STUK

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THE COMMISSIONING OF A NUCLEAR POWER PLANT

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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 Resolution (395/1991) on the Safety of Nuclear Power Plants
- Section 13 of the Government Resolution (396/1991) on the Physical Protection of Nuclear Power Plants
- Section 11 of the Government Resolution (397/1991) on the Emergency Preparedness of Nuclear Power Plants
- Section 8 of the Government Resolution (398/1991) on the Safety of a Disposal Facility for Reactor Waste
- Section 30 of the Government Resolution (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 Resolution (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

The commissioning of a nuclear power plant refers to the measures whose purpose is to demonstrate and verify the appropriateness of the licence-holder's organization as well as the planned operation and safe use of the plant systems, structures and equipment. Since the commissioning is an essential phase in terms of the safety of the subsequent power operation of the plant, it shall be planned carefully in advance and implemented with the aid of competent personnel.

STUK reviews the commissioning plan of a nuclear power plant as part of handling the construction licence. The commissioning and related start-up tests begin even before the plant is granted an operating licence and continue as testing at different power levels under STUK's control.

This Guide defines the requirements for the commissioning and testing of a nuclear power plant and the regulatory control by the Radiation and Nuclear Safety Authority (STUK) in the commissioning and testing phases. Where applicable, this Guide also applies to commissioning related to the modifications made to nuclear power plants that are being operated.

Where applicable, this Guide also concerns regulatory control of the commissioning of other nuclear facilities.

2 General objectives of the commissioning

During the commissioning of a nuclear power plant, the systems, structures and equipment built at the plant are commissioned, and it is verified that they fulfil the design requirements and that the instruction manuals drawn up for their operation are sufficient. During the commissioning, it is verified that the structure, functions and duties of the licence-applicant's organization as well as the number and competence of necessary personnel are sufficient to ensure the safe operation of the nuclear power plant. Furthermore, modifications made during the construction are inspected and recorded in documents during the commissioning.

The commissioning plan of a nuclear power plant shall be so extensive and specified that appropriate design and construction as well as safe operation of the plant can be verified on its basis. The commissioning shall be planned and implemented in such a manner that the operating personnel can get acquainted with operation of the plant during the commissioning and, at the same time, it can be verified that the training of the operating personnel is sufficient.

The testing of a nuclear power plant is an essential part of plant commissioning. The objective of the testing is to demonstrate that the plant has been constructed and operates as designed. The main stages of the testing are as follows:

- system performance tests;
- fuel loading and pre-criticality tests of the reactor systems;
- making the reactor critical and low-power tests;
- power tests.

Before testing the systems, the readiness of individual components and structures for operation shall be verified in accordance with the relevant YVL Guides.

System performance tests refer to tests that are carried out before fuel loading and to those tests of individual auxiliary systems that can only be conducted during fuel loading or thereafter. System performance tests also include compatibility tests of the main and auxiliary systems. Pre-criticality tests of the reactor systems refer to tests that cannot be carried out until after completion of the fuel loading. Low-power tests refer to tests during which the reactor power does not exceed 5% of the rated power.

During the commissioning, it shall be verified that the documents concerning the operation and periodic tests of the plant systems, structures and equipment are appropriate. To this end, it shall be verified in particular that the documents do not contain any errors that would jeopardize the safety. Furthermore, the clarity, unambiguity and applicability of the instructions and documents shall be verified.

The main stages of the testing are divided into sub-tests. One sub-test is a part of the testing for which a detailed test programme is drawn up. During system performance tests, one sub-test may comprise, for instance, all the measures taken to demonstrate that the boron control system fulfils the set requirements. During power tests, one sub-test may be, for instance, a turbine trip test.

During the testing, basic data shall be gathered on the operational properties of the systems and equipment; this data will be used later as a basis for assessing the results of the periodic tests to be carried out during operation. The suitability of the monitoring and control equipment necessary for the operation shall be verified at the same time.

