Safety Standards

of the
Nuclear Safety Standards Commission (KTA)

KTA 3601 (11/2017)

Ventilation Systems in Nuclear Power Plants

(Lüftungstechnische Anlagen in Kernkraftwerken)

The previous versions of this safety
standard were issued in 1990-06 and 2005-11

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KTA SAFETY STANDARD

November 2017	**Ventilation Systems in Nuclear Power Plants**	KTA 3601

Previous version of this safety standard: 1990-06 (BAnz-No. 41a of February 28, 1991)
2005-11 (BAnz-No. 101a of May 31, 2006)

Contents

Comments by the Editor:

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

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

Fundamentals

(1) The safety standards of the Nuclear Safety Standards Commission (KTA) have the objective to specify safety-related requirements, compliance of which provides the necessary precautions in accordance with the state of the art in science and technology against damage arising from the construction and operation of the facility (Sec. 7 para. 2 subpara. 3 Atomic Energy Act - AtG) in order to achieve the fundamental safety functions specified in the Atomic Energy Act and the Radiological Protection Ordinance (StrlSchV) and further detailed in the Safety Requirements for Nuclear Power Plants as well as in the Interpretations of the Safety Requirements for Nuclear Power Plants.

(2) The licensing requirements with respect to construction and operation of the plant in accordance with Sec. 7 Atomic Energy Act are fulfilled, among others, by the facilities for keeping solid, liquid and gaseous radioactive substances in the planned enclosures, by the facilities for the handling and controlled conduct of radioactive substances inside the plant as well as by the facilities for the release of radioactive substances via planned paths. The safety standards of the KTA 3600-series specifies concrete safety related requirements for these facilities.

(3) The ventilation systems in nuclear power plants, i.e., the ventilation, air heating and cooling and air filtration facilities, serve the following goals:

a) limiting the amount of radioactive substances to be released with the exhaust air at a low level during specified normal operation and during design basis accidents – in accordance with the radiological protection principles pursuant to Secs. 6, 47 and 49 para. 1 StrlSchV,

b) limiting the radiation exposure of the operating personnel from radiological substances in the inner atmosphere – in accordance with the radiological protection principles pursuant to Sec. 6 paras. 1 and 2 StrlSchV,

c) protecting systems and components by maintaining the specified conditions of the inner atmosphere,

d) protecting the plant from the penetration of flammable or harmful gasses and of pressure surges.

e) maintaining other specified conditions of the inner atmosphere with special regard to work protection.

(4) Requirements with respect to the ergonometric aspects of the work environs in the main control room, emergency control room and local control stations are specified in safety standard KTA 3904, Control Room, Emergency Control Room and Local Control Stations in Nuclear Power Plants.

(5) Requirements with respect to the fire protection of ventilation systems are specified in safety standards KTA 2101.1 through KTA 2101.3, Fire Protection in Nuclear Power Plants

Note:

a) Requirements regarding ventilation systems of laboratory rooms and radionuclide laboratories are specified in DIN 25425-1, DIN 25466 and DIN 1946-7.

b) Requirements regarding the design and operation of ventilation systems result from conventional standards, e.g., Workplace Guidelines, DIN Standards.

1 Scope

(1) This safety standard applies to stationary ventilation systems in nuclear power plants with pressurized water reactors (PWR for short) and in nuclear power plants with boiling water reactors (BWR for short). In case mobile filters are used for the filtration of exhaust air, the requirements of this safety standard shall be applied accordingly.

(2) The ventilation systems are correlated to specific room groups presented for the PWR and BWR plant types in **Tables A-1, A-2** and **A-3** of Appendix A.

(3) This safety standard does not apply to:

a) gas exhaust facilities,

b) leakage and vessel exhaust systems

Note:
Requirements regarding gas exhaust facilities and leakage and vessel exhaust systems are specified in safety standard KTA 3605.

c) facilities for measuring and monitoring the release of gaseous and aerosol-bound radioactive substances

Note:
Requirements regarding facilities for monitoring the discharge of gaseous and dispersed particle bound radioactive substances are specified in safety standards KTA 1503.1 through KTA 1503.3.

d) facilities for measuring and monitoring the concentration of radioactive substances in the ambient air of the room

Note:
Requirements regarding monitoring radioactivity in the inner atmosphere and air vented from the rooms are specified in safety standard KTA 1502.

e) facilities for the inertisation and de-inertisation of the containment,

Note:
Requirements regarding the inertisation and de-inertisation of the containment are specified in the German Accident Prevention Regulations and the Workplace Guidelines.

f) facilities for the monitoring, mixing and reduction of hydrogen released in the containment vessel by radiolysis, metal/water interaction or by core-melt/concrete interaction.

2 Definitions

Several terms are described pictorially in **Figure 2-1**.

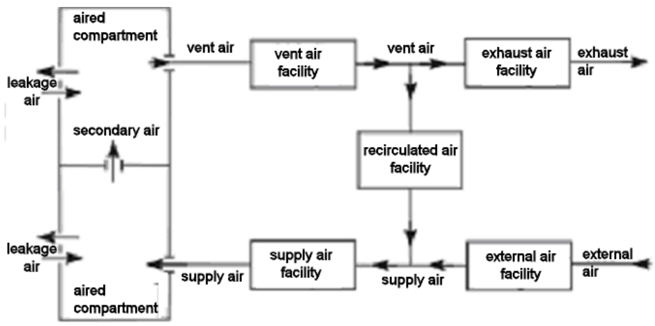

Figure 2-1: Nomenclature for air currents and facilities

(1) Vent air

Vent air is the air removed from a room or compartment.

(2) Separation efficiency of a filter

The separation efficiency of a filter with respect to a particular substance to be deposited on the filter is equal to the ratio of the mass of the substance retained by the filter to the mass of the substance fed into the filter.

(3) External air

External air is the air drawn in from the outer atmosphere.

(4) Decontamination factor

The decontamination factor of a filter with respect to a particular substance to be deposited on the filter is equal to the concentration of this substance in the air fed into the filter divided by the concentration of this substance in the air vented from the filter.

(5) Pressure zone of a ventilation system

A pressure zone of a ventilation system is a zone made up of contiguous rooms and room groups at the same pressure level.

(6) Exhaust air

Exhaust air is the vent air released to the outer atmosphere.

(7) K-factor of an iodine adsorber

The K-factor of an iodine adsorber is equal to the common logarithm of the decontamination factor of the iodine adsorber divided by the retention time of the air in the iodine adsorber.

Note:
The K-factor is dependent on the type of test medium and on the test conditions.

(8) Leakage air

Leakage air is the air that seeps in or out in an uncontrolled way.

(9) Train of the air conditioning system

A train of the air conditioning system is a contiguous arrangement of components in direction of the air current.

(10) Air exchange rate of a room

The air exchange rate of a room is the quotient of the volumetric air current into the room over the free air volume of the room.

(11) Redundancy

Redundancy is the existence of more functioning technical means than are necessary for the fulfillment of the planned function.

(12) Recirculated air

Recirculated air is the air circulated inside, or returned to, a confined region.

(13) Volumetric air current of a ventilation, air conditioning or filtration facility

The volumetric air current of a ventilation, air conditioning or filtration facility is equal to the air or gas volume passing through this facility or component in a given time period divided by this same time period.

(14) Supply air

Supply air is the air fed into a room.

(15) Secondary air

Secondary air is the supply air of a room that has first passed through another room..

3 Requirements for the Design Concept of ventilation systems

(1) The exhaust air from the restricted-access area shall be discharged in a controlled way, i.e., only via paths planned for this process.

(2) The air from the exhaust air trains shall be filtered to retain radioactive iodine and radioactive aerosols, provided, this is required under the design concept of the nuclear power plant for the protection of the environment.

(3) The activity concentrations of iodine and aerosols in the inner atmosphere shall be kept low by employing recirculated air filtration facilities or by properly dimensioning the amount of vent air, provided, this is required for the protection of the operating personnel.

(4) The negative pressures and pressure stages of the rooms and the air current directions shall be maintained as required for radiological protection.

(5) The specified permissible temperatures and humidity of the inner atmosphere and the minimum air exchange rates shall be maintained.

(6) Rooms accessible to personnel shall be supplied with the necessary proportion of external air.

(7) Combustible and harmful gases and fumes shall be vented with the inner atmosphere.

(8) Precautionary measures shall be taken against the penetration of combustible and harmful gases and pressure surges through air vents holes into areas with safety-related plant components.

4 Correlation of the ventilation systems with Respect to Air-Conditioning Classes

(1) Any ventilation systems that are correlated to one of the following Air-Conditioning Classes shall meet the requirements of this safety standard.

a) Air-Conditioning Class 1 comprises ventilation systems and components that are required for the precautionary measures to be taken against design basis accidents pursuant to Sec. 49 para. 1 StrlSchV.

   Note:
   This comprises facilities required to control routing of radioactive substances or to reduce their release during design basis accidents or that are required to remove heat from rooms with facilities for the mitigation of design basis accidents.

b) Air-Conditioning Class 2 comprises ventilation systems and components that are required for specified normal operation and that are relevant to radiological protection.

