STUK

GUIDE **YVL 6.3** / 28 MAY 2003

REGULATORY CONTROL OF NUCLEAR FUEL AND CONTROL RODS

continues

This Guide is in force as of 1 December 2003 until further notice.
It replaces Guide YVL 6.3, issued on 15 September 1993, and Guide YVL 6.6, issued on 5 November 1990.

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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

Regulatory control of nuclear fuel and control rods aims to assure that fuel and control rods fulfil the set design requirements for normal operational conditions, anticipated operational transients and postulated accidents. General license and approval procedures for fuel are described in Guide YVL 6.1.

General regulations for the safety of nuclear power plants are presented in the Government Decision (395/1991). These regulations also include requirements for fuel. Detailed requirements for the design, quality management, handling, storage and transport of fuel are given in Guides YVL 6.2, YVL 6.4, YVL 6.5, YVL 6.7 and YVL 6.8.

According to Section 15 of the Government Decision (395/1991)

The probability of significant degradation of fuel cooling or, of a fuel failure due to other reasons, shall be low during normal operational conditions and anticipated operational transients.

During postulated accidents, the rate of fuel failures shall be low and fuel coolability shall not be endangered.

The possibility of a criticality accident shall be extremely low.

Detailed safety regulations for the fuel design are presented in Guide YVL 6.2. General information on the safety of fuel and control rods is presented according to Guides YVL 1.1 and YVL 2.2 in the safety analysis report of the plant unit.

This Guide deals with the contents of the pre-inspection documentation of nuclear fuel as well as the control of manufacturing, receiving inspections, start-up of operation and operation of fuel and repairs and inspections of fuel. Surveillance of spent fuel is also dealt with in this Guide. This Guide does not cover the safeguards control of nuclear fuel. The presented control procedure applies also to the control rods and shield assemblies used in the reactor.

Fuel means an assembly of fuel rods with its fixed upper and lower tie-plates as well as the channel surrounding the assembly. Irradiated fuel means fuel that has been in the reactor and the burn-up of which may be so low that it can be reloaded in the reactor. Spent fuel means fuel that has been removed from the reactor and the burn-up of which is so large that it is not appropriate to load it again in the reactor.

2 Pre-Inspection documentation

2.1 General

Manufacturing of fuel or control rods cannot be initiated before Radiation and Nuclear Authority (STUK) has approved the pre-inspection documentation in question. When delivering the material the licensee shall see to it that STUK has adequate time to deal with the material.

In the case of a new manufacturer or a new fuel type, the manufacturing of test assemblies and their irradiation and inspections are normally included in the evaluation of the fuel acceptability. New manufacturer means in this connection a manufacturer to which the fuel type in question is new or which delivers its first fuel batch to Finland.

Pre-inspection documentation may be compiled separately for fuel assemblies and fuel channels. If there are significant variations in the initiation times of the manufacturing of various components, the material can be dealt with and delivered to STUK also in parts according to the manufacturing schedule, for example in the following way:

- Materials, e.g. fuel powder, billet of fuel cladding tube, plates of fuel channel, materials of upper and lower tie-plates
- Components, e.g. fuel pellets, cladding tube, fuel channel (may also be an end product), upper and lower tie-plates
- End product, fuel rods, fuel assembly, control rods.

As regards materials, the manufacturing is seen to be initiated when the manufacturing factory orders the material, for example when the factory manufacturing cladding tubes orders the billets of tubes or starts to manufacture them by themselves or when a factory manufacturing pellets orders fuel powder or starts to manufacture it. This is the point in time when the pre-inspection documentation related to the materials in question shall have the approval of STUK.

The manufacturing of components is seen to be initiated when the parts of the assembly are started to be cut and/or to be processed to their final form and size, for example when pellets are started to be manufactured from the powder or when cladding tube is started to be laminated from the billet of the cladding tube. At this point the pre-inspection documentation of components shall have the approval of STUK.

As regards the end product, the manufacturing is seen to be initiated when fuel rods and fuel assemblies are started to be made from finished components, for example when the welding of the fuel rod end plug to the cladding tube is initiated. At this point the whole pre-inspection documentation shall have the approval of STUK.

