Regulatory control of nuclear facility valves and their actuators

This Guide is valid as of 1 April 1991 until further notice. This Guide replaces Guide YVL 5.3 issued on 26 November 1979.

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Authorization

The Finnish Centre for Radiation and Nuclear Safety (STUK) issues detailed regulations concerning the safety of nuclear power plants by virtue of Section 55, second paragraph, point 3 of the Nuclear Energy Act (990/87) and Section 29 of the Decision of the Council of State on the General Regulations for the Safety of Nuclear Power Plants (395/91).

The YVL guides are rules an individual licensee or any other organization concerned shall comply with unless some other acceptable procedure or solution has been presented to STUK by which the safety level laid down in an YVL guide is achieved.

Translation. Original text in Finnish.

1 General

The reliable functioning of a nuclear power plant's systems is an important prerequisite for safety. The valves incorporated in the systems and their actuators, for their part, are of great significance to the functioning of the systems in question. The functional requirements of valves are thus determined on the basis of the functional requirements of the systems. Furthermore, the valves are designed, manufactured and installed to maintain their structural strength and prerequisites for functioning in operational, transient and accident conditions.

According to Guide YVL 2.1, a nuclear power plant's safety functions are assigned to Safety Classes 1, 2 and 3 and Class EYT (non-nuclear). Thus, the classification documents also contain the classification of valves and their actuators.

This Guide describes how STUK regulates valves and their actuators in a nuclear power plant and in other nuclear facilities. The scope of regulation depends on the Safety Class of the valve and actuator in question. The various regulatory phases are as follows:

- review of the construction plan
- regulatory control of manufacture and conduct of the construction inspection
- commissioning inspection
- regulatory control of operation.

The regulatory control of nuclear facility safety valves is described in Guide YVL 5.4.

2 Construction plan

The construction plans for Safety Class 1, 2 and 3 valves and actuators shall be submitted to STUK for approval prior to commencing manufacture, in accordance with Guide YVL 1.2, using a division as per this Guide. The construction plan shall give descriptions of the following issues:

a) Manufacturer of valve
b) Design bases
c) A description of the materials of construction
d) Quality Control programme
e) Valve dimensioning
f) Drawings
g) Valve type tests and operating experience
h) Actuator
i) Installation of valve and actuator.

The necessary descriptions shall be given of valves and actuators incorporated as components in Class EYT/A piping, either in conjunction with a piping description submitted for approval in accordance with Guide YVL 3.3 or in a separate document which shall contain at least the following information:

- manufacturer's name
- design bases
- materials of construction with reference to the applicable standards and the material certificate class of the material of construction
- dimensioning standards
- pressure class or basic dimensioning as per point 2.5.1
- instructions for manufacture (welding, heat treatment, coating etc.)
- Quality Control requirements
- assembly drawing
- possible special requirements related to installation
- actuator
- compatibility of valve and actuator as regards mechanical strength (dimensioning of power transmission train under operational and accident conditions).

A construction plan or a description need not be submitted to STUK for valves and actuators incorporated as components in such Class EYT/B piping as conforms to Guide YVL 3.3.

If the same valve and/or actuator type is intended to be used in several locations these

shall be indicated in the document by giving their component designations as per system and instrumentation diagram. The inclusion in the assembly drawing of component designations is recommended. If the above component designations cannot be given in the plan, the power company may submit another kind of follow-up procedure for approval however, by which it is ensured that a valve or actuator of an appropriate type and with the appropriate design values is installed and that the documents are updated.

Small diameter valves may be approved on the basis of the type document. The document shall indicate the valves' functional purpose, pressure class, materials of construction and tests. The size of small diameter valves shall be determined in the document. However, if the valve acts as another device's pilot valve or has a bearing on the operability of the main device, the construction plan shall be submitted to STUK for approval if a construction plan is required of the main device in question.

In the construction plan, reference can be made to documents submitted earlier.

