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Nuclear power plant pressure vessels

Inservice inspections

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Inservice inspections

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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 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.

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 the YVL Guides is achieved. This Guide does not alter STUK's decisions which were made before the entry into force of this Guide, unless otherwise stated by STUK.

Translation. Original text in Finnish.

1 General

As stipulated in section 117 of the Nuclear Energy Decree (161/88), the Finnish Centre for Radiation and Nuclear Safety (STUK) regulates pressure vessels of nuclear facilities in compliance with the Nuclear Energy Act (990/87) and, where applicable, with the Pressure Vessel Act (98/73) and the rules and regulations issued by virtue of them.

In this Guide, requirements are presented for the planning and reporting of inservice inspections of nuclear power plant pressure vessels. This Guide specifically applies to inservice inspections of Safety Class 1 and 2 nuclear power plant pressure vessels, piping, pumps and valves plus their supports and reactor pressure vessel internals by non-destructive examination methods (NDE). Preservice examinations are conducted before a nuclear power plant is commissioned. Individual inservice examinations are usually conducted during outages.

Inservice inspections according to the Pressure Vessel Decree (549/73) are discussed separately in Guide YVL 3.0.

2 Definitions

For the purposes of this Guide, the following definitions relate to the reporting of examination results:

Indications mean **flaw indications** and **geometrical indications**.

Flaw indication is evidence of a flaw that is detectable by NDE methods.

Geometrical indication is an indication of the geometry or metallurgical structure of the examination area that is detectable by NDE methods.

Flaw means an imperfection or unintentional discontinuity in the structure that is detectable by NDE methods.

Recording level is the threshold at which indications shall be recorded. Indications exceeding this threshold shall be entered in the examination records.

Evaluation level means the threshold at which the character, size, location and orientation of an indication shall be investigated in detail and compared with previous examination results and with the limits specified in the acceptance standards. Evaluation level is usually the same as recording level or it is established between the recording level and the acceptance standard due to statistical scattering of the examination results.

Acceptance standard denotes STUK-approved flaw indication acceptance standards or other documents presenting limits which, if exceeded, require further action such as analysis of flaw origin, repair of flaw, replacement of structure, extension of examination scope, fracture mechanical analyses and monitoring of flaw size growth by increased examination frequency.

3 Requirements

The inservice inspection basic requirements shall be according to ASME Boiler and Pressure Vessel Code, Section XI, Rules for Inservice Inspection of Nuclear Power Plant Components, Division 1, (ASME Code, Section XI) /1/. Deviations from the Code shall be justified and it shall be demonstrated that a corresponding level of safety and reliability is achievable in some other way. When establishing an inservice inspection practice, it is recommended that the International Atomic Energy Agency's safety guide "In-Service Inspection for Nuclear Power Plants" /2/ and the manual "In-Service Inspection of Nuclear Power Plants" /3/ are used.

STUK sets detailed requirements in separate decisions, if necessary.

A nuclear power plant's Preliminary Safety Analysis Report (PSAR) shall include a description of the principles applied during inservice inspections. The PSAR is dealt with according to Guide YVL 1.1. The description shall present general principles for inservice

inspections, indicating the prerequisites for reliable and sufficiently extensive inservice inspections.

4 Inservice inspection programme

In this Guide, the inservice inspection programme means a combination of documents relating to a nuclear power plant's inservice inspections. The documents referred to here are

— the summary programme
— the preservice inspection programme
— the individual inservice inspection programmes.

The inservice inspection programme shall be kept up-to-date and supplemented so that, at each time of inspection, an explicit and unambiguous programme plus procedures are available.

4.1 Summary programme

When an operating licence for a nuclear power plant is applied for, the applicant shall submit the inservice inspection summary programme to STUK for approval.

The summary programme shall cover all Safety Class 1 and 2 pressure vessels, piping, pumps and valves plus their supports and reactor pressure vessel internals. The principles governing selection of the areas of examination and the methods and frequency of the examinations, and also reporting of the examination results and the procedures for evaluating flaw indications shall be presented in the programme. The programme shall cover all inservice inspection procedures from preservice inspections of the nuclear power plant until the end of the plant's operating life.

If the acceptance standards in /1/ cannot be applied e.g. because the highest allowable membrance stresses employed deviate from the instructions of /4/, the licensee shall obtain STUK's approval for some other known acceptance standard or for case-specific acceptance limits.

The edition of the reference code /1/ and its addenda on which the programme is based shall be indicated and any deviations thereof justified.

