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QUALITY ASSURANCE OF NUCLEAR FUEL

CONTENTS

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1 GENERAL

The important systems, structures and components of nuclear power plants shall fulfil high quality requirements in order to attain sufficient safety and reliability. This principle also applies to nuclear fuel, which binds the bulk of the radioactive substances generated by the operation of the plants and which forms the first barrier preventing the release of these substances to the environment.

To attain the above-mentioned objectives, accepted quality assurance programmes are complied with in all activities affecting the quality of fuel. This guide sets forth quality assurance requirements for the procurement, design, manufacture, transport, handling and use of nuclear fuel. The guide is intended for the power company that is responsible for the procurement and use of fuel, for the designer and manufacturer of fuel and for other organizations whose activities affect the quality of fuel and the safety of the transport, storing and use of fuel. The guide is also applied to the procurement of control rods.

This guide does not deal with the control performed by the Finnish Centre for Radiation and Nuclear Safety (STUK) for the quality assurence of fuel. Procedures for that are presented in Guides YVL 6.1 "Licensing of nuclear fuel and other nuclear materials", YVL 6.3 "Supervision of fuel design and manufacture" and YVL 6.6 "Surveillance of nuclear fuel performance". These guides describe, for instance, which documents are submitted to STUK and what kind of inspections are performed by STUK. In addition, these guides give the requirements that are set for the schedule of these activities.

2 GENERAL REQUIREMENTS CONCERNING THE QUALITY ASSURANCE PROGRAMME

The general requirements concerning quality assurance are

set forth in Guides YVL 1.0 "Safety criteria for design of nuclear power plants" and YVL 1.4 "Quality assurance program for nuclear power plants". These guides are also applied to fuel. This guide, however, gives more detailed requirements than those laid down in the general guides mentioned above. The requirements deal with the procurement, design, maufacture, transport, handling and use of fuel and they have to be taken into account in the quality assurance programmes concerning fuel. In addition, the guides described in References /8...16/ can be applied to fuel.

The power company bears the principal responsibility for the implementation of the quality assurance reguirements of fuel presented in this guide. The power company can give duties concerning quality assurance to other organizations, e.g. the designer and manufacturer of fuel. However, the power company is responsible for the total efficiency of the programme, and in its quality assurance programme the power company shall set basic requirements for all quality assurance activities and they shall be taken into account in the quality assurance programmes of other organizations. In the first place, the structure, duties, responsibilities and authority of organizations affecting the quality and safety of fuel shall be clearly defined.

Prior to making an order, the power company shall inspect and accept the quality assurance programmes of the organizations that affect the quality and safety of the fuel, e.g. designer and manufacturer of the fuel and the most important subcontractors. Both beforehand and during the actual work the power company is obliged to conduct audits and inspections with the purpose of ensuring that these quality assurance programmes are acceptably followed in practice.

3 PROCUREMENT OF FUEL

In the procurement documents of fuel (including procurement, conversion and enrichment of uranium and related transports), attention shall be paid to the licensing and the obligations caused by the control of nuclear materials and by the international agreements concerning nuclear energy.

The procurement documents shall include or specifically refer to the regulations, technical requirements, standards and other guides that concern the products or services. These documents shall also present the requirements that concern the identification, receiving inspections, archive samples, packaging, handling, transport and storing of the products.

The procurement documents shall define the conditions and procedures for the acceptance of the products and services. The acceptance of the product is based on the review of design data as well as on the results of factory audits and control, receiving inspections, nuclear material accounting, and of the inspection of other documents defined in the procurement documents. The treatment and acceptance procedure of detected deviations shall be determined.

It shall be required in the procurement documents that the designer and manufacturer of the fuel and the most important subcontractors of the manufacturer have quality assurance programmes that meet the requirements in the power company's quality assurance programme for fuel. Furthermore, it shall be required in the documents that the designer and manufacturer of the fuel give such documents and records of the fuel design and manufacture that it can be consequently checked that the fuel meets the requirements set for it.

