STUK

GUIDE **YVL 6.7** / 17 MARCH 2003

# QUALITY MANAGEMENT OF NUCLEAR FUEL



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# Authorisation

By virtue of the below acts and regulations, the Radiation and Nuclear Safety Authority (STUK) issues detailed regulations that apply to the safe use of nuclear energy and to physical protection, emergency preparedness and safeguards:

- Section 55, paragraph 2, point 3 of the Nuclear Energy Act (990/1987)
- Section 29 of the Government Decision (395/1991) on the Safety of Nuclear Power Plants
- Section 13 of the Government Decision (396/1991) on the Physical Protection of Nuclear Power Plants
- Section 11 of the Government Decision (397/1991) on the Emergency Preparedness of Nuclear Power Plants
- Section 8 of the Government Decision (398/1991) on the Safety of a Disposal Facility for Reactor Waste
- Section 30 of the Government Decision (478/1999) on the Safety of Disposal of Spent Nuclear Fuel.

# Rules for application

The publication of a YVL guide does not, as such, alter any previous decisions made by STUK. After having heard those concerned, STUK makes a separate decision on how a new or revised YVL guide applies to operating nuclear power plants, or to those under construction, and to licensees' operational activities. The guides apply as such to new nuclear facilities.

When considering how new safety requirements presented in YVL guides apply to operating nuclear power plants, or to those under construction, STUK takes into account section 27 of the Government Decision (395/1991), which prescribes that *for further safety enhancement, action shall be taken which can be regarded as justified considering operating experience and the results of safety research as well as the advancement of science and technology.*

If deviations are made from the requirements of the YVL guides, STUK shall be presented with some other acceptable procedure or solution by which the safety level set forth in the YVL guides is achieved.

Translation. Original text in Finnish.

# 1 General

According to Section 2 of the Government Decision (395/1991) on the General Regulations for the Safety of Nuclear Power Plants, *quality assurance shall refer to all planned and systematic actions necessary to provide adequate confidence that a component, plant or activity will satisfy given requirements.* Guides YVL 1.4 and YVL 1.9 present requirements for the quality management of nuclear power plants and their operation. These Guides shall also be applied for nuclear fuel. Quality terminology according to the standard SFS-EN ISO 9000 [1] is used in this Guide. The term quality management system means same as quality assurance programme used earlier.

This Guide presents the quality management requirements to be complied with in the procurement, design, manufacture, transport, receipt, storage, handling and operation of nuclear fuel. This Guide also applies to control rods and shield elements to be placed in the reactor.

The Guide is mainly aimed for the licensee responsible for the procurement and operation of fuel, for the fuel designer and manufacturer and for other organisations, whose activities affect fuel quality and the safety of fuel transport, storage and operation.

General requirements for nuclear fuel are presented in Section 114 of the Nuclear Energy Decree and in Section 15 of the Government Decision (395/1991). Regulatory control of the safety of fuel is described in Guides YVL 6.1, YVL 6.2 and YVL 6.3. An overview of the regulatory control of nuclear power plants carried out by STUK is clarified in Guide YVL 1.1.

# 2 Licensee's responsibility for quality management

The licensee is responsible for seeing that the quality management system requirements presented in this Guide are fulfilled. The licensee may delegate quality management-related tasks as a written assignment to other organisations, e.g. the fuel supplier, designer and manufacturer. However, it is the licensee's responsibility to ensure that the quality management system is effective as a whole and that it fulfils the requirements of this Guide.

The licensee's quality manual for nuclear fuel shall establish the basic requirements for quality management. They have to be taken into account also in the quality manuals of other organisations. The duties, responsibilities and authority of organisations affecting fuel quality and safety shall be clearly defined.

The licensee shall audit the quality management systems of organisations affecting fuel quality and safety, i.a. the fuel designer and manufacturer as well as the most important subcontractors. Furthermore, the licensee shall ensure that the operations of those organisations are acceptable. Before signing a procurement contract, the licensee shall assess the acceptability of the quality management system of the fuel supplier. The licensee is responsible for assuring that the system is adequate and properly implemented. An audit programme covering several years shall be submitted to STUK for information. STUK oversees the auditing activities carried out by the licensee and participates in these audits as considered necessary. The licensee shall submit the programme for each audit to STUK for information. The conclusions of the audits prepared by the licensee shall also be submitted to STUK for information.

