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Implementation of the obligations of the

The fifth Swiss report in accordance with Article 5

July 2010

Convention on Nuclear Safety

The fifth Swiss report in accordance with Article 5

Contents

Foreword

Switzerland signed the Convention on Nuclear Safety (CNS) on 31 October 1995. It ratified the Convention on 12 September 1996, which came into force on 11 December 1996. In accordance with Article 5 of the Convention, Switzerland has prepared and submitted 4 country reports for Review Meetings of Contracting Parties organised in 1999, 2002, 2005 and 2008. These meetings at the IAEA headquarters in Vienna were attended by a Swiss delegation.

This 5th report by the Swiss Federal Nuclear Safety Inspectorate (ENSI) provides an update on compliance with CNS obligations. In addition, the report attempts to give appropriate consideration to issues that aroused particular interest at the 4th Review Meeting.

This report starts with general political information on Switzerland, a brief history of nuclear power and an overview of Swiss nuclear facilities. This is followed by a comprehensive overview of the status of nuclear safety status in Switzerland (as of July 2010).

The numbering in the report follows the numbering of Articles 6 – 19 of the CNS. The comments for each section indicate clearly how Switzerland complies with the key obligations of the Convention. Appendix 1 contains a list of abbreviations used in the text.

The chapter “Summary and Conclusions” provides an overview of the contents of the report and its conclusions on the degree of compliance with the obligations of the Convention.

Summary and conclusions

Several laws and ordinances of relevance to nuclear safety were passed or revised during the reporting period. In addition, the Swiss Federal Nuclear Safety Inspectorate – in this report also referred to as the Inspectorate – updated a substantial proportion of its guidelines. These new guidelines are compatible with current legislation and ordinances. They are also harmonised with the harmonised safety requirements of the Western European Nuclear Regulators Association (WENRA), which in turn are based on IAEA Safety Standards.

On 1 January 2009, the Swiss Federal Nuclear Safety Inspectorate, as the supervisory authority for nuclear safety including radiological protection and nuclear security, became formally independent of the Swiss Federal Office of Energy. It is now a stand-alone organisation controlled by its own management board (ENSI board) and has its own budget.

There has been a fundamental change in the prospects for nuclear energy in Switzerland and by association the tasks of the regulatory body since the submission of the three applications for new NPP general licences. Both the industry and the regulatory body are growing and each is seeking staff with similar qualifications.

Switzerland recently started a process to select a site for the disposal of radioactive waste in deep geological formations in Switzerland. The procedure is described at the end of the “Introduction” chapter of this report.

The following is a short summary of the detailed answers to Articles 6 – 19 of the Convention. The conclusion is that Switzerland complies with the obligations of these articles.

Article 6: Existing nuclear installations

The general safety of Swiss NPPs is good. The first generation of NPPs in Switzerland (Beznau units I and II and Mühleberg) – which started operation in the late 1960s and early 1970s – has been the subject of progressive back-fitting in response to major ongoing developments in NPP safety technology. First-generation of NPPs have been the subject of regular safety reviews. Licences for their continued operation were granted on the basis of these reviews. Periodic Safety Reviews (PSRs) were performed for the Mühleberg NPP in 2000/2001 and 2005 and for the Beznau NPPs in 2002. Both PSRs were reviewed in depth by the Inspectorate. The final review reports of the Inspectorate were published in 2002 and 2007 (Mühleberg) and 2004 (Beznau). These reports are available on the Inspectorate’s website (www.ensi.ch).

The second generation of NPPs (Gösgen and Leibstadt) incorporated various safety and operating improvements in their initial design. PSRs were performed for Leibstadt and Gösgen NPPs in 1996 and 1999 respectively. These reviews were then assessed by the Inspectorate. Towards the end of 2006, a further PSR was submitted for the Leibstadt NPP. The Inspectorate published its review report in 2009. The most recent PSR for Gösgen NPP was submitted towards the end of 2008 and the Inspectorate’s review report is due in 2011.

In conclusion, all Swiss NPPs have undergone the safety review process required under the Convention and have incorporated the improvements identified in the respective safety review reports. The Swiss policy of continuous improvements to NPPs based on the current state of science and technology ensures a high level of safety.

Article 7: Legislative and regulatory framework

The legislation and regulatory framework for nuclear installations is well established in Switzerland. It provides the formal basis for the supervision and the continuous improvement of nuclear installations. The main legal provisions for authorisations 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. The Nuclear Energy Act and its ordinance came into force in 2005.

Safety requirements and regulations are detailed in more than 40 regulatory guidelines of the Inspectorate, covering all aspects of NPP construction, operation and decommissioning, of nuclear waste transportation and disposal as well as radiation protection and emergency preparedness.

According to the Nuclear Energy Act, the first step of the licensing procedure for the building of a new NPP – the general licence – is subject to a facultative national referendum. Two additional licences are necessary: the construction licence and the operating licence. Appeals against these licences are possible.

The Nuclear Energy Act also provides for inspections and safety assessments performed by the Inspectorate, and for the enforcement of applicable regulations and of the terms of the licence.

Article 8: Regulatory Body

The Federal Council (federal government) grants licences. The Department of Environment, Transport, Energy and Communication grants construction licences and operating licences for nuclear facilities. The Swiss Federal Nuclear Safety Inspectorate ENSI is the supervisory authority for nuclear safety including radiological protection and nuclear security.

The responsibilities and tasks of the Inspectorate have increased in the last 20 years and so the workforce has gradually increased to about 120, including more than 100 specialists in reactor safety, radiation protection, waste management etc. In addition, its structure has been adapted to reflect changed requirements.

The Inspectorate is fully independent of organisations concerned with the promotion or utilisation of nuclear energy and the licensing of nuclear power plants. It was made independent of the Federal Office of Energy on 1 January 2009 and is controlled by its own management board (ENSI board) and has its own budget.

The Inspectorate uses a process-oriented management system, which was first awarded ISO 9001 certification in December 2001. In November 2007, it was also awarded ISO 14001 certification (environmental management). Certification under OHSAS 18001 (safety & health management) is planned for 2010. The management system applies to all relevant activities and is subject to continuous improvement based on management reviews, evaluation of performance indicators, internal audits and routine checks by the certification agency.

The existence of projects for new NPPs means that the Inspectorate is facing increased demand for experienced staff and so staff numbers will increase further in the next two years. Knowledge management including a career development programme is regarded as a valuable tool in efforts to cope with this demand. As a result, knowledge management is being integrated in the Inspectorate’s management system. In addition, the Inspectorate has increased its involvement and participation in nuclear safety cooperation programmes at many levels including

participation in IAEA services, such as IRRS and OSART missions, exchange of staff with foreign regulators and inspection workshops with other countries. Switzerland has signed bilateral agreements on the exchange of information on nuclear safety and radiation protection issues with its counterparts in four neighbouring states, i.e. Germany, France, Italy and Austria.

Article 9: Responsibility of the licence holder

The responsibilities of the licence holder for the safe operation of an NPP are expressly stated in the Nuclear Energy Act. Each NPP has accepted the conditions laid down for operation and a corresponding statement is included in the preamble of the operating manual for each NPP. The Inspectorate conducts inspections and technical discussions with the utilities to ensure that operators assume full responsibility for the safety of their installations.

Article 10: Priority to safety

Safety has always been afforded the highest priority by all organisations actively involved in building and operation of nuclear installations in Switzerland.

By 2002, all Swiss NPPs had been subject to an OSART mission, including a follow-up. Since 2005, all Swiss NPPs have taken part in the WANO Peer Review Process involving a WANO Peer Review and a WANO Follow-up Mission in a regular cycle of about six years. The plants informed the Inspectorate of the main findings and the action plans for the improvements identified in the WANO Peer Reviews.

All NPPs have implemented programmes to improve their safety culture. In 2005 the Inspectorate started regular technical discussions with each NPP on their safety culture programmes.

Article 11: Financial and human resources

NPP operators in Switzerland have sufficient financial resources to maintain a high level of safety throughout the lifespan of an NPP. Should an NPP no longer fulfil the regulatory safety requirements, its licence would be revoked and so it would not be able to continue operating. Decommissioning and waste disposal is funded by dedicated funds.

As required by the Swiss Nuclear Energy Act, corresponding ordinances and regulatory guidelines, the installations have sufficient qualified staff capable of managing and controlling nuclear installations. In the reporting period, staffing levels were substantially increased at all Swiss NPPs.

NPP personnel received regular education and training. Retraining is provided so that personnel keep abreast of advances in science and technology and plant modifications. All Swiss NPPs operate plant-specific full-scope replica simulators.

In terms of applicants for new-build licences, the Inspectorate will pay particular attention to the commitment and actual efforts by applicants to develop and maintain an organisation capable of satisfying the high standards required for nuclear safety in NPPs. For example, the applicants must provide the necessary human and financial resources during all phases of the construction.

Article 12: Human factors

The Inspectorate has a team of specialists in human factors, whose primary areas of competence and responsibility are as follows: organisation, training, qualification, human-system interface, safety culture and the investigation of human and organisational factors related to NPP events.

The Inspectorate is currently facing a range of challenges: projects to build three new reactors have been launched and existing plants have announced modernisation projects. Human and organisational factors (HOF) must be considered at an early stage in these ventures as they play an important role in safety.

The Nuclear Energy Ordinance lays down a series of NPP design principles, including a human factor principle: “Workstations and processes for the operation and maintenance of the installation must be designed so that they take account of human capabilities and their limits”. The Inspectorate pays particular attention to this principle in its consideration of plant modernisation projects.

Article 13: Quality assurance

The Management Systems in Swiss NPPs are compatible with the IAEA Safety Standard GS-R-3. They are certified under ISO 9001 (Quality Management) and OHSAS 18001 (Occupational Health and Safety) norms. Three of the four plants are also certified under ISO 14001 (Environmental Management). These certificates are renewed on a regular basis.

For projects to build new NPPs, the Inspectorate is currently establishing new guidelines stipulating the requirements to be met by applicants for licences during the design, construction and commissioning phases, whereby special attention will be given to the interface between licensee and contractors.

Article 14: Assessment and verification of safety

The review and assessment procedure includes an evaluation of the safety analysis report (SAR), safety-relevant systems, design-basis accident analyses, probabilistic safety analysis (PSA), reports on ageing surveillance programmes together with other safety-related documents if requested by the Inspectorate. As part of the integrated oversight approach (see below) an annual systematic assessment of nuclear safety is conducted for each NPP based on event analyses, inspection results, operator licensing reviews, safety-indicator data and information in the periodic licensee reports. The assessment of the periodic safety review (PSR) by an NPP is documented in a Periodic Safety Review evaluation report. PSRs are required every 10 years. Plant documentation must be regularly updated, including the SAR and PSA. The licence document includes important conditions and operating requirements. The Nuclear Energy Ordinance contains a requirement for a PSA.

An Ageing Surveillance Programme is in place for all NPPs. This programme serves to collect information on the structures, systems and components of relevance for the monitoring of ageing and understanding ageing mechanisms in order to maintain safety margins and the safety functions of structures, systems and components throughout the life of a plant. It is a prerequisite for long-term operation.

The following additional points help to ensure that the physical state of an NPP complies with its licence:

- Modifications to safety-related components require a permit.
- A plant review must be carried out after each refuelling outage.
- The Inspectorate has an efficient inspection programme in place in order to verify compliance with licensing requirements.

The Inspectorate adopts an integrated oversight approach. To obtain a realistic picture of the safety of each installation, the Inspectorate operates a systematic safety assessment system. Safety relevant information is structured in such a way that there is a distinction between the individual safety provisions as defined in plant documents and their real state and behaviour together with a distinction in terms of technical and human-organisational aspects. Every piece of data is assigned to fundamental safety functions and to levels of defence in depth and barriers.

The data for each NPP is summarised in a table. Inspection findings, operator licensing reviews, event analysis results, safety-indicator data and information in the periodic licensee reports are evaluated annually as part of the integrated oversight process.

Article 15: Radiation protection

The Radiological Protection Act and the Radiological Protection Ordinance have been revised in line with the recommendations of the International Commission on Radiological Protection (ICRP). The Inspectorate has subsequently updated most of its relevant guidelines. The supervisory and control methods currently applied by the Inspectorate comply with the requirements of the Convention to keep radioactive doses to the public and the environment as low as reasonably achievable and also to keep the generation of radioactive waste associated with the use of nuclear power at the lowest possible level.

Calculated doses based on annual emissions for a virtual-most-exposed group of the population, including exposure due to deposits from previous years, have remained well below 0.2 mSv per year. Since 1994, release-related values have been below 0.01 mSv per year for all Swiss NPPs.

With the exception of an incident in 2009, when two workers received a dose in excess of the national limit, no individual dose for plant personal or contractors exceeded 20 mSv per year during their work in Swiss NPPs. Since 1987, all annual collective doses have remained well below 4 person-Sv per unit and since 1995 have been below 2 person-Sv. The low annual individual and collective doses prove the effectiveness of measures taken in response to the most recent ICRP recommendations (e.g. guidelines, job planning and supervision).

The Inspectorate reviews the radiation planning process of NPPs. In addition the Inspectorate reviews all periodic reports by the Swiss NPPs on radiation protection measures.

Article 16: Emergency preparedness

Each nuclear installation has on-site and off-site emergency organisations and plans. The emergency planning zones around NPPs are defined. Emergency protective measures, e.g. sheltering and the availability of iodine tablets have also been established.

There is an automatic dose rate monitoring and emergency response data system (ANPA/MADUK) in and around all NPPs in Switzerland. The data is transmitted electronically to the Inspectorate, the National Emergency Operations Centre and the Ministry of the Environment of Baden-Württemberg (Germany). The MADUK/ANPA system also provides the Inspectorate with online access to measurement data for approximately 25 important plant parameters. The Inspectorate has also set up an automated system for radiological prognosis.

Exercises are conducted regularly to test emergency preparedness and plans. Appropriate channels exist for alerting the public, the National Emergency Operations Centre and neighbouring countries. There are bilateral agreements between Switzerland and neighbouring countries covering alerts in the event of an emergency.

In order to improve on-site emergency preparedness, the Inspectorate requires Swiss licensees to introduce severe accident management guidance (SAMG). In the event of an accident causing severe core damage, SAMG would guide the various emergency organisation teams at an NPP allowing them to take mitigation measures based on predefined strategies.

Article 17: Siting

The licensing procedure includes the steps and procedures required to evaluate the relevant NPP site-related safety factors. Under the Nuclear Energy Act and the Nuclear Energy Ordinance, a general licence for a nuclear installation can only be granted if the site is suitable. The decision on whether to grant a general licence is subject to a facultative national referendum. When evaluating the suitability of a potential NPP site, a comprehensive investigation of the external hazards has to be carried out as a basis for an appropriate plant design. All site-related factors must be included in a Safety Analysis Report (SAR). Furthermore, the general licence application must include an environmental impact report, a decommissioning concept and other safety-related documents.

Applicants for a construction licence must submit an updated SAR, a deterministic safety analysis (which can be part of the updated SAR) and a probabilistic safety analysis (PSA) as described in the chapter on Article 14. The Inspectorate reviews these documents and publishes the results in a safety evaluation report.

Currently, three new NPPs are planned in the vicinity of existing NPPs. For its site evaluation, the Inspectorate is relying on existing IAEA guidelines for siting. There is a strong emphasis on the estimated earthquake hazard as derived from geologic and seismological information. This estimate is based on both a deterministic and a probabilistic approach. The deterministic approach is not complete because the geological data itself is not complete.

Those living in the areas surrounding the site of a proposed NPP (including areas in neighbouring countries) are invited to participate in the comprehensive public consultation conducted as part of the licensing procedure. Switzerland has signed agreements on the exchange of information with its neighbours Austria, France, Germany and Italy. Site-related factors are re-evaluated periodically as part of a Periodic Safety Review.

The applicability and effectiveness of the Inspectorate's re-evaluation process has been demonstrated by the probabilistic re-assessment of seismic hazards at Swiss NPP sites (PEGASOS). This project was carried out by Swiss licensees in response to a requirement in the Inspectorate's PSA review process. In 2008, Swiss licensees launched a follow-up project – PEGASOS Refinement Project (PRP) – in order to take advantage of recent findings in earth

sciences and new geological and geophysical investigations at existing and new NPP sites. It seeks to reduce the uncertainty range of the former PEGASOS results. Based on PEGASOS insights, the Inspectorate has increased the seismic-hazard level for PSA studies. Higher hazard assumptions are also used for the design of new safety-related structures and components. Furthermore, various structures and components have been subject to seismic backfitting in the past.

Article 18: Design and construction

The design and construction of Swiss NPPs accord with the principle of defence in depth. To cope with external events in which no operator action is guaranteed, all Swiss NPPs have a special independent, bunkered system for shutdown and residual heat removal. The various levels of defence that exist ensure that safety limits and individual dose limits for the public are met during normal operation of the NPP and for all design-basis accidents. In addition, there are appropriate measures to mitigate the release of radioactive materials into the environment in the case of severe accidents beyond design-basis. Design, materials and components are subject to rigorous control and scrutiny and regular testing in order to verify their fitness for service. Safety assessments for the long-term operation of first-generation NPPs are performed as part of the periodic safety reviews and additional safety reviews. Backfitting is carried out when necessary. All Swiss NPPs possess a filtered containment venting system to mitigate radiological effects on the environment in the most severe accident scenarios. Currently, additional work is being done to redefine the seismic design requirements.

An analysis of the safety consequences of a deliberate aircraft impact showed that buildings of relevance to safety in the second generation NPPs at Gösgen and Leibstadt would provide full protection against a modern, fully-fuelled, long-range commercial airplane. For the first generation NPPs of Beznau and Mühleberg, analyses showed that the earlier backfitting of special bunkered shutdown and residual heat removal systems and the implementation of further fire protection measures meant that there were adequate levels of protection against aircraft impact.

The increased use of computerised plant monitoring improves the human-system-interface and facilitates NPP operation in all operating modes. Nevertheless, all Swiss NPPs have conventional reactor protection and control system redundancies.

Article 19: Operation

The requirements for the safe operation of Swiss NPPs are specified in the operating licence granted to each NPP. The operation licence includes commissioning approval. The commissioning programme, which requires the approval of the Inspectorate, comprises pre-operational and start-up tests as well as procedures for testing any equipment important for safety. The most important operational procedures are the Technical Specifications, which include the limiting conditions for operation and similarly require the approval of the Inspectorate. The operational procedures for an NPP also cover the maintenance, testing and surveillance of equipment.

Engineering and technical support in all fields of relevance to safety is available to all NPP staff. The low number of annual reportable events is evidence of the reliable operation of the Swiss NPPs.

The Nuclear Energy Act, the Nuclear Energy Ordinance and regulatory guidelines include requirements on the notification of events and incidents. Under the Ordinance, each NPP must use dedicated emergency operation procedures (EOPs) for operational anomalies and emergency conditions. The ultimate objective of EOPs is to bring the plant into a safe operational state. The legislation also requires an extension to EOPs in the form of severe accident management guidance. This is designed to prevent or at least minimise any impact on the environment.

In addition to its general inspection activities, the Inspectorate gains further insight into the operations of an NPP through a system of comprehensive operator reporting. Both the Inspectorate and the operators collect operating experience from domestic and foreign NPPs. In some cases, an analysis of a particular operating experience has resulted in important safety-related backfitting or modifications to Swiss NPPs.

The Nuclear Energy Act includes the principle that the originator of radioactive waste is responsible for its safe and permanent management. Because of fuel quality and plant cleanliness, the generation of radioactive waste at NPPs is kept to the minimum possible. The resultant waste is collected and separated. As a general rule, radioactive waste is conditioned as soon as practicable, mostly on site at an NPP or the Paul Scherrer Institute (PSI) but also in part externally at the Central Interim Storage Facility. All procedures for the conditioning of radioactive waste require the approval of the Inspectorate. Each NPP stores spent fuel discharged from reactors on site for a few years.

The Nuclear Energy Act prohibits the reprocessing of spent nuclear fuel for a period of ten years starting on 1 July 2006. At present, spent fuel is also stored in transport and storage casks at the Central Interim Storage Facility, which started active operation in June 2001. The return of waste from foreign reprocessing facilities to the Central Interim Storage Facility started in 2002 and is on schedule. There is an additional facility at the Beznau NPP site for the dry storage of spent fuel elements. It started active operation in April 2008. The Gösgen NPP site has a facility for the wet storage of spent fuel, which started operation in May 2008.

Introduction

Country and State

Switzerland is located in the middle of Europe and is surrounded by France in the west, Germany in the north, Austria and Liechtenstein in the east and Italy in the south. With a total surface area of 41,285 sq. km – more than half of which is mountainous – and a population of 7.8 million, Switzerland is a small, densely populated country. The Rhine, Rhone and Inn rivers originate in the Swiss Alps, which are often called the water tower of Europe.

Switzerland has four official languages: German, French, Italian and Rhaeto-Romanic, the latter being spoken only by a minority of some 0.5% of the population of Switzerland. About 20% of current residents are foreign nationals.

Structurally, Switzerland has evolved into a federal state with 26 member states, known as cantons. The federal authorities have responsibility under the Constitution for certain central functions. At each level, a significant number of rights are guaranteed to the people. All other legislative power remains with the cantons, which retain, therefore a high degree of autonomy. Municipalities and communities also enjoy considerable rights of self-government.

The Federal Council consists of seven ministers of equal rank, which acts as the federal government. Ministers are elected by the Swiss Parliament. The Parliament consists of two chambers: The National Council represents the population as a whole. It has 200 members, who are elected for a term of four years. The Council of States has 46 members and they represent the Swiss cantons.

The electorate has the constitutional right to introduce and sanction changes to the Federal Constitution and a right to vote in referendums on federal legislation. The electorate can also request changes or additions to the Federal Constitution through a popular initiative signed by at least 100,000 voters. Any change to the Constitution must be submitted to an obligatory national referendum. If a minimum of 50,000 voters challenge a proposal by parliament to pass a new federal law or change an existing law, the issue is put to a facultative national referendum. The rules on popular initiatives and referendums at the federal level are replicated in cantonal constitutions.

In 2009, Gross Domestic Product in Switzerland per capita was approximately CHF 68,000 (EUR 46,000). The most important economic sectors are banking, tourism, machinery manufacture, chemical and pharmaceutical industry, foodstuffs, watches and medical technology. Its major export partners are Germany, USA, Italy, France, UK and Spain.

In 2008, total energy consumption in Switzerland exceeded 900,000 TJ. Electricity consumption accounts for about 23% of energy consumption. Electricity consumption per capita is 20% higher than the EU average %, although total energy consumption per capita is slightly below the EU average. The main sources of electricity in Switzerland are hydroelectric (2009: 56%) and nuclear power (39%). As a result, CO_2 emissions per capita are the lowest in Western Europe – 5.8 t per year, compared to 8.2 t in the EU and 20.6 t in the USA.

Background of nuclear power in Switzerland

Until the late 1960s, Switzerland generated electricity exclusively from hydro power and did not resort to fossil fuels, as the latter was not available as a natural resource in Switzerland. By the mid 1950s, there was interest in the use of the relatively new nuclear energy technology in order to cover the increasing demand for power. In accord with the general policy on electricity production, it was left to the private sector to promote and use nuclear energy. However, it was recognised, that any nuclear programme would require a legislative framework to ensure safety and radiation protection. It was also recognised that such legislation should be exclusively at the federal level. As a result, an article was added to the Swiss Constitution, which was approved by a vote of the Swiss population in 1957. The Atomic Energy Act came into force in 1959 on the basis of this article.

In 2005, Switzerland enacted a new Nuclear Energy Act and its related ordinance to replace the Atomic Energy Act of 1959. Under the new Nuclear Energy Act, the unconditional authority of the Federal Council to grant general licences for new NPPs was abolished and decisions on general licences for new NPPs must be subject to a facultative national referendum. In addition, the Federal Government was given full legal responsibility for geological waste repositories.

As nuclear power production is part of the private sector, there is no national nuclear programme as such. During the 1960s, a series of projects for NPPs were initiated and four of them were realised. This resulted in the current five operating units, which were commissioned between 1969 and 1984. These five units account for approximately 40% of national electricity production. Two projects were cancelled.

In February 2007, the Federal Government issued a new national energy strategy, which included – in addition to the promotion of energy efficiency, renewable energy and international co-operation – the building of new large-scale power plants and in particular NPPs.

The regulatory authority

The first experimental nuclear reactor started operation in Switzerland in 1957. At that time there was no regulatory authority in Switzerland. The canton in which a reactor was located was responsible for its safety. The first nuclear regulator in Switzerland was the Swiss Federal Nuclear Safety Commission, which was set up in 1960. Between that date and 1982, its secretariat evolved in several stages into an independent authority. In 1964, the Federal Council decided to create the Department for the Safety of Nuclear Facilities, which later became the Swiss Federal Nuclear Safety Inspectorate. The duties of the regulatory body were formally defined in an ordinance published in 1982. Until the end of 2008, the Swiss Federal Nuclear Safety Inspectorate was part of the Swiss Federal Office of Energy.