2.1 Manufacturer of valve

Safety Classes 1 and 2:

A description shall be provided indicating that the manufacturer of the valve's pressure-retaining parts has adequate expertise. It shall contain a description of the organization confirmed by the company's management which shows i.a. the definition of duties, scopes of responsibility and qualifications as well as the arrangement of quality assurance.

Approval for the manufacturer's quality control department active in quality control or for a separate inspection agency as well as for the inspectors employed by them, is applied for in accordance with Guide YVL 1.3.

Safety Class 3 and Class EYT:

The valve manufacturer's name shall be given for items in Safety Class 3 and Class EYT. Approval in accordance with Guide YVL 1.3 shall be obtained for the company performing quality control and for the inspectors employed by it.

2.2 Design bases

The valve's functional and structural design bases shall be incorporated in the design bases. The design bases shall be so extensively presented that the valve design flow rate, valve functioning and the prerequisites for functioning as well as control of the materials of construction, solutions pertaining to structure, strength calculations, the quality control programme, inservice inspections and maintenance operations can be evaluated on their basis.

2.2.1 Valve functional design bases

The functional design bases include i.a.:

- function (control valve, stop valve, check valve, isolation valve, pressure reducing valve)
- system and component designation(s)
- Safety Class
- maximum pressure difference under which valve shall be able to change position
- requirements as regards lines/ assemblies for bypass, pressure balancing, venting, drainage and testing
- requirements concerning position indications
- normal operating position (open/ closed/intermediate position) and operating frequency
- requirements for valve tightness upstream and downstream
- requirements for valve opening and closure times
- requirements for valve functional direction upon loss of actuator power
- required check valve closure time to avoid pressure shocks.

2.2.2 Valve structural design bases

Structural design bases include i.a.:

- design temperature and normal operating temperature
- design, test and normal operating pressure
- the pressure and temperature changes to be employed in dimensioning and their number
- upper limits for forces and torques exerted by piping
- requirements for minimum forces and torques exerted by actuator
- allowable values for maximum forces and torques exerted by actuator
- quality of medium, phase transitions and chemical impacts
- environmental requirements set for valve and actuator under normal operating conditions and in transients (chemical impacts, temperature, pressure, humidity, radioactivity and duration of exceptional conditions)
- requirements for fire resistance
- ascertaining check valve tightness during operation
- requirements for valve decontaminability.

2.3 Description of the materials of construction

By means of a description of the materials of construction, the acceptability and suitability of the valve's materials of construction for their purpose of use shall be demonstrated. The construction and welding filler materials shall satisfy the requirements of Guide YVL 3.9. The description of the materials of construction shall contain a component and joint specific list of the construction and welding filler materials. A description of the manufacturing method of valve and actuator components as regards heat treatment, application of coating and cold working etc. shall be given. The applicability of the manufacturing instructions shall be checked by means of work and procedure tests as regards Safety Classes 1 and 2.

2.4 Quality control programme

A valve's quality control and the inspection and testing procedure to be observed therein shall be presented in the quality control programme.

The quality control programme contains

- inspection plans
- inspection instructions.

2.4.1 Inspection plans

Inspection plans concerning quality control of the material of construction, work tests, manufacture and the accomplished product shall be presented.

The inspection plan shall give

- component or joint specific numbering in accordance with drawings
- name of component
- marking in the construction or welding filler material indicating standard
- inspections to be conducted on each item and the inspection instructions
- time of inspection (manufacture of construction material, manufacture and installation of valve)
- performer of inspection/audit (e.g. manufacturer, plant supplier, approved inspection agency).

The welding procedure or work tests associated with manufacture or repair shall be performed on the pressure-retaining components of Safety Class 1 and 2 valves. The tests shall be performed on other valves if so required in the design bases.

2.4.2 Inspection instructions

There shall be inspection instructions for all inspections mentioned in the inspection

plans. An inspection instruction shall state the method and extent of the inspection, the requirements and reporting. As regards details, reference may be made to standards.