3 Organization and quality management of the commissioning

3.1 General requirements for organizing the commissioning

The licence-holder is responsible for nuclear and radiation safety whatever the way in which the commissioning has been arranged. The licence-holder shall plan and establish, well in advance, a commissioning organization that has the necessary expertise and experience to control the commissioning and to ensure the safety in all phases of the commissioning. Guide YVL 1.7 defines the operations and functions important for nuclear power plant safety and the requirements for the organization and personnel involved in these operations, as well as for the employment and training of the personnel. Furthermore, various YVL Guides contain requirements for the functions important to safety (e.g. radiation protection, maintenance). Guide YVL 1.6 gives the requirements particularly for the training and licensing of operators before the plant commissioning.

The personnel involved in the plant commissioning may consist of persons belonging to the following organizations:

- plant supplier and its sub-suppliers;
- testing group;
- operating group.

It is the licence-holder's responsibility to demonstrate that the plant has been constructed and the equipment installed in accordance with the plans and that the licence-holder's organization fulfils the requirements set by the authorities. The task of the testing group is to verify the future safe operation of the plant systems and equipment with the aid of start-up tests. The task of the operating group is to operate the plant and its systems in accordance with the inspected and approved operating instructions and test programmes. Some of the personnel of the plant operating group shall be involved in carrying out start-up tests in such a way they are able to get acquainted with the plant and its systems during the commissioning and testing. Some of the licence-holder's personnel normally belong to the testing group as well.

The licence-holder shall be responsible, for instance, for

- steering, assessing and co-ordinating the operations of the plant supplier, the testing group and the operating group;
- verifying that persons who have the necessary expertise and experience prepare, assess and approve the operating instructions and the test programmes, as well as documentation of the test results;
- planning the procedures to be followed in co-ordinating the commissioning;
- ensuring that a sufficient number of people who have been trained, qualified and authorized for their jobs are available for the commissioning operations;
- submitting the documents pertaining to the commissioning to STUK in accordance with Guide YVL 1.2.

The design organizations of the plant and systems, the equipment manufacturers and the quality control personnel take part in the commissioning as well. They shall co-operate closely with the organizations that carry out the testing. In particular, the licence-holder shall verify that the plant supplier's design engineers and equipment manufacturers supply the organizations

concerned with all information necessary for the commissioning. In addition, the licence-holder shall ensure that the design engineers examine the test results of the plant and verify that they are in accordance with the design and the set target values.

Since functions linked with the construction, commissioning and operation of a nuclear power plant partly coincide, the responsibilities of the different organizations shall be defined clearly and unambiguously such that no unclear or unsettled matters remain between the different organizations.

The recommendations given in Chapter 4 of Reference [1] shall be taken into account, where applicable, in organizing the commissioning.

3.2 Quality management of the commissioning

The licence-holder shall ensure that an advanced quality management system is applied in the plant commissioning. The quality management system shall define the requirements for the structure of the commissioning organization, the division of authority and responsibility, the management and working procedures, and the principal working processes. The quality management system shall also specify the procedures to control the quality management systems of external organizations involved in the commissioning.

The quality management system shall lay down the requirements for defining the interfaces between the quality management systems of the licence-holder and the external organizations. Furthermore, procedures shall be presented for definition and documentation of the responsibilities of the different organizations involved in the commissioning.

Since the commissioning begins during construction and continues after the granting of the plant operating licence, the requirements for the commissioning shall be correspondingly presented in the quality management systems of the construction and operating phases.

Requirements set for the licence-holder concerning quality management of the commissioning are specified below in the sections that deal with the commissioning and testing plans, testing programmes and system performance tests.

Guides YVL 1.4 and YVL 1.9 deal with the requirements for the quality management system of a nuclear power plant and for the functions and processes of the organization that shall be met in the quality management of the commissioning and testing.

4 Commissioning and testing plans

The commissioning plan shall contain a description of how the plant commissioning is organized. The plan shall describe how and in which stage of the commissioning the functions important for nuclear power plant safety and other operations referred to in Guide YVL 1.7 are performed.