Section 2.2 gives the requirements for the contents of the pre-inspection documentation of the initial core loading. Material referred to in Sections 2.2.2, 2.2.4-2.2.8 shall be delivered to STUK for approval with the exception of the quality manuals of the supplier, designer and manufacturer mentioned in Section 2.2.2. These manuals are delivered to STUK for information.

Section 2.3 describes how the pre-inspection documentation for a core reloading differs from the pre-inspection documentation of the initial core loading.

2.2 Initial core loading of a nuclear power plant, new type of fuel or control rod or new manufacturer

2.2.1 General

As regards the initial core loading, a new fuel or control rod type or a new manufacturer, the pre-inspection documentation is handled mainly as one entity.

If a separate approval is applied for the initiation of the manufacturing of materials or components, it is required that the documents referred to in Sections 2.2.2 and 2.2.3 and the pre-inspection documentation of the materials and components in question have been delivered for STUK.

2.2.2 Quality management

Guide YVL 1.4 presents general requirements on quality management and Guide YVL 6.7 detailed requirements on the quality management of fuel.

Quality manuals of the supplier, designer and manufacturer of fuel have to be delivered in connection with the pre-inspection documentation to STUK for information. Respectively, the licensee's own quality management manual for fuel has to be delivered as a separate item from the pre-inspection documentation to STUK for approval.

2.2.3 Behaviour analyses, experimental studies and operating experience

Based on analyses, experimental studies and operating experience it has to be demonstrated that the fuel and control rods fulfil the design basis requirements. These requirements are more specifically described in Guide YVL 6.2.

Calculation methods as well as their validation and uncertainty factors have to be presented in the analyses. Adequate initial data, experiment conditions and received results of experimental studies conducted in reactor conditions and laboratories have to be presented.

2.2.4 Product specification for each delivery batch

A list of each delivery batch has to be presented, giving the specifications and drawings of accomplished products, semi-manufactured products and materials for each part.

2.2.5 Technical requirements

Material- and part-specific technical requirements (specifications) have to be presented for the parts of fuel assemblies, channels and control rods and their base and welding filler materials. Alternatively, the unambiguous approval requirements and limits of accomplished products, semi-manufactured products and their materials and manufacturing methods have to be otherwise presented in the pre-inspection documentation.

Manufacturing method, identification of manufacturing batches, requirements for materials properties as well as testing and inspection requirements have to be presented in the specifications for the structural parts and materials of the fuel rods, assemblies and channels and control rods. The licensee shall inspect the fuel powder specification in connection with the inspection referred to in Section 3.3.

2.2.6 Drawings

Drawings for fuel and control rods as well as for their parts, used in production, have to be presented. They have to or other pre-inspection documentation has to indicate i.a.

- dimensions and geometries needed for the analyses, as well as allowable tolerances
- assembly data with part and material lists
- types, locations and dimensions of joints.

2.2.7 Quality inspection

The quality inspection programme shall include separate manufacturing and inspection plans, or it has to be indicated otherwise in the pre-inspection documentation, how fuel pellets, structural parts of the assembly and their base and welding filler materials, semi-manufactured products and accomplished products are inspected.

The manufacturing and inspection plans shall describe quality inspection measures specifying the following aspects:

- manufacturing phase when the inspection is conducted
- conductor of inspection
- supervisor of inspection
- document type to be prepared
- inspection method
- inspection scope
- inspection requirements
- reference to a specification and drawing
- inspection instructions for quality inspection measures.

Inspection instructions shall be prepared for all inspection measures related to the manufacturing and assembly. Detailed descriptions of the inspections shall be presented in the instructions. The licensee shall ensure in connection with the inspection referred to in Section 3.3 that the manufacturer has qualified instructions available.

2.2.8 Inspection programme for test assemblies

When the start-up of the operation of a new fuel type is being prepared at an operating plant unit, or when significant changes are planned in the design parameters or manufacturing technique of a previously used fuel type, it is appropriate to start gathering operation experience by using test assemblies. A programme for inspecting and examining such test assemblies shall be established.

