Quality assurance of nuclear fuel

This Guide is in force as of 1 January 1994 until further notice. The Guide replaces Guide YVL 6.7, issued on 11 October 1983.

Second, revised edition
Helsinki 1994
Erweko Painotuote Oy
ISBN 951-712-024-9
ISSN 0783-2427

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 the 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.

The 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 YVL Guides is achieved. Unless STUK states otherwise, this Guide does not change decisions made by STUK before the entry into force of this Guide. This Guide does not change STUK's decisions made before the entry into force of this Guide, unless STUK states otherwise.

Translation. Original text in Finnish.

1 General

According to section 2 of the Council of State Decision (395/91) on the General Regulations for the Safety of Nuclear Power Plants, quality assurance means all planned and systematic actions necessary to provide adequate confidence that a component, plant or activity will satisfy given requirements. The following are pre-requisites for an effective quality assurance function: clear delineation of responsibilities and authority, employment of proven methods of management and work, good working conditions, personnel's responsible attitude and familiarity with their work, plus systematic reporting and maintenance of documents.

Guides YVL 1.4 and YVL 1.9 present requirements for the quality assurance of nuclear power plants and their operation. These Guides shall also be applied to fuel.

This Guide presents the quality assurance requirements to be complied with in the procurement, design, manufacture, transport, handling and operation of nuclear fuel. This Guide also applies to the procurement of 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, 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 Council of State Decision (395/91). Control of the safety of fuel is described in Guides YVL 6.1, YVL 6.2, YVL 6.3 and YVL 6.6. These Guides specify i.a. what documents shall be delivered to the Finnish Centre for Radiation and Nuclear Safety (STUK) and what inspections STUK conducts. These Guides also clarify schedule requirements relating to control activities. An overview of the regulatory control of nuclear power plants carried out by STUK is given in Guide YVL 1.1.

2 Licensee's responsibility for quality assurance

The licensee shall see to it that the quality assurance requirements presented in this Guide are fulfilled. The licensee may delegate quality assurance-related tasks to other organisations, e.g. the fuel designer and manufacturer. It is the licensee's responsibility to see that the quality assurance programme is effective as a whole and that it fulfills the requirements of this Guide.

The licensee's quality assurance programme shall establish the fundamental requirements pertaining to the whole quality assurance function, which requirements shall be taken into account in the quality assurance programmes of other organisations. The duties, responsibility and authority of organisations affecting fuel quality and safety shall be clearly defined.

Before submitting an order, the licensee shall assess the acceptability of the quality assurance programmes of organisations affecting fuel quality and safety, i.a. the fuel designer, manufacturer and the most important sub-contractors. The licensee is also responsible for ensuring through his representatives, in advance and during manufacturing, that these quality assurance programmes are effective in practice.

3 Fuel procurement

Fuel procurement documents (including procurement, conversion and enrichment of uranium, plus related shipments) shall take into account obligations ensuing from safeguards of nuclear materials and from Finland's international agreements in the field of nuclear energy.

The procurement documents shall contain, or specify by references, requirements for products or services, and the technical specifications, standards and other instructions

applicable to products and services. These documents shall also present requirements for the identification, receiving inspections, archive samples, packaging, handling, transport and storage of products.

The procurement documents shall determine the conditions and methods of approval of products and services. Product approval is based on i.a. the checking of design data and on the results of inspections and monitoring at the factory, on receiving inspections, nuclear material accounting and the results of the review of other documents specified in the procurement documents. The procedure for handling and approval of deviations shall be specified.

The procurement documents shall require that the fuel designer, manufacturer and sub-contractors have their own quality assurance programmes which fulfill the requirements of the licensee's quality assurance programme for fuel. Also the following requirements shall be contained in the documents: the fuel designer and manufacturer shall draw up such documents and records as make it possible to inspect that fuel meets the requirements set for it.

It shall be stated in the procurement documents that the licensee and the regulatory authority have direct access to the quarters of the manufacturer and of the sub-contractors to inspect and monitor fuel design and manufacture, and that they may also review the necessary documents. During these visits, it shall be possible to require that quality control retesting be carried out, if necessary. It shall be possible for the licensee to take material specimens during the various manufacturing steps.

