STUK

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STEEL STRUCTURES FOR NUCLEAR FACILITIES

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Authorisation

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

- Section 55, paragraph 2, point 3 of the Nuclear Energy Act (990/1987)
- Section 29 of the Government Resolution (395/1991) on the Safety of Nuclear Power Plants
- Section 13 of the Government Resolution (396/1991) on the Physical Protection of Nuclear Power Plants
- Section 11 of the Government Resolution (397/1991) on the Emergency Preparedness of Nuclear Power Plants
- Section 8 of the Government Resolution (398/1991) on the Safety of a Disposal Facility for Reactor Waste
- Section 30 of the Government Resolution (478/1999) on the Safety of Disposal of Spent Nuclear Fuel.

Rules for application

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

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

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

Translation. Original text in Finnish.

1 General

By virtue of the Nuclear Energy Act [1] and Decree [2], the Finnish Radiation and Nuclear Safety Authority (STUK) is the authority that regulates safety at nuclear facilities in Finland. General procedures for STUK's regulatory control of nuclear facilities are set forth in Guide YVL 1.1. Safety regulation by STUK includes control of the steel structures of nuclear facilities in so far as they have a bearing on the facilities' nuclear and radiation safety. Guidelines on steel pressure equipment are provided in the Series 3 YVL Guides.

This guide presents requirements on the design and manufacturing of steel structures for nuclear facilities as well as on documents to be submitted to STUK. Inspection of steel structures during plant construction and operation is also described. In addition, STUK in its regulatory work takes into account the operation of other authorities and inspection organisations.

Typical steel structures at nuclear facilities include

- bearing structures of buildings
- bearing steel structures of the concrete reactor containment
- tanks loaded by hydrostatic pressure
- supports against piping rupture
- missile barriers
- storage racks for fresh and spent fuel
- gates and linings of spent fuel storage pools
- spent fuel handling equipment
- crane rails
- doors and hatches.

The Series 3 YVL Guides apply to the design, manufacturing and quality inspection of the steel reactor containment.

If the aforementioned structures, referred to as steel structures, are manufactured of metallic construction materials other than steel, this guide if followed to the appropriate extent.

The basis for the quality management of a nuclear facility's construction and operation is given in section 5 [3] of the Government Resolution (395/1991), according to which *advanced quality assurance programmes shall be employed in all activities which affect safety and relate to the design, construction and operation of a nuclear power plant.* More detailed quality management requirements are set forth in Guides YVL 1.4 and YVL 1.9. These requirements apply also to the design, manufacturing, installation and control during operation of steel structures.

Guide YVL 4.3 sets requirements for fire doors and hatches as well as for other separating structures of fire compartments.

2 Safety classification

In accordance with section 21 of Government Resolution [3], *the systems, structures and components of a nuclear power plant shall be classified according to their safety significance.* The steel structures of a nuclear facility shall be assigned to Safety Class 1, 2, 3 and 4, or class EYT (non-nuclear). The requirements for design, manufacturing, installation, testing and inspection are determined by safety class. The classification criteria are given in Guide YVL 2.1. Safety classification shall be presented in a separate document, as required in Guide YVL 1.1.

This guide presents requirements for the design, manufacturing and inspection of Safety Class 2 and 3 steel structures. Separate instructions are given for Safety Class 1 steel structures. The licensee shall have administrative procedures for the inspection of Safety Class 4 and Class EYT steel structures. Safety Class 4 and Class EYT steel structures are not inspected by STUK but STUK controls the licensee's inspection activities and the appropriateness of its administrative procedures. Safety Class 4 and Class EYT steel structures shall fulfil the regulations and guidelines of the Finnish Building Regulations (RakMK) [4].

3 Construction plan

3.1 General

The basis for the design and manufacturing of steel structures for nuclear facilities is provided in the Government Resolution (395/1991) [3], subsection 2 of section 21, according to which *the systems, structures and components important to safety shall be designed, manufactured, installed and operated so that their quality level and the*

inspections and tests required to verify their quality level are adequate considering any item's safety significance.

Prior to the start of manufacturing of Safety Class 2 or 3 steel structures, the licensee shall submit the construction plan to STUK for approval in accordance with Guide YVL 1.2. STUK may, at its discretion and at the licensee's request, delegate the review of a Safety Class 3 steel structure's construction plan to an inspection organisation approved to perform inspections in accordance with Guide YVL 1.3.

