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# Survey on requirements for independent reviews and inspections of electrical and I&C equipment

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## SSM Perspective

This survey is a first step to support the work to develop the Swedish regulations in the area of independent review and inspection in the process supporting implementation of electrical equipment in nuclear power plants. The report consists of a summary of different regulations in the area and also an analysis of the differences between the electrical and mechanical field especially in the area of independent review. SSM will use the results from the survey to develop the system of independent review in Sweden.

The survey was initiated by SKI (Swedish Nuclear Power Inspectorate) and completed just before SKI and SSI (Swedish Radiation Protection Institute) was merged into one authority - SSM (Swedish Radiation Safety Authority). The publication of the report has been delayed and is now published in the name of SSM.

This project was lead by the Department of Nuclear Power Plant safety by Tage Ericsson at the section of System Assessment and Peter Merck at the section of Reactor Technology and Structural Integrity

# 1 Summary

In this survey, licensing procedures for the implementation of different kinds of components and systems in nuclear power plants have been studied in four European countries: Belgium, Finland, Germany, and Switzerland. The main focus has been to describe the general features of the licensing procedures for electrical and for instrumentation and control (I&C) equipment and systems. A brief summary of regulations, authorities, and organisations involved in the safety licensing procedure for each of the studied countries is given below.

**Belgium**
The regulatory framework for the operation of nuclear power plants in Belgium is based on the American regulations. The licensing procedure for safety classified electrical and I&C equipment and systems is basically the same for the design phase as for the manufacturing, installation, and commissioning phases. The licensing procedure for each modification of significance for the safety of a plant is carried out by the authorised inspection organisation (AVN), which follows its own procedures for the review of the modification file, the commissioning, and conformity check of the installation. These procedures are very general and independent of the technical domain of the equipment or system and AVN uses the US regulations standard review plan (SRP) as a reference for technical reviews. The safety classification system is based on the US classification system with Belgian subcategories.

The Federal Agency for Nuclear Control (FANC) is responsible for the surveillance of all nuclear activities in Belgium, but the private non-profit authorised inspection organisation (AVN) does perform inspections and other regulatory tasks delegated by FANC. Hence, AVN acts both as an authority and as an authorised independent inspection organisation. In accordance with the US regulations, independent accredited organisations are involved in the inspections of mechanical installations important to safety in Belgian nuclear power plants, but there are no such requirements for inspections of electrical and I&C equipment and systems. Controls of electrical components and systems with regard to the general Belgian electrical regulations are performed by accredited inspection organisations, for example, Vincotte.

**Finland**
The regulatory framework for the safety of nuclear activities in Finland is domestic and detailed safety requirements are provided by the Radiation and Nuclear Safety Authority (STUK) through the YVL Guides. They cover specific requirements for the licensing procedure for electrical and I&C equipment. In Finland, there are no general differences in the licensing procedure for electrical, instrumentation, and mechanical equipment and the licensing procedure is basically the same for all types of systems, structures and equipment. However, one for Finland specific part of the licensing procedure is the suitability analysis performed on electrical and instrumentation equipment and cables of certain safety classes. The domestic classification system is described in the YVL Guidelines.

STUK has the responsibility for the regulatory control in Finland and may seek support from different expert organisations, for example, the Technical Research Centre of Finland (VTT). The Finnish regulations require that independent expert organisations be involved in certain steps of the licensing procedure for electrical and instrumentation equipment. In some cases,

the requirement is that the documentation shall be prepared for independent assessment, while the requirements in other cases are that tests, inspections, and controls are to be performed by independent expert organisations. Another example of independent involvement in the safety assurance procedure for installations in Finnish nuclear power plants is the type approval that is required for certain safety classed instrumentation equipment. The type approval shall be performed by an accredited type approval organisation.

**Germany**

The German regulatory framework for nuclear activities is based on domestic regulations of the Federation and the Länder authorities. Detailed safety standards are formulated by The Nuclear Safety Standard Commission (KTA). KTA consists of representatives from stakeholders within the nuclear industry (including all categories from manufacturers to the Federal and Länder authorities) and other representatives of general concerns. There are no general differences between the safety licensing procedure for electrical and I&C equipment and the safety licensing procedure for mechanical pressure and load bearing equipment. However, a formal licensing procedure is only required for major modifications. The documents that have to be provided with the application are specified in the federal Nuclear Licensing Procedure Ordinance. Regardless of whether a modification is categorised as minor or major, the KTA safety standards provides the details of the safety assurance procedure for electrical and I&C equipment including, for example the design. Variations in the safety assurance procedure for modifications are decided upon on a case by case basis by the authority of the Land in question after discussions with the licence holder. Other general requirements for electrical and I&C equipment are specified in Guidelines from the Reactor Safety Commission (RSK). The German classification system is domestic but corresponds to the classification by the International Electrotechnical Commission (IEC).

The responsibility for the supervision and licensing duties with regard to nuclear power plants is split between the Federal and Länder authorities. In the process of performing these duties, the authorities may engage expert organisations and the organisations that are engaged by the authorities of the Länder are the Technical Inspection Agencies (TÜV). The Technical Inspection Agencies are involved in almost all technical issues related to the assessment of safety of installations and their operation, including licensing procedures, tests, evaluations, reviews, supervisory procedures, and inspections. The expert organisations are part of the approval processes through their evaluations provided to the authorities in, for instance, expert analysis reports. But the experts are also authorised to give their approval to certain steps of the licensing procedure. Another role of independent experts is to certify the characteristics of certain devices through type approval tests, which involves both a physical test and a theoretical examination of the device. The type approval certificate is granted by an accredited inspector.

**Switzerland**
The Swiss nuclear regulatory framework is domestic. General requirements for the design as well as specific criteria for the licensing procedure are provided in the Nuclear Energy Ordinace (KEV). Detailed requirements of, for example, the design, review, and inspection of different kinds of safety-related electrical and I&C equipment are found in regulatory guidelines, which are provided by the Swiss Federal Nuclear Safety Inspectorate (HSK). In Switzerland, there are no general differences between the safety licensing procedure for electrical and I&C equipment and the procedure for mechanical equipment. The licensing procedure follows the four different phases: concept, design, realisation, and installation/commissioning. The safety classification system is based on the US classification system.

HSK may, as the federal supervisory authority, seek support from an expert organisation during different steps of the safety licensing procedure for equipment and systems in Swiss nuclear power plants. There are also other examples of the involvement of independent organisations in the safety assurance process for different kinds of equipment in Swiss nuclear power plants. The accredited organisation Electrosuisse inspects electrical installations with regard to general Swiss electrical regulations for personal safety and the Swiss Association for Technical Inspections, SVTI, inspects mechanical equipment.

# 2 Introduction

On behalf of The Swedish Nuclear Power Inspectorate, SKI, ÅF has performed a survey on the safety requirements for reviews and inspections of safety related electrical equipment, and equipment for instrumentation and control (I&C), in nuclear power plants. The purpose of the study is to get a general understanding of the requirements for the safety licensing procedures concerning reviews and inspections.

Of special interest is in what way review and inspections on electrical and I&C equipment are performed and if, and to what extent, independent expert organisations are involved, in so called third party inspections. The study concerns electrical and I&C equipment that are of direct or indirect importance for reactor safety, which means that, for example, recurrent licensing procedures and regulations regarding safety for personnel are not included.

Safety requirements that are of importance for this study are the regulatory requirements for inspections and reviews concerning design, manufacturing, installation, and commissioning of electrical and I&C equipment. Countries that have been invited to participate in the study are Belgium, Finland, Germany and Switzerland.

The report is based on a survey in which the following persons has contributed with valuable information on the issue, basic data and facts, references to literature and valuable comments on the final text in the report.

A special thanks to Tapane Eurasto, Radiation and Nuclear Safety Authority (STUK), Finland; Robert Grinzinger, Gesellschaft für Anlagen- und Reaktorsicherheit (GRS), Germany; Marc

Dubois, Association Vinçotte Nuclear (AVN), Belgium and Franz Altkind, Swiss Federal Nuclear Safety Inspectorate SHK, Switzerland.

# 3 Belgium

Belgium has seven nuclear generating units in operation, Tihange 1, 2, and 3, and Doel 1, 2, 3, and 4. The total installed capacity is 6 116 MW. The gross production was 47 TWh in 2006. The reactors are all pressurized water reactors, PWR, and were put into service between 1974 and 1985.

## 3.1 Electrical equipment versus mechanical installations

There is a general difference between the licensing procedure for mechanical pressure and load bearing equipment and the equivalent procedure for electrical and I&C equipment. In Belgium, the American rules and regulations are generally followed. In accordance with the American rules, no independent accredited inspections comparable to the inspections of mechanical equipment (ASME codes), are required for electrical and I&C equipment. There are no specific "nuclear safety" regulations concerning electrical and I&C systems, and the relevant regulations are the USNRC regulations and existing international norms.

## 3.2 Main players involved in safety licensing (permit procedures)

The general licensing process for construction and operation of nuclear power plants is set out in the Belgian legislation for nuclear activities[1]. The most important documents, such as licences, are issued by Royal Decrees. The Royal Decree of 20 July 2001, GRR-2001, specifies a number of tasks to be performed by the Federal Agency for Nuclear Control (FANC), which may delegate tasks to the authorised inspection organisation, the Association Vinçotte Nuclear (AVN).

The regulatory duties, surveillance, and inspection of the operation organisations are performed at two levels:

1. The level of general regulation and surveillance. The Safety Authority (FANC) is in charge of updating the general regulations, of implementation of European directives, international treaties, et cetera. In addition, FANC is responsible for maintaining internal coherence of the general regulations.

2. The level of detailed technical analysis and the permanent supervision of the operator as required by the regulations. AVN is in charge of conducting a safety review of the Safety Report presented by the applicant, and of presenting its conclusions to the Scientific Council (see 3.4)

[1] The two basic Belgian regulations regarding nuclear safety are the Law of 15 April 1994 and The Royal Decree of 20 July 2001 known as the "General Regulations regarding protection of the population, the workers and the environment against the danger of ionising radiation (GRR-2001).

**The Federal Agency for Nuclear Control (FANC)** is responsible for the surveillance of nuclear activities and constitutes the safety authority in Belgium. FANC is an autonomous governmental institution. The Agency exercises its authority with regard to the nuclear operators through one-sided administrative legal acts, such as the delivery, refusal, modification, suspension and withdrawal of licences, authorisations, recognitions or approvals. It organises inspections to verify that the conditions stipulated in these licences, recognitions and approvals are compiled with.
The Agency can claim all of these documents from the facilities and companies under its supervision.

**AVN – Association Vinçotte Nuclear**
AVN is the authorised inspection organisation which performs a number of inspection and regulatory tasks in the nuclear field, delegated by FANC. AVN performs permanent inspections during operation of the seven Belgian nuclear power plants, in accordance with the Belgium regulations, the GRR-2001[2]. The main goal of the inspections is to verify compliance with the licence, as well as to assess the licence holder's safety management[3]. AVN mainly uses its own experts, but to some extent also external specialist from universities or research centres. AVN is a private non-profit organisation.

Beside FANC and AVN, the following players are also fundamental for the safety assurance of Belgian nuclear power plants:

- **Electrabel** the licence holder of all nuclear power plants in Belgium. Electrabel has the final responsibility for the nuclear safety in the capacity of the licence holder.

- **Tractebel**, is the architect engineer who is performing different technical studies related to the nuclear safety for the Electrabel's nuclear power plants. Tractebel often verifies and controls the safety related issues for Electrabel[4].

### 3.2.1 Main players in the safety licensing of electrical and I&C systems

For the Belgian nuclear power plants, the main players in the safety licensing of electrical and I&C systems are the licence holder (Electrabel), its architect engineer (Tractebel), the manufacturers and the authorized inspection organisation AVN. For safety issues not directly related to nuclear safety, accredited inspection organisations, for example, Vinçotte, controls the conformity of the electrical and I&C equipment with regard to the Belgian electrical regulations (design, manufacturing, installation, et cetera). Vinçotte verifies and controls the "personal safety" of the electrical and I&C installations of the Belgian nuclear power plants and of all other industry or private electrical installations.

[2] General Regulations regarding protection of the population, the workers and the environment against the dangers of ionising radiation, the royal Decree of 29 July, 2001.
[3] AVN Annual Report 2006.
[4] Both Electrabel and Tractebel are subsidiaries to the international industry and service group SUEZ (www.suez.com).

## 3.3 Regulations for reviews and inspections

The two basic Belgian regulations regarding nuclear safety are the Law of 15 April 1994 and The Royal Decree of 20 July 2001 known as the "General Regulations regarding protection of the population, the workers, and the environment against the danger of ionising radiation" (GRR-2001). GRR-2001 covers practically all human activities or situations that could cause exposure to ionizing radiation to the workers as well as the public or the environment. Besides nuclear power production, GRR-2001 covers natural radioactivity and medical issues. The Law of 15 April 1994 created the Federal Agency for Nuclear Control.
Belgian nuclear power plants are pressurized water reactors of American design. The Belgian safety rules are mainly based on the American US NRC[5] rules (i.e. Regulatory Guides, IEEE Standards) and, in some cases, on the international IEC[6] norms. For safety reviews, AVN uses the Standard Review Plan[7] (SRP) to assure the quality and uniformity of the staff reviews. The SRP is not a regulation, but a tool used by experts within AVN to perform safety assessments. It is also used to evaluate different technical aspects described in the so called Safety Analysis Report (SAR) for installations in nuclear power plants. Examples of aspects are: geology, civil building, equipment qualification, neutronics, thermohydraulics, safety-related systems (injection safety, spray), mechanical systems, electrical- and I&C-systems, and accidents.

### 3.3.1 Regulations on electrical and I&C equipment

In Belgium, no specific regulations exist for electrical and I&C systems concerning nuclear safety and experts generally refer to the American rules for nuclear safety aspects. Contrary to what is required for mechanical equipment (ASME-codes), there are no requirements for inspections of electrical and I&C equipment by independent accredited organisations.

### 3.3.2 Safety classifications systems

In general, electrical and I&C equipment are categorized in different safety classes in accordance with the US regulations (i.e. Class 1E and not-classified systems) and regulator approval is only required for Class 1E systems. In Belgium, AVN has developed three sub-categories (1E1, 1E2 and 1E3) for Class 1E electrical and I&C systems following their relative importance for safety. The safety requirements may differ from one subcategory to another and the requirements are applicable for hardware and software.

## 3.4 Licensing procedure for reviews and inspections

The Royal Decree (GRR-2001) provides basic nuclear safety and radiological protection regulations. Facilities categorised as Class 1, 2, or 3 require licensing by the Authority specified by this regulation. Class 1 comprises nuclear reactors and facilities that store fissile substances in specified quantities. Class 2 and 3 comprises facilities where radioactive

[5] United States Nuclear Regulatory Commission (www.nrc.gov).
[6] IEC: The International Electrotechnical Commission (www.iec.ch).
[7] American regulations; SRP-Nureg 0800; United States Nuclear Regulatory Commission, (http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0800/)

substances are produced or stored. The categories are fully described in Belgium's National Report[8]. Controls are performed by three organisations: the licence holder, an independent authorized inspection organisation (AVN), and the Safety Authority (FANC).

