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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

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KTA SAFETY STANDARD

November 2003	**Storage and Handling of Fuel Assemblies and Associated Items in Nuclear Power Plants with Light Water Reactors**	KTA 3602

Previous versions of this safety standard: KTA 3602 06/1982 (BAnz No. 173a of September 17, 1982)
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)

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.

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 (**E**nriched **R**eprocessed **U**ranium).*

(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 facilitiy.

(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 keff, 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 hypothetic 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.

b) Neutron absorbing inserts in the fuel assemblies may be considered in the calculation, provided, it is ensured that they will remain present and that their neutron absorbing functions are proven to remain stable for the duration of storage.

(4) The fuel assembly configuration to be assumed shall also take a specified normal use of the transfer station, of the unpacking station and of the inspection station as well as the handling of one fuel assembly into consideration (cf. Section 3.1.3.2).

3.1.2.1.3 Requirements for specific configurations of the fuel rods

Individual proofs are required for the fuel rod configurations that can occur during the maintenance tasks specified und Section 3.2.4.

3.1.2.2 Protection against earthquakes

The design of the storage facility for new fuel assemblies shall meet the requirements specified in safety standard KTA 2201.1.

3.1.2.3 Protection against flooding

(1) Design measures shall be taken against flooding of the storage compartment unless flooding can be excluded on the basis of the structural arrangement.

(2) Water pipes shall not be routed through the storage compartment.

(3) If a wall of the storage compartment is also a wall of the fuel pool or of another storage pool, this wall shall meet the requirements in accordance with Category I specified in safety standard KTA 2201.1. Then, flooding of the storage compartment need not be postulated.

3.1.2.4 Fire protection

The requirements specified in safety standard KTA 2101.3 shall be applied.

3.1.3 Equipment of storage facilities for new fuel assemblies

3.1.3.1 Storage facility fixtures

(1) The storage facility fixtures shall be designed to withstand static loads. This requires that all operating loads - including those with asymmetrical loading - are taken into consideration. Under consideration of all these operating loads, the stress resulting from the calculation of the static load shall not exceed the values resulting from load condition H in accordance with DIN 18800-1 and DIN 18801. In case of materials not specified in these DIN standards, the allowable stresses shall be determined analogously to DIN 18800-1 and DIN 18801.

(2) It shall be postulated that the following loadings occur simultaneously:

a) loads from the entirety of fuel assemblies and associated items that, according to the design, can be stored at the same time, and

b) loads from transportation equipment.

(3) The supports for the fuel assemblies on the storage fixtures shall be designed such that their function and operating position are directly identifiable by the operating personnel.

(4) If the fuel assemblies are not stored in shafts, securing devices shall be provided which can be, individually, locked in their closed position. The locked condition shall be identifiable by the operating personnel.

(5) Supports and securing devices shall be designed such that, when handled properly, it is ensured that the fuel assemblies cannot be damaged.

3.1.3.2 Transfer positions, inspection support stands

(1) If the transfer of fuel assemblies from the unpacking station to their storage positions in the storage facility for new fuel assemblies, or from these storage positions to the fuel pool or to the reactor, requires the use of more than one lifting device, then a transfer position shall be provided where a fuel assembly can be set down by the delivering lifting device before it is picked up by the receiving lifting device for further transport.

(2) The transfer position shall comply with the requirements specified in Section 3.1.3.1 paragraph 1. The same applies to possibly provided inspection support stands for new fuel assemblies.

3.1.3.3 Fire protection equipment

Note:
Requirements regarding fire protection are specified in safety standards KTA 2101.1, KTA 2101.2 and KTA 2101.3.

(1) The dry fuel storage facility shall be provided with fire detection equipment in accordance with DIN VDE 0833-1 for the early detection of fires. At least two alarm devices based on different actuation criteria shall be provided..

(2) Fire fighting regulations, fire extinguishers and extinguishing agents shall be arranged outside of the dry fuel storage facility near the entrance ways. Only such extinguishing agents shall be provided which have been proved effective for the respective combustible materials and which agents were taken into consideration in the criticality examination as specified under Section 3.1.2.1.

3.1.3.4 Communication equipment

The requirements specified for communication equipment in safety standard KTA 3901 shall be applied.

3.1.4 Transport equipment for the handling of new fuel assemblies

(1) Lifting equipment and load attachment rigging for the unloading and plant-internal transport of packaged or unpacked new fuel assemblies shall meet the requirements specified in safety standard KTA 3902.

(2) Load attaching points on the fuel assemblies and handling equipment shall meet the requirements specified in safety standard KTA 3905.

(3) If a vehicle is provided for this transport, the vehicle shall be adequately dimensioned with respect to the weight and size of the items to be transported. It shall be possible to fasten-down the transport items such that they cannot fall off or tip over.

3.1.5 Air conditioning equipment

(1) If the permanent dry fuel storage facilities for new mixed-oxide fuel assemblies are located in controlled-access areas with monitored air supply, no separate air conditioning facility is required.

(2) Other permanent dry fuel storage facilities for new mixed-oxide fuel assemblies shall be provided with a device which can hold at least two fuel assemblies and which is equipped such that, if necessary, air exhaust is possible through high-efficiency particulate air filters of filter class H13 in accordance with DIN EN 1822-1.

3.2 Handling and Transport of New Fuel Assemblies

Note:
The transport of new fuel assemblies on public transport routes outside the enclosed plant site requires authorization by an organization to be named by the jurisdictional authority. Transport is conducted in compliance with the regulations specified in the transport license (in particular, the applicable transport regulations and ancillary provisions of the transport license).

3.2.1 Plant-internal transport

(1) The requirements regarding transport of new fuel assemblies within the enclosed plant site shall be part of the operating license of the plant.

(2) All lifting devices, load attachment riggings and means of conveyance used for the transport and handling for packaged or unpacked new fuel assemblies shall meet the requirements specified in safety standard KTA 3902.

(3) If a vehicle or palette is used for this transport, the transport items shall be securely fastened down such that they cannot fall off or tip over under the conditions of the planned transport.

(4) If fuel assemblies are to be transported outside of the buildings, they shall be packaged such that any soiling or inadvertent damaging is prevented.

(5) All plant-internal transports of new fuel assemblies or individual fuel rods shall be recorded. The transport sequence shall be coordinated with the other operational measures such that the transports can be carried out without hindrance.

3.2.2 Receiving inspection

(1) Upon receipt, each shipping cask with mixed-oxide fuel assemblies or with fuel assemblies containing recycled uranium and, randomly, the fuel assemblies it contains shall be checked for surface contamination.

(2) Before and after opening of the lid, the shipping cask shall be inspected for damages that possibly occurred during transport. The acceleration monitors (e.g., accelerometers, maximum limit indicators) shall be checked whether they were triggered or not.

(3) After their removal from the transport packaging, the fuel assemblies or fuel rods shall be inspected for damages that possibly occurred during transport. The results of this inspection shall be recorded. The identification code of the fuel assemblies or fuel rods shall be compared with the corresponding identification on the accompanying documents and shall be recorded.

(4) At least the following items shall be subjected to a visual inspection:

a) of the outside surface of fuel assemblies or, in the case of BWR fuel assemblies, of the outside surface of the fuel assembly channels, and

b) of the cooling channels, fuel element spacers and centering holes in the head and foot of the fuel assembly, as far as accessible, with respect to freedom of foreign particles.

(5) If any deviations from the proper condition are detected, the licensee shall analyze the safety related consequences and shall initiate the required corrective actions.

