Handling and storage of nuclear fuel

This Guide is in force as of 15 January 1992, until further notice.

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Authorisation

By virtue of section 55, second paragraph, point 3 of the Nuclear Energy Act (990/87) and section 29 of the Council of State Decision (395/91) on General Regulations for the Safety of Nuclear Power Plants, the Finnish Centre for Radiation and Nuclear Safety (STUK) issues detailed regulations concerning the safety of nuclear power plants.

YVL Guides are rules an individual licensee or any other organisation concerned shall comply with, unless STUK has been presented with some other acceptable procedure or solution by which the safety level set forth in the YVL Guides is achieved. This Guide does not alter STUK's decisions which were made before the entry into force of this Guide, unless otherwise stated by STUK.

Translation. Original text in Finnish.

1 General

The primary safety objectives in the storage and handling of nuclear fuel (henceforth, fuel) are the prevention of criticality and fuel failures and the assurance of sufficient cooling and radiation protection. A further safety objective is to prevent any loads lifted during fuel handling and transfers from dropping and endangering the performance of a nuclear power plant's safety-significant systems, components and structures.

Achievement of these safety objectives requires proven, high-quality technical solutions, competent personnel, well-known methods and appropriate instructions.

In this Guide, the safety requirements and regulatory control procedure for the storage and handling of nuclear power plant fresh and spent fuel are presented. The control covers all structures and components in storage, handling and inspection facilities which may have bearing on fuel safety. The control of fuel storage systems related to process technology (e.g. the cooling and purification systems) and of their structures and components is not dealt with in this Guide. As regards spent fuel storage, only wet storage is handled in this Guide.

A general description of nuclear fuel regulatory control by the Finnish Centre for Radiation and Nuclear Safety (STUK) is given in Guide YVL 6.1. Overall regulation of nuclear power plants by the Centre is described in Guide YVL 1.1.

2 Safety requirements for storage and handling

The safety principles for fuel storage and handling are presented in Guide YVL 1.0. When applying these principles, the requirements presented later in this document shall be taken into account.

Fuel storage, handling and inspection systems and the associated structures and equipment shall be classified according to GuideYVL 2.1.

In addition to the requirements relating to nuclear and radiation safety presented later in this document, the applicable regulations, guides and standards covering industrial safety, structural design etc. shall be taken into account. When applying this Guide to criticality analyses and thermal analyses plus to detailed equipment design, the instructions presented in /1—8/ may be observed in a manner approved by the Finnish Centre for Radiation and Nuclear Safety.

2.1 Fresh fuel storage facilities

Storage facilities shall be so designed that when all storage positions are occupied sub-criticality is maintained and the effective multiplication factor K_{eff} does not exceed the value of 0.95 even under postulated accident conditions although the entry of water or some other possible moderator into the storage is assumed. The accumulation of any moderator into the storage facility shall be prevented.

The possibility of the fuel being damaged during storage shall be extremely low. Hoisting and transfer of heavy loads above the fuel shall be avoided.

Appropriate places and facilities shall be designed for fuel inspections.

2.2 Spent fuel storage facilities

Storage facilities shall be so designed that when all storage positions are occupied, sub-criticality is maintained and the effective multiplication factor K_{eff} does not exceed the value of 0.95 even under postulated accident conditions.

The possibility of the fuel being damaged during storage shall be extremely low. Hoisting and transfer of heavy loads above the fuel shall be avoided.

The storage facility shall contain the below systems (or functions):

— a fuel cooling system to keep coolant temperature below 60 °C during normal

operation (taking a single failure into consideration) and below 100 °C during postulated accident conditions,
— a coolant purification system,
— a coolant make-up water system which can compensate loss of coolant during postulated accident conditions; the system must be able to maintain water level ensuring adequate radiation protection and fuel cooling,
— systems to detect and collect fuel pool leakages, and
— a ventilation system capable of restricting radioactive releases to the environment according to Council of State Decision No. 395/91.

There shall be adequate handling, de-contamination and inspection facilities for the handling of fuel transfer and transport packages. There shall also be appropriate places and facilities for fuel inspections and damaged fuel assemblies.

The storage conditions shall be such that corrosion of fuel and storage equipment is minimised. The coolant shall be kept sufficiently clear and clean to facilitate e.g. checking of fuel identification.

The gates between the pools shall be designed to maintain leaktightness in case of water loss in either pool.

