STUK

GUIDE **YVL 5.7** / 28 APRIL 2008

# NUCLEAR FACILITY PUMP UNITS



continues

As regards new nuclear facilities, this guide is valid as of 1 November 2008 until further notice. At operating nuclear facilities, and those under construction, this guide is enforced by a separate STUK decision. This guide replaces Guide YVL 5.7, issued on 23 November 1993.


Fourth, revised edition
Helsinki 2009
ISSN 0783-2400

ISBN 978-952-478-475-7 (print) Edita Prima Oy 2009
ISBN 978-952-478-476-4 (pdf)
ISBN 978-952-478-477-1 (html)



**STUK** • **SÄTEILYTURVAKESKUS**
**STRÅLSÄKERHETSCENTRALEN**
**RADIATION AND NUCLEAR SAFETY AUTHORITY**

Osoite/Address • Laippatie 4, 00880 Helsinki
Postiosoite / Postal address • PL / P.O.Box 14, FIN-00881 Helsinki, FINLAND
Puh./Tel. (09) 759 881, +358 9 759 881 • Fax (09) 759 88 500, +358 9 759 88 500 • www.stuk.fi

# Authorisation

By virtue of the below acts and regulations, the Finnish Radiation and Nuclear Safety Authority (STUK) issues detailed regulations that apply to the safe use of nuclear energy and to physical protection, emergency preparedness and safeguards:

- section 55 of the Nuclear Energy Act (990/1987)
- section 29 of the Government Decision (395/1991) on the safety of nuclear power plants
- section 13 of the Government Decision (396/1991) on the physical protection of nuclear power plants
- section 11 of the Government Decision (397/1991) on the emergency preparedness of nuclear power plants
- section 8 of the Government Decision (398/1991) on the safety of a disposal facility for reactor waste
- section 30 of the Government Decision (478/1999) on the safety of disposal of spent nuclear fuel.

# Rules for application

The publication of a YVL guide does not, as such, alter any previous decisions made by STUK. It is only after having heard those concerned that STUK makes a separate decision on how a new or revised YVL guide applies to operating nuclear power plants, or those under construction, and to licensees' operational activities. The guides apply as such to new nuclear facilities.

When considering how new safety requirements presented in YVL guides apply to operating nuclear power plants, or to those under construction, STUK takes into consideration section 27 of the Government Decision (395/1991), which prescribes that *for further safety enhancement, action shall be taken which can be regarded as justified considering operating experience and the results of safety research, as well as the advancement of science and technology.*

If deviations are made from the requirements of the YVL guides, STUK shall be presented with some other acceptable procedure or solution by which the safety level set forth in the YVL guides is achieved.

Translation. Original text in Finnish.

# 1 Preface

This guide presents the requirements for a nuclear facility's pumps and their electric motor drives placed by STUK on the licensee and the procedures by which STUK oversees compliance with these requirements. This guide applies to pumps in Safety Classes 1, 2, 3 and 4 and their electric motors in Safety Classes 2 and 3 as follows:

- design and dimensioning
- manufacturing control, inspection and testing
- installation and commissioning
- maintenance, modifications and repairs.

The licensee shall have available corresponding procedures for the procurement, operation and maintenance of pumps in Class EYT (non-nuclear) and their electric motors in Safety Class 4 and Class EYT.

This guide is primarily intended for centrifugal pumps and their electric motor drives. However, where applicable the requirements and control procedures given apply equally to the nuclear facility's other types of pumps and their drives.

# 2 Definitions

The following abbreviations and definitions are used in this guide:

**auxiliaries**
: a device that is part of the structure and functioning of a pump or an electric motor, such as gears, couplings, operating speed regulators, parts of the cooling, sealing and lubrication systems, supports, fastening and anchor bolts, bottom plates, local adjustment and protection devices

**non-serial**
: order-specific, entirely new or modified from a component that has been in service

**hold point**
: a notified inspection or test beyond which activities must not proceed without witnessing by STUK or a STUK-approved inspection organisation

**centrifugal pump**
: a dynamic radial, axial and semi-axial pump

**wearing spare parts**
: spare parts and materials (seals, bearings, lubricants, etc.) replaced during preventive maintenance

**major subcontractor**
: a subcontractor who manufactures, e.g., a pump casing, a pump impeller, a pump shaft, an electric motor shaft or a corresponding structurally significant pump unit component

**$NPSH_a$**
: net positive suction head available at pump inlet nozzle

**$NPSH_r$**
: net positive suction head required at pump inlet nozzle

**pump**
: a pump and its auxiliaries; gears, couplings and other such equipment between pump and electric motor are considered pump auxiliaries

**pump unit**
: a pump and electric motor

**reference pump or electric motor**
: similar to the manufactured pump or electric motor by construction, operating values and operating environment

**serial**
: manufactured in series (identical or similar materials, manufacturing methods, parts, structures and operating values) and has been in service

**strategic spare parts**
: replacement parts whose availability ensures operability of pump unit (impeller, pump, electric motor, etc.)