If there are areas in components and piping important to safety which are subject to particularly high stress, or, if it has not been possible to reliably define loads, these areas shall be taken into account when determining the examination scope. Examination frequency shall then be increased, if necessary.

The following items shall be included in the summary programme:

a) General procedures for inspection activities, quality assurance and the principles observed when selecting components for examination and the examination areas. They are i.a.:
   — practice for preparation and acceptance of programmes
   — general principles for selecting the areas, methods, extent and frequency of examinations
   — reporting of examination results and procedures for evaluating flaw indications.

b) List of main components subject to inservice examination of which the following information shall be given:
   — safety class
   — system
   — components to be examined (pressure vessels, pipelines, pumps and valves with their component identifications)
   — areas of examination (welded joints of pressure vessels and other main components are specified)
   — structural material
   — examination methods.

c) Equipment for examination of the reactor pressure vessel and other main components

d) Plan for qualification of examination procedures and equipment

e) Necessary drawings
   — structural drawings of pressure vessels and of other main components, specifying welded joints and other areas of examination
   — flow charts with examination areas clearly marked and specified by safety class.

4.2 Preservice inspection programme

The preservice inspection programme shall be submitted to STUK for approval not later than three months before the planned time of examination.

The edition of the reference code /1/ and its addenda on which the programme is based shall be given.

A preservice examination shall be performed also during plant operation if a component or a part of piping within the examination scope is repaired, modified or replaced.

The purpose of preservice inspections is to obtain data about the original condition of the areas of examination within the inservice inspection scope before the nuclear power plant is started up to complement quality control of manufacture and installation, and to offer basic data against which to compare the results of individual inservice examinations. As far as possible, the examinations shall be conducted by the same methods, techniques and types of examination equipment as are used in individual inservice examinations.

If the examination methods of preservice inspections deviate from the examination techniques determined in /1/, it shall be demonstrated that the results are at least as reliable as those obtained using the examination technique defined in the reference. However, standards notwithstanding, it is recommendable to use the best technique generally available.

The examination procedures and equipment shall be qualified. The extra qualification of personnel and the approval of the examination organisations required for inservice inspections are described in more detail in Guide YVL 1.3.

The following items shall be included in the preservice inspection programme:

a) Description of examination organisations
   — examination scopes
   — description of on-site organisation and responsible persons
   — applicable working instructions
   — reference is made to the qualification of personnel and the approval of the examination organisation required in Guide YVL 1.3.

b) List of examination areas
   — component or piping identification
   — safety class
   — unambiguous specification of welded joints and other areas of examination (reference is made to drawings)
   — nominal dimensions of the examination area
   — structural material
   — examination category in accordance with /1/
   — examination method
   — examination procedure
   — limitations on examinations.

c) Drawings of examination areas
   — drawings of the piping, with the examination areas marked
   — structural drawings of the components, with the examination areas marked
   — detailed drawings of welded joints and of other examination areas, indicating the geometry and dimensions of each area.

d) Examination procedures
   — description of the qualification of procedures
   — drawings of reference blocks with data on structural materials and applicable standards
   — scan path sketches, if such are required to establish the extent of examinations.

e) Testing procedures for examination equipment and a description of the qualification of equipment

The above information shall be given on examinations carried out during manufacture and installation if the examinations replace some of the preservice examinations. Pressure vessels shall be examined after pressure testing, and supports welded to the pressure-retaining parts of the vessels shall be examined after hot functional testing.

4.3 Individual inservice inspection programmes

The inservice inspection programme shall be submitted to STUK for approval not later than one month before the planned time of examination. If substantial alterations to an established inspection practice are planned STUK shall be notified well before the actual inspection programme is submitted.

The requirements of the preservice inspection programme presented in subsection 4.2 apply to an individual inservice inspection programme. In each inspection-specific programme, examinations conducted and examination procedures and other documents which have changed since the previous examination shall be stated. The edition of the reference code /1/ and its addenda on which the programme is based shall be indicated.

If new or improved methods, techniques, examination procedures or equipment are employed for inservice examinations their conformity with those employed for previous examinations shall be assessed. In the examinations, the best technique generally available shall be used, taking into account delays in standardisation. The examination procedures and equipment shall be qualified.

The individual inservice inspection programmes shall be so planned that, during the examination intervals the required number of examinations is completed in accordance with the summary programme. Fulfillment of the examination requirement shall be demonstrated by cumulative summary lists of examination history which show i.a. each area's examination date and indications recorded.