The licensing procedure for construction and operation licences for facilities of Class 1 is divided into two phases:

The application file is first presented for advice to the Scientific Council of FANC (previously known under the name Special Commission). A mandatory international consultation (required by the Article 37 of the Euratom Treaty and/or required by the Directives on the trans-boundary impact) and/or a voluntary consultation of the European Commission takes place. Afterwards, the file is submitted to a public enquiry and to the concerned local authorities for advice, and then to the standing committee of the concerned provinces. The file complete with comments is returned to the Scientific Council for final advice. A positive advice of the Scientific Council is necessary for a positive decision with conditions. The construction and operation licence allows the applicant to realise the installations in conformity with the Authorisation Decree.

The second phase aims at obtaining the decree confirming the construction and operation licence. The Federal Agency for Nuclear Control (FANC) or the authorised inspection organisation acting on behalf of the FANC proceeds to the acceptance inspection prior to the introduction of radioactive substances and the start-up. Given that the inspection results in a fully favourable acceptance report the confirmation decree is obtained, allowing operation of the facility. The general process for licensing is described in brief below and in Figure 1.

The license application file consists of three parts:

1. Administrative data (name, legal status, characteristics of the installed equipment, et cetera).
2. Preliminary safety analysis report containing:
    a. The safety principles that will be applied for the construction, the operation and "the design basis accidents",
    b. The available probabilistic safety analysis,
    c. The qualification of mechanical and electrical equipment,
    d. The principles that will be applied for quality assurance,
    e. The expected quantities of waste and their management, including those related to the dismantling.
3. An environmental impact assessment study.

[8] September 2007, Fourth meeting of the contraction parties to the convention on nuclear safety.

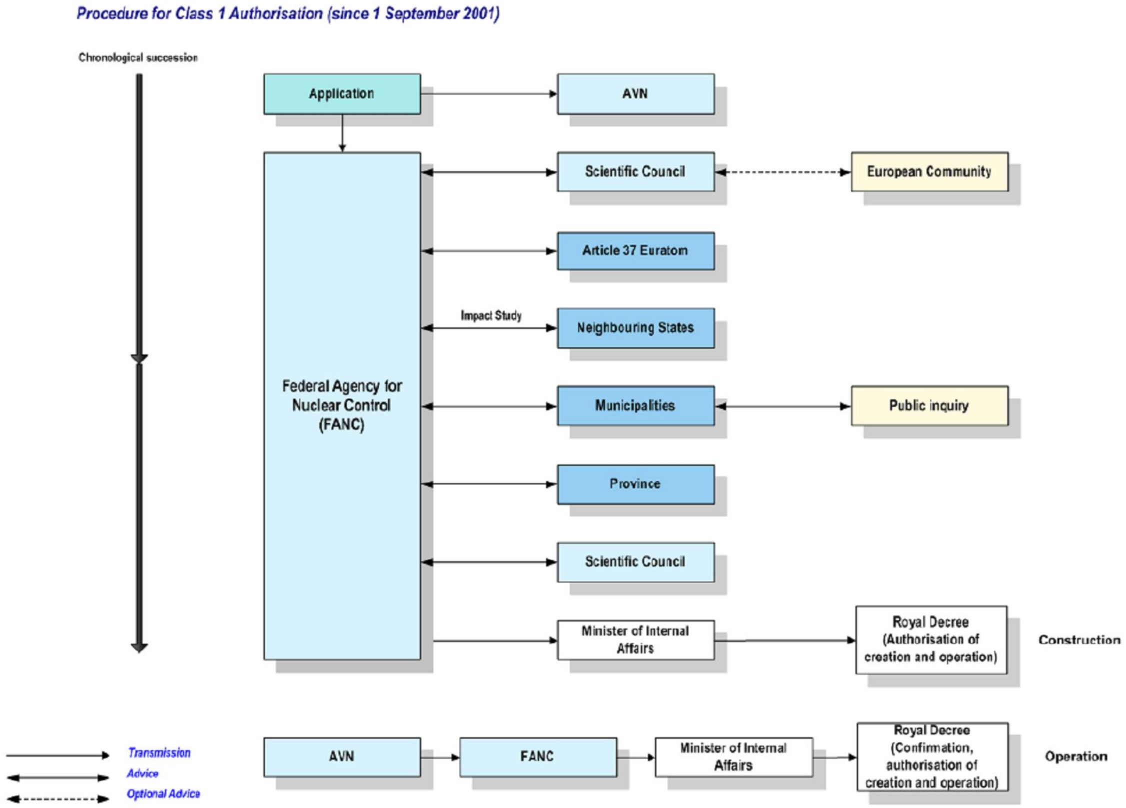


*Figure 1 The licensing procedure for nuclear installations in Belgium, following GRR-2001. Source: National Report September 2007, Begium.*

### 3.4.1 Licensing procedure for electrical and I&C equipment

The licensing procedure for electrical and I&C equipment is basically the same for the different phases design, manufacturing, installation and commissioning. The safety classes that need regular approval are electrical and I&C systems and components categorised as Class 1E (see section 3.3.2) and the inspection and control is required by the authorised inspection organisation, AVN.

The Licence holder (Electrabel) is always responsible for the design review of a proposed modification. Under the supervision of the licence holder, the review can be delegated to its architect engineer (Tractebel). Different phases of the safety assurance process (design review, inspection procedure, qualification of manufacturer, manufacturing quality, equipment qualification, factory acceptance test, etc.) are documented in the so-called “Manufacturer Files”. Following different cases, AVN requires reports or documents demonstrating the conformity to certain nuclear safety requirements, from the licence holder.

For each modification of the plant significant for safety, AVN examines the corresponding modification file. After reviewing the design on the basis of the rules and regulations, AVN approves the implementation of the modification. AVN has its own procedures for the commissioning and conformity check of the installation that follows a modification. These procedures are very general and independent of the technical domains, for example, mechanical or electrical installations.

For electrical and I&C equipment, AVN does not have specific written procedures for reviewing the design, manufacturing, installation, and commissioning. AVN uses the US nuclear regulation SRP (Standard Review Plan[9]) as a reference for technical reviews.

## 3.5 Introduction of digital systems

Belgium started shifting from analogue to digital equipment in the early nineties. So far, no analogue reactor protection system has been entirely replaced in the nuclear power plants. Examples of equipment that has been replaced are certain class 1E analogue I&C equipment, nuclear instrumentation systems, process instrumentation systems, recorders and relays.

The regulatory framework is being modified to the shift in technology. A safety guidance, which defines software requirements based on safety classed function categories has been discussed, developed, and approved in cooperation with the authorised inspection organisation (AVN), the architect engineer (Tractebel), and the licence holder (Electrabel). For the software aspects, AVN uses the IEC[10] and ANSI[11]-standards[12] as references. AVN also takes an active part in the Task Force of European Regulators on licensing safety critical software and follows the common positions for licensing issued by this task force[13].

## 3.6 Summary – degree of involvement of third party organisations

Independent, third party organisations are involved in the inspection of mechanical installations important to safety, in accordance with the US regulations. There are, however,

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9 American regulations; SRP-Nureg 0800; United States Nuclear Regulatory Commission, (http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0800/) Specifically, Appendix B of the 10CFR509 Code is applicable for the quality assurance procedures in Belgian nuclear power plants and relevant criteria are specified for different phases such as: quality assurance program (II), design control (III), procurement document control (IV), control of purchased material, equipment, services (VII), inspection (X), nonconforming materials, parts, or components (XV), et cetera. For software aspects, AVN uses the regulations IEC60880 (second edition, 2006), ANSI/IEEE-ANS-7-4.3.2 (2003) and IEC61226 (Second edition, 2005). In addition, the required periodic tests are specified in the Operating Limits and Conditions (so-called Technical Specifications, based on NUREG 1431) as agreed with AVN since the start of the operating licence.

10 IEC: The International Electrotechnical Commission, the worlds leading organisation that prepares and publishes International standards for electro technology (www.iec.ch)

11 ANSI: The American National Standards Institute.

12 For the software aspects, AVN promotes the use of the IEC 60880 (second edition, 2006), ANSI/IEEE-ANS-7-4.3.2 (2003) and IEC61226 (Second edition, 2005).

13 European Commission..Nuclear safety and the environment - Common position of European nuclear regulators for the licensing of safety critical software for nuclear reactors. European Commission's Advisory Experts Group, The Nuclear Regulators' Working Group, and Task Force on Safety Critical Software. Directorate-General for the Environment, EUR 19265 EN, Version 11, May 2000. See also: http://ec.europa.eu/energy/nuclear/publications/doc/eur19265.pdf

no such requirements for inspections of electrical and I&C equipment and systems. For safety issues not directly related to nuclear safety, accredited inspection organisations (for example Vinçotte) controls the conformity of the electrical and I&C equipment with regard to the Belgian electrical regulations.

The licensing procedure for safety classified electrical and I&C equipment and systems is basically the same for the design phase as for the manufacturing, installation, and commissioning phases. The licensing procedure for each modification of significance for the safety of a plant is carried out by the authorised inspection organisation (AVN), which follows its own procedures for the review of the modification file, the commissioning, and conformity check of the installation. These procedures are very general and independent of the technical domain of the equipment or system.

# 4 Finland

There are two nuclear power plants in Finland, namely the Loviisa and Olkiluoto plants. The Loviisa plant comprises two VVER units (Russian pressurised water reactor units), operated by Fortum Power and Heat Oy (Fortum), while the Olkiluoto plant comprises two BWR units, which are operated by Teollisuuden Voima Oy (TVO). At the Loviisa plant, unit 1 was connected to the electrical network in 1977 and unit 2 in 1980. At the Olkiluoto plant, unit 1 was connected in 1978 and unit 2 in 1980. The nominal reactor thermal power of the Loviisa units is 1500 MW and of the Olkiluoto units 2500 MW. A Construction License of a new plant unit was granted by the Government in 2005 to Teollisuuden Voima Oy for constructing a Pressurized Water Reactor (EPR) unit of nominal reactor thermal power 4300 MW at the Olkiluoto site (Olkiluoto 3).

## 4.1 Electrical equipment versus mechanical installations

In Finland, there is no general difference between the safety licensing procedures for electrical and I&C equipment in nuclear power plants and the safety licensing procedures for mechanical pressure and load bearing equipment. The licensing procedure is basically the same for all types of systems, structures, and equipment. The application procedure for a new licence, or the renewal of a licence, should encompass certain documents required by the Nuclear Energy Decree from 1988[14]. Examples of such documents are the Preliminary or Final Safety Analysis Reports (PSAR or FSAR) and the Probabilistic Safety Analysis Reports. The reports are submitted to the Radiation and Nuclear Safety Authority (STUK) for approval.

The general licensing procedure for modifications of nuclear power plants follows a similar path independent of the type of system, structure, or equipment that is affected by the modification. Major steps in the licensing procedure are covered in the so called Conceptual Design Plan and the System pre-inspection documents, which are followed by the Equipment Level Pre-inspection. However, for I&C and electrical equipment, some additional documents not necessary for mechanical and load bearing equipment should be provided. These documents are needed to prove that the life cycle model and the qualification methods of I&C and electrical systems are sufficient.

At the Equipment Level Pre-inspection, STUK, and for lower safety classes an inspection organisation approved by STUK, accepts construction plans of mechanical components. Here again the practice for electrical and I&C equipment is somewhat different from the practice for mechanical and load bearing equipment; an independent suitability analyst is to evaluate component suitability. Moreover, type approval[15] is required for the, for safety, most significant I&C components.

[14] The Finnish Nuclear Energy Decree from 1988 is a supporting document to the Nuclear Energy Act from 1987. Information from STUK-B 80 / September 2007.

[15] The type approval should be awarded by an accredited body or a body performing inspections with corresponding competence.

## 4.2 Main players involved in safety licensing procedures

The general licensing process for construction and operation of nuclear power plants is set out in the Finnish legislation for nuclear activities[16]. According to the Nuclear Energy Act, the overall authority in the field of nuclear energy is the Ministry of Trade and Industry. The Radiation and Nuclear Safety Authority (STUK) has, in accordance with the legislation, the legal authority to perform regulatory control of which safety reviews, assessment and inspection activities are vital parts. STUK is thereby the independent governmental organisation that oversees the construction and operation of the nuclear facility in detail and provides the Ministry of Trade and Industry with information. STUK may, in turn, seek advice from different expert organisations, see Figure 2 and the main technical support organisation of STUK is the Technical Research Centre of Finland (VTT).

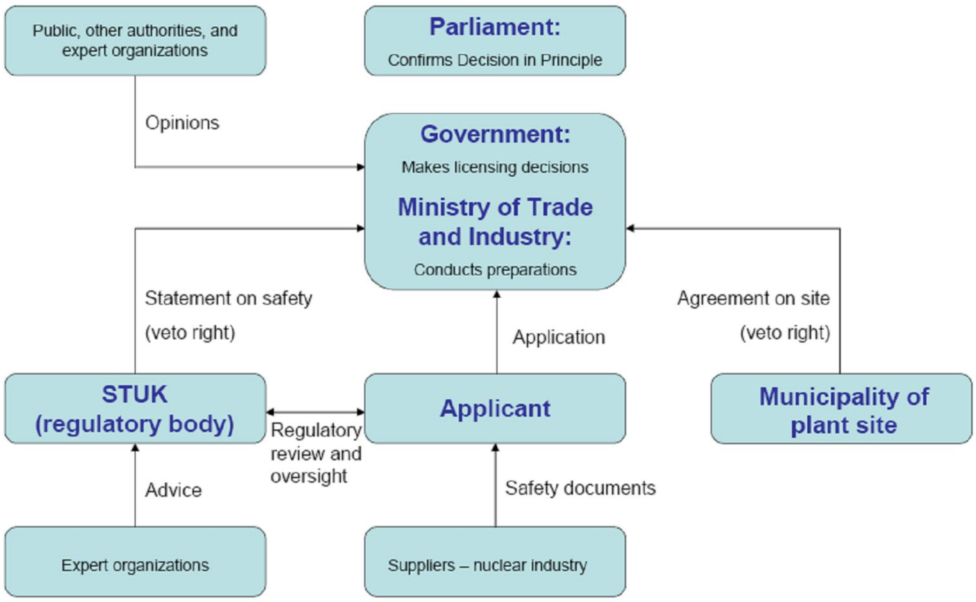


*Figure 2 Licensing of nuclear facilities in Finland. Source: Finnish report on nuclear safety, 2007*

### 4.2.1 Main players involved in the licensing procedure of electrical an I&C equipment

The main players involved in the licensing procedures of electrical and I&C equipment are the licence holders, the regulator STUK, the organisation that performs the suitability analyses, and the entity that carries out the type approval for I&C components for which this is required.

[16] Current nuclear legislation in Finland is based on the nuclear Energy Act from 1987, together with a supporting Nuclear Energy Decree from 1988.

## 4.3 Regulations on review and inspections

The current nuclear legislation in Finland is the Nuclear Energy Act from 1987 which was complemented by the Nuclear Energy Decree in 1988[17]. Detailed safety requirements are provided by STUK in the YVL Guides[18]. The YVL Guides also include administrative procedures for regulation of the use of nuclear energy. Individual licensees and all other organisations involved with nuclear energy shall comply with the YVL Guides, unless another procedure or solution of a safety level corresponding to those set out by the YVL Guides has been presented to, and approved by, STUK. The YVL Guides are continuously re-evaluated for updating[19].

### 4.3.1 Regulations on electrical and I&C equipment

Several of the YVL Guides set out requirements regarding electrical and I&C equipment. Two of the most essential are:

- The Guide YVL 5.2 (Electrical power systems and components at nuclear facilities).
- The Guide YVL 5.5 (Instrumentation systems and components at nuclear facilities).