(2) The correlation of the individual ventilation systems into Air-Conditioning Classes is equivalent to an evaluation of their safety relevance.

Note:
***Appendix A** contains examples for the correlation of the ventilation systems in actual PWRs and BWRs listing Air-Conditioning Class 1 in **Table A-1** and Air-Conditioning Class 2 in **Table A-2**.*

(3) The correlation of the ventilation systems and components into one of the two Air-Conditioning Classes in itself does not have any direct effect on the different requirements specified for individual components. Insofar as specific safety related requirements exist for the components, these are specified in this safety standard.

Note:
Other specific requirements regarding the design and testing of the components are contained in DIN 25496.

(4) This safety standard does not specify any requirements for ventilation systems and components that do not belong to one of the two Air-Conditioning Classes; however, pertinent requirements for these facilities and components are contained in technical standards, e.g., DIN 1946-7, DIN 1751, DIN EN 13779 and DIN EN 12792.

Note:
*Examples of these ventilation systems in current PWRs and BWRs are listed in **Table A-3.***

5 Overall ventilation system

5.1 Design Requirements

5.1.1 General requirements

(1) ventilation systems shall be designed for a reliable continuous operation and shall be constructed for easy testing, servicing and repair and shall be easily accessible in accordance with the radiological protection principles pursuant to Sec. 6 paras. 1 and 2 StrlSchV. It shall be possible to exchange components requiring servicing, e.g. fans, dampers, valves, measuring probes, without major structural building measures and without having to dismantle any components of safety related facilities.

(2) ventilation systems and components in Air-Conditioning Class 1 shall be designed to withstand the influences from those design basis accidents for the mitigation of which these facilities are required.

(3) The design of the support and suspension stability of ventilation systems and components shall be such that the facilities will withstand the induced vibrations from design basis accidents if, otherwise, secondary damages could occur to equipment that are required for ensuring safe enclosure of radioactive substances or are required in taking the reactor plant to the safe condition and keeping it in this safe conditions.

Note:
These requirements may also be met by providing special measures that limit the effects of vibrations on the components.

(4) The openings required for the external air supply or for the exhaust air in those buildings that are specified to be designed against pressure surges from external explosions shall be equipped with pressure surge protectors, e.g., pressure surge valves or labyrinth systems, provided, this is necessary for the protection of the components in these buildings.

(5) The surfaces of ventilation systems that are exposed to contamination shall normally be designed such that, either, the contamination remains negligibly small or a decontamination is possible.

(6) The design of the components of ventilation systems, e.g. ducts, flaps and measuring probes, shall be such that, with regard to materials and their construction, they will withstand the maximum pressures and pressure differences, the relative humidity as well as the choice of conditions of temperature, corrosion and radiation expected during specified normal operation. The design shall take the characteristics of organic insulation materials into consideration.

(7) With regard to a possible failure of the negative pressure control and to an inadvertent closing of the ventilation valves of the containment vessel, measures shall be taken that will effectively prevent the occurrence of impermissible pressures inside the containment under all operating conditions of the ventilation systems.

(8) The [operating] center of the external air supply facility in the restricted-access area shall normally be separated from the rest of the restricted-access area by pressure equalization locks.

(9) The structural enclosure of the restricted-access area shall be sufficiently air tight such that it is possible to achieve the guide values specified in **Tables 5-1** and **5-2** for negative pressures of the inner atmosphere required for maintaining a directed air current.

Note:
Currently, the inward flowing volumetric air leakage current in the steam turbine building of BWRs is limited to a maximum of one half of the nominal volumetric air current of supply air. In the case of the other rooms of the restricted-access area of light water reactors, the inward flowing air-leakage current is limited to a maximum of one tenth of the nominal volumetric inflow of the supply air.

(10) Doors shall be hung such that any existing pressure differences pull the doors shut, provided, there are no reasons of overriding importance, e.g., escape routes and pressure related design.

(11) The venting of combustible and harmful gases and fumes shall be based on sound engineering practice.

Note:
The removal of combustible gases and fumes is dealt with in safety standards KTA 2101.1 through KTA 2101.3.

(12) All electrical power consumers of the ventilation systems, e.g. ventilators, may be connected to the auxiliary power supply facility, provided, Section 5 does not specify otherwise.

Buildings, room group (pressure zone)	Negative pressure (mbar)
Reactor building	
1 large equipment compartments inside the containment vessel	2.5
2 small equipment compartments inside the containment vessel	2.0
3 service compartments inside the containment vessel	1.5
4 annulus during normal reactor operation	1.0
5 annulus during containment penetration isolation	≥ 1.0
Reactor auxiliary building	0.5

Table 5-1: Guide values for the pressure stages required in the buildings or room groups with respect to the outer atmosphere to achieve a directed air current in case of a nuclear power plant with pressurized water reactor

Buildings, room group (pressure zone)	Negative pressure (mbar)
Reactor building	
1 containment vessel	1.5 1)
2 annular gap, if present	10.0
3 reactor building during normal reactor operation	1.0
4 reactor building during containment penetration isolation in the case of plants without second liner	≥ 1.0
Reactor auxiliary building	0.5
Nuclear services building	0.5
Turbine building	0.3
1) in the case of non inerted containment vessels	

Table 5-2: Guide values for the pressure stages required in the buildings or room groups with respect to the outer atmosphere to achieve a directed air current in case of a nuclear power plant with boiling water reactor

5.1.2 Conditions of the inner atmosphere

(1) The inner atmosphere in the individual buildings and regions shall meet the conditions called for by systems engineering. The guide values specified in **Table 5-3** shall be taken into consideration.

(2) Any planned air humidification may not introduce harmful substances nor radioactivity to the air. If the humidifying steam is produced via heat exchangers with energy from the primary coolant, at least two material boundaries or one material boundary and one pressure boundary are required between the steam and the primary coolant.

5.1.3 Directing the air current

(1) The pressure stages and air guides of the rooms shall be adjusted such that the air currents from rooms or room groups of a lower contamination hazards to those of an increasingly higher contamination hazard.

(2) In order to prevent an inadvertent distribution of radioactive substances by the inner atmosphere, the negative pressures in the buildings shall meet the guide values specified in **Tables 5-1** and **5-2** with respect to the outer atmosphere. The design of the ventilation systems shall be such that it is ensured that no contamination occurs in the inner atmosphere of the radioactivity measurement room for monitoring the exhaust air that would affect the measurements.

(3) In order to prevent an inadvertent distribution of radioactive substances by the inner atmosphere and to ensure the required negative pressures, the different room groups shall be insulated with respect to each other and to the external atmosphere to such a degree that the values specified in **Tables 5-1** and **5-2** can be achieved.

(4) An hourly air exchange rate of 0.1 should be achieved for the service compartments within the containment vessel (PWR) and for the service compartments within the steam turbine building (BWR).

Note:
A specification of a minimum air exchange rate for the equipment facilities within the containment vessel is not necessary because access to these rooms is not required during power operation of the plant. The hourly air exchange rate for these rooms is determined by the requirement for a lowest possible release of radioactive substances to the environment and should not exceed a value of 0.1.

(5) The purge air shall be conducted within the containment vessel of a PWR such that the rooms can be purged under consideration of the principle specified under para. 1.

5.1.4 Leak tightness

(1) The maximum permissible specific leakage rate of any trains of the ventilation systems for which this safety standard specifies special leak tightness requirements shall not exceed a value of 10 liters per hour and square meter (at a pressure of 1 bar and a temperature of 20 °C) for a pressure difference of 20 mbar; the area on which the leakage rate is based is the surface area of the train of the ventilation systems that defines the boundary to the environment.

(2) The maximum permissible leakage rate specified under para. 1 shall be demonstrated either analytically on the basis of the measured pressure drop over a given time period, or by measuring the refilling volume required to maintain the pressure difference of 20 mbar, or by a soapsuds, e.g., Nekal test. The leakage rate of non-stationary penetrations in the train of the air conditioning system, e.g., of shaft penetrations or of filter elements, shall be included in the determination of the specific leakage rate of the train of the air conditioning system.

(3) Those trains of the ventilation systems which, with respect to ambient conditions, operate at overpressure and are used to direct contaminated air shall be designed to meet the leak tightness requirements specified under para. 1 in those regions that are operationally accessible and where a low contamination of the air is required. In the case of PWRs, this requirement also applies to the extraction ducts of the annulus air extraction system.

(4) Bypass ducts - including their ducts, flange connections, blind flanges and associated isolating dampers - connected to filtration facilities shall be designed to meet the leak tightness requirements specified under para. 1. This also applies to connecting ducts between the filter and the down-stream ventilator, provided, filter and ventilator are located in the room the air of which shall be filtered.

(5) The trains of the ventilation systems shall be equipped with accessible and tightly sealable openings for measuring the volumetric air current.

5.1.5 Ventilation of electrotechnical equipment

(1) The ventilation systems for cooling the components of the reactor protection system shall be designed in accordance with Sec. 8 of safety standard KTA 3501.

(2) The battery rooms shall be ventilated in accordance with DIN EN 50272-2.