The commissioning plan of the plant shall be presented in the preliminary safety analysis report or in a document supplied as a part of it. With regard to testing, the plan shall contain the following:

- the scope of the testing, including the main stages, and the areas of responsibility assigned to those organizations that are involved in planning the testing programmes necessary for the different stages and in implementing the tests;
- instructions and procedures to be followed in planning the testing;
- utilization of the experience gained with similar plants in planning the testing;
- identification of the items that require special attention, and separate summaries of the tests to be carried out on these items;
- a preliminary estimate of the testing schedule;
- the role of the testing in validating the plant operating instructions;
- an estimate of the number of personnel required in the different organizations during testing.

A testing plan shall be submitted to STUK for information well in advance before starting the system performance tests. This plan shall contain information on the following:

- principal stages of the testing and the objectives set for each stage;

- organizations involved in the testing, including their areas of responsibility, and definition of the duties of the most important persons;
- instructions and procedures to be followed in drawing up the testing programme;
- delineation of authority during the testing, the principles that ensure compliance with the testing programme, and the procedure for modifying the testing programme, if necessary, during its implementation;
- utilization of the experience gained with similar plants in drawing up the testing programme;
- a schedule for drawing up the plant operating instructions and a plan specifying the role of the testing in ensuring the correctness and adequacy of these instructions;
- a testing schedule, which specifies the planned durations and mutual chronological order of the different sub-tests, and deadlines for completion of the detailed test programmes;
- procedures to be followed in fuel loading and in achieving the criticality, including the safety measures and precautions;
- a summary plan for the system performance tests and the pre-criticality tests of the reactor systems, including the name of the detailed test programme drawn up for each test, any preliminary requirements for conducting the test, the purpose of the test, and a description of the test scope and acceptance criteria;
- a summary plan for the low-power and power tests, including the name of the detailed test programme drawn up for each test, the purpose of the test, a description of the test scope and acceptance criteria, and a description of the power levels at which the tests are planned to be conducted;
- the procedure for assessing the test results, including the division of duties, and measures to be taken in the event that some test results fail to meet the acceptance criteria;
- the method for recording the results.

The final safety analysis report shall contain a summary of the testing plan and other matters and descriptions connected with the testing stated above. A summary of the test results shall be attached to the final safety analysis report when they become available.

5 Requirements for the testing programmes

5.1 System performance tests

System performance tests shall be conducted to demonstrate that every system important to safety and every individual part thereof is capable of fulfilling its designed function. It shall be further demonstrated that the systems are capable of functioning together as designed. The tests shall ensure the operability under normal operating conditions and, as far as possible, under the transient and accident conditions in which the systems are required to function.

An example of the system performance tests is given in the Appendix to Reference [1]. The recommendations and instructions given in Sections 5.1–5.5 of Reference [1] shall also be taken into account, where applicable, in planning the tests. If it has been planned to conduct a system performance test after the beginning of fuel loading, this shall be justified test by test.

A detailed test programme shall be drawn up for each test in advance; the scope of the programme shall comply with the recommendations stated in Sections 5.6–5.20 of Reference [1]. The main sections of the programme are the following:

- an introduction;
- a description of the test sequence, if necessary owing to the nature, scope or clarity of the test;
- purpose of the test and test methods;
- acceptance criteria;
- limits on plant operation and other conditions for the test performance;
- initial state of the systems;
- prerequisites for performing the test;
- test conditions and instructions for the test performance;
- a description of the provision made for malfunctions during the test performance;
- instruments to be employed and other testing equipment required;
- the number of personnel involved in the test, requirements for the personnel and delineation of their responsibilities;
- specific instructions concerning occupational safety and component shielding;

- completion of the test;
- recording of the data to be monitored during the test;
- documentation of the test results.

In addition to the above, the programme shall contain, as a separate entry, a description of the measuring instruments or systems that may be required and that are not included in the plant fixed equipment.

The tests shall be carried out as closely in accordance with the established programmes as possible; any non-conformances and their causes shall be documented. All arrangements for the measurement and output shall be checked before conducting the test, and the test results shall be documented in a way agreed on in advance.

The test programmes of the system performance tests shall be submitted to STUK for approval in accordance with the regulations stated in Section 7.2 below.