The fact that the Swiss Federal Nuclear Safety Inspectorate reported directly to the Swiss Federal Office of Energy contravened the independence stipulated in both the Swiss Nuclear Energy Act of 2005 and the Convention on Nuclear Safety. As a result, the Act on the Swiss Federal Nuclear Safety Inspectorate ENSI – approved in 2007 – created a statutory framework for making the Swiss Federal Nuclear Safety Inspectorate independent of the Swiss Federal Office of Energy. Independence was achieved on 1 January 2009 when ENSI became an authority constituted under public law. ENSI itself is supervised by an independent body, the ENSI board. The Board is elected by the Federal Council to whom it reports directly.

Nuclear power plants

Switzerland has five NPPs – Beznau I and II, Mühleberg, Gösgen and Leibstadt. They are located at four different sites, have four different reactor and containment designs, which were delivered by three different reactor suppliers (Westinghouse, General Electric and Kraftwerk Union). Local suppliers were used for civil engineering, buildings and mechanical and electrotechnical equipment.

The NPPs are operated by the following companies:

Beznau I&II	Axpo AG
Mühleberg	BKW FMB Energie AG
Gösgen	Kernkraftwerk Gösgen-Däniken AG
Leibstadt	Kernkraftwerk Leibstadt AG

The main technical characteristics of the Swiss NPPs are summarised in Table 1.

Table 1: Main technical characteristics of the Swiss NPPs (July 2010)

	First generation NPPs			Second generation NPPs	
	Beznau I	Beznau II	Mühleberg	Gösgen	Leibstadt
Licenced thermal power P_{th} [MW_{th}]	1130	1130	1097	3002	3600
Nominal net electrical power P_{el} [MW_{el}]	365	365	373	985	1165
Reactor type	PWR	PWR	BWR	PWR	BWR
Containment type	Large dry, free standing steel inside concrete building	Large dry, free standing steel inside concrete building	Pressure suppression, Mk I inside concrete building	Large dry, free standing steel inside concrete building	Pressure suppression, Mk III inside concrete building
Normal heat sink	River Aare	River Aare	River Aare	Wet cooling tower (River Aare)	Wet cooling tower (River Rhine)
Number of reactor coolant pumps	2	2	2	3	2
Number of turbine sets	2	2	2	1	1
Number of fuel assemblies	121	121	240	177	648
Fuel	UO_2 (+MOX)	UO_2 (+MOX)	UO_2	UO_2 (+MOX)	UO_2
Number of control assemblies	25	25	57	48	149
Reactor supplier	W	W	GE	KWU	GE
Turbine supplier	BBC	BBC	BBC	KWU	BBC
Site Licence	1964	1967	1965	1972	1969
Construction licence	1964	1967	1967	1973	1975
First operating licence	1969	1971	1971	1978	1984
Commercial operation	1969	1971	1972	1979	1984
Backfitted bunkered automatic ECCS and residual heat removal system since:	1993	1992	1989	Included in the original design	Included in the original design
Filtered containment venting system sice:	1993	1992	1992	1993	1993

Abbreviations

Mk I, Mk III	GE Containment Types Mark I and Mark III
PWR	Pressurised Water Reactor
BWR	Boiling Water Reactor
W	Westinghouse Electric Corporation
GE	General Electric Technical Services Corporation
KWU	Siemens Kraftwerk Union AG (now Areva NP)
BBC	Brown Boveri & Cie, AG (now Alstom)
UO_2	Uranium oxide
MOX	Mixed oxide
ECCS	Emergency core cooling system

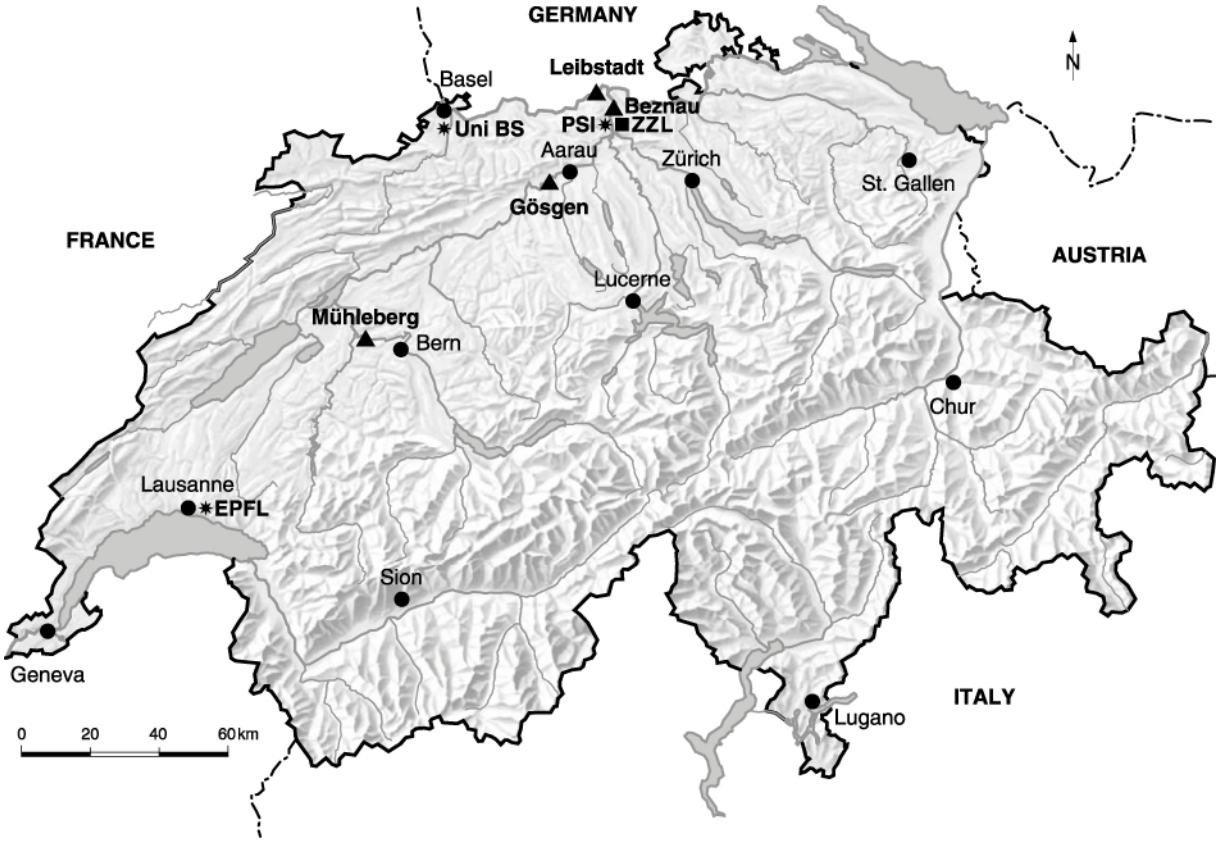

Figure 1: Geographic location of Swiss nuclear facilities. Triangles mark the NPP sites. Asterisks mark experimental and research installations. Squares mark facilities for nuclear waste management. The dots are major cities.

Because of Switzerland's mountainous landscape, the number of suitable sites for NPPs is limited. Two sites are located near the German border; Leibstadt is 0.5 km and Beznau 5 km from the border. The other two sites are located about 40 km from the French and 20 km from the German border respectively. The geographic location of all Swiss nuclear facilities is shown on the map in Figure 1.

New nuclear power plants

In June 2008, the Swiss Federal Office of Energy received an application for a general licence for a new NPP in the canton of Solothurn next to the existing Gösgen NPP. Two further applications for general licences were received in December 2008 where applicants want to replace the existing first-generation NPPs of Beznau I, Beznau II and Mühleberg. The Inspectorate is now scrutinizing these applications. Following the publication of the regulatory safety reviews on the applications for general licences, there will be a public consultation involving the general public, cantons and non-governmental organisations. The Federal Council and Parliament will then decide whether or not to grant the licences and this decision will be put to a facultative national referendum. Any new NPP in Switzerland is unlikely to be operational before 2025.

Facilities for nuclear education, research and development

Most nuclear research in Switzerland is performed at the Paul Scherrer Institute (PSI). Research at PSI is conducted in collaboration with other national and international research institutes and the industry. It covers the following areas: elementary particle physics, biological sci-

ences including radiation protection, solid state research and material science, nuclear energy research, non-nuclear energy research and environmental research related to energy production, medical research and medical treatment (oncology).

The PSI site has several nuclear installations and accelerators of which the research reactor PROTEUS and the Hot Laboratory are the most important in terms of nuclear safety. The research reactors DIORIT and SAPHIR have been decommissioned. Finally, there are two small research reactors ($P < 2\ kW_{th}$) used mainly for teaching purposes at the University of Basel and the Swiss Federal Institute of Technology in Lausanne.

The former experimental NPP in Lucens (underground, D_2O moderated, CO_2 cooled, 30 MW_{th}, 8 MW_{el}) was shut down and decommissioned after an accident involving loss of coolant in 1969. Apart from a small nuclear waste storage area, this site has been declassified and was released for non-nuclear activities in March 1995. In 2003, the nuclear waste from this storage area was transported to the Central Interim Storage Facility at Würenlingen. The Federal Council released the Lucens site from nuclear legislation in 2004.

Processing and interim storage of nuclear waste

Each NPP has facilities for the conditioning and interim storage of the radioactive waste that it produces. The Beznau site has an additional facility for the dry storage of spent fuel elements, which started active operation in April 2008. The Gösgen site has a facility for the wet storage of spent fuel elements. It started operation in May 2008.

PSI runs the national collection centre for all non-nuclear radioactive waste: waste from medicine, industry and research. This waste can be treated at PSI installations and interim storage is at the Federal Interim Storage Facility.

The utility-owned Central Interim Storage Facility was constructed adjacent to the Federal Interim Storage Facility on the PSI campus. In addition to storage capacity for spent fuel, vitrified high-level waste, intermediate and low-level radioactive waste, the facility contains installations for the conditioning of specific waste categories and the incineration or melting of low-level waste. The Central Interim Storage Facility started active operation in June 2001. The existence of this interim storage capacity relieves the pressure in terms of the time that will be required to implement final disposal facilities.

Current status of the process to select sites for geological repositories

In accordance with the Nuclear Energy Act, Switzerland recently started a process to select sites for the disposal of radioactive waste in deep geological formations. This process is organized and coordinated by the Swiss Federal Office of Energy and accords with current legislation on spatial planning. Safety is of paramount priority in the site-selection process but the process also considers socio-economic issues. The Federal authorities established a concept for the site selection procedure, which was subject to broad public consultation in 2007 not only in Switzerland but in neighbouring countries as well. Following revision in the light of comments received, the Federal Council (federal government) approved the site selection concept in April 2008.

The site selection procedure is based on a staged approach. **Stage 1** is the identification of suitable regions for the siting of the high-level waste (HLW) repository and the low-level and intermediate-level waste (L/ILW) repository. This is based on safety criteria defined by the regulatory authority. **Stage 2** is the identification of potential repository sites within the suggested

siting regions, each of which is then compared on the basis of provisional safety assessments. Socio-economic factors are taken into account at this stage. **Stage 3** will be a detailed investigation of sites still under consideration – at least two for each type of repository. This will include a detailed safety analysis for each selected site.

Based on the results of this process, a repository site will be selected for each type of repository. Each stage concludes with a broad public consultation process in both Switzerland and neighbouring countries. This three-stage process will end with approval by the Federal Council of the selected sites and should take some ten years to complete. It will be followed by the general licensing procedure specified in nuclear energy legislation. The Federal Council will grant the general licence, which will require the approval of Parliament. Approval is also subject to a facultative national referendum. Currently it is expected that the repository for L/ILW becomes operational in 2030, whereas the repository for HLW will become operational after 2040.

In 2008, the National Co-operative for the Disposal of Radioactive Waste proposed three possible siting regions for a geological repository for HLW and six possible siting regions for a geological repository for L/ILW. The Inspectorate has reviewed the documentation and has approved the proposed geological siting regions. The Federal Nuclear Safety Commission has given its comments on the Inspectorate's review and it too has approved the proposed siting regions. A broad consultation procedure is planned for the second half of 2010. The Federal Council is expected to make its decision on the potential siting regions in 2011, ending thus stage 1 of the site selection process.

Article 6: Existing nuclear installations

Each Contracting Party shall take the appropriate steps to ensure that the safety of nuclear installations existing at the time the Convention enters into force for that Contracting Party is reviewed as soon as possible. When necessary in the context of this Convention, the Contracting Party shall ensure that all reasonably practicable improvements are made as a matter of urgency to upgrade the safety of the nuclear installation. If such upgrading cannot be achieved, plans should be implemented to shut down the nuclear installation as soon as practically possible. The timing of the shut-down may take into account the whole energy context and possible alternatives as well as the social, environmental and economic impact.

The general safety of Swiss NPPs was satisfactory at the time the Convention came into force. All NPPs are subject to extensive reviews at least every 10 years (periodic safety review – PSR); the safety of all NPPs has been reliably established on the basis of deterministic and probabilistic assessments, operational performance and aspects of safety culture.

The **first generation of NPPs** in Switzerland (Beznau and Mühleberg) started operation between 1969 and 1972. At that time, the Swiss Federal Nuclear Safety Commission was responsible for the review and assessment of applications for site, construction and operating licences. It relied mainly on the US regulations and guidance dating from the period as the two reactors came from the USA.

However, certain principles of nuclear safety were not universally acknowledged at that time and so no account was taken of them, e.g.:

- separation criteria for electro-technical and mechanical equipment as a way of protecting an NPP from common cause failures resulting from fire or internal flooding, for example;
- rigorous application of the single failure criterion, including those relating to supporting systems in the event of a loss of offsite power;
- protection of residual heat removal (RHR) systems against external events (e.g. aircraft crashes, earthquakes, floods, lightning and sabotage);
- supplementary shutdown capability in a remote area if the main control room was lost.

By 1980, the safety authorities had demanded two major backfitting projects in order to improve RHR systems in first generation plants. These projects, which extended over several years, were known as “NANO” for the PWR twin-unit at Beznau and “SUSAN” for the BWR at Mühleberg. In addition, a seismic requalification was carried out in the late 1980's. This back-fitting project consisted primarily of adding one or two fully separated shutdown and RHR systems, including support systems, which addressed the above four issues. For further information on backfitting works see Articles 14 and 18.

Extensive reviews were conducted at both plants following these major backfitting projects. For the Mühleberg NPP, the review was completed in 1992 and in 1994 for the Beznau NPP. Following this backfitting work, the two plants were granted new operating licences. The most re-

cent extensive review of these two NPPs was in the form of PSRs. For the Mühleberg NPP, the assessment of the PSRs was completed in 2002 and 2007. For the Beznau NPP, it was completed in 2004.

The most important measures introduced after the most recent PSRs were as follows:

Beznau NPP: Installing a Full-Scope Replica Simulator, updating the probabilistic earthquake analysis to the state of the art and adapting the inspection programme for the reactor pressure vessel head and bottom penetration to reflect worldwide operating experience.

Mühleberg NPP: Adaptation of the PSA to state of the art, expansion of the ageing management programme and improvements to the technical specifications and instrumentation dedicated to accident management.

The **second generation of NPPs** started operation in 1979 (Gösgen) and 1984 (Leibstadt). They had a higher degree of redundancy and their protection against external events was significantly better than that in the first generation plants. Some further improvements were introduced during licensing and construction (in particular, inclusion of a special emergency heat removal system at the Leibstadt NPP).

In 1993, all plants were back-fitted with a filtered containment venting system to mitigate the consequences of severe accidents (e.g. failure of RHR systems). In addition to the NANO feedwater system, an emergency feed water system was installed in both units of Beznau in the year 1999 and 2000. This was done to improve the reliability and the capacity of the auxiliary feed water system. In both Beznau units improvements were also made to of the reactor protection system and the control systems for separation, redundancy, self-supervision, testability and reliability of power supply by replacing the original systems with a state-of-the-art computerised system in 2000 and 2001.

Table 1 (see Introduction) contains an overview of the main technical characteristics of the Swiss NPPs.

Both second generation plants have undergone PSRs. For the Leibstadt plant, the review was performed in 1996 together with a review of the 14.7 % power uprate request for the utility. The most recent PSR for Leibstadt was submitted to the Inspectorate towards the end of 2006 and the latter's review report was published in August 2009. The first PSR for the Gösgen plant was completed in 1999. The second PSR for Gösgen was submitted to the Inspectorate towards the end of 2008 and itsIts review report is due in 2011.

The most important measures introduced after the most recent PSRs were as follows:

Gösgen NPP: The lightning countermeasures were evaluated and improved, the primary venting system was upgraded to state of the art (controllable and venting of a vapour/water mixture) and several improvements were made to buildings to improve resistance to earthquakes. Improvements were also made to the instrumentation dedicated to accident management, ease of use, technical specifications and emergency plans, etc. An ageing management programme was established and improvements were made to the emergency organisation.

Leibstadt NPP: Only minor modifications were required after the reviews. They mainly related to improving the response to anticipated transients without scrams and modifications to maintenance/ageing/in-service inspection programmes, lightning countermeasures and accident analyses.

Developments and Conclusion

There are no important changes or developments relating to Article 6.

Switzerland complies with the obligations of Article 6.

Article 7: Legislative and regulatory framework

Clause 1: Each Contracting Party shall establish and maintain a legislative and regulatory framework to govern the safety of nuclear installations.

The legislative and regulatory framework in Switzerland for the peaceful use of nuclear energy, the safety of nuclear installations and radiological protection is based on a four-level system:

- 1st level: Federal Constitution of the Swiss Confederation;
- 2nd level: Federal Acts;
- 3rd level: Ordinances (issued by the Federation or a federal Department);
- 4th level: Regulatory guidelines.

Federal Constitution of the Swiss Confederation (1st level)

Articles 90 and 118 stipulate that legislation on the use of nuclear energy and on radiological protection is enacted exclusively at the federal (national) level. As a result, the Federal Parliament and the Federal Council (government) have exclusive authority to establish legislation in the field of radiation protection and the use of nuclear energy.

Federal Acts (2nd level)

The main legal provisions for authorisations and regulation, supervision and inspection are based on the following legislation:

- Nuclear Energy Act;
- Radiological Protection Act;
- Act on the Swiss Federal Nuclear Safety Inspectorate ENSI.

Nuclear Energy Act

Under this Act, nuclear installations are facilities that use nuclear energy, facilities that manufacture, use, process or store nuclear materials and facilities for the disposal of radioactive waste.[1]

The most important provisions of the Nuclear Energy Act are:

- basic principles of nuclear safety, including the precautionary principle, the protection of the people and the environment and measures to prevent sabotage and the proliferation of nuclear material;
- a licensing procedure describing authorisations (licences) for the siting, construction (including design), operation (including commissioning) and decommissioning[2];

[1] The English translation of the Nuclear Energy Act can be found on the website of the Swiss Confederation (www.admin.ch/ch/e/rs/c732_1.html).

- the general responsibilities of the licensee, including its responsibility for the safety of the installation, the obligation on NPPs to conduct periodic safety reviews and on licensees to back-fit installations to the extent that is necessary based on worldwide operating experience and current backfitting technology;
- regulations on decommissioning and on the disposal of radioactive waste, including the licensee's obligation to decommission and dispose of waste at its own cost;
- special provisions relating to geological repositories;
- the creation of supervisory authorities, their formal independence from licensing authorities and their duties, including the authority to order the application of any measure necessary and appropriate in order to maintain nuclear safety and security;
- legal sanctions.

Radiological Protection Act

The Radiological Protection Act covers every aspect of protection for personnel in NPPs, the public and the environment against hazards caused by ionising radiation resulting from any activities, facilities, events and circumstances involving such radiation.[3]

The Radiological Protection Act includes the following:

- fundamental principles (justification and limitation of exposure, dose limits);
- protection for persons who are occupationally exposed to radiation and for the general population;
- the evaluation of worldwide operating experience and the state of science and technology;
- permanent monitoring of the environment, including monitoring during periods of elevated radiation;
- radioactive waste management.

Act on the Swiss Federal Nuclear Safety Inspectorate ENSI

The Act on the Swiss Federal Nuclear Safety Inspectorate ENSI came into force on 1 January 2009, when the Inspectorate was separated from the Swiss Federal Office of Energy. The Inspectorate was founded as a new organisation, taking over the staff and responsibilities of its predecessor which had been part of the Swiss Federal Office of Energy (see Article 8, Clause 2).

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[2] Each licence may contain licensing conditions that are mandatory for the applicant. The procedure also includes the course of action for modifications to the licence. The licensing procedure furthermore grants extensive rights of appeal to third parties.

[3] The English translation of the Radiological Protection Act can be found on the website of the Swiss Confederation (www.admin.ch/ch/e/rs/c814_50.html).

Ordinances (3rd level)

There are a number of federal ordinances (lower level of legislation) of relevance to nuclear energy legislation. The most important are as follows:

- Nuclear Energy Ordinance;
- Radiological Protection Ordinance;
- Ordinance on Safety-Classified Vessels and Piping in Nuclear Installations;
- Ordinance on the Qualifications of Personnel in Nuclear Installations;
- Ordinance on Hazard Assumptions and Evaluation of Protection Measures against Accidents in Nuclear Installations;
- Ordinance on the Methodology and Boundary Conditions for the Evaluation of the Criteria for the Provisional Taking-out-of-Service of Nuclear Power Plants;
- Ordinance on the Federal Nuclear Safety Commission;
- Ordinance on the Swiss Federal Nuclear Safety Inspectorate;
- Several ordinances on emergency preparedness, emergency organisation, iodine prophylactics, alerts to the authorities and public etc. (see Article 16);
- Several ordinances on security issues that are not the subject of this report, e.g. security guards, trustworthiness checks for employees, protection of information or thread assumptions and security measures for nuclear installations and nuclear materials.

The following paragraphs contain a brief summary of the main ordinances:

Nuclear Energy Ordinance

This ordinance stipulates the rules for the implementation of the provisions of the Nuclear Energy Act. It contains basic design criteria for NPPs and specifies the licensing requirements as well as the documents to be submitted to licensing and regulatory authorities in support of the licensing processes. The appendix to this ordinance contains a list of the plant documents that are an integral part of the operating licence and specifies the reporting requirements both for normal operations and reportable events.[4]

Radiological Protection Ordinance

This ordinance is based on the Radiological Protection Act and takes account of recommendations of the International Commission on Radiological Protection (ICRP) (Publication No. 60). Together with the Radiological Protection Act, this ordinance regulates the radiological protection of humans (members of the general public and individuals working in radiation fields and with radioactive substances, including medical applications). Furthermore, the act and the ordi-

[4] The English translation of the Nuclear Energy Ordinance can be found on the website of the Swiss Confederation (www.admin.ch/ch/e/rs/c732_11.html).

nance on radiological protection also include all aspects of environmental protection associated with radioactive materials and ionising radiation.[5]

Ordinance on Safety-Classified Vessels and Piping in Nuclear Installations

This ordinance stipulates the criteria relating to the safety and periodic testing of vessels and piping.

Ordinance on the Qualifications of Personnel in Nuclear Installations

This ordinance stipulates the safety-related requirements in terms of the qualifications, training and eligibility of personnel in nuclear facilities.

Ordinance on Hazard Assumptions and Evaluation of Protection Measures against Accidents in Nuclear Installations

This Ordinance came into effect in August 2009. The basic principles of nuclear safety are provisions to prevent the undue release of radioactivity either in normal operation or in the event of an accident. This ordinance covers the specific hazard assumptions and evaluation criteria for accidents that are the subject of obligatory protection measures. The accident scenarios include externally and internally initiated events, e.g. earthquake, flooding, accidental aircraft crash, extreme weather conditions, lightning, explosion and fires or loss of coolant, loss of heat sink, damage to fuel elements etc.

Ordinance on the Methodology and Boundary Conditions for Evaluation of Criteria for Provisional Taking-out-of-Service of Nuclear Power Plants

Under the Nuclear Energy Act there are no operating lifetime limits for NPPs, i.e. they can be operated for as long as they are safe. This ordinance relates to Article 44 of the Nuclear Energy Ordinance and stipulates that the holder of an operating licence must take an NPP out of service and complete backfitting measures if one or more of the following technical criteria exist: events or findings indicating that cooling of the core cannot be assured in the event of an accident, that the integrity of the primary coolant system cannot be assured or that the integrity of the containment cannot be assured.

Ordinance on the Federal Nuclear Safety Commission

The Federal Nuclear Safety Commission is a permanent administrative commission and advises the Federal Council, the Federal Department of the Environment, Transport, Energy and Communications and the nuclear supervisory authorities on issues relating to the safety of nuclear facilities. The Commission was created on 1 January 2008 to replace the former Swiss Federal Nuclear Safety Commission. Its legal basis is Article 71 of the Nuclear Energy Act and the Ordinance on the Federal Nuclear Safety Commission (see Article 8, Clause 1 of this report).

Ordinance on the Swiss Federal Nuclear Safety Inspectorate ENSI

The Ordinance on the Swiss Federal Nuclear Safety Inspectorate includes stipulations on the domicile of the Inspectorate (Brugg), quality management and assessments and the duties of the ENSI board. This Ordinance came into force on 1 January 2009.

