

Safety Standards

of the

Nuclear Safety Standards Commission (KTA)

KTA 3602 (11/2003)

Storage and Handling of Fuel Assemblies and Associated Items in Nuclear Power Plants with Light Water Reactors

(Lagerung und Handhabung von Brennelementen und zugehörigen Einrichtungen in Kernkraftwerken mit Leichtwasserreaktoren)

The previous versions of this safety standard were issued in 06/1982, 06/1984 and 06/1990

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

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KTA SAFETY STANDARD

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Storage and Handling of Fuel Assemblies and Associated Items in Nuclear Power Plants with Light Water Reactors

KTA 3602

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KTA 3602 06/1984 (BAnz No. 191 of October 10, 1982, Appendix 51/84))

KTA 3602 06/1990 (BAnz No. 41a of February 28, 1991)

The following safety standard was prepared on behalf of the Nuclear Safety Standards Committee by the Technische Vereinigung der Großkraftwerksbetreiber e.V. (Technical association of large power utilities)

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PLEASE NOTE: Only the original German version of this safety standard represents the joint resolution of the 50-member Nuclear Safety Standards Commission (Kerntechnischer Ausschuss, KTA). The German version was made public in Bundesanzeiger BAnz No. 26 a of February 7, 2004. Copies may be ordered through the Carl Heymanns Verlag KG, Luxemburger Str. 449, 50939 Koeln, Germany (Telefax +49-221-94373603).

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Comments by the Editor:

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

shall	indicates a mandatory requirement,
shall basically	is used in the case of mandatory requirements to which specific exceptions (and only those!) are permitted. It is a requirement of the KTA that these exceptions - other than those in the case of shall normally - are specified in the text of the safety standard,
shall normally	indicates a requirement to which exceptions are allowed. However, 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) in order to attain the protective goals specified in the Atomic Energy Act and the Radiological Protection Ordinance (StrlSchV) and further detailed in the "Safety Criteria for Nuclear Power Plants" and in the "Guidelines for the Assessment of the Design of Nuclear Power Plants with Pressurized Water Reactors against Design basis accidents as defined in Sec. 28 para. 3 StrlSchV – Design basis accident Guidelines" (the version released Oct. 18, 1983).

(2) In order to comply with the licensing requirements specified under Sec. 7 of the Atomic Energy Act with respect to the construction and operation of nuclear power plants, certain equipment must be provided that retain solid, liquid and gaseous radioactive substances within the intended enclosures, other equipment for the handling and controlled conveyance of the radioactive substances inside the plant, and still other equipment for the intentional discharge of radioactive substances via intended pathways. Safety standards series KTA 3600 specifies the safety-related requirements for this equipment.

(3) The present safety standard contains requirements regarding the technical equipment and supplementary administrative measures which, if applied to the storage and handling of fuel assemblies and associated items as well as to the design of the civil structures and facilities, serve to achieve the protective goals that are specified, particularly, in Part 2 of the Radiological Protection Ordinance.

(4) Requirements with respect to quality assurance are specified in safety standard KTA 1401, General Requirements for Quality Assurance.

1 Scope

(1) This safety standard applies to the storage and handling of

- a) new and irradiated fuel assemblies,
- b) other fuel rod arrangements (e.g. fuel rod quivers) and individual fuel rods,
- c) associated items

in nuclear power plants with light water reactors.

(2) This safety standard also applies to other parts and equipment that, for operational reasons, are stored in the fuel assembly storage facilities.

(3) This safety standard does not apply to the dry storage of spent fuel assemblies, e.g., in shipping casks and storage containers, nor to the associated handling.

2 Definitions

(1) Allowance for fuel assembly burnup

Making allowance for fuel assembly burnup means taking into account the reactivity decrease in irradiated fuel assemblies due to fuel burnup.

Note:

Those new fuel assemblies that contain burnable neutron poisons may, initially, show a reactivity increase with increasing burnup.

(2) Irradiated fuel assemblies

Irradiated fuel assemblies are fuel assemblies which were involved with power generation in a critical arrangement.

(3) Fuel assemblies with recycled uranium

Fuel assemblies with recycled uranium contain fuel which, entirely or in part, consists of uranium recovered from spent fuel assemblies.

Note:

Such fuel assemblies are normally referred to as ERU fuel assemblies (*Enriched Reprocessed Uranium*).

(4) Refueling

Refueling is the entirety of all work tasks required for shuffling fuel assemblies or for replacing irradiated or defective fuel assemblies in the core.

(5) Joint storage of fuel assemblies

Joint storage of fuel assemblies refers to the storage of irradiated fuel assemblies from different nuclear reactors in a single fuel pool, possibly in differently equipped racks.

(6) Multi-zone fuel pool

A multi-zone fuel pool for irradiated fuel assemblies is a fuel pool with separate zones that are differentiated by the minimum burnup of the fuel assemblies to stored therein.

(7) Minimum burnup

Minimum burnup refers to the burnup that the fuel assemblies must experience before they can be safely handled and stored with regard to criticality safety in the facilities designed for such handling and storage.

Note:

The minimum burnup is usually specified as a function of the initial content of fissile material in the fuel assemblies. It is also dependent on the design characteristics of the fuel assemblies and on the design characteristics of the individual handling and storage facility.

(8) Mixed-oxide fuel assemblies

Mixed-oxide fuel assemblies are fuel assemblies in which the nuclear fuel consists of a mixture of plutonium and uranium oxide.

(9) Operative zone

The operative zone of a multi-zone fuel pool is that individual zone in which the storage racks are designed to accommodate fuel assembly types of the highest reactivity that are new or, initially having contained burnable neutron poisons, that are now in a state of their maximum reactivity taking storage conditions into account.