In the case the licensee uses a third party in the audits required by the YVL guides, the audit programmes and reports of the third party have also to be submitted to STUK for information.

# 3 Fuel procurement

The licensee has to control the procurement process of fuel so that the products to be ordered fulfil the requirements set by the licensee. When selecting a supplier it must be taken into account that the supplier has the ability to deliver fuel that fulfils the wanted requirements. This has to be evaluated as a part of the licensee's assessment of the supplier candidate's quality management system. The descriptions of the product to be ordered shall be clearly presented in the procurement documents, including especially

- requirements to ensure needed control possibilities

- requirements concerning the approval and qualification of the product
- requirements concerning the quality management system of the supplier.

In this Guide the procurement documents refer to invitations for tenders, orders, contracts, specifications, drawings, minutes and guides that are used in the definition of the procurement object and extent, as well as all the changes and complements made to these documents.

The procurement documents of nuclear fuel shall determine

- conditions and methods for the approval of products and services. Product approval shall be based i.a. on the checking of design data and on the results of inspections and monitoring at the factory, receiving inspections, nuclear material account inspections and review of other documents specified in the procurement documents.
- norm specification which means regulations, technical requirements, standards and other instructions related to products or services to be ordered
- requirements for the identification, receiving inspections, archive samples, packaging, handling, transport and storage of products.

The procurement documents of nuclear fuel (including procurement, conversion and enrichment of uranium as well as related shipments) shall also take into account obligations related to the control of nuclear materials and Finland's international agreements in the field of nuclear energy.

In addition, e.g. the following shall be included in the procurement documents (normally in the procurement contract):

- it shall be stated that the licensee and the regulatory authority have direct access to the factories of the manufacturer and to the premises of the subcontractors to inspect and monitor fuel design and manufacture. During these visits it shall be possible that the representatives of the licensee and regulatory authority can receive documents for review, which are necessary for verifying conformance to the order. During these visits, it shall also be possible to require re-testing to be carried out and to receive material specimens during the various manufacturing steps
- it shall be required that the fuel designer and manufacturer will prepare such documents and records, based on which it can be checked that fuel fulfils the set requirements
- those fuel manufacturing records shall be defined that will be delivered to the licensee, and the storage of complete manufacturing records shall be agreed upon
- it shall be agreed that the licensee and the regulatory authority have in their use updated operating experience data of the fuel supplier on the fuel type in question, including fuel failures and their causes.

The licensee has to ensure before the order decision that the last-mentioned requirements have been included in the procurement documents. The last-mentioned issues to be included in the procurement documents are significant to STUK's considerations on the acceptability of the fuel supplier. Therefore it is necessary that the contents of related procurement documents is discussed with STUK beforehand.

# 4 Fuel design

## 4.1 Design requirements

The design organisation shall systematically ensure the functionality of its quality management system. Fuel design bases are defined in writing. Safety requirements have to be taken into account in the design bases, covering normal operational conditions, anticipated operational transients and postulated accidents.

Adequate methods shall be available to demonstrate the fulfilment of the design bases. It shall be further ensured that standards, regulations and guides used are properly applied in the design. Deviations shall be identified and justified.

Design documents and other documentation shall be drawn up systematically, and they shall be stored for the lifetime of each nuclear facility for potential future review, unless STUK decides otherwise at the licensee's request.

Compatibility of fuel with the reactor and other plant systems shall be ensured during design. For this purpose, i.a. the following aspects

shall be taken into account in design: reactor core structure, thermo-hydraulic and reactor-physical properties of the reactor, characteristics of the coolant of the primary circuit and fuel storage pools, and fuel handling, transport and storage systems.

Design shall be based on analyses, experimental research results and operating experience data. Design shall take into account normal operational conditions, anticipated operational transients and postulated accidents.