5.2 Fuel loading and pre-criticality tests of the reactor systems

Guide YVL 1.1 defines the preconditions for the beginning of fuel loading. A loading plan shall be drawn up, containing the following information:

- a summary of the neutron flux and gamma radiation monitoring equipment required during loading and any other special measuring instruments;
- the organization responsible for the loading, and the number, training and duties of the personnel required during loading;
- the status of the reactor containment building and the systems contained in it during loading;
- detailed loading instructions;
- special safety instructions to be observed and precautions to be taken during loading.

The recommendations given in Sections 5.34–5.42 of Reference [1] shall be taken into account, where applicable, in planning the loading.

Examples of the pre-criticality tests of the reactor systems are given in Sections A3–A17 of the Appendix to Reference [1]. The requirements for system performance tests presented in Section 5.1 of this Guide also apply to the pre-criticality test programmes, performance of the tests and documentation of the test results.

The fuel loading plan and the pre-criticality test programmes of the reactor systems shall be submitted to STUK for approval.

5.3 Making the reactor critical and low-power tests

Making the reactor critical is considered to begin when either of the following takes place:

- boron dilution is begun in a pressurized-water reactor;
- the withdrawal of the first control rod from the reactor is begun in a boiling water reactor.

When making the reactor critical, the recommendations given in Sections 5.43–5.47 of Reference [1] and in Section A19 of its Appendix shall be taken into account, where applicable. The procedure shall be described in a detailed programme, which fulfils the requirements set for the system performance test programmes, where applicable.

The recommendations given in Sections 3.22–3.24 of Reference [1] shall be taken into account, where applicable, in planning low-power tests. An example of the low-power tests is given in Section A20 of the Appendix to Reference [1]. The requirements for system performance tests presented in Section 5.1 of this Guide also apply to the low-power test programmes, performance of the tests and documentation of the test results.

A test programme shall be drawn up to determine the neutron and gamma radiation. Radiation levels, particularly in the vicinity of the reactor, primary circuit and other principal radiation sources, are examined in accordance with this programme.

The programme concerning the making of the reactor critical and the low-power test programmes shall be submitted to STUK for approval.

5.4 Power tests

The purpose of power tests is to establish the plant performance at different power levels, e.g. at levels of 10%, 25%, 50%, 75%, 90% and 100% of the rated power.

The recommendations given in Sections 3.25–

3.28 of Reference [1] shall be taken into account, where applicable, in planning power tests. An example of the power tests is given in Section A21 of the Appendix to Reference [1].

The requirements for system performance tests presented in Section 5.1 of this Guide also apply to the power test programmes, performance of the tests and documentation of the test results. Furthermore, the required power level is stated in each test programme.

Radiation level measurements shall be conducted extensively at different power levels to ensure that the area classification and markings in accordance with Guide YVL 7.9 related to the working are correct.

The power test programmes shall be submitted to STUK for approval.

6 Requirements for the reporting

A report shall be drawn up on the results of all tests included in the testing programme. In addition to the final test results, the report shall contain information on the non-conformances and their causes and on the repair and improvement measures taken during the testing that have been necessary to achieve acceptable test results.

Furthermore, a summary report shall be drawn up on each stage of the testing. Besides essential results of the test stage concerned, the report shall contain a summary of the observations made during the testing as well as an assessment of the appropriateness of the testing performed in the stage concerned and of any necessary changes to the testing programme or the plant use.

On completion of the testing, the licence-holder shall assess the results of testing as a whole. As part of this, the licence-holder shall assess, for instance, whether any modifications to the plant's technical specifications are necessary. The necessary modifications to the technical specifications and other documents shall be made in accordance with the proper procedures.

7 STUK's control in the commissioning and testing phases

7.1 Commissioning

STUK inspects the commissioning plan of a nuclear power plant as part of the preliminary safety analysis report.

In addition, STUK controls the licence-holder's functions during the construction and commissioning in the manner and within the scope described in the relevant YVL Guides to ensure the safe commissioning of the plant.

7.2 System performance tests

The licence-holder shall request STUK's approval for all test programmes that involve systems belonging to safety classes 1, 2 and 3. Of the systems belonging to safety class 4, STUK determines, on the basis of the plant testing programme, those system tests whose programmes the licence-holder shall submit to STUK for approval. Other test programmes of the systems belonging to safety class 4 shall be submitted to STUK for information. The test programmes of compatibility tests of the main and auxiliary systems shall also be submitted to STUK for approval.

