measuring equipment shall normally be easily accessible with regard to testing, servicing and repair.

4.1.3 Design of the measuring equipment with regard to ambient conditions

(1) The stationary and the mobile measuring equipment shall be designed for those ambient and measurement media conditions as well as for that operating voltage range specified in **Table 4-1.**

(2) The measurement value may not vary by more than ± 30 % with regard to the measurement values obtained during calibration, when an influence parameter is varied within its nominal range of use individually listed in **Table 4-1** and, with the exception of the pressure of the ambient air and the measurement medium, all the other influence parameters (e.g., even filter loading and background radiation) stay close to the reference values of the calibration and will remain unchanged as far as possible. In this case, however, the pressure difference between measurement medium and ambience shall normally not exceed 200 hPa.

(3) The reference values listed in **Table 4-1** shall be applied to the individual influence parameters. The reference value of filter loading shall be the fresh (non-loaded) condition. The reference value of background radiation shall be specified by the manufacturer.

4.1.4 Response capability for other types of radiation

The response capability of gamma ray sensitive detectors to the beta radiation of Strontium 90/Yttrium 90 and the response capability of beta ray sensitive detectors to the gamma radiation of Cobalt 60 or Cesium 137 shall be known.

4.1.5 Adjustment devices

All measuring equipment which require adjustments in the course of operation shall be equipped with corresponding adjustment devices. The adjustment devices shall be arranged and secured such that it is made difficult for unauthorized persons to carry out adjustments. Any self-adjustment shall be impossible.

4.1.6 Count rate losses and overload resistance

Possible count rate losses of the measuring equipment (e.g., from dead-time effects) within the measurement range shall be known as a function of the count rate and shall be compensated for. It shall not occur that an increase of the measurement parameter can lead to a diminishing display value (overloading).

4.1.7 Signal generators and alarm devices

(1) The measuring equipment shall be equipped with a signal generator with respect to equipment failure and at least one signal generator for an upper warning threshold.

(2) In the case of stationary measuring equipment, a lower value than the lower limit value indicating an equipment failure and a higher value than the upper warning threshold shall cause optical and acoustic alarms in the central control room. The lower limit value signal may be combined in a group alarm with other alarm signals of that equipment. A signaling device indicating that test operation is being performed should also be provided. Group alarms may be used in the central control room, provided, in the control room or in a control room annex a trace-back to the originating measuring equipment is possible. Whenever the acoustic alarm signals are individually or mutually reset prior to a repair of the fault, the optical signals in the central control room indicating an equipment failure or that the upper warning threshold has been exceeded shall continue to indicate the individual alarm condition.

(3) It shall be possible to attach acoustic and optical warning devices to the mobile measuring equipment.

4.1.8 Secure power and operating media supplies

(1) If the stationary measuring equipment requires an operating medium, e.g., counter gas, the supply of this operating medium shall be designed to be fail safe and the supply shall be monitored.

(2) Electrical power loads of stationary measuring equipment shall be connected to the emergency power supply system and the electronic loads to the uninterruptible emergency power supply system with a parallel-connected battery. Stationary measuring equipment shall be designed to be self-monitoring. It shall be ensured (e.g., by a connection to an uninterruptible emergency power supply) that the switching-over to an emergency power supply will not impermissibly impair proper functioning of the measuring equipment.

4.1.9 Statistical safety

(1) The statistical safety factor at the decision limit shall be $k_E = 1.645$ for non-collecting continuous measurements, and $k_E = 3.0$ for collecting continuous measurements as specified under Sections 4.2.2.1 para. 1 and Section 4.2.3.1 para. 1.

(2) The statistical safety factor at the detection limits shall be $k_N = k_E + 1.645$ for the measurements specified under para. 1.

(3) The detection limits shall be determined with the influence parameters adjusted to the reference values listed in **Table 4-1**. The detection limits shall be determined at an ambient dose rate of 0.25 µGy/h (Cesium 137).

Note:
The determination of the detection limits for nuclear radiation measurements are dealt with in the standards series DIN 25482.

4.2 Special Requirements for Monitoring the Concentration of Radionuclide Groups

Note:
The parameters specified in this section are repeated as collective listings in **Tables 4-2** through **4-4**.

