

PUMPS OF A NUCLEAR FACILITY

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continues

With regard to new nuclear facilities, this Guide shall apply as of 1 December 2013 until further notice. With regard to operating nuclear facilities and those under construction, this Guide shall be enforced through a separate decision to be taken by STUK. This Guide replaces Guide YVL 5.7.

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Authorisation

According to Section 7 r of the Nuclear Energy Act (990/1987), *the Radiation and Nuclear Safety Authority (STUK) shall specify detailed safety requirements for the implementation of the safety level in accordance with the Nuclear Energy Act.*

Rules for application

The publication of a YVL Guide shall not, as such, alter any previous decisions made by STUK. After having heard the parties concerned STUK will issue a separate decision as to how a new or revised YVL Guide is to be applied to operating nuclear facilities or those under construction, and to licensees' operational activities. The Guide shall apply as it stands to new nuclear facilities.

When considering how the new safety requirements presented in the YVL Guides shall be applied to the operating nuclear facilities, or to those under construction, STUK will take due account of the principles laid down in Section 7 a of the Nuclear Energy Act (990/1987): *The safety of nuclear energy use shall be maintained at as high a level as practically possible. For the further development of safety, measures shall be implemented that can be considered justified considering operating experience, safety research and advances in science and technology.*

According to Section 7 r(3) of the Nuclear Energy Act, *the safety requirements of the Radiation and Nuclear Safety Authority (STUK) are binding on the licensee, while preserving the licensee's right to propose an alternative procedure or solution to that provided for in the regulations. If the licensee can convincingly demonstrate that the proposed procedure or solution will implement safety standards in accordance with this Act, the Radiation and Nuclear Safety Authority (STUK) may approve a procedure or solution by which the safety level set forth is achieved.*

1 Introduction

101. Pumps are used for the transfer of liquids for many applications at a nuclear facility. They are of essential importance for electricity generation and safety functions such as reactor cooling during accidents. It is important for the safety of a nuclear facility that the integrity and performance of pumps installed at the nuclear facility is assured until the end of their specified design service life in those postulated situations and conditions that may prevail in their service place.

102. This Guide sets requirements for the design, manufacturing, installation, commissioning, operation, condition monitoring and maintenance of pumps and describes STUK's oversight procedures to verify compliance with the requirements.

103. The following legislation sets the legal basis for this Guide:

Under Section 63(1)(3) of the Nuclear Energy Act (990/1987) [1], *STUK is authorised to require that nuclear fuel or the structures and components intended as parts of the nuclear facility be manufactured in a manner approved of by the Radiation and Nuclear Safety Authority (STUK), and oblige the licensee or licence applicant to arrange for STUK opportunity sufficiently to control manufacture of the fuel or such structures and components.*

Under Section 4(2) of the Government Decree (717/2013) [3], *the systems, structures and components that implement or are related with safety functions shall be designed, manufactured, installed and used so that their quality level, and the assessments, inspections and tests, including environmental qualification, required to verify their quality level, are sufficient considering the safety significance of the item in question.*

Under Section 7 of the Government Decree (736/2008) [4], *the systems, structures and components of a nuclear waste facility shall be classified on the basis of their significance in terms of*

the operational safety of the facility, or the long-term safety of disposal. The required quality level of each classified object, and the inspections and testing necessary for verifying the quality, shall be adequate as regards the significance of the object in terms of safety.

2 Scope of application

201. This Guide applies to Safety Class 1, 2 and 3 pumps in nuclear facilities in all phases of their service life. The Guide is correspondingly applicable to Safety Class 2 and 3 fans and compressors of nuclear facilities in the manner required by verification of their operability. The Guide's requirements apply to licensees as well as those in the pump supply chain.

202. The systems design requirements on which pump design is based are given in the B Series of the YVL Guides.

203. The requirements for the electrical and I&C equipment for pumps are given in Guide YVL E.7 Electrical and I&C equipment of a nuclear facility.

204. Strength analyses are addressed in Guide YVL E.4 Strength analyses of nuclear power plant pressure equipment.

205. The requirements for the processes and functions of the licensee and suppliers' management system are given in Guide YVL A.3 Management system for a nuclear facility.

206. STUK approves inspection organisations conducting inspections of nuclear facility pumps in accordance with Guide YVL E.1 Authorised inspection body and the licensee's in-house inspection organisation.

207. STUK approves inspection organisations conducting tests of nuclear facility pumps in accordance with Guide YVL E.12 Testing organisations for mechanical components and structures of a nuclear facility.

3 Licensee's component requirement specification

301. The licensee shall have a component requirement specification for the nuclear facility's pumps, which contains the general design and quality control requirements for Safety Classes 1, 2 and 3 as well as Class EYT (specified non-nuclear) pumps set by the licensee as well as the applicable regulatory requirements. In an individual pump purchase the design and quality control requirements are based on the component requirement specification. The service place requirements shall supplement the component requirement specification in the pump construction plan.

302. The design requirements of the component requirement specification shall specify the following for pumps:

- the design bases (normal operation, transients and accident conditions) such as design pressure, temperature, head and flow, forces and moments, seismic load, etc.;
- mechanical engineering as well as electrical and I&C design requirements such as critical rotation speeds, shaft seals, drive, instrumentation, etc.;
- structural material and material certificate requirements;
- applicable standards, procedures and criteria based on which pumps are designed and dimensioned;
- inspectability and maintainability requirements;
- all other structural and functional requirements set by the licensee for pumps to be purchased to the nuclear facility.

303. The quality control requirements of the component requirement specification shall specify the following for pumps

- inspections and tests conducted on structural materials and pumps during procurement, manufacturing, installation and commissioning;
- parties involved in the control of inspections and testing;
- reporting requirements for inspections and testing;

- inspection and testing procedures;
- reference standards for inspections and testing.

304. The component requirement specification shall make reference to the YVL Guides to be complied with and the requirements presented in separate STUK decisions relating to pump design, dimensioning or quality control.

305. The design or quality control requirements for built-to-order products, serially manufactured components or commercial-grade products shall be separately specified in the component requirement specification of pumps if the licensee sets mutually non-conformant requirements for them.

306. The licensee's component requirement specification, its reference documents and their updates shall be approved by STUK-approved before their use as the basis for pump requirements.