The construction plan for a steel structure shall present

- design bases
- construction materials
- coatings
- structural analysis and dimensioning
- drawings
- inspection programme
- type test results and type-approved products plus products in accordance with certified product declarations
- procedure qualification and work tests
- manufacturing procedures
- description of manufacturer and testing organisations.

Steel structures shall fulfil the requirements and directions of RakMK [4]. If these are insufficient, also foreign regulations, guidelines and standards may be proposed to be applied.

3.2 Design bases

As design data, all essential factors affecting the durability and functioning of a steel structure shall be presented. They include i.a.

- loads
- corrosion resistance
- accessibility for inspections and testing during operation
- the effects of ageing.

The design data of steel structures shall be based on requirements for systems and ambient conditions, as given in the Safety Analysis Report and in Safety Analyses.

Requirements on safety analyses are given in Guides YVL 2.2 and YVL 2.8. Seismic events shall be considered in the design of nuclear power plants in accordance with Guide YVL 2.6.

3.3 Construction materials

When choice is made between construction materials, the operating and environmental conditions of the steel structure as well as requirements and restrictions resulting from manufacturing and testing shall be considered.

In the construction material report or drawings, the following shall be presented for the different parts of the steel structure

- standard marking and type of base material and welding consumables in accordance with the applicable standard
- method of fabrication, delivery condition and type of material certificate for base materials in accordance with standard SFS EN 10 204 [11]
- grounds for the choice of construction material, where necessary.

3.4 Coatings

Under accident conditions, coatings of steel structures and components inside the containment are subjected to loads deviating essentially from loads during normal operation. The coatings used shall be such that they will not have an unfavourable effect on accident management. The licensee shall demonstrate i.a. that coatings would not flake off to an extent which would block flow paths and endanger core coolability or removal of residual heat. In addition, it shall be demonstrated that under accident conditions, potential chemical changes in coating material do not create new risk factors.

The licensee shall present how the requirements on the coatings of steel structures inside the containment are met, including

- radiation resistance
- decontaminability
- chemical resistance
- durability under operating conditions
- durability under postulated accident conditions
- fire technical properties.

The inspection programme shall present methods for verifying how coating materials, coating

systems and surface preparation work meet the requirements.

Only coatings that have passed tests demonstrating the meeting of requirements can be used on steel structures inside the containment. The tests shall be repeated in case a different coating material is used for repairs and/or recoating, or in case coating consistency has essentially changed compared with original. Individual components with a negligible coated surface may be an exception from this rule.

If the room classification in the Safety Analysis Report places decontaminability requirements on the coatings of steel structures external to the containment, corresponding analyses pertaining to coatings shall be presented.

Coatings-related requirements are given in USNRC Regulatory Guide 1.54 [10].

3.5 Structural analysis and dimensioning

A structural analysis showing that the dimensions and design of a steel structure fulfil the design basis requirements and those of applicable standards shall be presented in the construction plan.

The steel structures of nuclear facilities shall be designed according to valid Finnish building regulations, guidelines and standards [4]. In order to take into account the special features of the nuclear facility, the licensee may propose for application even foreign regulations and guidelines. In that case, it shall be ensured that they form an applicable entity. The regulations, guidelines and standards shall be itemised.

An analysis of stability, fatigue or other phenomena (e.g. brittle fracture) using design-basis loads shall be conducted according to Guide YVL 3.5, where necessary.

The licensee shall refer to source literature on which his calculation methods are based and shall also indicate the points in the source literature that have been used. The source literature shall be presented to the inspection organisation on request. The initial data given, the finite element mesh chosen, the assumptions made and an interpretation of the results shall be presented in a summary report. Guidelines applicable for structural analysis carried out by using the Finite Element Method (FEM) are given in Guide YVL 3.5.

3.6 Drawings

Drawings shall describe a steel structure's assembly and details in such a way that the size, shape, fabrication and installation of its components, with allowable tolerances, are accounted for in sufficient detail. The drawings shall be unambiguous and clear. As regards the steel structure, they shall include

- safety classes with their boundaries
- location and how a steel structure is connected to other structures
- assembly with summary lists of components, materials and welding consumables
- designed structural dimensions and shapes with their allowable tolerances
- location, sizes, shapes and types of joint preparations for welded joints as well as references to welding instructions
- a reference to either the inspection programme or to guidelines for inspections and tests
- surface treatment.

If necessary, drawings shall describe how structure can be manufactured, installed and verified by inspection.