(3) The exhaust air ventilators provided for battery rooms shall, basically, be connected to the emergency power system. This is not required if the expected duration of interruption of the auxiliary power supply system is shorter than the permissible interruption duration of the ventilation facility to be determined in accordance with Sec. 4.7 para. 4 of safety standard KTA 2103. The power interruption duration specified for the nuclear power plant shall be taken into consideration.

(4) The exhaust air ventilators for battery rooms shall be provided as redundant elements if the expected time for repair or for an exchange of the ventilators is longer than the permissible interruption duration of the ventilation facility in accordance with safety standard KTA 2103.

5.1.6 Air filtration facilities

(1) Air filtration facilities for cleaning the air from the restricted-access area shall normally be located inside the restricted-access area; they should, as far as possible, be installed on the suction end of the ventilators.

(2) The air filter shells shall be leak tight to such extent that the volumetric air leakage current does not exceed a value of 0.003 % of the nominal volumetric air current (manufacturer specification).

Note:

a) Test requirements are specified in DIN 25496.
b) The leak tightness requirements specified under Section 5.1.4 para. 1 also apply to the connecting channel trains

(3) For those air filtration facilities which are required to be operational during and after design basis accidents, a continuous and maintenance free functioning shall be ensured for the case that a design basis accident occurs.

(4) Those air filtration facilities which have to be operational during and after design basis accidents shall be designed such that the contained filter elements and their materials will withstand all loadings from those design basis accidents for the mitigation of which they are required; these loadings are, e.g., pressure, pressure surges, humidity, temperature, ionizing radiation, vibrations and corrosive substances.

Item No.	Buildings, Room Groups	Range of Average Inner Atmosphere Temperature [1] (°C)	Average Humidity [1]
1	Main control room	22 to 26	40 to 65 % relative. humidity
2	Other continuously staffed rooms	22 to 26	40 to 65 % relative. humidity
3	Electronic equipment rooms	15 to 35 [2]	-
4	Switch gear rooms	15 to 35 [2) 5]	-
5	Other always accessible rooms [3]	15 to 35	at least 4 g of water per kg of dry air; temperatures below the dew point are impermissible
6	Non-accessible rooms or rarely accessed rooms	15 to 35 [5]	temperatures below the dew point are impermissible
	Exceptions:		
	a) Main steam and feed water valve compartment (only PWR)	15 to 60	-
	b) Emergency feed building (emergency standby building)	15 to 35 [2) 6]	-
	c) Diesel engine buildings	10 to 50 [2] cf. KTA 3702	-
	d) Steam turbine building	10 to 45 [4]	-
	e) Battery rooms	18 to 25	-

1) The average air temperature and humidity in the inner atmosphere shall, basically, be determined from the conditions of the vent air.
2) The upper limit value applies also during and after design basis accidents.
3) Room included during specified normal operation are, among others, the annulus of the reactor building with its measurement transducer rooms.
4) In the recreation rooms for personnel.
5) The upper limit value applies to the 24 hour average; for short periods only, 40 °C are permissible.

Table 5-3: Guide values for the conditions of the inner atmosphere in the buildings or room groups during normal operation

(5) Air filtration facilities designed for continuous operation shall allow a filter change under condition of vent air operation without the separation efficiency of the filter ever falling below the minimum permissible limit value.

(6) The filter shells shall be designed in such a way that the high-efficiency particulate air filter elements can be exchanged without contaminating the surroundings or the clean-air end.

5.1.7 Iodine filtration facilities

(1) The design of the iodine filtration facilities shall be in accordance with the requirements regarding the iodine adsorber specified under Section B 3 **Appendix B**.

(2) The separation efficiency may never fall below the minimum permissible limit value under any operating conditions of specified normal operation, be it volumetric air current, temperature, relative humidity, loading of the iodine adsorber with pollutants and water condensate. This also applies with respect to the operating conditions during that design basis accident for the mitigation of which the iodine filtration facility is required.

Note:
A temperature rise is possible from the decay heat of accumulated radioactive substances.

(3) It shall be possible to exchange the iodine adsorber without causing contamination.

(4) The adsorption part of those iodine filtration facilities that are specified to filter the vent air during and after design basis accidents shall be designed as a deep bed filter. The overall bed depth of the iodine adsorber shall be at least 20 cm. The retention time may not be shorter than 0.5 sec.

Note:
With these design values, all margins are covered regarding possible loading with pollutants and a decrease of the separation efficiency over time.

(5) Iodine filtration facilities shall, on the intake side, be provided with high-efficiency particulate air filter elements of at least filter class H 13 in accordance with DIN EN 1822-1 and, on the exhaust side, with high-efficiency particulate air filter elements of at least filter class E 11 in accordance with DIN EN 1822-1.

(6) Iodine filtration facilities shall be equipped with a device for taking a representative test specimen of the iodine adsorber to test its separation efficiency.

a) If control filters are provided for this purpose, these shall consist of at least two individual filters connected in series. These control filters shall be connected by ducts with a diameter of at least 25 cm and such that the air flows from the top down onto the filters. Each of the individual filters shall have the same adsorber volume. The sum of these volumes shall equal the volume of a column with a diameter of 50 mm and a length corresponding to the bed depth of the iodine filtration facility to be tested.

b) If it is planned to take a test specimens directly from the adsorption filter, it shall be ensured that the specimen of the iodine adsorber is removed from that part of the filter bed that is directly affected by the air current.

(7) The velocity of the air current through the control filter shall be chosen such that the overall retention time in the control filter is the same as that in the iodine filtration facility.

Note:
This requirement for a specific adjustment of the velocity of the air current through the control filter may require reducing the bed depth of the control filter. In order to still achieve the volume of activated charcoal specified under para. 6, the diameter of the control filter will have to be enlarged to about 65 mm and certain equipment for the measurement and exact adjustment of the volumetric air current will become necessary.

(8) Equipment for lowering the humidity, e.g. air heaters or other equivalent technical equipment, shall be designed such that the relative humidity of the air will be at least 10 % lower than the relative humidity specified for the filter.

(9) It shall be ensured that no channel forms in the iodine adsorber charge, even at a volume reduction of 10 % due to compaction of the charge, by designing the feeder pipe accordingly or by providing, within the filter shell, an additional reserve volume for a self-replenishment of the filter bed. If the iodine adsorber is already compacted during the filling procedure, a volume reduction of only 5 % may be assumed.

5.2 Ventilation systems of Air-Conditioning Class 1

5.2.1 Air conditioning equipment for ensuring safe enclosure

(1) Duct penetrations through the containment vessel for operational airing and venting and for purging the containment vessel shall be equipped with at least two air valves connected in series; with regard to leakage tests, the sealing faces, housing penetrations and flange connections of these valves shall be provided with double seals including exhaust devices. Equivalent designs are permissible.

Note:
Requirements for Penetrating Pipes through the Containment Vessel are given in safety standard KTA 3404.

(2) The air valves shall be installed as close as possible to the wall of the containment vessel and, either, one outside and one inside or both outside of the containment vessel. The design of the air valves including duct penetrations shall correspond to that of the containment vessel with respect to design overpressure, design temperature and testing overpressure.

Note:
Design details are specified in safety standards KTA 3404 KTA 3407.

(3) The volumetric air leakage current of any air valve close to the containment vessel shall be specified in accordance with the leak tightness requirements of the containment vessel taking into consideration, e.g., sealing faces, housing penetrations, flange connections.

Note:
Generally, a value of about 0.5 liters per hour (at a pressure of 1 bar and a temperature of 20 °C) results at a pressure difference of 20 mbar.

(4) The proof that the maximum permissible specific leakage rate is not exceeded shall be produced by the pressure decay method. If structural reasons stand against applying the pressure decay method, then a qualitative test, e.g. with foam agents, is permissible.

(5) Penetrations through the containment vessel of ducts required for airing and venting the containment vessel during power operation of the plant shall each be equipped with two closure valves with closing times less than or equal to 3 seconds; these valves shall, basically, be actuated by different means. In case similar actuators are used for these two valves, then their reliability shall be demonstrated by a corresponding operation test. The actuating controls of these two valves shall be diverse or they shall be redundant for each valve. The diameter of the closure valves shall not exceed 1000 mm. Proof shall be provided that the closure valves will withstand the dynamic load of closing during the design basis accident; it shall be assumed that closure is achieved 5 seconds after start of the loss-of-coolant accident. The flaps and their actuators shall be protected such that a loss-of-coolant accident will not cause damages to an extent that a sure closure of the flaps would be prevented.

(6) Ventilation valves for duct penetrations not required for operational airing and venting of the containment vessel shall be closed and interlocked during power operation of the plant. Their diameters shall not exceed 1000 mm.

(7) The ventilation valves for duct penetrations, their controls, actuators and power supply shall be protected against the effects from flying debris, temperature, water, pressure and radiation such that, after a loss-of-coolant accident, a later airing and venting of the containment vessel will be possible.