3.2.3 Storage in the storage facility for new fuel assemblies

(1) The storage facility for new fuel assemblies shall only be used for the storing of new fuel elements and for the storing of storage items for which the facility was designed.

(2) The fuel assemblies and other storage items shall be stored in the storage facility for new fuel assemblies only in those positions provided for them.

(3) Within the storage facility for new fuel assemblies, only one fuel assembly shall be shuffled at a time or – if a removal from the shipping cask is provided for in the design of the storage facility – loaded shipping casks shall be transported only one at a time by means of the lifting or conveyance equipment.

(4) Fuel arrangement diagrams or lists shall be kept for the new fuel assemblies and other storage items stored in the storage facility for new fuel assemblies, listing the respective identification codes and the storage locations.

(5) For all fuel assemblies stored in the new fuel assembly storage facility, the supports and safety devices on the storage racks shall be functional at all times

(6) Work tasks are basically not permitted in the storage facility for new fuel assemblies unless they are connected with the storage and handling of the fuel assemblies or other storage items, or with the maintenance of the storage items or the storage equipment in the storage facility. In special cases, e.g., observation of the wet storage compartment through underwater windows, exceptions to this requirement are permitted if it is ensured that stored fuel assemblies can not be damaged and that no foreign bodies can enter into them.

(7) In the case of required work tasks on storage equipment in the storage facility, e.g., the servicing of lifting equipment, it shall be ensured that stored fuel assemblies can not be damaged and that no foreign bodies can enter into them.

(8) In accessible areas in the vicinity of mixed-oxide fuel assemblies or of fuel assemblies containing recycled uranium, the local dose rate shall be checked in regular (e.g., half-yearly) intervals.

(9) If the local dose rate in the dry fuel storage facility or in the neighboring compartments or transport paths due to the storage of mixed-oxide fuel assemblies or fuel assemblies containing recycled uranium exceeds the limit values of the individual room classification, this shall be unambiguously marked or proper shielding shall be installed at the storage locations or areas. In the case shielding measures are taken, their effect on the criticality safety shall be taken into account as specified under Section 3.1.2.1.2 paragraph 2.

3.2.4 Maintenance tasks on new fuel assemblies

(1) Before performing any maintenance tasks, suitable positions shall be specified for the fuel assemblies and fuel rods.

(2) With regard to criticality safety, it shall be proven that the maintenance tasks meet the requirements specified under Section 3.1.2.1.

(3) Maintenance tasks shall be carried out in accordance with work instructions which shall at least include the following information:

a) scheduled work steps,

b) safety regulations to be observed, and

c) tests and inspections upon completion of the work steps.

(4) Each of the work steps shall be recorded.

(5) Upon completion of the maintenance tasks, the fuel assembly shall be subjected to a visual inspection. The result of this inspection shall be recorded together with the type and extent of the repaired or replaced components of the fuel assembly.

3.2.5 Preparation for off-site shipment

Note:
The off-site shipment of new fuel assemblies is addressed here since it may become necessary, e.g., as a result of negative findings of the receiving inspection.

(1) The loading of a fuel assembly into a shipping cask shall be recorded specifying the fuel assembly identification code and the shipping cask number.

(2) Prior to off-site shipment, the sealed shipping casks shall be examined to see whether they comply with the applicable regulations (in particular, applicable transportation regulations and ancillary provisions of the transport license).

(3) Prior to transportation, the shipping casks shall be sealed and secured such that, at any time during or after transportation, it is possible to determine whether a shipping cask has been reopened after it was sealed.

(4) Loaded shipping casks that are set down on the plant site shall be secured by suitable means against access by unauthorized personnel.

3.2.6 Work tasks on new mixed-oxide fuel assemblies

When work tasks are performed on new mixed-oxide fuel assemblies as specified in Sections 3.2.1 to 3.2.5 and when mixed-oxide fuel assemblies are placed into the fuel pool, respirators shall be kept available for the personnel performing the tasks.

4 Wet Storage and Handling of New and Irradiated Fuel Assemblies

4.1 Location of Fuel Pools

(1) Fuel pools shall be located within closed buildings in controlled-access areas.

(2) Fuel pools shall be accessible at all times during specified normal operation of the nuclear power plant.

(3) The fuel pools shall be located such that transports of loads not associated with handling of fuel assemblies will not pass over the fuel pool unless a crash of these loads can be excluded as specified in safety standard KTA 3902.

4.2 Design of Fuel Pools

4.2.1 Capacity

(1) The space available in the fuel pool shall satisfy the following design requirements:

a) The number of fuel assembly storage locations shall be sufficient for at least one core load and one core replenishment load. An unscheduled unloading of the core shall be provided for by keeping storage positions in the fuel pools unoccupied or by other readily available measures (e.g., containers to accommodate the fuel assemblies).

b) A suitable place for one shipping cask for irradiated fuel assemblies and its handling shall be provided; this may also be an individual pool dedicated to this task.

c) Even when all storage positions in the pool are occupied, it shall be possible to perform the tasks of loading the reactor or loading a shipping cask under consideration of the provisions of the Radiological Protection Ordinance.

(2) Specified and marked storage positions shall be provided for the reception of fuel assemblies.

Note:
"Marked storage positions" may also imply their identification marking in the fuel arrangement diagrams of the fuel pool.

(3) Specified storage positions shall be provided for the reception of fuel rods and of the component parts of fuel assemblies, provided, such parts must be stored during specified normal operation of the nuclear power plant and must be stored independently of the fuel assemblies.

(4) Sufficient space shall be provided for the tools and equipment required for the handling, the repair and testing of the fuel assemblies and of the devices and component parts of the fuel assemblies.

4.2.2 Loading due to coolant and storage items

(1) The mechanical design of the fuel pool shall meet the requirements specified in safety standard KTA 2502.

(2) The effects caused by the fuel pool due to a particular design basis accident shall also be taken into account in the design of the safety-related equipment involved in mitigating this design basis accident in other parts of the plant.

4.2.3 Temperature limits

The temperature limits of the fuel pool shall be in accordance with the values specified in safety standard KTA 3303.

4.2.4 Shielding from the fuel pool contents

(1) The design of the shielding shall presume that all positions intended for receiving fuel assemblies are actually occupied by such fuel assemblies which, according to their characteristic power history, have the maximum expected source strength and which, according to the unloading process, have the shortest possible decay time.

(2) The concrete and water shielding of the fuel pool shall be dimensioned such that local dose rates in the adjacent compartments do not exceed the dose rate limits specified on the basis of the compartment classification as specified ins safety standard KTA 1301.1.

(3) A coolant level monitor shall be provided in the fuel pool with its measurement display and alarming device installed in the main control room of the nuclear power plant or in the plant unit control room.

4.2.5 Water quality

(1) A water purification facility shall be provided and designed such that

a) radioactive, ionic and solid impurities can be removed from the coolant, especially in the upper region,

b) limit values for the fuel pool water quality that shall be specified in the respective operating manual (e.g. boron concentration and pH value) can be achieved, and

c) suspended solids causing poor visibility can be removed.

(2) Equipment or devices shall be provided with the help of which surface impurities can be removed from the fuel pool water.

(3) With regard to work tasks during which, locally, an increase of the release of radioactive substances or suspended solids must be expected, e.g., during repairs of fuel assemblies, provisions shall be made, either, that the water of the fuel pool can be extracted locally and passed through a purification system or, else, that the water can taken up by local purification devices.