It shall be agreed in the procurement documents that the

power company and the regulatory authority can themselves perform audits and inspections concerning fuel design and manufacture, including also the review of necessary documents, at the manufacurer's and subcontractors' factories. During these audits there shall be an opportunity to have some quality control tests repeated. It shall be possible to obtain sample materials from the various phases of manufacture.

Furthermore, the procurement documents specify the documentary material concerning fuel manufacture that is submitted to the power company. It shall also be agreed in the procurement documents how the complete documentary material on fuel manufacture will be stored.

It shall be additionally agreed in the procurement documents that the fuel supplier provides the power company and the regulatory authority with updated data on the operating experience of the fuel type in question (including fuel damages and their causes).

4 FUEL DESIGN

4.1 Design requirements

The design bases shall be defined in writing by the fuel designer. The design bases shall take account of the safety requirements, which must cover normal operation, anticipated disturbances and postulated accident conditions.

There shall exist appropriate procedures whereby the fulfilment of the design bases is demonstrated. In addition, it shall be ensured that the available standards, regulations and guides are correctly interpreted during design. Deviations shall be pointed out and justified.

If changes are to be made in the fuel, they shall be reviewed and accepted by the organizational units responsible

for design and quality assurance. Where applicable, the changes shall be founded on analyses, experimental research and operating experience.

Design documents and other records shall be prepared in a systematic manner and they shall be stored for the whole operating life of the fuel for potential subsequent inspections.

Compatibility with the reactor and with other plant systems shall be ensured in the design. For this purpose, attention shall be paid to such features as the structure of the reactor core, thermohydraulic and reactor physical properties of the reactor, properites of the coolant in the primary circuit and in the fuel storage ponds, and fuel handling, transportation and storage systems.

The assessment of the design shall be based on analyses, experimental research results and data on operational experiences. In the assessment of the design, attention shall be paid to normal operation, anticipated disturbances and postulated accident conditions. The assessment of the design shall be continued for the whole operation of the fuel type in question.

In addition, assessment shall also be performed by experts who are independent of the design. The assessment shall at least include random checking of the analyses, tests and operating experiences that have been used, and comparing of results with the requirements set in the design bases. The assessment can also include alternative and simplified calculation methods.

4.2 Assessment of design performed by the power company

The power company shall assess the data and drawings concerning the fuel design and the materials to be used as well as the analyses, experimental results and data on

operating experiences that are used to demonstrate the fulfilment of the design bases. The assessment shall be based on independent analyses as well as on the power company's own and outside operating experiences, which the power company must systematically follow. In the assessment, the power company can utilize outside experts.

The assessment of the design shall continue for the whole operating time of the fuel type in question and so the design requirements are re-assessed to a necessary extent before a new supplementary batch is ordered. The extent of the assessment depends on the designer and manufacturer of the fuel and on the experiences gained of the fuel type.

In the assessment of a fuel type that the power company has used before, it is at least ensured that no unauthorized changes have been made to the design parameters of manufacture and that all new data and requirements concerning the fuel have been correctly taken account of.

If essential modifications are to be made to a fuel type that the power company has already used, it is necessary to check the design documents concerning the modification, to assess the modification in view of the design bases, to perform appropriate comparative analyses, and to study the effects of the modification on fuel behaviour. The compatibility of the modification with the reactor and the plant shall also be ensured.

The assessment of the design of a new fuel type shall be carried out in full.

In case the power company has no previous experience of the fuel designer and/or manufacturer, the assessment of the fuel design is carried out in full. However, if the fuel type remains the same, the assessment of the fuel design can be restricted to the effects of the changes that have taken place in the details of design and manu-

facture. If the fuel type is such that very little experience can be gained of it anywhere or if the designer and manufacturer have not much experience of the fuel type in question, the assessment of design shall include fabriction of test bundles and evaluation of the operating experience gained from there.

5 FUEL MANUFACTURE

5.1 Subcontracting

The requirements presented in sections 2 and 3 are applied in the preparation of procurement documents. The documents shall especially define the requirements concerning quality assurance, other requirements in regard to the products to be procured and the acceptance procedure for these products.