(8) The parts of air ducts that are open to the containment vessel during power operation of the plant and lie outside of the containment vessel shall be designed either to be leak tight as specified under Section 5.1.4 para. 1 and also pressure resistant, or they shall be capable of being closed at the penetration of the reactor building by containment isolation dampers. The design of the ducts is considered to be pressure resistant if the ducts withstand at least 1.1 times the maximum occurring pressure without detrimental effects on their functional capability. The duct sections designed to be pressure resistant may be isolated by pressure surge flaps.

Note:
The maximum pressure can occur when a ventilator works against a closed isolation damper.

(9) The requirements with respect to safe containment vessel penetration closures shall also be applied to the penetrations of the containment vessel required for the power supply, the controls, the measurement of negative pressures and the monitoring of ventilation systems.

(10) The valves shall be arranged such that an overpressure inside the containment vessel will cause the closure devices to be pressed into their sealing faces.

5.2.2 Ventilation systems for maintaining a negative pressure in the annulus

(1) The ventilators shall be designed such that in case of a non-availability of one ventilator, e.g. during repair, one additional redundancy will be available. The electrical drives of the ventilators shall be connected to emergency power facilities paying special attention to their trainwise separation.

(2) If the prevention of impermissible overpressures in the annulus requires a delayed closing of the isolation dampers between the annulus and the exhaust air facility of the annulus, then the radiological exposure of the environment shall be taken into consideration in specifying the delay time.

(3) It shall be ensured that after a loss-of-coolant accident the connected rooms are kept at negative pressures levels with respect to the outside atmosphere as specified in **Tables 5-1** and **5-2** at 75 % of the nominal volumetric air current of the exhaust air facility over an extended time period. Here it shall be taken into consideration that the pressure rise in the containment vessel after a loss-of-coolant accident will cause an overpressure in the connected air ducts up to that point in time when full closure of the isolation valves has been achieved. If this should lead to leakages, external air could be forced through the leakages into the rooms surrounding the containment vessel after an effected containment vessel isolation.

Note:
By limiting the volumetric air current of exhaust air, the retention time of the radionuclides in the connected rooms is increased which contributes to decreasing the radiological exposure of the environment.

(4) Isolation dampers for the air-wise separation of the reactor building from the external air supply facility specified under **Table A-2** Item No. 2.5 and from the exhaust air facility specified under **Table A-2** Item No. 2.1.3 shall be designed such that, for a pressure difference of 20 mbar, the specific leakage rate does not exceed 10 liters per hour and square meter (at a pressure of 1 bar and a temperature of 20 °C). The area on which the leakage rate is based is the actually closed-off flow cross section. Two dampers connected in series shall be installed.

5.2.3 Exhaust air filtration facility for required operation during or immediately after design basis accidents

(1) The iodine filtration facility shall, basically, consist of two 100% redundant, alternatively connectable trains. In the case of a single train iodine filtration facility, twice the mass of iodine adsorber calculated on the basis of the retention time specified under Section 5.1.7 para. 4 shall be employed.

(2) The filtration unit employed, seen in the direction of flow, shall consist of high-efficiency particulate air filter elements of at least filter class H 13 in accordance with DIN EN 1822-1 then, downstream, of the iodine filtration facility and, farther downstream, of other high-efficiency particulate air filter elements of at least filter class E 11 in accordance with DIN EN 1822-1. A roughing filter of at least filter class G4 in accordance with DIN EN 779 should be installed upstream of this filtration unit.

(3) Mist eliminators and air heaters or other technically similar equipment shall be provided upstream of those filtration units that shall remain operational after a loss-of-coolant accident even in the case of emergency power operation.

(4) Upon occurrence of a design basis accident, the exhaust air filtration facility shall be set in operation concurrently with the actuation of the containment isolation, and in such a way that the air dampers are opened, either, without need of any auxiliary power or with the help of a secure and independent source of auxiliary power (e.g., hydraulic accumulator).

(5) Adequate measures shall be applied, e.g., installation of check valves or explosion diaphragms, to prevent that, during specified normal operation of the nuclear power plant, air can be forced from the exhaust air channel back through the filter. In this instance, the specific leakage rate for a pressure difference of 4 mbar shall not exceed 100 liters per hour and square meter (at a pressure of 1 bar and a temperature of 20 °C); the area on which the leakage rate is based is the actually closed-off flow cross section.

(6) The exhaust air filtration facility shall, basically, not be operated during power operation of the plant. Whenever the facility has been in operation, tests as specified under Section 8.3.2 shall be performed within 4 weeks. In the case of inservice inspections, the duration of operation shall be limited such that no impermissible loading of the iodine filtration facility will occur.

5.2.4 Recirculated air cooling facilities

(1) The ventilators of the recirculated air cooling facilities shall be at least of the same redundancy as the safety related equipment for the function of which they are required.

(2) The recirculated air cooling facility for the main control room shall, basically, be designed to be redundant. A non-redundant (100 %) design of the recirculated air cooling facility for the main control room is permissible, provided, an emergency control room exists in addition to the main control room. It shall be possible to operate the recirculated air cooling facility without provision of external air.

(3) Depending on the overall plant concept, the recirculated air cooling facility for the main control room may be correlated to Air-Conditioning Class 2, provided, the condition specified under para. 2, sentence 2 applies.

(4) The recirculated air cooling facilities shall normally be equipped with air coolers and, if necessary, with mist eliminators.

(5) The air coolers shall normally be connected to the associated cooling system backed up by an emergency power supply.

(6) The drives of the ventilators shall normally be connected to an emergency power facility.

(7) It is recommended that, during specified normal operation, the external air to be provided in accordance with DIN 1946-7, DIN EN 13779, DIN EN 12792 und ASR 5 can be mixed into the recirculated air.

(8) The supply air for the switchgear room and the electronics room shall normally be conducted through filters of filter class F 7 in accordance with DIN EN 779.

5.2.5 Exhaust air facilities for the removal of thermal leakage heat

(1) The ventilators of the exhaust air facilities for the removal of thermal leakage heat shall have at least the same redundancy as the safety related equipment for the function of which they are required.

(2) The drives of the ventilators shall normally be connected to an emergency power facility.

5.3 Ventilation systems of Air-Conditioning Class 2

5.3.1 Exhaust air facility

The ventilators shall be designed to be redundant in respect to the required exhaust air volumetric air current for achieving the pressure stages in accordance with **Tables 5-1** and **5-2**. The drives of the ventilators shall normally be connected to an emergency power facility.

5.3.2 Exhaust air filtration facilities

(1) Exhaust air facilities required for maintaining negative pressures in those regions inside the containment vessel that contain components of the primary coolant system, e.g. equipment compartments of a PWR, shall be designed such that the exhaust air can be continuously filtered by the aerosol and iodine filtration facility during power operation of the plant.

(2) It shall be ensured that the exhaust air specified under para. 1 can be filtered even when a filter change becomes necessary during operation. In this case, it is not permissible to employ mobile filtration equipment.

(3) The system-internal air and gases from facilities conducting radioactive substances (e.g. sample extraction equipment, chemical digesters, work place exhausts, vessels) shall be cleaned by high-efficiency particulate air filter elements and, if necessary, by an iodine filtration facility. Insofar as compartment regions are concerned, the corresponding guide values [specified in **Tables 5-1** and **5-2** shall be maintained.

(4) If the design concept calls for an on-demand filtration of the vent air from compartment regions, then a manual activation is permissible. Until the leakage location has been identified, it is permissible to reduce the volumetric air current of exhaust air from partial regions and, thereby, to adjust it to the volumetric air current of the filtration facility, provided, the specified direction of the air current is maintained and the concentration of harmful substances in the air around continuously staffed work places does not exceed permissible limit values.

(5) Mist eliminators and air heaters or technically similar equipment shall be provided upstream of the filters for the vent

air from the containment vessel as specified under para. 1 and, if necessary, from the system-internal air as specified under para. 3.

(6) If the exhaust air filtration facility contains a high-efficiency particulate air filter, this shall correspond at least to filter class H 13 in accordance with DIN EN 1822-1.

(7) In case an iodine filtration facility is part of the exhaust air filtration facility, then the filtration unit employed, seen in the direction of flow, shall consist of high-efficiency particulate air filter elements of at least filter class H 13 in accordance with DIN EN 1822-1 then, downstream, of the iodine filtration facility and, farther downstream, of other high-efficiency particulate air filter elements of at least filter class E 11 in accordance with DIN EN 1822-1.

5.3.3 Recirculated air filtration facility inside the containment vessel

(1) The filter units employed shall consist, upstream of the iodine filtration facility, of high-efficiency particulate air filter elements of at least filter class H 13 in accordance with DIN EN 1822-1 and, downstream, of high-efficiency particulate air filter elements of at least filter class E 11 in accordance with DIN EN 1822-1.

(2) If temperatures below the dew point are expected, the filtration unit shall be equipped with an air heater.

5.3.4 Cooling facilities for building structures inside the containment vessel (e.g. reactor shield cooling)

(1) The recirculated air cooling facilities required for cooling the building structures shall be designed as redundant facilities.

(2) The facilities shall normally be equipped with air coolers and, if necessary, with mist eliminators.

(3) The associated air coolers shall normally be connected to the associated cooling system backed up by an emergency power supply.