The Guide YVL 5.2 (Electrical power systems and components at nuclear facilities) outlines licensee obligations regarding electrical power systems and components at nuclear power plants. The guide also provides information about the requirements for the control and inspections procedures of electrical power systems and components, which are carried out by STUK. The requirements for control and inspections are either laid out directly in Guide YVL 5.2, or are specified in other YVL Guides, such as Guide YVL 2.0, where the general requirements for the preliminary inspection of system are set out.

The Guide YVL 5.5 (Instrumentation systems and components at nuclear facilities) outlines licensee obligations regarding the design, implementation and operation of instrumentation and components at nuclear power plants. The guide also provides information about the requirements for the control and inspections procedures of instrumentation and components, which are performed by STUK. Requirements for control and inspections are either laid out directly in Guide YVL 5.5, or are specified in other YVL Guides, such as Guide YVL 2.0, where the general requirements for the preliminary inspection of system are set out. Guide YVL 5.5 refers to several international standards such as IEC 60880[20]. The regulations include specific clauses for the review and inspection of digital equipment that apply to both hardware and software.

[17] Finnish report on nuclear safety, STUK-B 80 / September 2007.
[18] In Finnish: Ydinvoimalaitosohjeet, which means Regulatory Guides on nuclear safety.
[19] Finnish report on nuclear safety, STUK-B 80 / September 2007.
[20] International Electrotechnical Commission (IEC) 60880, Nuclear power plants – Instrumentation and control systems important to safety – Software aspects for computer-based systems performing category A functions, 2006. .

The YVL Guides are prepared, established, and issued by the regulator (STUK). However, license holders are invited to comment on the development of new regulations during the preparation work. When a new YVL Guide is issued, STUK makes separate decisions on how a new or revised YVL Guide applies to operating nuclear power plants, to plants under construction, and to licence holders' operational activities. These decisions are influenced by discussions with the parties that may be concerned by the new YVL Guides. For new nuclear power plants the new guides apply as such, without any separate decisions.

Requirements, inspections and regulatory overview are dependent on the safety class of the object. Specifically, for qualification of the design process for I&C systems and equipment at nuclear power plants, the following is said about safety classes and independent expert assessments:

(Guide YVL 5.5, section 4.3.1 )
*"The inputs and the results of each phase shall be documented such that they can be assessed by a person who is independent from the supplier, the licensee, and the design."*

(Guide YVL 5.5, section 4.4.1)
*"The licensee shall draw up a special qualification plan to demonstrate the suitability of Safety Class 2 and 3 I&C systems and equipment for their intended use. The qualification plan shall include material from four areas: design and manufacturing process, tests, analyses, and operating experiences."…*

*"Independent expert assessment is used as part of the qualification of a Safety Class 2 system."*

### 4.3.2 Safety classification of systems, structures and components

YVL Guide 2.1 (Nuclear power plant systems, structures and components and their safety classification) specify safety classes according to the relative safety significance of different systems, structures, and components in Finnish nuclear power plants:

*"the systems, structures and components of the nuclear power plant are grouped into Safety Classes 1, 2, 3, 4 and Class EYT (classified non-nuclear). The items with the highest safety significance belong to Safety Class 1."*

The safety class will, hence, determine the quality requirements that apply to specific nuclear power plants' systems, structures and components and to their quality assurance. The applicant for a construction or operating licence shall define how the safety class and quality requirements on one hand, and the safety class and quality assurance on the other hand, are interrelated.

Instrumentation systems, electrical systems, and their components are classified in Safety Classes 2, 3, 4 and Class EYT (classified non-nuclear). Within these categories, the items with the highest safety significance belong to Safety Class 2. Guide YVL 2.1 (Nuclear power plant systems, structures and components and their safety classification) describe criteria for how systems, structures and components are to be assigned to different safety classes in accordance with their relative importance for safety.

## 4.4 Licensing procedure on reviews and inspections

The licensing procedure for instrumentation systems, electrical systems, and their components in Finnish nuclear power plants is described below. General requirements applicable to the preliminary inspection of systems are set out in Guide 2.0 (Systems design for nuclear power plants). The guide prescribes that systems approval is to be carried out as part of the review of the Preliminary and Final Safety Analysis Reports[21]. General design requirements are set forth in Guide YVL 1.0 (Safety criteria for design of nuclear power plants). Major documents in the licensing procedure for modifications of operating nuclear power plants are the Conceptual Design Plan and the System pre-inspection documents; this is independent of the type of system, structure, or equipment.

According to the general principle applied in the control of both electrical power systems and instrumentation systems at nuclear power plants, the Conceptual Design Plan and System Pre-inspection documents of Safety Class 2 and 3 systems, as well as those of systems whose inspection is separately required by a STUK decision, shall be sent to STUK for approval. The pre-inspection documents of Safety Class 4 systems shall be sent to STUK for information[22].

One for Finland specific part of the licensing procedure is the suitability analysis performed on electrical and instrumentation equipment and cables of Safety Class 2 and 3. The suitability analyses of Safety Class 2 and Safety Class 3 essential accident[23], instrumentation and electrical equipment, and cables are to be sent to STUK for approval, while the suitability analysis of other Safety Class 3 equipment may be sent to STUK for information[24].

### 4.4.1 Quality management

The Finnish Government Resolution 396/1991 states that:

*“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.”*

Guide YVL 5.2 and 5.5 specifies that a quality plan shall be drawn up for the design and implementation of instrumentation systems and Safety Class 2 and 3 electrical power systems. The plan shall cover the design, implementation and the commissioning of the system as a whole. Guide YVL 5.2 specifies that the licence holder shall consider making an independent assessment of the quality plan for Safety Class 2 electrical systems. Those making the assessment shall have competence in the quality management of safety applications and in the

[21] YVL 5.2 Electrical power systems and components at nuclear facilities. STUK 24 June 2004;
YVL 5.5 Instrumentation systems and components at nuclear facilities. STUK 13 September 2002.
[22] STUK’s approval shall be obtained for modifications to Safety Class 4 and Class EYT (non-nuclear) systems if the modifications affect the modification of the design principles set forth in Guide YVL 1.0.
[23] According to National Regulatory Commission (NRC) Regulatory Guide 1.97, cat. 1.
[24] YVL 5.5 Instrumentation systems and components at nuclear facilities. STUK 13 September 2002.

technology in question. For Safety Class 2 instrumentation systems, Guide YVL 5.5 specifies that the quality plan shall include an assessment of the compliance with the quality plan and of the adequacy of the measures taken to correct any revealed deficiencies. Again, those making the assessment shall have competence in the quality management of safety applications and in the technology in question.

The guides YVL 5.2 and 5.5 specify that the suppliers of electrical and instrumentation systems and equipment belonging to Safety Class 2 or 3 shall employ a quality management system in compliance with an appropriate standard and that the quality management system has to be independently assessed.

### 4.4.2 Requirement specification

A requirement specification shall be drawn up as part of the design process for electrical and instrumentation equipment and systems in Finnish nuclear power plants. The requirement specification shall include all significant functional, performance, and reliability requirements. Guide YVL 5.5 specifies that, for Safety Class 2 instrumentation systems, the correctness, completeness, and consistency of the requirement specification shall be independently assessed. For Safety Class 2 electrical systems, the requirement is somewhat different. Guide YVL 5.2 specifies that the licence holder's quality management system shall present the procedure by which the correctness, completeness, and consistency of the requirement specification is validated independently of its writers.

### 4.4.3 Qualification plan

The licence holder is obliged to draw up a qualification plan to demonstrate the suitability of Safety Class 2 and 3 electrical and instrumentation systems and equipment for their intended use. The plan shall include material from four areas: design and manufacturing processes, tests, analyses, and operating experiences. YVL Guide 5.2 specifies that the qualification plan for Safety Class 2 electrical power systems shall describe the procedure for independently assessing the acceptability of the qualification. The assessment may be performed by an expert in the licence holder's own organisation, or by an organisation unit, not involved in design. For the qualification assessment of electrical systems with nuclear safety significance, the use of an expert from an independent organisation shall be considered. For Safety Class 2 instrumentation equipment, YVL Guide 5.5 specifies that independent expert assessment shall be used as part of the qualification. Plans shall be drawn up for independent verifications and validations to be performed. The scope, criteria, and mechanisms of the independent assessment, the observations of the assessment and a justified conclusion shall be presented in the assessment report.

A requirement within the qualification process is that a test plan shall be created within the qualification process for the tests that are to be performed on electrical and instrumentation systems and equipment. Test experts, who are independent from design and manufacturing, shall perform the tests in accordance with the test plan. The test plan, acceptance criteria and results shall be documented such that they can be independently assessed.

### 4.4.4 PSAR/Conceptual Design Plan and FSAR/System Pre-inspection documents

For modifications of electrical and instrumentation equipment and systems in operating nuclear power plants, some additional documents should be provided beside the documents required for the Preliminary and Final Safety Analysis Reports (PSAR and FSAR) ) for nuclear power plants under construction[25]. For modifications, the Conceptual Design Plan corresponds to the Preliminary Safety Analysis Report (PSAR) and the System Pre-inspection Documents corresponds to the Final Safety Analysis Report (FSAR).

At the Conceptual Design Plan level, the additional documents cover aspects such as system interfaces including man machine interfaces, preliminary safety classification of system functions and equipment, principles for the quality management plans, and preliminary qualification plans. At the System Pre-inspection level, the additional documents are, in line with the additional documents required for the Conceptual Design Plan, associated with the quality and qualification plans and the result thereof, as well as with system specific aspects, such as the requirement specification and electrotechnical dimensioning.

In summary: The Conceptual Design plan and System Pre-inspection documents are required and supervised by the regulator STUK. They are performed by the licence holder. It is a routine procedure with coverage of 100%.

### 4.4.5 Equipment suitability analysis

In Finland, a suitability analysis has to be performed for Safety Class 2 and 3 electrical and instrumentation components, cables and essential accident instrumentation equipment[26]. The suitability analysis should be performed in accordance with the licence holder's quality management system. Guide YVL 5.2 declares that:

*"The suitability analyses of Safety Class 2 and 3 electrical components and cables may only be carried out by a STUK-approved organisation unit and an expert, who is not the designer, manufacturer or supplier of the electrical components to be analysed, or who is not the authorised representative of any of the aforementioned parties."*

Contrary to this, Guide YVL 5.5 does not state that the suitability analysis ought to be performed by an independent approved organisation unit and an expert, which implicitly means that the licence holder shall perform a suitability analysis for Instrumentation Equipment.

In the analysis, a component's functional and performance capabilities shall be assessed against the requirements specified for it. For electrical equipment this means assessment of the component's operational performance and environmental tests, electro technical dimensioning and protections, EMC (electromagnetic compatibility) characteristics, operational experiences,

[25] Required by Guide YVL 2.0 (System Design for Nuclear Power Plants).
[26] YVL 5.2 Electrical power systems and components at nuclear facilities. STUK 24 June 2004;
YVL 5.5 Instrumentation systems and components at nuclear facilities. STUK 13 September 2002.

and reliability in relation to its importance to safety. The examination of instrumentation equipment should include environmental tests, evaluation of the software, assessments of equipment operating experiences, and assessment of the functional reliability in relation to the equipments safety importance. For both electrical and instrumentation equipment, the supplier's capability to deliver the product in question shall be described. The suitability analyses of the below electrical and instrumentation components are to be submitted to STUK for approval[27]:

- Safety Class 2 electrical components, cables, and instrumentation equipment.
- Safety Class 3 essential accident instrumentation[28] and related electrical components and cables.
- Electrical components and cables needed in accidents for whose environmental qualification special requirements have been set.

Other Safety Class 3 suitability analyses are sent to STUK for information. For suitability analyses of instrumentation equipment that need approval from STUK in accordance with the criteria above, type approval is also part of the process. A preliminary suitability analysis has to be submitted to STUK for approval in case a piece of equipment needs to be subjected to type approval[29]. The type approval should be performed by an accredited body or a body performing inspections with corresponding competence.

In summary: The licensing procedure pertaining suitability analysis is required by the regulator and supervised by the licence holder and the regulator STUK. The suitability analyses of Safety Class 2 and 3 electrical components and cables are carried out by a STUK-approved organisation and an independent expert. It is a routine procedure with coverage of 100%.

### 4.4.6 Manufacturing process and factory tests

STUK is by inspections at its discretion controlling the manufacturing of safety classified electrical power systems and components as well as instrumentation systems and equipment. During such inspections, STUK must be provided with the opportunity to check the manufacturing processes and quality management systems of the manufacturer, the documents on quality control produced during manufacturing, and those referred to in the qualification plan, etc[27].

The licence holder is responsible for the creation of general plans for the quality control of all steps from design to commissioning of equipment of various safety classes, which includes manufacturing. These plans shall be submitted to STUK prior to the different phases. A test plan shall be drawn up for tests during the design and manufacturing phases of instrumentation and electrical equipment and systems. Experts, who are independent from design and

[27] YVL 5.2 Electrical power systems and components at nuclear facilities. STUK 24 June 2004; YVL 5.5 Instrumentation systems and components at nuclear facilities. STUK 13 September 2002.
[28] According to National Regulatory Commission (NRC) Regulatory Guide 1.97, cat. 1.
[29] YVL 5.5 Instrumentation systems and components at nuclear facilities. STUK 13 September 2002.

manufacturing, shall perform the tests in accordance with the test plan. The test plan, acceptance criteria, and results shall be documented for independent assessments.

In summary: The licensing procedure pertaining manufacturing quality and test protocols is required and supervised by the licence holder and regulator STUK. The tests are performed by the manufacturer, by the manufacturer and the licence holder, by the manufacturer, the licence holder and the regulator, or by an independent expert. The tests are generally performed as a sample or a type test, and documented in a test protocol.

### 4.4.7 Installation

The licensee shall perform an installation inspection on installed Safety Class 2 and 3 instrumentation systems and equipment, as well as Safety Class 2 and 3 electrical power systems and components. The licensee shall thus ascertain the appropriateness of the installations. At its discretion, STUK controls the installation of Safety Class 2 and 3 instrumentation systems and equipment, as well as Safety Class 2 and 3 electrical power systems and components. If required by STUK, the installation schedule of Safety Class 2 and 3 electrical power systems and components subject to pre-inspection shall be sent to STUK for information prior to commencement of installation. This also applies to Safety Class 2 and 3 instrumentation systems and equipment. During the inspections STUK verifies that the implementation process for the installation corresponds with the plans in the approved Pre-inspection document.

In summary: The licensing procedure pertaining installation is required by the regulator STUK, and performed and supervised by the licence holder with or without the regulator STUK. The procedure is routine with coverage of 100 %. The documentation is an inspection report.

### 4.4.8 Commissioning inspections

The licence holder shall perform a commissioning inspection[30] on installed and modified safety-classified electrical and I&C components. The licence holder shall thus verify that installed components comply with accepted plans and that this has been ascertained by sufficient inspections and tests. It shall also be verified that any shortcomings and defects detected in the inspections have been corrected. In addition, it shall be ascertained that any changes made during commissioning were implemented in accordance with established change management procedures.