The competence of subcontractors shall be ascertained in accordance with the significance that the procurement has to safety. The competence can be ascertained, for instance, on the basis of inspections and audits, earlier experiences and sample deliveries. A record shall be kept of the approved subcontractors and they shall be controlled according to a systematic programme.

5.2 Manufacture

The actions required by the quality assurance programme shall be taken during manufacture. The quality assurance organizations of the designer and the manufacturer shall systematically ensure that they are executed.

For the manufacture there shall be sufficient instructions and drawings in which the requirements concerning quality assurance and fuel design are taken account of. Similarly, there shall be sufficient instructions for inspections and control of testing. They shall present, among other

things, requirements concerning inspection and test arrangements, equipment and records as well as acceptance limits and scopes of inspections.

Manufacturing processes and quality control procedures shall be qualified for use according to written instructions. Especially it is necessary to specify those manufacturing and inspection procedures which, due to their complexity, sensitivity or some other reasons, require re-qualification and personnel with extra skills. They include manufacturing and inspection procedures that are, for instance, essential to the quality of the product, such as working, welding, heat treatment and non-destructive testing. Detailed instructions shall be prepared for the qualification and periodic re-qualification of these procedures, for their use and for the continuous assurance of the personnel's competence. Data on the persons, working procedures and equipment that meet the qualification requirements shall be recorded in continuously updated documents.

During manufacture, fuel bundles and boxes and their parts shall be marked unambiguously according to written instructions so that their identification and control is possible right back to the beginning of the manufacturing process and the initial materials. Where applicable, materials shall be physically separated during manufacture.

For controlling products, work performances and functions that do not meet the requirements, there shall be a written procedure. The procedure shall include instructions for the identification and isolation of a non-conforming product or process, for deciding about the necessary steps to be taken, for finding the reasons for the non-conformance, and for informing the appropriate organizations. Non-conforming products shall be assessed and accepted, rejected or repaired according to written instructions and plans. These instructions shall also define the respon-

sibilities and authorities in regard to the actions. Factors that have a harmful effect on quality, such as faulty materials and equipment, malfunctions and other deficiencies, shall be specified and repaired as soon as possible according to written instructions.

5.3 Storing and shipping

For the storing, handling and packaging of the fuel and its parts, there shall exist instructions whereby the fuel is reliably prevented from reaching criticality or becoming damaged in any other way.

5.4 Manufacturing control performed by the power company

On the basis of written material, the power company shall assess the procedures and specifications concerning the manufacture and quality control of fuel. In accordance with section 2, the power company shall perform systematic inspections and audits of the fuel manufacture. These inspections shall also be extended to the most important subcontractors. The power company shall ensure that the manufacture utilizes procedures that comply with the accepted quality assurance programmes and other technical requirements and guides. Inspections shall be performed before the manufacture of the product is begun and also during the manufacture on a regular basis and, when necessary, by means of random tests. In these inspections the power company can use outside experts as assistance.

6 TRANSPORTATION, RECEIVING, STORING AND HANDLING OF FUEL

6.1 Transportation

Fuel is transported in packages described in Ref. /5/. For the transportation, there shall be a transportation plan /6/, which includes the necessary procedures and instructions. These instructions shall depict the actions

that are needed to assure the safety of the transportation as well as the requirements whereby the fuel is prevented from becoming damaged during the transportation. The consignor and the consignee shall beforehand agree on the tranportation. The requirements concerning nuclear materials control and physical protection and the provisions included in international agreements shall also be taken into account.

6.2 Receiving inspection

The receiving inspections at the plant site shall be conducted according to instructions that have been prepared in advance. The instructions shall specify the organizational unit that is responsible for the inspections in the power company, and the competence that is required of the personnel. Furthermore, the instructions shall indicate the requirements concerning the performance of the inspection, the records that are written, and the procedures in case of deviations.