The most common quality control measures for which instructions shall be drawn up can be grouped as follows:

- identification of the materials of construction, their marking and the construction material certificates
- test sampling and test batches
- destructive testing
- non-destructive testing
- supervision of welding and welders' qualifications
- control of heat treatment
- inspection of the structure's dimensions
- visual inspection
- tightness downstream
- pressure and tightness tests
- valve/actuator performance tests.

The pressure and tightness tests shall be performed in accordance with the design basis standard. If not so required in the design bases, a separate pressure and leaktightness test plan shall be presented for Safety Class 1 valves. Other Safety Classes shall conform to Standard SFS 4134 /1/ or a comparable standard.

2.5 Valve dimensioning

It shall be demonstrated by dimensioning that a valve's dimensions and design satisfy the strength and functional requirements set by the system.

2.5.1 Strength calculations

Dimensioning pertaining to strength is divided into basic dimensioning and stress and fatique analysis.

The valve's design conditions, which generally do not include changes in temperature or load, shall be employed as the input values for basic dimensioning. The forces and torques exerted by piping can be taken into account in the form of an equivalent pressure increase.

The loads to which the structure is subjected during a stress and fatique analysis shall be taken into account as realistically as possible. In that case the input values shall be as follows: temperature gradients, dynamic loads, cyclic loads as well as the forces and torques exerted by piping.

The dimensioning calculations shall be accompanied by clarifying drawings presenting loads, system information and necessary dimensions.

The basic dimensioning of Safety Class 1 valves shall be in accordance with ASME Boiler and Pressure Vessel Code, Section III (ASME Code, Section III), NB-3500 /2/ or some other nuclear power plant standard approved by STUK.

In Safety Class 1, in addition to basic dimensioning, a stress and fatique analysis in accordance with ASME Code, Section III, NB-3500 or some other nuclear power plant standard, shall be presented together with the below additions:

- If the thermal expansion coefficients of the materials of a valve's body and bolts vary and the design temperature is in excess of 200 °C, resilience and fatique analyses of the body-to-bonnet bolting shall be carried out. Also resilience calculations of other pressure-retaining bolting shall be performed if they are subjected to abrubt temperature gradients.

- A fatique assessment of $DN \leq 100$ (4 in) valves shall be performed if they are subjected to loads causing significant fatique.

- If a valve's nominal diameter is equal to or larger than 500 mm, the adequacy of a simple fatique analysis in accordance with Standard ASME III NB-3500 shall be justified.

Safety Class 2 or 3 valves shall be correspondingly dimensioned in accordance with Standard ASME Code, Section III, NC-3500 /3/ and ND-3500 /4/ or some other nuclear power plant standard approved by STUK. Also the SFS Standards in the series 2610 may be used in dimensioning provided that special attention is paid to quality control.

Safety Class 2 and 3 valves shall, in addition to internal pressure, be dimensioned against the greatest possible force exerted by piping. If a valve is subjected to a load causing significant fatique, the valve shall undergo fatique analysis in accordance with Standard ASME Code, Section III, NB-3500.

Dimensioning shall also be presented for nonpressure-retaining components essential for functioning. An example of the acceptable scope is given in Ref. /5/.

The durability of a valve's seat and disc surfaces in Safety Classes 1 and 2 shall be demonstrated by means of one of the following clarifications:

- surface pressure calculations
- impact velocity
- experimental investigations and operating experience.

2.5.2 Flowdynamic design

Dimensioning pertaining to the flow rate shall demonstrate how a valve's design bases pertaining to the flow rate have been implemented.

The following facts shall be given:

- capacity correction factor Kv or pressure-loss coefficient Z
- dimensioning of components which affect the operating rate.

2.6 Drawings

Drawings shall present a structure's composition and details in such a way that valve dimensions, configuration and manufacture are accounted for in sufficient detail. If valves shall be subjected to inservice inspections using NDT methods, as required in Guide YVl 3.8, it shall be possible to assess from drawings whether inspections of the valve body and its welded joints, and of the welded joints between the valve and the piping can be carried out reliably.