4.2.6 Criticality safety

4.2.6.1 Storage of fuel assemblies

Note:
*The requirements under this section are visualized in the block diagram of **Figure 4-1**.*

4.2.6.1.1 Basic requirements

(1) Specified normal operation

Under consideration of the coolant and of the permanent intermediate structures, the distance between the fuel assemblies in the storage racks for the fuel assemblies shall be chosen such that the neutron multiplication factor k_{eff} of the arrangement of fuel assemblies, with k_{eff} being calculated on the basis of the assumptions and requirements specified under Section 4.2.6.1.2, does not exceed 0.95 taking into account any tolerance and calculation uncertainty. If a conservative approach is proven, the calculation of k_{∞} is sufficient.

Note:
Tolerance implies the functional clearance as well as variations of the material composition and of the dimensions of the storage racks and fuel assemblies or other storage items (e.g., containers with individual fuel rods).

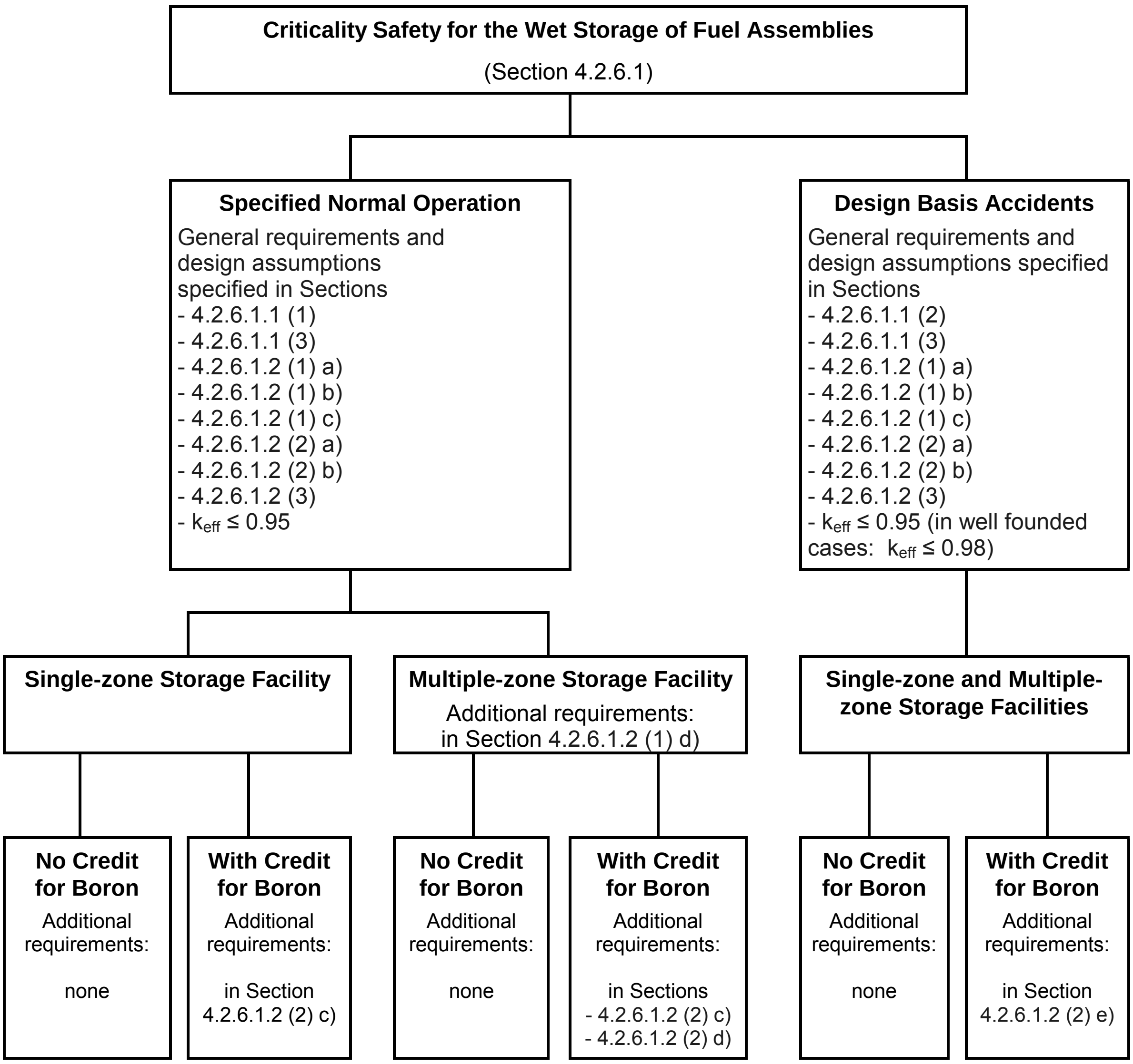

Figure 4-1: Block diagram of the requirements specified in Section 4.2.6.1

(2) Design basis accidents

Taking the assumption and requirements specified under Section 4.2.6.1.2 into account, it shall be demonstrated for each of the design basis accidents to be assumed for the fuel pool that subcriticality is ensured for a design-conform fuel loading of the fuel pool. The proof of sub-criticality shall be based on a calculated neutron multiplication factor k_{eff} that shall, basically, not exceed 0.95 taking into account any tolerance and calculation uncertainty. In well substantiated cases a higher value, the maximum permissible value being 0.98, may be used.

Note:
The following considerations could govern the decision to exceed k_{eff} = 0.95:

a) the probability of the occurrence of a design basis accident,

b) the accuracy behind modeling the configuration of the design basis accident,

c) the serious consequences of a hypothetic criticality, and

d) the validation quality regarding the analysis of the design basis accident configuration.

(3) The required procedure for proving criticality safety as well as the uncertainties and tolerances to be assumed in the calculations are specified in DIN 25471 together with DIN 25478.

4.2.6.1.2 Design assumptions and requirements

(1) Fuel assemblies and storage racks

The following design assumptions shall be made and requirements met with regard to the fuel assemblies to be stored and to the nuclide inventory of their fuel material in order to demonstrate the criticality safety of the storage facility; any deviation from these assumptions and requirements requires substantiation:

a) If it is planned to store various types of fuel assemblies, calculations shall be based on that fuel assembly type which, under the corresponding physical and technical conditions, would lead to the highest neutron multiplication factor. In case of joint storage, this requirement shall be applied for each type of rack.

Note:
Storage of specialty fuel assemblies is such 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 neutron multiplication factor.

c) Burnable neutron poisons, in so far as they are integral part of the new fuel assemblies, may be taken into account under consideration of their spatial distribution. The possible increase of the neutron multiplication factor with increasing burnup shall be taken into account.

d) If the fuel storage pool is designed as a multi-zone pool, the following requirements shall, additionally, be applied:

da) The number of zones should be no larger than three. One of these zones shall be designed to be the operative zone. Each zone shall be spatial unit in itself.

db) The requirements specified under item a) shall be applied only to the operative zone.

dc) The design of the storage racks in the other zones may be based on a minimum burnup for the fuel assemblies to be stored. This minimum burnup shall be determined as based on the dependency between initial inventory of fissile materials and design characteristics of the fuel assemblies in accordance with Sec. 4 DIN 25471. Nuclides with negative effects on criticality may be taken into account, provided, the insecurities involved with respect to the corresponding inventory and their contribution to k_{eff} are quantifiable.