The procurement documents shall also specify the manufacturing quality control records to be delivered to the licensee. It shall also be agreed in the procurement documents where the complete manufacturing quality control documentation is retained.

It shall be further agreed in the procurement documents that the licensee and the regulatory authority may have in their use, through the fuel supplier, updated operating experience data on the fuel type in question, including fuel failures and their causes.

4 Fuel design

4.1 Design requirements

The fuel design requirements shall be defined in writing. The design criteria shall take into account safety requirements and shall cover normal operating conditions, anticipated operational occurrences and postulated accident conditions.

Adequate methods shall be available for demonstrating the meeting of the design criteria. It shall also be ensured that standards, instructions and guides used are correctly interpreted in design. Any deviations shall be identified and substantiated.

Design documents and other documentation shall be drawn up systematically and they shall be maintained for the lifetime of the nuclear facility in question 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 assured during design. For this purpose, i.a. the following aspects shall be taken into account in design: reactor core structure, thermo-hydraulic characteristics of the reactor and reactor-physical properties, characteristics of the coolant of the primary circuit and of the fuel storage pools, and the 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 operating conditions, anticipated operational occurrences and postulated accident conditions.

Operating experience data on fuel shall be collected systematically. Further analyses and investigations plus the necessary changes of 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 assurance are allowed. The modifications shall be justified by appropriate analyses, experimental research and potential operating experience. The modifications' potential effect on the plant unit's safety analyses shall be taken into account.

Experts not involved in the design process shall perform assessment of design. The assessment shall contain at least a random inspection of the analyses and tests conducted and of the operating experience gained. The results shall also be compared against the requirements of the design criteria. The assessment may also include alternative and simplified calculating methods.

4.2 Design assessment by the licensee

In connection with fuel procurement, the licensee shall assess the analyses, experimental research results and operating experience data which demonstrate the meeting of fuel design criteria. In the assessment, the required number of independent analyses and operating experience data from Finland and from abroad are used which the licensee shall monitor systematically. In carrying out the assessment, the licensee may use experts outside its own organisation.

The meeting of design criteria shall be re-assessed before a new delivery batch is ordered. The extent of the assessment depends on the operating experience gained from the fuel type.

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

Fundamental 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 effect on fuel behaviour is clarified. The modification's compatibility with the reactor and other plant systems shall be ensured. The modification's potential effect on the plant unit's safety analyses shall also be clarified.

If the fuel type remains the same but the manufacturer changes, the assessment can focus on the effect of potential differences between the design parameters and the details of manufacturing.

A new fuel type's design shall be assessed completely also as regards changes required in the plant's safety analyses.

If the fuel type is new in the meaning that the designer and the manufacturer have little or no experience of it, the assessment of design shall include manufacturing of lead test assemblies, of which operating experience shall be obtained.

5 Fuel manufacturing

5.1 Sub-contracting

The requirements presented in points 2 and 3 shall be applied when drawing up procurement documents. The documents shall in particular define the requirements for quality assurance and other requirements for the products to be procured; also the product approval procedure shall be determined.

Sub-contractor qualifications shall be ensured, taking into account the safety significance of the procurement in question. Assurance of qualification may take place i.a. by inspection and control visits, on the basis of earlier experience and test delivery batches. A list shall be kept of approved sub-contractors who shall be monitored on a regular basis.

5.2 Manufacturing

The manufacturer's quality assurance organisation shall ensure systematically that the quality assurance programme is 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 requirements for i.a. the arrangement of inspections and tests, 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 NDT. There shall be written instructions for the approval, periodic reapproval 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 up-to-date.

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

Written procedures shall be drawn up to provide 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 relative to 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

On the basis of written documentation, the licensee shall assess the methods and specifications concerning fuel manufacturing and quality control. In accordance with point 2, the licensee shall make control visits before manufacturing of the product to be procured is commenced; regular visits shall be made during manufacturing. These visits shall also cover the most important sub-contractors.

The licensee shall ensure that procedures conforming to approved quality assurance programmes and other technical specifications and instructions are applied in manufacturing. The licensee shall assess the acceptability of all deviation reports concerning each delivery batch. External experts may be employed for the inspections.