(4) The drives of the ventilators shall normally be connected to an emergency power facility.

(5) The guide values specified in **Table 5-3** shall be taken into consideration.

5.3.5 External air supply facility for the restricted-access area

(1) A penetration of combustible gases and fumes from the outside shall be prevented. Here it is permissible for as long as it is necessary not to follow the requirement of a negative pressure in the restricted-access area and to shut down the supply air and vent air facilities.

Note:
Sec. 5 of safety standard KTA 2103 specifies requirements regarding early alarms and the initiation of control measures.

(2) The supply air for the restricted-access area shall normally be conducted through air filters of at least filter class F 7 in accordance with DIN EN 779.

5.3.6 Pressure surge protectors

(1) By taking suitable measures, e.g. installation of pressure surge valves, it shall be ensured that, in case of a loss-of-coolant accident and despite the pressure buildup inside the containment vessel in the closing phase of the containment isolation valves, the connected ventilation and filtration facilities remain functional, provided, this is required for a later airing and venting of the containment vessel.

(2) In designing the pressure surge protectors for the external air supply and exhaust air openings, the characteristic values of the external pressure surge shall be specified for the particular nuclear power plant. The analysis shall be based on the assumption that the pressure surge comes from outside. The pressure surge valves shall be designed such that they will withstand at least 1.1 times the maximum expected pressure from a design basis accident without detrimental effects on their function.

6 Instrumentation and Control Equipment

6.1 General Requirements

(1) The reliability of the air conditioning systems shall not be limited by the reliability of the instrumentation and control equipment.

(2) It shall be possible to test the instrumentation and control equipment during specified normal operation of the nuclear power plant.

(3) It shall be possible to monitor the functioning of the ventilation systems from the main control room with the help of displays, signals and alarms.

(4) The ventilators of the supply air and vent air facilities in the controlled-access area shall be dimensioned such that the adjusted volumetric air current will be able to maintain the air flow directions and the pressure stages in the buildings in accordance with the guide values specified in **Tables 5-1** and **5-2**.

(5) The negative pressures in the buildings and room groups of **Tables 5-1** and **5-2** shall be measured, displayed and recorded. Any deviation outside the permissible tolerance range shall trip an alarm.

(6) The locations of the connection points for measuring pressure differences shall be chosen such that an adequate monitoring of the required pressure stages is possible.

6.2 Ventilation systems of Air-Conditioning Class 1

6.2.1 Air conditioning equipment to ensure safe enclosure

(1) Upon initiation by the reactor protection system, the isolation valves required to ensure a safe enclosure shall close automatically. It shall also be possible to manually initiate the isolation function.

(2) The isolation valves of the containment vessel that are not required for operational airing and venting shall be interlocked in such a way, e.g., as being dependant on the pressure and temperature of the primary coolant system, that they can only be opened when the reactor is shut-down.

(3) The air conditioning equipment specified under Sections 5.2.1, 5.2.2 and 5.2.3 shall be controlled by the reactor protection system.

(4) It shall normally be possible to operate the ventilation systems and components specified under paras. 3 and 5 from the main control room, provided, this is permissible from a safety standpoint. With regard to operation during design basis accidents, the emergency control room shall be equipped with operating controls, displays and alarms for the recirculated air system of the emergency feed building.

(5) The instrumentation and control equipment for the redundant partial systems of the trains of the ventilation systems specified under Sections 5.2.4 and 5.2.5 shall themselves be independent of each other such that a failure inducing event will not be able to affect more than one of the partial systems.

(6) The functioning of each of the redundant partial systems shall be monitored. Those partial systems that are provided for

the equipment of the reactor protection system and for the active engineered safety features and that, however, are not controlled by the reactor protection system shall be monitored by Class I hazard alarms in accordance with safety standard KTA 3501. In the case of the partial systems that are controlled by the reactor protection system, their testability and monitoring of the functionability shall be ensured in accordance with Sec. 4.1.9 of safety standard KTA 3501.

6.2.2 Exhaust air facility and exhaust air filtration facility for required operation during and immediately after a design basis accident

(1) Whenever the ventilators are operated for testing purposes it shall be ensured, in order to protect the iodine adsorber, that they are shut down at the latest after 5 minutes; this may be manually effected after a corresponding alarm, or by automatic controls. The controls effective in the case of required operation shall have priority over these automatic controls. It shall be possible to turn on the ventilators by hand.

Note:
Limiting the test duration to 5 minutes has the purpose of largely reducing the amount of carbonic pollutants (e.g., oil, grease, solvents) introduced into the iodine adsorber.

(2) The volumetric air currents of the ventilation system shall normally be measured and displayed and should be recorded.

6.2.3 Recirculated air facilities and exhaust air facilities

(1) The recirculated air facilities and exhaust air facilities, either, shall be in operation continuously, shall be turned on automatically before the maximum permissible air temperature of the room is reached or it shall be possible to turn them on simultaneously with the equipment to be cooled.

(2) It is required that

a) the room air temperature is measured and displayed in the main control room and

b) alarms are issued when the limit values of the room air temperature are exceeded.

(3) The operation of the ventilators shall be monitored; it shall be ensured that the required ventilation power is maintained.

6.3 Ventilation systems of Air-Conditioning Class 2

6.3.1 Exhaust air facilities

(1) The operation of the exhaust air ventilators shall be monitored; in case of failure of a ventilator, operation shall automatically be switched over to the other one of the redundant ventilators.

(2) In case of a shutdown or failed exhaust air facility, the external air supply facility shall automatically be shut down.

(3) If the pressure rise exceeds the maximum permissible pressure of the vented buildings, building sections or internal structures, measures shall be taken to prevent impermissible pressures in the case of a failure of the controls.

(4) The volumetric air current of the exhaust air released through the exhaust stack shall be measured and recorded.

6.3.2 Exhaust air filtration facilities

It shall be possible to redirect the exhaust air of the reactor building or of other compartment regions to a corresponding filtration facility by a switching operation in the main control room.

6.3.3 Recirculated air cooling facilities inside the containment vessel

(1) The operation of the ventilators for the recirculated air in the equipment compartments shall be monitored. In case a ventilator fails, operation shall be automatically switched over to the other one of the redundant ventilators.

(2) Alarms shall be tripped if limit values for the temperature of the inner atmosphere of equipment compartments are exceeded, e.g. in the steam generator compartment, ventilated region of the biological shield, reactor well, transducer compartments. In addition, the room air temperatures of equipment compartments, e.g. steam generator compartment and reactor well, shall be measured and recorded.

6.3.4 External air supply facility for the restricted-access area

(1) The external air temperature shall be displayed.

(2) The temperature of the supply air shall be regulated.

(3) The humidity of the supply air shall normally be monitored and regulated.

(4) If no check valves are installed, it shall be possible to close the external air dampers from the main control room.

(5) The operation of the external air supply ventilators shall be monitored.

6.4 Air Filtration Facilities and Components

6.4.1 Air Filtration facilities

(1) The pressure drop over the high-efficiency particulate air filtration stage and, upstream, over the air filtration stage shall each be separately monitored. The maximum permissible pressure drops shall be marked on the measurement instruments.

(2) The air filtration facilities shall be protected from a temperatures increase beyond permissible limits. Therefore, the air temperature shall be monitored. In case an electric air drying facility is used, the volumetric air current shall, additionally, be monitored. The air heater equipment shall be automatically shut down when the maximum permissible air temperature is exceeded or if the volumetric air current drops below the minimum permissible limit value.

6.4.2 Dampers

The position of all controlled dampers shall be reported by feedback signals from end-position switches. Dampers used for regulating the air current shall be designed to issue feedback signals that indicate their position.

7 Tests and Inspections of Air Conditioning Equipment

The requirements for tests and inspections of components before and during manufacturing are specified in DIN 25496.

Note:
In the following several tasks are addressed that, in accordance with specifications of the competent authority, require the participation of the authorized expert under Sec. 20 Atomic Energy Act or of another expert to be named by the authority. For the sake of simplicity, this safety standard simply refers to ‘authorized expert’.

7.1 Commissioning Tests of the Ventilation systems

(1) The air conditioning equipment in accordance with **Tables A-1** and **A-2** shall be subjected to the following tests and inspections. The results of the tests and inspections shall be

recorded. The authorized expert shall certify the results of those tests and inspections performed under his responsibility.

(2) In the course of the commissioning tests, all parts relevant to safety shall be tested with regard to whether or not their construction, performance and function is in conformance with the design.