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[5] The English translation of the Radiological Protection Ordinance can be found on the website of the Swiss Confederation (www.admin.ch/ch/e/rs/c814_501.html).

Regulatory guidelines (4th level)

The Inspectorate is responsible for preparing and establishing regulatory guidelines. The nature and use of regulatory guidelines is explained in the comments on Clause 2 (i) of this Article.

Clause 2 (i): The legislative and regulatory framework shall provide for the establishment of applicable national safety requirements and regulations.

National requirements

Safety requirements and regulations are specified in ordinances and regulatory guidelines. The requirements and conditions in ordinances are mandatory, whereas the content of regulatory guidelines is semi-mandatory. The regulatory guidelines state how the supervisory authority should carry out its supervision. It may be detailed or limited to safety objectives. In the latter case, the applicants and licensees must seek and propose technical solutions reflecting the internationally recognised state of science and technology. The supervisory authority is responsible for reviewing and assessing these proposals (they are an integral part of the application).

Regulatory guidelines may contain design or procedural guidance and may stipulate the procedures to be followed. Applicants may choose alternative solutions, but if they do so, they must demonstrate that the same level of safety is attained.

Since the guidelines were based on the former Atomic Act of 1959, a complete revision was started when the Nuclear Energy Ordinance came into force in 2005; it is still ongoing. Appendix 2 contains a list of the regulatory guidelines currently in force. The current status of the guidelines is available on the Inspectorate's website (www.ensi.ch). Some guidelines have been translated into English or French and can be found in the English or French section of the website.

Regulatory guidelines go through a consultation procedure before they come into force. During the consultation "hearings", stakeholders and the public can comment in writing on the draft guidelines. Most of the feedback comes from licensees.

International harmonisation

In addition to the IAEA and the OECD Nuclear Energy Agency, the Western European Nuclear Regulators' Association WENRA is a major driving force in efforts to harmonise nuclear safety requirements at the international level. Switzerland was one of the founding members of WENRA. WENRA provides regulatory authorities with a single forum to which they can contribute their years of experience in regulating a range of nuclear facilities and formulating and implementing standards. This expertise allows WENRA to draft rules for nuclear safety – so called Safety Reference Levels (SRLs) – which can then be adopted and incorporated into national legislation.

The Inspectorate participates in the following WENRA groups: "Reactor Harmonisation" and "Waste and Decommissioning". The Swiss self-assessment in the area of "Reactor Harmonisation" identified a number of SRLs which ought to be incorporated into the Swiss regulatory framework. By mid 2010 a significant portion of these SRLs will be part of the Inspectorate's new regulations. Discrepancies relating to the SRL sets in the areas of waste and spent fuel

storage and decommissioning will be incorporated into the Swiss regulatory framework by the end of 2013.

In parallel with the work on the SRLs, the WENRA group “Reactor Harmonisation” is studying the requirements for new reactors and it published a draft report on safety objectives in January 2010.

The Inspectorate takes part in several IAEA committees. At the beginning of the planning process for a new guideline, the Inspectorate conducts an evaluation of the existing Safety Fundamentals and Safety Requirements in fields of relevance to the new guideline. In 2007, the Inspectorate started a review of the extent to which the IAEA Safety Fundamentals and Safety Requirements had been incorporated in Swiss law, including a reference to WENRA Reference levels. Discrepancies between Swiss law and internationally harmonised standards will be identified and if there is no justification for a discrepancy, Switzerland will remedy it.

Clause 2 (ii): The legislative and regulatory framework shall provide for a system of licensing with regard to nuclear installations and the prohibition of the operation of a nuclear installation without a licence.

The Swiss licensing procedure results directly from the requirements of the legislative and regulatory framework described above in Clause 1 of this Article. This licensing system involves the establishment of a supervisory body (see Article 8), the requirement for licences and the creation of a licensing process. There are several criminal sanctions, the most important of which is in Article 90, Paragraph 1 of the Nuclear Energy Act. Under this article, it is a criminal offence to construct or operate a nuclear facility without a licence.

In Switzerland there are two main types of licences:

- **General Licence:** Since 1978, this licence has applied to any new nuclear installation. It entails licensing in the pre-construction phase and covers the siting and the main features of the project. A valid general licence must exist before construction and operating licences can be granted. The four NPPs (five units) currently in operation have no such licence since they were granted site and construction licences prior to 1978.
- **Construction Licence and Operating Licence:** These licences relate to the technical and organisational requirements for nuclear safety and security.

The licensing procedure described below must be conducted before either licence can be granted.

Licensing procedure

The **General Licence** is issued by the Federal Council (the Swiss government). The review of an application for a General Licence is coordinated by the Swiss Federal Office of Energy. Environmental aspects are the responsibility of the Federal Office of the Environment. Compliance with spatial planning requirements is assessed by the Federal Office for Spatial Development. The Inspectorate is responsible for evaluating nuclear safety and security on the basis of the reports submitted with the application: Safety Analysis Report, Security Report, Concept for the Disposal of Radioactive Waste and Decommissioning Concept.

In this phase, the applicant is not required to select a design or a set thereof and so there is no evaluation of a specific design.

The safety assessment by the Inspectorate covers the following:

- location, including geography and population distribution, transport routes and industry, logistics and construction site, meteorology, hydrology and ground water, geology, foundation materials and seismology, connection to the power grid;
- selected plant parameters, including maximal reactor power, main cooling system, arrangement of the main buildings;
- radioprotection, including source-related dose limits for routine releases, expected annual releases in normal operation;
- human and organisational factors, including project management, future organisation, human factors engineering;
- security;
- decommissioning, including choice of the final state for the facility and choice of decommissioning concept;
- waste disposal, including its inclusion in the national waste disposal programme.

The Inspectorate reviews and reassesses the application taking into account national and international experience as well as the state-of-the-art in nuclear technology and research. The result of the regulatory review and reassessment is documented in a safety evaluation report (SER), which may include the licence conditions to be included in any licence (see Article 14).

A second evaluation of the application is made by Federal Nuclear Safety Commission. It focuses on basic aspects of the application and on the SER. If appropriate, it may include the licence conditions.

After that, the licensing process involves the cantons (regional authorities) and neighbouring countries. The application and the corresponding review by the federal and cantonal authorities are published as official documents and are subject to a 3-month consultation period during which anyone can raise an issue.

The Licence is then drafted and submitted to the Federal Parliament for approval. It is also put to a facultative national referendum.

The **Construction Licence** is issued by the Department of Environment, Transport, Energy and Communications. The Swiss Federal Office of Energy coordinates the review of the application for a Construction Licence. As with the review of the application for a General Licence, the various Federal offices, the Inspectorate and the Federal Nuclear Safety Commission are involved in issues relating to their specific responsibilities. The Inspectorate is responsible for the safety review of the site specific design as submitted by the applicant.

The safety assessment by the Inspectorate covers the reactor design on the specified site. This takes the form of an evaluation of the various aspects of the planned concept (overall plant design, reactor technology, civil engineering, systems engineering, human-factor engineering, quality and project management, etc.) and the relevant implementation plan.

After that, the licensing process involves the canton where the plant is to be constructed. The application and the corresponding review by the federal and cantonal authorities are published

as official documents and during a 1-month consultation period, parties with an involvement may raise an issue.

The Construction Licence can be challenged and there are two appeal stages that can be invoked before it is legally binding.

The **Operating Licence** is issued by the Department of Environment, Transport, Energy and Communications. The Swiss Federal Office of Energy is responsible for the review of an application for an Operating Licence. The Inspectorate has primary responsibility for reviewing the application for an Operating Licence.

The safety assessment by the Inspectorate covers an evaluation of the plant as built together with the operating provisions and the commissioning/ start-up tests.

After that, the applicant must complete the same steps as described for the Construction Licence.

Licence conditions are legally binding if included in the grant of a licence. They constitute, therefore a powerful tool by which requirements can be imposed. The licensing procedure affords an extensive right of appeal to the licensee and to third parties affected by plans to construct a nuclear installation.

A permit procedure has been instituted in order to control the conditions of the licence. The permits granted by the supervisory authorities as part of a valid licence are defined in the Nuclear Energy Ordinance or in the licence. They include selected elements of the construction work, the manufacture of important components, assembly and wiring on site, sets of commissioning tests as well as any safety-relevant changes to the installation during operation. This “permit procedure” can be considered, therefore as an enforcement tool in the hands of the Inspectorate (see Clause 2 (iv) of this article).

Clause 2 (iii): The legislative and regulatory framework shall provide for a system of regulatory inspection and assessment of nuclear installations to ascertain compliance with applicable regulations and the terms of licences.

The legal basis for inspections by the Inspectorate is contained in the Nuclear Energy Act, which prescribes supervision, hence inspection, by Federal authorities.

The Nuclear Energy Act grants the Inspectorate unrestricted right of access. This right of access extends to all relevant documents, including documentation located in the offices of supplier organisations. This right of access is also granted to the Inspectorate’s representatives and external experts acting under contract for the Inspectorate.

The aim of regulatory inspections is to obtain evidence on the quality of the licensee’s activities and so to ensure that the licensee fulfils its primary responsibility for safety. The Inspectorate, with the help of experts working on its behalf, reviews the licensee’s programmes and independently assesses the performance of the licensee by (i) observing specific activities and by (ii) carrying out its own inspections and taking its own measurements.

Clause 2 (iv): The legislative and regulatory framework shall provide for the enforcement of applicable regulations and of the terms of the licences, including suspension, modification or revocation.

The licensing and regulatory authorities have full enforcement powers based on the Nuclear Energy Act. They can order any measure necessary to protect persons, property and other important rights, to safeguard Switzerland's national security, to ensure compliance with its international commitments and check that measures have been implemented.

In terms of licences, the licensing authorities (Federal Council; Department of the Environment, Transport, Energy and Communications) will not grant a licence (general licence, licence for construction, commissioning, operation, modification or decommissioning of NPPs) unless the legal requirements are met. Under Article 67 of the Nuclear Energy Act, they shall withdraw a licence if these requirements are no longer met. The Federal Council is responsible for decisions concerning the withdrawal of a general licence. The withdrawal of a general licence also results in the withdrawal of the construction and operating licences. The Inspectorate has the authority to suspend or withdraw permits.

The supervisory authorities are required to issue regulations on measures necessary and reasonable in order to maintain nuclear safety and security. In the event of an immediate threat, they may impose emergency measures that deviate from the licence or a ruling. If necessary they may seize nuclear goods or radioactive waste and eliminate potential threats and charge the cost to the owner. They may seek intervention by cantonal and communal police forces, including the investigating arm of the customs branch. If the provisions of the Act are breached, the supervisory authorities may call in the relevant federal police authority. The Federal Council may order the precautionary shutdown of a nuclear power plant if an extraordinary situation exists.

Developments and Conclusion

The Nuclear Energy Act and the Nuclear Energy Ordinance came into force in 2005 and are now well established. New ordinances have been introduced. The new legal framework specifies the requirements for guidelines issued by the Inspectorate and so the Inspectorate is carrying out a formal and substantial revision of the guidelines. By conducting hearings for new regulatory guidelines, the Inspectorate has improved the transparency of the regulatory process. Furthermore each new regulatory guideline will include the related international WENRA and IAEA requirements.

Switzerland complies with the obligations of Article 7.

Article 8: Regulatory body

Clause 1: Each Contracting Party shall establish or designate a regulatory body entrusted with the implementation of the legislative and regulatory framework referred to in Article 7, and provided with adequate authority, competence and financial and human resources to fulfil its assigned responsibilities.

Organisation and competence of the regulatory body

Licensing

The **Federal Council** is the authority that grants general licences. The **Department of the Environment, Transport, Energy and Communications** grants construction licences and operating licences for nuclear facilities (see Article 7). For the three kinds of licences mentioned, the Swiss Federal Office of Energy is responsible for the co-ordination of the application procedure. In addition, the Swiss Federal Office of Energy issues licences for the handling of nuclear materials and radioactive waste.

Supervision

The **Swiss Federal Nuclear Safety Inspectorate** is the supervisory authority for nuclear safety including radiological protection and nuclear security.

Its responsibilities and duties are as follows:

- to establish safety and security criteria and requirements that reflect experience (feedback) and the state of science and technology;
- to prepare safety and security evaluation reports (SER) to support decisions by the licensing authority;
- to monitor compliance with regulations including inspections and reports and to request documentation on aspects of nuclear safety, nuclear security and radiological protection;
- to grant, suspend or withdraw permits;
- to order the application of measures necessary and appropriate to maintain nuclear safety and security, including the precautionary and active protection of personnel in NPPs, the public and the environment against radiation hazards;
- to ensure on-site and off-site emergency planning and the dissemination of appropriate information in an emergency according to Article 16.

Advisory committee

The **Federal Nuclear Safety Commission**, which in 2008 replaced the former Swiss Federal Nuclear Safety Commission, is designated as an advisory committee to the Federal Council and the Department of the Environment, Transport, Energy and Communications. It is involved in the licensing process as it reviews and comments on the safety evaluation reports prepared by the supervisory authorities.

Moreover, the Federal Nuclear Safety Commission monitors the operation of nuclear installations and in so doing focuses on fundamental aspects of nuclear safety and suggests necessary measures. The Federal Nuclear Safety Commission has the following responsibilities:

- to comment on new legislation or amendments and the development of regulations relating to nuclear safety and to recommend additions or amendments to regulations;
- to recommend measures to improve the safety of nuclear installations;
- to suggest research projects in the field of nuclear safety.

Others

The authorities listed below have responsibilities associated with the operation of NPPs. However, they are not involved in the licensing process and have no authority over the plants:

- the **National Emergency Operations Centre** – part of the Federal Office of Civil Protection in the Federal Department of Defence, Civil Protection and Sports – in charge of all emergency situations, including those arising from events at NPPs and relating to the protection of the public and the environment;
- the **Division of Radiological Protection** at the Federal Office of Public Health – in charge of the radiological monitoring of the environment (in the vicinity of nuclear installations);
- several advisory committees to the government or governmental departments covering aspects of radiological protection, emergency planning and waste disposal.

Financial and human resources

Costs incurred by the safety authorities (with exception of the regulatory framework and information to the public) totalling some 50 million Swiss Francs per year, are covered by fees from licensees. Nuclear safety research promoted and endorsed by the regulatory body has a budget of about 5 million Swiss Francs: some 2 million Swiss Francs comes from public funds and 3 million Swiss Francs comes from NPPs.

Supervisory authorities

On 1 January 2009, the Swiss Federal Nuclear Safety Inspectorate was formally separated from the Swiss Federal Office of Energy. It is now a stand-alone organisation controlled by its own management board (ENSI board) and with its own budget. This gives the Inspectorate complete flexibility over budget decisions and independence when recruiting personnel.

The Inspectorate currently has a staff of about 100 specialists covering the following fields:

- 5 site inspection;
- 40 reactor safety;
- 20 radiation protection and emergency preparedness;
- 15 waste management and transport safety;
- 5 human and organisational factors;
- 5 security (since 2008; previously part of the Swiss Federal Office of Energy);

- 5 project management for new NPPs;
- 5 regulatory framework and international affairs.

Some 20 staff are involved in administration and infrastructure tasks.

Independent consultants are commissioned in certain specialist fields. In special technical areas (e.g. civil engineering) substantial financial means are spent every year. The Swiss Association for Technical Inspections, an independent private company is responsible for monitoring the manufacture, repair, replacement, modification and in-service inspection of pressure-boundary components.

Advisory committee

The Federal Nuclear Safety Commission consists of 7 part-time members, supported by a secretariat with a staff of 3 full-time positions and, if necessary, supplemented by experts in specific disciplines. Its members are appointed by the Federal Council from names put forward by the Commmission itself. All 7 members are appointed on a personal basis and so do not represent their organisations. Members have a broad range of expertise including most if not all the disciplines relating to reactor safety, radiation protection, emergency preparedness, waste management, human and organisational factors and transport safety.

Quality management

The Inspectorate uses a process-oriented Management System, which was granted ISO-9001 certification in December 2001 and ISO 14001 certification (environmental management) in November 2007. The current certificates are valid until the end of November 2010. It is planned to obtain OHSAS 18001 certification (safety & health management) in November 2010 when the process of 9001 and 14001 recertification will also take place.

The Management System is applied to all relevant activities and includes the Inspectorate's safety, quality and environmental policies as well as the performance agreement between the ENSI board and the Inspectorate. The performance agreement includes strategic and operational goals as well as budget allowance for the Inspectorate for one year. All system documents can be easily accessed by all staff members using an easy-to-use IT tool.

The Management System is subject to continuous improvement ranging from self-evaluation to internal audits, management reviews, evaluation of performance indicators and routine checks by the certification agency.

- **Internal audits:** ISO 9001 requires that an institution conducts an audit of its activities at appropriate intervals to verify that operations still comply with the requirements of the quality system. A team of 12 staff members, assigned to this function and trained as quality auditors, carries out the internal audits on the basis of an annual audit plan. All processes are subject to an internal audit at least once every three years.
- **Management reviews:** These are carried out twice a year by senior management at the Inspectorate in order to assess the quality of staff performance (e.g. by appraising performance indicators) and to reflect changes that have occurred (or are expected to occur) in the organisation, staffing, procedures, activities and workload. Senior management is also responsible for ensuring the implementation within a

specified period of actions identified by an internal audit, surveillance or reassessment visit by IRRS or the certification body together with complaints from customers and internal suggestions for improvements. This process is supported and managed by a sophisticated but simple IT tool.

- **Performance indicators:** Performance indicators are defined for each process, including the indicators contained in the performance mandate. The results are evaluated by the owners of the process and reviewed in conjunction with the management review mentioned above.
- **External audits:** Having undergone a follow-up mission by an IAEA International Regulatory Review Team in 2003, external audits in this reporting period were restricted to the annual supervisory and renewal audits required for ISO 9001 and 14001 certification by the certification company SQS. The next IRRS mission is scheduled for 2011.

These mechanisms and measures provide the means for continuous assessment and opportunities for improvements to the Management System. They also facilitate the introduction of the New Public Management Elements and generally strengthen the Inspectorate's regulatory effectiveness.

Knowledge management and training

The Inspectorate currently faces a "renaissance" of nuclear power. There are currently plans for 3 new NPPs in Switzerland and the Inspectorate is required as part of the initial stage to prepare safety evaluation reports (SER). This requires substantial additional resources and so staff numbers will increased by about 20 persons in the next two years. If the Swiss citizens endorse the construction of one or more new NNPs, the Inspectorate will face major challenges. Experienced staff are required both the safety evaluation of new-build projects and the oversight of existing plants. As the availability of well-trained and experienced experts is limited, it is essential to have a good training programme for new staff.

Knowledge management and training measures are an integral part of the Inspectorate's Management System. The process includes an annually-updated systematic compilation of the skill and knowledge requirements for each organisational unit. Staff training is based on this compilation. The Inspectorate operates a career development programme in order to exploit staff potential. In addition, it tries to replace employees who resign at a very early stage in order to have a degree of overlap between the person leaving and his/her successor.

The Inspectorate has also increased its involvement and participation in nuclear safety assistance programmes at many levels. This includes participation in international working groups and IAEA services, such as the IRRS and OSART missions, staff exchanges with foreign regulators and inspection workshops in other countries. There is also close collaboration with the Swiss Federal Institute of Technology.

Co-operation with neighbouring countries

Switzerland has concluded agreements on the bilateral exchange of information on nuclear safety and radiation protection issues with its counterparts in many countries, in particular with its neighbours Germany and France. As a minimum, the agreements include early notification of

nuclear accidents or extraordinary radiological situations. Collaboration with France, Germany and Austria also includes standing bi-national committees.

The German-Swiss and French-Swiss committees are the most active because those countries have sizeable nuclear power programmes. They go well beyond early notification and include the exchange of information on all relevant aspects of nuclear safety and radiation protection. Each has a permanent technical working group that meets at least once a year. Collaboration with France includes inspections of nuclear installations in both countries conducted jointly by members of the French and Swiss safety authorities. Both German-Swiss and French-Swiss commissions have proved instrumental in harmonising and coordinating trans-border emergency management.

Openness and transparency of regulatory activities

Under the Nuclear Energy Act (Article 74) the Inspectorate "shall regularly inform the general public about the condition of nuclear installations and any matters pertaining to nuclear goods and radioactive waste" and "shall inform the general public of any special occurrences". Furthermore the Inspectorate is obliged to respond to questions from parliament on nuclear safety and the work of the regulatory body.

The information services of the Inspectorate go well beyond these legal requirements. In addition to annual reporting – Regulatory Oversight Report, Research and Experience Report, Radiation Protection Report and Business Report – it publishes reports on current topics – e.g. earthquakes, plane crashes, disposal of radioactive waste, etc. Media activities include press conferences and press releases as well as interviews on issues of nuclear safety that are the subject of current media discussion. The Inspectorate's website www.ensi.ch is now an important information tool covering all aspects of nuclear safety in Switzerland. Other PR activities include responses to questions from Non-Governmental Organisations and individuals as well as participation in public hearings, symposia and panel discussions on nuclear safety.

In 2006, the Swiss Federal Law on Administrative Transparency came into effect. It allows individuals to access information and obtains information on the content of documents. There are certain exceptions, e.g. documents with security-related information, professional or trade secrets. The Inspectorate fully complies with this legal requirement by marking all its documents "public" except where it is not allowed to distribute them. Furthermore, the Inspectorate uses its website www.ensi.ch to provide updates on the status of all ongoing projects. However, experience to date has shown that requests to access documents are few.

Clause 2: Each Contracting Party shall take the appropriate steps to ensure an effective separation between the functions of the regulatory body and those of any other body or organisation concerned with the promotion or utilisation of nuclear energy.

Swiss nuclear power plants

Swiss NPPs are operated by private companies. Individuals as well as cantons and municipalities hold major shares in these companies. The federal administration does not hold shares in

the nuclear industry. The regulatory body is therefore not directly linked to any person or organisation with a commercial interest in nuclear power.

Separation of the supervisory authority for nuclear safety from other governmental bodies concerned with the use and promotion of nuclear energy

The Nuclear Energy Act requires the supervisory authorities to be independent of technical directives and formally independent of the licensing authorities. It also clarifies and expands the position, duties and responsibilities of the Inspectorate as the supervisory authority for nuclear safety in terms of the development of safety criteria and the maintenance of nuclear safety. The Swiss Federal Office of Energy is in charge of the execution of energy legislation. It deals with questions of energy economics and politics and considers issues relating to the security of energy supply.

Until 2008, the Inspectorate was part of the Swiss Federal Office of Energy, although at the technical level its actions were independent of the rest of the Office and the Federal Department of Environment, Transport, Energy and Communication. The legal review and assessment of applications by the Inspectorate was based solely on nuclear safety criteria and excluded any other consideration.

In order to grant the Inspectorate complete independence in law and to achieve formal separation between the Inspectorate and the licensing authorities, new legislation was passed: the Act on the Swiss Federal Nuclear Safety Inspectorate ENSI. In passing this Act on 22 June 2007, the National Council and the Council of States, the two parliamentary chambers in Switzerland, resolved to convert the Inspectorate into a body constituted under public law but formally, institutionally and financially independent. The Act on the Swiss Federal Nuclear Safety Inspectorate ENSI came into force on 1 January 2009 and on that date the Inspectorate was separated from the Swiss Federal Office of Energy. A new organisation was established, which took on the staff and responsibilities of the former organisation that had been part of the Swiss Federal Office of Energy. The new Inspectorate is supervised by the ENSI Board whose members are elected by the Federal Council and report directly to it.

Developments and Conclusion

The Management System of the Inspectorate is well established and provides effective support for both management and daily operations. It is subject to regular minor modification in order to develop and improve the Management System. However, the basic structure of the system remains the same and still covers the requirements set down in the related ISO and IAEA standards.

Since the beginning of 2009, the Inspectorate has been an independent body constituted under public law. It reports direct to the Government but is completely separate from the Swiss Federal Office of Energy. In other words, the regulatory body is now legally, institutionally, politically and financially independent. The remit and the staff of the Inspectorate have not changed except that nuclear security has been added to its responsibilities.

Switzerland complies with the obligations of Article 8.

Article 9: Responsibility of the licence holder

Each Contracting Party shall ensure that prime responsibility for the safety of a nuclear installation rests with the holder of the relevant licence and shall take the appropriate steps to ensure that each such licence holder meets its responsibility.

The Nuclear Energy Act stipulates that the licence holder is responsible for the safety of the installation. The most important duties of licence holders are as follows:

- to accord nuclear safety sufficient priority at all times when operating the nuclear installation and in particular to comply with prescribed limits and conditions;
- to establish a suitable organisation and employ suitable, qualified specialists in sufficient numbers (The Federal Council defines the minimum requirements and regulates the training of specialised personnel);
- to take measures to keep the installation in good condition;
- to carry out inspections and safety and security assessments throughout the entire life of the installation;
- to conduct a safety review of NPPs at periodic intervals;
- to report periodically to the regulatory authorities on the condition and operation of the installation and provide immediate notification of reportable events;
- to backfit as required on the basis of experience and current backfitting technology and to exceed those requirements if this contributes to a further reduction in risk and is reasonable;
- to keep track of developments in science and technology and operating experience at comparable installations;
- to maintain complete records on technical facilities and their operation and to revise the safety analysis report and security analysis report when necessary;
- to exercise quality-assurance measures for all activities conducted in the course of operation;
- to keep updated the decommissioning plan, the plan for the observation phase and the plan for sealing the installation, as applicable.