307. When the requirement specifications of plant contractor or component suppliers are applied, these shall not contradict the licensee's requirement specification for equipment. These requirement specifications shall be approved by STUK before their use as the basis for pump-related requirements or before they are referred to in pump-related documents submitted to STUK or an authorised inspection body.

308. The licensee shall submit the STUK-approved component requirement specification for pumps for information to the authorised inspection bodies it uses.

4 Manufacturer

401. The pump manufacturer shall have an appropriate certified or equivalent management system independently evaluated by a third party. In addition, a manufacturer of Safety Class 1 and 2 pumps shall fulfil the management-system related requirements of Guide YVL A.3.

402. The manufacturer shall have in its employment competent and experienced personnel as well as the methods, equipment and tools required for its operations.

403. The manufacturer shall have documented procedures for qualification of manufacturing procedures and personnel, validity of qualifications, manufacturing, testing and handling of non-conformances.

404. If the manufacturer uses special processes in manufacturing of the pump's pressure retaining parts, the licensee shall apply for a workplace-specific approval for the manufacturer from STUK in accordance with Guide YVL E.3. Such special processes are welding, heat treatment as well as hot and cold forming.

405. The manufacturing procedures for special processes shall be qualified by procedure tests before manufacturing. As regards demanding components, STUK or an authorised inspection body can request for a review of the suitability of manufacturing procedures by works tests before manufacturing or production tests during manufacturing.

406. As regards the supply chains of parts important to pump operability, the manufacturer shall ensure that subcontractors are familiar with the requirements relating to their delivery and also make sure before assembly that the components manufactured by the sub-contractors fulfil these requirements.

5 Design

5.1 General

501. The requirement specifications of the nuclear facility's process systems shall specify all the service place requirements (design bases), which are required as input data for pump design and dimensioning and which the pump shall fulfil in normal operation as well as during transients and accidents (design basis operational conditions).

502. The pump's structural design and dimensioning shall be based on standard ASME Boiler & Pressure Vessel Code (Section III, Division 1); as regards Safety Class 1 on Subsection NB-3400 [6] and as regards Safety Class 2 on Subsection NC-3400 [7]. Other standards are acceptable provided that it can be demonstrated that an equivalent certainty of pump integrity and per-

formance can be achieved by design and dimensioning based on them.

503. The structural design and dimensioning of Safety Class 3 pumps shall be based on a design standard generally applied by the pump-manufacturing industry.

504. If the standards applied present different requirement levels for design and dimensioning requirements, the requirement levels applied shall correspond to the pump's safety class.

505. The same standard series shall be applied in pump design and manufacturing. In case of deviations from this rule, the licensee shall justify the acceptability of the procedure.

506. A technically justified assessment of pump service life shall be provided indicating the time it reliably maintains operability.

507. The margins between excitations (internal and external) and natural frequencies and/or structural damping in the pump shall be large enough for the pump to maintain its operability in all design basis operational conditions.

508. The pump shall maintain its operability during an exceptional connection situation of its drive's supply voltage (e.g. restarting in phase opposition) in accordance with its design bases.

509. The performance of Safety Class 1 and 2 pumps shall be monitored on-line in cases where a pump's real-time condition monitoring enhances the nuclear facility's safety as compared to corresponding measurements conducted periodically.

510. A pump's $NPSH_a$ shall be at least equal to its $NPSH_r$ with an added margin of 0.5 m. The $NPSH_r$ of pumps intended for long-term operation under accident conditions shall be equivalent to the NPHS at which incipient cavitation occurs with the cavitation having no effect as yet on the head. In other cases the pump's $NPSH_r$ must not be less than the NPSH at which the head measured over the pump's first-stage impeller decreases by 3%.

511. The pump shall be equipped with a minimum line for running the pump at minimum flow without the danger of vibrations, temperature rise or other stresses harmful for the pump.

512. The pump shall be capable of starting under the most unfavourable start-up conditions. Drive torque must not be lower than the pump's counter torque during start-up under any design basis operational conditions.

513. The design of the pump's electrical and I&C equipment shall fulfil the design requirements of Guide YVL E.7.

5.2 Structure

514. The pump's design solutions shall employ proven technology. Fulfilment of the pump's performance requirements shall be experimentally demonstrated if this is the only reliable method to verify conformity.

515. If the pump contains commercial-grade parts, these shall be suitable, characteristics and quality-wise, for their intended use so as not to degrade pump operability.

516. The pump shall have such material thicknesses that stresses exerted by piping or other components on the pump structures do not cause deformations in moving parts and clearance surfaces that would impair performance during design basis operational conditions.

517. The pump's structural materials, structure and operating environment shall be such that monitoring, inspection and maintenance of its integrity, leaktightness and performance are possible in its service place.

518. The potential leak points of pumps transferring radioactive liquid, e.g. shaft seals shall be equipped with a leakage collection system.

519. The pump shaft shall be fitted with a throttling ring or an equivalent solution to prevent external leak in case of a shaft seal failure.

520. The pump's frame structures shall be fitted with wearing or sealing rings to prevent loss of

pump integrity in case of bearing damage or in other situations leading to a potential contact between the rotor and frame.

521. The cooler of a water-cooled drive in Safety Class 1 and 2 pumps shall be equipped with leakage control. Leakage data shall be available in real time in the nuclear facility's control room.

5.3 Materials

522. The pump's structural materials and hard-facings shall withstand stresses arising from design basis service. Material selection shall ensure that corrosion, erosion, radiation or other corresponding harmful phenomena do not endanger pump operability.

523. The structural materials of the pump's pressure-retaining parts and parts essential for operation shall be standardised materials, which have been proven suitable in practise for the applications. However, the structural materials shall be separately approved in accordance with Guide YVL E.3 if they are not based on a material standard generally known in Finland.

524. The conformity of material properties shall be demonstrated in the material manufacturing documentation as extensively as required by the material standard. Changed material properties shall be specified whenever the standards-compliant delivery condition is altered during pump manufacturing by heat treatment, forming or welding, and it shall be ensured that the changed values are used in analyses associated with the pump's acceptability.

525. Austenitic cast steel shall not be used as the structural material of the casings of pumps subject to in-service inspections in accordance with Guide YVL E.5, unless their inspectability can be reliably demonstrated.