4.2.1 Radioactive noble gases

4.2.1.1 Monitoring with stationary measuring equipment

(1) Measurement of the concentration of radioactive noble gases shall be performed by an integral beta ray measurement. To avoid any falsification of the measured values by aerosol contamination, a high-efficiency particulate air filter of at least class H12 in accordance with DIN EN 1822-1 shall be installed upstream of the measurement points and shall, if necessary, be shielded.

(2) The sampling related volumetric flow rate shall be monitored. If the volumetric flow falls below the required value by more than 20 %, this fact shall be recorded and indicated by optical and acoustic alarms in the central control room.

(3) The detection limit of the measuring equipment shall basically be smaller than 1 x 10^4 Bq/m^3 relative to Xenon 133, with the exception of the measuring equipment in the exhaust air collecting duct of the compartment group 1 of pressurized water reactors, the detection limit of which does not need to be smaller than 5 x 10^4 Bq/m^3 relative to Xenon 133.

(4) The upper limit of the measurement range of the measuring equipment shall basically be at least 5 x 10^8 Bq/m^3 relative to Xenon 133, with the exception of the measuring equipment in the exhaust air collecting duct of compartment group 1 of pressurized water reactors, the upper limit of which shall be at least 5 x 10^9 Bq/m^3 relative to Xenon 133.

4.2.1.2 Monitoring with mobile measuring equipment

(1) Measurement of the concentration of radioactive noble gases shall be performed by an integral beta ray measurement. To avoid any falsification of the measured values by aerosol contamination, a high-efficiency particulate air filter of at least class H12 in accordance with DIN EN 1822-1 shall be installed upstream of the measuring equipment.

(2) The detection limit of the measuring equipment shall be smaller than 1 x 10^5 Bq/m^3 relative to Xenon 133.

(3) The upper limit value of the measurement range of the measuring equipment shall be at least 5 x 10^8 Bq/m^3 relative to Xenon 133.

(4) The volumetric flow rate through the measuring equipment shall be monitored, and, both, a breakdown of the volumetric flow rate and its exceeding of an upper alarm threshold shall cause onsite alarms.

(5) Manual sampling and collecting of specimens can be performed by using gas collector tubes or pressure bottles that are, then, analyzed in the laboratory.

4.2.2 Aerosol-bound radioactive substances

4.2.2.1 Monitoring with stationary measuring equipment

(1) The continuous monitoring of the concentration of aerosol-bound radioactive substances shall be performed by accumulating the aerosols from a partial air stream for sampling with a constant volumetric flow rate on a high-efficiency particulate air filter of at least class H12 in accordance with DIN EN 1822-1, and by simultaneously measuring the radioactivity of the radioactive aerosols accumulated on the high-efficiency particulate air filter.

(2) The volumetric flow rate of the partial air stream that is used for the aerosol accumulation shall be monitored. A deviation by more than 20 % of the required value shall be recorded and indicated by optical and acoustic alarms in the central control room.

(3) Based on the ionizing radiation caused by the filter loading, a measurement value shall be formed that is a measure for the radioactivity loading of the high-efficiency particulate air filter (e.g., detector pulse rate) or a measure for the concentration of aerosol-bound radioactive substances in the monitored air (e.g., gradient of the detector pulse rate including, if necessary, a decay correction). The background level of the detector signal and the influence of natural radioactive aerosols on the detector signal may be suppressed when forming the measurement value.

Note:
The measurement of the concentration of aerosol-bound radioactive substances can be falsified by interferences, e.g., from aerosols trapped in the high-efficiency particulate air filters that carry naturally created radioactive substances, and from noble gases, and these interferences shall be taken into consideration when interpreting the measurement results.

(4) The measuring equipment shall be designed such that, starting out with a fresh (non-loaded) high efficiency particulate air filter, after a short-time influx of aerosol-bound radioactive substances of a time integrated concentration of 10 (Bq/m^3)h within the maximum time of one hour the display of the measurement parameter “Radioactivity on the filter” or of the measurement parameter “Increasing radioactivity on the filter” will exceed the detection limit. The test regarding this requirement is specified in Section 5.2.2.1. In the case of aerosol monitors involved in monitoring the airborne radioactive substances in the compartment group Containment of boiling water reactors, the corresponding time integral is 100 (Bq/m^3)h.

Note:
The determination of the detection limits for nuclear radiation measurements is dealt with in the standards series DIN 25482.