The supervisory authority must ensure that the licensee fulfils its legal duties and implements the conditions and obligations stated in the licence.

Safety and security requirements are laid down in the Nuclear Energy Act and the corresponding ordinances. Regulatory guidelines amplify these ordinances. During daily regulatory work, e.g. if a deviation is detected during an inspection, the Inspectorate requires licence holders to correct it.

During daily regulatory work (inspections, document reviews, safety reviews, regulatory meetings), the Inspectorate verifies that decisions taken by the licensee are safety-oriented, i.e. the licensee retains responsibility for safe operation.

The responsibilities of interfacing organisations and contractors are laid down in contracts between individual licensees and outside companies. The procedure for drawing up these contracts is part of the plant's management system and is inspected by the Inspectorate in accordance with the regulatory guidelines on the organisation of NPPs.

The Leibstadt and Beznau NPPs established a system of safety audit in 2006. The safety controller – who has no operational duties – independently reviews a whole range of safety factors, e.g. decision-making, operations, day-to-day work and resource allocation in respect of safety. The safety controller notifies the plant manager of issues relating to safety and reports to the CEO of the plant. The safety controller's mandate lasts for about 3 years. A new person is then appointed to carry out these duties.

Developments and Conclusion

The present report gives practical examples of how Switzerland complies with this Article.

Switzerland complies with the obligations of Article 9.

Article 10: Priority to safety

Each Contracting Party shall take the appropriate steps to ensure that all organisations engaged in activities directly related to nuclear installations shall establish policies that give due priority to nuclear safety.

Switzerland gave top priority to the safety of NPPs from the beginning and will continue to do so in future. The relevant legislation expressly stipulates that all reasonable measures must be taken to protect persons, property and other important rights (including those relating to the environment, nature, landscape and land use planning). Furthermore, it is essential that Switzerland's national security is safeguarded and that the country complies with its international commitments at all times. In its supervisory functions, the regulatory body has a legal obligation to afford the highest priority to nuclear safety.

In addition, as far as the utilities are concerned, their top priority is the safe and reliable operation of the NPPs: this is a precondition for economic and long-term operation. The priority given to safety is expressed in the operating policy of an NPP prepared by its management. This is communicated to all staff in the NPP and submitted with other documents to the Inspectorate.

From a technical standpoint (i.e. design and construction), Swiss NPPs comply with the current state of science and technology, both by virtue of their original design and backfitting. However, their operation and maintenance may be influenced by economic and social changes. Operators are required to ensure that such changes do not reduce safety. In turn, the Inspectorate must ensure that the licensee uses all means at its disposal to discharge this obligation. Personnel in all plants are very aware of the safety implications of their activities and this level of awareness is continuously reinforced by safety-related training. The safety culture in all Swiss NPPs is an important means in fostering high levels of safety (see Article 12). All plants reflect this understanding of the importance of safety culture by designing programmes to improve it. These programmes take the form of training sessions, workshops, investigation of safety significant events, self-assessments etc. The Inspectorate conducts periodic technical discussions with each plant on their programme and their understanding of safety culture.

In 2007 and 2008 the Inspectorate performed inspections designed to review decision-making processes in all NPPs. During these inspections, the Inspectorate reviewed the formal obligations on NPPs to investigate the safety implication of events and implement findings into the daily routine of an NPP. In addition, it also reviewed the qualifications and experience of personnel tasked to evaluate the safety significance of events and incidents in NPPs. In another aspect of inspection, the Inspectorate reviewed the decision-making tools and instruments used in NPPs.

Switzerland has participated in the OSART programme since 1992. By 2002, all Swiss NPPs had undergone an OSART review, including a follow-up. Every Swiss NPP is a member of the World Association of Nuclear Operators (WANO) and since 2005, all Swiss NPPs have been involved in the WANO Peer Review Process. The scheduled cycle for WANO Peer Reviews and WANO Follow-up Missions is about six years and so, in the past three years all Swiss NPPs have undergone either a WANO Peer Review, a WANO Follow-up Mission or is planning one of them. The NPPs inform the Inspectorate of the main findings and remedial action is taken.

Occasionally, there is a difference of opinion between the safety authority and NPPs on the need for certain regulatory requirements. In the ensuing discussions, a cost benefit analysis is conducted to compare the cost and the technical justification for the required regulation. To ensure that the decision-making process is transparent, the Inspectorate uses the following graded approach in order to decide whether a safety measure is justified:

- safety measures required by legislation (this includes licence conditions);
- recommended safety measures based on the state of science and technology;
- safety measures that appear desirable on the basis of experience and current back-fitting technology and are also reasonable based on a cost-benefit analysis.

Different external influences, e.g. economical constraints, changes in the availability of suppliers, etc. may force nuclear installations to adapt their structure to new scenarios. To ensure that organisational changes do not impact negatively on safety, the Inspectorate stipulates in its guidelines on the organisation of NPPs (Guideline G07), that NPPs must complete the following steps when managing change:

- examine the safety impact of organisational changes prior to implementation;
- implement changes with the help of a system of project management that reflects staff-related issues;
- conduct an internal evaluation of the change processes to ensure that the expected safety-related effects are valid as soon as a change takes effect.

Developments and Conclusion

The Inspectorate is continuing its regular discussions on the safety culture in each NPP and is continuing to review the suitability of organisational structures, resources and processes in all Swiss NPPs.

Switzerland complies with the obligations of Article 10.

Article 11: Financial and human resources

Clause 1: Each Contracting Party shall take the appropriate steps to ensure that adequate financial resources are available to support the safety of each nuclear installation throughout its life.

Nuclear legislation stipulates that nuclear installations must be kept in good condition and the licensee must provide persons with responsibility for the safe operation of a nuclear installation with the necessary resources.

Licensees are well-established companies with a good financial record. To date, they have covered all costs associated with the construction, operation and maintenance (including replacement of obsolete or worn components) of their NPP. They have also paid fees to the regulatory body (see Article 8). They have voluntarily implemented many modifications or backfitting measures shown to be necessary by virtue of developments in science and technology that are in addition to those required by the safety authorities (see Articles 6 and 18). There are currently applications for 3 new-build projects in Switzerland. Basically, the companies submitting applications are owned by the companies that own (or partially own) the existing NPPs.

If, for any reason, (e.g. inadequate financial resources), the licensee could or would not implement the backfitting measures considered necessary and required by the safety authorities, the licensing authority would suspend or revoke its operating licence. An NPP facing such a suspension or withdrawal of a licence would obviously have an interest in ensuring that requirements are met if it wished to continue normal operations.

A decommissioning fund has been established as required by the Nuclear Energy Act. It covers the cost of decommissioning, including later dismantling. It is financed by regular contributions from the licence holder. If the resources in the fund are insufficient to cover the cost of decommissioning an NPP, the owners of the other NPPs would be required to intervene to cover the deficit.

Clause 2: Each Contracting Party shall take the appropriate steps to ensure that sufficient numbers of qualified staff with appropriate education, training and retraining are available for all safety-related activities in or for each nuclear installation, throughout its life.

Requirements regarding qualified staff

Under the Nuclear Energy Act, there must be a sufficient number of qualified staff with the expertise required to manage and control a nuclear installation during all phases of its life cycle. The specific minimum qualifications and training of specialised staff are laid down in the relevant ordinances (Nuclear Energy Ordinance, the Ordinance governing the requirements for personnel in nuclear installations, the Ordinance relating to checks on the trustworthiness of personnel and the Ordinance on security guards). The Inspectorate does not require a regular fit-for-duty programme. However, the Ordinance on the requirements for personnel in NPPs does require personnel to undergo annual medicals to test for the regular consumption of psychotropic substances.

Staffing

The Nuclear Energy Ordinance and a related guideline issued by the Inspectorate (organisation of NPPs) stipulate the organisational arrangements required for the operation of nuclear installations. The Nuclear Energy Ordinance stipulates that the facility must be structured in a way that ensures internal responsibility for at least the following activities and areas:

- operation of the facility in all operating modes;
- maintenance, material and testing methods, technical support;
- design and monitoring of the reactor core;
- radiation protection and radioactive waste;
- water chemistry and use of auxiliary chemicals;
- emergency planning and preparedness;
- supervision and assessment of nuclear safety;
- security;
- quality assurance for services provided by contractors;
- training and education of personnel;
- promotion of safety awareness.

There are no specific requirements with regard to staffing levels in NPPs. At the end of 2009, the Mühleberg NPP had a workforce of 340, the twin-unit Beznau NPP had a workforce of 525, Gösgen NPP had 478 and Leibstadt NPP had 497. These figures represent a substantial increase in staffing at all Swiss NPPs.

Staff turnover in NPPs is low. All Swiss plants have well established programmes for the early replacement of retiring staff so that sufficient time is available for the transfer of know-how to new employees. This ensures that the necessary knowledge and experience required to operate an NPP is maintained.

In addition to employing their own personnel, licensees use contractors, particularly for maintenance during the annual refuelling outages and plant modifications. They include specialists from the manufacturer or supplier of major components or systems and other external experts for specific tasks, e.g. inspection of specific components or computer calculations for specific safety issues.

Licensing of operators

The control room operators, shift supervisors, and stand-by safety engineers working in NPPs need a licence. In the research reactors, licences are required for control room operators, reactor technicians and reactor physicists. Licences are granted by the NPP or research reactor licensee to specialists who satisfy the conditions in the Ordinance relating to the Qualifications for Personnel in Nuclear Installations. The licensee can only grant a licence to an operator if the candidate passes the examinations specified in the Ordinance relating to the Qualifications of Personnel in Nuclear Installations. The examination board consists of representatives from the licensee, the relevant training organisation and the Inspectorate. To pass an examination, the candidate must have the unanimous consent of all parties.

Education and training

Switzerland offers high-quality opportunities for professional scientific and engineering education and training. This ensures a satisfactory base from which to recruit qualified personnel. However, recent changes to the education system (application of the European Bologna Process) have tended to modify the educational base. In recent years, industry has complained of a reduction in the number of young engineers. The Inspectorate is keeping a close eye on this trend.

For those working in nuclear installations, the Ordinance relating to the Qualifications of Personnel in Nuclear Installations specifies the education, knowledge and experience required by plant managers, executives, licenced shift personnel, training manager for licenced personnel, head of the organisational unit for radiation protection and the head of the security guards. Similar requirements apply to personnel working in research reactors and storage facilities.

The personnel selected as potential candidates for a licence to occupy key functions in an NPP – control room operators, shift supervisors and radiation protection experts – must successfully complete vocational training of 3 – 4 years in a technical profession and have a minimum of two years' experience in their profession (the latter is not compulsory for radiation protection experts). Safety engineers must have an engineering or university degree. The Reactor School at the Paul Scherrer Institute provides specific training in nuclear fundamentals, the basics of electrical and mechanical engineering, water chemistry, safety concepts and radioprotection. The selection procedure for all licenced control room personnel includes aptitude tests. Under the Ordinance relating to the Qualifications of Personnel in Nuclear Installations, plant managers must have an engineering or university degree, basic knowledge of nuclear engineering and the specific knowledge required for the individual function together with management experience and experience in the relevant NPP.

All staff members must undergo sufficient training to enable them to discharge their responsibilities.

The education and training required for licenced personnel is given in summary form below:

- **Field operators**: Employees wishing to become licenced control room personnel must start as field operators. There is no licensing at this level. However, it is common for such operators to have passed an officially recognised examination. Courses and on-the-job training provide them with a good understanding of the NPP and also a basic understanding of radiation protection, physics and nuclear engineering.
- **Control room operators:** This function requires a formal licence. Candidates for positions as control room operators must have worked for one or two years as a field operator. They must complete a detailed theory course at the Reactor School at the Paul Scherrer Institute or an equivalent institution. On completion of this basic education, candidates complete plant-specific training. This takes the form of various courses at the NPP, on-the-job training and simulator training. The licence is granted after examination by experts from the relevant NPP and the Inspectorate.
- **Shift supervisors:** Applicants for this function must be experienced control room operators (one to three years of experience). They receive additional education and training in leadership, specific plant behaviour, procedures and also undergo full-

scope simulator training with their team. The examination procedures mentioned above also apply to the licensing of shift supervisors.

- **Stand-by safety engineers:** Shift supervisors with an engineering or university degree can become stand-by safety engineers. In particular, they need further training in leadership under unfavourable conditions plus an extensive and detailed knowledge of emergency procedures. The licence is granted after examination by experts from the relevant NPP and the Inspectorate.
- **Radiation protection experts:** Radiation protection specialists and radiation protection technicians are trained at the Radiation Protection School at the Paul Scherrer Institute or an equivalent institution. The final examination of candidates for both functions is supervised by the Inspectorate. The licence for experts in high-level radiation protection is granted on successful completion of high-level courses.

Adequate training exists for all of the above functions. It comprises simulator training (except for radiation protection experts), plant-specific courses and theoretical courses, usually at the Reactor and Radiation Protection Schools at the Paul Scherrer Institute. The training of licenced control room personnel is provided by members of the training section of the relevant operational department. They are professionals and hold a diploma in adult education.

Each NPP has its own site-specific simulator training, which is also used for requalification purposes. All Swiss NPPs have full-scope replica simulators on site. Training activities are supervised by the Inspectorate.

Personnel in NPPs are well educated and trained. Regular retraining is provided to ensure that personnel are up-to-date with advances in science and technology and plant modifications.

The financial resources allocated to training are defined in the annual budget produced by the NPP. The annual management meeting between NPPs and the Inspectorate includes an overview of this budget.

In order to maintain specific expertise in nuclear technology within Switzerland, Swiss NPPs sponsor a dedicated professorship at the Swiss Federal Institute of Technology, Zurich.

New-build projects

General licence

Three applications for general licences for new NPPs were submitted to the authorities in 2008. The Nuclear Energy Ordinance gives general guidance on the documents to be included with an application for a general licence (see Article 7). In particular, applicants must submit a safety analysis report to the Inspectorate and include information about personnel and organisation. This is a requirement specified by the Inspectorate and applicants are required to include (see for example Article 12) details of their project organisation and must commit to a systematic approach to the development of a future operating organisation. All three applicants have given a commitment that they will develop and continuously adapt an appropriate organisation employing qualified and experienced personnel during all stages of the project. As part of the preparation for the application for a construction licence, applicants are adapting and enlarging their own organisations in order to meet the requirements in terms of the qualifications, experience and resources required for subsequent phases of the project.

Construction licence

The Nuclear Energy Ordinance specifies that applicants for a construction licence must submit information on the organisational structure, number of employees, staff training and deployment during the construction phase, as well as a concept for the training of personnel. Moreover, they must submit a quality management programme for the planning and construction phase, which describes the applicant's organisational structure and processes. The Inspectorate is currently developing further guidance for applicants with regard to the content and format of documents to be submitted.

In its oversight activities, the Inspectorate will dedicate particular attention to the commitment and actual efforts by applicants to develop and maintain an organisation capable of satisfying the high standards of nuclear safety. For example, applicants must provide the necessary human and financial resources during all phases of the project.

Developments and Conclusion

As in the previous reporting period, existing nuclear installations have adequate financial resources to support the safety of each nuclear installation. They also have sufficient qualified staff with appropriate education and training for all safety-related activities together with adequate retraining opportunities.

With regard to applicants completing the licensing process for new builds, the Inspectorate will pay particular attention to their commitment and actual efforts to develop and maintain an organisation that is capable of satisfying the high standards of nuclear safety required by NPPs (see Article 7). For example, the applicants must provide the necessary human and financial resources during all phases of the construction.

Switzerland complies with the obligations of Article 11.

Article 12: Human factors

Each Contracting Party shall take the appropriate steps to ensure that the capabilities and limitations of human performance are taken into account throughout the life of a nuclear installation.

The Inspectorate currently has a team of specialists in human factors. Their primary areas of competence and responsibility are as follows: Organisation, training, qualification, human-system-interface, safety culture, and investigation of the human and organisational factors involved in NPP events. It dedicates resources because it understands that nuclear safety depends on man, technology, organisation and their mutual interaction. It reflects, therefore the so-called MTO or socio-technical systems approach.

The Inspectorate is currently facing a range of challenges: projects to build three new reactors have been launched and existing plants have announced modernisation projects. Human and organisational factors (HOF) need to be considered at an early stage in these ventures as they play an important safety role.

In 2009, ENSI conducted two workshops at which the Inspectorate presented its expectations on how HOF should be integrated into the projects to build new reactors and modernise existing plants. These expectations will be incorporated into regulatory guidelines (e.g. in the guideline on the organisation of nuclear installations that is currently being revised).

Monitoring human and organisational factors in modernisation projects

The Nuclear Energy Ordinance lays down a series of design principles for NPPs, including a principle relating to human factors: “Workstations and processes for the operation and maintenance of the installation must be designed so that they take account of human capabilities and their limits”. The Inspectorate pays particular attention to this principle when it considers projects to modernise plants. To ensure that a licensee considers human and organisational factors appropriately, the Inspectorate demands that a human and organisational factors programme (HOF programme) is included in any plan to modernise an NPP. This ensures a systematic and continuous HOF approach (e.g. a human-centred design process, integration of operating experience from predecessor or similar systems, multidisciplinary project management) throughout the project. Below some recent examples:

- In 2006, the Beznau NPP started to replace the remote control rooms for the control of processes with low safety significance with digital instrumentation and control systems. From a technical perspective, the systems to be modified had low safety significance. However, the planned modification had a high safety impact as it completely changed the working environment and the working habits of the operating and maintenance personnel.
- In 2008, the Beznau NPP started a large plant-modernisation project to replace the existing hydroelectric power station that is part of the emergency power supply systems with seismically qualified diesel generators.

- In 2009, the Gösgen NPP announced that it planned to replace all its instrumentation and control systems. This modification will have a major impact on the safety of the working condition of operators and in particular maintenance personnel.

The HOF programme adopts a graded approach. This ensures that appropriate resources are allocated in accordance with the criteria in Paragraph 2.6 of the IAEA Safety Standard GS-R-3. This graded approach is also being applied to projects to build new NPPs. The applicants for a general licence (see Article 7) were required to give a general commitment that they would give full consideration to HOF and integrate it in all phases of the project to build a new NPP, i.e. from the outset. In concrete terms, this means that they are required to develop systematic and comprehensive HOF programmes. As part of the next stage in the licensing process, i. e. the application for a construction licence, they are required to submit a HOF programme for the design phase of the new NPP and a HOF programme for construction together with related reports on the implementation of these programmes. In addition, they are required to submit a concept for the development of the future operating organisation.

Event Analysis

All NPPs conduct thorough investigations of human and organisational factors whenever they are identified as the root cause or a contributing factor in events with a relevance to safety. If these investigations identify weaknesses in these areas, this triggers an assessment of similar situations in other NPPs.

The Nuclear Energy Ordinance states that all NPPs must appoint a committee to analyse events and outcomes attributable to human and organisational factors. All NPPs have appointed such committees, who receive adequate education and training on a regular basis.

Organisation and safety culture

The revised guideline on the Organisation of nuclear power installations came into effect in 2008. The legal basis for this guideline are the relevant articles on organisational requirements in the Nuclear Energy Act, the Nuclear Energy Ordinance, the Convention on Nuclear Safety, the IAEA requirements on Management Systems and the Reference Levels issued by the Western European Nuclear Regulators' Association (WENRA).

The guideline describes the requirements of the Inspectorate in terms of organisational structure and work processes of the NPPs together with the requirements to be taken into account by the operating organisation to ensure the safe management of organisational changes. The guideline also stipulates that the operating organisation must give top priority to safety in all plant activities.

Attention is also given to the concept of safety culture. The guideline stipulates that an NPP must analyse, monitor, reflect and foster its own safety culture.

The guideline is currently being revised (see above) in the light of major changes to the requirement to integrate HOF in new-build and modernisation projects.

The Inspectorate has conducted a series of oversight activities in the area of safety management and safety culture, including in particular inspections and technical discussions. The purpose of inspections is to check whether the organisational structure and the work processes of the relevant nuclear power installation meet the legal requirements for organisation. Technical

discussions are a less formal exchange of information between Inspectorate and operating organisation on aspects of safety culture and related activities.

Developments and Conclusion

In accordance with the Nuclear Energy Ordinance, the Inspectorate has given concrete form to the requirement to integrate human and organisational factors in both projects to modernise plants and to build new reactors.

Switzerland complies with the obligations of Article 12.

Article 13: Quality assurance

Each Contracting Party shall take the appropriate steps to ensure that quality assurance programmes are established and implemented with a view to providing confidence that specified requirements for all activities important to nuclear safety are satisfied throughout the life of a nuclear installation.

NPP Operational Safety

As specified in the Inspectorate's Guideline G07, NPPs have management systems compatible with the IAEA Safety Standard GS-R-3. All Swiss NPPs have an Integrated Management System and are certified under ISO 9001 (Quality Management) and OHSAS 18001 (Occupational Health and Safety) norms. Three out of four NPPs are also certified under ISO 14001 (Environmental Management). These certificates are renewed on a regular basis.

The Inspectorate concentrates its supervisory activities on those elements of an NPP management system of relevance to safety. It does this by performing targeted team inspections on safety-relevant processes (e.g. plant modifications, decision making, etc.). During these inspections, inspectors assess whether the system complies with safety requirements and with IAEA requirements on management systems (IAEA Safety Standard GS-R-3). Regulatory inspections are also performed in respect of other specific issues (e.g. quality management documentation and records, etc.) or the results of assessment methods independent of NPPs (results of internal and external audits, non-compliance etc.) and the resultant improvement measures. The formal aspects of the management system such as structure, organisation, etc. are not inspected regularly and for these, the Inspectorate relies partly on the certification. Specific inspections are conducted if major changes are made to the management system requiring notification to the Inspectorate.

Furthermore, the Inspectorate requires the inclusion of a documented self-assessment function in the management system. NPPs have incorporated appropriate self-assessment processes in their management systems and perform the self-assessment periodically.

NPPs must report major activities and their outcomes to the Inspectorate for assessment. This includes the drafting of the relevant standards. All NPP activities other than normal operation, e.g. backfitting, replacement and modifications to systems and components, etc. need a permit. In specific areas, some quality-assurance measures are defined in guidelines published by the Inspectorate or there is a requirement for quality plans.

Transport of radioactive material

The Inspectorate requires all Swiss NPPs to include in their management system specific quality management rules on the transport of radioactive materials. These rules comply with the IAEA Safety Standard TS-R-1 and were approved by the Inspectorate following the positive results of an audit. Regular audits take place at 2 – 3 year intervals.

NPP new build projects

To ensure that it can supervise the quality of the management during the design, construction and commissioning phases for new NPPs, the Inspectorate is drafting guidelines stipulating the requirements to be met by applicants for licences during the above phases. Special attention will be given to the interface between licensee and contractors as subcontractor chains for projects of this size are typically both long and multinational. In compliance with Paragraph 3.5 of the IAEA Safety Fundamentals SF-1, the guidelines will stipulate the requirements for the intelligent customer capability of the applicant.

Developments and Conclusion

All NPPs in Switzerland have introduced management systems compatible with IAEA Safety Standard GS-R-3.

For new-build projects, the Inspectorate is currently establishing new guidelines stipulating the requirements to be met by applicants for licences during the design, construction and commissioning phases, whereby special attention will be given to the interface between licensee and contractors.

Switzerland complies with the obligations of Article 13.

Article 14: Assessment and verification of safety

Clause 1: Each Contracting Party shall take the appropriate steps to ensure that comprehensive and systematic safety assessments are carried out before the construction and commissioning of a nuclear installation and throughout its life. Such assessments shall be well documented, subsequently updated in the light of operating experience and significant new safety information, and reviewed under the authority of the regulatory body.

Overview of Safety Analyses

Article 7 describes the individual steps and scope of the review and assessment required for the licensing of new nuclear power plants.

For existing plants, a Periodic Safety Review (PSR) is required at least every ten years. Important elements of a PSR are an update to the Safety Analysis Report (SAR), an assessment of design base accidents, an assessment of the ageing surveillance programme, an update to the Probabilistic Safety Analysis (PSA) and an evaluation of operating experience in the last 10 years. The details (scope and process) for PSR are defined in the Inspectorate's Guideline R-48.

Modifications to or the backfitting of components and documents important to safety (e.g. Technical Specifications) must be approved by the Inspectorate. The Inspectorate's associated review may involve inspections (see Clause 2).

Relevant data from inspections, event assessments and safety indicators is collated and informs the systematic assessment of operating safety carried out annually (Integrated Oversight see Clause 2).

The above safety analyses are anchored in the Nuclear Energy Ordinance as are the requirements for the analysis and reports to be submitted for decommissioning projects. The following paragraphs provide further information on certain safety analyses.

