

Safety Standards

of the

Nuclear Safety Standards Commission (KTA)

KTA 3403 (2022-11)

Cable Penetrations through the Reactor Containment Vessel of Nuclear Power Plants

(Kabeldurchführungen im Reaktorsicherheitsbehälter von Kernkraftwerken)

Previous versions of this safety standard were issued 1976-11, 1980-10, 2010-11 and 2015-11.

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

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Cable Penetrations through the Reactor Containment Vessel of Nuclear Power Plants

KTA 3403

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

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

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Comments by the editor:

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

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

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) Basic requirements for the reactor containment are contained in the Safety Requirements for Nuclear Power Plants in Requirement No. 3.6, "Requirements for the Safety Enclosure" as well as in Sec. 6 "Containment" of Interpretation I-2 "Requirements for the design of the reactor coolant pressure boundary, the external systems as well as the containment". Among others it is specified that cable penetrations through the reactor containment vessel shall meet the same design requirements that apply to the reactor containment vessel itself. Furthermore, the cable penetrations shall be protected against sequential damages from released media, reaction forces and debris. The functional capability of the electrical and optical conductors of safety related cable penetrations shall be ensured even under design basis accident conditions. The safety standard KTA 3403 serves the purpose of concretizing the measures that, within its scope, must be taken to meet the above requirements. In this context, a number of individually cited, conventional engineering standards, especially DIN standards, are referenced. The requirements of the Safety Criteria cited above are comprehensively covered with respect to steel containment vessels by the following safety standards

KTA 3401.1	Steel containment vessels Part 1: Materials,
KTA 3401.2	Steel containment vessels; Part 2: Design and analysis,
KTA 3401.3	Steel containment vessels; Part 3: Manufacture,
KTA 3401.4	Steel containment vessels; Part 4: Inservice inspections,
KTA 3405	Leakage testing of the containment vessel,

with respect to penetrations and airlocks by the following safety standards:

KTA 3402	Airlocks on the reactor containment vessel of nuclear power plants - personnel locks,
KTA 3403	Cable penetrations through the reactor containment vessel of nuclear power plants,
KTA 3407	Pipe penetrations through the reactor containment vessel,
KTA 3409	Airlocks on the reactor containment vessel of nuclear power plants - equipment airlocks,

and, with respect to the design life of components by the safety standard:

KTA 3706	Ensuring the loss-of-coolant-accident resistance of electrotechnical components and of components in the instrumentation and controls of operating nuclear power plants.
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Furthermore, safety standard KTA 3404 applies to the isolation of operation-system related pipes penetrating the reactor containment vessel in the case of a release of radioactive materials into the reactor containment vessel.

(3) By fulfilling the requirements contained in the present safety standard regarding

- spatial arrangement of the cable penetrations along the reactor containment vessel wall,
 - physical characteristics,
 - functional characteristics,
 - tests and examinations regarding mechanical properties,
 - tests and examinations of the electrical cable penetrations,
 - tests and examinations of the optical cable penetrations, and
 - qualification of the testing personnel,
- it is ensured that the safety related requirements for cable penetrations through the reactor containment vessel will be fulfilled throughout the operating life of the power plant.

(4) General requirements regarding quality assurance are specified in safety standard KTA 1401. Requirements for quality assurance specific to cable penetrations including the respective tests and inspections are dealt with in Sections 6.2, 6.3, 7.2, 7.3, 8.2 and 8.3 of the present safety standard KTA 3403.

1 Scope

This safety standard applies to the design, analysis, materials, manufacture, assembly, inspection and testing, the storage and shipping of cable penetrations that penetrate the reactor containment vessel of stationary nuclear power plants (in the following: the *containment vessel*).

2 Definitions

(1) Cable penetration

A cable penetration is the technically gas-tight and pressure-resistant penetration of single or multiple conductors through the containment vessel.

Note:

With respect to the requirements in the present safety standard, a unit assembled from multiple individual cable penetrations is considered as being a single cable penetration.

A cable penetration is comprised of the following parts:

- electrical or optical conductors (penetrating cable conductors) out to the nearest connection points inside and outside of the containment vessel,
- component parts constituting the insulation of these conductors,
- connector elements for the penetrating cable conductors,
- component parts constituting the pressure-retaining, gas-tight and temperature-resistant enclosure of this conductor arrangement, and the component parts for installing the enclosure on the containment vessel wall,
- built-in leak-tightness test equipment.

Note:

The following are not considered as being part of the cable penetration:

- component parts of the containment vessel wall to which the cable penetrations are fastened, such as flange facings for bolt connections or pipe nozzles for weld connections,
- cables and conductors to be connected to the penetrating cable conductors,
- connector elements for the cables to be connected, such as plugs, cable lugs, sockets, soldering sleeves, crimping sleeves, and
- leak-tightness test equipment or vacuum equipment only temporarily connected to the cable penetrations.