Note:
Further details for the ventilation valves in accordance with Section 5.2.1 paras. 1 and 5 are specified in Sec. 4.3 of safety standard KTA 3404, Isolation of Operating System Pipes Penetrating the Containment Vessel in the Case of a Release of Radioactive Substances into the Containment Vessel

(3) The tests and inspections shall comprise:

a) Visual inspection of the assembled ventilation systems,

b) Functional tests of the facilities including

  ba) power-on, power-off and switching procedures under conditions of specified normal operation and emergency power operation,

  bb) test of the interlock conditions,

  bc) test of the controls, e.g. for the temperature, pressure and volumetric air current,

  bd) check of the measurement equipment, e.g. for temperature, volumetric air current, negative pressure,

c) Check of the limit value adjustments,

d) Check of the connections of the power supply and of the instrumentation and control equipment to the corresponding power supply bus,

e) Measurement of the volumetric air currents in safety related and radiologically relevant room groups using fresh filters and simulation-loaded filters,

f) Check of the pressure stages or of the directed air currents in individual room groups during specified normal operation, during operation of the facilities in accordance with Sections 5.2.2 and 5.2.3 as well as during change-over procedures,

g) Leak tightness tests, e.g., of ducts, dampers,

h) Check of the conditions of the inner atmosphere as far as this is possible without full power operation of the nuclear power plant. A final check of the conditions of the inner atmosphere shall be performed during power operation of the nuclear power plant,

i) Check of the testability and of the accessibility for maintenance and repair.

7.2 Inservice Inspections

(1) The inservice inspections of the ventilation systems in accordance with **Tables A-1** and **A-2** shall, basically, be performed in accordance with **Table 7-1**.

Note:
Further details for the ventilation valves in accordance with Section 5.2.1 paras. 1 and 5 are specified in safety standard KTA 3401.4.

(2) If the ventilation systems or components have not been in operation or were not needed to be available for a duration longer than the time between two regular inservice inspections, e.g. during an extended reactor shut down, then the next inservice inspection shall be performed, in deviation of the specifications under **Table 7-1,** at the latest before the next operation or required availability of the ventilation systems or components.

(3) If defects are detected during the inservice inspections, they shall be evaluated with respect to safe operation of the nuclear power plant, and the maximum time period for the removal of deficiencies shall be specified. The removal of deficiencies shall be certified after performing a renewed test.

(4) The results of the inservice inspections shall be recorded in test reports that shall contain the following information:

a) test results,

b) detected deficiencies,

c) evaluation of the detected deficiencies,

d) maximum time period for removal of deficiencies.

It is permissible to reference the commissioning tests.

(5) The inservice inspections shall be used to determine whether or not the safety related and radiologically relevant equipment and precautionary measures regarding ventilation systems meet the specified requirements and whether or not an impermissible reduction of the effectiveness of the facilities has occurred in comparison to the commissioning test.

Item No.	Required Tests and Inspections	Air-Conditioning Class 1	Air-Conditioning Class 2	Air-Conditioning Classes 1 and 2
		Tester		
		Experts (e.g. of the operator)		Authorized Experts
		Test Intervals (years)		
1	Condition of overall facility by visual inspection	1 [1)]	1 [1)]	1
2	Perfect function of the instrumentation, control and alarm equipment with relevance to safety	¼	1	1
3	Perfect function of the ventilation systems including the interlocks	1	1	1
4	Function, adjustment time and required leak tightness of the valves	½	1	1
5	Air isolation valves of the containment vessel as specified under Section 5.2.1 para. 1 and 5			
	a) visual inspection	¼	-	1
	b) function	¼	-	1
	c) time to valve closure	½	-	1
	d) leak tightness	during refueling	-	during refueling
6	Air valves of the containment vessel specified under Section 5.2.1 para. 6			
	Visual inspection, function, leak tightness	during overall maintenance inspection or refueling prior to resuming full power operation	-	during overall maintenance inspection or refueling prior to resuming full power operation
7	Maintaining of differential pressures, directions of air currents and, as required, volumetric air currents	1	1	1
8	Leak tightness of the sealing faces of high efficiency particulate air filter elements specified under Section 8.3.1 para. 2	1 [2)]	1 [2)]	1 [3)]
9	Leak tightness of all pressure ducts downstream of the ventilators including the filter shells and connecting ducts between filter and ventilator on the suction side of the ventilators	9	9	9

1) In addition, VDI 6022 Sheet 1 shall be taken into consideration.
2) Annually and during filter change.
3) Annually and during filter change in Air-Conditioning Class 1.

Table 7-1: Inservice inspections of ventilation systems

8 Tests of the Filtration Facilities

Note:
In the following several tasks are addressed that, in accordance with specifications of the competent authority, require the participation of the authorized expert under Sec. 20 Atomic Energy Act or of another expert to be named by the authority. For the sake of simplicity, this safety standard simply refers to 'authorized expert'.

8.1 General Requirements

(1) It shall be verified by tests that the requirements specified under Sections 5.1.6 and 5.1.7 are fulfilled; these tests shall be certified by an authorized expert.

(1) Filtration facilities for holding back aerosols shall be tested as specified under Section 8.2.1 paras. 1, 2 and 3. The results of these tests shall be documented.

8.2 Acceptance and Functional Tests

8.2.1 Aerosol filtration facilities

(1) The high-efficiency particulate air filter elements shall be tested with regard to the requirements in accordance with B 2 and DIN EN 1822-1. The manufacturer shall certify in a test report that the required characteristics have been achieved.

(2) Proper functioning of the aerosol filtration facility shall be ensured by performing at least one of the on-site tests specified below under items a) through d). The test results for the high-efficiency particulate air filters, shall be certified by an authorized expert. Positive test results for the methods specified under items a), b) and c) would indicate that the requirements under Section 5.1.6 para. 2 are met (i.e., that the volumetric air leakage air current is sufficiently small).

a) Counting of particles (natural dust particles)

   With the high-efficiency particulate air filter elements in place, a proper functioning of the aerosol filtration facility shall be ensured by tests it in accordance with DIN EN 1822-1.

b) Measurement with aerosol test particles

   With the high-efficiency particulate air filter elements installed in its place, the separation efficiency shall be determined using aerosol test particles. The separation efficiency shall be as specified for filter class H 13 in accordance with DIN EN 1822-1.

   Note:
   The test medium used is, e.g., sodium fluorescine. The requirements regarding the test instructions for this procedure are currently under review.

c) In the case of high-efficiency particulate air filter elements with a specially designed filter shells, an oil thread test may be applied with the filter installed in its place to prove sufficient leak tightness of the filter element and of the sealing face.

d) Immediately before installation, each high-efficiency particulate air filter element shall be tested for leak tightness (e.g. by an oil thread test). After installation, the sealing face of the filter element shall be tested for leak tightness. Here, it shall be demonstrated that the requirements specified under Section 5.1.6 para. 2 are fulfilled, i.e., that the volumetric air leakage current at a test pressure of 20 mbar does not exceed 0.003 % of the nominal volumetric air current for the filter element (manufacturer specification).

(3) The leak tightness of the filter shells, both to the outside and between the dirty-air side and the clean-air side, shall be demonstrated prior to any surface treatment. This test shall normally be performed at an overpressure of 20 mbar inside the filter shell. Here, the volumetric leakage air current shall, basically, not exceed 0.003 % of the nominal volumetric air current. Deviations are permissible, provided, it is ensured, that no contaminated air can be sucked in through any of the leakage orifices. It is permissible to present a qualitative proof in the form of a soap suds, e.g. Nekal test.

(4) The proof of leak tightness in accordance with DIN 25496 shall be certified by the licensee or by a third party commissioned by the licensee and, additionally, by an authorized expert.

(5) The high-efficiency particulate air filter elements of the air filtration facility required in case of a design basis accident shall be able to withstand an absorbed dose of at least 10^4 Gy without reducing their functional capability to an extent that would cause the separation efficiency at the end of the planned operating time to drop below the value specified for the corresponding filter class.

8.2.2 Iodine filtration facilities

(1) Iodine filtration facilities shall meet the requirements in accordance with DIN 25496.

(2) The iodine adsorber filled into the iodine filtration facility shall have the characteristics as specified under Section B 3.

(3) The separation efficiency of the iodine adsorber shall be determined prior to loading the filter into the filter bed; this test shall be performed on a specimen taken from the same batch of the iodine adsorber intended for the iodine filtration facility, taking care to adjust the

a) linear velocity of the air,
b) relative humidity,
c) temperature,
d) pressure, and
e) loading with radioactive methyl iodide

with respect to the design specifications and using a bed depth that corresponds to that of the iodine filtration facility. A storage period of up to three years is permissible without a renewed test. The storage conditions specified under Section B 4 shall be met.

(4) Each batch of the iodine adsorber shall be certified by a laboratory test in which the separation efficiency of the unused iodine adsorber with respect to its retention of radioactive methyl iodide is determined. At least two individual and independent laboratory tests shall be performed on the iodine adsorber intended for iodine filtration facilities that will be required in the course of a design basis accident. The average value of the separation efficiency shall be determined from the results of the two test. The individual values shall not deviate from the average value by more than 30 % of the value specified for the transmission factor (transmission factor = 1.0 minus specified separation efficiency). In the case of those facilities of Air-Conditioning Classes 1 and 2 listed in **Tables A-1** and **A-2**, the corresponding test results shall be certified in the form of a qualification report by an authorized expert.