526. Structural materials containing elements that could become activated shall be avoided in the clearance and guiding surfaces or similar surfaces of pumps injecting water to the primary circuit or in other equivalent surfaces from which material could peel off due to erosion-corrosion or some other phenomenon. The concentrations

of elements that could become activated shall be low enough for them to have no significant effect on the level of radiation at the nuclear facility.

6 Construction plan

601. The licensee shall submit the pump's construction plan containing the following documents

- licensee's summary of justifications
- preliminary suitability analysis for electrical and I&C equipment
- manufacturer report
- design bases
- design data
- dimensioning calculations
- operating experiences and type test data
- manufacturing procedures
- inspection plan and procedures.

A corresponding construction plan shall also be presented of a spare parts procurement significant for the pump's integrity or performance if the structure or material of the spare part changes.

The construction plan of a pump equipped with a non-electrically operated drive (in which case a preliminary suitability analysis in accordance with Guide YVL E.7 is not submitted) shall include such data on the drive manufacturer, design and manufacturing quality control that its acceptability can be assessed based on the data submitted.

602. When the procured pump is a built-to-order product and belongs to Safety Class 1 or 2, the licensee shall apply approval for the construction plan before the start of the pump's manufacturing. Application for a separate approval of the dimensioning and inspection plan (material manufacturing) of a pump part is recommended before material procurement starts in case the prefabricated product to be ordered for the manufacture of this particular part, such as body casting or forging, fixes the final dimensioning of the pump.

603. For a Safety Class 3 pump which is a built-to-order product or a serially manufactured pump

without type approval, the licensee shall apply for approval of the construction plan before the pump's construction inspection at the latest.

604. In case the construction plan must be updated later, the licensee shall apply for approval for the revisions. Minor revisions can be submitted for information.

6.1 Summary of justifications

605. The construction plan shall include a summary of justifications in which the licensee presents the scope, results and approval criteria of their in-house inspection. With the construction plan data, the summary of justifications shall justify as to why:

- manufacturer and their subcontractors have readiness for a delivery;
- pump design bases correspond to the requirements of its service place and operating conditions;
- calculations, operating experience feedback and type tests demonstrate fulfilment of the design requirements;
- manufacturing quality can be extensively verified by inspections and testing of structural materials, components and pumps.

606. The justifications shall make reference to individual documents of the construction plan and, where necessary in case of extensive documents, also to their page numbers.

607. The summary of justifications shall designate testing organisations conducting destructive or non-destructive testing of the pump's structural materials or parts during manufacturing and draw up a summary of the approvals. A summary shall also be given on manufacturer approvals when special processes are used in pump manufacturing.

6.2 Preliminary suitability analysis of electrical and I&C equipment

608. The construction plan shall include a preliminary suitability analysis of the pump's electrical and I&C equipment in accordance with Guide YVL E.7.

6.3 Manufacturer report

609. The construction plan shall include a manufacturer report containing data on the manufacturer's organisation, operation, qualification of personnel and manufacturing procedures, copies of valid certification decisions and the manufacturer's recent delivery references. A reference to a manufacturer report possibly submitted earlier or a valid approval of manufacturer in accordance with Guide YVL E.3 is sufficient when data is unchanged.

610. The manufacturer report shall also be submitted on subcontractors or alternative subcontractors manufacturing pump drives and other pump parts significant to operability. The manufacturer report shall also be submitted on the materials manufacturers of pressure-retaining parts of the pump's frame structure in Safety Classes 1 and 2.

6.4 Design bases

611. The construction plan shall give the pump design bases:

- highest allowable system pressure and temperature of the process system
- system flow requirement and pressure loss
- design basis service and operability requirements
- loading and stresses exerted on the pump
- process, driving power and ambient conditions
- pump service life and number of start-ups during service life
- other service place-related pump requirements

612. Pump operability requirements (integrity, leaktightness and performance) in design basis operational conditions and after them shall be specified.

613. Loadings and stresses shall be presented to the extent they are considered the pump's design bases. They typically include

- forces and moments exerted by piping and supports
- mechanical and thermal load fluctuations
- exceptional connection situations of the drive
- impact loading (accelerations caused by pipe breaks and seismic events)

- ambient conditions (temperature, humidity, radiation).

6.5 Design data

614. The construction plan shall present the pump's design and other technical data to the extent they apply to the pump to be approved. Based on the data, it shall be possible to assess whether the pump is designed to fulfil the requirements set by its service place.

- service place code and safety class
- design pressure and temperature
- characteristic curves
- purpose in the process system and functional description (including PI diagrams for local control and auxiliary systems)
- construction drawings (assembly and sectional drawings)
- part lists
- structural and coating materials as well as welding filler materials
- the pump's allowable forces and moments in piping connections
- quality requirements for lubricants as well as for seal and cooling water
- operational clearances and plays to allow thermal expansion
- interlocking, protections, alarm and trip limits.

615. The pump's characteristic curves shall be presented for head, the required suction head (NPSH_r) and output as a function of flow as well as of drive torque and pump countertorque as a function of rotation speed in rated and dimensioning conditions.

616. In addition to the pump's main dimensions, the construction plans shall show the dimensions used as initial data for calculations, clearances and plays essential for operation, part markings, part materials, hard-facings, surface treatments and welded joints.

6.6 Calculations

617. Calculations to be included in the construction plan shall demonstrate that the pump's operability requirements are fulfilled in design basis events. Nominal output and safety class-

specific minimum requirements for the calculations, which shall be included in the construction plan, are given in Appendix C.

618. The pump's structural strength shall primarily be demonstrated by classification in accordance with an applicable standard and/or computational analyses, such as a stress analysis based on a standard or one based on detailed modelling of the structure.

619. Acceptability of commercial-grade parts shall be justified in the construction plan. This shall be done by calculations, dimensioning sheets, applicable operating experience or other reports confirming the conformity of the part.

620. As initial data for the calculations, the most unfavourable combination of loading and conditions that the pump could be exposed to shall be used. Such approval criteria shall be used for the results that the pump reliably maintains its operability in the design basis service.

621. Of the calculations, the standards applied, loading used as initial data and material properties, calculation methods, visualised results, acceptance criteria and conclusions shall be presented.

622. In Safety Classes 2 and 3, the construction plan's calculations can be replaced by the operating experience feedback or type test data of a pump having equivalent structural and design parameters in case the pump's conformity can be equally demonstrated by these data. The manufacturing quality of the pump submitted for approval shall then be equal to that of the reference pump, which is to be demonstrated in the construction plan.