Evaluation of Periodic Safety Review

In addition to the continuous review and evaluation of plant modifications, the PSR is an important control mechanism for both licensees and the Inspectorate. It enables them to identify and assess actual safety in a plant. The actual plant status and past operating experience are compared against the current state of science and technology and operating experience from other plants. The licensee carries out the PSR and the Inspectorate evaluates the PSR report submitted by the licensee. The Inspectorate adds its own experience from previous inspections, assessments and reviews.

The concept of defence in depth as described in the IAEA Safety Standard NS-R-1 plays a central role in the PSR and its evaluation. In its report, the licensee is required:

- to explain the plant-specific implementation of safety policy;
- to assess the operating performance and management of the plant;
- to perform a deterministic safety status evaluation;

- to perform a probabilistic safety analysis.

Based on the above, the licensee must demonstrate that the fundamental safety functions specified in NS-R-1 and radiological protection issues are effective in both normal and abnormal plant operation. The licensee must also demonstrate how it takes account of the evolving state of science and technology in the plant's design and operation and how it addresses the issue of experience gained from similar plants worldwide. In addition, in its assessment of operating experience in the last 10 years, the licensee must give special attention to human and organisational factors and their impact on safety. The Inspectorate's assessment also considers the licensee's safety culture.

The PSR includes not only a review of the plant's current safety status but also an assessment of its future safety status.

Review of Ageing Surveillance Programme and Long Term Operation

In 1991, the Inspectorate required Swiss NPPs to introduce an Ageing Surveillance Programme (ASP). The aim of this programme is to collect the information on structures, systems and components (SSCs) required for the monitoring of ageing and understanding ageing mechanisms in order to maintain safety margins and safety functions of SSCs throughout the life of the plant.

The ASP is part of the overall maintenance strategy for Swiss NPPs. It addresses issues relating to civil engineering, electrical and mechanical components and focuses on SSCs important to safety. More specifically, the ASP aims to provide information on the ageing and degradation mechanisms associated with component materials, environmental effects, operating history, etc. It is designed to identify potential deficiencies in the existing maintenance programme for every component important to safety

In November 2004 the Inspectorate has issued an ASP guideline (Guideline R-51) which is based on the IAEA Safety Reports Series No. 15 "Implementation and Review of a Nuclear Power Plant Ageing Management Programme". Guideline R-51 specifies the requirements for implementing and documenting the ASPs. Currentliy this guideline is beeing updated. The revised guideline will be based on Article 35 of the Nuclear Energy Ordinance and the IAEA-Safety Standard "Ageing Management of Nuclear Power Plants" NS-G-2.12. In the new guideline the Inspectorate also requires Swiss NPPs to take account of recent findings with a relevance to their plant and this necessitates active tracing and documentation of relevant internal and external operating experience. Furthermore latest conclusions of ageing surveillance e.g. laboratory results, sensitivity studies are reflected in the revison of the guideline.

The Swiss ASPs cover mechanical and electrical components, concrete structures and buildings with a safety classification. Non-classified components are only covered if they are of relevance to the risk. Licensees must update their ASP documents to reflect new safety-related findings or at least once every ten years.

Since 2004, all Swiss NPPs have prepared a set of ageing management documents in accordance with the requirements of the Inspectorate's Guideline R-51 on ASP and they are now revising this documentation. Therefore, extensive experience has been built up, which allows utilities to implement and maintain an ageing surveillance programme and similarly allows the Inspectorate to monitor the process.

Periodic testing, maintenance tasks and in-service inspections, as well as routine controls are performed in accordance with planned schedules or when required. In accord with the most recent requirements for an ageing surveillance programme, the annual refuelling outage also provides an opportunity for additional inspections with suitable non-destructive evaluation methods (NDE) or other examinations such as metallographic investigations. Particularly for mechanical parts such as safety-classified pipes and vessels, the Inspectorate requires that all inspections adopt a qualified testing procedure in accordance with Guideline B07.

In terms of ensuring the long-term operation of Swiss NPPs, attention must be given to the Ordinance on the Methodology and Boundary Conditions for Evaluation of Criteria for the Provisional Taking out of Service of Nuclear Power Plants. This Ordinance came into effect in 2008 and defines – in addition to design-related criteria – a number of ageing-related criteria to be met by Swiss NPPs at all times. The ageing criteria relate to ageing degradation mechanisms in primary circuit components and the containment.

Review of design-basis accident analyses

This review aims to verify the expected behaviour of the plant under assumed abnormal conditions as defined in the Inspectorate's Guideline A01. Based on a set of accident scenarios, the licensee must demonstrate that the relevant plant and core-specific parameters remain within safety limits. In addition, the licensee must demonstrate that it complies with the individual dose limits for the public, as defined in the Radiological Protection Ordinance.

The Inspectorate's review covers at least the following aspects:

- suitability, validation and state-of-the-art of computer software;
- compatibility of assumptions with system and component design;
- conservatism of simplifications and assumptions;
- adequacy of assumed single failures and
- compliance with pertinent operating and safety limits.

Review of beyond-design-basis accident analyses

The Nuclear Energy Ordinance requires NPPs to use Probabilistic Safety Analysis (PSA). The Ordinance on Hazard Assumptions and Evaluation of Protection Measures against Accidents in Nuclear Installations requires the probabilistic consideration of beyond-design-basis accidents.

Two new PSA guidelines were issued in 2008 and 2009 in order to harmonize the implementation of PSAs at Swiss NPPs:

- Guideline A05 defines the quality and scope of requirements for the plant-specific Level 1 and the Level 2 PSA for NPPs and other nuclear installations.
- Guideline A06 formalises the requirements for applying PSAs to NPPs. It defines the general principles, requirements for the review and upgrade of PSAs and the required scope of PSA applications.

All Swiss NPPs maintain plant-specific Level 1 and Level 2 studies, including internal and external events such as fire, flooding, earthquakes, aircraft impacts and high winds. Low-power and

shutdown modes are considered for both the Level 1 and Level 2 PSA. However, for two NPPs the Level 2 PSA for shutdown mode is still under development.

The PSA studies are reviewed and updated regularly in order to reflect PSA-relevant plant hardware and operational changes. As part of the PSR, PSA studies are revised as needed to reflect advances in methods and reflect current operating experience. At least once every five years, PSA models are updated to reflect plant modifications and the availability of additional reliability data. Guideline A06 also defines the conditions for updating the PSA models at other times for plant modifications not yet incorporated in the PSA models but which may have an impact on PSA outcomes.

For each Swiss NPP, the Inspectorate has developed a plant-specific regulatory PSA model. These regulatory PSA models enable the Inspectorate to perform independent confirmatory analyses and to assess the risk implications of various safety issues and regulatory actions.

The Inspectorate's PSA review aims to develop a thorough understanding of plant attributes, its vulnerability to potential severe accidents and plant-specific operating characteristics. The review focuses on a general evaluation of PSA models, assumptions, analytical methods, data and numerical results and also on understanding the range of uncertainties in core-damage frequency, fuel-damage frequency, containment performance and radioactive releases.

The first stage of the review is a qualitative evaluation of the PSA based on the requirements of Guideline A05. In particular, it verifies whether PSA documentation is complete and assesses the PSA approach and analytical methods, plant design features intended to prevent and mitigate potential severe accidents. It also identifies areas for the more comprehensive assessment and analysis required in the next stage of the review. Based on the results of this evaluation, the Inspectorate submits requests for additional information to the licensee and its responses are used for the review. In a further stage, the Level 1 PSA is verified against the Inspectorate's plant-specific PSA model. For the Level 2 PSA, the evaluations include state-of-the-art computer codes, an assessment of severe accident behaviour, containment loads, containment performance, containment failure modes and accident source terms. In addition, site audits, including plant walkdowns are conducted. They focus on a review of the external event analysis. A detailed qualitative approach is used to review the low-power and shutdown PSA studies. This is largely based on insights gained from the review of full-power studies.

To ensure that both the licensee and the Inspectorate gain an insight into the relevant risks identified in PSA studies, the following PSA applications are included in Guideline A06 as a requirement:

- probabilistic evaluation of the safety level;
- evaluation of the balance of risk contributions;
- probabilistic evaluation of plant modifications including technical specifications;
- assessment of components with a risk significance;
- probabilistic evaluation of operating experience (two types of analyses are conducted: analysis of the annual, plant-specific cumulative risk and an analysis of any event affecting PSA-relevant structures, systems and components).

Review and assessment of safety systems, safety-related systems and their components

This process is described in a number of the Inspectorate's guidelines (R-23, R-31, R-35, R-51, G-11 and B-06). The Inspectorate's review covers (but is not limited to) the following aspects:

- quality assurance of manufacturing, assembly and commissioning;
- personnel qualifications (e.g. for welders);
- specifications of systems and components, system and instrumentation, control equipment drawings and construction drawings;
- impact on safety concepts and on results of safety analyses as appropriate;
- operating experience from NPPs and other nuclear installations;
- implementation and test plan.

The depth of the review depends on the safety significance of the relevant systems/components. The licensee's quality assurance systems must encompass all safety-relevant aspects and describe the measures taken to ensure safety.

Clause 2: Each Contracting Party shall take the appropriate steps to ensure that verification by analysis, surveillance, testing and inspection is carried out to ensure that the physical state and the operation of a nuclear installation continue to be in accordance with its design, applicable national safety requirements, and operational limits and conditions.

As already mentioned in the response to Clause 1, appropriate safety analyses must be submitted to the Inspectorate to support the application required before any modification or backfitting to safety (related) systems or components. The following are required before any such permit can be granted: evidence of the suitability of the manufacturing, assembly and commissioning processes, evidence of compliance with safety limits, details of the special start-up tests as necessary and the procedure for periodic inspections and audits. These are required in order to ensure that each modification or backfitting accords with previously approved safety requirements and that the relevant safety margins and operational limits are maintained.

The following activities play a central role in verifying the safe condition and operation of nuclear installations:

Refuelling and outage activities

During each refuelling outage, the plant is subject to a review, which covers many aspects. Below are some examples:

- The Inspectorate monitors in-service inspections, preventive maintenance and repairs/modifications to safety-related mechanical equipment undertaken by licensees to maintain or enhance plant safety. Its mandated expert, the Swiss Association for Technical Inspections supervises and verifies these activities using a combination of selective supervision and random checks. In contrast, the Inspectorate focuses on special issues.
- The licensee carries out a review of mandatory periodic functional testing of systems and components, including switchover tests for the electricity supply. These tests

are performed in accordance with written procedures and all test results are documented. The Inspectorate attends selected tests and also reviews the results of the entire test programme.

- Cycle-specific fuel and core-related issues are reviewed as part of the “Refuelling Licensing Submittal” submitted by the licensee at the beginning of the plant-refuelling outage. The Inspectorate must approve fuel and core loading before any cycle start-up. The Inspectorate also reviews fuel handling and inspection and attends selected fuel inspection campaigns.

The Inspectorate issues a letter granting permission to restart plant operation after the maintenance/refuelling outage. In this letter, the Inspectorate gives its assessment of the outage maintenance and refuelling activities, the radiological status of the plant and the cycle-specific safety analyses. The permit may also include conditions for plant operation or requirements and recommendations for maintaining and improving plant safety. The Inspectorate documents its own activities during the outage in a separate outage report.

Backfitting and replacement

Backfitting and the replacement of safety-related equipment are necessary when existing equipment no longer satisfies current standards or it becomes difficult to maintain. The Inspectorate may also require backfitting or replacement of equipment, e.g. following a PSR. New equipment is mainly installed and commissioned during plant outages. The Inspectorate reviews the process for such activities and so follows the process closely. In most cases, the Inspectorate must approve the installation and commissioning.

Examples of backfitting and replacement:

- replacement of the existing reactor protection and control systems with a computer-based system at both units of Beznau NPP;
- replacement of source and intermediate-range nuclear instrumentation with a digital-wide range monitor system at Beznau and Mühleberg NPPs;
- installation of computer-based operator support systems (process computer, process visualisation, online operating procedures) at Gösgen, Mühleberg and Beznau NPPs;
- installation of the systems/equipment required for primary feed and bleed operation in accident conditions at Gösgen NPP;
- reinforcement of brick walls for improved seismic resistance at Gösgen NPP.

It is common practice in Swiss NPPs to carry out preventive replacement of safety-classified electrical equipment before ageing effects occur, e.g. batteries for emergency DC power supplies.

Inspection, reporting and information meetings

Inspection

Inspections in nuclear installations are primarily performed by the Inspectorate. In the field of mechanical engineering, some elements of inspections are delegated to external experts, who act on behalf of the Inspectorate.

The regulatory inspections by the Inspectorate serve to provide the basis for independent judgements on safety-related issues such as:

- quality measures during construction, plant modifications and operation;
- availability of documentation (e.g. operating instructions, technical specifications, emergency instructions and emergency plans);
- adherence to operating instructions and technical specifications;
- plant operation and recording of safety performance;
- adequacy of PSA models in representing the current plant configuration and operational characteristics;
- housekeeping practices designed to prevent or mitigate fire and the effects of seismic hazards;
- availability and training of operating personnel;
- radiation protection;
- human factors engineering (e.g. human-system-interface);
- organisation and safety culture;
- protection against sabotage and malicious acts.

The inspections cover all aspects of engineering of relevance to safety (including fire protection), the relevant disciplines of natural sciences (e.g. reactor physics, water chemistry) and work sciences (e.g. work and occupational psychology).

The Inspectorate plans inspections in accordance with its Basic Inspection Programme, which provides a systematic basis for **periodic inspections**. The inspection intervals are based on the safety relevance of items (components, systems, processes) to be inspected and on operating experience.

In addition to the above *periodic* inspections, the Inspectorate's management defines **issue-based inspections**. They focus on specific issues identified in the annual systematic safety assessment described below. If necessary, **reactive inspections** are carried out, e.g. in response to events or plant modifications proposed by the licensee.

Inspections are performed at any time and are more frequent during outages than during normal operation. In most cases, the licensee is given advance notice of inspections. This ensures that activities covered by the inspection are running at the time, components are accessible and the relevant staff are available for discussions. Inspections by the site inspector (see below) are not usually pre-announced.

Most inspections are done during the operation of nuclear installations although a few inspections cover research reactors, which have been shut down. In 2009, the Inspectorate started

work on the development of the principles required for NPP oversight during planning and construction and subject to a political decision in favour of building new NPPs, a suitable inspection programme will be implemented.

In 2008, the Inspectorate appointed a site inspector to each NPP. Other nuclear installations have part-time installation inspectors. As the Inspectorate's offices at Brugg and the NPP sites are in relatively close proximity, regional offices are not required and for the same reason, there are no resident inspectors.

During normal operation, the site inspector is typically on site one day per week. During outages, the site inspector is present for four or five days. Inspections by specialists focus on specific issues, whereas site inspectors develop a more general view of the NPP. Findings of potential interest are reported to the specialists. The duties of site inspectors are not limited to inspections. They also act as a conduit between the licensee and the Inspectorate. Site inspectors take the lead role in the systematic safety assessments (see below), which are part of the process of integrated oversight. Site inspectors also contribute to the annual regulatory oversight report published by the Inspectorate on their particular site.

Reporting

Article 37 of the Nuclear Energy Ordinance specifies the reports to be submitted to the regulatory body in order to assess the status and operation of the facility. Articles 38 and 39 and Appendix 6 address the reporting of planned activities, event reports and findings of relevance to safety and security. The Nuclear Energy Ordinance delegates the detailed requirements in terms of report content to the Inspectorate. These are published in Guidelines B02 and B03, both of which came into force in 2009. Guideline B02 deals with periodic reporting, e.g. monthly reports, annual safety reports and outage reports. Guideline B03 addresses the reporting of planned activities, events and findings of relevance to safety. Data relating to general plant performance, including radiological characteristics and plant modifications for which a permit is not required, must be reported periodically (monthly or yearly). However, events such as equipment failures, scrams and the failure of mandatory tests must be reported within the (short) period of time specified in Appendix 6 of the Nuclear Energy Ordinance.

The licensee must also review information on international events available through various channels such as WANO, IAEA and supplier information letters. The insights gained from these reviews must be reported on a monthly basis. A set of safety indicators has been defined and the raw data for these indicators must be included in the monthly reports.

Reports by licensees may trigger regulatory requirements or recommendations for improvement. The Inspectorate also reviews information on international events as well as insights from safety research. Its review may also trigger regulatory action and if appropriate, requirements or recommendations to the licensee.

Information meetings

Each site inspector (see above) conducts monthly meetings with the respective licensee, in order to obtain the latest information on plant status and performance.

Members of the management of the Inspectorate and the licensee meet annually for an information meeting at which the licensee reports on plant operation. The meetings also discuss special issues and ongoing or planned projects. The Inspectorate will give its view on the various topics

and clarify current or future requirements (safety-related requirements are normally presented to the licensee before enforcement).

In addition, there is an annual meeting between senior managers from the Inspectorate and licensee in order to discuss current safety issues. There are also annual management meetings between the Inspectorate's senior management and senior managers from all nuclear utilities.

In addition to these regular information meetings, the Inspectorate may arrange meetings on specific issues at any time as appropriate.

Integrated Oversight: Annual Systematic Safety Assessment

Under the Inspectorate's integrated oversight approach – an approach continuously refined since the last report – all aspects of relevance to nuclear safety must be integrated into a single comprehensive oversight strategy. The aim is twofold: firstly, the Inspectorate must ensure it has sufficient information on the design, state and effectiveness of all safety provisions so that it can provide a realistic assessment of the safety of each nuclear installation. Secondly, the Inspectorate must ensure it takes adequate and effective measures if it detects a weakness in a safety provision. Every assessment and action must be justified and traceable.

In order to obtain a realistic picture of the safety of each installation, the Inspectorate operates a systematic safety assessment system. Firstly, safety information is structured based on the following key issues:

- requirements subdivided into design and operational requirements;
- operating experience subdivided into state and behaviour of the plant and the state and behaviour of man and organisation.

Secondly, information is structured based on the following safety goals:

- safety functions;
- levels of defence in depth and barrier integrity.

For each NPP, data is collected as shown in the Tables 2a and 2b.

Currently, inspection findings, operator licensing results, event analysis results, safety-indicator data and information in the periodic licensee reports are evaluated annually as part of the integrated oversight process.

Goals \ Subject		Requirements		Operational experience	
		Design requirements	Operational requirements	State and behaviour of the plant	State and behaviour of man and organisation
Levels of defence in depth	Level 1				
	Level 2				
	Level 3				
	Level 4				
	Level 5				
Barrier integrity	Fuel integrity				
	Integrity of the primary cooling system boundary				
	Containment integrity				
overall defence in depth aspects					

Table 2a: Safety Assessment Table – Defence in Depth

	Subject / Goals	Requirements		Operational experience	
		Design requirements	Operational requirements	State and behaviour of the plant	State and behaviour of man and organisation
Safety functions	Controlling reactivity				
	Cooling the fuel				
	Confining radioactive materials				
	Limiting exposure to radiation				
	overall aspects				

Table 2b: Safety Assessment Table – Safety Functions

Each finding identified during an inspection is assigned to one or more cells in each table (defence-in-depth and fundamental safety function). The same process is used for the event analysis results with each direct or indirect cause and each effect of relevance to safety being assigned. Finally, operator licensing results and the safety indicator assessments are assigned.

Findings are rated on a scale based on the International Nuclear Event Scale (INES). The scale is designed to assess in one single scale all levels of safety performance ranging from good practice to a severe accident. The categories are defined as follows:

- **Category G: Good practice**
  All requirements are fulfilled and the practice of other NPPs is clearly exceeded.
- **Category N: Normality**
  All requirements are fulfilled.
- **Category V: Need for Improvement**
  Deviations from requirements in documents not requiring formal authorisation by the Inspectorate fall into this category
- **Category A: Deviation**
  Deviations from normal operation within operational limits and conditions
- **Categories 1 to 7**
  Rating based on the INES Manual

Categories V and A correspond to INES 0. Findings from inspections falling in Category A or higher are classed as events. Any finding of V or higher requires action.

Inspection data, operator licensing data, event-analysis data, safety-indicator data and the periodic licensee report data are entered in a database. A software tool allows the display of safety as-

sessment data and it is possible to display the ratings in a table for any period and any installation. Each rating is linked to a source document and the resultant rating distribution for each NPP is evaluated at the end of the year. The result of this evaluation influences the focus of inspections for the following year. Insights gained from the annual safety assessment of each plant are included in the annual regulatory oversight report published by the Inspectorate.

Developments and Conclusion

Clause 1: The requirements of the Ageing Surveillance Programme are currently being updated to cover long-term operation. Additional legal criteria are included for this purpose in the Ordinance on the Methodology and Boundary Conditions for the Evaluation of Criteria for the Provisional Taking out of Service of Nuclear Power Plants specifies. Extensive new regulation exists with regard to the analysis of beyond-design-basis accidents.

Clause 2: By appointing site inspectors, the Inspectorate has significantly intensified its inspection programme. Since the last report, it has continuously refined the integrated oversight approach provided by the annual systematic safety assessment.

Switzerland complies with the obligations of Article 14.

Article 15: Radiation protection

Each Contracting Party shall take the appropriate steps to ensure that in all operational states the radiation exposure to the workers and the public caused by a nuclear installation shall be kept as low as reasonably achievable and that no individual shall be exposed to radiation doses which exceed prescribed national dose limits.

The Radiological Protection Act and the Radiological Protection Ordinance are based on the recommendations of the International Commission on Radiological Protection (ICRP) (mainly Publication 60). The Inspectorate specifies the legal requirements in the following guidelines:

- R-07 Guideline for the area of radiation protection of the nuclear installations and the Paul Scherrer Institute
- R-11 Aims in radiation protection for normal operation of nuclear installations
- R-12 Collecting and reporting of doses of personnel exposed to radiation in nuclear installations and the Paul Scherrer Institute
- B04 Clearance of materials and areas from controlled zones
- G14 Calculation of radiation exposure in the vicinity due to emission of radioactive substances from nuclear installations
- G13 Radiation protection measuring devices in nuclear installations: Concepts, requirements and testing

The Radiological Protection Ordinance was revised in October 2007. Relevant changes were distinct dose factors for infants (1 a), children (10 a) and adults as well as irradiation dose factors for plume and soil. In another innovation, the threshold at which it was necessary to notify the authority of radioactive sources was reduced by a factor of 100.

The most recent revision to the Radiological Protection Ordinance was in January 2009 in order to ensure that it was compatible with the Nuclear Energy Act. A comparison with the new Recommendations of the International Commission on Radiological Protection (ICRP-Publication 103) published in 2007 revealed only slight differences, e.g. concerning some tissue and radiation weighting factors.

A new ordinance is in preparation on the handling of unsealed radioactive material in nuclear facilities, which will include detailed requirements on buildings and equipment. This ordinance will partially replace the Inspectorate's Guideline R-07.

Dose limits

The Radiological Protection Ordinance limits the general maximum individual total dose for radiation exposed NPP personnel (plant personnel and contractors) to 20 mSv per year. In exceptional circumstances if the task is important, the Inspectorate can authorise a limit of 50 mSv per year but the limit may not exceed 100 mSv in five years.

Since 1987, all annual collective doses have remained well below 4 person-Sv per unit and since 1995, they have been below 2 person-Sv. Annual collective doses in the last 20 years are shown in Figure 2 (note: the NPP Beznau consists of two units both located on the same site).