Note:

The operative zone (also called "Zone 1") is used, among other things, for the provision of fuel assemblies during refueling, for unloading fuel assemblies from the reactor without consideration of the experienced burnup as well as for storage of such fuel assemblies that cannot, or should not, be stored in other zones.

(10) Transfer carriages

Transfer carriages are carriages used for the transport of items out of, or into, the containment vessel.

(11) Partition gate (steel/water engineering)

A partition gate is considered to be a component that is able to create a leak-tight closure between various pools and wells, e.g., fuel pool, reactor well, setdown compartment, shipping cask setdown pool.

Note:

Depending on the facility and location of the partition gate, different terms are used, like sluice gate, refueling slot gate, partition gate.

(12) Transport

a) Plant-internal transport

Plant-internal transport is any transport where the transported item does not leave the plant site.

b) Plant-external transport

A typical plant-external transport is the transport of irradiated fuel assemblies via public transport routes outside of the enclosed plant site.

(13) Dry fuel storage facility

The dry fuel storage facility is a facility provided for the dry storage of new fuel assemblies.

(14) Shuffling of fuel assemblies

The shuffling of fuel assemblies is the movement of fuel assemblies between correspondingly appropriated positions within closed buildings.

(15) Associated items

The term associated items is understood as comprising the core internals and other components like, e.g., control assemblies, flow restrictor assemblies, poison and dummy assemblies, fuel channels and fuel channel mountings, neutron sources, neutron absorbing inserts in fuel assemblies, and the detector assemblies. The associated items of fuel assemblies are used in the reactor core or in handling of the fuel assemblies and they may be stored in the fuel pool.

3 Dry Storage and Handling of New Fuel Assemblies

3.1 Arrangement, Design and Equipment of Storage Facilities for New Fuel Assemblies

3.1.1 Arrangement of the storage facilities for new fuel assemblies

(1) It shall be possible to close off the storage facilities against entry by unauthorized persons.

(2) A storage compartment shall not be part of the access route to other service compartments. Performing operational tasks in other service compartments shall be possible without having to enter a storage compartment.

(3) It shall be ensured that the storage compartments are accessible at all times during specified normal operation of the nuclear power plant.

(4) Rescue routes shall be provided. The doors along these rescue routes shall be easily accessible and it shall be possible at all times to open them in the direction of escape without auxiliary means.

(5) Storage facilities shall be arranged such that the transport routes from the unpacking station to the dry fuel storage facility and from the dry fuel storage facility to the fuel pool are short and unobstructed.

3.1.2 Design of the storage facilities for new fuel assemblies

3.1.2.1 Criticality safety

3.1.2.1.1 Basic requirements

(1) Specified normal operation

Storage racks shall be provided for storing the fuel assemblies. These storage racks shall be designed such that, under consideration of the permanent intermediate structures, the neutron multiplication factor k_{eff} , calculated under the assumptions and in accordance with the requirements specified under Section 3.1.2.1.2, does not exceed 0.95 for the chosen arrangement of fuel assemblies, taking into account any tolerances and calculation uncertainties. If a conservative approach is proven, the calculation of k_{∞} is sufficient.

Note:

Tolerances are understood as pertaining to the functional clearance as well as to the variations of material composition

and the dimensions of the storage racks and fuel assemblies or other storage items.

(2) Design basis accidents

For each of the design basis accidents to be assumed for the fuel pool, it shall be demonstrated that subcriticality is ensured for the design-conform fuel pool loading, taking the assumptions and requirements specified under Section 3.1.2.1.2 into account. The proof of subcriticality shall be based on a calculated neutron multiplication factor k_{eff} that shall, basically, not exceed 0.95, taking into account any tolerances and calculation uncertainties. In well substantiated cases (e.g., handling procedures of only short duration) a higher value, but no higher than 0.98, may be used.

Note:

The following considerations can govern the decision to exceed $k_{eff} = 0.95$:

- a) the probability of occurrence of a design basis accident,
- b) the precision behind modeling the configuration of the design basis accident,
- c) the serious consequences of a hypothetical criticality, and
- d) the validation quality regarding the analysis of the design basis accident configuration.

3.1.2.1.2 Design assumptions and requirements

(1) The following design assumptions and requirements shall be applied with respect to the fuel assemblies to be stored and to the nuclide inventory of their fuel material in demonstrating criticality safety of the storage facility; any deviation from these assumptions and requirements requires substantiation:

- a) If storage of various types of fuel assemblies is intended, the calculations shall be based on that fuel assembly type which, under the corresponding physical and technical conditions, would lead to the highest reactivity.

Note:

The storage of specialty fuel assemblies is a case where a deviation from, e.g., item a) is permissible.

- b) In the case of a variable distribution of fissionable nuclides in a fuel assembly, a homogenous isotope distribution of the fissile material or materials in the fuel assembly may be assumed, provided, this distribution would lead to the highest reactivity.
- c) Neutron poisons, in as far as they are integral part of the new fuel assemblies may be taken into account under consideration of their spatial distribution.

(2) With regard to neutron moderation and reflection the following applies:

- a) The moderation and reflection conditions to be assumed during specified normal operation shall be those that lead to the highest neutron multiplication factor.
- b) Covering all design basis accidents that lead to modification of the moderation (e.g., influx of water, steam, fire extinguishing agents), the moderation shall be assumed to be due to clean water at a density that leads to the highest neutron multiplication factor.

(3) With regard to the neutron absorbing component parts or inserts of the storage facility or of the fuel assemblies the following applies:

- a) Neutron absorbing component parts of the storage facility and of the fuel assemblies may be considered in the calculation, provided, they are an integral part of the storage facility internals or of the fuel assemblies and their neutron absorbing functions are proven to remain stable for the duration of storage.