In the dimensioning of the pool structures, the severest possible load combinations (e.g. dropping of heavy objects possibly transferred above the pools or in their immediate vicinity and other mechanical impacts, hydraulic events and natural phenomena) shall be taken into account. Furthermore, the storage pool structures shall be designed to withstand boiling of the cooling water.

The pool water level shall be kept at least 2.5 m above the fuel during normal operations. Continuous monitoring of water temperature and level must be possible.

The fuel pools must not contain connections through which the water level could decrease so much that fuel coolability and adequate radiation protection would be compromised.

The storage facilities shall be so designed that the fuel in any individual pool or reactor can be totally removed for storage in other on-site pools.

2.3 Storage racks

Fuel storage racks shall be designed to meet safety requirements. The racks and their fastenings shall also be so designed that hoisting forces transferred to the racks do not increase the multiplication factor K_{eff}. Regular inspection of the storage racks and the neutron absorbators they may contain must be possible.

The storage racks shall be designed and placed in the storage pool in such a way that fuel cooling by natural circulation can take place. The potential for fuel sticking, scratching or becoming otherwise damaged shall be extremely low.

The materials chosen for the storage racks shall be such that, taking the operating conditions into account, no substances will depart from them to the fuel and cause fuel failures during operation.

The structure of the storage rack shall be such that it maintains balance under any combination of loads.

2.4 Handling and inspection systems

The fuel handling and inspection systems shall be so designed that, during handling and inspections, criticality is prevented, adequate cooling and radiation protection is ensured and the potential for fuel failure is extremely low.

Handling and inspection measures shall be so planned that
— transfer of heavy objects above the fuel is avoided,
— transfer of heavy objects is avoided above locations where, if dropped, they might endanger safety-significant components,
— they do not compromise the integrity of storage pools or fuel, and that

— the layer of water ensuring radiation protection is maintained adequate also after a single failure.

The possibility of fuel being misplaced in the storage racks shall be extremely low.

There shall be adequate lighting for fuel handling and inspections, and high-quality image transmission and recording methods for visual inspections.

The fuel handling machine shall be fitted with i.a. the below protective devices:
— limit switches to stop movement when load is significantly reduced,
— limit switches to interrupt lifting or rotational movement in case of overloading,
— switches limiting transfers to allowable areas,
— mechanical restraints preventing transfer, hoisting and lowering beyond certain limits,
— zones for slow hoisting, lowering and transfer,
— prevention of simultaneous horizontal and vertical movement,
— limit switches for pre-determined movement ranges of crane bridge and trolly,
— prevention of movement if hoisting cable is slack,
— indication of load attachment and detachment,
— display of load weight and
— emergency stop device for simultaneous stoppage of all work movements.

The fuel handling machine must have instrumentation for accurate determination of fuel location and an adequate lighting and TV system.

The fuel transfer equipment shall meet the applicable general requirements for cranes. The transfer movement must stop automatically if power supply is lost and also if the system overloads and -speeds. The equipment may not lose their ability to safely carry their load in consequence of a single failure.

The gripping devices shall be so designed that loss of grip is prevented by two ways independent of each other and that the devices fail safely if their power supply is lost.

The fuel leak testing devices shall be so designed that adequate fuel cooling is ensured under all circumstances and that the temperature and radiation level of sampling water can be monitored.

The components and parts of components in contact with pool water shall be designed to resist contamination, and they must be decontaminable.

Fuel transfer containers shall meet the design requirements presented in Guide YVL 6.4 to the extent appropriate. It shall be possible to continuously monitor their temperature, internal pressure and radiation level.

In provision against the drop of a fuel transfer or transport container, shock absorbers necessary to prevent the container from breaking shall be designed.

2.5 Operation

There shall be instructions and procedures for the storage, handling and inspection systems and for the operation of their equipment. In these, i.a. operations to which fuel can be subjected, prerequisites for the operations, measures, responsibilities and records shall be defined.

Fuel may be handled only by personnel who have the appropriate training and who have been ascertained competent.

Conditions ensuring safe storage, handling and inspection of fuel shall be drawn up and included in the Technical Specifications for the plant unit.

Inservice inspections of the storage, handling and inspection systems and of their equipment shall be conducted according to a system- or equipment-specific programme. The programme shall present
— inspection items and scopes,
— inspection intervals,
— applicable regulations and standards,
— qualification requirements for inspection personnel,
— preparation of inspection item for inspection,

— the inspection methods and equipment to be used,
— calibration requirements for the inspection equipment,
— acceptance criteria for inspection results, and
— inspection reports and filing of the result documentation.