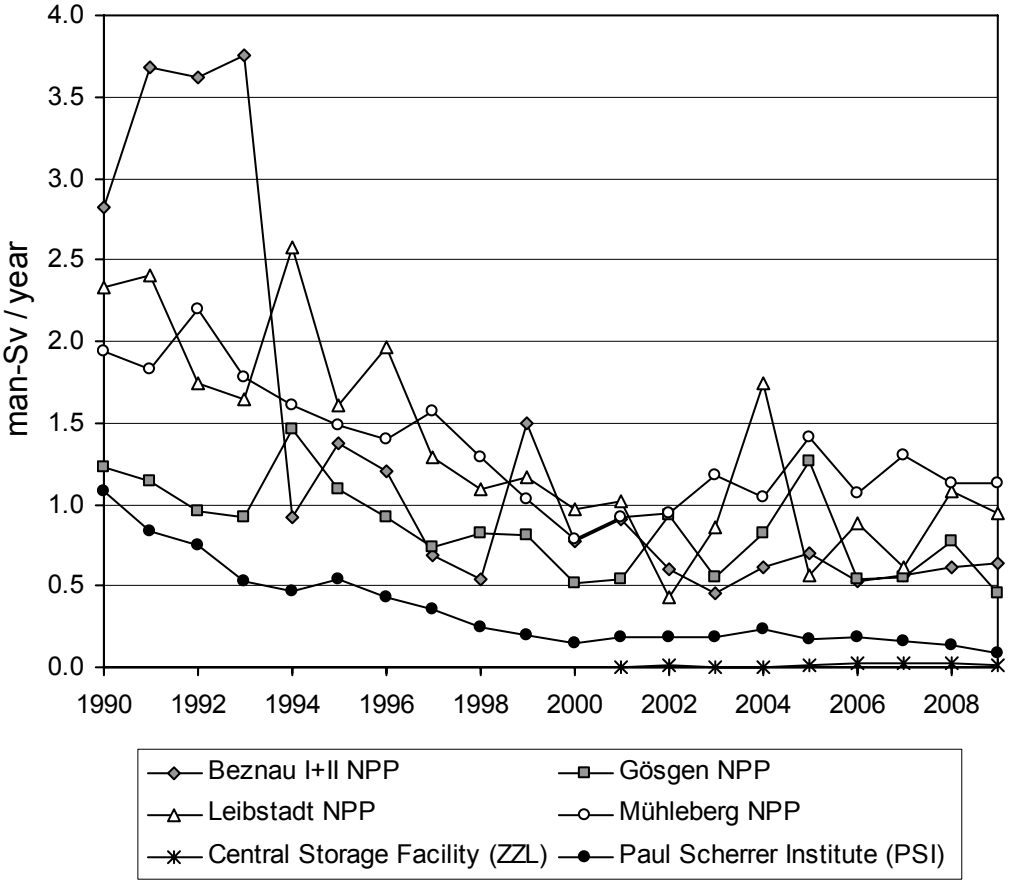

Figure 2: Annual collective doses for personnel in Swiss NPPs, the central interim storage facility and the research institute PSI. All peaks relate to the completion of special work: In 1993, the steam generators at the Beznau I NPP were replaced and this resulted in a collective dose of 1.2 person-Sv. In 1999, the same work was performed at the Beznau II NPP resulting in a collective dose of 0.64 person-Sv. This dose reduction is largely attributable to "lessons learned" from previous similar operations and to an optimisation of radiation protection processes. At the Leibstadt NPP, extensive structural alterations associated with the planned power uprating resulted in higher collective doses in 1994 and 1996. In 2004, additional inspections were carried out, which resulted in a higher collective dose. The primary safety valve was replaced in 2005 at the Gösgen NPP resulting in a higher collective dose.

An incident rated at Level 2 on INES occurred at the Beznau II NPP during the outage in 2009. Following a modification to plans at short notice, two incompatible tasks were completed at the same time although originally the tasks had been scheduled consecutively. A maintenance worker was installing lamps under the reactor pressure vessel. A radiation protection specialist was positioned in front of this room and occasionally controlled the dose rate; it was around 1.5 mSv/h when the maintenance worker entered the area. At the same time, employees positioned in a separate room located at a higher level withdrew the highly activated tubing of the incore measurement equipment from the reactor pressure vessel. The local dose rate beneath the reactor suddenly increased to over 1.000 mSv/h. As a result, the two workers accumulated

individual doses of 37.8 mSv and 25.4 mSv respectively, which is beyond the statutory dose limit of 20 mSv per year.

Apart from this incident, there have been no instances since 1994 of plant personnel or contractors accumulating individual dose limits in excess of the annual limit of 20 mSv whilst working in Swiss NPPs.

For members of the general population, the Radiological Protection Ordinance limits the dose from non-natural sources to 1 mSv per year. The Inspectorate's Guideline R-11 defines a source-related dose constraint of 0.3 mSv per year; this represents the maximum allowed dose rate per NPP site (independent of the number of reactors) for persons living near nuclear installations as a result of emissions and direct radiation. Direct radiation must not generate a corresponding dose rate of more than 0.1 mSv per year.

A nuclear facility must be designed in such a way that the source-related dose constraints are not exceeded as a result of incidents with an occurrence rate in excess of 0.01 per year. The dose limit for members of the public must not be exceeded as a result of incidents with an occurrence rate in excess of 0.0001 per year.

The Inspectorate's Guideline G14 defines the rules for calculating doses resulting from emissions and discharges. The maximum allowed emissions are defined in the licences; they are based on the characteristics of the NPP and the results of dose calculations that take account of the ALARA principle. Doses based on annual emissions and calculated for a virtual-most-exposed group of the population, including exposure resulting from deposits in previous years, have always been well below 0.2 mSv per year. Since 1994, calculated rates for annual releases have been below 0.01 mSv per year for all Swiss NPPs. This is shown in Figure 3. For all Swiss NPPs, doses resulting from direct radiation have been below 0.1 mSv per year. This means that the sum total of annual doses caused by direct radiation and emissions has always been below the source-related dose constraint.

Steps taken to ensure that radiation exposure is kept as low as reasonably achievable

Over the years, NPP-specific methods have been gradually introduced in order to keep radiation exposure from operations and maintenance work at NPPs as low as reasonably achievable. Since 1994, when the new dose limit of 20 mSv came into force, this limit has only been exceeded once – as a result of the incident in the Beznau I NPP in 2009. This means that individual doses for plant personnel and contractors (see Figure 4) have declined in recent years in all Swiss NPPs – evidence of major efforts, particularly since 1988.

The most significant measures taken by Swiss NPPS in recent years to reduce dose rates are shown in Table 3.

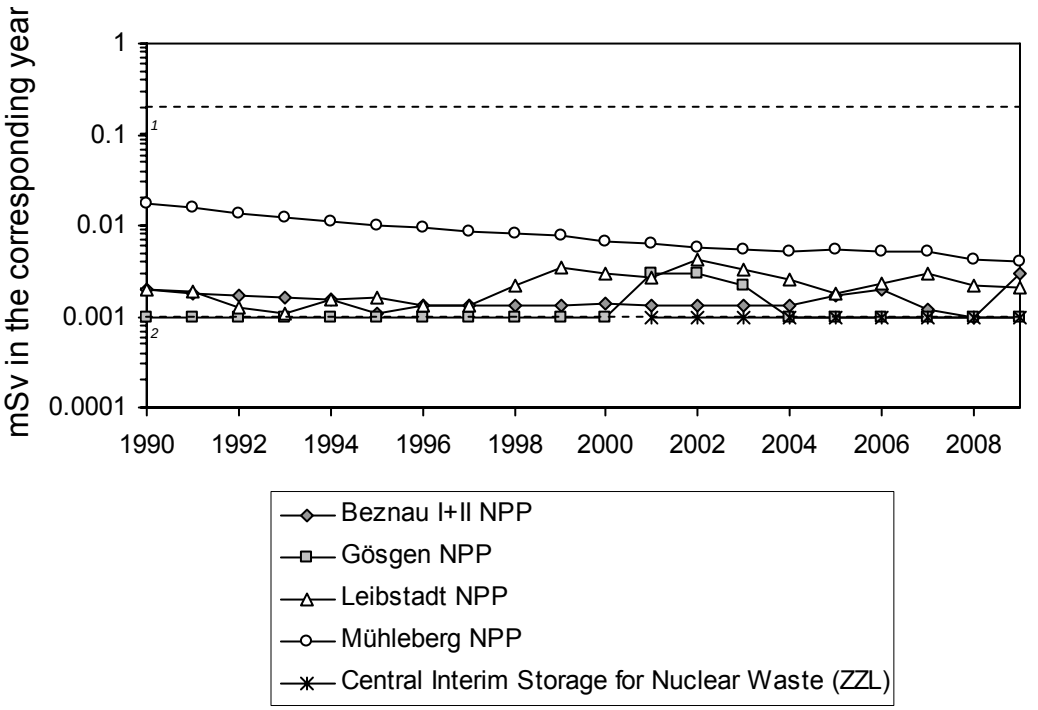

Figure 3: Doses calculated on the basis of annual emissions from Swiss NPPs and the central interim storage facility excluding direct radiation. The annual doses calculated relate to a virtual-most-exposed group of the population[3], including exposure due to deposits from previous years. The higher value for the Mühleberg NPP is the result of emissions of radioactive particles in 1986 (malfunction of the waste treatment system for dry resin).

[1] 0.2 mSv per year: source-related dose constraint minus direct radiation constraint

[2] Values below 0.001 mSv per year are not shown as such in Figure 3.

[3] Virtual person, permanently located at the main plume area, consuming all food produced locally and all drinking water from the river downstream of the NPP in question

To ensure that doses are kept low in as reasonable way as possible and reflecting the principle of optimisation, the ICRP recommends, in its Publication 75, the use of operational dose constraints based on estimated levels achievable from good practice. As a result, the Inspectorate's Guideline R-11 requires NPPs to determine dose planning objectives (e.g. max. individual doses or collective job doses) for its activities on the basis of the following:

- empirical values for comparable activities in its own or a comparable installation;
- current radiological situation;
- international experience;
- optimisation processes.

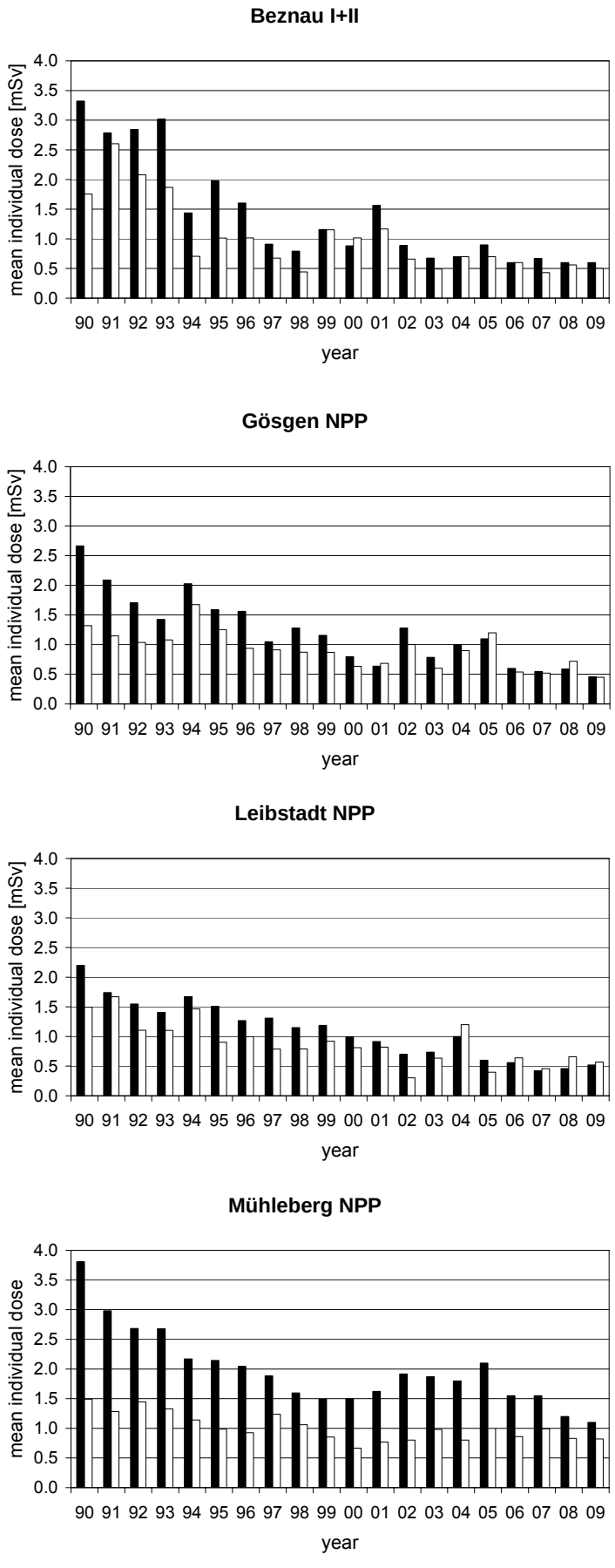

Figure 4: Mean individual dose for plant personnel (dark bars) and contractors (white bars) in Swiss NPPs.

Plant	Average collective dose during outage in last five years [person-mSv]	Main dose reduction measures
Beznau I and Beznau II NPPs	496	• temporary lead shielding (70 tons) • low dose rate areas for personnel (< 0.005 mSv/h) • individual acoustic dose and dose rate warning • strong emphasis on training and motivation • daily job-specific follow-up of doses vs. planning including intervention if necessary to keep the NPP-internal dose constraint of 10 mSv p.a. for workers • remote tools for primary system inspection • improved water chemistry, reducing fixation of colloids on primary system surfaces
Mühleberg NPP	898	• temporary lead shielding (85 tons) • permanent racks for supporting removable lead sheets • use of conveyor belt to transport the temporary lead shielding into the drywell • replacing components containing “Stellite” parts with components made from a cobalt-free alloy • daily follow-up of job specific actual doses vs. planning doses • Zn-64-depleted zinc feed in primary water • online noble chemistry (OLNC) primary water operation mode reduced dose rates in the recirculation pipes • no longer adding hydrogen to the primary water system some hours before the reactor is shut down for the outage
Gösgen NPP	635	• temporary lead shielding (25 tons) • highly compartmentalised containment with compartments made out of concrete • replacing the old isolation system with new isolation cassettes on the primary coolant tubes • daily follow-up of total and selected job specific actual doses vs. planning doses • extensive mock-up training • Zn-64-depleted zinc feed in primary water • shut-down procedure adapted to the specific current activity of the primary coolant water • decontamination of all three reactor coolant pumps

Plant	Average collective dose during outage in last five years [person-mSv]	Main dose reduction measures
Leibstadt NPP	661	• temporary lead shielding (32 tons) • temporary shielding with water bags • job tickets (bar code) with online follow-up • very detailed job planning for jobs implying collective doses > 50 person-mSv • job planning for jobs implying collective doses > 10 person-mSv • replacing components containing “Stellite” parts with components made from a cobalt-free alloy • Zn-64-depleted zinc feed in primary water • extensive mock-up training • online noble chemistry (OLNC) primary water operation mode reduced the dose rates in the recirculation pipes • no longer adding hydrogen to the primary water system some hours before the reactor is shut down for the outage • extensive camera system in the power house to reduce the number of tours around the plant

Table 3: Main dose reduction measures in Swiss LWRs

Under the Radiological Protection Ordinance, radiation protection is regarded as optimised if the following conditions are met:

- different possible solutions have been individually assessed and compared;
- sequence of decisions leading to a particular solution is traceable;
- due consideration to be given to the possibility of incidents and the safe storage of radioactive sources no longer in use.

In detail the Inspectorate requires:

- special quality management rules for the radiation protection department (see Article 13), including procedures for determining the dose planning objectives, the optimisation process, documentation and regulations on individual responsibilities;
- radiation protection planning (including determination of dose planning objectives) in compliance with internal procedures, if the anticipated collective dose for a planned activity in a nuclear installation leads to higher individual or collective doses than the planning thresholds set internally (typically 5, 10 or 20 person-mSv);
- a report addressed to the authority on radiation protection planning in the case of a planned shutdown or if the planned activity might result in an anticipated collective dose higher than 50 person-mSv.

The Inspectorate is required to examine dose planning objectives in detail, if the expected annual collective dose exceeds 1.5 person-Sv per NPP. In this case, the Inspectorate will require optimisation measures, as appropriate.

The NPP must compare actual doses with the dose planning objectives. If there is evidence of an obvious deviation, the activity must be stopped, plans revised and improvements made.

In all Swiss NPPs, waste water is collected and treated in batches. However, each NPP uses a different abatement technique for the treatment of waste water. At Beznau NPP, radioactivity in the waste water is reduced by centrifugation, chemical precipitation and nanofiltration. The Gösgen NPP uses evaporation, the Leibstadt NPP uses centrifugation and evaporation and the Mühleberg NPP uses centrifugation and ion exchange techniques.

Three NPPs in Switzerland – Gösgen, Leibstadt and Mühleberg – have offgas treatment systems which consist of catalytic recombiners, offgas-condensers, hold-up-lines, activated carbon filter columns, HEPA-filters and offgas pumps. The Beznau NPP has a system, which works with four pressurised hold-up-tanks. The NPPs have site-specific target values for liquid und gaseous discharges designed to keep doses for the general public low in a reasonable way and reflecting the principle of optimisation. To reduce iodine gaseous discharges, the Leibstadt NPP has added a filter to the gland seal system in the turbine building. The filter cleans the feed water used for producing the gland seal steam.

Every ten years, the licensee of each Swiss NPP is required to conduct a periodic safety review (PSR). As part of the PSR, the licensee must assess the liquid and gaseous discharges from the plant and benchmark them against the corresponding discharges from similar European reactors. As a result of this process, the Beznau NPP improved the abatement system for liquid discharges by using nanofiltration. Since 2007, liquid discharges from Beznau NPP have been less than 1 GBq per year.

The Mühleberg NPP conducted a periodic safety review in 2005. The Inspectorate assessed this review in depth and required the licensee to reduce the activity without tritium in the liquid discharges to less than 1 GBq per year until 2010 under restriction of commensurability. To achieve this, the licensee studied ways of reducing the quantity of waste water as well as separating different qualities of waste water for specific treatment. This work has resulted in a decrease in the activity released from 7 GBq in 2007 to less than 3 GBq in 2009.

Operating radiation protection organisation

To ensure that the radiation protection organisation is independent of the operation department of the facility, the licensee must comply with three requirements based on provisions in the Radiation Protection Act.

1. The licensee must provide a direct communication link between the authorised radiation protection expert and the licensee’s management representative.
2. The licensee must delegate responsibilities to the radiation protection experts allowing them to intervene in the operation of an NPP if rules on radiation protection are breached.

3. The licensee must provide adequate human resources for the radiation protection organisation. Its staff must consist of professionals with approved education and training. Tasks relating to radiation protection may only be carried out by these professionals.

A detailed description of these rules is part of the documentation that an NPP must provide before it is granted an operating licence. Changes to the NPP's radiation protection rules must be authorised by the Inspectorate.

Regulatory control activities

As mentioned above, the Inspectorate reviews the NPPs radiation protection planning process, typically before outages.

Inspections relating to radiation protection are concentrated on outage phases. These inspections focus mainly on activities with an anticipated collective dose greater than 50 person-mSv. Other routine inspections are performed during power operation and include radiation instrumentation, contamination control etc.

In addition, the Inspectorate reviews the periodic reports of the NPPs on radiation protection measures. The Inspectorate operates a computerised database containing radiological and chemical plant data which is updated monthly with data from licensees.

Environmental radiological surveillance

The Radiological Protection Act establishes the legal basis for the radiological surveillance of the environment. The Radiological Protection Ordinance and legislation on foodstuffs contain the basic requirements. For each NPP, the Inspectorate has issued plant-specific discharge and environmental monitoring directives. They contain the conditions relating to the control of discharges and a complete programme on the environmental monitoring of radioactivity and direct radiation in the vicinity of a facility. Under the Radiological Protection Ordinance, this programme must be drawn up by the Federal Office of Public Health in co-operation with the Inspectorate, the National Emergency Operations Centre and the cantons. The programme is reviewed annually and modified as necessary.

The Inspectorate defines requirements for measuring devices together with information on the measurements required. It monitors the correct maintenance of devices and audits the process of measurement accounting during annual inspections. In addition, it performs its own quarterly benchmark tests for each plant.

The environmental surveillance programme has three main aspects:

1. Measurement of emissions from the plant and comparisons between actual emissions and the limits set in the operating licence of the NPP: Limits are selected so that the dose for persons living in the vicinity of the plant remains well below the source-related dose constraint (see section "dose limits" above).
2. Calculation of the dose from measured emissions for persons subject to the most exposure and living in the vicinity of the NPP: There is a direct comparison between calculated values and the source-related dose constraint. The models and parameters used for the calculation are defined in the Inspectorate's Guideline G14.

3. Programme for the radiological surveillance of immissions: The Federal Office of Public Health monitors the environment nationally. In addition, the vicinity of NPPs is monitored by the NPPs and by the Inspectorate separately. The programme includes online measurements for the dose rate near plants (MADUK, see Article 16) together with regular sampling and measurements of air, aerosol fallout, water, soil, plants and foodstuffs.

The results are published in the Inspectorate's annual reports. A summary of the results of the full environmental radiological surveillance programme is also published in the annual report of the Federal Office of Public Health.

Developments and Conclusion

The annual collective doses cited for personnel in Swiss NPPs, the mean individual dose for plant personnel and contractors and the annual doses for a virtual-most-exposed group of the population cover the period up to and including 2009.

The comments also include the results of activities by licensees designed to keep discharges as low as reasonably achievable.

With the exception of an incident in 2009, when two workers received doses in excess of the national limit, Switzerland complies with the obligations of Article 15.

Article 16: Emergency preparedness

Clause 1: Each Contracting Party shall take the appropriate steps to ensure that there are on-site and off-site emergency plans that are routinely tested for nuclear installations and cover the activities to be carried out in the event of an emergency. For any new nuclear installation, such plans shall be prepared and tested before it commences operation above a low power level agreed by the regulatory body.

Prior to the start-up of a new NPP, on-site and off-site emergency plans must be established and approved by the Inspectorate. The general requirements for emergency preparedness are based on the following acts, ordinances, Inspectorate's guidelines and concepts:

Acts:

- Nuclear Energy Act;
- Radiological Protection Act.

Ordinances:

- Nuclear Energy Ordinance;
- Radiological Protection Ordinance;
- Ordinance on the Protection of the Population in the Vicinity of Nuclear Installations in the Case of an Emergency (Emergency Preparedness Ordinance);
- Ordinance on the Emergency Organisation in Case of Increased Radioactivity;
- Ordinance on Iodine Prophylactics in the Case of a Nuclear Accident;
- Ordinance on Alerting the Authorities and the Public;
- Ordinance on Foreign Substances and Food Contaminants.

Guidelines:

- Planning and execution of emergency exercises in Swiss NPPs (Guideline B11);
- Emergency protection in nuclear facilities (Guideline B12).

Concepts

- Concept for the emergency protection in the vicinity of nuclear power plants, Federal Commission for NBC Protection (2006).

On-site emergency organisation

Each NPP has plant-specific documents on emergency preparedness, which include the following:

- operating procedures for abnormal situations;

- emergency operating procedures;
- severe accident management guidance (SAMG);
- procedures for reporting to the Inspectorate and to the National Emergency Operations Centre;
- procedure for reporting to cantonal police for fast-evolving accidents.

The NPP's emergency preparedness documentation is reviewed regularly.

The introduction of SAMG programmes at Swiss NPPs started in 2001 and recently completed. All plants have appropriate validated guidance for the mitigation of severe accidents during full-power operation. Validation is the result of emergency exercises at which the Inspectorate is an observer. The Beznau and Leibstadt NPPs (Westinghouse PWR/GE BWR) decided to follow the SAMG approach adopted by the owners' group (WOG/BWROG), whereas the Mühleberg NPP (GE BWR) and the Gösgen NPP (Siemens KWU PWR) developed new concepts. In addition to the full-power SAMG, all plants have developed special guidance for low power/shutdown conditions.

To ensure communication in an emergency, there are dedicated telephone and fax lines between the NPPs, the Inspectorate and the National Emergency Operations Centre. These communication systems are tested once a month.

Off-site emergency organisation

The off-site emergency organisation is based on resources built up as part of the general protection concept developed for the Swiss population as a whole. They consist of a well-developed shelter infrastructure and well-trained troops for fire and disaster intervention. In the event of a radiological emergency the Emergency Organisation Radioactivity (EOR) co-ordinates civil and military support at federal and regional levels.

The legal basis for the EOR is contained in the Ordinance on the Emergency Organisation in Case of Increased Radioactivity. The link to the Federal Council (government) is through the Steering Committee on Radioactivity consisting of the directors of the relevant federal offices. The EOR runs a stand-by emergency service, the National Emergency Operations Centre, which is responsible for alerting and informing the public and for initiating early countermeasures in the event of a radiological accident. The Ordinance on the Emergency Organisation in Case of Increased Radioactivity is currently being revised to include chemical, biological as well as natural risks. The new Ordinance is scheduled to come into effect in 2011.

The major organisations involved in emergency preparedness have the following responsibilities:

- NPPs are responsible for detecting and assessing an accident, for implementing on-site countermeasures to control it and for disseminating information immediately and continuously to the relevant off-site authorities.
- The Inspectorate is responsible for judging the adequacy of on-site countermeasures implemented by NPP staff. The Inspectorate also advises the National Emergency Operations Centre on potential off-site radiological effects on the public.

  An automatic dose rate monitoring and emergency response data system (MADUK/ANPA) has been installed around all NPPs in Switzerland. The system

monitors dose rates continuously at 12 to 17 locations in the vicinity of each NPP. The data is transmitted online to the Inspectorate and the National Emergency Operations Centre. The Ministry of the Environment of Baden-Württemberg (Germany) receives online data from the dose rate monitors in the vicinity of the Beznau NPP and Leibstadt NPP. All data is also available on the Inspectorate's website (www.ensi.ch).

The MADUK/ANPA system also provides the Inspectorate with online access to measurement data for about 25 important plant parameters. The Inspectorate uses special software – the Accident Diagnostics, Analysis and Management system ADAM – to visualise these measurements, diagnose the state of the plant and simulate the development of potential accidents in future.

The Inspectorate has set up an automated system for radiological prognosis. Calculations are performed hourly using the ADPIC-Dispersion code (Monte-Carlo) with actual and forecast meteorological data. The results of these calculations are also made available to the National Emergency Operations Centre and the responsible authorities in Germany. In the event of an accident, the radiological impact on the basis of available source term is calculated within about 30 minutes.