Guide YVL 1.3 presents requirements set for examination organisations and for individuals conducting inservice examinations.

5 Implementation and regulatory control of inservice inspections

STUK's approval shall be obtained for an examination organisation and its personnel in accordance with Guide YVL 1.3. Extra qualification is then required of personnel performing inservice examinations.

Inservice inspections shall be performed in accordance with STUK-approved programmes. Deviations with justifications shall be presented in a summary report. Flaw indications exceeding acceptance standards are subject to STUK's approval before the reactor is made critical again.

5.1 Control of inservice inspections

STUK oversees inservice inspections on site by making audits in the extent considered necessary. Included are general arrangements for the inspections, reporting of results and flow of information between various parties. The licensee shall deliver to STUK a preliminary examination schedule for the main components or for their parts and assign a contact person. Based on the schedule, STUK designates those areas of examination for which the exact time of commencement of the examination must be given.

5.2 Exceeding of acceptance standards

If flaw indications exceed thresholds specified in acceptance standards, measures shall be taken such as repairs, structure replacements, fracture mechanical analyses, additional examinations, extended examination scopes, increased examination frequencies and special measures to prevent and monitor flaw growth, or combinations thereof.

An assessment of mechanisms affecting flaw generation shall always be presented.

The Appendix "Flow chart for evaluating the examination results" gives an example of the decision-making process in case the acceptance standards have been exceeded.

Besides the established examination technique, it is often advisable to perform examinations using supplementary techniques to define the exact character, location, orientation and size of flaws.

If flaw indications exceeding the thresholds specified in acceptance standards are detected in inservice examinations, the examinations shall be extended to cover equivalent areas of examination, as required in /1/. The aim is to investigate whether the flaw indications are generic in other corresponding areas of examination.

Components and piping or parts thereof in which flaw indications exceeding acceptance standards are detected during inservice examinations must usually be repaired or replaced. Requirements for repairs and modifications are presented in Guide YVL 1.8.

If flaw indications are to be approved for operation on the basis of fracture mechanical analyses and without repairing or replacing the structure, the analyses can be made in accordance with Appendices A, C and H of /1/, or with some other procedure separately approved by STUK. In a cladded structure, the effect of the cladding shall be taken into account. Possible flaw growth shall be monitored by increasing the examination frequency as prescribed in /1/, until it can be demonstrated that no significant flaw growth occurs during the examination interval.

New flaw indications or indications which have grown compared with previous examinations can be submitted to monitoring case by case by increasing the examination frequency to detect growth, if any, before it reaches limits specified in acceptance standards.

In addition, further measures may be required in cases where, on the basis of fracture mechanical analyses, flaw indications exceeding acceptance standards are permitted in a structure. The measures aim to prevent and observe flaw growth during the subsequent examination period. The measures may be based on the origin of the flaw, type of structure and material, ambient and operating conditions and estimated flaw growth rate.

Further measures may be taken e.g. to
— lower residual stress
— modify ambient conditions
— lower primary and secondary stresses.

If a flaw indication exceeding thresholds specified in acceptance standards is allowed in a structure during operation, STUK's approval shall be obtained before restarting the reactor after shutdown.

6 Reporting of inservice inspection results

The completion of the preservice inspection is one of the requirements to be met before STUK can accomplish an inspection in accordance with section 20 of the Nuclear Energy Act (990/87). For this purpose, STUK shall be given documented notification of the completion of the inspections, specifying:
— the examinations performed (reference is made to programmes)
— deviations from the approved inspection programme and their causes
— flaw indications exceeding the acceptance standard and further actions thereupon.

Corresponding documented notification of completion of individual inservice inspections is one prerequisite for restarting the reactor after shutdown.

Reports summarising the results of a preservice inspection or an individual inservice inspection shall be submitted to STUK for approval in four months from the completion of a nuclear power plant unit's inspections or maintenance outage.

The summary report shall include the following items:

a) Summary of examinations performed
   - a description of organisations which participated in the examinations and of their examination personnel
   - examinations performed (reference is made to the programme)
   - a statement on the acceptability of examination results
   - deviations from approved examination programme and procedures, with justifications
   - flaw indications detected and further action taken or planned thereupon
   - comparison against the results of previous examinations.

b) Detailed list of examinations performed
   - welded joints and other areas of examination
   - methods of examination
   - reference to examination procedures (revision identification to be given) in each examination area
   - indications detected and their character
   - reference to examination records
   - reference to characterisation records of indications and to other supplementary analyses
   - reference to deviation reports, if any.

c) Description of flaw indications exceeding evaluation level
   - examination area
   - characterisation records of flaw indications
   - definition of size, character, location and orientation of flaw indications according to /1/ and their comparison with acceptance standards, or an indication-specific strength analysis
   - comparison of the size of flaw indications measured during previous examinations
   - an assessment of the causes of a flaw
   - a statement signed by experts on the acceptability of flaw indications
   - further actions.

d) The examination equipment and devices used.