3.7 Inspection programme

3.7.1 General

The construction plan shall include an inspection programme for each steel structure. The inspection programme may be based on a quality manual that presents nuclear facility specific requirements for steel structures and has been approved in advance.

As one phase, the inspection programme shall include a construction inspection in accordance with Guide YVL 1.15.

The inspection plan can be divided into an inspection and testing plan as well as inspection and testing instructions, which describe in more detail methods, reporting and control.

3.7.2 Inspection and testing plan

The inspection and testing plan shall present the methods for inspecting and testing base materials, welding consumables, welded joints and completed structures during the various manufacturing phases.

The plan shall be drawn up such that it shows

- component or weld-specific identification data and references to steel structure drawings
- markings in accordance with the standard applied in the manufacturing of construction and welding consumables as well as the necessary references to material specifications
- weld-specific references to the welding procedures and, where necessary, to the procedure and work tests conducted to qualify these procedures
- the detailed tests and inspections to be conducted on a steel structure assembly as well as its components and welds; and a reference to the testing or inspection instructions.

If the inspections and tests of a component or a weld are carried out during more than one manufacturing phase, whether they are repeated in part or completely, they shall be presented as separate inspections (e.g. a radiographic testing of the weld root, or an ultrasonic testing of a weld prior to and after heat treatment).

If procedure qualification or work tests are needed to qualify the manufacturing procedures, a separate inspection plan shall be presented for them, the contents of which are determined by the above principles. A separate plan is required also when the properties of construction materials or welds are changed during manufacturing such that the facts given in the construction material report do not apply any more.

The following shall be evident from the inspections and tests marked in the plan: in whose premises they take place and who (manufacturer, subcontractor, approved testing or inspection organisation, installer) carries them out; should a report be written on these inspections; and who supervises the inspection or testing.

3.7.3 Inspection and testing procedures

The licensee shall present the testing and inspection procedures that apply to the material tests of steel structures. In addition, testing and inspection procedures shall be given that apply to the manufacturing and installation of steel structures. The instructions shall include the method, scope, acceptance criteria and reporting of the inspection or testing. As to details, a reference to applicable standards can be made.

The procedures shall cover the destructive testing of materials with relevant material certificate and control requirements, the methods of fabrication, non-destructive testing as well as the testing (e.g. leakage and functional tests) and inspection of the final product.

3.8 Type test results and type-approved products

To demonstrate the acceptability of structural solutions, the licensee shall present a summary of the techniques and results of mock-up or full scale tests that may have been conducted earlier. Where necessary, STUK or a STUK-approved inspection organisation may in their decision require type tests if there are special grounds justifying them.

The Finnish building regulations (RakMk) [4] allow the use of products that have either type-approval granted by the Ministry of the Environment, a European Technical Approval (ETA), or certified product declarations given by organisations authorised by the Ministry of the Environment. The products shall be used in accordance with the relevant decision of approval and the associated manufacturer's instructions. The acceptability of the products onsite shall be separately authenticated should there be any reason to believe that a product does not correspond to the type approval decision. In case installation is not included in the type approval decision, installation instructions shall be drawn up that cover installation quality control.

Type approval decisions pertaining to type-approved products shall be submitted to STUK for information.

The suitability of a CE marked product for its purpose shall be presented in the construction plan. No separate approval is needed if a CE marked product is used in accordance with its CE approval.

3.9 Procedure qualification and work tests

Procedure and work tests shall be determined based on a steel structure's safety class and how demanding the structure is. Potential test specimens shall correspond to the final structure. The

acceptability of the final structural properties and the qualification of the company to manufacture the structure shall be shown by procedure qualification tests. For approval of a procedure qualification pertaining to Safety Class 3 structures, it is sufficient that the manufacturing method is known and conforms to the standard applied.

Work tests refer to weld or weld group and coating specific tests made by competent welders during the manufacturing of the structure, or prior to it. At least the most demanding welds shall be subjected to work tests.

Work tests are valid as long as manufacturing, as based on them, takes place within the range of essential parameters, e.g. for welding, base material, filler material and welding process. Work tests are valid for a fixed period and they are welder, structure, weld or coating specific.

Welder qualifications shall be established in accordance with standard SFS-EN 287-1 [12].

The scope of STUK's control of procedure qualification and work tests is according to Guide YVL 1.14.

3.10 Manufacturing procedures

The manufacturing procedures of Safety Class 2 components shall be submitted to STUK for approval. Those of Safety Class 3 components shall be submitted when applicable.