- The National Emergency Operations Centre is responsible for the transmission of warnings and alerts to the cantonal authorities and also for initial countermeasures to protect the population. The National Emergency Operations Centre is responsible for coordinating measurement teams, data processing and evaluation, for assessing the radiological situation and for informing and communicating with international partners.
- The Steering Committee on Radioactivity is responsible for suggesting appropriate measures to the Federal Council (government) who then issues the associated instructions to cantonal authorities and the general population.
- The cantonal and communal authorities are responsible for executing protective countermeasures for the public.
- The medical service of the Swiss army is responsible for the pre-distribution of iodine tablets to those living in Zones 1 and 2.
- The canton where the NPP is located is responsible for informing its citizens of the potential consequences of an accident in a facility and providing advice on how to respond in an emergency.

In the event of an accident, information is disseminated to the media by the above authorities in line with their individual responsibilities.

Emergency planning zones

Under the Emergency Protection Ordinance (currently being revised), each NPP in Switzerland has three distinct emergency planning zones:

- Zone 1 is the area around an NPP in which there could be acute danger to the public in the event of an accident and so for whom immediate protective measures are required. Depending on the NPP's power rating and the exhaust height of its stack, Zone 1 covers a radius of about 3 – 5 km.

- Zone 2 adjoins Zone 1. It encloses an area with an outer radius of about 20 km and is divided into 6 overlapping sectors. The public can be alerted in individual sectors as appropriate.
- The rest of Switzerland, (outside Zones 1 and 2) is referred to as Zone 3. It is not expected that measures would be necessary to protect the public in Zone 3 during the passage of a radioactive plume. It is assumed that the measures actually required could be implemented without detailed pre-planning.

The outer border of Zones 1 and 2 generally follow the boundaries of the relevant municipal authorities.

Emergency protective measures

The primary objective of emergency protective measures in the vicinity of NPPs is the prevention of acute radiation sickness resulting from the accidental release of radioactive materials. In addition to this primary objective, emergency protective measures are designed to minimise the prevalence of long-term, genetic radiation damage.

Protective measures designated for the general public are based on the Concept of emergency reference levels as a function of the dose quoted in the Ordinance on the Emergency Organisation in Case of Increased Radioactivity. This Concept describes the protective measures to be considered (see Table 4). There is an upper dose and lower dose intervention level for each potential protective measure. If the expected dose is above the lower intervention level, optimised protective measures reflecting negative side-effects are required. However, if the expected dose is above the upper intervention level, the corresponding protective measure must be taken.

Protective measures	Dose acquired in the first year after the accident	Lower dose intervention level	Upper dose intervention level
Stay indoors	Effective dose from external radiation and inhalation	1 mSv	10 mSv
Stay inside cellars or shelters	Effective dose from external radiation and inhalation	10 mSv	100 mSv
Evacuation	Effective dose from external radiation and inhalation	100 mSv	500 mSv
Take iodine tablets	Thyroidal dose from inhalation of radioactive iodine	30 mSv	300 mSv
Restrictions on certain foodstuffs	Effective dose from ingestion	1 mSv	20 mSv

Table 4: Intervention levels

The Concept of emergency reference levels as a function of dose is currently being revised.

In addition, the Ordinance on Foreign Substances and Food Contaminants contains limits and tolerance levels for foodstuffs. The limits correspond to the maximum permitted levels of radioactive food contamination under EURATOM regulations.

The protective measures applied during the cloud phase must be planned so that they can be implemented as a preventive measure in the initial phase of an accident. During the cloud

phase, the primary measures include sheltering, taking of iodine tablets and possibly evacuation before any release. They reflect the following:

- The solid construction of houses in Switzerland and the high availability of private and public fallout shelters and shelter in houses, cellars or fallout-shelters mean that in most cases sufficient protection is provided against the radioactive cloud shine in the cloud phase of an accident. This is considered, therefore as the most important protective measure. In order to prevent infiltration of radioactive material, windows and outside doors should be closed and air-conditioning systems turned off.
- Iodine tablets are distributed to all houses, schools and companies in Zones 1 and 2. In Zone 3, tablets are stored by the cantons so that they are available to the general public within 12 hours.
- Evacuation of some members of the population (especially in Zone 1) during the initial phase of an accident will be considered provided that no release of radioactive materials is expected during the evacuation period.

Protective measures during the ground phase are based on the actual radiological situation in the environment as indicated by measurement data. Important protective measures are: staying indoors, evacuation after the cloud passage, restricted access to certain areas, restrictions on certain foodstuffs, countermeasures for agriculture, decontamination and medical support.

Alert procedures

If an accident occurs, the NPP is required to inform the Inspectorate and the National Emergency Operations Centre immediately. If the accident poses a threat to the public and the environment, this triggers a three-stage warning and alert procedure. To be effective, measures to protect the public should be taken before any radioactivity is released from the plant. Therefore, the warning and alert criteria are based primarily on the situation in the NPP.

- A **warning** is issued at the latest when a high dose-rate is monitored inside the containment. The warning (by telephone) puts federal, cantonal and municipal organisations (within Switzerland) on stand-by for a possible alert. The National Emergency Operations Centre informs the IAEA and authorities in neighbouring countries. It also activates the hotline operated by a professional medical call centre.
- The first **alert** is by siren if an accident develops in such a way that it might lead to a dangerously high release of radioactive materials into the environment. This alert ensures that the population at risk is aware of the emergency situation, so that it can prepare to take countermeasures. Instructions are given over the radio.
- Further **alerts** are issued if necessary in order to give advice to the population on taking iodine tablets, staying indoors, using shelters, etc.

Swiss telephone books contain information on the siren signal and its significance.

Special regulations exist for the initiation of countermeasures in the event of an accident involving auxiliary systems such as off-gas systems. They are required because releases may occur rapidly with such accidents. In this case, the NPP assesses the dose to the public. The decision to alert the public depends on the time available and the amount of any release. If the annual limit for the release of noble gases (10^{15} Bq) is likely to be released in less than 1 hour, which would result in a dose in the immediate vicinity of a plant of about 1 mSv, sirens will alert the

public located in the Emergency Planning Zone 1. The public will be advised to stay indoors for the next few hours. The NPP initiates the action and the cantonal police (responsible for countermeasures in Emergency Planning Zone 1) initiate the alert without waiting for an order from the National Emergency Operations Centre.

Emergency exercises

Emergency training is checked periodically during the emergency exercises to be conducted annually by each NPP (Inspectorate's Guideline B11). Every two years, there is a combined exercise in order to practice co-operation between the various teams and co-operation with external organisations. In addition, every emergency team in a plant, e.g. fire brigade, must conduct its own exercises.

Clause 2: Each Contracting Party shall take the appropriate steps to ensure that, insofar as they are likely to be affected by a radiological emergency, its own population and the competent authorities of the States in the vicinity of the nuclear installation are provided with appropriate information for emergency planning and response.

All those living in the vicinity of Swiss NPPs have been sent a leaflet from the cantonal authorities describing the potential dangers associated with a nuclear accident. The leaflet also explains existing countermeasures to cope with the consequences. The procedure for warning and alerting population in case of accidents is described in Clause 1 of this Article.

Switzerland is party to the Convention on Early Notification and the Convention on Assistance. Switzerland has bilateral agreements covering notification and information exchange in case of a nuclear accident with its neighbours. Although Switzerland is not member of the European Union, it is part of the European Community Urgent Radiological Information Exchange Network ECURIE. The National Emergency Operations Centre is responsible for the notification process and for providing the necessary information. Switzerland also participates in the INES reporting network and has undertaken to report all events rated as Level 2 or higher. If an incident occurs in an NPP, reporting is the responsibility of the Inspectorate. For other radiological incidents, it is the Federal Office of Public Health.

Because the Leibstadt and Beznau NPPs are close to the national border, special plans have been agreed with Germany. These plans are designed to ensure the same level of protection on both sides of the border for the public and the environment. They also seek to harmonise procedures. Dedicated telephone lines exist for communication between authorities. Plans and procedures are updated regularly by bilateral working groups as part of the German-Swiss Commission for the Safety of Nuclear Installations.

In case of an accident in an NPP, long term consequences may extend beyond planning zones and so Switzerland has intensified its collaboration with France and Austria. For France, an expert group on nuclear emergency matters has been set up as part of the "Commission Franco-Suisse". For Austria, there is a yearly exchange of information.

Emergency plans are not only tested at the national level. German authorities at both the local and federal level take part in exercises at the Leibstadt and Beznau NPPs. The most recent exercise took place in 2005. The next exercise with international participation is scheduled for

2011. Switzerland participates in exercises at the French NPPs of Fessenheim and Bugey, which are located some 30 km and 70 km from the Swiss border respectively.

The preparedness of Switzerland and its response at the international level is regularly verified by its participation in international exercises conducted by the IAEA or ECURIE. The OECED/NEA INEX exercises are another opportunity to verify certain aspects of emergency management. Switzerland usually participates in these exercises.

Emergency plans and procedures must be regularly improved and adapted to reflect new challenges and changing situations. Experts from several Swiss authorities take an active part in these activities. Recently, Switzerland supported the IAEA international action plan for strengthening the international preparedness and response system for nuclear and radiological emergencies. A representative of the National Emergency Operations Centre chaired the working group on International Communications and was a member of the working group on the Long Term Sustainability of Emergency Preparedness and Response Programmes, which concluded its work at the end of 2009.

Finally, in order to improve the emergency response system at the national and international level, members of the Inspectorate and the National Emergency Operations Centre actively support the activities of the OECD/NEA working party on Nuclear Emergency Matters.

Clause 3: Contracting Parties which do not have a nuclear installation on their territory, insofar as they are likely to be affected in the event of a radiological emergency at a nuclear installation in the vicinity, shall take the appropriate steps for the preparation and testing of emergency plans for their territory that cover the activities to be carried out in the event of such an emergency.

This Clause does not apply to Switzerland.

Developments and Conclusion

Several ordinances relating to emergency preparedness are currently being revised: the Ordinance on Emergency Preparedness, the Ordinance on the Emergency Organisation in the Case of Increased Radioactivity, the Ordinance on Alerting the Authorities and the Public, the Ordinance on the National Emergency Operations Centre. On completion of this revision, there will be a single intervention level for each measure planned for protecting the population.

The Guideline B12 on emergency protection in nuclear facilities has been published. All plants have developed a SAMG applicable to both full-power operation and low-power and shutdown conditions.

Switzerland complies with the obligations of Article 16.

Article 17: Siting

Clause 1: Each Contracting Party shall take the appropriate steps to ensure that appropriate procedures are established and implemented for evaluating all relevant site-related factors likely to affect the safety of a nuclear installation for its projected lifetime.

Under the Nuclear Energy Act and the Nuclear Energy Ordinance, a general licence for a nuclear installation can only be granted if the site is suitable. The procedures for granting a general licence and the associated requirements are discussed in the chapter on Article 7.

The Nuclear Energy Act contains a list of conditions governing the issue of a general licence. The first two are that humans and the environment must be protected and the granting of a licence does not conflict with other provisions of federal legislation, in particular legislation on environmental protection, preservation of the local natural and cultural heritage and the area development plan.

Under the Nuclear Energy Ordinance, the following reports must be submitted with the application for a general licence:

- a safety analysis report (SAR);
- a security report;
- an environmental impact report;
- a report on compliance with area planning requirements;
- a concept for decommissioning;
- a report on the management of the resultant radioactive waste.

When evaluating the suitability of a potential NPP site, it is necessary to assess protection against external hazards, including earthquakes, flooding, accident-induced civil or military aircraft crashes, extreme weather conditions (including winds, tornados, and lightning), shock waves, fire, interruption to or failure of external cooling water or power supply. The site-related external hazards are defined in the Ordinance on Hazard Assumptions and Evaluation of Protection Measures against Accidents in Nuclear Installations. The SAR must include all relevant factors relating to the site (natural characteristics and human activities), in particular:

- geology, seismology, hydrology (including flooding and ground water) and meteorology;
- population distribution, neighbouring industrial plants and installations;
- anticipated exposure to radiation in the vicinity of the facility;
- routes and frequency of transport by air, waterways and land.

During the licensing procedure, the Inspectorate evaluates the site-related factors likely to affect the safety of a nuclear installation and produces a safety evaluation report (SER) in which it defines, if necessary additional requirements for plant design.

Before the construction of an NPP, the Federal Office of Public Health and the Inspectorate establish a programme for radiological surveillance in the vicinity of the NPP. The programme in-

cludes sampling and the measurement of air, water, soil and foodstuffs. The first set of data is collected before an NPP is commissioned and this is then used as a baseline when investigating the effects of an NPP after commissioning.

Specific siting criteria do not exist. However, the relevant safety factors must be evaluated whenever there are plans to build a new feature (e.g. gas pipeline or industrial building) in the vicinity of an NPP. The Inspectorate is basing its assessment of the current applications for licences for new NPPs largely on the existing IAEA guidelines for siting, e.g. IAEA Safety Requirements NS-R-3 and Safety Guide NS-G-3.3.

Clause 2: Each Contracting Party shall take the appropriate steps to ensure that appropriate procedures are established and implemented for evaluating the likely safety impact of a proposed nuclear installation on individuals, society and the environment.

Switzerland is a small and densely populated country. The number and size of suitable sites for NPPs are limited. The concept of safety by distance encounters natural limitations in Switzerland. However, existing NPPs are sited in areas where population density is relatively low compared with the mean for industrialised regions in Switzerland. New NPPs are planned in the vicinity of existing sites.

When an application is made for a construction licence, the applicant must submit an updated SAR, a deterministic safety analysis (which can be part of the updated SAR) and a probabilistic safety analysis (PSA).These documents evaluate the likely safety impact of the NPP on individuals, society and the environment as described in Article 14. The Inspectorate reviews these documents and publishes the results in a SER.

The Nuclear Energy Ordinance contains requirements relating to measures designed to prevent accidents initiated either within or outside the facility. For the purposes of the deterministic safety analysis, the Radiation Protection Ordinance gives dose constraints for the public during normal operation and for design-basis accidents. On the basis of this, the Inspectorate defines actual dose limits in Guideline R-11 for normal operation and in Guideline R-100 for transients and accidents. Dose constraints are ranked as a function of incident frequency. The Inspectorate's Guideline G-14 (see Article 15) specifies the methodology and boundary conditions for dose assessments in normal operation for the public from radionuclide transfer and for accident analysis. For the purposes of the PSA, the Nuclear Energy Ordinance demands that the mean core damage frequency for any newly constructed NPP is not greater than 10^{-5} per year.

Clause 3: Each Contracting Party shall take the appropriate steps to ensure that appropriate procedures are established and implemented for re-evaluating as necessary all relevant factors referred to in subparagraphs (1) and (2) so as to ensure the continued safety acceptability of the nuclear installation.

When re-evaluating the relevant factors, the procedure is basically the same as that applied to the initial review and assessment (see Clauses 1 and 2 above). Because the reporting procedures applicable to power plants include the relevant site factors, any modifications to these factors are known (e.g. creation of a new industrial plant in the vicinity of the NPP). The notification by the licensee of such modifications normally includes an assessment of their possible

consequences. Site-related factors are re-evaluated as part of the PSR and in particular the SAR and the PSA are reviewed (including the deterministic safety analysis).

In essence, the re-evaluation processes help to ensure the continued safety acceptability of the NPP as it confirms the validity of earlier assessments or indicates the impact of changes to site-specific safety factors. The applicability and effectiveness of the Inspectorate's re-evaluation process are illustrated by the probabilistic reassessment of seismic hazards at Swiss NPP sites (the PEGASOS project and the PEGASOS Refinement Project):

The large-scale project PEGASOS – a German acronym for "Probabilistic Assessment of Seismic Hazards for Swiss Nuclear Power Plant Sites" – was carried out by Swiss licensees in response to a requirement that came out of the Inspectorate's PSA review process. In order to achieve a thorough quantification of the uncertainty of seismic-hazard estimates, an extensive elicitation process was conducted involving technical experts, scientific institutions and engineering organisations from Europe and the USA. The complete project report was released in 2006 at an OECD specialists' meeting in Korea. A summary report in German can be downloaded from the Inspectorate's homepage.

In 2008, Swiss licensees initiated a follow-up project, the PEGASOS Refinement Project (PRP). The project takes advantage of the most recent findings in earth sciences and new geological and geophysical investigations at Swiss NPP sites. A particular objective is to reduce the uncertainty range of the PEGASOS results. As with the PEGASOS project, the PRP seeks primarily to characterise seismic sources, ground motion attenuation on rock and the local soil response at the NPP sites. In 2009 the scope of the PRP was extended to include the sites for the proposed new Swiss NPPs. The Inspectorate is following the study closely through a system of continuous peer reviews similar to that for PEGASOS. It is expected that PRP will run until 2012. The projects PEGASOS and PRP follow the state of the art of the Senior Seismic Hazard Analysis Committee (SSHAC) level 4 methodology.

Based on the PEGASOS insights, the Inspectorate increased the level of seismic hazards level to be assumed for PSA studies. Higher hazard assumptions are also used for the design of new safety-related structures and components. Furthermore, in the context of the continuous backfitting process undertaken by Swiss NPPs, the Inspectorate places particular emphasis on seismic safety. In addition to the major seismic backfitting projects completed in the past (e.g. installation of bunkered emergency systems), the components and structures backfitted in recent years include electrical cabinets, motor control centres, cable trays, diesel-oil day tanks, pipe runs, control room bracing and masonry walls.

Clause 4: Each Contracting Party shall take the appropriate steps to ensure that appropriate procedures are established and implemented for consulting Contracting Parties in the vicinity of a proposed nuclear installation, insofar as they are likely to be affected by that installation and, upon request providing the necessary information to such Contracting Parties, in order to enable them to evaluate and make their own assessment of the likely safety impact on their own territory of the nuclear installation.

The population in areas surrounding a proposed NPP (including areas in neighbouring countries) is included in the comprehensive public consultation conducted during the licensing procedure.

Switzerland has signed agreements on the exchange of information with Austria, France, Germany and Italy.

The German-Swiss Commission for the Safety of Nuclear Installations, including its working groups, and the Franco-Swiss Nuclear Safety Commission meet annually to consult and exchange information and experience. They also define the terms of reference for individual working groups, e.g. exchange of operational experience, emergency protection planning and exercises, radiation protection, surveillance of ageing and waste disposal.

In addition, representatives from Austria and Switzerland meet annually to share information on nuclear programmes, operational experience in nuclear installations and the legislative framework for nuclear safety and radiation protection.

Developments and Conclusion

Changes and developments: The comments on Clause 1 describe the new requirements for site-related external hazards as defined in the Ordinance on Hazard Assumptions and Evaluation of Protection Measures against Accidents in Nuclear Installations and reflect how they are specified in the current guidelines. The comments on Clause 3 provide an update on the reassessment of seismic hazards at Swiss NPP sites (projects PEGASOS and PRP).

Switzerland complies with the obligations of Article 17.

Article 18: Design and construction

Clause 1: Each Contracting Party shall take the appropriate steps to ensure that the design and construction of a nuclear installation provides for several reliable levels and methods of protection (defence in depth) against the release of radioactive materials, with a view to preventing the occurrence of accidents and to mitigating their radiological consequences should they occur.

The design and construction of Swiss NPPs are based on US standards (Beznau I and II, Mühleberg, Leibstadt) and German standards (Gösgen) that applied at the time of construction. The standards used are still internationally and incorporate the principle of defence in depth. The various levels of defence ensure that the NPP remains within safety limits in the event of a design-basis accident and that individual dose limits for the general public are not exceeded (see also Article 14). In addition, systems exist to prevent or at least limit the release of radioactive materials into the environment in the event of a severe accident beyond a design-basis accident. Severe Accident Management Guidance (regarded as an element of defence) exists in all Swiss NPPs (see Article 16) for mitigating accidents beyond design-basis accidents.

The design and construction of Swiss NPPs were thoroughly assessed as part of the **licensing procedure**. The results of this assessment are part of the safety evaluation report (SER) and play an important role in licensing decisions (see Articles 7 and 14). In compliance with the IAEA Safety Standard NS-R-1, Switzerland included design requirements in Article 10 of the Nuclear Energy Ordinance and the Inspectorate's Guideline R-101. Appendix 2 contains a list of other important guidelines published by the Inspectorate for the licensing process.

After a licence has been granted, the design and construction of existing NPPs are reassessed periodically. An in-depth review comparing the actual design and the current state of science and technology is performed at least every 10 years (PSR, see Article 14). This identifies deficiencies in the NPP compared with the current state of science and technology. If they have a major safety impact, they must be addressed and remedied by appropriate backfitting.

The **first generation** of Swiss NPPs (Beznau I and II, Mühleberg) were constructed using designs from the late 1960s and before the establishment of the general design criteria (GDC, in 1972, by the US Atomic Energy Commission – now the US-NRC). A comparison between the design of first-generation NPPs and the GDC revealed that the main design criteria had been recognised and incorporated. These NPPs also included several unique design features, which were not standard at the time of construction:

- double containment (free-standing leak-tight steel plus concrete outer shell);
- load rejection and turbine trip without scram;
- continuous emergency power supply from a nearby hydro-electric plant;
- ground water as emergency feedwater system (Beznau NPP);
- doubled containment size in relation to reactor power (Mühleberg NPP);
- hilltop reservoir to flood the core (NPP Mühleberg);
- outer torus (NPP Mühleberg).

However, three important deficiencies were identified:

- insufficient protection from external events of natural origin, especially earthquakes and flooding;
- insufficient protection from man-made external events, e.g. aircraft crash;
- lack of separation of safety-relevant systems.

The seismic risk for first-generation NPPs was established on a deterministic basis by experts from the utilities in the mid 1960s. Since 1974, the basis of the seismic design for NPPs is the Safe Shutdown Earthquake and the Operating Basis Earthquake. The former is defined as an earthquake with a peak horizontal acceleration at the rock surface of 0.15 g corresponding to a median frequency of about 10^{-4}/year (based on the seismic risk map developed in 1977 by the Inspectorate's experts). The seismic hazard was reassessed as part of the PEGASOS project (see Article 17, Clause 3), which applied state of the art probabilistic methods. Based on the insights gained in the first project phase (completed 2004), the Inspectorate increased the seismic-hazard level to be applied to the PSA. The results of the revised Seismic PSA triggered seismic backfitting projects in all Swiss NPPs. There is currently a follow-up project looking at reducing the uncertainty range of the PEGASOS results – the PEGASOS Refinement Project (see Article 17, Clause 3). This project may lead to modifications in design requirements.

As Switzerland is a mountainous country with hundreds of dams, the most probable cause of the flooding of first-generation NPPs is a dam break. This could result in the loss of hydro-electric emergency power at the NPP. The impact of external flooding has been analysed on a deterministic basis, assuming a sudden dam collapse. To mitigate flooding effects, special equipment has been installed at the NPPs. For instance, at Beznau NPP there are special diesel generators and auxiliary feedwater pumps in flood-proof areas; Mühleberg NPP has installed a flood-proof diesel generator and there is a hilltop reservoir, which could be manually aligned to the plant to flood the core. Originally, only the reactor building was designed as flood-proof. However, the backfitted shutdown and residual heat removal systems for the Mühleberg and Beznau plants (SUSAN and NANO projects, see Article 6) are both installed in flood-proof buildings.

The Beznau NPP has been in operation for 40 years. In order to ensure its safe long-term operation, the hydro-electric emergency power supply will be replaced by an additional state-of-the-art emergency diesel generator system. This backfitting project will be completed in 2014.

In conclusion, all first generation NPPs have completed or are completing a comprehensive analysis and backfitting programme and improvements have been made. The backfitting projects include the addition of one or two completely separated shutdown and residual heat removal systems. NPPs are protected against external events (see Article 6), so that they can cope with external events where no operator action is guaranteed. This includes support systems (see Article 6) which can function without operator action during the first 10 hours.

The **second-generation** plants were based on US and German design criteria. In contrast to the first-generation plants, the design of second-generation plants included protection against aircraft crashes (see below).

The sites for the second-generation plants (Leibstadt NPP and Gösgen NPP), were selected so that they could not be flooded by an upstream dam break. Special measures were taken with regard to the loss of cooling water. Both plants have special well-water sources to cope with the loss of normal water intake from the rivers. Leibstadt NPP has three (small) cooling towers as an emergency heat sink should there be a loss of cooling water. With regard to external events

and third party intervention, the US design of the Leibstadt NPP had to be adapted to specific Swiss requirements. In accordance with the Inspectorate's Guideline R-101, a special emergency heat removal system using groundwater as an ultimate heat sink was incorporated in the plant design during the construction period. In addition, a steel construction was installed at the interface between the nuclear and turbine islands to protect the nuclear island from the effects of multiple pipe breaks in the turbine island, which has a lower seismic level. At Gösgen NPP, a special emergency heat removal system, again using groundwater as an ultimate heat sink, was included in the original design. In 2005, it installed the systems and equipment necessary for a primary feed and bleed in accident conditions.

To mitigate the radiological effect on the environment in the event of a severe accident, a filtered containment venting system was backfitted in all Swiss NPPs in the early 1990s at the request of the regulatory body. The main design criteria are:

- capacity in decay heat ≈ 0.5% for PWRs and ≈ 1% for BWRs;
- active venting by a valve;
- passive venting by a rupture disc.