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 transport shall also take into account the requirements for safeguards of nuclear materials and for physical protection and the obligations ensuing from Finland's international agreements.

6.2 Receiving inspection

Receiving inspections of fuel on site 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 documentation to be drawn up of them and the procedures for deviations.

At least the following items are to be inspected:

- the documentation for the consignment, and the transport protocol
- the transport package which shall be inspected visually
- fuel; fuel visual and dimensional inspections.

Fuel manufacturer and/or designer shall agree in advance upon the repair and/or approval of deviations detected in the receiving inspections.

6.3 Handling and storage

There shall be written instructions for on-site storage of fresh fuel which determine 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 the work.

A reload plan, as referred to in Guide YVL 1.13, shall be drawn up for loading of fuel to the reactor, in which reference is made 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 in handling supervision shall be ensured in advance. They shall be given 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. Safeguards of nuclear materials and the requirements 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 programme for fuel operation required in Guide YVL 6.6.

Data and observations on fuel operation and inspections shall be documented and assessed. The causes of fuel failures 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 IAEA Safety Series No 50-C-QA, Safety Standards, Code on the Safety of Nuclear Power Plants: Quality Assurance.

2 IAEA Safety Series No 50-SG-QA11, Safety Guides, Quality Assurance in the Procurement,Design and Manufacture of Nuclear Fuel Assemblies.

YVL guides

General guides

YVL 1.0 Safety criteria for design of nuclear power plants, 1 Dec. 1982

YVL 1.1 The Finnish Centre for Radiation and Nuclear Safety as the regulatory authority in control of the use of nuclear energy, 27 Jan. 1992

YVL 1.2 Documents to be submitted to the Finnish Centre for Radiation and Nuclear Safety concerning the regulation of nuclear facilities, 22 May 1991 (in Finnish)

YVL 1.3 Mechanical components and structures of nuclear power plants. Inspection licenses, 25 March 1983

YVL 1.4 Quality assurance of nuclear power plants, 20 Sep. 1991

YVL 1.5 Reporting nuclear power plant operation to the Finnish Centre for Radiation and Nuclear Safety, 18 Aug. 1989

YVL 1.6 Nuclear power plant operator licensing, 3 March 1989

YVL 1.7 Duties important to nuclear power plant safety, personnel qualifications and training, 28 Dec. 1992 (in Finnish)

YVL 1.8 Repairs, modifications and preventive maintenance at nuclear facilities, 2 Oct. 1986

YVL 1.9 Quality assurance during operation of nuclear power plant, 13 Nov. 1991

YVL 1.13 Regulatory inspections related to shutdowns at nuclear power plants, 9 May 1985

YVL 1.15 Mechanical components and structures in nuclear installations, Construction inspection, 16 April 1984

Systems

YVL 2.1 Safety classification of nuclear power plant systems, structures and components, 22 May 1992

YVL 2.2 Transient and accident analyses for justification of technical solutions at nuclear power plants, 7 Oct. 1987

YVL 2.3 Preinspection of nuclear power plant systems, 14 Aug. 1975

YVL 2.4 Over-pressure protection and pressure control during disturbances in the primary circuit and steam generators of a PWR plant, 19 Sept. 1984

YVL 2.5 Pre-operational and start-up testing of nuclear power plants, 8 Jan. 1991

YVL 2.6 Provision against earthquakes affecting nuclear facilities, 19 Dec. 1988

YVL 2.7 Failure criteria for the design of a light-water reactor, 6 April 1983

YVL 2.8 Probabilistic safety analyses (PSA) in the licensing and regulation of nuclear power plants, 18 Nov. 1987

Pressure vessels

YVL 3.0 Pressure vessels in nuclear facilities. General guidelines on regulation, 21 Jan. 1986

YVL 3.1 Nuclear power plant pressure vessels. Construction plan. Safety classes 1 and 2, 11 May 1981

YVL 3.2 Nuclear power plant pressure vessels. Construction plan. Safety class 3 and class EYT, 21 June 1982

YVL 3.3 Supervision of the piping of nuclear facilities, 21 May 1984

YVL 3.4 Nuclear power plant pressure vessels. Manufacturing license, 15 April 1981