7 Updating of inservice inspection documents

Inservice inspection programmes and reports of inspection results shall be available for the whole operating life of the nuclear power plant. Thus, special care shall be taken to ensure that documents are accurate, their wording unambiguous and the filing and updating system explicit.

The licensee shall have an explicit filing and updating system for the inservice inspection documents which covers all documents relating to inservice inspections.

The documents shall be given unambiguous headings using the terminology in this Guide. It shall be indicated in the documents how they are combined with the rest of related documents in accordance with the filing and updating system.

The whole system of inservice inspection programmes shall be regularly reviewed and, if necessary, revised. The inservice inspection programmes may have to be revised for example due to the following reasons:
- changes in standards and requirements
- developments in examination techniques
- inspection experience
- nuclear power plant operating experience in Finland and elsewhere.

If it has not been possible to perform an examination required by STUK due to technical difficulties, such an examination shall be included in the programme again without a separate request when the facilities for performing the examination have improved due to the advancement of technology.

If STUK in its decisions requires that examinations similar in character to those presented in this Guide are to be carried out periodically, these are added to the inservice inspection programmes and are dealt with in accordance with this Guide.

The licensee shall see to it that all changes are entered in the documents without delay. All revised programme pages shall be submitted to STUK for approval. The revised sections shall be clearly marked and justification provided, if necessary.

8 References

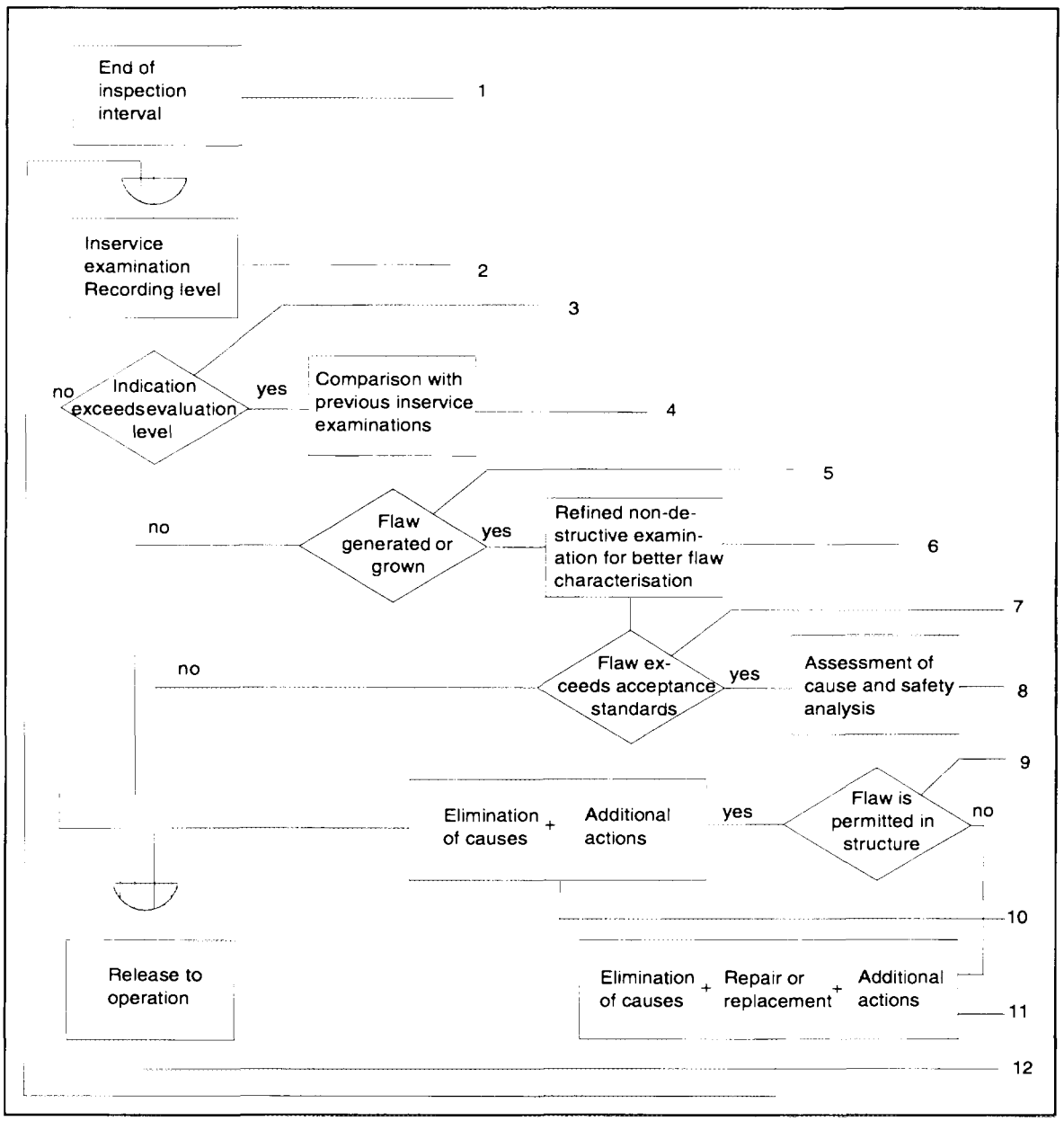
1 ASME Boiler and Pressure Vessel Code, Section XI, Rules for Inservice Inspection of Nuclear Power Plant Components, Division 1, Rules for Inspection and Testing of Components of Lightwater Cooled Plant, American Society of Mechanical Engineers, New York, 1992.