The drawings shall present

- assembly data with lists of components and materials of construction
- dimensions and configurations employed for dimensioning or arrived at by means of them and necessary tolerances
- types, locations and dimensions of joints and fastenings
- coatings of structural materials
- gaps, fits and plays essential for functioning.

2.7 Valve type tests and operating experience

In connection with the construction of a new nuclear power plant unit, a type testing programme with an implementation schedule shall be drawn up for valves important to safety. It shall be adequately taken into account in the planning of type testing schedules that only sufficiently tested valve types may be installed in the power plant. The following points in particular shall be emphasized in the test programme:

- adequacy of performance characteristics under various operational and accident conditions
- preservation of performance characteristics under the system conditions concerned
- mechanical and corrosion resistance
- maintenance of leaktightness
- functional reliability.

Type testing might be replaced by the results of earlier type testing and operating

experience. In that case detailed clarifications shall be presented in the construction plan and the principles to be observed shall be given in the type testing programme.

Type information for new valves purchased for an operating nuclear facility are reviewed in conjunction with the construction plan.

2.8 Actuator

2.8.1 Information pertaining to actuator design and manufacture

The following information shall be presented on actuators of Safety Class 1 or 2 valves and actuators of Safety Class 3 valves the safety classification of which is based on the functional requirements set for the valves:

- Safety Class
- description of manufacturer
- quality control programme with its inspection and performance test information
- description of the materials of construction
- drawing presenting components and main dimensions
- electrical connections diagrams of actuator and its motor
- design information.

Design information includes i.a.:

- operating voltage required by electrical actuators
- starting current and rated power
- manner of implementation of electrical protection
- enclosure and insulation class of electrical actuator
- type, pressure, temperature and quality (particle-type impurities, moisture content etc.) of hydraulic and pneumatic actuator medium
- functioning upon loss of actuator power (valve opens/closes/retains position)
- information pertaining to functioning of torque, bypass and limit switches and set values with justifications
- normal ambient conditions and extreme ambient conditions (pressure, temperature, moisture content, chemicals, radiation level) which require operability.

The omission of the above information shall always be separately justified for Safety Class 3 components.

2.8.2 Actuator type tests and dimensioning

Type tests shall demonstrate that the actuator functions reliably and is not susceptible to malfunctions arising from external factors.

The operability of actuators, the functioning of which is required under accident conditions, shall be experimentally demonstrated by tests which correspond to the accident conditions under which the actuators will have to function. Further details are presented in Guide YVL 5.5.

Type testing information is given in References /6/ and /7/. The impact of a seismic event on dimensioning shall be taken into account in accordance with Guide YVL 2.6.

As an actuator's dimensioning data, the size, duration and number of loads which affect strength shall be presented. The dimensioning bases shall be presented, as well as the safety factors employed for various load situations and the materials information pertaining to the materials of construction of load transferring components. Guidelines are given in the relevant standard /7/.

The dimensioning criteria which affect the operating rate of pneumatic and hydraulic actuators and the safety factors used shall be stated.

2.9 Installation of valve and actuator

The document shall describe how the forces and torques created have been transferred to support structures and how servicing (replaceability, decontamination, drainage, conservation, automated welding etc.), testing and inspection possibilities and quarters have been taken into account.

The description shall present the following information for the installation of a valve and its actuator:

- welding information
- information on support structures of piping/valve/actuator
- functional requirements for control lines
- information pertaining to connections for drainage and testing (adequacy of testing connections shall be justified)
- information on measurement points and position indications required to monitor valve operation
- information with justifications (allowable and required torques, loads caused by actuator acceleration etc.) for ascertaining sizing of valve and actuator
- positions recommended for installation.