(5) The authorized expert shall be provided with the following detailed information on the iodine filtration facilities:

a) purpose and location, e.g., vent air annulus, vent air equipment compartments, recirculated air,
b) operating conditions,
c) dimensions of the filter elements,
d) type of iodine adsorber,
e) grain size distribution of the iodine adsorber,
f) impregnation of the iodine adsorber,
g) effective bulk volume of the iodine adsorber in each iodine filtration facility,
h) mass of the iodine adsorber in each iodine filtration facility,
i) bed depth of the iodine adsorber,

k) maximum permissible air throughput of each iodine filtration facility,
l) pressure difference for the nominal air throughput,
m) maximum and minimum permissible operating temperature,
n) applied materials that will come in contact with the iodine adsorber,
o) maximum permissible relative humidity,
p) test type and concept for checking the iodine adsorber, e.g., with the help of control filters,
q) manufacturer of the filtration facility,
r) available test certificates,
s) scheduled tests and inspections.

Note:
The effective bulk volume of the iodine adsorber specified under item g) does not include the volumes of the filler and extraction nozzles.

(6) The following tests shall be performed and the corresponding test results documented. The following tests shall be certified by an authorized expert:

a) Checking whether or not the iodine adsorber was properly filled into the deep bed filters and into the control filters and of the subsequent adjustment of the air throughput and secure sealing of the control filters in a condition ready for operation – to be performed after every new filling.
b) The first test of the separation efficiency of the iodine adsorber (laboratory test) to verify conformance with the requirements specified under Section B 3 para. 1 shall be performed no earlier than 4 months and no later than 10 months after the initial filling.
c) The specific separation efficiency shall be determined for each iodine filtration facility after the initial filling. A generally accepted procedure shall be used on-site for this test. The following conditions shall be observed:
   ca) With regard to determining physical leakages in the iodine adsorber layer, five plugged openings shall be provided at suitable locations: two each in the dirty-air side and the clean-air side and an additional opening for feeding the test medium into the facility.
   cb) It shall be ensured that test medium will be homogeneously mixed into the air.

   Note:
   This may be achieved, e.g., by positioning the test medium feed opening and the clean-air specimen removal opening each at a distance from the filter that is equal to 10 times the diameter of the duct.

   cc) Two test medium insertion nozzles shall be installed 90° apart from each other at accessible locations at the center of the channel. The distance of the nozzle projections onto the channel axis shall be no smaller than 100 mm. It is permissible to position the test specimen extraction nozzles upstream of the high-efficiency particulate air filter elements installed on the intake side of the iodine filtration facilities; it is also permissible to use the nozzles for the high-efficiency particulate air filter tests, provided, they are suited to this task.
d) The specific separation efficiency shall be determined after every new filling of iodine filtration facilities of Air-Conditioning Class 1 and after every new filling of those iodine filtration facilities of Air-Conditioning Class 2 with a retention time shorter than one second,.
e) In the case of iodine filtration facilities of Air-Conditioning Classes 1 and 2, any change of the type of iodine adsorber (cf. Section 8.2.2 para. 5 item d)) shall require performing the same test as the one specified under Section 8.2.2 para. 6 item c) as being required after initial filling of the iodine filtration facility.

8.3 Operational Monitoring and Inservice Inspections of the Filters and the Iodine Adsorber

The inservice inspections shall be performed in intervals as specified in **Table 7-1.**

8.3.1 High-efficiency particulate air filter elements

(1) The pressure differences at the high-efficiency particulate air filter elements shall be monitored (cf. Section 6.4.1 para. 1). The high-efficiency particulate air filter elements shall be renewed as soon as the maximum specified operating pressure difference is reached.

(2) The leak tightness of the sealing faces of high-efficiency particulate air filter elements shall be tested annually, e.g., by the oil thread test specified under Section 8.2.1 para. 2 item d) or by the integral tests specified under Section 8.2.1 para. 2 items a), b) and c).

(3) The high-efficiency particulate air filter elements specified under Section 5 shall be subjected to a function test as specified under Section 8.2.1 para. 2 items a), b) and c), the latest, after 27000 operating hours and from then on in yearly intervals, and they shall be renewed, the latest, after an operating term of 9 years.

8.3.2 Iodine filtration facilities

(1) Prerequisite for testing the separation efficiency of the iodine adsorber are that the material for the laboratory test specimen and that for the iodine filtration facility belong to the identical batch and that they have been exposed to vent air over an identical length of time. This test shall be performed in annual intervals. The results of the test shall be certified by an authorized expert.

(2) The fill level of the iodine adsorber shall be checked immediately after extracting the test specimen for the laboratory test from the filter bed. The fill level shall, in any other case, be checked at least every two years.

(3) Depending on the rate of change of the separation efficiency, additional laboratory tests shall be performed on the iodine adsorber at points in time that shall be arranged with an authorized expert.

Appendix A

Examples for Design Requirements and Requirements for Test and Inspections in Actual Ventilation systems

The buildings listed in the following **Tables A-1**, **A-2** and **A-3** are typical for current PWRs and BWRs (cf. Section 1 para. 1)

Item No.	Air conditioning equipment [1]	Design requirements specified under Section	Tests and inspections specified under Section
1.1	Air conditioning equipment for ensuring the containment	5.2.1	7.1, 7.2
1.2	Exhaust air facility for maintaining a negative pressure in the annulus	5.2.2	7.1, 7.2, 8
1.3	Exhaust air filtration facility the operation of which is required during or immediately after design basis accidents	5.2.3	7.1, 7.2, 8
1.4	Recirculated air cooling facilities for the	5.2.4	7.1, 7.2
1.4.1	Emergency feed building		
1.4.2	Service water pump and purification plant [2]		
1.4.3	Cable ducts		
1.4.4	Local control stations		
1.4.5	Switch gear building sections for redundancies relevant to safety		
1.4.6	Emergency core cooling and residual heat removal systems (provided, the heat is not planned to be removed by emergency-power-connected cooling circuits)		
1.4.7	Emergency power generating building		
1.4.8	Main control room [3]		
1.5	Exhaust air facilities for the removal of thermal leakage heat	5.2.5	7.1, 7.2
1.5.1	Emergency power generating building		

[1] The names of the individual buildings are in accordance with current practice, nevertheless, shall be seen as exemplary only.

[2] This categorization does not apply if it is demonstrated that, without ventilation, the temperature limit values will not be exceeded.

[3] Cf. Section 5.2.4 para. 3

Table A-1: Requirements, tests and inspections for air conditioning equipment of Air-Conditioning Class 1

Item No.	Air conditioning equipment [1)]	Design requirements specified under Section	Tests and inspections specified under Section
2.1 2.1.1 2.1.2 2.1.3 2.1.4 2.1.5	Exhaust air facilities for the Containment vessel Annulus Reactor and reactor auxiliary building Nuclear services building Steam turbine building (BWR)	5.3.1	7.2, 7.2
2.2	Exhaust air filtration facilities	5.3.2	7.1, 7.2, 8
2.3	Recirculated air filtration facility inside the containment vessel	5.3.3	7.1, 7.2, 8
2.4 2.4.1 2.4.2	Recirculated air cooling facilities for the Building structures inside the containment vessel (reactor shield cooling) Main control room [2)]	5.3.4	7.1, 7.2
2.5 2.5.1 2.5.2	External air supply facilities for the restricted-access areas of the Reactor and reactor auxiliary building Steam turbine building (BWR)	5.3.5	7.1, 7.2
2.6	Pressure surge protectors	5.3.6	7.1, 7.2

1) The names of the individual buildings are in accordance with current practice, nevertheless, shall be seen as exemplary only.

2) Cf. Section 5.2.4 para. 3

Table A-2: Requirements, tests and inspections of air conditioning equipment of Air-Conditioning Class 2

Item No.	Air conditioning equipment
3.1	Exhaust air facilities[1] for the removal of thermal leakage heat and for maintaining the minimum air exchange rate in the
3.1.1	Emergency power generating building
3.1.2	Switch gear building
3.1.3	Emergency feed building
3.1.4	Steam turbine building (PWR)
3.2	Recirculated air cooling facilities [1] for the
3.2.1	Cable ducts
3.2.2	Computer room
3.2.3	Emergency feed building
3.2.4	Feed water valve compartment
3.2.5	Emergency core cooling and residual heat removal systems (if the heat is not planned to be removed by emergency-power-connected cooling circuits)
3.2.6	Other regions in the restricted-access area (e.g. accessible operating rooms, upper part of the annulus)
3.3	External air supply facilities[1] for maintaining the minimum air exchange rate and for removing thermal leakage heat in the
3.3.1	Switch gear building
3.3.2	Steam turbine building (PWR)
3.3.3	Emergency feed building
3.4	Ventilation system for the non-bunkered part of the service water pump and purification station
3.5	Ventilation system for the machine shop and laboratory building
3.6	Ventilation system for the supply systems building
3.7	Ventilation system for the demineralization system building
3.8	Ventilation system for the cooling tower make-up water treatment building
3.9	Ventilation system for the administration and operations building
3.10	Ventilation system for the circulating water pump system building
3.11	Air recirculation equipment and blower ventilators without relevance to safety or radiology, even those within the restricted-access area

[1] Relates only to those system parts not listed under **Tables A-1** and **A-2**.