(5) A clearly perceptible alarm shall be triggered whenever a specified loading of the filter with aerosol-bound radioactive substances is exceeded. The radioactivity on the high-efficiency particulate air filter shall be monitored with regard to a value at which aerosol-bound radioactive substances at a time integrated concentration of 500 (Bq/m^3)h can be detected within less than one hour with a standard deviation of 10 % or less. If this value is exceeded and the value of the actual concentration of aerosol-bound radioactive substances cannot anymore be determined with a standard deviation of 10 % or less, the high-efficiency particulate air filter shall be exchanged. Irrespective of this requirement, the filter shall be exchanged at least every 14 days.

(6) The measuring equipment shall be designed such that the measurement value specified under para. 3, can be formed, displayed and registered up to a concentration of the aerosol-bound radioactive substances of 5 x 10^4 Bq/m^3 and a time integrated concentration of 10^5 (Bq/m^3)h.

(7) The reference nuclide for the requirements specified under paras. 3 through 5 shall be Cesium 137.

4.2.2.2 Monitoring with mobile measuring or sampling equipment

(1) The concentration of aerosol-bound radioactive substances at work places shall be monitored by accumulating the aerosols from an air stream with a constant volumetric flow rate on a high-efficiency particulate air filter of at least class H12 in accordance with DIN EN 1822-1 and measuring the radioactivity of the radioactive aerosols collected on the high-efficiency particulate air filter either immediately during its accumulation (direct measurement) or later by analyzing the loaded filter in the laboratory.

(2) In the case of measuring equipment, the volumetric flow rate of the partial air stream that is used for the aerosol accumulation shall be monitored. A deviation by more than 20 % from the required value shall be indicated onsite by optical and acoustic alarms. In the case of sampling equipment, the volumetric throughput shall be determined.

(3) In the case of the direct measurement, based on the ionizing radiation caused by the filter loading, a measurement value shall be formed that is a measure for the radioactivity loading of the high-efficiency particulate air filter (e.g., detector pulse rate) or a measure for the concentration of aerosol-bound radioactive substances in the monitored air (e.g., gradient of the detector pulse rate including, if necessary, a decay correction). The background level of the detector signal and the influence of natural radioactive aerosols on the detector signal may be suppressed when forming the measurement value.

(4) The measuring equipment shall be designed such that, starting out with a fresh (non-loaded) high efficiency particulate air filter, after a short-time influx of aerosol-bound radioactive substances of a time integrated concentration of 10 $(Bq/m^3)h$ within the maximum time of one hour the display of the measurement parameter “Radioactivity on the filter” or of the measurement parameter “Increasing radioactivity on the filter” will exceed the detection limit. The test regarding this requirement is specified in Section 5.2.2.1.

(5) In case of the direct measurement, the measuring equipment shall be designed such that the measurement value specified under para. 3 can be formed and displayed up to a concentration of the aerosol-bound radioactive substances of 5×10^4 Bq/m^3 and a time integrated concentration of 10^5 $(Bq/m^3)h$.

(6) When a direct measurement reaches the end of the display range, it shall be checked whether a laboratory evaluation of the filters is necessary or not.

(7) In case of a laboratory evaluation, the ionizing radiation stemming from the filter loading shall be measured, and the detector pulse rate shall be used to determine the radioactivity loading of the high-efficiency particulate air filter.

(8) With regard to laboratory measurements, the measurement and sampling equipment shall be designed such that an average concentration of aerosol-bound radioactive substances of 5 Bq/m^3 can be detected within two hours from the start of sampling.

(9) In the case of work place monitoring, if directly measuring equipment is used in addition to laboratory measurements, this measuring equipment shall be designed such that, starting out with a fresh (non-loaded) high efficiency particulate air filter, after a short-time influx of aerosol-bound radioactive substances with a time integrated concentration of 100 $(Bq/m^3)h$ within the maximum time of one hour the display of the measurement parameter “Radioactivity on the filter” or of the measurement parameter “Increasing radioactivity on the filter” will exceed the detection limit. The test regarding this requirement is specified in Section 5.2.2.1.

Note:
The determination of the detection limits for nuclear radiation measurements is dealt with in the standards series DIN 25482.

(10) The reference nuclide for the requirements specified under paras. 4, 5, 8 and 9 shall be Cesium 137.