Valve and actuator compatibility as regards technical strength shall be justified by power transmission train strength calculations in which the loads exerted by the actuator and system on the power transmission train will be taken into account. The actuator's limit switches are assumed inoperable. The minimum set values of the limit switches shall be justified by taking into account, in addition to the loads arising from the system, the friction which occurs in the power transmission train.

A separate document pertaining to the installation of the valve and its actuator may be presented for approval in conjunction with i.e. the piping plan.

3 Regulatory control of manufacture and conduct of the construction inspection

STUK controls the manufacture of Safety Class 1 and 2 valves and their actuators by audits to the manufacturing plant. STUK shall be given the opportunity of getting acquainted with the plant's organization and quality assurance as well as of witnessing manufacture and testing. STUK oversees manufacture in the extent it deems necessary.

It will be separately announced if STUK considers it necessary to control the manufacture of a Safety Class 3 valve or an actuator thereof.

The construction inspection of Safety Class 1,2 and 3 valves is aimed to be performed at the manufacturing plant. Construction inspection shall be requested for in writing in good time prior to the time of inspection. If the entire construction inspection has been planned to take place during one audit it is proper to execute it at a time when performance tests can be witnessed and the post-test visual inspections can be conducted.

STUK conducts the construction inspection of Safety Class 1 and 2 valves with the valve assembled and disassembled.

A full construction inspection is usually performed on one Safety Class 3 valve out of each series of identical valves in the same batch. The final manufacturing documentation is fully reviewed and the scope of the rest of the construction inspection will be agreed upon separately.

If STUK requires a construction inspection of the actuator this will be mentioned in the decision by which the construction plan is approved.

A construction inspection pertaining to installation is performed on all Safety Class 1, 2 and 3 valves and their actuators after completion of installation. Class EYT/A valves may be structurally inspected in conjunction with the construction inspection pertaining to installation.

The requirements for construction inspection are presented in Guide YVL 1.15.

As regards small Safety Class 3 and Class EYT valves for drainage and venting, a procedure can be approved on application in which the manufacturing plant inspects its own products. The prerequisites for such a procedure are i.a.:

- approval from the pressure vessel authority of the manufacturing country for the procedure in question and for the documents to be used
- approval from the power company for the procedure in question and for the documents to be used
- possible familiarization with the manufacturer's quality assurance as well as with the manufacturing plants and methods.

The power company shall perform a receiving inspection of the valves in question.

4 Commissioning inspection

STUK performs the commissioning inspection of a nuclear power plant's valves and their actuators in conjunction with the inspection of the accessories of the pressure vessel or piping, in accordance with the below principles:

- The commissioning inspection of the actuator is performed in accordance with Guide YVL 5.5.
- The commissioning inspection of Safety Class 1, 2 and 3 and Class EYT/A valves is performed after the components and structures of the system or a portion thereof have been installed in their place.
- The commissioning inspection of Class EYT valves is performed in conjunction with the commissioning inspection of the system or a portion thereof. STUK does not perform the commissioning inspection of valves installed in Class EYT/B piping. The nuclear facility's owner shall see to it that also these valves are being properly controlled and inspected.

The commissioning inspection is divided into two parts: the verification inspection and witnessing of performance tests.

4.1 Verification inspection

In the verification inspection it is ascertained that the valve and its installation are ready for the granting of the performance test permit.

The documents pertaining to Safety Class 1, 2 and 3 valves and actuators shall be collected and filed. The state of approval of the documents is reviewed in the verification inspection pertaining to the commissioning inspection. The documentation to be presented shall contain i.a.:

- the list of documents
- the covering letters and front pages of the documents
- STUK's decisions and letters
- the construction inspection protocols
- clarifications pertaining to the remarks made in the inspections, in writing, where necessary
- the result documentation of performance tests carried out at the manufacturing plant
- the assembly and installation drawings.

4.2 Control of performance tests

The performance tests pertaining to the commissioning inspection may be performed as part of the trial run of the whole system, as referred to in Guide YVL 2.5. STUK controls the trial run by reviewing the system-specific trial run programmes and result reports as well as by witnessing the systems tests. The trial run shall demonstrate a valve's/actuator's suitability for the system's various operational conditions.