Table A-3: Air conditioning equipment to which this safety standard does not apply

Appendix B

Additional Requirements for Filtration Media and Filter Elements

B 1 Scope

Appendix B applies to high-efficiency particulate air filtration media and high-efficiency particulate air filter elements in accordance with DIN EN 1822-1 installed in components of Air-Conditioning Class 1 (**Table A-1**) and in components of Air-Conditioning Class 2 (**Table A-2**).

B 2 High-Efficiency Particulate Air Filter Elements

(1) High-efficiency particulate air filter elements and their mounting frames shall withstand, for the entire planned operating life, the effects from the external pressure required to achieve a leak-tight seating without detrimental effects to functionality. The employed sealant material shall stay permanently elastic and resistant to aging for the entire planned operating life.

(2) High-efficiency particulate air filter elements shall be permanently marked with the following information:

a) name and location of the manufacturer or supplier,

b) type specification,

c) fabrication series,

d) filter class in accordance with DIN EN 1822-1,

e) initial pressure difference at nominal volumetric air current,

Note:
The nominal volumetric air current is the volumetric air current specified by the manufacturer for the filter.

f) direction of flow.

(3) The filter medium shall be water repellant.

(4) High-efficiency particulate air filter elements shall be designed for continuous operation at a relative humidity of at least 90 % and a temperature of at least 80 °C.

B 3 Iodine Adsorber

The separation efficiency of activated charcoal freshly filled into an iodine filtration facility shall, with respect to methyl iodide, be sufficiently high that the K-factor of the activated charcoal does not fall below a value of 8 sec^{-1}. The K-factor of the activated charcoal in its unused state shall be determined by, initially, subjecting the charcoal to water vapor at a relative humidity of 95 % and a temperature of 30 °C in a bed depth of 10 cm and a retention time of 0.2 sec until the activated charcoal has reached its adsorption equilibrium; subsequently, the activated charcoal shall be subjected to radioactively marked methyl iodide for the duration of one hour.

Note:
A higher relative humidity leads to a lower value for the K-factors.

(2) The minimum permissible values for the separation efficiency of iodine filtration facilities with respect to methyl iodide are listed in **Table B-1**.

(3) Activated charcoal may be used at temperatures above 120 °C, provided, it has been demonstrated by measurements under the most unfavorable simulated operating conditions and the maximum possible temperature that, over a time period of two weeks, the separation efficiency does not increase due to desorption of radioactive iodine by more than 20 % of the value determined in a short-duration test with a two hour flushing time. If the activated charcoal shall be used at operating temperatures exceeding 180 °C, then its ignition temperature shall be determined.

Facility	Initial condition of iodine adsorber	Final condition of iodine adsorber
Facility in Air-Conditioning Class 2 required during specified normal operation	99 %	90 %
Air filtration facility in Air-Conditioning Class 1 required during design basis accidents	99,99 %	99 %

Table B-1: Minimum permissible values for the separation efficiency of iodine adsorption filters with respect to methyl iodide

(4) The grain size of the activated charcoal shall normally lie between 1 and 2 mm. The following grain size distribution of the activated charcoal (screen size in accordance with DIN ISO 3310-1) is recommended:

Grain Size	Proportion
> 2.5 mm	max. 0.5 %
>2 mm	max. 5 %
1 - 2 mm	min. 94 %
< 1 mm	max. 6 %
< 0.8 mm	max. 0.5 %

Table B-2: Recommended grain size distribution of the activated charcoal

(5) The material characteristics of the activated charcoal with respect to breakage and abrasion should be such that it is ensured that after conveyance by mechanical or pneumatic means the requirements for the grain size specified under para. 4 are maintained.

(6) The self-ignition temperature of activated charcoal impregnated with a 1.5 % solution of potassium iodide shall normally not be lower than about 300 °C.

(7) The impregnation of the activated charcoal with potassium iodide shall normally amount to a weight percentage of between 1 % and maximum 2 %.

(8) After filling the iodine adsorber (either manually, mechanically or pneumatically) into the iodine filtration facility, the pressure drop shall normally not exceed 10 mbar based on a linear air current of 0.5 m per second and an activated charcoal bed depth of 10 cm.

B 4 Storage Conditions for the Iodine Adsorber

(1) The barrels with activated charcoal shall be stored frost-free in a dry room. The room should be aired.

(2) When put into storage, all barrels shall be individually documented and marked with the date of the first day of storage. With regard to their removal, the barrels shall be positioned such that the barrel marking is well visible .

(3) The barrels shall remain closed for the entire duration of storage to prevent penetration of humidity and pollutants.

Appendix C

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.

AtG		Act on the peaceful utilization of atomic energy and the protection against its hazards (Atomic Energy Act – AtG) of December 23, 1959, revised version of July 15, 1985 (BGBl. I, p. 1565), most recently changed by Article 2, Sec. 2. of the Act of July 20, 2017 (BGBl. I, p. 2808)
StrlSchV		Ordinance on the protection from damage by ionizing radiation (Radiological Protection Ordinance – StrlSchV) of July 20, 2001 (BGBl. I, p. 1714; 2002 I, p. 1459), most recently in accordance with Article 10 changed by Article 6 of the Act of Janu-ary 27, 2017 (BGBl. I, p. 114, 1222)
Safety Requirements for Nuclear Power Plants (SiAnf)	(2015-03)	Safety Requirements for Nuclear Power Plants (SiAnf) of 22 November 2012 (BAnz AT 24.01.2013 B3), revised version of 3 March 2015 (BAnz AT 30.03.2015 B2).
Interpretations of the "Safety Requirements for Nuclear Power Plants" (Interpretations)	(2015-03)	Interpretations of the "Safety Requirements for Nuclear Power Plants of 22 November 2012" (BAnz AT 24.01.2013 B3), revised version of 3 March 2015 (BAnz AT 30.03.2015 B2)
KTA 1502	(2017-11)	Monitoring Radioactivity in the Inner Atmosphere of Nuclear Power Plants
KTA 1503.1	(2016-11)	Monitoring the Discharge of Radioactive Gases and Airborne Radioactive Particulates Part 1: Monitoring the Discharge of Radioactive Matter with the Stack Exhaust Air During Specified Normal Operation
KTA 1503.3	(2017-11)	Monitoring the Discharge of Radioactive Gases and Airborne Radioactive Particulates Part 3: Monitoring the Non-Stack Discharge of Radioactive Matter
KTA 1503.2	(2017-11)	Monitoring the Discharge of Radioactive Gases and Airborne Radioactive Particulates Part 2: Monitoring the Discharge of Radioactive Matter with the Vent Stack Exhaust Air During Design-Basis Accidents
KTA 2101.1	(2015-11)	Fire Protection in Nuclear Power Plants; Part 1: Basic Requirements
KTA 2101.2	(2015-11)	Fire Protection in Nuclear Power Plants; Part 2: Fire Protection of Structural Components
KTA 2101.3	(2015-11)	Fire Protection in Nuclear Power Plants; Part 3: Fire Protection of Mechanical and Electrical Plant Components
KTA 2103	(2015-11)	Explosion protection in nuclear power plants with light water reactors (General and case-related requirements)
KTA 3401.4	(2017-11)	Steel Containment Vessels; Part 4: Inservice Inspections
KTA 3404	(2013-11)	Isolation of Operating System Pipes Penetrating the Containment Vessel in the Case of a Release of Radioactive Substances into the Containment Vessel of Nuclear Power Plants
KTA 3407	(2014-11)	Pipe Penetrations through the Reactor Containment Vessel
KTA 3501	(2015-11)	Reactor Protection System and Monitoring Equipment of the Safety System
KTA 3702	(2014-11)	Emergency Power Generating Facilities with Diesel-Generator Units in Nuclear Power Plants
DIN EN 779	(2012-10)	Particulate air filters for general ventilation - Determination of the filtration performance

DIN EN 1751	(2014-06)	Ventilation for buildings - Air terminal devices - Aerodynamic testing of dampers and valves
DIN EN 1822-1	(2011-01)	High efficiency particulate air filters (EPA, HEPA and ULPA) Part 1: Classification, performance testing, marking
DIN 1946-7	(2009-07)	Ventilation and air conditioning - Part 7: Ventilation systems in laboratories
DIN ISO 3310-1	(2001-09)	Test sieves - Technical requirements and testing Part 1: Test sieves of metal wire cloth
DIN EN 12792	(2004-05)	Ventilation for buildings - Symbols, terminology and graphical symbols; Correction 1
DIN EN 13779	(2007-09)	Ventilation for non-residential buildings – Performance requirements for ventilation and room-conditioning systems
DIN 25425-1	(2016-10)	Radioisotope laboratories - Part 1: Rules for design
DIN 25466	(2012-08)	Fume hoods for radioactive materials - Rules for construction and tests
DIN 25496	(2013-04)	Ventilating components in nuclear facilities
DIN EN 50272-2	(2001-12)	Safety requirements for secondary batteries and battery installations - Part 2: Stationary batteries
VDI 6022 Sheet 1	(2011-07)	Ventilation and indoor-air quality - Hygiene requirements for ventilation and air-conditioning systems and units (VDI Ventilation Code of Practice)
ASR 3.6	(2012-01)	Workplace Guideline (ASR) No. 3.6, Ventilation