STUK controls the pre-operational and start-up testing of the nuclear power plant and the system tests of electrical power and instrumentation systems in accordance with Guide YVL 2.5 (The commissioning of a nuclear power plant). The Guide YVL 2.5 defines the requirements for the commissioning and testing of a nuclear power plant and the regulatory control by STUK. STUK reviews the commissioning plan of a nuclear power plant and STUK also witnesses onsite testing and system tests at its own discretion. During the commissioning

[30] Commissioning inspections include, for instance, inspection of material resulting from quality control during manufacturing and installation, visual inspection and inspection of performance tests.

inspections, the licence holder is required to present STUK with the results of its own commissioning inspection. It is during the Pre-inspection of electrical power and instrumentation systems that STUK specifies the systems whose commissioning inspections it conducts. However, the commissioning inspections of safety-classified electrical power systems and components may only be conducted by an organisation unit and expert authorised by STUK upon application by the licence holder.

The test programmes and the result reports of Safety Class 2 and 3 electrical power and instrumentation systems shall be submitted to STUK for approval. The test programmes and results for by STUK selected Safety Class 4 systems shall be submitted to STUK for information[31].

In summary: The licensing procedure pertaining commissioning is required by the regulator STUK, and performed and supervised by the licence holder with or without the regulator STUK. However, the commissioning inspections of safety-classified electrical power systems and components may only be conducted by an organisation unit and expert authorised by STUK upon application by the licensee. The procedure is routine with coverage of 100 % and it is documented in an inspection record.

## 4.5 Introduction of digital systems

Finland started shifting from analogue to digital equipment in 1996 with the shift in the Olkiluoto turbin system. At the same nuclear power plant, the turbine side automation (Safety Class 4 and EYT) is presently renewed. A renewing program, including digitalisation, of all automation systems is ongoing at the Loviisa site. The first phase including Safety Class 3 and 4 and Class EYT with, for instance reactor preventive protection systems will be implemented during the planned outage in 2008. The second phase, including reactor protection and diverse protection systems, will be implemented in 2010.

The major digital automation projects in Finland have advanced steadily between 2005 and 2007. The regulatory framework has been modified to adapt to the introduction of digital equipment and the practical implementation of Guide YVL 5.5 (Instrumentation systems and components at nuclear facilities) from 2002, is now maturing[32]. Existing plants are moving towards so called hybrid control rooms where digital and analogue displays, switches, and indicators are utilized side by side. The new Oikiluoto 3 plant will also have a hybrid control room. Guide YVL 5.5 specifies special requirements for programmable systems and components regarding, for example, qualifications, design, and testing procedures. The requirements, inspections, and regulatory overview is, as for other typer of systems, dependent on the safety class of the programmable system.

[31] YVL 5.2 Electrical power systems and components at nuclear facilities. STUK 24 June 2004;
YVL 5.5 Instrumentation systems and components at nuclear facilities. STUK 13 September 2002.
Guide IVL 2.5 The commissioning of a nuclear power plant 29 Septebmer 2003.
[32] Finnish report on nuclear safety, STUK-B 80 / September 2007.

## 4.6 Summary – degree of involvement of third party organisations

Independent, or so called third party, organisations are involved in different steps in the licensing procedure for electrical and instrumentation systems and equipment. For several different phases in the safety assurance procedure of electrical and instrumentation systems and equipment, it is required that the documentation be prepared for independent assessment. For other phases, independent assessments are required explicitly.

An example of the latter concerns electrical components and cables, where an independent STUK-approved organisation unit or expert is required to perform the suitability analysis. In addition to inspection of documents this also may involve tests. Other examples are the requirements for independent assessments of quality plans and the adequacy of the measures taken to correct any revealed deficiencies for instrumenttation systems. The guides YVL 5.2 and 5.5 specify requirements for independent assessment of the quality management system for the suppliers of electrical and instrumentation systems and equipment belonging to Safety Class 2 or 3.

Independent assessment is required for the requirement specification, which is part of the safety assurance process of the design of electrical and instrumentation systems in Finnish nuclear power plants. For Safety Class 2 instrumentation systems, the requirement specification shall be independently assessed while the requirement for electrical systems is that the licence holder’s quality management system shall present the procedure by which the requirement specification is validated independently of its writers.

For Safety Class 2 instrumentation equipment, YVL Guide 5.5 specifies that independent expert assessment shall be used as part of the qualification of Safety Class 2 instrumentation systems. A test plan shall be created as part of the qualification of Safety Class 2 and 3 electrical and instrumentation equipment and systems. Tests that are to be performed in accordance with the test plan shall be carried out by test experts who are independent from design and manufacturing. A type acceptance certificate is required for Safety Class 2 and essential accident instrumentation of Safety Class 3. This is also an example of an independent organisation involved in the licensing procedure. The guideline requires that the equipment “shall possess a type acceptance certificate according to an applicable nuclear engineering standard awarded by an accredited body or a body performing inspections with corresponding competence”.

YVL Guide 5.2 also specifies requirements for the safety assurance procedure of safety-classified electrical power systems and components after design and manufacturing. The commissioning inspections of electrical power systems and components may only be conducted by an organisation unit and expert authorised by STUK upon application by the licence holder.

# 5 Germany

Germany runs 17 nuclear power plants at 11 locations. Of these 17 plants, 11 are pressurized water reactors (PWR) and 6 boiling water reactors (BWR). They were all designed and built by *Kraftwerk Union AG* (KWU) and connected to the grid between 1974 and 1988.

## 5.1 Electrical equipment versus mechanical installations

There are no general difference between the safety licensing procedures for electrical and I&C equipment in comparison with mechanical pressure and load bearing equipment. However, specific requirements are dependent upon the type of equipment and are specified in different regulations.

## 5.2 Main players involved in safety licensing procedures

Germany is a federal republic. Unless otherwise specified, the execution of federal laws lies in principle within the sole responsibility of the federal states, the Länder. The “regulatory body” in Germany is, hence, composed of the federal government and Länder government authorities, see Figure 3. The responsibility for the organisation, staffing and financing of the federal government’s nuclear regulatory authorities lies with the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)[33]. BMU is the supreme regulatory authority in charge of nuclear safety and security in Germany. The respective Länder governments establish the supreme Länder authorities in charge of licensing and supervision of nuclear power plants. The licensing authorities and supervisory authorities of different Länder are listed in Table 1.

[33] In German: Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU)

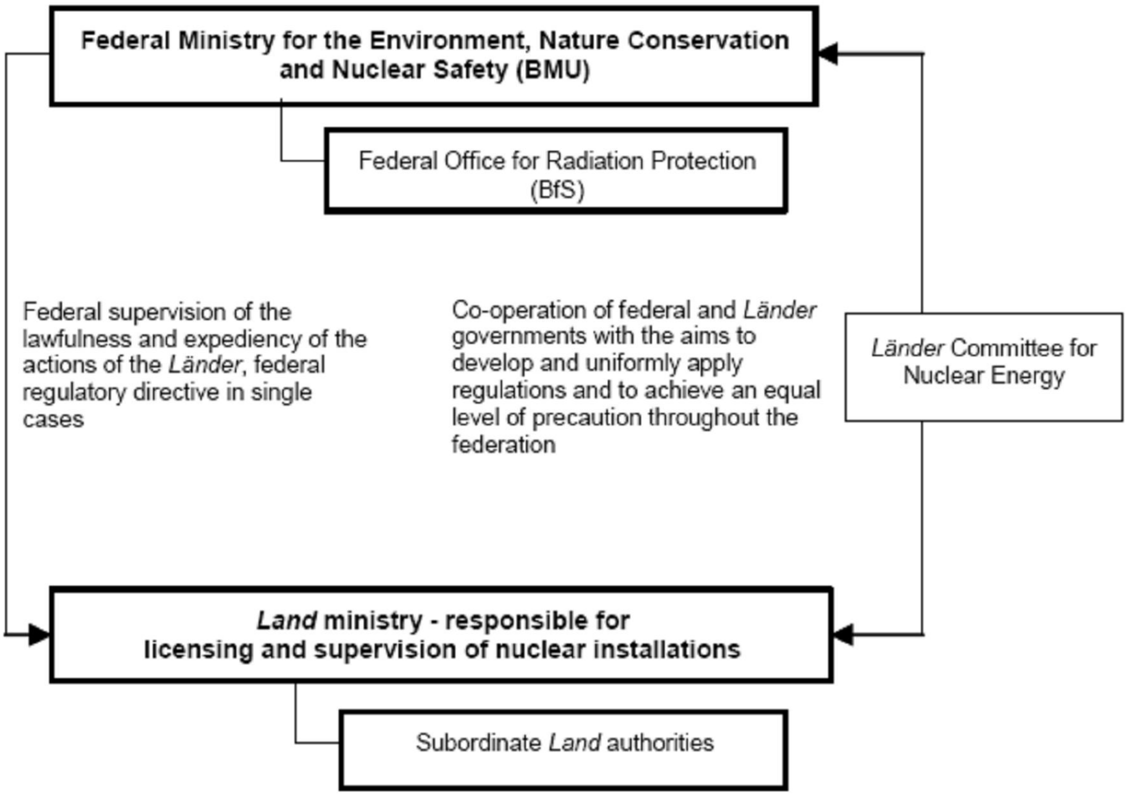


*Figure 3 Organisation of the Regulatory Body in Germany. Source: Convention on Nuclear Safety, Report by the Government of the Federal Republic of Germany for the Fourth Review Meeting in April 2008, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).*

The federal government as well as the Länder governments are involved in the basic functions, albeit with different competencies, responsibilities and duties to co-operate, to fulfil the safety requirements for nuclear power plants, e.g.:

- The development of safety procedures and regulations,
- Licensing procedures,
- Regulatory examination and assessment, and
- Execution and inspection.

The licence application as well as accompanying documents should be submitted to the authorities of the Länder. It is also the authorities of the Länder that grant licences and other approvals. The authorities in the Länder inform and discuss applications with BMU, which, in turn, seek advice from its expert organisations at the federal level[34]. After consulting its expert

[34] The organisations that BMU frequently seek advice from are the Reactor Safety Commission, RSK (In German: Reaktor-Sicherheitskommission), the Commission on Radiological Protection, SSK, (In German: Strahlenschutzkommission), and the Gesellschaft für Anlagen- und Reaktorsicherheit, GRS, which does not have an English translation.

organisation, BMU provides a comment to the responsible licensing authority (in the Land in question).

In both the licensing and supervising duties, the authorities from the Länder may engage technical expert organisations or individual experts. The main independent organisations involved in such duties are the Technical Inspection Agencies (TÜV)[35], see 5.2.2. The Technical Inspection Agencies are involved in almost all technical issues related to the assessment of the safety of installations and their operation including licensing procedures. In the latter, the expert organisations are for instance involved in review of documentation. They also perform their own tests, evaluations, and calculations. Nevertheless, the Länder authorities are not bound by the decisions of the experts organisations.

*Table 1 Licensing and supervisory authorities for nuclear installations in different German Länder. Source: Convention on Nuclear Safety, Report by the Government of the Federal Republic of Germany for the Fourth Review Meeting in April 2008, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).*

| *Land* | Nuclear Installations | Licensing Authority | Supervisory Authority |
|---|---|---|---|
| Baden-Württemberg | Obrigheim<br>Neckarwestheim 1<br>Neckarwestheim 2<br>Philippsburg 1<br>Philippsburg 2 | Environment Ministry<br>in agreement with<br>Economics Ministry and Interior Ministry | Environment Ministry |
| Bavaria | Isar 1<br>Isar 2<br>Grafenrheinfeld<br>Gundremmingen B<br>Gundremmingen C | State Ministry of the Environment, Public Health and Consumer Protection<br>In agreement with<br>State Ministry of the Economy, Infrastructure, Transport and Technology | State Ministry of the Environment, Public Health and Consumer Protection |
| Hesse | Biblis A<br>Biblis B | Ministry of the Environment, Rural Areas and Consumer Protection | |
| Lower Saxony | Unterweser<br>Grohnde<br>Emsland | Environment Ministry | |
| Schleswig-Holstein | Brunsbüttel<br>Krümmel<br>Brokdorf | Ministry for Social Affairs, Health, the Family, Youth and Senior Citizens | |

Other main players involved in the safety licensing procedures in German nuclear power plants are the licence holders and the manufacturers of equipment and systems.
The licence holders[36] submit the application to the licensing authority and they are involved in the preparation of the required documents accompanying the application. Manufacturers

[35] In German: Technischer Überwachungsverein (TÜV).
[36] Since the German Atomic Energy Act does not approve licences for new nuclear power plants, it is only major modifications of existing nuclear power plants that require licences. Hence, it is only licence holders and not other utilities that submit applications.

behind the modification requiring the licence application are also involved in the preparation of these documents[37].

Both the licence holder and the manufacturer evaluate different steps in the licensing procedure through, for example, tests, calculations, and inspections and they have to document the evaluations. They provide documents to the supervising expert organisation and the authority during the licensing procedure. The documents that have to be provided with the application are specified in the Nuclear Licensing Procedure Ordinance (AtVfV)[38]. One of the principal documents is the safety report including site plans and survey diagrams.

In its decision to grant the licence or reject the application, the authorities from the Länder considers the opinion of the experts, comments from BMU, comments from other involved authorities, objections brought forward by the general public, and the results from the environmental impact assessment. Mandatory steps for public announcements are set out in the Nuclear Licensing Procedure Ordinance and the general public is, hence, involved in the nuclear licensing procedure in Germany. For the required environmental impact assessment, other organisations (site and neighbouring communities, recognised environmental conservation associations) and the general public are involved, thus being part of the licensing procedure.

### 5.2.1 Licences, approvals, or notifications for modifications

As previously noted, the German Atomic Energy Act does not grant licences for new nuclear power plants, but the licensing procedure is applicable for modifications of existing nuclear power plants and new non-industrial facilities, such as research and disposal facilities. Modifications that require the licensing procedure in accordance with the Atomic Energy Act are modifications that may have greater than obviously insignificant impacts on the safety level of the nuclear installations. They are labelled essential or major modifications[39]. Only when possible impact is clearly insignificant the licensing procedure need not be applied.

Authorities from the Länder are involved in the safety assurance process for less important “smaller” modifications, but these modifications will only require an approval or merely a notification from the licence holder. Nevertheless, the authorities will examine the less important modifications together with its expert organisations and decide whether the modification, according to the authority, is still a major one that requires a licence.

### 5.2.2 TÜV - authorised experts

In performing their licensing and supervisory activities, the Länder ministries may engage expert organisations or individual experts and Germany has a long tradition of using

[37] In case of a major modifications of the nuclear power plants, the manufacturer is the manufacturer of the nuclear plant itself, which in Germany is the KWU (Kraftwerk Union AG), today Areva NP.
[38] In German: Verordnung über das Verfahren bei der Genehmigung von Anlagen nach § 7 des Atomgesetzes (Atomrechtliche Verfahrensverordnung - AtVfV)
[39] Convention on Nuclear Safety – Report by the Government of the Federal Republic of Germany for the Fourth Review Meeting in April 2008, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), October 2007.

independent authorised experts for different safety-related duties. The special technical knowledge and independence are the decisive criteria for the involvement of authorised experts. This is mainly ensured by the Technical Inspection Agencies (TÜV), which act on behalf of the authority as so-called “main consultants” of the Länder authorities. As described above, the Technical Inspection Agencies are involved in almost all technical issues related to the assessment of the safety of installations and their operation including licensing procedures, tests, evaluations, reviews, supervisory procedures, and inspections. The results are evaluated in expert assessments, which also give criteria used in the assessment by the authorities of the Länder. However, in making their decisions, the Länder authorities are not bound by the authorised experts´ evaluation results. The prerequisites under which the authorised experts work are given in the German Atomic Energy Act which under section 20 states:

*“In the licensing and supervisory procedures hereunder or under the statutory ordinances issued hereunder, the authorities in charge may consult authorized experts.”*

### 5.2.3 Gesellschaft für Anlagen- und Reactorsicherheit

Gesellschaft für Anlagen- und Reaktorsicherheit (GSR)[40] is a central expert organisation that supports the BMU as its technical support organisation for technical issues concerning reactor safety. In this role, GRS’s support to BMU by providing relevant technical expertise is similar to TÜV’s support to the authorities of the Länder. In addition to these duties, GRS is performing a limited amount of work commissioned by the licensing and supervisory authorities of the Länder and performs scientific research in the field of nuclear safety technology, predominantly sponsored from federal funds. An overview of the different parties involved in the nuclear licensing procedure in Germany is given Figure 4 below. This also includes the Federal Office on Radiation Protection (BfS).