Notes:

(1) Regarding mixed-oxide fuel assemblies:

The demonstration of criticality safety for mixed-oxide fuel assemblies under consideration of a minimum burnup is considerably more complex than for UO_2 fuel assemblies due to:

a) nuclear characteristics of the plutonium isotopes,

b) use of plutonium with various isotope compositions, and

c) an inhomogeneous distribution of the initial inventory of fissile material,

(2) Regarding BWR fuel assemblies:

The demonstration of criticality safety for BWR fuel assemblies under consideration of a minimum burnup is more complex than for PWR fuel assemblies due to:

a) an inhomogeneous distribution of the initial inventory of fissile material,

b) the larger diversity and complexity of the design characteristics of modern BWR fuel assemblies,

c) the spatial (axial) and temporal variation of the steam bubble content of the moderator in a BWR core.

dd) Measures as specified under Section 4.4.1 paragraph 9 shall be provided during operation of the fuel pool that ensure that the minimum burnup specified for the individual zones of the fuel assembly storage is maintained. The individually required minimum burnup shall be demonstrated by applying the procedures in accordance with Sec. 5.2 DIN 25471.

(2) Coolant

With respect to the coolant, the following design assumptions shall be made and requirements met:

a) That coolant density that leads to the largest neutron multiplication factor and being possible under the given circumstances shall be assumed.

b) The demonstration of criticality safety shall basically be based on the assumption that the coolant is pure water.

c) In the case of fuel pools with borated water, the demonstration of criticality safety during specified normal operation may take credit of that part of the boron dissolved in the pool water. The following requirements shall be met:

ca) Under the hypothetical assumption of pure water, the neutron multiplication factor shall not exceed a value of 0.98.

cb) The applied boron concentration shall not be higher than the lowest local boron concentration of the pool water in the vicinity of the storage racks resulting from the event sequence analyses of the procedures and design basis accidents involving boron dilution.

cc) The boron concentration shall be monitored with a sufficient spatial and temporal resolution.

cd) Administrative or technical operational measures shall ensure that the boron injection into the fuel pool is carried out when triggered by automatic alarm signals as specified in safety standard KTA 3501. The warning threshold shall be specified on the basis of the minimum boron concentration required for mitigating design basis accidents and under consideration of item e).

d) In the case of a multi-zone fuel pool, the boron dissolved in the pool water as specified under item c) may only be taken into account for the operative zone.

e) In the case of fuel pools with borated water, the proof of criticality safety may take the addition of boron to the pool water into account for those design basis accidents where it is ensured that the minimum required boron concentration is present in the pool water at all times. This boron concentration shall be documented in the criticality safety analysis. The measures taken to ensure the required value of the boron concentration shall meet the following requirements:

ea) The boron concentration shall be monitored with a sufficient spatial and temporal resolution. Criteria shall be established that cover the administrative or technical measures with respect to the injection of boron into the fuel pool.

eb) If the analysis of that design basis accident for which the boron concentration in the pool water is taken into account results in a required minimum boron concentration higher than half of the operational boron concentration, then administrative or technical operational measures shall ensure that the boron injection into the fuel pool is carried out when triggered by automatic alarm signals as specified in safety standard KTA 3501. The warning threshold shall be specified on the basis of the minimum boron concentration required for mitigating the design basis accidents.

(3) Neutron absorbing components and inserts

With respect to the neutron absorbing components and inserts of the pool or of the fuel assemblies, the following requirements shall be met:

a) The neutron absorbing components of the pool and of the fuel assemblies may be considered in the analysis, provided, they are integral parts of the fuel pool internals or of the fuel assemblies and their neutron absorption function has been proven for the length of the term of operation.

b) The neutron absorbing inserts in the fuel assemblies may be considered in the analysis, provided, their actual presence is ensured and their neutron absorption function has been proven over the entire term of operation.

4.2.6.1.3 Requirements regarding specific fuel configurations

With respect to the storage of containers with individual fuel rods (e.g. fuel rod quivers, fuel rod cans) as well as of incompletely assembled or repaired fuel assemblies in the fuel pool, in each case an individual proof shall be provided in which the requirements specified in Sections 4.2.6.1.1 and 4.2.6.1.2 shall be applied accordingly. In the case of containers with individual fuel rods, the requirements specified in Section 4.2.6.2 paragraph 4 shall, additionally, be applied.

4.2.6.2 Handling, examination and repair of fuel assemblies

(1) In each case an individual proof shall be provided which shall meet the requirements specified in Sections 4.2.6.1, accordingly, and as far as they apply. If this includes the consideration of a minimum burnup of the fuel assemblies, then the proof of criticality safety during specified normal operation shall be based on the assumption that the coolant is pure water (cf. Section 4.2.6.1.2 paragraph 2 item b)).

(2) With regard to the handling of individual fuel assemblies (e.g., transport, shuffling, visual inspection), if the proof of criticality safety includes the consideration of that part of the boron dissolved in the pool water, it shall be ensured, before beginning the handling procedures and in sufficiently short intervals during these procedures, that a sufficient level of the boron concentration is maintained. In this case and under the hypothetical assumption of pure water, k_{eff} may not exceed a value of 0.98.

(3) If fuel rods are pulled out of a fuel assembly or if neutron absorbing inserts or structural parts are removed (e.g. with regard to repairs or inspections) then the associated change of the neutron multiplication factor shall be taken into account.

(4) With regard to containers with individual fuel rods, the following requirements shall be met:

a) The analysis shall be based on new (unirradiated) fuel rods. Here, burnable neutron poisons in the fuel material may not be taken into consideration.

b) The analysis shall be based on a moderation which would lead to the highest neutron multiplication factor for the given arrangement of fuel rods.

4.2.7 Leak-tightness

(1) The fuel pool shall be leak-tight to the extent that detrimental effects of the pool water on the supporting structure of the pool can be excluded.

(2) If a lining is provided it shall be possible to determine its water tightness with respect to paragraph 1 even when the plant is in operation and when the pool is fully occupied.

(3) It shall be possible to locate and repair leaks.

(4) Fuel pool internals shall be arranged and fastened down such that no impermissible forces can be transmitted through them onto the lining.

(5) Pipe penetrations shall be arranged in such way that, in the case of a break in the connected pipes, the fuel pool can empty out only so far that a minimum shielding of the activated parts stored in the pool is ensured to the extent that is necessary for maintaining accessibility of the pool platform for the purpose of initiating emergency measures and for maintaining cooling by additional measures.

(6) It shall only not be possible to siphon off the fuel pool farther down than the water level required for ensuring that the minimum shielding as specified in paragraph 5 and the cooling of the fuel assemblies stored in the fuel pool are sustained.

(7) Pipes shall be arranged and connected to the pipe penetrations such that no impermissible forces can be transmitted through them onto the lining of the fuel pool.

(8) A water overflow channel shall be provided through which the maximum operationally possible water feed rate can be drawn off.

(9) As far as necessary, equipment shall be provided near the partition gate between the fuel pool and other pools (e.g., setdown pool, reactor well) to detect, collect and draw off any leakage water so that, e.g., there will be no need to postulate that leakage water can reach any pressurized parts of the primary system.

4.2.8 Design of the fuel pool and the set-down place for shipping casks

Note:
Maximum allowable temperatures of the fuel pool are specified in safety standard KTA 3303.

(1) The concrete structure shall be able to withstand the loading specified in Section 4.2.2.

(2) The set-down place for fuel assembly shipping casks shall be designed such that all forces are directly transmitted into the concrete. Forces may only be transmitted into the lining material if the lining has been designed for this loading (cf. Section 4.2.7 paragraph 4).