4.2.3 Radioactive iodine

4.2.3.1 Monitoring with stationary measuring equipment

(1) The continuous monitoring of the concentration of radioactive iodine shall be performed by accumulating the iodine from a partial air stream with a constant volumetric flow rate on an iodine filter and by simultaneously measuring the radioactivity of the radioactive iodine accumulated on the iodine filter.

(2) The volumetric flow rate of the partial air stream used for the iodine accumulation shall be monitored. A deviation by more than 20 % from the required value shall be recorded and indicated by optical and acoustic alarms in the central control room.

(3) The gamma radiation caused by the filter loading shall be converted to a measurement value that is a measure for the radioactivity loading of the iodine filter (e.g., detector pulse rate) or a measure for the concentration of radioactive iodine in the monitored air (e.g., gradient of the detector pulse rate).

Note:
The measurement of the concentration of radioactive iodine can be falsified, e.g., by noble gases in the medium, and this shall be taken into consideration when interpreting the measurement results.

(4) A clearly perceptible alarm shall be triggered whenever a specified loading of the iodine filter is exceeded. The radioactivity on the iodine filter shall be monitored with regard to a value at which radioactive iodine at a time integrated concentration of 500 $(Bq/m^3)h$ can be detected within less than one hour with a standard deviation of 10 % or less. If this value is exceeded and the value of the actual concentration of radioactive iodine cannot anymore be determined with a standard deviation of 10 % or less, the iodine filter shall be exchanged.

(5) In case of the direct measurement, the measuring equipment shall be designed such that the measurement value as specified under para. 3 can be formed and displayed up to a concentration of the radioactive iodine of 2×10^3 Bq/m^3 and a time integrated concentration of 2×10^4 $(Bq/m^3)h$.

(6) If in accordance with **Table 3-1** or **3-2** measuring equipment is required for the measurement of the concentration of radioactive iodine in the exhaust air collecting ducts, this measuring equipment shall be designed such that, starting out with a fresh (non-loaded) iodine filter, after a short-time influx of radioactive iodine with a time integrated concentration of 10 $(Bq/m^3)h$ within the maximum time of one hour the display of the measurement parameter “Radioactivity on the filter” or of the measurement parameter “Increasing radioactivity on the filter” will exceed the detection limit. The test regarding this requirement is specified in Section 5.2.2.1.

Note:
The determination of the detection limits for nuclear radiation measurements are dealt with in the standards series DIN 25482.

(7) The reference nuclide for the requirements specified under paras. 4 through 6 shall be Iodine 131.

(8) The design of the filter cartridge and the choice of filter material shall be such that, even for organically bound iodine, a separation efficiency of at least 90 % is achieved. The applicable temperature range of the iodine sorption material shall be specified and adhered to.

(9) In order to reduce interference from radioactive noble gases absorbed in the filter material, the chosen sorption material shall be distinguished by a low retention capability for noble gases.

4.2.3.2 Monitoring with mobile measuring equipment or sampling equipment

(1) The concentration of radioactive iodine at work places shall be monitored by accumulating the iodine from an air stream with a constant volumetric flow rate on an iodine filter and measuring the radioactivity of the radioactive iodine accumulated on the iodine filter

(2) In the case measuring equipment, the volumetric flow rate of the partial air stream used for accumulating the iodine shall be monitored. A deviation by more than 20 % of the required value shall be indicated onsite by optical and acoustic alarms. In the case of sampling equipment, the volumetric throughput shall be determined.

(3) The design of the filter cartridge and the choice of filter material shall be such that, even for organically bound iodine, a separation efficiency of at least 90 % is achieved. The applicable temperature range of the iodine sorption material shall be specified and adhered to.

Note:
The separation efficiency can be reduced by light, air, humidity and aging.

(4) The gamma radiation caused by the filter loading shall be converted to a measurement value that is a measure for the radioactivity loading of the iodine filter (e.g., detector pulse rate).

(5) If in addition to laboratory measurements directly measuring equipment is used for onsite monitoring, this measuring

equipment shall be designed such that, starting out with a fresh (non-loaded) iodine filter, after a short-time influx of radioactive iodine with a time integrated concentration of 10 $(Bq/m^3)h$ within a maximum time of one hour the display of the measurement parameter “Radioactivity on the filter” or of the measurement parameter “Increasing radioactivity on the filter” will exceed the detection limit.