**design conditions**
: design basis operational conditions, transients and accidents as well as design basis ambient conditions (temperature, humidity, radiation, pressure difference, characteristics of pumped liquid, etc.)

**electric motor**
: an electric motor and its auxiliaries

**testing organisation**
: performs non-destructive or destructive materials testing

**product class**
: based on the design work required for the pump unit, previous manufacturing volumes

and operating experience, a product is classified as either serial or non-serial

**witness point**

a notified inspection or test beyond which activities can proceed without witnessing by STUK or a STUK-approved inspection organisation.

# 3 Manufacturer, testing and inspection organisation

## 3.1 Manufacturer

Pump and electric motor manufacturer must have

- competent and experienced personnel
- facilities and equipment for manufacturing as well as qualified manufacturing methods
- systematic procedures for assessing, selecting and supervising subcontractors
- references to pumps and electric motors with similar operating parameters and structures
- a management system that fulfils the requirements of Guide YVL 1.4 "Management systems for nuclear facilities".

The manufacturer or the subcontractor shall have STUK's approval in accordance with Guide YVL 3.4 "Approval of the manufacturer of nuclear pressure equipment" when they fabricate pump unit's pressure-retaining structures by permanent joining, heat treatment or forming. The acceptability of the manufacturing methods of the pump unit's other structures is assessed by STUK or a STUK-approved inspection organisation based on the pump and electric motor construction plans and a possible audit at the manufacturer's premises.

The manufacturer shall submit the following documents to the licensee:

- documents for pump unit pre-inspection, as required in the construction plan
- manufacturing and inspection records
- requirements and instructions for pump unit installation, commissioning, operation, maintenance, condition monitoring, in-service inspection and testing, and ageing management.

## 3.2 Testing and inspection organisation

The testing organisation and inspection organisation performing pump unit materials testing, and whose duties relate to the conformity assessment and approval of design and manufacturing, shall be STUK-approved in accordance with Guide YVL 1.3 "Mechanical components and structures of nuclear facilities. Approval of testing and inspection organisations".

# 4 General pump unit requirements

Pump unit design, dimensioning, manufacturing and fabrication, inspection and testing shall be based on generally used component and nuclear engineering standards [1–18].

The integrity of the pump unit's pressure retaining parts is to be maintained and the pump unit is to fulfil the system's operational requirements under design conditions for the duration of its design service life. This shall be demonstrated by calculations, tests and previous operational experience data. Where separate strength calculations are not required the dimensioning of pressure retaining structures or other load bearing structures shall be based on applicable standards.

Pump unit materials shall be applicable for their intended use. Material properties with their manufacturing tolerances must fulfil the requirements of design conditions and related phenomena such as fatigue, wearing, corrosion, cavitation and radioactivity of medium. The materials and welding filler materials of pressure retaining structures shall be approved and their material properties verified in accordance with Guide YVL 3.9 "Nuclear power plant pressure equipment. Construction and welding filler materials".

The pump unit shall fulfil the following requirements:

- It must have a design basis operating lifetime of at least three years of uninterrupted operation, with the exception of wearing spare parts.
- Pump unit structure, location and process environment shall allow the performance of

regular maintenance work, in-service inspection and testing.
- Pump unit performance and condition monitoring (e.g. bearing, shaft seals, lubrication, cooling) shall be possible during operation. The monitoring of a Safety Class 1 or 2 pump shall be possible at the nuclear facility's main or local control room.
- Start-up and stopping must not cause undue wear or strain on the pump unit structures.
- Planned and unplanned leaks from a pump pumping radioactive liquid must be controllably led to a drain collection system.
- The pump must have a decreasing head within its operating range.
- The pump's available suction head $NPSH_a$ must be adequate to ensure undisturbed operation under design conditions.
- The pump must have wearing rings, or equivalent devices, to prevent loss of integrity in failures leading to rotor displacement.

# 5 Pump specification

The licensee shall have a nuclear facility and safety class specific pump specification defining the general requirements for the nuclear facility's pump units as follows:
- design basis
- structural and functional dimensioning
- inspection plan
- inspection procedures
- manufacturer-related requirements.