6.7 Operating experience feedback and type test data

623. The construction plan shall include such references and type test records that can be used to assess the capabilities of the manufacturer and the subcontractors as well as the pump's suitability for its intended application.

624. Acceptable delivery references are pumps whose design parameters, bases and solutions have been equivalent to the pump to be accepted. Of these, the construction plan shall present at least the types, design parameters, materials, quantities, delivery years and purchasers of the pumps and drives. It is recommended that operating conditions and periods and other corresponding operational experience history is included in the data provided.

625. Acceptable type test records are those that present the results of tests of a pump that has equivalent design parameters, bases and solutions. With the results, it shall be possible to unambiguously confirm the conformity of the design solutions of the pump to be accepted.

626. In the absence of acceptable delivery references or type test reports, a pump's acceptance requires a type test and the type test plan shall be attached to the construction plan. The type test plan shall unambiguously describe the test arrangements and circumstances as well as specify the test criteria whose fulfilment provides reliable pump conformity data.

6.8 Manufacturing procedures

627. When special processes are used in the manufacture of a Safety Class 1 or 2 pump which is a built-to-order product, the manufacturing procedures of the special processes and their qualification data shall be included in the construction plan. This requirement applies also to the surfacing of clearance and guiding surfaces.

6.9 Inspection plan and procedures

628. A plan for inspections and testing during pump manufacturing shall be included in the construction plan.

629. The inspection plan shall present the inspections, testing and other control of the structural materials, parts and pump, including i.a.

- part markings and reference to drawings
- structural material (standard markings and material certificate requirement)
- reference data of the instruction/standards to be complied with in inspections/testing

- performers of inspections/testing
- records of inspections/testing (reporting requirements)
- hold points and witness points (STUK, authorised inspection body, licensee, third party, others).

630. Referred instructions shall define the scope of inspections and testing, approval criteria of results, methods, equipment and qualification requirements of the persons carrying out testing.

631. The construction plan shall include instruction at least for the pressure tests of pressure-retaining parts and functional tests of the pump (performance and endurance tests). In addition, in Safety Classes 1 and 2, the construction plan shall include inspection procedures for non-destructive testing during pump part manufacturing.

632. The inspection plan shall define the scope of pump disassembly after functional testing and which pump parts are then available for visual inspection. The scope of disassembly shall typically enable the inspection of the condition of clearance and guiding surfaces of hydraulic parts as well as other parts significant for the pump's performance.

633. Factory tests shall be mainly conducted using the pump's original parts, i.e. the assembly to be installed at the nuclear facility. If deviations are made from this rule, the test assembly shall be stated in the inspection plan and it shall be justified as to why the pump's conformity can be demonstrated by means other than the pump's original parts.

7 Type test

701. The conformity of the pump's design solutions shall have been experimentally demonstrated by type tests. A type test is not required when earlier type test results or operating experience can be used to demonstrate pump's conformity in a similar way.

702. The structure, dimensions and materials of the type-tested pump shall correspond to the pump to be approved.

703. Type testing shall be implemented in conditions corresponding to design basis service using testing parameters by which the pump's conformity can be unambiguously demonstrated based on the test results. This requirement specifically concerns design solutions whose conformity cannot be reliably verified by analytical methods.

704. The pump's type test shall be conducted at the limit values of actuating force parameters, such as voltage and frequency, for their design basis durations.

705. Verification of conformity of the pump's electrical and I&C equipment shall fulfil the requirements of Guide YVL E.7.

706. When a type test is conducted on a pump subject to approval the licensee shall apply approval of the type test plan before the type test is conducted and submit the type test result report for information before the pump's installation.

8 Manufacturing

801. The pump shall be manufactured and manufacturing quality controlled in accordance with an approved construction plan and the associated inspection plan.

802. The licensee shall prior to the start of manufacturing ensure that the manufacturer has the administrative and technical readiness for conformity-compliant operation and that the manufacturer has the approved construction plan and the decision pertaining to it at its disposal.

803. The machines, equipment and tools used in manufacturing shall ensure the achievement of a quality level set by the requirements. The machines and equipment shall be periodically tested and calibrated as required by the manufacturer's quality management system. The test results shall be recorded and presented upon request.

804. The structural materials for which a batch-specific material certificate is required shall be identifiable and traceable from their lot-specific melting up until the finished structure. The mini-

mum requirements for the material certificates of structural materials are given in Appendix B.

805. The manufacturer shall identify the manufacturing non-conformances detected, determine their causes, assess their importance and carry out corrective actions. The licensee shall apply approval from STUK or an authorised inspection body for any non-conformances remaining in the pump that are significant in terms of operability. Non-conformance management-related requirements are given in Guides YVL A.3 and YVL A.5.

806. For the manufacturing documentation, the manufacturer shall compile into manufacturing documentation the testing, inspection and control records that comply with the approved inspection plan and were drawn up during manufacturing. Inspection documents for construction materials and welding filler materials, qualification certificates of personnel, the non-conformance reports as well as other records drawn up during manufacture, control of manufacturing and testing shall be attached to the manufacturing documentation.

807. The licensee shall ensure that the manufacturer compiles and hands over to the licensee the manufacturing documentation as well as the installation, operation and maintenance instructions before the pump's commissioning at the nuclear facility.

9 Construction inspection

901. The licensee shall arrange for STUK or an authorised inspection body a construction inspection to demonstrate that the pump materials, manufacturing, structures and operation are as described in the construction plan. In the construction inspection, the manufacturing documentation is assessed, visual inspections are conducted and factory tests witnessed.

902. Every pump shall be subject to a construction inspection. The construction inspection scope of serially manufactured pumps may be reduced on a case by case basis by the licensee's application so that a full construction inspection is conducted by STUK or an authorised inspection body only

on a part of the pumps belonging to the delivery lot. When making a construction inspection, an inspector selects the pumps to be inspected.

903. When making a construction inspection, an inspector of STUK or an authorised inspection body shall have available the approved construction plan, possible modification documents and the related decisions of approval. Reference documents of the construction plan that are not attached to the construction plan shall be presented upon request.

904. At the construction inspection, the inspector shall be provided with adequate lighting, calibrated measuring instruments and auxiliaries as well as the necessary assisting personnel.