Steel structures may be fixed to concrete structures by anchors if one of the below conditions apply to them:

- type-approval decision of the Ministry of the Environment
- certified product declaration
- European Technical Approval (ETA)
- CE approval.

In the below cases, post-installed anchors are allowed for a justified reason only:

- post-installed anchors that may become subject to dynamic loads
- post-installed anchors of Safety Class 2 steel structures.

Separate guidelines shall be provided for the installation and inspection of post-installed anchors for attachment to the construction plan. Also the competence of installers shall be defined.

A clarification of the use, installation and quality inspection of other types of anchorages or supports shall be provided as an attachment to the construction plan.

3.11 Description of manufacturer and testing organisation

For assurance of reliable operation, manufacturer and subcontractor shall have sufficient experience for implementation of the steelwork; competent personnel; and a functional quality management system. The description of the manufacturer and subcontractors shall indicate that they can fulfil these requirements.

The qualifications of testing organisations shall be presented in the description. The requirements, approval procedures and control of operation of testing organisations and testing personnel conducting non-destructive testing are described in Guide YVL 1.3.

STUK's approval is not needed for testing organisations and testing personnel conducting destructive tests but the organisations shall have relevant accreditation.

4 Control of manufacturing

Guide YVL 1.14 deals with manufacturing control performed by the licensee and the steel structure manufacturer.

STUK controls manufacturing of Safety Class 2 steel structures in accordance with Guide YVL 1.14.

5 Construction inspection

The construction inspection of a Safety Class 2 steel structure is always conducted by STUK. STUK may, at its discretion and at the licensee's application, delegate the construction inspection of a Safety Class 3 steel structure to an inspection organisation that has been authorised in accordance with Guide YVL 1.3 and also has the facilities required for the inspection.

The construction inspection of a steel structure comprises

- a review of construction plan implementation
- a review of manufacturing documents
- a visual inspection of structure
- potential functional and leakage test.

Welds are inspected before the application of coating on steel surfaces. Construction inspection is addressed in Guide YVL 1.15.

Type-approved products [4] are not subject to construction inspection. In so far as type-approval is not valid, in the installation of a product for example, construction inspection is carried out as presented above.

6 Commissioning inspection

Prior to their commissioning, steel structures are subject to a commissioning inspection by STUK.

A steel structure's commissioning inspection is performed after

- the structure's construction plan has been approved
- the structure's installation on final location has been done
- the structure has passed its construction inspection.

For the commissioning inspection, the below information shall be provided

- approved construction and installation plan plus a clarification of the fulfilment of the conditions of approval in the relevant decision
- original construction inspection protocols with attachments.

A steel structure may be commissioned after it has been approved in a commissioning inspection conducted by STUK.

7 Control during plant operation

The licensee shall draw up a periodic inspection programme for Safety Class 2 and 3 steel structures, for attachment to a periodic inspection programme covering the entire facility. The plan shall contain potential design-basis periodic inspection requirements. In addition, requirements pertaining to a steel structure's use and reliability as well as the monitoring of ageing shall be taken into account when deciding about inspection intervals and the scope of periodic inspection and testing.

Detailed inspection instructions shall be drawn up, with the below information on each inspection and testing

- responsible organisation
- plant operational state during inspection or testing
- dates and intervals
- methods and arrangements
- documentation
- acceptance criteria.

STUK controls periodic inspections in the extent it considers necessary. The licensee shall notify STUK of the periodic inspections of Safety Class 2 and 3 steel structures into which STUK has informed its inspectors will participate. In addition, STUK periodically inspects steel structures in accordance with its own inspection programme.

8 Modifications and repairs

Requirements for the repair and modification of steel structures in an operating nuclear power plant are given in Guide YVL 1.8.

9 References

1. The Nuclear Energy Act (990/1987).
2. The Nuclear Energy Decree (161/1988).
3. Government Resolution on the general requirements for nuclear power plant safety (395/1991).
4. The Finnish Building Regulations, RakMK.
5. The Chemicals Act (744/1989).
6. The Chemicals Decree (675/1993).
7. Decision of the Ministry of Trade and Industry on flammable and combustible liquids (313/1985).
8. SFS 3350. Bulk plant for storage of flammable and combustible liquids.
9. Decision of the Ministry of the Environment on type approvals in building trade 273/1989.
10. USNRC Regulatory Guide 1.54.
11. SFS-EN 10 204 Metal products. Material certificates.
12. SFS-EN 287-1 Welder qualification test. Fusion welding. Part 1: Steel materials.