Of the design basis and dimensioning, the following shall be presented: the design conditions of the nuclear facility's pump units; the requirements set for their materials, structures and functioning; and the component and nuclear engineering standards used in dimensioning.

The inspection plan shall define the inspections and testing to be performed on the materials, structures and functioning of the pump unit and its electric motor during manufacturing, fabrication and factory acceptance tests. In the inspection procedures, the performance, scope and approval criteria of the most important inspections and tests shall be given.

Requirements pertaining to the manufacturer shall describe the requirements set for the quality management, previous nuclear facility experience, expertise and delivery references of the manufacturer of the pump and electric motor.

# 6 Pump construction plan

## 6.1 General requirements

The following information shall be given in the pump's construction plan:
- tag (KKS code or equivalent), safety class and product class
- manufacturer and testing organisation
- previous operating experience
- design basis
- dimensioning calculations
- technical specifications
- inspection plan
- inspection procedures
- spare parts.

In accordance with Guide YVL 1.2 "Documents pertaining to safety control of nuclear facilities", the licensee shall submit to STUK in three copies the construction plan they have approved. To a STUK-approved inspection organisation, a similarly approved plan shall be submitted using a procedure required by the organisation.

## 6.2 Manufacturer and testing organisation

If the pump's manufacturer or a major subcontractor is STUK-approved, the construction plan shall contain references to the relevant STUK decisions and their expiration dates. Otherwise, of manufacturers of Safety Class 1 and 2 valve units, the corporate structure (parent company/companies, design and manufacturing organisation), management system description, management system quality certificates, major subcontractors and previous references shall be given. Of manufacturers of Safety Class 3 and 4 valve units, at least the management system quality certificates and previous references shall be given.

For non-serial Safety Class 1 or 2 pumps, manufacturing and repair methods of importance and their qualification data shall be given.

As regards approval of testing organisations, the construction plan shall contain references to the relevant STUK decisions and their expiration

dates If the testing organisation is accredited, documents proving the accreditation submitted earlier to STUK for information shall be referred to.

## 6.3 Operating experience and type test data

The types, rated values, quantities, delivery years, purchasers and type test reports of reference pumps shall be given. When the construction or functioning of a pump differs from the reference pumps, information shall be given that makes it possible to evaluate the effect of the differences.

For Safety Class 1 and 2 reference pumps, operating experience data should include operating times and conditions with fault and maintenance history information.

## 6.4 Design basis

As the design basis, the requirements set for the pump by the system and the environment under design conditions shall be presented as follows:

- flow, head and $NPSH_a$ calculations
- mechanical loadings and their combinations
  - design pressure and temperature
  - forces and torques exerted by piping
  - forces and torques exerted by electric motor
  - dynamic loadings (periodic operation, pressure and temperature transients)
  - external dynamic loadings (seismic event, aircraft impact, pressure wave)
- liquid properties
- ambient conditions (temperature, humidity, radiation, etc.)
- integrity and operability requirements under design conditions
- service life
- decontamination.

## 6.5 Dimensioning

### 6.5.1 General requirements

The design and dimensioning standards used shall be referred to.

Dimensioning calculations shall be presented covering initial data, calculation methods, visualised results, acceptance criteria and conclusions.

### 6.5.2 Strength calculations

**Safety Classes 1 and 2**

For Safety Class 1 and 2 pumps, strength calculations shall be given as follows:

- basic dimensioning
  - casing and nozzles
  - load transfer parts
  - frame structures
  - components subject to centrifugal loading
  - pressure retaining or other load bearing auxiliaries
  - supports and anchoring bolts
- fatigue analysis for structures subject to fatigue induced by alternate loading
- stress analysis for pressure retaining main structures (Safety Class 1 pump)
- a fast fracture analysis for pressure retaining main structures and flywheel (Safety Class 1 pump).

Strength analysis requirements are presented in Guide YVL 3.5 “Ensuring the strength of pressure equipment at nuclear facilities”.

Strength calculations are not required for a serial pump with a rated output less than 15 kW (electric motor) unless required by its special construction or operation.

**Safety Classes 3 and 4**

For a Safety Class 3 or 4 non-serial pump, basic dimensioning of pump casing, suction and discharge nozzles as well as supports and anchoring bolts shall be presented. Basic dimensioning is not required for serial pumps unless required by their special construction or operation.

### 6.5.3 Hydraulic analyses

When the intake of a pump, or a number of pumps, is located in an open tank, the hydraulic dimensioning of the system shall be verified by mock-up tests or sound hydraulic operation of the system under design conditions shall be otherwise demonstrated.