(3) The partition gate between the fuel pool and other pools (e.g., setdown pool, reactor well) shall be designed such that

a) it is water-tight to the extent of meeting the requirements specified in Section 4.2.7 paragraph 1,

b) it can safely withstand the hydrostatic pressure and loadings specified in Section 4.2.2,

c) it can be safely opened and closed and this as easily as possible,

d) the sealing on the partition gate can be easily replaced by simple means.

(4) Surfaces shall be designed such that they can be easily decontaminated..

4.3 Equipment of Fuel Pools and Storage Buildings

4.3.1 Set-down place for fuel assembly shipping casks

The set down place provided for fuel assembly shipping casks shall be located and designed such that

a) the transport route for the shipping cask is as short as possible and does not pass over the storage racks for fuel assemblies,

b) the rigging required for the transportation of the shipping cask can be mounted and removed without hindrance,

c) sufficient shielding is provided during loading of the shipping cask,

d) the shipping cask cannot damage the fuel pool or fuel assemblies if it should slip or tip over on account of any of the induced vibrations to be assumed,

e) the requirement specified in Section 4.2.7 paragraph 4 is met, analogously.

4.3.2 Storage racks

(1) The equipment provided to hold the storage items shall be corrosion resistant.

(2) Storage racks for fuel assemblies shall be designed and arranged such that

a) criticality safety in accordance with Section 4.2.6.1 is ensured in the fuel pool,

b) cooling of the stored fuel assemblies is ensured,

c) the spatial arrangement and function of those neutron absorbing component parts which were taken into consideration in designing for criticality safety (cf. Section 4.2.6.1.2 paragraph 3) will not change in an impermissible manner,

d) fuel assemblies are protected against damage while being lowered into the racks, taking into account any possible dimensional modifications of the fuel assemblies and fuel channels, and

e) they cannot tip over.

4.3.3 Lighting

(1) The lighting of the fuel pool shall ensure good visibility for the work tasks performed in the fuel pool.

(2) In the case of underwater lighting fixtures, the light source shall be protected against damage.

(3) It shall be possible to replace the lighting fixtures with the pool in a flooded condition.

(4) Only such lighting fixtures shall be installed which, when destroyed, do not give rise to impermissible corrosion of the existing materials.

4.3.4 Prevention and removal of contamination

(1) As far as possible, the shipping cask shall be protected by suitable means against any contamination by the fuel pool water.

(2) In order to be able to lower a possible surface contamination far enough for the shipping cask to satisfy the requirements specified under Section 4.5.2.2 paragraph 1, suitable means for decontamination shall be provided.

4.3.5 Handling equipment

(1) Handling equipment for fuel assemblies and associated items shall be designed to withstand external and internal events if their availability after such impacts is required for safety-related reasons or if there is cause to expect impermissible consequential damage.

(2) It shall be ensured by design measures that, regarding the use of lifting equipment and tools, there will always remain a sufficient water cover as shield from radioactivity.

(3) The transfer station for new fuel assemblies operated in nuclear power plants with pressurized water reactors shall meet the requirements specified in safety standard KTA 3902.

(4) With regard to the fuel channel stripping machine in nuclear power plants with boiling water reactors, the platform for receiving the fuel assemblies and the associated hoist shall be designed in accordance with safety standard KTA 3902.

4.3.6 Devices for the repair and inspection of fuel assemblies

(1) Devices for the repair and inspection of fuel assemblies shall be designed and constructed such that, when in specified use with respect to, both, the necessary handling of fuel assemblies and the operation of the devices,

an impermissible radiation exposure or contamination of personnel is avoided.

(2) Devices for the repair and inspection of fuel assemblies shall be designed such that inadvertent damaging of fuel assemblies is prevented.

(3) These devices are within the scope of safety standard KTA 3902, provided, they are each individually equipped with a hoist actuator.

4.3.7 Lifting equipment and load attaching points

Safety standard KTA 3902 shall be applied to lifting equipment for the handling of shipping casks and fuel assemblies. The design of the load attachment points shall meet the requirements of safety standard KTA 3905.

4.3.8 Floor-bound transportation equipment

4.3.8.1 Transfer carriage

(1) The transfer carriage shall be dimensioned to be sufficient with regard to size and weight of the items to be transferred through the lock. Its supporting steel structure shall be designed for Load Case H in accordance with DIN 18800-1 and DIN 18801. The transfer carriage shall meet the requirements of VBG 36. The nominal load of the transfer carriage shall be the weight of the item to be transferred through the lock plus the transport rigging. A collision safety factor of 1.1 shall be applied, unless the collision safety factor has been determined experimentally.

***Note**:*
If the transfer carriage is moved onto a lifting gantry, a higher safety as specified in safety standard KTA 3902 and KTA 3903 Level 4.2 is required and suitable quality assurance measures shall be applied.

(2) It shall be demonstrated for the safety earthquake load case that the unloaded transfer carriage in its intended permanent parking position, will not damage any plant components necessary for the mitigation of this load case, nor that it will damage the fuel pool, nor the fuel assemblies stored in the pool. The same shall be proven for the transfer carriage loaded with the shipping cask, provided, it is intended that the transfer carriage remains on the operating platform in the reactor building for a duration longer than operationally required for the delivery and removal transportation.

(3) It shall be ensured that the transfer carriage, during the process of being loaded, cannot perform any unintentional travel moves.

(4) Wheel-break supports and rail sweeps shall be provided.

4.3.8.2 Other floor-bound transportation equipment

(1) If other transportation vehicles are provided, they shall be sufficiently dimensioned with regard to the weight and size of the items to be transported.

(2) It shall be possible to secure the items to be transported such that they cannot fall off or tip over.

4.3.9 Permanently installed radiation measuring instruments

The requirements for the local dose rate monitor on the refueling machine are specified in safety standard KTA 1501.

4.3.10 Rescue routes and rescue equipment

(1) A rescue route shall be provided, kept clear and properly marked, by which allows all persons present in the compartment around the fuel pool to leave the danger zone as quickly as possible. The provisions of ASR 10/1 No. 2 shall be applied.

(2) Rope equipment and life buoys shall be available in sufficient quantities.

(3) The fuel pool shall be surrounded by a railing and provided with a device that aids in getting out of the pool in an emergency. The provisions of ASR 12/1-3 No. 2.3 and ASR 20 shall be applied.

4.3.11 Communication equipment

(1) The requirements regarding communication equipment are specified in safety standard KTA 3901.

(2) A direct line for voice communication shall be provided between the refueling machine and the central control station.

4.4 Storage and Handling of Fuel Assemblies and Associated items in the Fuel Pool and during Refueling

4.4.1 General requirements

(1) Fuel assemblies and other storage items shall be stored in the fuel pool only in the position specified for the individual item.

(2) Fuel arrangement diagrams or lists shall be provided for the reactor and the storage racks listing the identification codes and the respective storage locations of the fuel assemblies and the associated items. Other storage items present in the storage racks shall also be listed in the fuel arrangement diagrams.

(3) In case of a multi-zone fuel pool, the initial inventory of fissile material and the burnup shall be documented for each fuel assembly.

(4) Any handling of fuel assemblies and associated items in the reactor pressure vessel and in the fuel pool may only be performed following written work instructions, e.g. in the form of a step-by-step plan.

(5) Before commencing work, it shall be ensured that all tools and devices are in proper functioning order. All tests, modifications and repairs shall be documented.

(6) Without a specific proof of safety, no more than one fuel assembly at a time may be handled or transported inside the fuel pool. Simultaneous handling of fuel assemblies is permitted in the channel stripping machine, the inspection equipment and the repair devices.