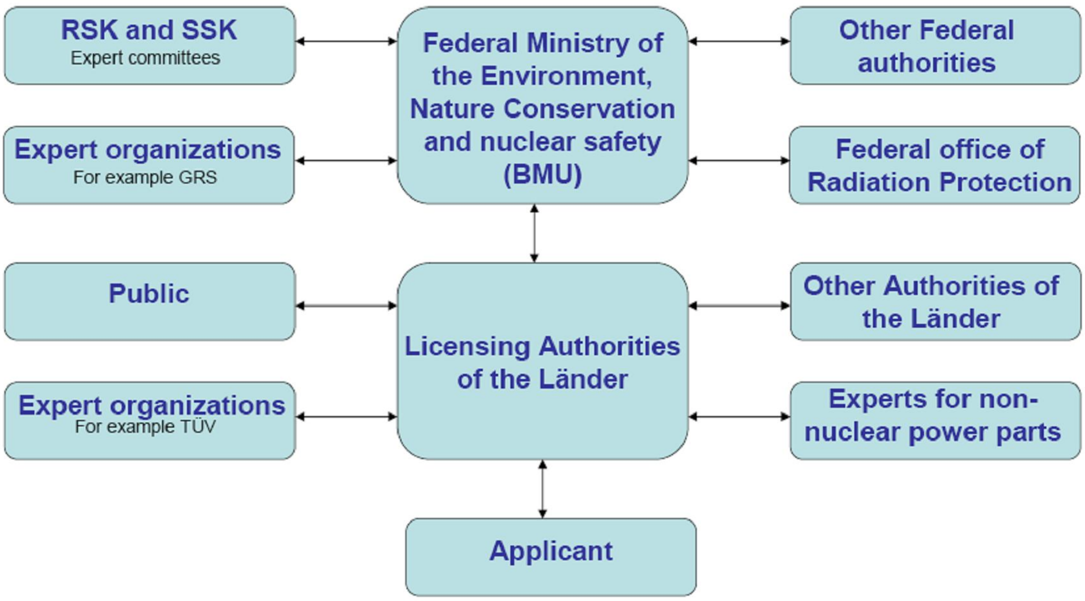


*Figure 4 Overview of parties involved in the nuclear licensing procedure in Germany.*

[40] The name of this safety authority does not have an English translation in the studied references.

# 5.3 Regulations in review and inspection

In Germany, The Federal Government has the exclusive legislative power for peaceful use of nuclear energy, according to the Basic Law[41], but responsibilities for the development, establishment, and execution of the legislation are assigned to organs of the Federation and the Länder. The Atomic Energy Act[42], which provides the legal framework for the use of nuclear energy, is executed by the Länder on behalf of the Federal Government. The Länder authorities are under the supervision of the Federation with regard to the lawfulness and expediency of their actions. The hierarchy of the German regulatory framework for governing the use of nuclear energy is illustrated in Figure 5 together with the authority or institution issuing the regulation and the organisational target for the different regulations.

## 5.3.1 Basic Law, ordinances and general administrative provisions

The Basic Law includes provisions on the competencies of the Federation and the Länder regarding the use of nuclear energy. The main purpose of the Atomic Energy Act is to protect the population against the dangers of nuclear energy and to ensure the orderly phase-out of nuclear energy. The Atomic Energy Act enables provisions for the issue of ordinances, which are to be approved by the Federal Council[43]. Among the most central ordinances is the Nuclear Licensing Procedure Ordinance (AtVfV), which specifies the actual details of the licensing procedure. It contains information about the application procedure, including the submittal of supporting documents.

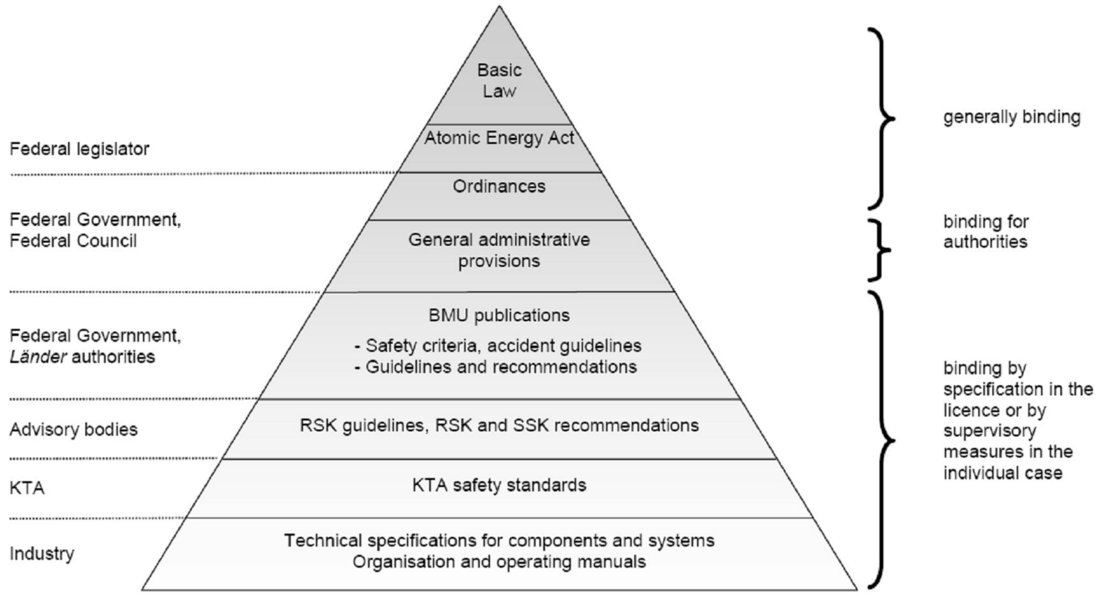


*Figure 5 Regulatory Pyramid. Source: Convention on Nuclear Safety 2008, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety.*

[41] In German: Grundgesetz, GG
[42] In German: Atomgesetz, AtG.
[43] In German: Bundesrat

Safety related issues such as the technical plant safety or safe operation and the requirements for training and technical qualification are not specified in the ordinances, even if this is made possible by the Atomic Energy Act. Requirements for these issues are found in non-legally binding regulator guidance instruments. Ordinances may include additional authorisations for issuing general administrative provisions that regulates measures of the authorities.

### 5.3.2 Regulatory guidelines and recommendations from BMU, RSK and SSK

After having consulted the Länder, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) prepares regulatory guidelines, which, in contrast to the general administrative provisions, are not binding for the Länder authorities. The regulatory guidelines include safety criteria, strategies for accidents, and recommendations. Generally, the guidelines are regulations passed by consensus with the competent licensing and supervisory authorities of the Länder. In the recommendations, BMU describe its view on general questions related to nuclear safety and the administrative practice, and serve as orientation for the Länder authorities regarding the execution of the Atomic Energy Act. Currently about 60 BMU regulatory guidelines exist in the field of nuclear technology.

In addition to advising BMU on issues like licensing and supervisory procedures, development of rules and regulations or safety research, the Reactor Safety Commission[44] (RSK) and the Commission on Radiological Protection[45] (SSK) may also give advice on their own initiative. After discussions with different parties such as plant operators, industry, and the Länder authorities, BMU verifies and implements the results, which may be guidelines (from RSK) or recommendations (from RSK or SSK). The RSK guidelines are, for exemple, used by the Länder authorities for the assessment of the adequacy of further development of plant safety.

### 5.3.3 KTA Safety Standards

The Nuclear Safety Standard Commission[46] (KTA) was established at the BMU. The Commission consists of interest groups with representatives from manufacturers, licence holders, federal and Länder authorities, expert organisations, and representatives of general concerns, for example, unions and industrial safety and liability insurers. The office of the KTA is affiliated to the Federal Office for Radiation Protection (BfS)[47].

In accordance with its statues, the KTA formulates detailed safety standards, if “experience indicates that the experts representing the manufactures and utilities of nuclear installations, the expert organisations and the federal and Länder authorities would reach a uniform opinion”[48]. The safety standards are prepared by expert meetings in sub-committees and working groups and are then passed on to the KTA for final approval.

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[44] In German: Reaktor-Sicherhetiskommission (RSK).
[45] In German: Strahlenschutzkommission (SSK)
[46] Kerntechnischer Ausschuss (KTA)
[47] The Federal Office for Radiation Protection (In German: Bundesamt für Strahlenschutz, BfS) is an authority subordinated BMU that handles administrative duties on the federal level.
[48] A 5/6 majority of the committee members is required for passing a new safety standard.

The KTA standards pertain to:

- Orgnisational issues,
- Industrial safety,
- Civil engineering,
- Nuclear and thermal-hydraulic design,
- Issues regarding materials,
- Instrumentation and control,
- Monitoring of radioactivity, and
- Other provisions.

Historically, the KTA safety standards have been developed on the basis of applicable German technical standards and regulations and the American nuclear safety standards. The ASME-Code (Section III) was used as a model for specifying the requirements regarding the design and construction of components. KTA has up till now, issued a total of 90 safety standards. KTA safety standards are not legally binding. However, due to the nature of their origin and their high degree of detail, they have a far-reaching practical effect.

### 5.3.4 Conventional technical standards

Conventional technical standards are applied in the design and operation of all technical installations in nuclear power plants, as far as the conventional standards correspond to the state of the art in science and technology and are not contrary to the nuclear standards. Examples of frequently applied technical standards are the national standard of the German Institute for Standardisation (DIN) and the international standards of ISO and IEC. Guidelines and recommendations from VDE, the German Association for Electrical, Electronic & Information Technologies[49], are also applied in electrical installations in nuclear power plants.

### 5.3.5 Safety classifications systems

In German nuclear power plants, the electrical and I&C equipment is classified in one of three categories according to the RSK Guidelines for Pressurized Water Reactors[50]:

- Category 1: The instrumentation and control functions of category 1 comprise all functions which are necessary to prevent intolerable effects of accidents.
- Category 2: The instrumentation and control functions of category 2 comprise all functions which are necessary to prevent a disturbance from turning into an accident.
- Category 3: The instrumentation and control functions of category 3 comprise all other safety-relevant functions.

Category 1, 2, and 3 generally corresponds to Safety Class A, B, and C of the German industrial standard DIN IEC 61226[51], which is the safety classification system referred to in

[49] In German: Verband der Elektrotechnik Elektronik Informationstechnik e.V. (VDE)
[50] In German: RSK – Leitlinien für Druckwasserreaktoren, Budesamt für Strahlenschutz (BfS) Salzgitter, 3. Ausgabe vom 14. Oktober 1981, ergänzt 1982, 1984 und 1996.
[51] DIN IEC 61226 (2005-09) Nuclear power plants - Instrumentation and control systems important

the KTA nuclear safety standards. The I&C functions will in turn assign I&C equipment of safety to two categories with different qualification requirements:

- Category E1: The equipment of category E1 comprises all the equipment performing the instrumentation and control functions of categories 1 or 2.
- Category E2: The equipment of category E2 comprises all the equipment performing the instrumentation and control functions of category 3.

There is, however, no I&C equipment of category E2 installed in German nuclear power plant, since I&C equipment that fulfils the I&C functions of category 3 in reality has been classified as category E1 equipment. Electrical equipment is not classified in the German nuclear regulatory framework. The regulatory framework applied for electrical equipment in nuclear power plants is the German industrial standards (DIN) and the VDE-Guidelines.

### 5.3.6 Regulations on electrical and I&C equipment

Requirements for electrical and I&C equipment in nuclear power plants are specified in the RSK Guidelines and, more detailed, in the KTA safety standards. These requirements for electrical equipment are an extension of the industrial standards of the German Institute for Standardization (DIN)[52], the German Association for Electrical, Electronic & Information Technologies (VDE), and the International Electrotechnical Commission (IEC).

The RSK Guidelines contain some general clauses for the design, testing, operation and security of software. Except for these regulations, the German nuclear safety standards for I&C equipment do not contain any specific clauses for digital equipment or software. Hence, the existing regulations for analogue I&C systems are applied to digital equipment correspondingly. Below is an overview of the existing nuclear safety standards applicable for electrical and I&C equipment.

#### 5.3.6.1 Electrical equipment

Nuclear safety standard KTA 3701, 6/99, “General Requirements for the Electrical Power Supply in Nuclear Power Plants”. The standard specifies general requirements for safety-related electrical equipment in nuclear power plants. However, more detailed requirements are specified in the following nuclear safety standards that cover steps such as design, manufacturing, installation, commissioning, and in-service inspections in the safety assurance process.

Nuclear safety standard KTA 3702, 06/2000, “Emergency Power Generating Facilities with Diesel-Generator Units in Nuclear Power Plants”.

Nuclear safety standard KTA 3703, 06/99, “Emergency Power Facilities with Batteries and AC/DC Converters in Nuclear Power Plants”.

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to safety - Classification of instrumentation and control functions. This standard is equivalent to IEC (International Electrotechnical Commission) standard 61226.

[52] In German: Deutsches Institut für Normung e. V. (DIN)

Nuclear safety standard KTA 3704, 06/99, “Emergency Power Facilities with DC/AC Converters in Nuclear Power Plants”.

Nuclear safety standard KTA 3705, 06/99, “Switchyards, Transformers and Distribution Networks for the Electrical Power Supply of the Safety System in Nuclear Power Plants”.

#### 5.3.6.2 I&C equipment

Nuclear safety standard KTA 3501, Issue 6/85, “Reactor Protection System and Monitoring Equipment of the Safety System”. This nuclear safety standard covers I&C systems with functions corresponding to category 1 or A. The standard specifies requirements for the design, equipment quality, installation, and testing. However, more detailed requirements are specified in the following nuclear safety standards:

Nuclear safety standard KTA 3503, 11/2005, “Type Testing of Electrical Modules for the Safety-Related Instrumentation and Control System”. This safety standard provides guidance for the type approval test for I&C equipment used for measurement and control functions in accordance with category 1 or A.

Nuclear safety standard KTA 3504, 11/2006, “Electrical Drives of the Safety System in Nuclear Power Plants”. The considered electrical drive mechanisms are the electrical drive mechanisms of the safety system in nuclear power plants, including actuators, actuating magnets of valves, drive mechanisms of driven machines, and the control rod drive mechanisms. This nuclear safety standard covers suitability certification, design, factory tests, commissioning tests and in-service inspections.

Nuclear safety standard KTA 3505, 11/2005, “Type Testing of Measuring Transmitters and Transducers of the Safety-Related Instrumentation and Control System”. Type approval tests of the measuring sensors and transducers that perform measurement and control functions of category 1 or A.