For a Safety Class 1 pump, flow characteristics shall be analysed by means of three dimensional computational fluid dynamics. Analyses shall be used in the pump design to ensure favou-

rable velocity and pressure fields, e.g. over the impeller and guide vanes, and ultimately to estimate pump performance head vs. flow. Results of the design point analyses shall be presented to a minimum.

#### 6.5.4 Other dimensioning

For a Safety Class 1 or 2 pump unit (serial pumps with an electric motor having a rated output less than 15 kW excluded) or a non-serial Safety Class 3 or 4 pump, the following dimensioning data shall be given:

- vibration analysis
- analysis of operational clearances
- dimensioning of bearing and shaft seals.

The aforementioned data is not required for other pump units, unless required by their special construction or operation.

A vibration analysis shall present calculations for pump unit dynamics or equivalent justification to demonstrate that the margin between natural frequencies and excitations as well damping is adequate to ensure sound pump unit operation under design conditions. The analysis shall cover pump unit rotating components (torsional vibrations and lateral vibrations) and static main structures.

Dimensioning data for operational clearances and plays to allow thermal expansion shall be presented to demonstrate their adequacy under design conditions.

Selection criteria for bearings and shaft seals,shall be presented to demonstrate their structural and functional acceptability under design conditions.

### 6.6 Technical specifications

The following technical specifications for the pump shall be given:

- characteristic curves (whole control range when speed controlled pump)
  - head, $NPSH_r$, shaft power and efficiency vs. flow
  - torque vs. rotation speed
- minimum and maximum flow with associated time limits
- assembly and sectional drawings
- drawings of auxiliaries (shaft seal, bearing, coupling, gear etc.)
- part list and construction materials
- welding materials
- material specifications of major structural parts (Safety Classes 1 and 2)
- instrument list
- interlockings, protections, alarm and trip limits
- pump unit start-up procedure
- flow rate, temperature and quality requirements for cooling water and shaft seal water.

Drawings shall present main dimensions, refer to the part list and material specifications and also indicate welded joints and hardfacings. The drawings shall also show the operation of the pump as well as essential tolerances, clearances and plays.

A process and instrument diagram shall be given when the pump unit has such instrumented auxiliaries as lube oil, shaft seal and cooling systems.

### 6.7 Inspection plan

An inspection plan for the inspection and testing of the materials, structures and operation of the pump shall be presented. It defines inspection and test steps as well as their supervision whose scope depends on the pump's safety significance. For the performance of the inspections and testing, the inspection plan shall refer to relevant inspection procedures and/or standards and include STUK or a STUK-approved inspection organisation hold and witness points.

### 6.8 Inspection procedures

Procedures to inspect and test pump materials, structures and operation shall be drawn up or applicable standards be used as such procedures. The inspection procedures shall include instructions, scope and approval criteria for the performance of the inspections and tests.

Inspection procedures shall be presented at least for hydrostatic and leaktightness tests, functional tests (performance test, endurance test and other functional tests), and, in Safety Classes 1 and 2 for a pump's DT and NDT testing (material manufacturing and pump fabrication) and rotor balancing. A reference to the relevant decisions is adequate for inspection procedures approved by STUK earlier.

### 6.9 Spare parts

The construction plan shall define those wearing spare parts and strategic spare parts of the pump that are available, where necessary, at the nuclear facility or stored elsewhere for maintenance and repair work.

# 7 Electric motor construction plan

### 7.1 General requirements

The following information shall be contained in the electric motor's construction plan:

- tag (KKS code or equivalent), safety class and product class
- manufacturer and testing organisation
- previous operating experience
- design basis
- dimensioning calculations
- technical specifications
- inspection plan
- inspection procedures
- spare parts.

In accordance with Guide YVL 1.2 "Documents pertaining to safety control of nuclear facilities", the licensee shall submit to STUK in three copies the construction plan they have approved. To a STUK-approved inspection organisation, a similarly approved plan shall be submitted using a procedure required by the organisation.

### 7.2 Manufacturer and testing organisation

Of the manufacturer of a Safety Class 2 electric motor, the corporate structure (parent company/ companies, design and manufacturing organisation), management system description, management system quality certificates, major subcontractors and previous references shall be given. Of manufacturers in Safety Class 3, at least the management system quality certificates and previous references shall be given.

As regards approval of testing organisations, the construction plan shall contain references to the relevant STUK decisions and their expiration dates. If the testing organisation is accredited, documents proving the accreditation submitted earlier to STUK for information shall be referred to.