2.2.9 Plan for the control of manufacturing

A plan shall be compiled for the control of the manufacturing of each delivery batch. The plan shall be submitted to STUK for information. The plan shall indicate all parties conducting the control of the fuel batch in question and all chosen control points. It shall also show how the control is implemented in the different phases of the manufacturing.

2.3 Delivery batches for reloads

In the case of a fuel that has been already earlier delivered to the plant, the pre-inspection documentation can be submitted in separate parts e.g. according to the division given in Section 2.1. If the manufacturing of components or the delivery of materials is wanted to be initiated before the whole pre-inspection documentation has been approved, STUK's approval shall be applied for the pre-inspection documentation of the materials or components in question. A precondition for the approval is that fuel and control rods as well as their components and materials fulfil the design basis requirements.

Requirements in Sections 2.2.1–2.2.9 are applicable to the contents of the pre-inspection documentation. Unchanged documents delivered to STUK already earlier may be referred to. However, updated operating experience data has to be presented in the pre-inspection documentation of each delivery batch for reloads.

Updated data and analysis methods of behaviour analyses and experimental studies are presented.

A summary of changes implemented in the design bases and manufacturing shall be presented. Significant changes shall be justified with experimental results and analyses, if needed. Also significant changes done to manufacturing or quality inspection methods have to be justified.

3 Control of manufacturing

3.1 General requirements

The licensee's primary responsibility is to ensure through its own control of manufacturing that fuel and control rods fulfil the requirements set

for their design and manufacturing. The purpose of STUK's regulatory control is to ensure that the activities of the licensee are adequate.

Prerequisites for the starting of manufacturing are that the inspections mentioned in Sections 3.2 and 3.3 have been conducted and that STUK has approved the pre-inspection documentation or a specific part of it, if the manufacturing is commencing in phases.

The control of manufacturing includes inspections referred to in Sections 3.2-3.5. The licensee shall submit to STUK for information reports on all inspections conducted according to the mentioned sections.

The licensee shall provide STUK with an opportunity to participate in the mentioned inspections. Adequate time shall be reserved for possible corrective actions and re-inspections.

If the licensee uses a third party in the control of manufacturing, the reports of the third party shall also be submitted to STUK for information.

3.2 Evaluation of quality management system

The licensee shall evaluate the acceptability of the quality management system of a new fuel supplier before signing a procurement contract.

The licensee shall audit the quality management systems of the organisations affecting the quality and safety of fuel, such as the fuel designer and manufacturer and the most important subcontractors. The licensee shall ensure that the operation of those organisations is acceptable.

The control of quality management is described in more detail in Guide YVL 6.7.

3.3 Manufacturing and quality inspection methods

The licensee shall inspect the most important manufacturing and quality inspection methods and approve their qualification before the manufacturing of a new fuel and control rod type is commenced. Respectively, a new manufacturer's fabrication and quality inspection methods are reviewed.

As regards the manufacturing of recurrent delivery batches, the licensee shall inspect the significant changes of manufacturing and quality inspection methods and approve their new/changed qualification before they are taken into use.

3.4 Subcontracting

The licensee shall review to an adequate extent the quality management systems of the suppliers of the most important structural materials and components. The licensee shall also review their most important manufacturing and quality inspection methods according to Section 3.3.

3.5 Quality inspection records

The licensee shall inspect adequately the quality inspection records of each delivery batch, including deviation reports in question. The licensee shall inform STUK without delay on deviations which have come up. The deviation reports on the most important deviations have to be submitted to STUK for approval after they have been dealt with by the licensee. As regards other deviations, STUK's approval is applied for in connection with the records. The documentation shall include the justifications of the supplier and licensee for the approval of the deviations.

A repair plan shall be submitted to STUK for approval on those deviations affecting safety, which are intended to be corrected. The plan shall include, as appropriate, the information presented in Section 7.

A list of the deviation reports on fuel and control rods and the certificate of manufacturing shall be submitted to STUK for information not later than in connection with the commissioning application of the fuel batch.