During the trial run, each valve's and actuator's specific basic values shall be determined to which the results of later periodic tests can be compared. By these comparisons any changes possibly occurring in the valve's/actuator's functioning are intended to be observed.

A written instruction shall be drawn up for the determination of the basic values. On the basis of this Guide and the trial run results, instructions for periodic tests shall also be drawn up. The instructions shall state the valves/actuators to be tested, the method of performing each measurement, the measuring equipment to be used and their calibration requirements as well as the retention of the results.

The method of performing the measurements shall be such that the joint operation of the valve and actuator and the functioning of the limit switches can be ascertained. New nuclear facilities shall, already during construction, be fitted with plugs which conform to the method of measurement in question. The method of measurement used in the performance tests of the valves and actuators of operating nuclear facilities shall be developed in the above direction. The instructions shall also state the limits of approval for the measurement results based on accident analyses and valve periodic inspection requirements. The use of Standard ASME Code Section XI, Subsection IWV /8/ is recommended for assistance in preparing the instructions.

5 Regulatory control of operation

5.1 Periodic tests and periodic inspection methods

Safety Class 1, 2 and 3 valves and actuators shall undergo periodic tests to verify operability and condition of the valves. For this purpose, the operator of the plant shall have a programme presenting the testing times for each component and the instructions to be followed in testing. The test results shall be filed in such a way that results obtained later can be compared with them, when required.

The valves and their actuators shall be monitored, for applicable parts, also by on-line diagnostic monitoring equipment. STUK oversees the implementation of the programme pertaining to periodic testing as well as the use of the on-line diagnostic monitoring equipment by inspections repeated at regular intervals.

5.2 Non-destructive inservice inspections

In the inservice inspections of valves the requirements presented in Guide YVL 3.8 shall be observed.

5.3 Preventive maintenance

For the preventive maintenance of Safety Class 1, 2 and 3 and Class EYT/A valves and actuators, the operator of the nuclear facility shall draw up programmes describing the preventive maintenance procedures to be performed on the valves and actuators.

Typical such procedures are i.a. oil and grease replacements, monitoring of operability by component disassembly and replacement of worn parts.

A data file shall be kept at the nuclear facility of Safety Class 1, 2 and 3 and Class

EYT/A valves and their actuators in which the repair, service and maintenance operations performed on the components are stored.

STUK controls the implementation of the preventive maintenance programme by inspections repeated at regular intervals.

5.4 Repairs and modifications

The requirements presented in Guide YVL 1.8 shall be observed in the design and implementation of repairs and modifications as well as in the installation of approved spare part valves.

5.5 Spare parts

The operator of the nuclear facility shall see to it that the necessary spare parts are purchased for each type of valve and actuator and that their adequacy is monitored.

The construction plan for the valve and its actuator also applies to spare parts. Possible modifications shall be subjected to STUK for approval. The scope of the construction inspection performed on spare parts is equal to that performed on the original parts.

6 References

1 Finnish Standards Association (SFS), Standard SFS 4134, Industrial valves. Pressure testing of valves
2 ASME Boiler and Pressure Vessel Code Section III, Article NB-3500 Valve Design
3 ASME Boiler and Pressure Vessel Code, Section III, Article NC-3500 Valve Design
4 ASME Boiler and Pressure Vessel Code Section III, Article ND-3500 Valve Design
5 ASME Code Case N-62-6, Dec. 11, 1989
6 ANSI/IEEE Std 382-1985, IEEE Standard for Qualification of Actuators for Power Operated Valve Assemblies with Safety-Related Functions for Nuclear Power Plants
7 KTA 3504, Elektrische Antriebe des Sicherheitssystems in Kernkraftwerken
8 ASME Boiler and Pressure Vessel Code, Section XI, Subsection IWV, Inservice Testing of Valves in Nuclear Power Plants

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