### 7.3 Operating experience and type test data

The types, rated values, quantities, delivery years, purchasers and type test reports of reference electric motors shall be given. When the construction or functioning of the electric motor differs from the reference electric motor, information shall be given that makes it possible to evaluate the effect of the differences.

For Safety Class 2 reference electric motors, operating experience data should include operating times and conditions with fault and maintenance history information.

### 7.4 Design basis

As the design basis, the requirements set for the electric motor by pump, the system, the electrical grid and the environment under design conditions shall be presented as follows:

- pump mechanical power and rotation speed
- range and duration of supply voltage and frequency
- number of repeated start-ups
- mechanical loadings and their combinations
  - mechanical design parameters
  - exceptional reclosing
  - design pressure and temperature (wet motor)
  - external dynamic loadings (seismic event, aircraft impact, pressure wave)
- ambient conditions (temperature, humidity, radiation, etc.)
- moments of inertia of pump and coupling
- functional requirements under design conditions
- service life.

### 7.5 Dimensioning

#### 7.5.1 General requirements

The design and dimensioning standards used shall be referred to.

Dimensioning calculations shall be presented covering initial data, calculation methods, visualised results, acceptance criteria and conclusions.

#### 7.5.2 Electrotechnical calculations

For a Safety Class 2 electric motor, coil temperature rise calculations shall be presented.

Calculations are not needed for Safety Class 3 electric motors unless required by their special construction or functioning.

#### 7.5.3 Strength calculations

For a Safety Class 2 electric motor (serial electric motors having a rated output less than 15 kW excluded) or for a non-serial Safety Class 3 electric motor, strength calculations shall be given. Strength calculations are not needed for other electric motors unless required by their special construction or operation.

The electric motor's strength calculations shall include basic dimensioning for the following components:

- load bearing or transferring parts, e.g. a shaft
- supports and anchoring bolts
- pressure retaining components, e.g. a wet motor shell.

#### 7.5.4 Bearings

For a Safety Class 2 electric motor (serial electric motors having a rated output less than 15 kW excluded) or a non-serial Safety Class 3 electric motor, bearing dimensioning data shall be given. Bearing dimensioning data is not required for other electric motors unless required by their special construction or operation.

Selection criteria for bearings shall be presented to demonstrate their structural and functional acceptability under design conditions.

### 7.6 Technical specifications

The following technical specifications for the electric motor shall be given:

- rated values
- torque curve (torque exerted by electric motor and pump countertorque) vs. rotation speed
- start-up times and longest allowable locked-rotor times
- assembly and sectional drawings
- part list and construction materials
- instrument list
- enclosure, temperature rise and insulation classes
- interlockings, protections, alarm and trip limits
- cooling water volume, temperature and quality requirements.

Electric motor torque with rated voltage as well as with undervoltages and over frequencies shall be presented.

Drawings shall present main dimensions, refer to the part list and material specifications and also indicate welded joints and hardfacings. The drawings shall also show essential operational tolerances, clearances and plays.

Process and instrument diagrams shall be given when the electric motor has such instrumented auxiliaries as lube oil and cooling systems.

### 7.7 Inspection plan

An inspection plan for the inspection and testing of the materials, structures and functioning of the electric motor shall be presented. It defines inspection and test steps as well as their supervision whose scope depends on the electric motor's safety significance. For the performance of the inspections and testing, the inspection plan shall refer to relevant inspection procedures and/or standards and include STUK or STUK-approved inspection organisation hold and witness points.

### 7.8 Inspection procedures

Procedures to inspect and test electric motor materials, structures and functioning shall be drawn up or applicable standards be used as such procedures. The inspection procedures shall include instructions, scope and approval criteria for the performance of the inspections and tests.

Inspection procedures shall be presented at least for factory tests (routine tests and other functional tests) and in Safety Class 2 (serial electric motors having a rated output less than 15 kW excluded) also for the DT and NDT testing (material manufacturing and motor fabrication) of electric motors, the insulation and impulse voltage testing of the coils of a medium voltage motor, and rotor balancing. A reference to the relevant decisions is adequate for inspection procedures approved by STUK earlier.

### 7.9 Spare parts

The construction plan shall define those strategic spare parts and wearing spare parts of the electric motor that are available, where necessary, at the nuclear facility or stored elsewhere for maintenance and repair work.

# 8 Inspections and testing

## 8.1 General requirements

The licensee shall ensure that the specified inspections and testing are performed on the materials, structures and functioning of the pump and electric motor, and make it possible for STUK or a STUK-approved inspection organisation to oversee manufacturing as well as the inspections and testing in the scope they deem necessary.