At least the following items are subject to inspection:

a) Fuel shipping documents and transportation log

b) Fuel manufacturing records to be submitted to the power company.

In the inspection it is ascertained on the basis of the records that the requirements set for the fuel are met as regards the manufacture.

c) Transportation package

The transportation package is inspected visually.

d) Fuel

The fuel is subjected to appropriate visual inspections and measurements. The repairing and/or acceptance of non-conformances detected in receiving inspections shall be agreed upon beforehand with the fuel designer.

6.3 Storing and handling

For the storing of fresh fuel at the plant site there shall be plans and instructions which define the storing conditions and other protective measures taken in respect of the fuel bundles.

For the handling of the fuel there shall be instructions which include any recommendations given by the fuel manufacturer. The acceptablility of the instructions shall be ascertained during the testing of the fuel handling systems. In addition, the instructions shall define the order of handling procedures, responsibility for the performance and supervision of the work, and the number and competence of personnel needed in the work.

For the loading of the fuel into the reactor there shall be a separate loading plan /2/ which refers to the appropriate procedures and instructions concerning loading. In preparing a loading plan, it shall be ensured that the fuel bundles have been accepted for use /4/.

The competence of the personnel participating in the handling of fuel and in the supervision of handling shall be ascertained beforehand in accordance with written instructions. The persons participating in the work shall be given basic training according to Guide YVL 1.7 "Qualifications of Nuclear Power Plant Personnel" as well as appropriate supplementary training and practice in the duties involved.

Technical requirements concerning the handling and storing of fuel and the systems and components needed therein are presented in a separate guide. Furthermore, the requirements concerening nuclear materials control and physical protection shall also be taken into account in the handling and storing of the fuel.

7 FUEL UTILIZATION AND INSPECTIONS

The principal provisions and limitations in regard to the use of fuel are given in the Technical Specifications of the plant unit. The surveillance of fuel performance and the inspections of spent fuel shall be conducted in accordance with a fuel surveillance programme /7/ prepared in advance.

The operational units that are responsible for fuel design in the power company shall assess the data obtained from the use and inspections of the fuel. An effort shall be made to find out reasons for fuel damages. These data shall be taken into account when analysing fuel performance for future operating cycles, when ordering new supplementary batches and when supervising the design and manufacture of fuel.

8 REFERENCES

1 Guide YVL 1.4 "Quality assurance program for nuclear power plants"

2 Guide YVL 1.13 "Supervision of shutdowns at nuclear power plants"

3 Guide YVL 6.1 "Licensing of nuclear fuel and other nuclear materials"

4 Guide YVL 6.3 "Supervision of fuel design and manufacture"

5 Guide YVL 6.4 "Supervision of nuclear fuel transport packages"

6 Guide YVL 6.5 "Supervision of nuclear fuel transport"

7 Guide YVL 6.6 "Surveillance of nuclear fuel performance"

8 Code of Practice "Quality assurance for safety in nuclear power plants", 50-C-QA, IAEA 1978

9 Safety Guide "Quality assurance records system for nuclear power plants", 50-SG-QA2, IAEA 1979

10 Safety Guide"Quality assurance in the procurement of items and services for nuclear power plants" 50-SG-QA3, IAEA 1979

11 Safety Guide "Quality assurance during site construction of nuclear power plant", 50-SG-QA4, IAEA 1981

12 Safety Guide "Quality assurance during operation of nuclear power plants", 50-SG-QA5, IAEA 1981

13 Safety Guide "Quality assurance in the design of nuclear power plants" 50-SG-QA6, IAEA 1981

14 Safety Guide "Quality assurance in the manufacture of items for nuclear power plants", 50-SG-QA8, IAEA 1981

15 Safety Guide "Quality assurance auditing for nuclear power plants", 50-SG-QA10, IAEA 1980

16 Safety Guide "Quality assurance in the Procurement, Design and Manufacture of Nuclear Fuel Assemblies", 50-SG-QA11, IAEA 1983

In the event of any differences in interpretation of this guide, the Finnish version shall take precedence over this translation.