(6) The reference nuclide for the requirement specified under para. 4 shall be Iodine 131.

(7) In order to reduce interference from radioactive noble gases absorbed in the filter material, the chosen sorption material shall normally be distinguished by a low retention capability for noble gases.

(8) With regard to laboratory measurements, the measurement and sampling equipment shall be designed such that an average concentration of radioactive iodine of 20 Bq/m^3 can be detected within two hours from the start of sampling.

4.3 Measurement Data Display, Automatic Recording and Documentation

4.3.1 Monitoring with stationary measuring equipment

(1) The display and automatic recording devices for the measurement data shall be located in the main control room or in a control room annex. Multi-track plotters or multi-track printers shall have no more than six tracks. The tracks on the recording strips shall be directly visible for a time period of at least three hours and shall be well legible.

(2) In the case of measuring equipment with switchable display ranges, the individual display range shall be discernable on the recording strip.

(3) If the measurement value display is exclusively on a linear scale, an automatic measurement range switching shall be provided.

(4) The computer based recording and screen display of the measurement values is permissible, provided one computer screen is dedicated primarily to the presentation of these values, that a hardcopy of the screen display can be printed out at all times and that the measurement values are stored. Whenever a computer screen is used, it shall allow displaying a time span of no less than three hours. A second computer screen shall be available as a redundancy.

(5) In case of an electronic storage of the measurement data, the data shall be stored redundantly. The storage capacity shall be sufficiently large to keep the measurement data and the alarms from the last twelve months available.

(6) The recorded data shall be evaluated in regular intervals and shall be stored in accordance with legal regulations or with provisions by the authorities.

4.3.2 Monitoring with mobile measuring equipment

(1) The mobile measuring equipment used for monitoring the concentration of radionuclide groups in compartments shall be such that measurement data is displayed directly on the measurement device.

(2) If a work place surveillance with mobile measuring equipment shows that within eight hours the time integrated concentration of aerosol-bound radioactive substances exceeds 80 $(Bq/m^3)h$ and that of radioactive iodine 120 $(Bq/m^3)h$, then the measurement data shall be recorded.

Influence Parameters	Nominal Operating Range	Reference Value
Operating voltage		
Alternating current voltage supply	85 to 110 % of the nominal operating voltage	manufacturer specification
Direct current voltage supply	specified voltage range of the DC voltage net	manufacturer specification
Ambient temperature	15 to 40 °C	20 °C
Ambient atmosphere pressure	900 to 1100 hPa	manufacturer specification
Relative humidity of ambient atmosphere	10 to 95 %, non-dewing	60 %
Temperature of measurement medium	15 to 40 °C	20 °C
Pressure of measurement medium [1)]	700 bis 1100 hPa	manufacturer specification
Relative humidity of measurement medium	10 to 95 %, non-dewing	60 %

1) Pressure difference between ambient atmosphere and measurement medium shall not be larger than 200 hPa

Table 4-1: Nominal operating ranges and reference values for the influence parameters (cf. Section 4.1.3 para. 2)

Characteristic Parameters	Values for the characteristic parameters for		
	stationary measuring equipment PWR and BWR	stationary measuring equipment of compartment group 1 PWR	mobile measuring or sampling equipment PWR and BWR
Detection limit of noble gas concentration	1×10^4 Bq/m^3	5×10^4 Bq/m^3	1×10^5 Bq/m^3
Reference nuclide to be used	Xenon 133		
Upper limit of measuring range	5×10^8 Bq/m^3	5×10^9 Bq/m^3	5×10^8 Bq/m^3

Table 4-2: Characteristic parameters of the noble gas measuring equipment specified und Section 4.2.1

Characteristic Parameters	Values for the characteristic parameters for	
	aerosol-bound radioactive substances (cf. Section 4.2.2.2 para. 8)	radioactive iodine (cf. Section 4.2.3.2 para. 8)
Smallest, within two hours detectable concentration of airborne radioactive substances	5 Bq/m^3	20 Bq/m^3
Reference nuclide to be used	Cesium 137	Iodine 131

Table 4-3: Characteristic parameters for the sampling and laboratory evaluation for aerosol-bound radioactive substances and radioactive iodine