The licensee shall arrange the pump unit's construction inspection as well as the other hold and witness points defined in the approved inspection plan or whose performance is otherwise required.

## 8.2 Construction inspection

In accordance with the principles set out in Guide YVL 1.15 "Mechanical components and structures in nuclear installations. Construction inspection", the construction inspections of pumps and electric motors are intended to ensure that

- materials, manufacturing, fabrication, structures and functioning comply with the approved construction plan
- the scope of inspections and tests comply with the approved inspection plan and their results are acceptable.

In the construction inspection, the pump with part markings is visually inspected, the procurement and fabrication documentation is reviewed and appropriate tests witnessed. The tests to be witnessed are the pump's hydrostatic, leaktightness and functional tests. Functional testing comprises both performance tests and endurance tests. The minimum length of an endurance test in Safety Classes 1 and 2 is 48 h and every pump is to be tested. In Safety Classes 3 and 4 a corresponding endurance test is to last at least for 12 hours and one pump out of every batch of identical pumps is to be tested at a minimum. Pumps shall be disassembled and parts visually inspected after the endurance tests.

The scope of an electric motor's construction inspection is decided upon case-by-case during the construction plan review. An electric motor's construction inspection typically includes a visual inspection, a review of its procurement and fabrication documentation and a witnessing of factory tests.

The procurement and fabrication documentation approved by those in charge and construction plans approved by STUK with their reference documents shall be available at the construction inspection.

## 8.3 Type test

The pump and electric motor shall be tested in such a way that one or more electric motors per type are tested to demonstrate compliance with requirements. Type test may be replaced with information given in the construction plan (records of previous type tests, good operating experience) that similarly demonstrates the compliance.

When a type test is required, pump or electric motor structures and functioning shall be tested in conditions similar to design conditions in such a way that compliance with the requirements can be justifiably concluded from the test results. A type test procedure shall be drawn up that gives the test instructions, scope and acceptance criteria.

# 9 Installation

## 9.1 General requirements

Prior to installation, the licensee shall make an acceptance inspection to ensure that the pump and electric motor were delivered to the nuclear facility defect-free and are as specified in the construction plan. Records shall be kept of the acceptance inspection.

If installation includes fabrication, e.g. welded nozzles, the organisation installing the pump unit shall be STUK-approved in accordance with Guide YVL 3.4 "Approval of the manufacturer of nuclear pressure equipment".

## 9.2 Installation plan

The licensee shall draw up a pump unit installation plan containing the following information:

- installation procedure and drawings, incl. tightening of threads
- qualified welding procedures if installation includes welding
- inspection plan of installation.

Where necessary, the installation inspection plan shall include installation steps for welding, alignment and other inspections to demonstrate acceptability of the pump unit's mechanical installation.

### 9.3 Installation inspection

The licensee shall arrange an visual inspection to demonstrate acceptability of the pump unit's mechanical installation. Reports of inspections specified in the installation inspection plan are also reviewed during the installation inspection.

# 10 Commissioning

### 10.1 General requirements

Manufacturers' instructions shall be followed during the pump and electric motor's commissioning.

The licensee shall arrange a separate two-phased commissioning inspection of the pump unit whose first phase ensures the pump unit's trial run readiness and the second its readiness for operation. However, in case of a Safety Class 3 or 4 pump with an electric motor having a rated output less than 100 kW, and if the system the pump unit belongs to is subject to a commissioning inspection, the licensee may demonstrate the pump unit's acceptable readiness for operation during the system's commissioning in accordance with Guide YVL 2.5 "The commissioning of a nuclear power plant".

Before the pump unit is put into service, the licensee shall perform a commissioning inspection on its electric motor in accordance with Guide YVL 5.2 "Electrical power systems and components at nuclear facilities".

### 10.2 Commissioning inspection

#### 10.2.1 Phase 1

The licensee shall demonstrate during Phase 1 that the inspections and testing relating to the installed pump unit's electrical and I&C systems have been acceptably performed.

The licensee shall present a pump unit construction plan, a construction inspection protocol and an installation inspection protocol that have been approved. The manufacturer's commissioning procedures shall be presented as well.

#### 10.2.2 Phase 2

The licensee shall perform a trial run during Phase 2 to demonstrate that the pump unit fulfils the functional requirements as part of the system.

The licensee shall draw up for Phase 2 a pump unit trial run plan (incl. process arrangements, measured data, acceptance criteria, etc.). The licensee shall present the plan before Phase 2 is started.

