

Safety Standards

of the
Nuclear Safety Standards Commission (KTA)

KTA 3601 (2022-11)

Ventilation Systems in Nuclear Power Plants

(Lüftungstechnische Anlagen in Kernkraftwerken)

The previous versions of this safety
standard were issued in 1990-06, 2005-11 and 2017-11

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

Editor:

KTA-Geschäftsstelle

c/o Bundesamt fuer die Sicherheit der nuklearen Entsorgung (BASE)

Willy-Brandt-Str. 5 • 38226 Salzgitter • Germany

Telephone: +49 (0) 30 184321-2907

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Ventilation Systems in Nuclear Power Plants

KTA 3601

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

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

KTA-Geschaftsstelle c/o BASE, Willy-Brandt-Strasse 5, D-38226 Salzgitter, Germany or kta-gs@base.bund.de

Comments by the Editor:

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

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

Basic Principles

(1) The safety standards of the Nuclear Safety Standards Commission (KTA) have the task of specifying those safety-related requirements which shall be met with regard to precautions to be taken in accordance with the state of science and technology against damage arising from the construction and operation of the plant (Sec. 7, para. (2), subpara. (3) Atomic Energy Act - AtG) in order to attain the protective goals specified in the AtG, the Radiation Protection Act (StrlSchG) and the Radiation Protection Ordinance (StrlSchV) as well as further detailed in the Safety Requirements for Nuclear Power Plants (SiAnf) and the Interpretations of the SiAnf.

(2) The 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:

- 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 Sec. 8 StrlSchG and Secs. 99 and 104 para. 1 StrlSchV,
 - limiting the exposure of the operating personnel from radiological substances in the inner atmosphere – in accordance with the radiological protection principles pursuant to Sec. 8 StrlSchG,
 - protecting systems and components by maintaining the specified conditions of the inner atmosphere,
 - protecting the plant from the penetration of flammable or harmful gasses and of pressure surges.
 - maintaining other specified conditions of the inner atmosphere with special regard to work protection.
- (4) Requirements with respect to the ergonomic 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:

- Requirements regarding ventilation systems of laboratory rooms and radionuclide laboratories are specified in DIN 25425-1, DIN EN 14175-8 and DIN 1946-7.
- 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:

- gas exhaust facilities,
- leakage and vessel exhaust systems

Note:

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

- 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.

- 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.

- 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.

- 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**.

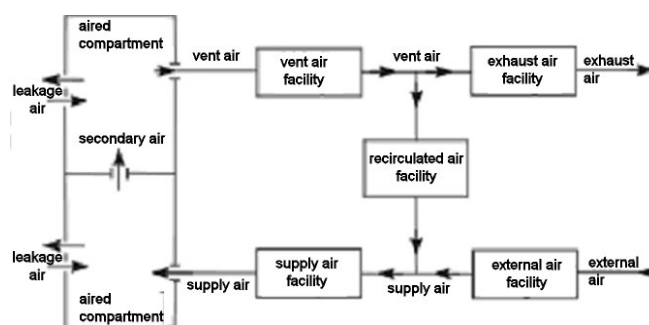


Figure 2-1: Nomenclature for air currents and facilities

(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. 104, 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 16798-3 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. 8 paras. 1 and 2 StrlSchG. 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