YVL 3.7 Pressure vessels of nuclear facilities. Commissioning inspection, 12 Dec. 1991

YVL 3.8 Nuclear power plant pressure vessels. Inservice inspections, 3 Dec. 1993 (in Finnish)

YVL 3.9 Nuclear power plant pressure vessels. Construction and welding filler materials, 6 Nov 1978

Buildings and structures

YVL 4.1 Nuclear power plant concrete structures, 22 May 1992 (in Finnish)

YVL 4.2 Steel structures for nuclear facilities, 19 Jan. 1987

YVL 4.3 Fire protection at nuclear facilities, 2 Feb. 1987

Other structures and components

YVL 5.3 Regulatory control of nuclear facility valves and their actuators, 7 Feb. 1991

YVL 5.4 Supervision of safety relief valves in nuclear facilities, 3 June 1985

YVL 5.5 Supervision of electric and instrumentation systems and components at nuclear facilities, 7 June 1985

YVL 5.6 Ventilation systems and equipment for nuclear power plants, 23 Nov. 1993 (in Finnish)

YVL 5.7 Pumps at nuclear facilities, 23 Nov. 1993 (in Finnish)

YVL 5.8 Hoisting appliances and fuel handling equipment at nuclear facilities, 5 Jan. 1987

Nuclear materials

YVL 6.1 Control of nuclear fuel and other nuclear materials required in the operation of nuclear power plants, 19 June 1991

YVL 6.2 Fuel design limits and general design criteria, 15 Feb. 1983

YVL 6.3 Regulatory control of fuel design and manufacturing, 15 Sept. 1993

YVL 6.4 Supervision of nuclear fuel transport packages, 1 March 1984

YVL 6.5 Supervision of nuclear fuel transport, 1 March 1984

YVL 6.6 Surveillance of nuclear fuel performance, 5 Nov. 1990 (in Finnish)

YVL 6.7 Quality assurance of nuclear fuel, 23 Nov. 1993

YVL 6.8 Handling and storage of nuclear fuel, 13 Nov. 1991 (in Finnish)

YVL 6.9 The national system of accounting for and control of nuclear material, 23 Nov. 1993 (in Finnish)

YVL 6.10 Reports to be submitted on nuclear materials, 23 Nov. 1993 (in Finnish)

YVL 6.11 Physical protection of nuclear power plants, 13 July 1992 (in Finnish)

YVL 6.21 Physical protection of nuclear fuel transports, 15 Feb. 1988 (in Finnish)

Radiation protection

YVL 7.1 Limitation of public exposure in the environment of and limitation of radioactive releases from nuclear power plants, 14 Dec. 1992

YVL 7.2 Evaluation of population doses in the environment of nuclear power plants, 12 May 1983

YVL 7.3 Evaluating the dispersion of radioactive releases from nuclear power plants under operating and in accident conditions, 12 May 1983

YVL 7.4 Nuclear power plant emergency plans, 12 May 1983

YVL 7.5 Meteorological measurements of nuclear power plants, 28 Dec. 1990 (in Finnish)

YVL 7.6 Monitoring of discharges of radioactive substances from nuclear power plants, 13 July, 1992

YVL 7.7 Programmes for monitoring radioactivity in the environment of nuclear power plants, 21 May 1982

YVL 7.8 Reporting radiological control of the environs of nuclear power plants to the Institute on Radiation Protection, 21 May 1982

YVL 7.9 Radiation protection of nuclear power plant workers, 14 Dec. 1992 (in Finnish)

YVl 7.10 Monitoring occupational doses at nuclear power plants, 29 Aug. 1994 (in Finnish)

YVl 7.11 Radiation monitoring systems and equipment in nuclear power plants, 1 Feb. 1983

YVL 7.14 Action levels for protection of the public in nuclear power plant accidents, 26 May 1976

YVL 7.18 Radiation protection in design of nuclear power plants, 14 May 1981

Radioactive waste management

YVL 8.1 Disposal of reactor waste, 20 Sept. 1991

YVL 8.2 Exemption from regulatory control of nuclear wastes, 19 March 1992

YVL 8.3 Treatment and storage of radioactive waste at the nuclear power plants, 1 July 1985

The YVL-guides without any language marking are available both in English and Finnish.