Characteristic Parameters	Values for the characteristic parameters for			
	aerosol-bound radioactive substances			radioactive iodine
	stationary measuring equipment in the compartment group Safety Vessel BWR	other stationary and directly measuring mobile measuring equipment	directly measuring mobile measuring or sampling equipment with subsequent measuring in the laboratory	stationary and directly measuring mobile measuring equipment
Smallest, within one hour detectable time integrated concentration of radioactive substances [1)]	100 $(Bq/m^3)h$	10 $(Bq/m^3)h$	100 $(Bq/m^3)h$	10 $(Bq/m^3)h$
Reference nuclide to be used	Cesium 137			Iodine 131
Largest measurable concentration [2)]	5×10^4 Bq/m^3			2×10^3 Bq/m^3
Largest time integrated concentration [2)]	1×10^5 $(Bq/m^3)h$			2×10^4 $(Bq/m^3)h$

1) Cf. Section 4.2.2.1 para. 4, Section 4.2.2.2 paras. 4 and 9, and Section 4.2.3.1 para. 6

2) Cf. Sections 4.2.2.1 para. 6, Section 4.2.2.2 para. 5, and Section 4.2.3.1 para. 5

Table 4-4: Characteristic parameters of the stationary and of the directly measuring mobile measuring or sampling equipment with regard to aerosol-bound radioactive substances and to radioactive iodine

5 Maintenance, Tests and Examinations

5.1 Maintenance

5.1.1 Performance of maintenance

All maintenance measures on the measuring or sampling equipment shall be performed by qualified personnel and in accordance with the individual operating and maintenance instructions.

5.1.2 Records

Records shall be kept on all maintenance tasks. These records shall contain at least the following information:

a) unambiguous identification of the measuring equipment,

b) type of maintenance performed,

c) type and number of replaced parts,

d) reasons for the replacement of parts,

e) in case of new replacement parts – date and identifying description of the test certificates as well as of the test certifications required in accordance with the present safety standard.

f) in case of stationary measurement and sampling equipment – information on the outage times,

g) date when maintenance was performed,

h) name and signature of qualified persons.

5.2 Tests and Inspections

5.2.1 Point in time of tests and inspections

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

a) Prior to deployment in any nuclear power plant
   - aa) certification of suitability,
   - ab) calibration.

b) Prior to deployment in a specific nuclear power plant
   - ba) verification of suitability,
   - bb) factory test,
   - bc) verification of calibration with solid calibration source,
   - bd) commissioning test.

c) During deployment in the nuclear power plant
   - ca) periodic inservice inspections,
   - cb) tests and inspections following maintenance and repair tasks.

5.2.2 Initial tests and inspections

5.2.2.1 Certification of suitability

(1) Prior to their initial deployment in a nuclear power plant it shall be certified that the measurement and sampling equipment can fulfill their purpose and that they meet the specified requirements.

(2) The certification of suitability consists of the plant independent certification of the equipment characteristics and of the plant dependent suitability check.

(3) The certification of the equipment characteristics shall be performed either on the basis of a proven service record, of available test certificates, of an extended commissioning test, or within the framework of a type test. In substantiated individual cases, e.g. new development of measuring or sampling equipment, this certification may also be performed by other means.

(4) This certification shall be performed by authorized experts.

Note:
Requirements regarding the suitability certification of the radiation monitoring equipment are specified in safety standard KTA 1505 (11/2003).

5.2.2.2 Calibration

(1) Prior to a first deployment of the equipment, suitable calibration factors shall have been specified for the measuring equipment including the measuring equipment for the volumetric flow rate. The calibration factors may also be determined on measuring equipment of a similar type. The calibration shall be carried out for the reference values specified in **Table 4-1**.

(2) The measuring equipment for monitoring the overall beta activity concentration of radioactive noble gases shall be performed using Xenon 133 and Krypton 85. The energy dependency of the response capability of the measuring equipment for measuring the beta radiation of radioactive noble gases shall be determined with at least three representative beta nuclides with a maximum beta energy in the energy range from 150 keV to 2500 keV.

(3) The measuring equipment for monitoring the concentration of aerosol-bound radioactive substances with regard to beta radiation shall be calibrated with Technetium 99 or Cobalt 60 as well as with Chlorine 36 or Cesium 137, and with regard to gamma radiation with Barium 133 and Cesium 137. The energy dependency of the response capability for beta radiation shall be determined 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 detection probability of interfering nuclides and background radiation, gamma radiation may be used to raise the lower threshold of measuring equipment for monitoring the concentration of aerosol-bound radioactive substances to a maximum of 250 keV.