905. At the construction inspection, the licensee shall present

- the necessary regulatory approvals (testing organisations, manufacturer);
- systematically compiled and licensee-approved documentation including the manufacturing records in the scope specified in the inspection plan;
- the review status of the final suitability analysis of the electrical and I&C equipment in accordance with Guide YVL E.7;

and arrange the following in a scope that complies with the inspection plan

- structural inspection (visual inspections, dimension inspections, verification of part identification markings)
- witnessing of pressure and functional tests (performance and endurance).

906. Factory tests shall be conducted in accordance with the approved procedures. Factory tests belonging to the construction inspection can be conducted after the result documentation review and structural inspection when an inspector of STUK or an authorised inspection body has confirmed testing readiness.

907. A performance test shall measure the head, flow, output, vibration and other parameters significant for performance within the pump's operating range.

908. The minimum length of a non-stop endurance test in Safety Classes 1 and 2 shall be 48 h and every pump shall be tested. In Safety Class 3, the minimum length of the endurance test shall be 24 hours and at least one of identical pumps shall be tested. During the endurance test, the pump shall be driven in different service positions, started up and stopped at least ten times and operational parameter trends measured.

909. In Safety Classes 1 and 2, all pumps and in Safety Class 3 at least one of identical pumps shall be visually inspected after factory testing. The scope of pump dismantling after factory testing to check the condition of pump parts shall be as approved in connection with the construction plan review.

910. If the pump or its parts essential for operability are repaired or modified or wearing parts other than those that are disposable are replaced after factory tests, the pump's conformity shall be verified by repeated factory tests after the modifications.

911. The final suitability analysis of the electrical and I&C equipment shall have been reviewed as defined in Guide YVL E.7 before the completion of the pump's construction inspection.

912. When the construction inspection of serially manufactured pumps is carried out in the form of random inspections covering only part of the delivery batch of identical pumps and significant defects are observed, the construction inspection shall be conducted on the whole delivery batch in question.

913. Construction inspection shall be acceptably conducted before the pump's transfer to its installation position.

10 Installation

1001. The licensee shall conduct an acceptance inspection on the pump before storage and installation. In the acceptance inspection, the pump shall be removed from its packing and its flawless condition verified before installation.

1002. The licensee shall have a construction plan for the pump's installation. The installation construction plan shall state

- procedures, drawings and part lists required in the installation
- qualified welding procedure specification (if the pump is connected to piping by welding)
- inspection plan
- inspection procedures.

The installation construction plan can be submitted as a separate document or as part of other documentation such as the pump manufacturing or piping construction plan.

1003. The pump's installation inspection plan shall contain inspections that reliably confirm the conformity of the installation. Inspection procedures shall be in place and their references presented in the inspection plan.

1004. The licensee shall arrange an installation construction inspection to demonstrate that the pump's installation and installation quality control comply with the installation construction plan.

1005. The licensee shall present an approved installation construction plan at the construction inspection. Reference documents of the construction plan that are not attached to the construction plan shall be presented upon request.

1006. Before the pump's installation, the licensee shall apply for approval of the installation construction plan.

1007. The installation construction inspection shall be acceptably completed before the pump's commissioning inspection.

11 Commissioning

1101. The licensee shall arrange for STUK or an authorised inspection body a commissioning inspection, which in two phases demonstrates the pump's readiness for a test run and operation. The licensee is responsible for the availability of the documents and records required in the inspection as well as for guidance to the plant.

1102. The first phase of the commissioning inspection verifies that

- the pump's construction plan, construction inspection and installation construction inspection have been approved and the earlier inspections show no unaccounted for matters preventing the test run
- the licensee has confirmed the conformity of the electrical and I&C equipment installations in an inspection report
- the pump's test run plan has been approved
- the pump's operating and maintenance procedures are available
- the pump's assembly and process interface comply with the plans
- the pump is in an inspectable and maintainable condition
- the location is acceptable for safe use and potential pump malfunctions do not pose a nuclear safety risk.

1103. During the second phase of the commissioning inspection, the operability of the pump installed in its service place shall be demonstrated by a test run. At facilities under construction this is typically done in connection with a system's commissioning testing, while at operating facilities separate test run arrangements are employed. For the test run, a test run plan shall be drawn up containing

- the test run arrangements and measurements
- the description and phases of the test run
- the acceptance criteria for the results.

The test run plan may be a separate document or part of a process system's commissioning plan.

1104. The second phase of the commissioning inspection verifies that

- the licensee has confirmed the conformity of the commissioning of the electrical and I&C equipment in an inspection report
- non-conformances preventing operation are not detected
- the scope of the test run complies with the test run plan and the results are acceptable.

1201. The first phase of the commissioning inspection shall be acceptably conducted before the start of the test run.

1202. Both phases of the commissioning inspection shall be acceptably conducted before a pump operating licence is granted. The operating licence can also be granted for a fixed period when it is not possible to complete all planned test run phases at the same time and the pump is operable until the next test run phase.

12 Operation, condition monitoring and maintenance

1203. The pump's operating parameters as well as loading, process and ambient conditions shall be monitored and maintained within the limits of design basis service. Unnecessary loading and unfavourable operating conditions shall be avoided.

1204. The pump shall reliably maintain its operability over the maintenance interval in all design basis service. Maintenance needs shall be reliably detected before failure.

1205. Instructions shall be given for the pump's operation, condition monitoring and maintenance. The instructions (operating procedures as well as maintenance, inspection and testing programmes and the related instructions) shall be based on the manufacturer's recommendations, operational experience feedback of the licensee or that from other nuclear facilities, and it shall be regularly assessed and the modification needs detected analysed.

1206. The pump's condition monitoring instructions shall present the parameters, methods, inspection and test intervals and acceptance limits to be monitored. Depending on the pump type, pumps need to be monitored in the following scope

- flow and head
- bearing vibration (horizontal, vertical and axial) and temperatures
- leaktightness of shaft seals and other seals
- integrity of pressure retaining parts
- condition of bearings, clearance and guiding surfaces

- condition of load path parts
- the drive's power consumption and coil temperature
- number of start-ups.

1207. The pump's maintenance instructions shall define the work and inspections to be carried out during periodic maintenance, timing of the maintenance work as well as the spare parts and supplies required.