2 IAEA Safety Series No. 50-SG-02, Safety Guides, In-Service Inspection for Nuclear Power Plants, Vienna, 1980.

3 IAEA Safety Series No. 50-P-2, Safety Practices, In-Service Inspection of Nuclear Power Plants, Vienna, 1991.

4 ASME Boiler and Pressure Vessel Code, Section III, Rules for Construction of Nuclear Power Plant Components, American Society of Mechanical Engineers, New York, 1992.

APPENDIX FLOW CHART FOR EVALUATING THE EXAMINATION RESULTS /3/



FLOW CHART FOR EVALUATING THE EXAMINATION RESULTS /3/ **APPENDIX**

1 Inservice inspections are conducted before the inspection interval ends.

2 Inservice examinations are performed and indications exceeding the recording level are recorded.

3 Any indication exceeding the recording level is evaluated. If it exceeds the evaluation level it is investigated whether it is a geometrical or a flaw indication.

4 The flaw indication is compared against the results of previous inservice examinations.

5 It shall be investigated whether the flaw is new or has grown.

6 The type, location and size of a new or grown flaw is characterised by refined NDE, if necessary.

7 It is investigated whether the flaw indication exceeds the limits specified in acceptance standards.

8 A safety assessment is performed for any flaw indication larger than the limits specified in the acceptance standard and the cause of the flaw is assessed.

9 After the cause of the flaw is assessed and a safety assessment performed it is decided whether the flaw is allowed in the structure.

10 If the flaw is allowed in the structure it is assessed what further measures are required to eliminate its causes and to prevent its growth.

11 A defective structure is repaired or replaced and new preservice examinations are conducted. The flaw's causes are eliminated and the need for further measures is assessed.

12 A decision is made about the structure's fitness for its purpose.

Further measures may be e.g.:
- restrictions or alterations to operating conditions
- continuous flaw monitoring
- structural modifications such as weld overlays or modifications of supports
- additional examinations and reduction of examination interval.

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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, 11 Sept. 1995 (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, 1 Jan. 1995 (in Finnish)

YVL 1.6 Nuclear power plant operator licensing, 9 October 1995 (in Finnish)

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 plants, 13 Nov. 1991

YVL 1.11 Nuclear power plant operating experience feedback, 22 Dec. 1994 (in Finnish)

YVL 1.13 Shutdowns at nuclear power plants, 9 Jan. 1995 (in Finnish)

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

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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

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YVL 3.9 Nuclear power plant pressure vessels. Construction and welding filler materials, 6 April 1995 (in Finnish)

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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, 6 April 1995 (in Finnish)

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

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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 Supervision of fuel design and manufacture, 15 Sept. 1993

YVL 6.4 Supervision of nuclear fuel transport packages, 9 October 1995 (in Finnish)

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YVL 6.6 Surveillance of nuclear fuel performance, 5 Nov. 1990

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

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YVL 7.8 Environmental radiation safety reports of nuclear power plants, 11 December 1995 (in Finnish)

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

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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.