Nuclear safety standard KTA 3506, 11/84, “Tests and Inspections of the Instrumentation and Control Equipment of the Safety System of Nuclear Power Plants”. System testing of I&C equipment with functions corresponding to category A, B, and C (corresponding to categories 1, 2, or 3 in the RSK Guidelines for Pressurized Water Reactors). Commissioning tests and in-service inspections are included, accompanying tests during assembly are not included. The standard also comprises requirements for testing following repairs and system modifications.

Nuclear safety standard KTA 3507, 06/02, “Factory Tests, Post-repair Tests and Certification of Satisfactory Performance in Service of Modules and Devices for the Instrumentation and Controls of the Safety System”. The standard include requirements for factory tests, post-repair tests, and the certification of the in-service performance of modules and equipment of I&C equipment for I&C functions of category 1 or A.

## 5.4 Licensing procedure on reviews and inspections

In Germany, licences are only required for major modifications of nuclear power plants. The documents that have to be provided with the application are specified in the Nuclear Licensing Procedure Ordinance (AtVfV). Nevertheless, most modifications in nuclear power plants are categorised as smaller modifications and they are subject to approval from the authorities of the Länder or a notification.

Independent of the type of modification, the details of the safety assurance procedures for electrical and I&C equipment and systems are specified in the KTA safety standards. A normal safety assurance procedure for the different steps design, manufacturing, installation, and commissioning are laid out below, but the procedure may vary depending on the type of system or equipment and the safety class. Variations in the safety assurance process from case to case may also be decided upon by authorities from the Länder after discussions with the licence holder.

For electrical systems and equipment, general requirements for the safety assurance are laid out in KTA 3701, General Requirements for the Electrical Power Supply in Nuclear Power Plants, while KTA 3501, Reactor Protection System and Monitoring Equipment of the Safety System, is the equivalent for I&C systems and equipment.

### 5.4.1 Design

Criteria for the design of different electrical components and systems are different for different systems, but the general requirements for the design of emergency power systems electrical power supply[53] are given in KTA 3701:

*"With respect to the design review by the authorized experts (under Sec. 20 Atomic Energy Act), documented proof shall be provided that the electrical components, electrical modules and systems have been designed, tested and assembled in accordance with the requirements important to safety."*

Examples of documents that have to be reviewed by the independent expert organisation are the functional description data sheet, the test records, and the operation manual. More technically specified design criteria for emergency power facilities, switchyards, transformers, and distribution networks for the electrical power supply of the safety systems are laid out in KTA 3702, KTA 3703, KTA 3704 and KTA 3705. KTA 3701 specifies that type tests should be performed on fabrication samples to demonstrate the essential characteristics of the component. If there are characteristics which cannot be demonstrated by type tests, special validation tests shall be performed. KTA 3504 (Electrical Drive Mechanisms of the Safety System of Nuclear Power Plants) describes criteria for design, including type tests, for electrical drive mechanisms of the safety system in nuclear power plants.

For I&C equipment and systems important to safety of the nuclear power plants, i.e. equipment that perform functions of category 1 or A, the safety assurance procedure is similar to the safety assurance procedure for electrical equipment and systems. This also includes variations in requirements depending on the type of equipment. KTA 3501[54] specifies details about the technical design of the reactor protection system, and the standard is supplemented by KTA 3503, KTA 3504, KTA 3505, KTA 3506, and KTA 3507. Safety standard KTA 3501 specifies the following basic requirements (section 3.1):

*"To determine the functions which the reactor protection system has to fulfil, chains of events specified in section 3.2 shall be analyzed. The analysis of the chains of events shall be* (carried, author's remark) *out using analytical procedures, experimental or plausible considerations. The basis for all assumptions made in the analysis must supply all requirements for the design of the reactor protection system."*

About the design of the reactor protection system (section 5.1, Equipment Quality):

*"5.1.1 Demonstration of Suitability of Service Proved Equipment*
*(1) Service proved equipment and components should be employed.*
*(2) The demonstration of service proveness should be carried out by statistical analysis of service records on the basis of operational characteristics specified in the data sheet and of the operating conditions.*

[53] That is: Electrical power supply of the power loads important to safety in nuclear power plants.
[54] Reactor Protection System and Monitoring Equipment of the Safety System

*(3)Regarding the service proveness, supplementary tests in accordance with Section 11.1.1.1 shall be carried out if the operational conditions exceed the operational characteristics specified in the data sheet or if they were not covered by the demonstration of service proveness. Certain characteristics of the equipment may, in coordination with the authorized expert (under Sec 20 Atomic Energy Act), be demonstrated analytically.*

*5.1.2 Demonstration of Suitability for Newly Developed or Modified Equipment*
*Newly developed or modified equipment shall be subjected to tests in accordance with Section 5.1.1.2.*

*5.1.4 Reliability and Quality Testing*
*(1) Data regarding the reliability of the equipment types shall be presented based on, e.g., statistical methods, failure effect analyses critical load tests or the evaluation of operating experience.*

*11.1.1.1 Supplementary Type Tests for Service-Proved Equipment*
*(1) In the case of service-proved equipment, supplementary type tests shall be carried out to demonstrate certain not certified characteristics in accordance with Section 5.1.1.(2).*
*(2)The documents for the theoretical part of the type tests should be prepared by the manufacturer. These documents should be checked by the authorized expert (under Sec. 20 Atomic Energy Act). The testing program for the practical part of the type tests should be prepared by the manufacturer and agreed upon by the authorized expert (under Sec. 20 Atomic Energy Act). The practical tests should be carried out by the works inspector."*

Here we can note that type tests are, in analogue with what has been described for electrical systems, required for I&C equipment and systems important to safety of the nuclear power plants, i.e. that perform functions in accordance with category 1 or A. More specific details about the type tests for electrical modules for the safety related instrumentation and control system and for measuring sensors and transducers of the safety-related instrumentation and control systems are given in KTA 3503 and KTA 3505 respectively.

For both electrical and I&C equipment and systems, the tests will result in a test report and a test certificate (type approval). Involved parties in the safety assurance process of the design are the manufacturer, the consulted experts, the authority of the Länder, and an accredited inspector for the type approval. The manufacturer, the consulted expert, and the accredited type approval inspector are involved in the testing and preparation of documents (test records). The last two are involved also in the review. The authorities are involved in the review process, the granting of approvals and in contacts with the independent expert organisations.

## 5.4.2 Manufacturing

As for the design, criteria for the manufacturing of different electrical and I&C components and systems are different for different systems, and information about specific requirements are given in the KTA nuclear safety standards. General requirements for the manufacturing of emergency power systems are described in KTA 3701. Piece tests shall, in principle, be performed on each piece of the delivered lot. An exception from this is when series are produced and tests are performed on random samples in accordance with general statistical safety procedures. The goal of the piece test is to detect material and fabrication defects. KTA 3702 specifies the required production tests for different parts of emergency power generating facilities with diesel-generator units in nuclear power plants, while KTA 3703 specifies the same requirements for emergency power facilities with batteries and AC/DC converters in nuclear power plants. The KTA standards specify that an authorised expert should be involved in the productions tests, but in different ways depending on the component or system. The authorised expert may be involved in the specification of the required tests or in the review or approval process for the production tests, depending on the type of component or system. Production tests for different components in the emergency power facilities with DC/AC converters in nuclear power plants are specified in KTA 3704, where it is stated that both the tests and inspections normally should be performed by the inspectors of the licence holder. However, in substantiated cases, authorised experts shall be consulted.

KTA 3705 specifies requirements for switchyards, transformers and distribution networks for the electrical power supply of the safety system in nuclear power plants. For switchyards handling more than 1 kV and for emergency power distribution transformers, it shall be demonstrated that production tests have been carried out on each unit. For components of the emergency power distribution network the manufacturer shall carry out production tests within the scope of quality assurance. KTA 3504 states that the factory tests of Electrical Drive Mechanisms of the Safety System of Nuclear Power Plants shall be performed by piece tests in accordance with KTA 3701.

For manufacturing of the reactor protection system and its components, for example, monitoring equipment, KTA 3501[55] specifies that:

*"5.1.4 Reliability and Quality Testing*

*(2) The required equipment quality of production lots shall be verified within the framework of the factory tests on a representative random sample that are subjected to operating loads and critical loads.*
*(3) The quality assurance system for ensuring the equipment quality shall be demonstrated.*

*11.1.2 Factory Tests*

*The correct manufacturing of the electrotechnical modules, equipment and system parts of the safety system shall be demonstrated by a factory test.*

[55] Reactor Protection System and Monitoring Equipment of the Safety System

*Note:*
*Requirements regarding the factory tests are dealt with in safety standard KTA 3507."*

Safety standard KTA 3507[56] specifies that the manufacturer is responsible for the factory test, but that the licence holder, or a contractor engaged by the licence holder, shall accept the quality assurance procedure as demonstrated by the manufacturer. Quality audits shall be performed by the licence holder, or a contractor engaged by the licence holder, but in case of repeated occurrence of deficiencies in the delivered products, the quality audit shall be performed in consultation with an authorised expert. KTA 3507 also specifies the general requirements for factory tests of modules and equipment of I&C equipment of the safety system, including the required documents, tests, and inspections.

"*Exceptions from this procedure are only admissible if they are approved of by the persons specifically appointed for this task in the quality assurance system and if these exceptions are recorded in the non-conformance reports.*"

KTA 3506, which deals with the testing of completely assembled systems in nuclear power plants, specifies that:

*"2.2.1. General Requirements*

*(1) Through system testing it shall be demonstrated without any gaps that the instrumentation and control equipment of the safety system were fabricated and assembled in accordance with the documents reviewed by the authorized expert*
*(under Sec. 20 Atomic Energy Act) and fulfil their intended functions."*

For both electrical and I&C equipment and systems, the safety assurance process for manufacturing will result in a number of test records. Involved parties are the manufacturer, the consulted experts, and the authority of the Länder. Generally, the manufacturer and the consulted expert are involved in testing, in factory inspections, and in the preparation of documents (test records), while the licence holder, a contractor employed by the licence holder, or an authorised expert is involved in the review of documents and in auditing. The roles of the different parties are dependent upon the type of equipment or system and these roles are outlined in the KTA safety standards.
For some components, the testing, inspections and auditing of the manufacturing may, for example, be performed without the authorised expert. The authorities are involved in the review process, the granting of approvals and in contacts with the independent expert organisations.

### 5.4.3 Commissioning

As for the design and manufacturing of electrical and I&C equipment and systems, the requirement for the tests, inspection and review of the commissioning is dependent upon the

[56] KTA 3507, Factory Tests, Post-repair Tests and Certification of Satisfactory Performance in Service of Modules and Devices for the Instrumentation and Controls of the Safety System.

equipment or system as specified by the KTA safety standards. Commonly, the personnel for the inspection and preparation of the documents required for the commissioning is supplied by the manufacturer, but the review of the documentation is performed by the licence holder accompanied by an authorised expert. The authorised expert may also be involved in the supervision of tests and inspections performed by the manufacturer. Examples of the documents that are generated from the commissioning are the testing schedule, the description of the commissioning procedure, and the test records. KTA 3701 provide general requirements for the commissioning of electrical power supply in nuclear power plants:

*"4.16.4 Commissioning Tests*
*Commissioning tests shall be performed on-site to demonstrate the fulfilment of the specified safety requirements and the function of the electrical power supply in their interaction with the process engineering systems and the instrumentation and control equipment. The commissioning tests should be performed under the most realistic conditions possible."*

KTA 3703 specifies that the commissioning tests and inspections for emergency power facilities with batteries and AC/DC converters in nuclear power plants should be carried out by competent personnel of the plant operator or of the manufacturer in agreement with the authorised expert. For emergency power facilities with DC /AC converters, KTA 3704 states that test and inspections during assembly together with acceptance and functional tests at the construction site shall be performed by the expert personnel of the manufacturer in coordination with the authorised expert. Contrary to this, KTA 3705 and KTA 3504 specifies that the commissioning tests for the emergency power switchyards and the emergency power distribution transformers and electrical drive mechanisms of the safety system shall be performed by expert personnel specified by the licence holder and that authorised experts shall be consulted if this is specified in the testing schedule.

The general requirements for the safety assurance procedure of the commissioning of I&C equipment of the safety system of nuclear power plants are set out in KTA 3506. The standard set out general requirements regarding testing schedules, testing instructions, visual inspections including criteria, and functional tests. It also specifies the documents that are to be included in the three parts of the documentation of the commissioning tests: testing schedule, description of procedure, and test records. The commissioning tests for I&C equipment of the safety system shall according to KTA 3506 be carried out by expert personnel designated by the applicant and the authorised experts shall be consulted if this is provided in the testing schedule. Other safety standards, such as KTA 3504, are also referring to KTA 3506 for the requirenemts during commissioning.

As with the safety assurance procedure for the design and the manufacturing, the safety assurance procedure for the commissioning of electrical and I&C equipment and systems is different for different components and systems. Involved parties are the manufacturer, the consulted experts, and the authority of the Länder.

Generally, the licence holder is involved in testing and in the preparation of documents (testing schedules, description of documents, and test records), while the authorised expert is involved in the review and in other parts of the safety assurance procedure provided this is required in the testing schedule. However, there are exceptions from this, see above. The authorities are involved in the review process, the granting of approvals and in contacts with the independent expert organisations.

# 5.5 Introduction of digital systems

The introduction of digitalised I&C equipment in German nuclear power plants started in the beginning of the 1990-ies. Examples of I&C functions that have been digitalised in between three to five nuclear power plants are the operational and safety related functions of the refuelling machine, the limitation system, and the turbines control system. The neutron flux control system has been digitalised in one nuclear power plant, but the reactor protection system has not yet been digitalised in any German nuclear power plants. The modification process of the regulatory framework has been initiated due to the introduction of the digitalised I&C equipment, but the process is not yet finished. An overview of parts of the regulatory framework relevant for digitalised equipment is given below.

The RSK Guidelines for Pressurized Water Reactors contains general criteria for the design, testing, operation, and security of safety instrumentation and control software (software for the safety instrumentation and control of functions of categories 1 to 3). Examples of the design principles for Safety Category 1 software are:

*"7.6.1.2.1 Principles*
*(1) The development and qualification of the software of category 1 is to be carried out in such a way that a continual verification of the precise mode of software operation is ensured. Formal[8] and computer-aided construction and examination methods are to be used for design and implementation. These methods are also largely to be used during the other phases of the development.*
*(2) The software of category 1 is to be simply structured.*
*(3) The functional scope of the software of category 1 is to be restricted to the necessary extent.*
*(4) The programs are to be designed in a robust and self-monitoring way.*

*[8] Formal methods have a mathematical basis. The notation (syntax) as well as the meaning (semantics) of the symbols used are defined exactly. The descriptions thus prepared are accessible for mathematical analysis."*

The number of references to digitalised equipment and software are few in the KTA safety standards and, hence, the existing regulations for analogue I&C systems are applied to digital equipment correspondingly. This procedure is also acknowledged for reactor protection system and monitoring equipment of the safety system in KTA 3501:

*5.5.1.2 Analog Initiation Channels*
*The safety variable should be a continuous function of the process variable. If a direct measurement of the safety variable is not possible (e.g., DNB-ratio) or if the use of a direct measuring technique is technically not reasonable, computing circuits may be used , e.g., flow measurements using an orifice together with a radicating signal transducer.*

*5.5.1.3 Digital Initiation Channels*
*If digital initiation channels are used in the reactor protection system, these shall be designed in accordance with the requirements of Section 5.5.1.2.*

Different requirements for the type testing of electrical modules for the safety related I&C systems are specified in KTA 3503. This includes the specification of documents for hardware and software that are required as part of the type testing procedure. Other regulations that are applied for digitalised equipment in German nuclear power plants are the existing industrial standards (DIN-IEC).