4 Receiving inspections

An inspection programme covering the receiving inspections of fuel and control rods at the nuclear power plant shall be drawn up. The programme shall be submitted to STUK for information.

A summary report of the results of the receiving inspections shall be delivered to STUK for information. The report may also be delivered to STUK in connection with the commissioning application referred to in Section 5.

A deviation report on deviations detected during the receiving inspections shall be submitted to STUK for approval. It shall contain a plan for potential repairs or an assessment on the acceptability of the deviation.

5 Start-up of operation

The licensee shall apply for STUK's approval for the operation of the initial core loading batch of fuel and control rods and of each delivery batch. The application shall include a list indicating the documents sent to STUK concerning the batch, the decisions made by STUK, and the manufacturing and receiving inspections conducted by the licensee.

The prerequisites for a positive commissioning decision are as follows:

- STUK has approved the pre-inspection documentation of the batch
- during the control of manufacturing and receipt, no such matters have surfaced as would prevent the taking into operation of the batch
- potential deviation reports and the certificate of manufacturing have been delivered to STUK.

Any potential unaccomplished matters shall be mentioned in the application, and a plan for corrective actions shall be presented. The application shall also contain the identification markings of fuel assemblies, fuel channels and control rods of the batch in question.

6 Operation and post-operation surveillance

6.1 Surveillance programme for fuel operation

6.1.1 General requirements

To ensure the safe use of nuclear fuel, its operating conditions are monitored and its mechanical condition is controlled by inspections and examinations both during refuelling and after removal from service. For this activity the licensee shall establish a surveillance programme for fuel operation.

In the programme the licensee's measures and plans shall be presented for

- monitoring fuel operating parameters and conditions
- inspection and examination of irradiated fuel
- collection of reference data.

In addition, the programme shall include the general principles for inspections. The programme shall be submitted to STUK for approval. Any changes and supplements to the programme are subject to STUK's approval. The programme may also be divided into sub-programmes.

More detailed requirements for the various parts of the programme are given in Sections 6.1.2, 6.1.3 and 6.1.4.

6.1.2 Fuel operating conditions

The operating conditions of the fuel, reactor core and coolant must be known. The power of the reactor and fuel, power changes, power distribution, safety margins (e.g. margin to critical heat flux ratio), burn-up, and also coolant activity and water chemistry shall be monitored.

The essential safety requirements for the parameters to be monitored are given in the plant's Technical Specifications. Methods for monitoring the operating conditions are stated in the surveillance programme.

Actions in provision for fuel leaks shall be planned in advance. These plans and the methods to assess the number and extent of fuel leaks are presented in the surveillance programme. The first observation about a fuel leak shall be informed to STUK in the daily report. STUK shall be informed immediately, if a significant leak occurs.

Every plant unit must have facilities for carrying out fuel assembly leak tests. Leak tests shall be conducted during refuelling and, where necessary, also during other outages if observations made during the operation indicate that the reactor may contain leaking fuel assemblies. The requirements for leak testing are presented in the programme. Through leak tests it shall be reliably ensured that no leaking fuel assemblies remain in the reactor.

The licensee's methods for reporting on and for inspecting the fuel operating conditions shall also be specified in the programme.

6.1.3 Inspection and examination of irradiated fuel

In addition to the surveillance programme, an annual fuel inspection and examination plan shall be submitted to STUK for information. The

scope of all planned inspections and examinations for various fuel types shall be presented in the plan.

The purpose of the inspections and examinations is to observe whether the fuel assemblies behave as planned. The purpose is also to detect any unexpected phenomena related to the fuel behaviour and structure as well as to distinguish leaking assemblies from non-leaking ones. Therefore, visual inspections of fuel channels, assemblies and rods shall be systematically carried out at every plant unit.

This means that the structure and components of fuel and control rods shall be designed in such a way that their condition can be inspected to an adequate extent at regular intervals.

In addition to visual inspections, fuel assemblies, rods and channels of all plant units shall be subject to dimensional inspections and to other non-destructive tests, and, where necessary, to destructive tests and examinations.