(2) Authorized Expert

The authorized expert for the tests and investigations under the present safety standard is the expert appointed in accordance with Sec. 20 Atomic Energy Act by the licensing or supervisory authority.

3 Spatial Arrangement of the Cable Penetrations on the Containment Vessel Wall

3.1 Installation Locations on the Containment Vessel

The cable penetrations shall be arranged in groups at dedicated locations on the containment vessel wall. They shall be arranged or protected in those regions such that neither escaping media, nor reaction forces, nor debris nor fire will cause any loadings that are not covered by the design.

3.2 Spatial Separation

The spatial arrangement of the cable penetrations shall be in accordance with the requirements for spatial separation of redundant systems as conceptually developed for the overall plant.

3.3 Spare Cable Penetrations

Spare cable penetrations or closed-off spare openings for a later installation of additional cable penetrations shall normally be provided for each redundancy in order to accommodate additional cable penetrations without modifications of the containment vessel itself.

3.4 Accessibility of the Cable Penetration for Testing and Repairs

The spatial arrangement of the cable penetrations shall be such that their accessibility is ensured, in particular, with regard to radiation exposure.

3.5 Identification Marking

An identification marking of the cable penetration shall make an unambiguous identification possible. For this purpose, the type specification and fabrication number shall be marked on the cable penetration and the respective code of the power plant identification system shall be marked at the location of installation of the cable penetration.

4 Physical Requirements

4.1 Basic requirements

(1) Cable penetrations shall comply with the design requirements for the containment vessel. This pertains to, e.g., static and dynamic loading, temperature resistance, service life, radiation resistance, decontaminability, fire resistance, pressure resistance, leak-tightness, earthquake resistance, and corrosion resistance. In this respect, protection measures as indicated under Section 3.1 may be taken into account.

(2) Any potential (e.g., thermal) loadings that may occur during storage and shipping shall be taken into account.

(3) Cable penetrations with weld seams shall normally be designed such that it is possible to perform non-destructive examinations on the pressure-retaining welds.

(4) Blind flanges shall be designed in accordance with the same mechanical requirements that apply to cable penetrations.

4.2 Materials

The materials, weld fillers, soldering, brazing and insulation materials of all parts of the cable penetrations required with regard to the pressure resistance and leak-tightness of the containment vessel shall be chosen in accordance with the requirements specified

- a) for the design of the containment vessel, and
- b) for the intended application of the cable penetration.

Notes:

(1) Requirements for the containment vessel are specified in the safety standards KTA 3401.1, KTA 3401.2, KTA 3401.3 and KTA 3401.4.

(2) In addition to the materials specified in these safety standards, special materials are used in cable penetrations to ensure their proper functioning (e.g., conductor materials, insulation materials, sealants, soldering and brazing materials). The suitability of these materials is to be verified by the tests and examinations specified under Sections 6 through 8 of the present safety standard.

4.3 Thermal Resistance in Special Cases

If the mechanical function of the cable penetration cannot be ensured for the design temperature, a suitable protection of the cable penetration region shall be provided. In this case, the maximum possible temperature within this protected region shall be considered as the respective design requirement.

4.4 Effects of Current Flow

The cable penetrations shall be designed such that, during specified normal operation and in case of design basis accidents, they will withstand all thermal and mechanical loads from the specified currents (e.g., nominal current, short circuit current) in the penetrating cable conductors and cables.

4.5 Radiation Resistance

Changes of the material characteristics due to ionizing radiation shall be considered in choosing the materials for the cable penetrations. The radiation dose considered in this context shall be that on which the design of the containment vessel is based. If necessary, a radiation shielding of the cable penetration region shall be provided.

4.6 Decontaminability

The cable penetrations, together with the respective outer casings, shall be decontaminable in accordance with the respective requirements for the containment vessel.

4.7 Fire Protection

(1) The cable penetration shall be designed using suitable materials such that, in the case of a fire, the necessary integrity of the containment vessel is not adversely affected to an impermissible degree. In this context, the possible fire effects at the location of installation shall be taken into account. The fire load shall be kept as small as possible.

(2) As far as the containment vessel must comply with requirements regarding fire resistance, the respective characteristics shall not be impaired to an impermissible degree by the design and construction of the cable penetration. In this context, the certifications of applicability required by the building authorities shall be submitted.

(3) In the case of cable penetrations with non-metallic materials (e.g., insulation materials), it shall be verified that the materials are classified, at least, as flame retardant, e.g., Class B1 in accordance with DIN 4102-1. With respect to smoke emission, the materials shall comply with Class B1 in accordance with DIN 4102-1. Certain special insulation materials may be neglected as fire load and with respect to smoke emission, provided, it is verified that they will have only a negligible effect on the fire scenario due to their type, amount and condition of installation.

Note:

Such special insulation parts are, e.g., insulation components, plugs or of other connectors with specific electrical characteristics,