It shall be possible by means of the trial run to ascertain the pump unit's operability under design operational conditions. An uninterrupted trial run period is to be long enough to allow for the process to reach steady conditions; one hour duration is considered the minimum, however. During the trial run, condition monitoring reference values (electric parameters, vibrations, bearing temperatures, etc.) shall be recorded for the pump unit.

# 11 Operation, maintenance and modifications

The licensee shall operate and maintain pumps and their electric motors in such a way that they fulfil their set requirements for the duration of their design lifetime. The licensee shall have in place procedures and plans for the operation and maintenance of the pumps and their electric motors (preventive maintenance, in-service inspection and testing, repairs). The procedures and plans shall be based on manufacturer requirements and recommendations as well as decisions given by authorities and shall be continually updated and developed based on accumulated operating experience.

Preventive maintenance shall be timed so that, by the next scheduled maintenance, the remaining service hours of wearing parts always exceed the designed uninterrupted operation period without maintenance. Approved construction plans shall be complied with in spare parts procurement.

The pump unit shall be periodically inspected and tested unless operability can be verified on-line by other means.

The licensee shall draw up construction, installation and trial run plans for repairs and modification and similarly arrange construction, installation and commissioning inspections. The plans and inspections shall, where applicable, correspond to those required for a new pump unit.

The licensee shall maintain a data acquisition system where documents on modifications and maintenance works are recorded, and shall ensure that they are at STUK's disposal on request.

The licensee shall have spare parts available for maintenance and repair work as defined in the pump unit construction plan.

# 12 Oversight by STUK

## 12.1 General

By the procedures described in this guide STUK oversees the nuclear facility's Safety Class 1, 2, 3 and 4 pumps and their Safety Class 2 and 3 electric motors.

STUK oversees the appropriateness and implementation of procedures which the licensee has prepared to procure, operate and maintain the nuclear facility's Safety Class EYT pumps and their Safety Class 4 and Class EYT electric motors.

Upon the licensee's application STUK delegates, in accordance with Table 1, inspections of Safety Class 3 and 4 pumps and Safety Class 3 electric motors to the inspection organisations it has approved for the purpose.

The licensee shall send a notification to STUK or a STUK-approved inspection organisation to perform inspections or supervise testing early enough before proposed date.

## 12.2 Pump specification

A nuclear facility specific pump specification shall be STUK-approved before the the construction plans of pumps and their electric motors can be submitted for approval to STUK or a STUK-approved inspection organisation.

## 12.3 Construction plans

### 12.3.1 General

Construction plans shall be licensee-approved before their submission for approval to STUK or a STUK-approved inspection organisation and before the start of manufacturing.

### 12.3.2 Pump construction plan

The construction plan shall be approved by STUK or a STUK-approved inspection organisation before the manufacturing of Safety Class 1 or 2 pumps (serial pumps having a rated output less than 15 kW excluded) or non-serial pumps. Manufacturing means here the manufacturing of a prefabricated or other part that essentially relates to the acceptability of the pump's structural or functional dimensioning.

The construction plan of a serial pump shall be approved by STUK or a STUK-approved inspection organisation before construction inspection if the electric motor's rated output is less than 15 kW or the pump belongs to Safety Class 3 or 4.

A STUK-approved system level design basis for the pump is a prerequisite for construction plan approval.

### 12.3.3 Electric motor construction plan

The construction plan shall be approved by STUK or a STUK-approved inspection organisation before the manufacturing of a Safety Class 2 electric motor or a non-serial electric motor (serial pumps having a rated output less than 15 kW excluded). Manufacturing means here the manufacturing of a prefabricated or other part that essentially relates to the acceptability of the electric motor's structural or functional dimensioning.

The construction plan of a serial electric motor shall be approved by STUK or a STUK-approved inspection organisation before construction inspection if the electric motor's rated output is less than 15 kW or the electric motor belongs to Safety Class 3.

A STUK-approved system level design basis for the electric motor is a prerequisite for construction plan approval.