(4) The measuring equipment for monitoring the concentration of radioactive iodine shall be calibrated with Iodine 131.

(5) During initial calibration, a set of solid radiation sources shall be specified with each of which an individual display value in one of the lower and one of the upper decades of the measurement range can be checked. This requires providing the following solid radiation sources:

a) For the monitoring of the concentration of radioactive noble gases with measuring equipment for beta radiation – Cobalt 60 or Technetium 99;

b) For the monitoring of the concentration of radioactive aerosol-bound radioactive substances with measuring equipment for beta radiation – Cobalt 60 or Technetium 99, and with measuring equipment for gamma radiation – Barium 133 or Cobalt 57;

c) For monitoring the concentration of radioactive iodine – Barium 133.

(6) Subsequent to initial calibration of the measuring equipment, a special display value (transfer value) shall be established with a solid radiation source in a defined and reproducible geometry which will make it possible to check the calibration at a later date and will also enable connecting equipment of a similar type.

(7) Prior to the initial deployment of the sampling equipment, suitable calibration factors shall be determined for the volumetric flow rate measuring equipment.

5.2.2.3 Factory test

(1) A factory test shall be performed to certify proper manufacturing and functioning of the measuring equipment. If the measuring equipment consists of components from different manufacturers, proper manufacturing and functioning of these component shall be certified at the individual manufacturers.

(2) The factory test of the measuring equipment shall be performed as a production (or piece) test and shall comprise:

a) visual inspection,
b) test of the output value as a function of the specified operating voltage fluctuation,
c) test of the characteristic using an impulse of current generator with at least one test value per decade of the measurement range,
d) test of the overload resistance (electronically or with a radiation source),
e) check of the response capability at the transfer value specified under Section 5.2.2.2 para. 6,
f) monitoring the flow rate or measuring the mass flow,
g) testing for leak-tightness,
h) transfer value with solid radiation source for the commissioning tests.

(3) The factory test of the sampling equipment shall be performed as a production (or piece) test and shall comprise:

a) visual inspection,
b) monitoring the flow rate or measuring the mass flow,
c) testing for leak-tightness.

(4) The factory test shall be performed by plant inspectors and, in well-founded cases, in the presence of authorized experts appointed by the proper authority.

5.2.2.4 Commissioning tests

(1) A commissioning test shall be performed on the stationary measurement and sampling equipment after their installation to certify their proper construction and function.

a) The tests to be performed on measuring equipment shall be directed to:
    aa) installation of the equipment,
    ab) construction of the equipment,
    ac) display (using an impulse of current generator with at least one test value per decade of the measurement range),
    ad) calibration check (using solid radiation source),
    ae) limit value adjustments and the data and alarm annunciation,
    af) monitoring of flow rate,
    ag) measurement value processing,
    ah) supply of operating media,
    ai) equipment failure alarm,
    ak) connection to emergency power supply.
b) The tests to be performed on sampling equipment shall be directed to:
    ba) installation of the equipment,
    bb) construction of the equipment,
    bc) monitoring of flow rate,
    bd) measurement value processing.

(2) Prior to the commissioning of a sampling device, the losses of airborne radioactive substances in the sampling pipe lines shall be estimated and described by a correction factor. As soon as the operating conditions after plant commissioning allow, an experimental verification of the correction factor shall normally be performed on selected sampling pipe lines, unless the measurement results are transferable from other plants.

(3) The commissioning tests shall be performed by the operating utility and, to the extent specified by the proper authority, by, or in the presence of, authorized experts.

(4) The display values of the tests specified under para. 1 item ad) shall not deviate by more than 30 % from the transfer value determined in the factory test under consideration of the onsite conditions.

(5) The commissioning tests to be performed on the mobile measuring equipment shall be directed to:

a) construction of the equipment,
b) display (using an impulse of current generator with at least one test value per decade of the measurement range),
c) calibration check (using solid radiation source),
d) data and alarm annunciation,
f) monitoring of flow rate,
g) measurement value processing,
h) supply of operating media,
i) equipment failure alarm.