Operating experience data on fuel shall be systematically collected. Further analyses and studies as well as necessary changes in the fuel design shall be implemented on the basis of operating experience.

Only fuel modifications reviewed and approved by the organisational units responsible for design and quality management are allowed. The modifications shall be justified by appropriate analyses, experimental studies and potential operating experiences. The modifications' potential effects on the plant unit's safety analyses shall be taken into account.

Design shall be assessed by experts not involved in the design process. The assessment shall contain at least a random inspection of the analyses and tests conducted and of the operating experience gained. In addition, the results shall be compared against the requirements presented in the design bases. The assessment may also include alternative and simplified calculating methods.

### 4.2 Design assessment by the licensee

The acceptability of the quality management system of the design organisation referred to in Section 2 shall be evaluated before starting the manufacture. When procuring fuel the licensee shall ensure that the used analyses, experimental research results and operating experience data indicate that the design bases of fuel are fulfilled. Adequate amount of independent analyses shall be used in the evaluation, including also the use of own and others operating experience data which the licensee shall follow systematically. In the evaluation, the licensee may use experts outside its own organisation.

Before ordering a new fuel delivery batch the fulfilment of the design bases shall be re-evaluated. The extent of the review depends on the operating experience gained from the fuel type.

As regards the fuel type earlier used by the licensee, it shall be at least ensured that unapproved modifications to design parameters and manufacturing have not been made, and that possible new data on and requirements for fuel have been taken correctly into account.

Significant modifications to the fuel type already used by the licensee require that the design documents of the modification are reviewed, that the required comparative analyses are made and that the modification's effects on fuel behaviour are clarified. The modification's compatibility with the reactor and other plant systems shall be ensured. The modification's potential effects on the plant unit's safety analyses shall also be clarified.

If the fuel type remains the same but the manufacturer is new, the assessment may focus on the potential effects of differences between the design parameters and details of manufacturing.

The assessment of a new fuel type's design shall include also a complete evaluation of changes needed in the plant's safety analyses.

If the fuel type is new in such a way that the designer and the manufacturer have little or no experience of it, the assessment of design shall cover manufacturing of lead test assemblies and their operating experience.

## 5 Fuel manufacturing

### 5.1 Subcontracting

According to Section 2 the licensee shall evaluate the acceptability of the quality management systems of the most important subcontractors before the subcontractor in question starts manufacturing. The licensee shall ensure that the requirements presented in Sections 2 and 3 are applied when drawing up procurement documents. The documents shall in particular define the requirements for quality management, other requirements for the products to be procured and procedures for the product approval.

The licensee shall ensure the qualification of the subcontractors, taking into account the safety significance of the procurement in question. The qualification may be ensured i.a based on inspection and control visits, earlier experience and test

delivery batches. A list shall be kept of approved subcontractors, and they shall be monitored on a regular basis.

### 5.2 Manufacturing

The manufacturer shall ensure systematically that its quality management system is properly implemented.

There shall be adequate instructions and procedures as well as drawings for manufacturing. There shall also be adequate instructions for inspections and materials testing. The instructions shall present i.a. requirements for the arrangement of inspections and tests, and for the equipment and documentation to be used. The limits of approval and the scope of the inspections shall also be given.

Those methods of manufacture and inspection shall be identified which, due to their complicacy, sensitivity or other reasons, require procedure tests and particular skills of those who perform the work. Such methods include i.a. manufacturing and inspection methods essential for product quality, such as welding, heat treatment and non-destructive testing. There shall be written instructions for the approval, periodic re-approval and use of these methods and for continued assurance of personnel qualifications. Qualified individuals, methods of work and equipment shall be listed in documents which shall be kept continuously up-to-date.

During manufacturing, fuel assemblies and channels and their components shall be marked unambiguously and in accordance with written instructions, so that their identification and control is possible during the whole manufacturing process, including input materials, and during the fuel operation in the reactor.

Written instructions shall be drawn up for situations during which non-conforming products, work performances or other activities are observed. The instructions shall contain procedures for the identification and separation of a non-conforming product or work performance. They shall also describe how the necessary actions are decided upon, how causes for the non-conformance are clarified and how the organisations concerned are notified.