## 5.6 Summary – degree of involvement of third party organisations

As previously described in this chapter, independent experts or expert organisations hold a central position in the German safety assurance system for the operation of nuclear power plants. According to section 20 of the Atomic Energy Act it is possible for the authorities to consult authorised experts for the licensing and supervising procedures. In reality, this possibility is not only an option but sometimes an obligation for the authorities, since the use of experts is required in various parts of the German safety assurance procedure as stipulated for example by the RSK Guidelines and the KTA safety standards.

The Technical Inspection Agencies (TÜV), which are employed by the authorities of the Länder, are involved in almost all technical issues related to the assessment of the safety of installations and their operation. This may include tests, evaluations, reviews of documents, inspections, and supervisory procedures, but the manufacturer of the equipment and the licence holder is generally also involved in the tests, controls, and inspections depending on the regulatory framework. Independent experts are also directly involved in the safety assurance procedure during operation, which includes duties such as the assessment of reportable events and in-service inspections. The expert organisations are part of the approval processes through their evaluations provided to the authorities in, for instance, expert analysis reports, but the experts are also authorised to give their approval to certain steps of the licensing procedure[57]. Another role of independent experts is to certify the characteristics of certain devices through type approval tests, which both involves a physical test and a theoretical examination of the device. The type approval certificate is granted by an accredited inspector. Nevertheless, the Länder authorities are not bound by the authorised experts´ evaluation results in making their decisions.

[57] See, for example, Bundsamt Für Strahlenschutz. (BfS), Compilation of Information Required for Review Purposes under Licensing and Supervisory Procedures for Nuclear Power Plants, Ed. 10/82.

# 6 Switzerland

There are five nuclear power plants in operation in Switzerland, which contribute by approximately 38 percent to the country's electricity production. Beznau I and II, (2*365 MW) and Mühleberg (355 MW) are of the first generation of nuclear power plants in Switzerland, while the second generation comprises Goesgen (970 MW) and Leibstadt (1165 MW).

## 6.1 Electrical equipment versus mechanical installations

In Switzerland, there is no general difference between the safety licensing procedures for electrical and I&C equipment in comparison to the procedures for mechanical pressure and load bearing equipment. The licensing procedure is basically the same for all kinds of equipment and it follows the four phases: concept, design, realisation, and installation/-commissioning. The types of documents to be delivered for licensing are in part different for each type of equipment.

## 6.2 Main players involved in safety licensing procedures

The Nuclear Energy Act of 2005, the Nuclear Energy Ordinance, the Radiological Protection Act, and the Radiological Protection Ordinance comprise the legislative framework that specifies the main legal provisions for authorisation and regulation, supervision, and inspections of nuclear facilities in Switzerland. The Nuclear Energy Act requires the supervisory authorities to be formally independent of the licensing authorities and this separation is presently fulfilled on a technical level.

The Federal Council is the authority which grants general licences, including site licenses, and approves the main features of a project. A valid general license is a prerequisite for the subsequent granting of construction and operating licences. Licences such as licences for construction, commissioning, operation, modification, or decommissioning, are granted by the Department of the Environment, Transport, Energy and Communications (UVEK). In addition to UVEK, the Swiss regulatory body comprises the Swiss Federal Nuclear Safety Inspectorate (HSK[58]), which is a part of
the Swiss Federal Office of Energy (BFE) until the end of 2008. Subsequently, HSK will become an independent institution called ENSI (Federal Nuclear Safety Inspectorate). Since 1 January 2008 HSK is the supervisory authority not only for nuclear safety but also for nuclear security and protection against sabotage of nuclear facilities. Previously, the supervisory authority for nuclear security and safeguards has been the Safeguards and Protection against Sabotage of nuclear Facilities Section of BFE. The safeguard division still belongs to the Swiss Federal Office of Energy (BFE).

The responsibility of the licence holder for the safe operation of a nuclear power plant is explicitly required by the Nuclear Energy Act, which also specifies general responsibilities for

[58] In German: Hauptabteilung für die Sicherheit der Kernanlagen (HSK). In this text referred to as the Inspectorate, the regulator, and the supervising authority.

areas linked to the licensing procedure. This includes the general responsibility for the safety of installations, the requirement of periodic safety reviews, and obligations linked to the back-fitting of installations. Other stipulated responsibilities of the licence holders are to[59]:

- carry out inspections as well as safety and security assessments throughout the entire life of the installation,
- report to the regulatory authorities periodically on the condition and operation of the installation and immediately on reportable events, and to
- maintain complete records on the technical facilities and on operation, and to revise the safety analysis report and security analysis report when necessary.

It is relevant for the licensing procedure that the responsibilities of interfacing organisations and contractors are defined in contracts between the licensee and the organisations. The procedure to establish these contracts is part of the plant's management systems and is inspected by HSK in accordance with the regulatory guideline on the organisation of nuclear power plants.

HSK may also seek advice from independent expert organisations which will be involved in the licensing procedure. An independent third party, Electrosuisse, is an accredited organisation which inspects electrical equipment and installations. Electrosuisse is responsible for the reliability of the electrical installations and for personal safety. Their primary regulations are the Swiss electrical standards. Some of the responsibilities of the HSK and Electosuisse are therefore overlapping.

Independent consultants are hired for the supervision of Swiss nuclear power plants in some areas. Examples of areas of inspection that have been outsourced to the Swiss Association for Technical Inspections[60] (SVTI) are the manufacturing, repair, replacement, modification, and in-service inspections of pressure-bounding components.

### 6.2.1 Duties of the Swiss Federal Nuclear Safety Inspectorate (HSK)

As mentioned previously, the Swiss Federal Nuclear Safety Inspectorate (HSK) is the authority that supervises nuclear installations. This includes all stages of the nuclear power plants lifecycles. The supervision includes duties such as:

- establishing safety criteria and requirements,
- preparation of safety evaluation reports (SER) to support decisions of the licensing authority,
- supervising the fulfilment of regulations including inspections, reporting and the request for documentation,
- granting, suspension, or withdrawal of permits, and
- ordering the application of all measures that are necessary and appropriate for the preservation of nuclear safety.

[59] Convention on Nuclear Safety, the fourth Swiss report in accordance with Article 5, July 2007.
[60] In German: Schweizerischer Verein für technische Inspektionen

HSK is responsible for the licensing procedures of all Swiss nuclear power plants and will in this way support the Department of the Environment, Transport, Energy and Communications (UVEK) in its licence granting process.

This means that HSK is responsible for the assessment and inspection of electrical equipment related to plant safety, even if this responsibility at times overlaps with the inspection duties of the independent third party Electrosuisse. In some areas of the licensing procedure for electrical and I & C equipment, such as lightning protection and computer based safety systems, HSK is partly supported by other expert organisations.

## 6.3 Safety classification systems

Switzerland applies the IEEE (Institute of Electrical and Electronics Engineers) US classification system 1E (corresponding to SA, safety systems and equipment, in accordance with the IAEA classification) or 0E (corresponding to SB, safety related systems, in accordance with the IAEA classification)[61].

## 6.4 Regulations on reviews and inspections

The legislation and the regulatory framework for nuclear installations provide the formal basis for the supervision and the continuous improvement of nuclear installations. The Swiss regulatory framework that governs the use of nuclear energy is established on a four-level system based on the preemption principle, where the Federal Constitution is found on the first level, Federal Laws (also referred to as Federal Acts) on the second, Ordinances on the third, and regulatory guidelines on the fourth. The main legal provisions for authorisation and regulation, supervision, and inspection are regulated in the Nuclear Energy Act, the Nuclear Energy Ordinance, the Radiological Protection Act, and the Radiological Protection Ordinance. Safety requirements and regulations are detailed in more than 40 regulatory guidelines of the Inspectorate HSK. These guidelines cover all aspects of nuclear power plant construction, operations and decommissioning, of nuclear waste transportation and disposal, as well as radiation protection and emergency preparedness[62].

The Nuclear Energy Act regulates the basic principles of nuclear safety and the licensing procedure describing authorisation (licensing) for siting, construction, (including design), operation (including commissioning) and decommissioning. The Radiological Protection Act covers every aspect of the protection of personnel in nuclear power plants, the public and the environment against hazards caused by ionising radiation. Among the most important ordinances for nuclear safety is the Nuclear Energy Ordinance (KEV), which came into force 2005.

There are also a number of Federal Acts and Federal Ordinances that are related to security matters of importance for the safety of nuclear energy. They cover areas such as land use planning, protection of the environment, forestry, fire protection, and occupational safety, as

[61] Richtlinie für schweizerische Kernanlagen - Sicherheitstechnische Klassierung,Klassengrenzen und Bauvorschriften für Ausrüstungen in Kernkraftwerken mit Leichtwasserreaktoren. HSK-R-06/d, Mai 1985.
[62] Convention on Nuclear Safety, the fourth Swiss report in accordance with Article 5, July 2007.

well as technical safety and radiological protection aspects of the transport of radioactive substances.

### 6.4.1 Nuclear Energy Ordinance (Kernenergieverordnung - KEV)

The Nuclear Energy Ordinance (In German: "Kernenergieverordnung", KEV) contains the rules for the implementation of the provisions of the Nuclear Energy Act. It contains basic design criteria for nuclear power plants and specifies the licensing requirements as well as the documents to be submitted to the licensing and regulatory authorities in support of the licensing or permit process. The specified licensing requirement includes basic rules for the licensing of all kinds of installations related to reactor safety, i.e. both mechanical installations and electrical and I&C equipment. Moreover, the Nuclear Energy Ordinance (KEV) states that the regulator is assigned to provide detailed regulations in appropriate guidelines.

### 6.4.2 Regulatory guidelines with regard to Nuclear Energy Ordinance (Kernenergieverordnung - KEV)

The regulatory guidelines are drafted by the regulator, HSK, who may use the support of experts or specialists while designing the regulations. The regulations are subsequently put into force by the regulator after consultation with the license holders, the Swiss Federal Department of Energy, and appropriate Swiss institutes, consultants or providers. In general the hearing procedure includes a time frame where the public may view the document on the internet for comments. Currently, the following regulatory guidelines are directly applicable for electrical and I&C equipment (the titles are translated from German to English):

- R-23 "Revisions, tests, replacements, repairs and modifications of electrical equipment in nuclear power plants" (In German: „Revisionen, Prüfungen, Ersatz, Reparaturen und Änderungen an elektrischen Ausrüstungen in Kernkraftwerken")

- R-31 "Licensing procedure for Safety Class 1E electrical equipment" (In German: „Aufsichtsverfahren beim Bau und dem Nachrüsten von Kernkraftwerken, 1E klassierte elektrische Ausrüstungen")

- R-35 "Licensing procedure for systems engineering" (In German: „Aufsichtsverfahren bei Bau und Änderungen von Kernkraftwerken, Systemtechnik")

- R-46 "Requirements for the application of computer based I&C of importance for safety in nuclear power plants"(In German: „Anforderungen für die Anwendung von sicherheitsrelevanter rechnerbasierten Leittechnik in Kernkraftwerken")

The regulatory guideline R-46 gives indications for review and inspection of digital equipment. Among other points, it states that the assessment of digital equipment shall be focused on the system level of the application. A precondition for the system level assessment is that there already exists a traceable approval of the generic part (for hardware, software, and system level). The approval must have been performed by a recognised institution of the country of the provider, for example, TÜV (In German: „Technischer Überwachungsverein") in Germany.

## 6.5 Licensing procedures for Swiss nuclear power plants

There are two types of main licences applied in Switzerland[63]:

- General Licence: It is applicable to any new nuclear installation after 1978 and includes the site licence. (The current nuclear power plants were all taken in operation before 1978)
- Licences for construction, commissioning, operation, modification or decommissioning. These licences are primarily technical and the main requirements relate to nuclear safety.

The general licence is granted by the Federal Council and must first be approved by the Federal Parliament, and, in case of a popular referendum, by the people of Switzerland. The Licences for construction, commissioning, operation, modification, or decommissioning are granted by the Department of the Environment, Transport, Energy, and Communications (UVEK). The decision is based on:

- the application for a project, which is supported by a safety analysis report (SAR), and, for the construction and operation licences, a probabilistic safety analysis (PSA), all to be submitted by the applicant,

- the safety evaluation by the Inspectorate (HSK), which reviews and reassesses the application of the project concerning nuclear safety and radiation protection. The result of the regulatory review and reassessment is documented in a safety evaluation report (SER), and

- a comprehensive public consultation.

A general description of licensing procedures for construction, commissioning, operation, modification, or decommissioning including the relevant documents follows below.

### 6.5.1 Licences for construction, commissioning, operation, modification or decommissioning

The Inspectorate HSK is established as the authority for supervising nuclear installations by the Nuclear Energy Ordinance for all stages of the installations' lifecycles. This means that

[63] Convention on Nuclear Safety, the fourth Swiss report in accordance with Article 5, June 2007.

HSK, as the supervising authority:

- establishes the safety criteria and requirements,
- prepares the safety evaluation reports (SER) to support the decision of the licensing authority (which is UVEK, except regarding the general license),
- supervises the fulfilment of regulations including inspections and reporting,
- requests documentation on aspects of nuclear safety, and
- grants, suspends, or withdraws permits.

The Inspectorate HSK is the key authority in terms of the licensing procedure for construction, commissioning, operation, modification, or decommissioning. According to the Swiss regulation, any modification of a system or equipment that has an influence on safety or security must be approved by the regulator (HSK). In principle this means that the documents affected by modifications have to be delivered to HSK. The items to be reviewed depend on the kind of the modification and the coverage is decided upon on a case-by-case basis by HSK. The reason is that guidelines are describing the general process and not details.

The Swiss regulation is focused on the quality of the items itself not on the development process. The licensing procedure is a process which runs in parallel with the project development process. One of the requirements of the regulator HSK is that the licensee has a quality assured project procedure for the whole life cycle of equipment and systems.

### 6.5.2 The licensing procedure for electrical and I&C systems and equipment

The Nuclear Energy Act regulates the basic principles of nuclear safety including the licensing procedure for electrical and I&C systems and equipment installed at Swiss nuclear power plants. The routines for the licensing procedure are independent of the type of system or equipment. The four phases in the licensing procedure are concept, design, realisation, and installation/commissioning, but the types of documents that have to be delivered in the licensing process depend on the type of system or equipment that should be licensed. For each phase, the license holder has to deliver the appropriate documents to HSK for assessment and each phase has to be concluded by a letter of approval from the regulator. The license holder is not permitted to continue the project until the letter of approval has been received.

The regulator HSK is always responsible for review and inspection of the electrical equipment, although support from an expert organisation may be needed. It is the responsibility of the license holder that the delivered documents are complete, correct and of appropriate quality. In case the documents have been provided by an external party, the licensee should review the documents of the provider before deliverance to the regulator. The licence holder has his own quality procedures for backfitting and modification projects.

The regulator HSK decides on the level of detail and on the coverage for the assessment. On a case-by-case basis, HSK determines whether the assessment should be performed in-house or with the support of external experts. The latter may, for example, be the preference for large and complicated projects, like the replacement of a conventional reactor protection system by a digital system, or for special projects such as lightning protection.