5.2.3 Inservice inspections

5.2.3.1 General Requirements

(1) Type, extent and intervals of the tests and inspections shall be specified in the documents specified in safety standard KTA 1202.

(2) It shall be possible to perform the tests and inspections without any manipulation, e.g., soldering, of the electric circuit.

5.2.3.2 Periodic inservice inspections

(1) Periodic inservice inspections shall be performed to certify proper functioning of the measurement and sampling equipment. The required tests and inspections and their test intervals are listed in **Table 5-1**.

(2) The verification of calibration listed under Running No. 1 in **Table 5-1** shall be performed on the measuring or sampling equipment with the same geometry and solid radiation source as the commissioning test specified under Section 5.2.2.4 para. 1 item ad). The display value shall be achieved with the accuracy specified in the testing manual.

5.2.3.3 Tests after repairs

After any repair, proper functioning shall be certified by performing a commissioning test as specified under Section 5.2.2.4 to an extent that corresponds to the extent of the repair.

5.3 Elimination of Defects

Identified defects including the measures taken for their elimination shall be documented. The (maximum allowed) repair times for stationary and mobile measuring equipment or sampling device shall be specified in the operating manual.

5.4 Test Certificates

All tests performed, with the exception of visual inspections, shall be documented by test certificates. The test certificates shall be put in safe keeping. They shall contain the following information:

a) test object,
b) type of test,
c) test documents,
d) test results,
e) in case of defects:
   specified time limit for the elimination of the defects or for the exchange of the test object,
f) date of the test,
g) name and signature of the testers.

Running No.	Test Object	Testing Method	Test Frequency for		
			stationary equipment		mobile equipment
			by the operating utility	by the authorized expert appointed by proper authority	by the operating utility [1]
1	1a Measuring or sampling equipment	Visual inspection	during inspection rounds	annually	during deployment
	1b Measuring equipment	Calibration check with a test source and, in the case of counter tubes, if necessary, check of the plateau	semi-annually	annually	at least annually
2	Test and maintenance records	Inspection	-	annually	-
3	Electronic module	Input of standard signals into the transmitters (at least one value per decade of the measuring range) [2] Comparison of all displayed values and recordings	annually	annually	-
4	Annunciation				
	operational availability	Visual inspection	during inspection rounds	annually	prior to each deployment
	lower limit value	- interruption of the power supply of the detector, or - separating the signal connection between measuring transmitter and detector, or - in the case of digitally operating measurement and sampling equipment it is sufficient to test the annunciations by applying the programmed functions, provided the program has been tested and is self-monitoring	semi-annually	annually	annually
	upper alarm threshold	with a test source or artificial actuation	semi-annually	annually	annually
5	Flow rate monitoring and operating media supply				
	without automatic function control	Visual inspection	during inspection rounds	annually	prior to each deployment
	with automatic function control	Comparison of the required value with the actual value	semi-annually	annually	annually
6	sampling equipment	Visual inspection, checking the switching of ventilators or blowers	annually	annually	during deployment

1) The tests of mobile equipment by authorized experts appointed by the proper authority are specified in individual cases by the proper authority.

2) This test method of inputting standard signals into the transmitter with at least one value per decade of the measuring range is not required in the case of digitally operating measuring or sampling equipment, provided the program has been tested and is self-monitoring. In this case, it is sufficient to input one signal in the upper decade of the measurement range, provided, the pre-processing electronics does not perform any switch-overs in the entire measurement range. Even this test can be omitted if the calibration check is performed in the topmost decade of the measurement range.

Table 5-1: Recurrent inservice inspections

Appendix

Regulations Referred to in this Safety Standard

Regulations referred to in this safety standard are valid only in the versions cited below. Regulations which are referred to within these regulations are valid only in the version that was valid when the latter regulations were 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, p. 814) in the version of July 15, 1985 (BGBl. I, p. 1565), most recently changed by Act of August 12, 2005 (BGBl. I, p. 2365)
StrlSchV	Ordinance on the protection from damage by ionizing radiation (Radiological Protection Ordinance - StrlSchV) of July 20, 2001 (BGBl. I, p. 1714), most recently changed by Act of September 1, 2005 (BGBl. I, p. 2618)
KTA 1202 (06/84)	Requirements for the testing manual
DIN EN 1822-1 (07/98)	High efficiency particulate air filters (HEPA and ULPA) Part 1: Classification, performance testing, marking