Non-conforming products shall be assessed and approved, rejected or repaired. Factors impairing quality, such as defective equipment, malfunctions and other deficiencies shall be identified and repaired. These actions shall be based on written instructions and plans which also define responsibilities and authority for decision-making.

### 5.3 Handling, storage and packaging

There shall be written instructions on the handling, storage and packaging of fuel and fuel components. Adherence to these instructions shall reliably prevent fuel damage.

### 5.4 Control of manufacturing by the licensee

In accordance with Section 2, the acceptability of the manufacturer's quality management system shall be evaluated before starting the manufacture.

The licensee shall assure by the audits mentioned above that procedures consistent with accepted quality manuals and other technical requirements and instructions are followed in manufacturing.

The monitoring of manufacturing is described more specifically in Guide YVL 6.3.

## 6 Fuel transport, receipt, storage and handling

### 6.1 Transport

Requirements for fuel transport are presented in Guides YVL 6.4 and YVL 6.5. A transport plan in accordance with Guide YVL 6.5 shall be drawn up, and all the necessary instructions for actions and procedures shall be attached to the plan. These instructions shall present the measures necessary to ensure the safety of the transport, and also the requirements necessary to prevent fuel damage during the transport. The consignor and the consignee shall agree upon the transport in advance. The requirements for the control of nuclear materials and for physical protection and the obligations of Finland's international agreements shall also be taken into account in the transport.

### 6.2 Receiving inspection

On-site receiving inspections of fuel shall be conducted according to written instructions. The instructions shall determine the organisational unit of the licensee responsible for the inspections and the qualifications required of personnel. The instructions shall further present the requirements for the inspections, the records to be drawn up of them and the procedures for deviations.

E.g. the following items are to be inspected:

- fuel shipping documents and transport log
- transport package which shall be inspected visually
- fuel; fuel visual and dimensional inspections shall be carried out.

The repair and/or approval of deviations detected in the receiving inspections shall be agreed with the fuel manufacturer and/or designer before the action is taken.

### 6.3 Handling and storage

There shall be written instructions for on-site storage of fresh fuel determining the storage conditions and possible other protection provided for fuel assemblies.

There shall be written instructions for fuel handling containing recommendations possibly provided by the fuel manufacturer. Acceptability of the instructions shall be assured in connection with the test run of the fuel handling systems. The instructions shall further determine the order of the handling measures, the responsibility for the accomplishment and supervision of work and the number and qualifications of personnel required for work.

A reload plan, as referred to in Guide YVL 1.13, shall be drawn up for loading fuel to the reactor. The plan shall include references to appropriate instructions and procedures concerning reload measures. When writing the reload plan, it shall be ensured that fuel assemblies can be approved for operation in accordance with Guide YVL 6.3.

The qualifications of individuals participating in fuel handling and its supervision shall be ensured in advance. They shall be given a basic training in accordance with Guide YVL 1.7 and also relevant further training and familiarisation with the tasks in question.

The technical requirements for fuel handling and storage, the required systems and equipment are presented in Guide YVL 6.8. The requirements for the control of nuclear materials and for physical protection shall be taken into account in fuel handling and storage.

## 7 Fuel operation and inspections

The plant unit's Technical Specifications shall present the most important conditions of and restrictions on the operation of fuel. Control of fuel operation and inspections of spent fuel shall be conducted in accordance with the surveillance programme for fuel operation required in Guide YVL 6.3.

Data and observations on fuel operation and inspections shall be documented and assessed. The causes for fuel failures shall be clarified if possible. This information shall be taken into account when analysing fuel behaviour during forthcoming cycles, when ordering new delivery batches and when controlling fuel design and manufacture.

## 8 References

1. SFS-EN ISO 9000, Quality management systems. Fundamentals and vocabulary. 2001.
2. IAEA Safety Series No 50-C-Q, Quality Assurance for Safety in Nuclear Power Plants and other Nuclear Installations, 1996.