In Swiss nuclear power plants, external - or third party - organisations are also involved in parts of the safety assurance process indirectly linked to the safety licensing procedure. Two such independent organisations are Electrosuisse, which inspects electrical installations, and the Swiss Association for Technical Inspections (SVTI), which inspects pressure-boundary equipment but not electrical and I&C equipment.

### 6.5.3 Required documents for different phases of the licensing procedure for electrical and I&C systems and equipment

The aforementioned four phases in the licensing procedure systems and equipment in Swiss nuclear power plants are the concept phase, the design phase, the realisation phase, and the installation/commissioning phase. A number of documents are required by the Inspectorate HSK for each of these phases. The documents required for Safety Class 1E equipment during the first phase, i.e. the concept phase, are the following[64]:

- Safety evaluation reports
- System specifications
- System diagrams
- Function charts
- Component lists
- Quality Management Concepts
- Arrangements in DWG (the most common format for CAD, computer-aided design)
- Reference lists

The Inspectorate HSK also has to approve the concept and for this approval a preliminary version of the documents, except for the Quality Management Concept and the Reference list, are required. The final versions of the documents above are required for the design phase as well as two additional documents, a qualification programme and a document describing the instrumentation. The same documents are also required for Safety Class 0E equipment, except for the component list and the qualification programme.

The second phase of the licensing procedure in the Swiss regulation is called the realisation phase[65]. A letter of approval from the Inspectorate HSK needs to be obtained before installation work may begin at the plant. The following documents are required for Safety Class 1E equipment during the realisation phase:

[64] A list of the required documents may be found in HSK-R-35/d "Licensing procedure for systems engineering" (In German: Aufsichtsverfahren bei Bau und Änderungen von Kernkraftwerken, Systemtechnik) from May 1996.

[65] Corresponds to the, in some countries, more frequently used term manufacturing

- Function charts
- Signal flow diagrams
- System descriptions
- Qualification certificates
- Final component lists
- Results from the factory acceptance test (FAT)

For the Safety Class 0E equipment, the required documents for the realisation phase are: the final documents of the concept phase and, in addition to this, the results from the factory acceptance test (FAT).
In the Swiss licensing procedure, installation and commissioning are combined to one licensing phase, called implementation. The approval of this phase is necessary for the licensee to obtain the permission for the operation of the system or equipment and this requirement affects both Safety Class 1E and 0E equipment. The following documents are required for Safety Class 1E equipment during the implementation phase:

- Site test requirements descriptions
- Reports of the pre-tests
- Quality end-reports
- Programmes and rules for the periodic tests of systems

For Safety Class 0E equipment, the required documents are the site test description and the reports of the pre-tests. In addition to the required documents for different phases of the licensing procedure for equipment and systems as described above, the Swiss regulation requires an approval from the regulator HSK for any modification of a system or equipment. In principle all documents which are affected by the modification have to be delivered to the regulator.

# 6.6 Introduction of digital systems

Switzerland started shifting from analogue to digital equipment in 1989 when the alarm signalisation system in Beznau was digitalised. The older plants (Beznau and Mühleberg) have shifted to digitalised instrumentation systems to a larger extent than the second generation plants (Gösgen and Leibstadt). All Swiss nuclear power plants have a modernised plant information system. In addition, the older plants (Beznau and Mühleberg) have had the following systems replaced by digital I&C systems:

Beznau 1&2: reactor protection systems, plant control systems, turbine control systems, rod control and indication systems, part of neutron flux detection systems, alarm signalisation systems, chemical and volume control systems (planned 2008-2009), fuel pool filtered ventilation systems (planned 2008-2009).

Mühleberg: plant control system, turbine control system, rod control and indication system, part of neutron flux detection system, alarm signalisation system.

Parts of the regulatory framework have been modified to adapt to the introduction of digital equipment. Examples of such modifications can be found in Guideline R-46, which has been established explicitly in order to deal with all important aspects of digital I&C, and Guideline R-23, which has been slightly revised. Among other aspects, the following assessments and analyses have been introduced for digital I&C systems:

- diversity analysis for functions of safety systems,
- categorisation analysis according to IEC 61226[66] for functions of safety related systems,
- interdisciplinary assessments, especially for the system requirements specification (electrical engineering in combination with nuclear systems engineering) and the man-machine interface (electrical engineering in combination with human-factors engineering), and
- assessment and licensing of safety related systems have been enhanced since the introduction of digital I&C system.

## 6.7 Summary – degree of involvement of third party organisations

Independent, so called third party organisations are involved in different steps of the safety assurance and safety control procedures in Swiss nuclear power plants. One such example is the surveillance of manufacturing, repair, replacement, modification, and in-service inspections of pressure-boundary components, which the Inspectorate HSK has outsourced to the independent organisation Swiss Association for Technical Inspections (SVTI). The Inspectorate HSK may also involve different external expert organisations for consultation in the licensing procedure of different categories of equipment and systems.

Another example of external involvement in the safety assurance and control procedures of electrical and I&C systems and components is when the independent third party, Electrosuisse, inspects electrical equipment and installations in Swiss nuclear power plants. However, the responsibilities of the Inspectorate HSK and Electrosuisse are different, albeit to some extent overlapping. The Inspectorate HSK is responsible for assessment and inspection of electrical equipment relating to plant safety, specifically reactor safety, which includes the safety and the reliability of the electrical equipment. Electrosuisse is responsible for the reliability of electrical installations and for personnel safety and their primary regulations are the Swiss electrical standards. Since both the reliability and the personal safety of electrical equipment are parts of the safety assurance of the nuclear power plants, Electrosuisse is an independent accredited third party involved in the process of safety assurance. For electrical and I&C equipment and components, there is also an overlap in aspects covered by the Inspectorate HSK and Electrosuisse. The common basis for overlapping aspects is the relevant Swiss electrical standards and not the regulatory guidelines for nuclear power plants in Switzerland.

[66] IEC 61226 (International Electrotechnical Commission), Nuclear power plants - Instrumentation and control systems important to safety - Classification of instrumentation and control functions, Ed. 2.0 b, 2005.

# 7 References

The report is mainly based on a survey which has been answered and communicated with the following persons:

**Tapani Eurasto, Radiation and Nuclear Safety Authority (STUK), Finland**

**Robert Grinzinger, Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) mbH, Germany**

**Marc Dubois, Association Vinçotte Nuclear (AVN), Belgium**

**Franz Altkind, Swiss Federal Nuclear Safety Inspectorate SHK, Switzerland**

**The survey has been complemented with the following references and sources:**


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AVN Annual Report 2006

**Finland**
Finnish report on nuclear safety, September 2007, STUK-B 80
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GUIDE YVL 2.5 The commissioning of a nuclear power plant, 29 September 2003
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Act on the Peaceful Utilization of Atomic Energy and the Protectin against its Hazards (Atomic Energy Act) of December 23, 1959.
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KTA Safety Standard

- KTA 3501 Reactor protection System and Monitoring Equipment of the Safety System.
- KTA 3503 Type Testing of Electrical Modules for the Safety Related Instrumentation and Control System
- KTA 3504 Electrical Drive Mechanisms of the Safety System in Nuclear Power Plants
- KTA 3505 Type Testing of Measuring Sensors and Transducers of the Safety-Related Instrumentation and Control System

– KTA 3506 Tests and Inspections of the Instrumentation and Control Equipment of the Safety System of Nuclear Power Plants
– KTA 3507 Factory Tests, Post-repair Tests and Certification of Satisfactory Performance in Service of Modules and Devices for the Instrumentation and Controls of the Safety System
– KTA 3701 General Requirements for the Electrical Power Supply in Nuclear Power Plants
– KTA 3702 Emergency Power Generating Facilities with Diesel-Generator Units in Nuclear Power Plants
– KTA 3703 Emergency Power Facilities with Batteries and AC/DC Converters in Nuclear Power Plants
– KTA 3704 Emergency Power Facilities with AC/DC Converter in Nuclear Power Plants
– KTA 3705 Switzyards, Transformers and Distribution Networks for the Electrical Power Supply of the Safety System in Nuclear Power Plants

Bfs Safety Codes and Guides – Translations, Edition 1/01, Bundesamt für Strahlenschutz Salzgitter

**Switzerland**

Convention on Nuclear Safety, Federal Department for the Environment, Transport, Energy and Communication DETEC, Switzerland July 2007

**Others**

Licensing of safety critical software for nuclear reactor. Common position of seven European nuclear regulators and authorised technical support organisations, AVN, Isteck, Bundesamt für Strahlendschutz, SCN, STUK, SHE, SKI, Revistion 2007.

Management of life cycle and ageing at nuclear power plants; Improved I&C maintenance, IAEA August 2004.

# Appendix 1
## Comparison of safety classifications systems

The classification protocols are not the same in different stats. The table below shows/illustrates how the different classifications systems relate to each other.

Both Switzerland and Belgium applies the US classification system, class 1E and not-classified systems. In Belgium the regulator, AVN has developed three sub-categories, 1E1, 1E2 and 1E3 to the Class 1E. 1E is equivalent with SA, corresponding to safety systems and equipment according to IAEA and 0E is equivalent SB, according to IAEA.

Finland classifies electrical and I&C systems and components into Safety Classes 2, 3, 4, and Class YET (classified non-nuclear). The items with highest safety significance belong to Safety Class 2.

In Germany, KTA has developed safety standards on German technical standards and deregulations and the American nuclear safety standards. The safety classifications for electrical and I&C equipment are divided in three categories, 1, 2 and 3 of which Category 1 has the highest safety significance.

<table>
<tr><th>ORGANIZATIONS AND/OR COUNTRIES</th><th colspan="10">CLASSIFICATION</th></tr>
<tr><td rowspan="2">IAEA</td><td colspan="6">Systems Important to Safety</td><td colspan="4" rowspan="2">Systems not important to safety</td></tr>
<tr><td colspan="2">Safety system</td><td colspan="4">Safety related system</td></tr>
<tr><td>IEC</td><td colspan="2">Category A</td><td colspan="3">Category B</td><td colspan="3">Category C</td><td colspan="2">Unclassified</td></tr>
<tr><td>France</td><td colspan="2">1E</td><td colspan="3">2E</td><td colspan="5">IFC/NC</td></tr>
<tr><td>European Utilities Requirements (EUR)</td><td>F1A (Automatic)</td><td colspan="3">F1B (Automatic and Manual)</td><td colspan="5">F2</td><td>Not Classified</td></tr>
<tr><td>UK</td><td colspan="3">Category 1</td><td colspan="4">Category 2</td><td colspan="3">Not classified</td></tr>
<tr><td>USA</td><td colspan="2">1E</td><td colspan="8">Non-nuclear safety</td></tr>
</table>

*Figure 6 : Safety Classification of Important Functions in NPPs. Source: Management of life cycle and ageing at nuclear power plants: Improved I&C maintenance, IAEA-TECDOC-1402.*

### 7.1.1 German safety classifications on electrical and I&C equipment

The I&C functions are classified in one of three categories according to the RSK-guideline:
category 1 or A: I&C functions which are necessary to avoid non tolerable consequences of accidents (e.g. reactor protection system)
category 2 or B: I&C functions which are necessary to avoid the increase of a incident to an accident (e.g. limitation system)
category 3 or C: all other safety related I&C functions
The RSK-guideline contains requirements for two different categories of I&C equipment:
E1: equipment which implements? I&C functions of category 1 or 2
E2: equipment which implements? I&C functions of category 3
But, as far as our experience goes, there's no I&C equipment of the category E2 installed in German NPPs. I&C equipment which fulfils I&C functions of the category C is of the category E1, too.

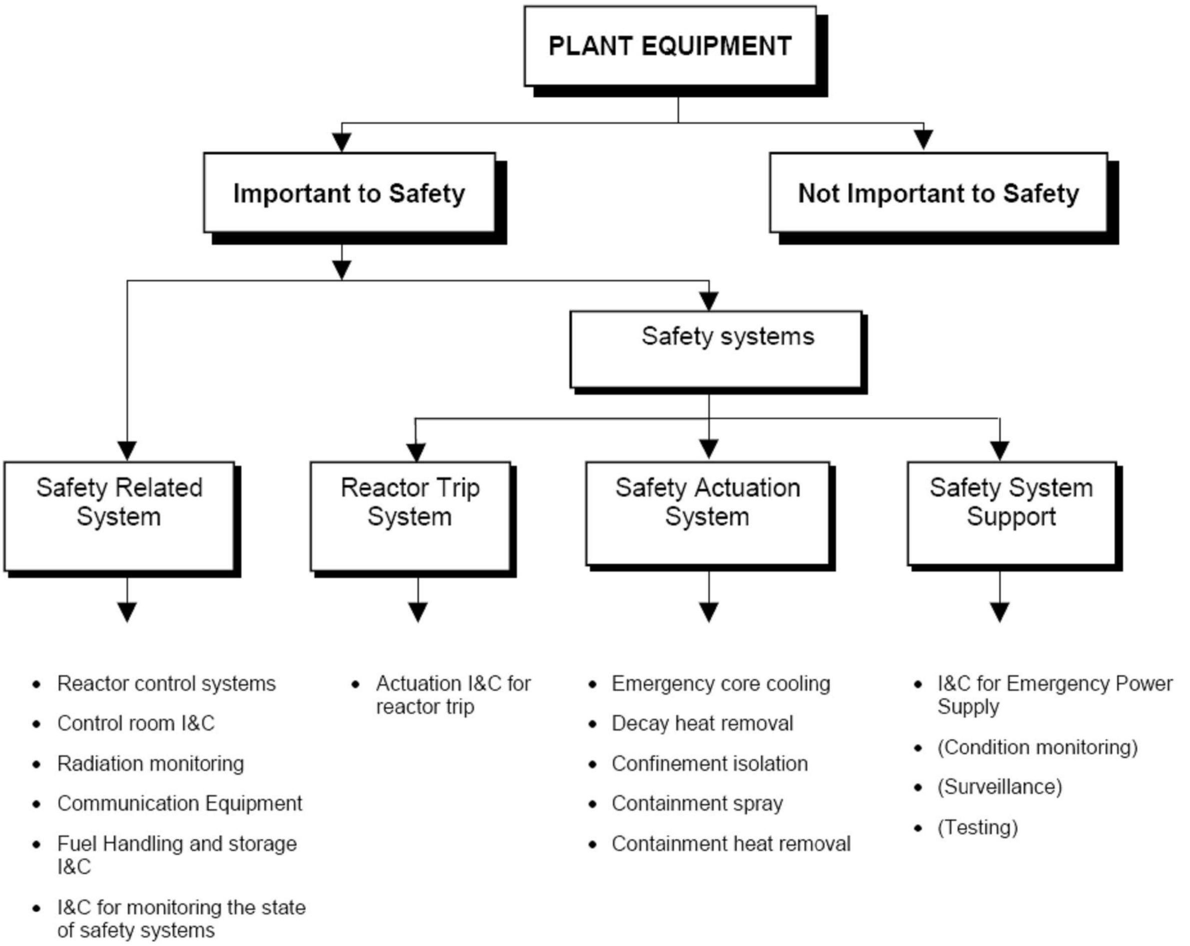


*Figure 7 Break down of Safety Equipment of an nuclear power plant. Source: Source: Management of life cycle and ageing at nuclear power plants: Improved I&C maintenance, IAEA-TECDOC-1402.*

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