(7) Fuel assemblies and associated items shall only be handled in the presence of a competent person in charge who shall coordinate the radiological protection measures required during handling with the radiological protection officer. At least two persons shall be present at all times during such handling procedures.

(8) The completion of the transport or shuffling of each fuel assembly or other storage items shall be documented. The fuel arrangement diagrams shall be updated upon completion of the work instructions specified under paragraph 4.

(9) In case of a multi-zone fuel pool, it shall be ensured that no fuel assembly whose burnup is to low to be permitted to be stored in another zone of the fuel pool is inadvertently stored in this other zone. In accordance with

Sec. 5.1 DIN 25471 it shall be ensured that this requirement is not violated before at least two independent simultaneous event sequences occur that have not been assumed to occur during specified normal operation. To this end, the requirements specified in Sections 4.4.2, 4.4.3.4 paragraph 2 and 4.4.4 shall be met and corresponding technical and administrative measures (e.g., electro-technical interlocks) provided.

4.4.2 Loading new fuel assemblies into a multi-zone fuel pool

(1) New fuel assemblies (e.g., coming from the dry fuel storage facility) may be loaded only into the operative zone.

(2) During the entire duration of the procedure of loading the new fuel assemblies, shuffling procedures are only permitted in the operative zone of the multi-zone fuel pool.

4.4.3 Refueling

4.4.3.1 General requirements

(1) Refueling includes the following tasks:

a) opening the reactor pressure vessel,

b) shuffling the core inserts,

c) shuffling, loading and unloading the fuel assemblies,

d) loading tests and functional tests, and

e) closing the reactor pressure vessel.

(2) In addition, the following tasks may also become necessary:

a) inspection of fuel assemblies or associated items,

b) replacement of associated items, and

c) the repair of fuel assemblies or associated items.

4.4.3.2 Preparatory tasks before refueling

(1) In the case of nuclear power plants with pressurized water reactors, it shall be ensured that the connection between reactor well and fuel pool has been established and that the boron concentration in the water of the fuel pool and reactor well is at least equal to the boron concentration specified for ensuring subcriticality in the reactor during refueling.

(2) Before opening the reactor pressure vessel, that part of its interior not filled with coolant shall be flushed with air or some other suitable gas in order to remove radioactive substances. During this procedure, the coolant should be at least 10 K warmer than that temperature which should be maintained after having opened the pressure vessel.

(3) It shall be ensured that during the flooding procedure no loose parts can be flushed into the reactor pressure vessel.

4.4.3.3 Required measures when opening the reactor pressure vessel

(1) For the entire time of refueling, the reactor shall be secured in the shutdown condition in such a way that sufficient subcriticality is maintained and that any convergence to the state of criticality will be detected by monitors (cf. safety standard KTA 3101.2).

(2) Work on engineered safety features of the nuclear steam generator system may be undertaken, provided,

a) the function of these safety features can be performed to a sufficient extent by other facilities or measures, or

b) a safety oriented function is immediately initiated (fail-safe principle) in case the engineered safety features are inoperative or fail, and

c) the operating condition of the nuclear steam generator system is such that the intended work tasks can be performed without endangering the personnel involved.

(3) When removing the shielding over the reactor pressure vessel, the radiological protection personnel shall measure the dose rate and check the reactor well for radioactivity from aerosols.

(4) Respirators shall be kept in readiness.

(5) Before removing the pressure vessel closure head, it shall be ensured that loose objects cannot drop into the reactor pressure vessel when the head is removed. The air supply and extraction openings in the reactor well shall be closed before starting with flooding.

(6) When working in the area over the opened reactor pressure vessel, only buoyant or non-losable tools and auxiliary equipment shall be used.

Note:
"Non-losable" tools and auxiliary equipment indicates such items having safety devices that prevent them from unintentionally dropping or being released from the service facility (e.g., crane, auxiliary bridge, refueling machine).

(7) No work shall be carried out in the area over the open reactor pressure vessel that is not directly associated with the refueling process, with the inspection or with the maintenance of other component parts of the reactor pressure vessel or its internals.

(8) When the reactor pressure vessel internals that must be dismantled for refueling are transported within the reactor well and the set-down pool, the partition gate between reactor well and fuel pool shall, basically, be kept closed. This requirement may be deviated from, provided, the lifting equipment used meets the requirements specified in Sec. 4.3 of safety standard KTA 3902.

(9) The reactor pressure vessel internals shall be stored such that they cannot tip over.

(10) Sufficient shielding from the stored reactor pressure vessel internals shall be provided.

4.4.3.4 Refueling

(1) All steps of the work tasks and all necessary tools and auxiliary equipment required for the refueling process shall be specified in an operating instruction.

(2) In case of a multi-zone fuel pool, the fuel assemblies unloaded from the reactor may only be set down into the operative zone of the multi-zone fuel pool. Any shuffling of fuel assemblies from the operative zone into other zones of the multi-zone fuel pool are, basically, impermissible while the work tasks specified under Section 4.4.3.1 paragraph 1, items b) through d), are being performed. Should unpredictable situations require a shuffling between zones, then any work tasks specified under Section 4.4.3.1 paragraph 1, items b) through d) shall be suspended for the duration of these shuffling procedures.

(3) The planned loading and unloading of fuel assemblies and fuel assembly inserts into and from the reactor core shall be carried out with a refueling machine as specified in safety standard KTA 3902. Any handling tasks, including those within the reactor pressure vessel,

that cannot be performed with the refueling machine, shall be carried out with lifting equipment that meet the requirements specified in safety standard KTA 3902.

(4) Even the shuffling of fuel assemblies in fuel pools that are not connected with the reactor well during these procedures, shall be performed only with lifting equipment that meet the requirements specified in safety standard KTA 3902.

(5) The route traversed by the refueling machine shall be kept clear of obstacles while the machine is in operation.

(6) In the operating area of the refueling machine no other work tasks may be carried out that might endanger the refueling procedure.

(7) During breaks as well as during change of shift or of personnel, the grabs and load attachment riggings in their unloaded state shall be moved into a safe position.

(8) The rescue routes leading out of the area of the pools shall be kept free of obstacles.

4.4.3.5 Loading and functional tests before closing the reactor pressure vessel closure head

(1) The loading of the reactor shall be inspected with special regard to the planned positions and orientation of the fuel assemblies and fuel assembly inserts; this inspection shall be documented.

(2) The freedom of movement of the control assemblies shall be checked.

4.4.3.6 Measures required when closing the reactor pressure vessel closure head

(1) The requirement of Section 4.4.3.3 paragraph 8 shall be fulfilled.

(2) When reinserting reactor pressure vessel internals and repositioning the reactor pressure vessel closure head, the operating instructions regarding dismantling and reassembling these parts shall be observed.

(3) When draining the reactor well and the set-down pool, the dose rate shall be measured by the radiological protection personnel. Suitable measures shall be taken with regard to minimizing the radiation exposure from aerosols.

(4) Before placing the shielding back over the reactor pressure vessel, it shall be ensured that any residual water has been drained from the reactor well and the set-down pool, that loose parts have been removed and that the air supply and vent openings in the reactor well have been opened.

(5) The functional availability of the leak monitoring system for the partition gate shall be checked.

4.4.4 Shuffling of irradiated fuel assemblies in a multi-zone fuel pool apart from refueling

(1) The shuffling of fuel assemblies between zones shall be carried out from one zone to the next and at different points in time.

(2) The correct minimum burnup shall be proven in accordance with Sec. 5.2 DIN 25471.