3 Regulatory control by the Finnish Centre for Radiation and Nuclear Safety

3.1 Control of design, construction and operation

The safety requirements for fuel storage, handling and inspection are presented in Guide YVL 1.0 and in chapter 2 of this Guide. It shall be demonstrated in a safety analysis report, topical reports and in the pre-inspection documentation and structural design plans of systems, components and structures that these requirements are met.

Guide YVL 1.1 shall be observed in the drawing up of the safety analysis report. The report shall present i.a. descriptions of systems and their design bases; transient and accident analyses for storage and handling, including errors in fuel handling, and anticipated operational occurrences and postulated accident conditions for the systems in question. The requirements for these analyses are given in Guide YVL 2.2.

In the control of concrete structures Guide YVL 4.1 shall be observed, in the control of steel structures Guide YVL 4.2 shall be followed, and in the control of hoisting and transfer equipment and of other equipment for fuel handling or support, Guide YVL 5.8 shall be complied with.

The principal rule is that the instructions for test loading and functional tests of equipment and structures shall be stated in the inspection plan contained in the structural plan of a piece of equipment or of a structure.

The Finnish Centre for Radiation and Nuclear Safety carries out the commissioning inspection of class EYT equipment belonging to a safety classified system. This inspection may be contained in the whole system's commissioning inspection in the same way as the functional tests of the item concerned may be included in the trial run programme of the whole system.

Trial run programmes shall be drawn up for fuel handling and storage systems and for their main equipment to verify that the systems and equipment meet the functional requirements set for them. At the same time, performance and safety of their joint operation is verified (e.g. loading from one piece of equipment to another, and operation ranges in relation to restraints, other equipment and forbidden areas).

The trial run requirements are presented in Guide YVL 2.5.

STUK's approval shall be obtained for the use, if any, of temporary equipment during fuel inspection, handling and repair. These equipment shall meet the requirements presented in this Guide. If the meeting of these requirements cannot be directly verified by equipment source data, substitutive safety assessments for the equipment shall be conducted (containing the necessary strength calculations and inspections). The previous operation of the equipment shall also be reported.

If a permanent procedure for a fuel handling, inspection or repair work has not been accepted, Guide YVL 6.3, point 6, "fuel repairs" shall be observed.

The instructions and procedures for fuel storage, handling and inspection shall be delivered to STUK for information. The inservice inspection programmes for storage,

handling and inspection systems and for their equipment are subject to the Centre's approval.

As part of the regulatory control of plant operation, STUK oversees the inservice inspections and maintenance of the fuel storage, handling and inspection systems and of their equipment, as well as fuel handling and storage. Part of the inspections are included in the periodic inspection programme referred to in Guide YVL 1.1, and part are done as specific inspections. The specific inspections are conducted on the basis of inspection requests from utilities and on the basis of utility announcements about future actions.

3.2 Spent fuel condition surveillance

To monitor the effects of long-term storage on spent fuel, a spent fuel condition surveillance programme shall be drawn up which is subject to the Centre's approval. The programme shall describe inspections of fuel and of storage conditions to be made at regular intervals; the sequence, scope, methods and equipment of the inspections shall be given. Reports on the results of the inspections with conclusions shall be sent to the Centre for information.

4 References

1 Design Requirements for Light Water Reactor Spent Fuel Storage Facilities at Nuclear Power Plants, ANSI/ANS 57.2, 1983

2 Design Requirements for New Fuel Storage Facilities at Light Water Reactor Plants, ANSI/ANS 57.3, 1983

3 U.S. Nuclear Regulatory Commission, Regulatory Guide 1.13 "Spent Fuel Storage Facility Design Basis"

4 U.S. Nuclear Regulatory Commission, NUREG-0554 "Single-Failure-Proof Cranes for Nuclear Power Plants", 1979

5 U.S. Nuclear Regulatory Commission, Regulatory Guide 3.49 "Design of an Independent Spent Fuel Storage Installation (Water-Basin Type)", 1981

6 Design Criteria for an Independent Spent Fuel Storage Installation (Water-Pool Type), ANSI/ANS 57.7, 1988

7 Auslegung von Hebezeugen in Kernkraftwerken, Sicherheitstechnische Regel des KTA, KTA 3902, Fassung 11/83

8 Criticality Safety Criteria for the Handling, Storage and Transportation of LWR Fuel Outside Reactors, ANSI/ANS 8.17, 1984