1208. If special processes are used in pump maintenance, the party shall have STUK's facility-specific approval in accordance with Guide YVL E.3.

1209. If a maintenance task is not part of the pump's maintenance programme the maintenance task is considered repair work for which the licensee shall draw up a repair plan. A repair plan is not, however, required for repair work where parts are only replaced with approved spare parts and during which no special processes are used.

1210. The repair plan shall include all data needed to carry out the work and inspections that are required to assess the acceptability of the repair work and that typically include manufacturing and inspection procedures, illustrative drawings as well as an inspection plan covering the manufacturing phases, installation and commissioning.

1211. The licensee shall apply for approval of the pump's repair plan before the repair is started.

1212. The licensee shall arrange for a construction inspection of the repair work. The repair work construction inspection shall be acceptably conducted before the pump is used.

13 Modifications

1301. A pump modification shall not compromise the nuclear facility's safety or the prerequisites for the pump's condition monitoring or maintenance. Modifications shall also include the procurement of a spare part significant in terms

of operability, if the structure or material of the spare part changes.

1302. The licensee shall draw up a construction plan for the pump modification. The modification construction plan shall include design data, design bases, dimensioning calculations, manufacturing procedures, an inspection plan and inspection procedures. The inspection plan and related instructions shall cover all phases of the modification from manufacturing to commissioning. In Safety Classes 1 and 2, the construction plan shall also include an analysis of the modification's safety effects.

1303. Update needs arising from a pump modification to drawings, procedures and other documents shall be identified and the updates implemented without delay in connection with the modification. It shall be ensured that the potential effects of the modification on pump operation, condition monitoring and maintenance are communicated to the operation and maintenance organisation.

1304. If special processes are used during a pump modification, the actor shall have a facility-specific approval from STUK in accordance with Guide YVL E.3.

1305. The licensee shall apply for approval of the construction plan of the pump modification before the start of the modification.

1306. The licensee shall arrange for a construction inspection of the modification. The construction inspection of the modification shall be acceptably conducted before the pump is used.

14 Type approved pumps

1401. A pump type-examination and a declaration of conformity assessment by a third party are an alternative procedure to a design and construction inspection by STUK or an authorised inspection body. If the procedure is used, it shall unambiguously demonstrate that the pump's structure and operation correspond to the requirements specified.

1402. The prerequisite for a pump's type approval is a type-examination certificate by which a third party has confirmed the acceptability of the pump design and dimensioning against the pump's design bases. In addition, a declaration of conformity is required by which the third party, based on a product verification and testing, has confirmed the conformity to type of the manufactured pumps. The type-examination and conformity verification shall be implemented by applying modules B and F of Decision 768/2008/EC of the European Parliament and of the Council [8].

1403. A third party licensed to conduct the pump's type-examination and conformity to type assessment is a certification body in accordance with Standard SFS-EN ISO/IEC 17065 [9] accredited to assess the conformity of applicable standards or an inspection organisation in accordance with Standard SFS-EN ISO/IEC 17020 [10] accredited to conduct a corresponding task. An applicable qualification in accordance with Standard SFS-EN ISO/IEC 17025 [11] is required of a certification body or inspection organisation witnessing testing. A certification body or inspection organisation shall also be a notified body suitable for the a task.

1404. The accreditation decision by an organisation conducting type-examination and conformity to type assessment shall be attached to the application to use a type approved pump in a nuclear facility. If the same organisation conducts several type approvals, the accreditation decision may be submitted once only but the application shall refer to the previously submitted documentation.

1405. A third party shall inspect the pump during the type-examination as a combination of design type and production type in compliance with module B. The third party shall then have available the technical documents containing the pump's design parameters and data, dimensioning calculations, test reports and operating experience feedback. The third party shall be reserved the possibility of making inspections and testing in the scope they consider necessary to ensure the pump's product conformity in accordance with module F.

1406. The type-examination certificate or assessment report shall show all the data (technical specifications) confirmed by the type-examination, which is required in assessing the pump's acceptability for use in its service place. Such data typically includes:

- design parameters for pressure, temperature, flow and head
- allowed forces and moments exerted by piping and supports
- ambient conditions
- other design basis requirements
- assembly and sectional drawings
- structural and coating materials.

1407. A third party shall make a conformity assessment based on product verification in accordance with module F in the following scope:

- in Safety Class 2, at least 20% of a manufacturing batch of identical pumps shall be inspected and at least one if the pumps number less than five
- in Safety Class 3, at least one in a manufacturing batch of identical pumps shall be inspected.

Pumps are selected for inspection at random from a manufacturing batch. Out of the pumps selected, the third party shall at minimum

- inspect the material certificates of pressure-bearing and functionally significant components
- review the inspection records of non-destructive testing during manufacturing
- witness pressure, performance and endurance tests
- conduct visual inspections of pump parts.

1408. A declaration of conformity granted on the basis of product verification and testing shall indicate

- pump identifications of the delivery batch and the identifications of the individually inspected pumps in the delivery batch
- the inspection and testing scope of individually inspected pumps in the delivery batch.

The declaration of conformity shall make reference to the type-examination certificate and confirm that the structure, dimensions and materials

of the pumps inspected are of the same pump type as the one for which the type-examination certificate was granted.

1409. The licensee shall draw up an application for the use of the type approved pump at the nuclear facility. The application shall include

- a summary of justifications drawn up by the licensee
- a copy of the type-examination certificate granted by a third party
- a copy of the type-examination assessment report drawn up by a third party
- a copy of the declaration of conformity granted by a third party
- the installation and test run plan of the pump.

1410. The licensee shall in their summary of justifications

- present each pumps' position and position-related requirements for the pump
- justify with the type-examination certificate and declaration of conformity data why the pump fulfils its integrity and performance requirements specified for its service place
- justify as to why the pump manufacturer has the readiness for making the delivery.

1411. The licensee shall apply for pump approval with the above documentation before the pump is installed at the latest.

1412. The operation of a pump approved by a type-examination and conformity to type assessment is always position specific and the pump shall not be installed in other positions without a separate approval.

1413. The licensee shall upon request submit to STUK or an authorised inspection body for information the documents relating to the pump's type-examination and/or conformity to type assessment such as dimensioning calculations and test reports.