If a test programme is subject to STUK's approval, the test may be begun only upon receipt of the approval. Beginning the test means the first measure aimed to demonstrate the performance of the tested item and whose results are documented for use during the acceptance procedure. However, inspections and tunings of the automation equipment, flushing of the pipework and other preparatory measures can be carried out before beginning the test programme.

The Radiation and Nuclear Safety Authority supervises system performance tests at the power plant, as it deems necessary. The general principle is to oversee the tests of systems belonging to safety classes 1 and 2 and some of the tests of systems belonging to safety classes 3 and 4. For the purpose of overseeing the tests, STUK shall be provided with testing schedules well in

advance. STUK shall be informed of any changes in the schedules without delay. STUK shall be informed of the tests early enough, but the presence of STUK's representative is not a precondition for conducting the test, unless STUK has required this in its decision of approval on the testing programme concerned. Performance tests of the auxiliary equipment of the pressure equipment form part of the commissioning inspection in accordance with Guide YVL 3.7 and, as far as they are concerned, STUK's control is dealt with in Guides YVL 3.0 and YVL 3.7. Preliminary documents of the system performance test results, which have been inspected by the testing organization, shall be submitted of all tests whose programmes are subject to STUK's approval no later than as part of the application concerning fuel loading.

7.3 Fuel loading and pre-criticality tests of the reactor systems

The operation of a nuclear power plant is considered to begin when the loading of nuclear fuel into the reactor begins. Loading the reactor may begin after the plant has been granted an operating licence and STUK has accepted the application concerning fuel loading and the reports on the reactor and fuel behaviour in the first operating cycle. To ensure that the plant fulfils the requirements set for it, STUK carries out an inspection in accordance with Section 20 of the Nuclear Energy Act before fuel loading. Guide YVL 1.1 describes the contents of the inspection.

STUK oversees the fuel loading and inspects, upon its completion, whether the loading has been performed in accordance with the loading plan and that compliance of the loading with the plans has been verified in the way required by the licence-holder's quality management system. The closing of the primary circuit and pre-criticality tests of the reactor systems may be begun after STUK has inspected the loading pattern of the fuel assemblies and approved the pre-criticality test programmes. STUK supervises pre-criticality tests of the reactor systems, as it deems necessary.

When results that meet the acceptance criteria have been achieved in the pre-criticality tests of the reactor systems, STUK's permission may be requested to make the reactor critical and to perform the low-power tests at the power specified in the application. Preliminary results of the preceding tests, which have been inspected by the testing organization, shall be submitted as part of the application within the scope necessary to prove that the acceptance criteria have been met.

7.4 Making the reactor critical, low-power tests and power tests

Making the reactor critical may be begun after STUK has taken a decision to approve the programme that describes the measures concerned. The same decision may also apply to low-power tests provided that the related programmes have been approved.

STUK supervises the making of the reactor critical, low-power tests and power tests, as it deems necessary.

When results that meet the acceptance criteria have been achieved in the low-power tests, STUK's permission may be requested to perform the power tests at a certain power specified in the application. Preliminary results of the preceding tests, which have been inspected by the testing organization, shall be submitted as part of the application within the scope necessary to prove that the acceptance criteria have been met.

When results that meet the acceptance criteria have been achieved at the specified power level, STUK's approval may be requested for the use of a higher power. The application shall contain preliminary results of the tests conducted at the previous power, which have been inspected by the testing organization, within the scope necessary to prove that the acceptance criteria have been met. The power may be raised to a new, higher level after STUK has preliminarily inspected the results of the tests conducted at the previous power level and taken a decision to approve the programmes of the tests to be carried out at the new power level.

7.5 Documentation of the test results

Final documentation of the results of all tests whose test programmes are subject to STUK's ap-

proval shall be submitted to STUK for approval within two months of the completion of the tests, unless no other deadline has been required by YVL Guides for the documentation concerned.

8 References

1. IAEA Safety Guides, Safety Series NS-G-2.9, Commissioning of Nuclear Power Plants Safety Guide, IAEA, Vienna, 2002.