In determining the scope of fuel inspections and examinations, operating experience about fuel of a similar type under equivalent conditions may be taken into account. The scope is affected also by it whether there is a question of an old fuel design, on which much examination and operating experience data is available, or of a new design, on which there are only little or no information. Any modifications to the fuel design parameters and fabrication methods, and also facts observed during other inspections shall be taken into consideration.

In so far as the licensee intends to base actions on data provided by the fuel manufacturer, the manufacturer's follow-up surveillance programme shall be included in the utility's programme.

On the basis of observations, more detailed inspections and examinations on the site or in a hot cell shall be undertaken, where necessary. The causes of fuel failures shall be clarified, as far as possible. Fuel assemblies confirmed as leaking shall be removed from service or they shall be repaired.

Where it is necessary for clarifying various fuel behaviour phenomena (e.g. fission gas release, swelling and densification of UO_2, changes in fuel assembly and rod dimensions, fuel rod temperature distributions etc.), carefully pre-characterised fuel rods shall be manufactured. After irradiation, these rods are subjected to non-destructive and destructive tests according to a detailed programme.

Inspection and examination reports shall be submitted to STUK not later than four months from the accomplishment of each inspection or examination. The licensee's assessment on the made observations shall be attached to the reports. However, abnormal observations shall be informed to STUK without delay.

6.1.4 Obtaining reference data

The licensee's actions for obtaining reference data from organisations using similar fuel types under equivalent conditions are presented in the surveillance programme for fuel operation.

6.2 Surveillance programme for control rods operation

An operation surveillance programme shall be established for control rods. It shall be control rod type specific, aiming to ensure a faultless behaviour of control rods throughout their planned operation. The programme shall be submitted to STUK for approval. In the programme, attention shall be paid to the specific failure mechanisms of each control rod type. Specifically control rods near to the end of their operation shall be subject to inspections.

6.3 Surveillance of spent fuel condition

A surveillance programme of the condition of spent fuel shall be established to monitor the effects of the long-term storage of spent fuel. It shall be submitted to STUK for approval. In the programme the periodic inspections of spent fuel and storage conditions shall be presented with their intervals, scope, methods and equipment. The special requirements for the long-term storage of damaged fuel shall be taken into account in the programme. Inspection reports with conclusions shall be submitted to STUK for information.

7 Repairs and inspections

7.1 General requirements

The procedure described in this section concerns all on-site repairs and inspections of fuel and control rods.

There shall be written instructions for fuel and control rods repairs, inspections, supervision and reporting. These can be work-specific procedure instructions or - particularly for supervision, reporting and documentation - guidelines of a more general nature, applicable to various work assignments.

The licensee is responsible for following the instructions and for submitting them to STUK, as necessary.

The fuel spare parts to be used shall have been inspected and approved according to Section 3 of this Guide. In addition, the spare parts shall have passed the nuclear facility's receiving inspection.

7.2 Repair work and inspections requiring disassembling

Fuel and control rods repairs and inspections requiring disassembling shall be carried out according to a written plan approved by STUK. The plan shall contain the following information:

- overall work description and previous experience of the method
- list of instructions to be used in work
- list of equipment to be used in work
- work schedule.

The licensee shall see that at least the following measures have been implemented on time and that they have also been documented:

- approval of the records of spare parts to be used in work
- approval of the tools/inspection equipment to be used in work
- work quality certificate
- licensee's approval for the further operation of fuel
- if irradiated fuel has been significantly repaired, after repair a fuel leak test shall be carried out before fuel is taken into use.

The documents mentioned above are presented to STUK during the inspection concerning the repair and modification work. During the inspection the further operation or storage of the fuel assembly is decided by STUK.

7.3 Other inspections

If the inspection of a fuel assembly does not require disassembling, it is adequate that the inspection plan referred to in Section 7.2 is submitted to STUK for information. As regards new spare parts, equipment and instructions, the requirements of Section 7.2 are applied. Based on a separate application, STUK may grant the licensee's inspectors the right to inspect repetitive work which is of minor significance to the integrity of the fuel assembly.