(3) The principle of two independent event sequences as specified in Section 4.4.1 paragraph 9 shall be adhered to.

4.4.5 Maintenance of fuel assemblies and associated items

4.4.5.1 Inspections

(1) The personnel involved with the inspection of the fuel assemblies and associated items shall be provided with an operating instruction specifying the proper operating procedure in detail.

(2) The fuel assemblies and associated items to be inspected shall be set down only in those positions of the fuel pool that are designated for this purpose.

(3) Any handling of fuel assemblies and associated items within the framework of these inspections shall be recorded.

Note:
In this context, "inspection" indicates optical inspections with binoculars, television systems or similar equipment and, also, nondestructive examinations of fuel assemblies by means of sipping tests, ultrasonic and eddy-current examinations or other procedures. The object of such inspections is to test the fuel assemblies and associated items for their integrity and to locate possible defects.

4.4.5.2 Repairs and Modifications

(1) The requirements specified in Section 3.2.4 paragraph 2 through 5 shall be met, accordingly. In particular, the work instructions regarding radiological protection measures shall be carefully planned.

Note:
These repairs and modifications may be:

a) replacement of structural parts of fuel assemblies,

b) exchange of fuel rods,

c) reconfiguration of the skeleton, and

d) dismantling and reassembly of fuel assemblies.

(2) The criticality safety shall be proven in accordance with the requirements and specifications of Section 4.2.6.2.

4.5 Loading and Transportation of Fuel Assembly Shipping Casks

4.5.1 Loading of fuel assembly shipping casks

(1) Only such shipping casks may be loaded that are of a suitably designed structural type.

(2) The suitability shall be proven.

(3) The shipping casks shall be manufactured to meet the corresponding regulations (e.g., type permit according to traffic regulations, storage permit according to Sec. 6 Atomic Energy Act).

(4) The shipping casks may only be loaded on the basis of a fuel loading schedule and a written instruction which specify the intended relocation of the individual fuel assemblies (old position in the fuel pool, new position in the shipping cask) and which describe the individual steps of the required work tasks and testing steps (cf. Section 4.5.2.2).

(5) In accordance with the fuel loading schedule, fuel assembly shipping casks shall be loaded at the position in the fuel pool provided for this purpose or in the separate shipping cask setdown pool.

Note:
The rules and regulations that apply to the loading of the

shipping casks are specified in the qualification certificate of the shipping cask; with respect to criticality safety, these rules and regulations can deviate from the requirements in Section 4.2.6.

(6) The fuel assembly shipping casks shall be loaded and unloaded using lifting equipment as specified in safety standard KTA 3902.

4.5.2 Transportation

Note:
The transport of new fuel assemblies on public transport routes outside the enclosed plant site requires authorization by that organization named by legislation. It is conducted in compliance with the regulations specified in the transport license (in particular, the applicable transportation regulations and ancillary provisions of the transport license).

4.5.2.1 Plant internal transportation

(1) The plant internal transportation shall be regulated by the plant license.

(2) If, outside the reactor building, a vehicle is used for transportation it shall meet the requirements of Section 4.3.8.2.

(3) A short, safe route between the point of departure and the point of arrival shall be chosen; no unnecessary stops shall be made during transportation.

4.5.2.2 Tests before transportation

(1) Before transportation, tests and inspections regarding loading, leak tightness, safety devices, radiation level and contamination shall be performed to verify that the conditional provisions and limit values are adhered to that are specified for the type of transportation in the

a) operating instruction of the shipping cask,

b) Radiological Protection Ordinance,

c) technical receiving conditions of the incorporating nuclear facility (e.g., external intermediate storage or intermediate on-site storage) including the corresponding codes and specification in case of plant external transports,

d) transport license including the handling and operating instructions for the particular type of shipping cask as well as the associated servicing, assembling and testing instructions.

(2) The loading of the shipping cask shall be documented.

(3) Transportation shall only be carried out if the permissible limit values are not exceeded and all conditional provisions are fulfilled.

4.5.2.3 Handling of the shipping cask

(1) Only suitably designed lifting equipment which meets the requirements specified in safety standard KTA 3902 shall be used for handling and transportation.

(2) It shall be ensured that any transportation of the shipping cask by crane is only along a specified transport route. This route should not pass unnecessarily over safety-related equipment.

5 Storage and Handling of Neutron Sources

5.1 Equipment

(1) Neutron sources shall be stored in their sealed transport or storage containers in suitable storage compartments until they are used in the reactor. The neutron sources shall be shielded such that the dose rate specified for the storage compartment is not exceeded.

(2) The requirements of Sections 3.1.2 to 3.1.4 shall be applied analogously to storage compartments for the neutron sources.

(3) The storage and shipping containers for neutron sources shall be clearly, permanently and visibly marked and shall be secured against unauthorized opening.

5.2 Administrative Measures

(1) The deliverer or sender shall demonstrate by means of a certificate in accordance with Sec. 69 para. 2 of the Radiological Protection Ordinance that the supplied fresh source is leak-tight and free from contamination.

(2) When the neutron source shipping container arrives at the power plant site, the gamma and neutron dose rates at the surface of the container shall be measured and its contamination checked.

(3) Only competent personnel under the supervision of a radiological protection officer or of a person commissioned by him to act on his behalf may handle the neutron sources.

(4) Only those persons shall be allowed in the vicinity that are necessary for the handling of the sources and for the radiological protection surveillance.

(5) The individual dose, including neutron dose, from handling the source shall be determined in accordance with the Radiological Protection Ordinance; if necessary, a controlled-access area in accordance with the Radiological Protection Ordinance shall be erected.

(6) In the fuel pool and over the reactor core only one neutron source may be handled at a time.

(7) Each neutron source shall be identified and examined for external damage before it is inserted into the core.

(8) Neutron sources activated in the reactor shall be stored in the fuel pool.

6 Tests of the Storage and Handling Facilities, and Documentation

6.1 General Principles

(1) Facilities for the storage and handling of fuel assemblies and associated items in nuclear power plants shall be subjected to the following tests:

a) tests before construction,

b) in-process surveillance,

c) inservice inspections.

(2) The results of these tests shall be recorded in reports, attestations or certificates. These test certifications shall contain all important data relating to the tests performed. These data shall, at least, include:

a) unambiguous designation of the test object,

b) type of test with information regarding the associated test instructions,

c) list of the documents presented for checking,

d) individual tests performed and their results,

e) any defects detected and, if necessary, time limits for their removal and the subsequent renewed testing,

f) summarizing comments regarding whether, or under what restrictions, the test object is in accordance with the requirements and may be used as specified,

g) name and signature of the tester including location and date of the test.

(3) The tester shall place his mark of approval and a reference mark indicating the test certification it belongs to on every individual document checked.

(4) In case documents which have already been checked are modified, they shall be checked again with regard to this modification.

(5) The lifting equipment used for handling fuel assemblies and associated items shall be tested as specified in safety standard KTA 3903 and the load attaching points as specified in safety standard KTA 3905.

6.2 Tests Before Erection

(1) Before an erection license or modification license is issued, tests shall be performed to determine:

a) whether all necessary plant components and facilities for the storage and handling of fuel assemblies and associated items have been provided,

b) whether the plant components and facilities are designed in compliance with the applicable standards, rules and guidelines, and whether they meet the safety-related requirements, and

c) whether the inservice inspections specified in the test schedule (Section 6.4) can be carried out on these plant components and facilities.