**Table 1.** General sharing of pump unit inspections (STUK and inspection organisation).

| Safety Class | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Design | | | | |
| Pump specification / pump unit | STUK | STUK | STUK | STUK |
| Construction plan / pump | STUK | STUK | IO | IO |
| Construction plan / electric motor | | STUK | IO | |
| Manufacturing and fabrication | | | | |
| Construction inspection / pump | STUK | STUK | IO | IO |
| Construction inspection / electric motor | | STUK | IO | |
| Installation / pump unit | | | | |
| Installation plan | STUK | STUK | IO | IO |
| Installation inspection | STUK | STUK | IO | IO |
| Commissioning / pump unit *) | | | | |
| Commissioning inspection, Phases 1 and 2 | STUK | STUK | STUK | STUK |
| Trial run plan | STUK | STUK | STUK | STUK |
| Operation / pump unit | | | | |
| Plans for repairs and modifications; construction and installation inspection | STUK | STUK | IO | IO |
| Commissioning inspection of repairs and modifications | STUK | STUK | STUK*) | STUK*) |

STUK = The Finnish Radiation and Nuclear Safety Authority, IO = inspection organisation

*) the commissioning inspection of Safety Class 3 or 4 pumps and electric motors having a rated output less than 100kW is conducted during system commissioning

## 12.4 Inspections and testing

STUK or a STUK-approved inspection organisation performs pump and electric motor inspections and tests (hold and witness points) that are defined in the approved inspection plan or whose preformance is otherwise required.

When a type test is required, a type test procedure shall be approved by STUK before the test.

A test report of electric motor factory tests shall be submitted to STUK or a STUK-approved inspection organisation for approval.

Construction inspections shall be approved by STUK or a STUK-approved inspection organisation before the pump unit is installed.

## 12.5 Installation

The pump unit's installation plan shall be approved by STUK or a STUK-approved inspection organisation before installation is started.

The pump unit's installation inspection is performed by STUK or a STUK-approved installation organisation.

The installation inspection shall be approved by STUK or a STUK-approved inspection organisation before the pump unit is put into service.

## 12.6 Commissioning

STUK performs a separate two-phase commissioning inspection on the pump unit or carries it out during the system's commissioning as stated earlier in the text. In the separate two-phase inspection

- the trial run plan shall be approved by STUK before the trial run
- Phase 1 of the commissioning inspection shall be approved by STUK before Phase 2
- Phase 2 of the commissioning inspection shall be approved by STUK before the pump unit is put into service.

## 12.7 Operation, maintenance and modifications

STUK oversees that the instructions and plans used for pump unit operation and maintenance are adequate and that they are complied with.

Construction, installation and trial run plans for repairs and modifications shall be approved by STUK or a STUK-approved inspection organisation before entering a corresponding phase of the repair or modification.

The construction inspections of repairs or modifications, and of the strategic spare part procured for this purpose, shall be approved by

STUK or a STUK-approved inspection organisation before installation.

The installation inspection of repairs or modifications shall be approved by STUK or a STUK-approved inspection organisation before the pump unit is put into service.

The commissioning inspection of repairs or modifications shall be STUK-approved before the pump unit is put into service.

# 13 References


1. API Standard 610 ”Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries”, Tenth Edition.
2. EN ISO 9905 ”Technical specifications for centrifugal pumps. Class I”.
3. EN ISO 5199 ”Technical specifications for centrifugal pumps. Class II”.
4. ISO 9908 ”Technical specifications for centrifugal pumps. Class III”.
5. EN ISO 9906 ”Rotodynamic pumps. Hydraulic performance acceptance tests. Grades 1 and 2”, 1st Edition.
6. 2004 ASME Boiler & Pressure Vessel Code, Section III, Division 1, Subsection NB Pump Design.
7. 2004 ASME Boiler & Pressure Vessel Code, Section III, Division 1, Subsection NC Pump Design.
8. ASME OM CODE-2001 ”Code for Operation and Maintenance of Nuclear Power Plants”, Subsection ISTB ”In-service Testing of Pumps in Light-Water Reactor Nuclear Power Plants”.
9. ASME QME-1-2002 ”Qualification of Active Mechanical Equipment Used in Nuclear Power Plants”.
10. ISO 7919 ”Mechanical vibration of non-reciprocating machines – Measurements on rotating shafts and evaluation criteria”, Parts 1–5.
11. ISO 10816 ”Mechanical vibration – Evaluation of machine vibration by measurements on non-rotating parts”, Parts 1–5.
12. ISO 1940-1 ”Mechanical vibration – Balance quality requirements of rigid rotors – Part 1: Determination of permissible residual unbalance”.
13. ANSI/HI 9.8-1998 ”American National Standard for Pump Intake Design”.
14. KTA 3504 ”Elektrische Antriebe des Sicherheitssystems in Kernkraftwerken”.
15. IEC 60034 ”Rotating electrical machines, rating and performance”.
16. IEC 71-1 ”Insulation co-ordination, Definitions, principles and rules”.
17. IEC 71-2 ”Insulation co-ordination, Application guide”.
18. IEC 60085 ”Electrical insulation, Thermal classification”.