15 Regulatory oversight by the Radiation and Nuclear Safety Authority

15.1 General

1501. STUK or an authorised inspection body's oversight encompasses the pump's design approvals at system and component level as well as inspections to be conducted during manufacturing, installation, commissioning and operation as specified in this Guide.

1502. STUK may grant inspection rights in accordance with Guide YVL E.1 to an authorised inspection body it has approved. Appendix A defines the principles of division of inspection responsibilities between STUK and an authorised inspection body, which can be supplemented by separate decisions.

1503. STUK or an authorised inspection body makes a decision about their design review. Even approval decisions can contain requirements and deadlines for the responses to be submitted on them.

1504. The licensee shall in advance by their own inspections ensure that the prerequisites for design approval exist.

1505. The licensee shall request monitoring (construction and commissioning inspections and other control) from STUK or an authorised inspection body approximately two weeks before the date. The manufacturer, (in case of plant projects) the plant supplier, a third party and the licensee shall in advance ensure by their own inspections that prerequisites for the requested inspections exist.

1506. STUK or an authorised inspection body draws up a record of their inspections itemising the inspection item and the inspections conducted. Potential requirements and deadlines for responses to be submitted based on them are entered in the record.

1507. The inspection ends and the record is closed when all the inspections specified are accomplished and the requirements possibly presented during the inspections clarified. The inspector signs the record and the licensee's representative acknowledges its receipt by signing it.

15.2 Requirement specification for equipment

1508. STUK assesses the acceptability of the licensee's pump-related requirement specification for equipment.

1509. STUK or an authorised inspection body oversees compliance with the requirement specifications of pumps in connection with design and construction inspections.

15.3 Approval of manufacturer

1510. STUK's approval is needed for such pump manufacturers and installation organisations that use special processes in manufacturing. The requirements as well as approval and monitoring procedures are given in Guide YVL E.3.

1511. STUK assesses the acceptability of manufacturers other than those using special processes based on the manufacturer report included in the construction plan.

15.4 Approval of third party

1512. A notified body or a recognised third party in accordance with the Pressure Equipment Directive [12] as well as an authorised inspection body approved in accordance with Guide YVL E.1 can in the scope of their competence areas act as a third party witnessing and verifying sampling, destructive or non-destructive testing or qualifications without separate approval. If an authorised inspection body approved by STUK acts as the third party, it cannot act as an inspection organisation conducting public administrative duties for the same structure or component.

1513. The expertise of the third party conducting control of manufacturing is assessed by STUK based on the report included in the construction plan.

15.5 Construction plan

1514. STUK or an authorised inspection body reviews the pump's construction plan and makes a decision on it. The pump's approved design bases at system level are the prerequisite for the construction plan review.

15.6 Control of manufacturing and construction inspection

1515. STUK or an authorised inspection body can witness pump manufacturing by factory visits during manufacturing before the pump's final construction inspection.

1516. STUK or an authorised inspection body conducts on the ready pump the construction inspection specified in this Guide

15.7 Type approved pumps

1517. A notified body reviews the documents and conducts the inspections in the scope specified in this Guide to establish conformity of design and dimensioning. If conformity can be confirmed the body grants the pump a type-examination certificate.

1518. A notified body carries out the product verifications and witnesses testing in the scope specified in this Guide to establish manufacturing conformity. If conformity can be confirmed the body grants the pump a declaration of conformity.

1519. STUK or an authorised inspection body reviews the pump's type approval documentation and makes a decision on it. The type approval documentation includes the documents specified in this Guide.

15.8 Type test witnessing

1520. If a type test is conducted on a pump subject to approval, STUK or an authorised inspection body reviews the type test plan and the type test result report. STUK or an authorised inspection body shall also be invited to witness type testing conducted in accordance with the plan.

15.9 Installation witnessing and construction inspection

1521. STUK or an authorised inspection body reviews the installation construction plan submitted by the licensee, which contains the documents specified in this Guide.

1522. STUK or an authorised inspection body conducts on the pump the installation construction inspection specified in this Guide.

15.10 Commissioning inspection

1523. STUK or an authorised inspection body conducts a two-phased commissioning inspection on the pump as specified in this Guide.

15.11 Operation, condition monitoring and maintenance

1524. STUK oversees the operation, condition monitoring and maintenance of the nuclear facility's pumps during inspections belonging to its inspection programme during operation. The monitoring also covers instructions and plans relating to the inspections.

1525. STUK or an authorised inspection body reviews the pump's repair plan submitted by the licensee and makes a decision on it.

1526. STUK or an authorised inspection body carries out the repair work construction inspection in the scope specified in the repair inspection plan.

1527. STUK or an authorised inspection body reviews the inspection and testing records for pump maintenance work (maintenance, overhauls and repairs) as well as feedback. If pumps are disassembled during maintenance work, STUK or an authorised inspection body visually inspects the parts before assembly.

15.12 Modifications

1528. STUK or an authorised inspection body reviews the pump's modification construction plan submitted by the licensee and makes a decision on it.

1529. STUK or an authorised inspection body carries out the modification construction inspection

in the scope specified in the modification inspection plan.

Definitions

Special process

Special processes shall refer to manufacturing processes, the results of which cannot be directly verified by means of a product inspection or testing after manufacture; instead, any shortcomings in the process may only appear later while the product is in use.

Commercial-grade product

Commercial-grade product shall refer to a standard-quality product (seal, bearing, bolt etc.), for which the part manufacturer has defined design parameters, and the conformity to requirements of the design and manufacture of which can be established when necessary.

Operability

Operability shall refer to the integrity and performance of SSC in conformance with its design bases.

Modification

Modification shall refer to introducing changes to a system, structure or component so that it no longer corresponds to previous specifications.

Pump

Pump shall, in the context of Guide YVL E.9, refer to an entity (pump unit) including a hydraulic machine transferring liquid, its drive and any other structures and parts that are essentially involved in the entity.

Pump NPSH value

Pump NPSH (Net Positive Suction Head) value shall refer to the difference between the pressure at the intake flange and the steam pressure corresponding to the temperature of the fluid pumped. Pump NPSH_a value shall refer to an NPSH value available at the service place, and the NPSH_r value shall refer to an NPSH value that the pump requires to operate without the adverse effects of cavitation.

Serially manufactured pump

Serially manufactured pump shall refer to a pump that is manufactured in large batches. The structure, dimensions and materials of the pump, and the methods and quality of manufacture, do not essentially differ within or across manufacturing batches.