Note:
The documents to be submitted for the various planning, construction and operational stages of the nuclear power plant are listed in BMU Guideline "Compilation of the Information Required for Review Purposes under the Licensing and Supervisory Procedures for Nuclear Power Plants" from October 20, 1982 (BAnz No. 6a, January 11, 1983).

6.3 In-Process Surveillance

6.3.1 Extent of the in-process surveillance

(1) The in-process surveillance shall include:

a) design reviews,

b) material testing and construction testing,

c) acceptance tests and functional tests.

(2) The type and extent of the tests shall be specified in a test schedule.

6.3.2 Design reviews

(1) As required by specification of the proper authority the following shall be subjected to a design review

a) the storage facility for new fuel assemblies and the storage and transport equipment contained therein,

b) the fuel pool, partition gates, storage racks and other pool equipment,

c) the transfer carriage,

d) the rescue equipment,

e) the tools and riggings for the handling or maintenance of the fuel assemblies.

(2) For the facilities and equipment listed under paragraph 1 items a) through e), construction documents and, if applicable, calculations shall be presented in accordance with design reviewed system specifications.

Note:
Regarding the design review of lifting equipment and load attaching points, cf. Section 6.1 paragraph 5.

6.3.3 Material tests and construction tests

The fabrication and assembly of facilities and equipment for the storage and handling of the fuel assemblies and associated items which are subject to design reviews (Section 6.3.2) shall be examined at the factory or on the construction site. It shall be verified that the plant components are in conformance with the design reviewed documents. These tests shall be performed by competent personnel of the utility or of the manufacturer and shall be carried out in accordance with the specifications of the proper authority.

6.3.4 Acceptance tests and functional tests

(1) Prior to commissioning as well as after repairs, the components of the facilities and equipment for the storage and handling of fuel assemblies and associated items shall be subjected to an acceptance test and a functional test. These tests shall be performed by competent personnel of the utility or of the manufacturer and shall be carried out in accordance with the specifications of the proper authority.

(2) The results of the material tests and construction tests shall be available before the acceptance and functional tests are performed on design reviewed plant components. As far as necessary, the acceptance tests and functional tests shall be performed based on the following documents:

a) test schedules,

b) plant specifications,

c) process descriptions and diagrams,

d) operating and servicing instructions,

e) transportation flow charts,

f) measurement point and interlock plans,

g) valve lists,

h) piping diagrams.

(3) Within the framework of the acceptance tests and functional tests, it shall be determined whether the facilities have been constructed in accordance with the approved documents and whether they can be operated safely and maintained as specified.

(4) Upon completion, the fuel pool shall be subjected to a test for leak-tightness at a water temperature of 60 °C. No detectable leakage may occur through the pool lining. The leakage through the partition gate may not exceed 3 liters per day.

6.4 Inservice Inspections

(1) Inservice inspections shall be performed to determine whether the facilities for the storage and handling of

fuel assemblies and associated items continue to satisfy the specified requirements.

(2) The type and extent of the tests, the test intervals and the tester shall be specified in a test schedule.

(3) These tests shall include:

a) inspection of the operating records pertaining to operation, inspection, servicing and repair tasks,

b) verification of the proper functioning of the facilities and equipment for storage and handling of fuel assemblies and associated items, of the engineered safety features and of the safety provisions, and

c) inspection of the certificates or attestations for replacement parts.

6.5 Documentation

(1) The documents prepared for the construction and operation of the facilities for storage and handling of fuel assemblies and associated items shall be compiled before their commissioning. These documents shall, at all times, describe the actual state of the planned storage and handling.

(2) The documents shall indicate the technical and administrative measures necessary for meeting the requirements specified in Sections 3 to 5. In particular, the planned procedures and the necessary radiological protection measures shall be described and, if necessary for the sake of clarification, shall be accompanied by explanatory drawings.

(3) The personnel entrusted with the planning or management of storage, handling and transport procedures shall have access to all documents necessary for the proper performance of their tasks.

(4) If in individual cases storage and handling cannot be carried out according to the planning documents specified in paragraph 1, appropriate additional documents shall be attached to the documentation.

Appendix A

Regulations Referred to in this Safety Standard

Regulations referred to in this safety standard are valid only in the versions cited below. Regulations which are referred to within these regulations are valid only in the version that was valid when the latter regulations were established or issued.

Atomic Energy Act		Act on the peaceful utilization of atomic energy and the protection against its hazards (Atomic Energy Act) of December 23, 1959 (BGBl. I, p. 814) in the version of July 15, 1985 (BGBl. I, p. 1565), most recently changed by Article 7 of the Act of August 21, 2002 (BGBl. I, p. 3322)
StrlSchV		Ordinance on the protection from damage by ionizing radiation (Radiological Protection Ordinance - StrlSchV) of July 20, 2001 (BGBl. I, p. 1714, 2002 BGBl. I, p. 1459), most recently changed by Article 2 of the Ordinance of June 18, 2002 (BGBl. I, p. 1869)
ASR 10/1	(09/1985)	Doors and gates (BArbBl, 1985, No. 9, p. 79-81)
ASR 12/1-3	(10/1986)	Protection against the falling of persons and falling objects (BArbBl, 1986, No. 10, p. 61-62)
ASR 20	(06/1997)	Access hook ways and step ladders (BArbBl, 1997, No. 7/8, p. 66-70)
KTA 1301.1	(11/1984)	Radiation protection considerations for plant personnel in the design and operation of nuclear power plants; Part 1: Design
KTA 1501	(06/1991)	Stationary system for monitoring the local dose rate within nuclear power plants
KTA 2101.1	(12/2000)	Fire protection in nuclear power plants; Part 1: Basic principles
KTA 2101.2	(12/2000)	Fire protection in nuclear power plants; Part 2: Structural components
KTA 2101.3	(12/2000)	Fire protection in nuclear power plants; Part 3: Mechanical and electrical components
KTA 2201.1	(06/1990)	Design of nuclear power plants against seismic events; Part 1: Principles
KTA 2502	(06/1990)	Mechanical design of fuel storage pools in nuclear power plants with light water reactors
KTA 3101.2	(12/1987)	Design of reactor cores of pressurized water and boiling water reactors; Part 2: Neutron-physical requirements for design and operation of the reactor core and adjacent systems
KTA 3303	(06/1990)	Surveillance of the irradiation behaviour of reactor pressure vessel materials of LWR facilities
KTA 3501	(06/1985)	Reactor protection system and monitoring equipment of the safety system
KTA 3901	(03/1981)	Communication means for nuclear power plants
KTA 3902	(06/1999)	Lifting equipment in nuclear power plants
KTA 3903	(06/1999)	Inspection, testing and operation of lifting equipment in nuclear power plants
KTA 3905	(06/1999)	Load attaching points on loads in nuclear power plants
DIN VDE 0833-1	(01/1989)	Alarm systems for fire, intrusion and hold-up; Part 1: General requirements
DIN 18800-1	(11/1990)	Structural steelwork; design and construction
DIN 18800-1/A1	(02/1996)	Steel structures; Part 1: Design and construction; Amendment A1
DIN 18801	(09/1983)	Structural steel in building; design and construction
DIN EN 1822-1	(07/1998)	High efficiency particulate air filters (HEPA and ULPA); Part 1: Classification, performance testing, marking
DIN 25471	(09/2000)	Criticality safety taking into account the burnup of fuel elements when handling and storing of nuclear fuel elements in fuel pools of nuclear power stations with light water reactors
DIN 25478	(07/1994)	Application of computer codes for the assessment of criticality safety
VBG 36	(01/1997)	Industrial trucks