Built-to-order product

Built-to-order product shall refer to a product designed and manufactured for a special application as single pieces or in small manufacturing batches.

Type approved pump

Type approved pump shall refer to a pump, the conformity to requirements of which a third party verifies by applying the modules of Decision 768/2008/EC.

Witness point

Witness point shall refer to an inspection for which advance invitations have been sent to the parties defined in the inspection plan but whose supervision is not a condition for proceeding with the work. Having received the invitation, the invited parties may, however, separately require that they be present in order for the work to be continued.

Manufacturer

Manufacturer shall refer to an individual or organisation responsible for the design, manufacture, testing, inspection and installation of equipment or sets of assemblies. A manufacturer may subcontract one or more of the said tasks under its responsibility.

Hold point

Hold point shall refer to an inspection for which advance invitations have been sent to the parties defined in the inspection plan and whose supervision is a condition for proceeding with the work unless the parties have given written permission to proceed without their presence.

References

1. Nuclear Energy Act (990/1987).
2. Nuclear Energy Decree (161/1988).
3. Government Decree on the Safety of Nuclear Power Plants (717/2013).
4. Government Decree on the Safety of Disposal of Nuclear Waste (736/2008).
5. SFS-EN ISO 9001, Quality management systems. Requirements
6. ASME Boiler & Pressure Vessel Code, Section III, Division 1, Subsection NB-3400 Pump Design.
7. ASME Boiler & Pressure Vessel Code, Section III, Division 1, Subsection NC-3400 Pump Design.
8. Decision No 768/2008/EC of the European Parliament and of the Council.
9. SFS-EN ISO/IEC 17065, Conformity assessment. Requirements for bodies certifying products, processes and services.
10. SFS-EN ISO/IEC 17020, Conformity assessment. Requirements for the operation of various types of bodies performing inspection.
11. SFS-EN ISO/IEC 17025, General requirements for the competence of testing and calibration laboratories.
12. Pressure Equipment Directive 97/23/EC.
13. SFS-EN 10204 Metallic products. Types of inspection documents.

APPENDIX A Pump inspection scope and division of inspection responsibilities

Approval or witnessing IO = authorised inspection body, TP = third party	Safety Class		
	1	2	3
Licensing			
Manufacturer (when special processes are used in manufacturing)	STUK	STUK	STUK
Manufacturer report (as part of the construction plan)	STUK	STUK	IO
Requirement specification for equipment	STUK	STUK	STUK
Design bases	STUK	STUK	STUK
Construction plan	STUK	STUK	IO
Type test witnessing	STUK	STUK	IO
Type approval documentation ¹⁾	STUK	STUK	IO
Type approval design review 1)	TP	TP	TP
Manufacturing			
Manufacturing control	STUK	STUK	IO
Construction inspection	STUK	STUK	IO
Product verification of type approval 1)	TP	TP	TP
Installation and commissioning			
Installation construction plan	STUK	STUK	IO
Installation construction inspection	STUK	STUK	IO
Test run plan	STUK	STUK	STUK
Commissioning inspection	STUK	STUK	IO
Maintenance, repairs and modifications			
Inspection of maintenance work	STUK	STUK	IO
Plan for repairs and modifications	STUK	STUK	IO
Inspection of repairs and modifications	STUK	STUK	IO

1) Type approved pumps.

If special processes are used in pump manufacturing, the minimum scope of qualification and control of manufacturing complies with Table A of Guide YVL E.3 as regards these manufacturing procedure.

APPENDIX B Material certificate requirements for pump structural materials and welding filler materials

Table B01. Material certificate requirements for pump structural materials (SFS EN 10204 [13]).

Pump part	Safety Class		
	1	2	3
Pressure-retaining main parts	3.2	3.2	3.1
Pressure-retaining bolts, impeller, pump and pump drive shafts, flywheel	3.1	3.1	2.2
Other parts significant for pump integrity or performance	2.1	2.1	2.1

Table B02. Material certificate requirements for pump welding filler materials (SFS EN 10204 [13]).

Weld	Safety Class		
	1	2	3
Pressure-retaining pump welds	3.2	3.1	3.1
Welded claddings	3.1	2.2	2.2
Other welds significant for pump integrity or performance	2.2	2.2	2.2

A higher level material certificate is always acceptable.

APPENDIX C Construction plan calculations

Shaft output	≤ 15 kW			> 15 kW		
	1	2	3	1	2	3
Safety Class						
Stress analysis for pressure-retaining main parts ¹⁾	N/A	X		X	X	X
Dimensioning of other parts ²⁾	N/A	X		X	X	X
Hydraulic dimensioning ³⁾	N/A	X		X	X	
Dynamic calculations ⁴⁾	N/A			X	X	
Play calculations ⁵⁾	N/A	X		X	X	X
Calculations for pumps positioned in an open tank ⁶⁾	N/A			N/A	X	

- 1) Design standard compliant stress analysis or stress analysis based on detailed structural modelling. Fatigue analysis shall be presented for parts subjected to fatigue-inducing loads. If a stress analysis based on the design standard is not possible due to a non-conformant structure or if the pump is subject to loads the stresses induced by which cannot be reliably analysed, a detailed stress analysis shall be conducted on the pump. The requirements for a detailed stress analysis are given in Guide YVL E.4.
- 2) Strength calculations for pump pressure-retaining or other load-bearing parts (other than pressure-retaining main components), which can be based on the applicable design standard or a detailed stress analysis. Such typical parts include shafts, keys, couplings, flywheels, supports, fastening bolts and auxiliaries such as coolers. A fatigue analysis is required for parts subject to loading fluctuations.
- 3) Calculations based on system pressure losses and head differences to dimension pump flow and adequacy of NPSH, in design basis operational conditions.
- 4) Pump vibration analysis or equivalent analysis covering rotor torsional and lateral vibrations (pump, coupling, gears, drive) as well as vibrations of static structures (supports, foundations).
- 5) Calculations for radial and axial thermal expansion of pump structures to verify adequacy of pump operational clearances and plays for undisturbed operation. Play calculations are only required for a Safety Class 3 pump intended for severe accident management.
- 6) Calculations demonstrate that the air intake of a pump or parallel pumps does not take place from a free surface and do not compromise each other's operation. Can be replaced by mock-up tests.