Following the terrorism attacks on the World Trade Centre on 11 September 2001, the Inspectorate required Swiss NPPs to carry out safety analyses covering a deliberate aircraft impact. Analyses showed that the safety-relevant buildings in the second-generation of NPPs at Gösgen and Leibstadt would provide complete protection if hit by a modern, fully-fuelled, long-range commercial aircraft. The first-generation NPPs at Beznau and Mühleberg were not designed for such scenarios. Nevertheless, the analyses showed that an adequate level of protection against aircraft impact existed as a result of the earlier backfitting of special decay heat removal systems and the implementation of further of fire protection measures.

Clause 2: Each Contracting Party shall take the appropriate steps to ensure that the technologies incorporated in the design and construction of a nuclear installation are proven by experience or qualified by testing or analysis.

The design, materials and components are subject to rigorous control and scrutiny and regular testing to verify their fitness for service. Swiss NPPs are legally obliged to comply with the current state of science and technology and this ensures that technology incorporated in the construction are proven by experience or qualified as suitable by testing or analysis.

All four NPPs used the US ASME-Code for the design of the primary circuit, containment, and safety systems. The Inspectorate also required the Gösgen NPP – of German design – to comply with the ASME-Code.

The Swiss SIA-Code was used for civil engineering purposes. For faulted loads, e.g. loss of coolant accidents, earthquakes, and aircraft crashes, the design incorporated special load combinations with special safety factors. The Inspectorate required and reviewed common, updated concepts for the fastening of installations and for the gearings in concrete structures. These apply to all Swiss NPPs.

The various systems, structures and components (SSCs) are classified in accordance with internationally recognised Nuclear Safety Classes. These classifications reflect their relevance to safety. Safety-classified components must fulfil high requirements in terms of design, materials, fabrication processes, maintenance and inspection. Nevertheless, some material and design

deficiencies have appeared over time. The following paragraphs describe major examples of deficiencies, together with steps taken by the Swiss NPPs to control, eliminate or mitigate them:

- In the late 1960s, the nickel-based material Alloy 600 was used extensively in the primary circuits of NPPs. Its manufacturing, corrosion and mechanical properties appeared favourable for the then operating conditions and service requirements. However, despite earlier experience, this material suffered from stress corrosion cracking in the LWR coolant environment. In Switzerland, the steam generator tubing at the Beznau I and II NPP experienced stress corrosion cracking after only a few years in service. After years of sleeving and plugging, the problem was resolved by replacing the steam generators (at Beznau I in 1993 and Beznau II in 1999). The new steam generators contain tubing material that is much more resistant to stress corrosion cracking.
- Plans are being prepared for the preventive replacement of reactor vessel heads at Beznau I and II in order to eliminate more Alloy 600 material, although operating experience has not identified signs of stress corrosion cracking.
- Stainless steel was used for the re-circulation piping in the Mühleberg BWR NPP. This was normal practice and in line with the standards for this type of component. However, after 14 years in service, as at other BWRs of a similar design and construction, certain areas of the welds developed stress corrosion cracking. The issue has been addressed by replacing the re-circulation piping with improved material.
- In 1990, after 18 years of operation, the Mühleberg NPP was the first BWR worldwide to report horizontal cracks in the stainless steel core shroud welds. These were discovered during the annual in-service inspection. Until then, stainless steel (Type 304) had been deemed adequate for this application. However, the special water chemistry and the fabrication methods used result in the long-term development and growth of cracks. The design of the core shroud does not allow a simple replacement. As a precautionary measure, tie rods have been put in place. Even if there were full circumferential separation of the core shroud welds, these tie rods would hold the core shroud together and in place. This would ensure that the core itself would remain undamaged. About 30 BWRs are now reporting core shroud cracking. In 2000, NPP Mühleberg introduced hydrogen water chemistry and noble metal chemical addition to protect the reactor internals against stress corrosion cracking. In 2005, the injection method was modified to OnLine NobleChemTM. Measurements of crack lengths in 2007 and 2009 confirmed a considerable reduction in the rate of crack growth for most cracks. Nevertheless, further maintenance of the core shroud will be performed to reduce stress corrosion cracking in order to ensure long-term operation.

Article 14 describes the strategies for managing ageing problems as an integral part of a comprehensive ageing surveillance programme.

For the proposed third-generation plants, the Inspectorate will ensure that applicants consistently apply the latest regulatory basis and state of science and technology.

Clause 3: Each Contracting Party shall take the appropriate steps to ensure that the design of a nuclear installation allows for reliable, stable and easily manageable operation, with specific consideration of human factors and the man-machine interface.

As mentioned in the comments on Clause 1 of this Article, Swiss NPPs were constructed using US or German designs and therefore met the requirements of these countries for reliable, stable and easily manageable operation, as well as the requirements in terms of human factors and the human-system-interface.

However, in NPP control rooms – the most important element of the human-system-interface, – all Swiss NPPs have made improvements compared with the original design (see also Article 12). They have introduced computerised process visualisation techniques, including for abnormal conditions in order to facilitate operational control. The degree of automation has been increased to reduce the need for manual action for 30 minutes in the event of a design-basis accident and for 10 hours in the case of an external event.

The Beznau NPP has installed two computerised systems to improve the human-system-interface. The first is a computerised alarm system with a prioritisation scheme for displaying important messages with a safety function. The second is a computerised system for emergency operating procedures (EOPs) based on the printed EOPs. This system guides the shift supervisor step-by-step through the EOPs. Printed EOPs are available in case there are computer failures. The Inspectorate required the plant to perform a verification and validation programme for the two computerised systems as part of exercises on a full-scope simulator. The plant was also required to resolve any human engineering discrepancies identified. The Inspectorate closely monitored these activities.

The Mühleberg NPP has introduced a computerised visualisation system, including a safety parameter display system (SPDS) to support operating staff and to improve the display of plant data.

The Leibstadt NPP installed an SPDS shortly after it started commercial operation. The Gösgen NPP recently introduced a SPDS.

Developments and Conclusion

Currently, additional work is being done to redefine the seismic design requirements (see Article 17, Clause 3).

Switzerland complies with the obligations of Article 18.

Article 19: Operation

Clause 1: Each Contracting Party shall take the appropriate steps to ensure that the initial authorisation to operate a nuclear installation is based upon an appropriate safety analysis and a commissioning programme demonstrating that the installation, as constructed, is consistent with design and safety requirements.

All five Swiss NPPs have valid operating licences granted in accordance with the law. The initial operating licence includes the commissioning licence. Essentially, the granting of an operating licence is based on the following elements:

- an extensive set of technical and organisational documents as specified in Appendices 3 and 4 of the Nuclear Energy Ordinance and submitted by the applicant with the formal application;
- a safety evaluation report by the Inspectorate;
- proof of insurance;
- report that plant conforms with the general licence and construction licence.

The Federal Nuclear Safety Commission may comment on the Inspectorate's safety evaluation report. The licensing procedure is described in the chapter on Article 7.

The operating licence includes authorisation for commissioning. The commissioning programme must be approved by the Inspectorate and consists of pre-operating and start-up tests as well as procedures for testing all equipment important for safety. The licensee conducts a design review to verify that the "as built state" properly reflects the proposed design in terms of safety requirements (safety criteria and licence conditions). Commissioning itself and all stages of start-up tests are under regulatory control as permits are required from the Inspectorate.

As part of the operating licence, the Inspectorate issues a specialist report for each new operating cycle after outage for maintenance and refuelling. This report is also the regulator's substantiated opinion that the NPP is safe for the next operating cycle in accordance with specified requirements. It is based on the Inspectorate's assessment of operating performance including radiation protection, events during the last cycle, the results of maintenance and refuelling activities during the outage period and approval of the reload licensing documentation (see Article 14).

Clause 2: Each Contracting Party shall take the appropriate steps to ensure that operational limits and conditions derived from the safety analysis, tests and operational experience are defined and revised as necessary for identifying safe boundaries for operation.

see Clause 3 below

Clause 3: Each Contracting Party shall take the appropriate steps to ensure that operation, maintenance, inspection and testing of a nuclear installation are conducted in accordance with approved procedures.

This Clause is closely linked to Clause 2 and so they are covered together in the following paragraphs.

The operation of each NPP must accord with an appropriate set of limiting conditions for operation (LCO) approved by the Inspectorate. The LCO constitute boundary conditions for procedures and the instructions for normal operation. They are derived from safety analyses and test results and are included in the Technical Specifications for the plant. The Technical Specifications also contain the plant-specific surveillance requirements. Technical Specifications are based upon the Standard Technical Specifications issued by the reactor supplier. The Inspectorate is currently preparing guidelines on the content and structure required for Technical Specifications together with the analyses required for any modification to conditions. The initial Technical Specifications and later modifications require a permit from the Inspectorate. Modifications are required as a result of plant modifications, operational experience and new knowledge. Although the Technical Specifications are mature documents, there is some need for harmonisation and thus the reason for these particular guidelines.

Additional procedures implemented by licensees ensure the safe operation of NPPs. They are based on the regular verification of the operability of safety-related equipment. These procedures are used in the extensive surveillance programmes for maintenance, inspection and testing. They encompass in-service inspections using a non-destructive examination of components, periodic examinations of electronic, electro-technical and mechanical equipment, periodic functional testing of systems and components as well as an ageing surveillance programme (see Article 14). Non-destructive testing must accord with the Inspectorate’s Guideline B07.

The regulatory surveillance of plant operation relies on information obtained from the reports submitted by operating organisations (in accordance with the Inspectorate's Guidelines B02 and B03), on information collected during the Inspectorate's inspections and on its own measurements. Since the INES classification was introduced into Switzerland in 1992, there have been 9 events in Swiss NPPs rated at Level 1 on INES and 1 event at Level 2. The annual number of reportable events as specified in the Inspectorate’s Guideline B03 (until 2008 Guideline R-15) is shown in Figure 5. Because of changes in the criteria for event reporting, the figures for 2009 are not comparable with those for 1996 to 2008.

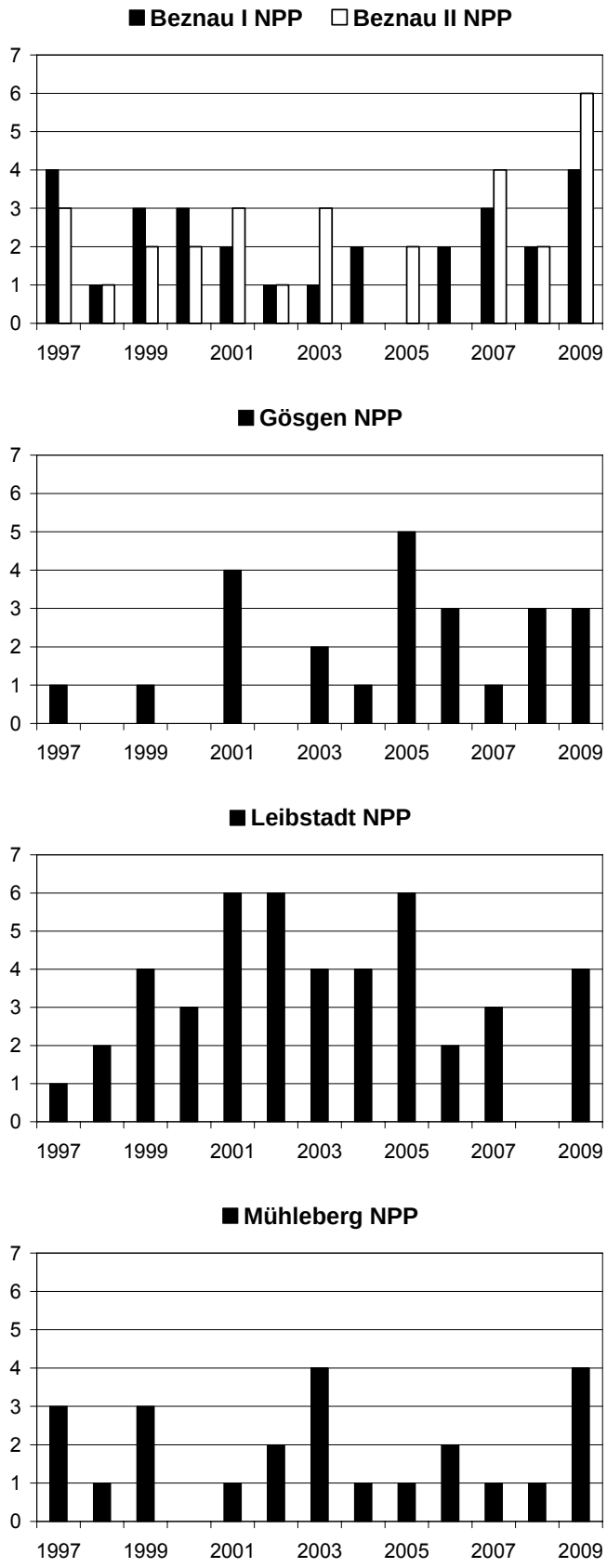

Figure 5: Annual number of reportable events in Swiss NPPs.

The reporting system requires operating organisations to report periodically (monthly, annually, after refuelling outage) on operational performance and activities relating to safety. The most

important of these are modifications to plant equipment, procedures and organisation and doses to personnel and the public. There is particular emphasis on event reporting and investigation. Lessons learned and event feedback are essential elements of operational experience. In addition, the level for event reporting in Switzerland is low and so the Inspectorate receives comprehensive reports on even minor events of relevance to safety. The analysis of incidents by both the utility and the Inspectorate is an important tool in efforts to increase nuclear safety (see also Clause 4).

Because of increased price competition in the market for electricity, all licensees have sought to optimise plant operation. In two NPPs, the optimisation programme includes an initiative to perform short and long outages in alternate years. The short outage is used mainly for refuelling. As a result, some safety-related equipment is subject to testing and maintenance on a two-year cycle. This required a change to the plant's Technical Specifications and required review and approval by the Inspectorate. With regard to the ongoing process of deregulation in the electricity market, the utilities are planning what are known as risk-informed projects for maintenance and testing in particular. However, the priority with which these ideas are being pursued is currently low.

Clause 4: Each Contracting Party shall take the appropriate steps to ensure that procedures are established for responding to anticipated operational occurrences and to accidents.

In addition to the operating procedures for all modes of normal operation, each NPP has dedicated procedures for operational anomalies and emergency conditions. They are known as emergency operation procedures (EOPs). EOPs are a requirement of the Nuclear Energy Ordinance and they specify the measures required to manage incidents and accidents prior to core damage. Since the EOPs only provide partial support in terms of the mitigation of severe accidents, the Nuclear Energy Ordinance requires an extension of the EOPs in the form of severe accident management guidance (SAMG). The Nuclear Energy Ordinance delegates regulation on the content of EOPs and SAMGs to guidelines published by the Inspectorate. Changes in the content of EOPs and SAMGs must be reported to the Inspectorate. Plants develop and implement EOPs and SAMGs as part of the top-level organisational documents required by the Nuclear Energy Ordinance. They reflect the policy of the operating organisation. Plant modifications, operating and training experience, scientific and technological developments and lessons from events in NPPs trigger modifications to EOPs and SAMGs if necessary.

The emergency procedures for NPPs include the steps for alerting the NPP stand-by safety engineer. They specify the duties of the stand-by safety engineer, in particular, the requirement to determine whether an emergency actually exists, to alert the plant's emergency staff and inform the Inspectorate if an event requires immediate reporting. The procedures also define the on-site criteria for alerts and alarms (see Article 16).

EOPs are designed to bring the plant into a safe operational state. SAMGs are designed to prevent or at least minimise any environmental impact. The plant can only restart normal operations after an event if the state of the plant accords with the Technical Specifications.

If an event impairs or might impair nuclear safety, the Nuclear Energy Ordinance and the Inspectorate's Guideline B03 require a review and an evaluation of the event and the regulatory body must be notified.

Clause 5: Each Contracting Party shall take the appropriate steps to ensure that necessary engineering and technical support in all safety related fields is available throughout the lifetime of a nuclear installation.

NPPs have developed their own on-site technical support covering the surveillance test programme, reactor engineering and fuel management, operational experience feedback, plant modifications and safety-related computer applications. These functions are the responsibility of the various technical departments in an NPP. In most cases, a department at the licensee's headquarters is responsible for core and cycle design and for fuel procurement. If additional expertise is required, each plant can obtain technical support from the reactor supplier by subcontracting work to them. Nevertheless, the licensee must have sufficient expertise within its own organisation to ensure the quality of any outsourced tasks.

With the deregulation of the electricity market and the current increase in economic pressures, retaining corporate knowledge has become an important issue. The Inspectorate is aware of this and the issue is discussed at the regular management meetings between the Inspectorate and NPPs. To ensure adequate technical support in Switzerland, the level of research has increased. In addition, a master's course in nuclear engineering at the Swiss Federal Institute of Technology and a training course for graduates in nuclear engineering have been established.

Clause 6: Each Contracting Party shall take the appropriate steps to ensure that incidents significant to safety are reported in a timely manner by the holder of the relevant licence to the regulatory body.

The Nuclear Energy Act, the Nuclear Energy Ordinance and the Inspectorate's guidelines contain requirements on the notification of events and incidents:

- notification of events to allow early recognition of deviations and their correction;
- notification of incident/accident conditions to alert the Inspectorate's emergency organisation and other authorities;
- notification of events of public interest to allow the Inspectorate to make an independent assessment and inform the public quickly.

The Nuclear Energy Act obliges licensees to notify the supervisory authorities within a specified time of special activities or occurrences relating to the handling of nuclear materials and which might interfere with nuclear safety or security. The Nuclear Energy Ordinance specifies reporting requirements for nuclear safety, security and the transport of nuclear materials. The Inspectorate is required to regulate the detailed reporting procedures and the method of classifying events and findings in accordance with the Nuclear Energy Ordinance. As a result, the Inspectorate's Guideline B03 contains criteria defining the reportability threshold for events. The licensee is responsible for giving a preliminary rating to each reportable event or finding on the basis of INES, whereas the Inspectorate is responsible for the final INES rating. The Nuclear Energy Ordinance specifies the time limits for initial notification, receipt of the event history report and the report on remedial action based on the INES rating. There is an additional class for events of public interest. For example, if ambulances, fire engines or police cars enter the precincts of a nuclear installation with sirens wailing, this requires immediate reporting, even if there is no event of significance to nuclear safety. The Inspectorate uses the written confirmation by the licensee of an event as the basis for its initial review of the classification and also any immediate action required should an event reveal unexpected barrier degradation. If an event is re-

ported as INES Level 2 or higher or if there is a public interest, the Inspectorate's special emergency team meets as required by its own internal rules on emergency preparedness. The meeting will review the event and inform the media if necessary. Following a minor amendment to the Nuclear Energy Ordinance, the former national event rating scale has been abolished. The INES scale was being used in parallel and so the national scale provided no additional benefit.

To ensure that nuclear installations apply the Inspectorate's guidelines correctly, event classification is part of both the initial licence exams for shift supervisors and on-call engineers and their relicensing. During the periodic emergency exercises, event classification is an important objective for both NPP and regulatory staff.

As part of its quality management system (see Article 8, Clause 1), the Inspectorate has its own internal procedures for event investigation, which include the independent assessment and classification of all events reported nationally. It has set up a working group consisting of experts in engineering, human factors and radiation protection, which assesses events in cooperation with specialists from individual sections. If the final rating is INES 0, the decision on this final INES rating is taken by the Head of the Division responsible for the oversight of plant operation. If the rating is INES 1 or higher, the decision is taken by the CEO of the Inspectorate. The results are communicated to the licensee and entered in the systematic safety assessment database.

For several years, it has been the Inspectorate's practice to include a summary of reported events and their classification in the Inspectorate's annual regulatory oversight report. This report is publicly available.

Clause 7: Each Contracting Party shall take the appropriate steps to ensure that programmes to collect and analyse operating experience are established, the results obtained and the conclusions drawn are acted upon and that existing mechanisms are used to share important experience with international bodies and with other operating organisations and regulatory bodies.

An important process in Swiss NPPs is the process dealing with non-conformance control and remedial action. It is guided by procedures that form part of the management system. Any non-conformance is reported and discussed at the daily morning meeting held by each NPP and where necessary follow up action (e.g. work authorisations) is initiated.

The safety impact of non-conformances is evaluated. If the event is of interest or significance to safety, the non-conformance must be reported to the Inspectorate. In addition, an internal investigation team in the plant is required to conduct a thorough analysis of the event. If the event is more complex, the NPP will use dedicated root-cause analysis methods. Based on these analyses, the event investigation team will suggest what action is required. These suggestions are reviewed by the plant's internal safety committee before implementation.

Low level non-conformance events (below the reportability level), near misses and other types of failures or malfunctions are reported to the daily meeting of plant managers and representatives from the main technical divisions. Their significance is then evaluated. Depending on the safety relevance or operational impact of the non conformance, remedial action is initiated immediately or the problem is transferred for further evaluation to the event investigation team or a technical division.

Having decided what remedies are appropriate, responsibility for implementation is assigned to a division. The final details must be reported to the safety review committee and the resultant operating experience is used to inform future plant improvement programmes.

The CEOs of all NPPs monitor the exchange of operating experience between Swiss NPPs. This CEO group is supported by several working groups who deal with issues such as training, nuclear safety performance, ageing surveillance, management systems, radiological and chemical plant performance, fire services and industrial safety.

Each NPP has a process for dealing with external operating experience, which screens and evaluates information on external events. Depending on their significance and applicability to an individual plant, the information is evaluated in detail and modifications are implemented as necessary. The Inspectorate periodically inspects this process. Furthermore, plants must provide a monthly report to the Inspectorate with information on external events evaluated in detail. Important sources of external information are the World Association of Nuclear Operators (WANO), the Plant Owners' Group, the Incident Reporting System (IRS) of IAEA and NEA and the Association of Power and Heat Generating Utilities in Germany. Specialist groups of experts from Swiss NPPs meet periodically to exchange operational experience, information from abroad and the exchange of detailed information on recent events in their own plants.

Each NPP is required to carry out a Periodic Safety Review (PSR) at least every 10 years (see Article 14). As part of the PSR, each plant is required to assess in summary form its own operating experience and any important external event of relevance to the plant. This review is also assessed by the Inspectorate and its report is publicly available.

The Inspectorate has its own process for assessing events in nuclear installations in other countries. If the Inspectorate's assessment indicates potential for safety improvements at Swiss NPPs, the plants are required to analyse the situation in their own installation and take appropriate action. The IRS is the main source of information for the Inspectorate. The Inspectorate has been a member of IRS since it was founded in 1980. Members prepare reports on safety issues of relevance to the nuclear community and attend and organise meetings and workshops on important safety issues. The Inspectorate sends delegates from amongst its own staff to the OECD/NEA/CSNI "Working Group on Operational Experience" (WGOE) and to the "Working Group on Human and Organisational Factors" (WGHOF).

The Inspectorate obtains other important information from IRS reports, NRC information letters and bilateral contacts (e.g. safety commissions) with its neighbours France and Germany.

The following are some examples of Swiss events reported to the IRS during the reporting period:

- unintentional opening of the automatic depressurization system (ADS) safety relief valves at Leibstadt NPP;
- non compliances with the technical specification during start-up near end of cycle at Leibstadt NPP;
- significant rise in core damage frequency due to unavailability of both the Beznau NPP Unit 1 emergency diesel generator and the offsite power source;
- exposure of two workers to doses in excess of the statutory annual limit at Beznau NPP Unit 2.

The following are some examples of information on operational experience from abroad that resulted in major modifications at Swiss NPPs:

- Based on the Generic Letter 89-10 of the US-NRC, the Inspectorate required all Swiss licensees to re-evaluate the functional analysis of motor-operated valves in safety related systems. As a consequence, all Swiss NPPs modified certain gate valves.
- Following the incident at Barsebäck 2 (Sweden) on 28 July 1992 involving clogging of the suction-line strainers in the suppression pool, the Inspectorate initiated a programme of short-term measures designed to resolve the problem in all NPPs. The short-term measures included inspections, a detailed review of the types of thermal insulation in use, a clogging analysis of strainers and the preparation of accident management measures in BWR plants. This resulted in the replacement of all suction strainers in the emergency core cooling system of BWRs (Mühleberg and Leibstadt) during their outage periods in 1993. In the new equipment, the strainer area was much larger. For the PWRs, backfitting was not considered necessary at the time and a reassessment of the issue in the light of recent results from French and NRC research showed that the design of PWR suction strainers is still appropriate. However, one licensee has installed new state-of-the-art cassette-type suction strainers in order to improve safety and allow greater flexibility in the type of thermal insulation material used in the containment.
- Two hydrogen explosions occurred in European and Japanese BWRs at the end of 2001 resulting in ruptured pipes. This is a known phenomenon and had been the subject of previous assessments; following those two events, the two BWRs in Switzerland were required to re-evaluate the earlier assessments. This resulted in immediate improvements to procedures (e.g. filling empty pipes with water). Minor hardware modifications (e.g. improved insulation, installation of thermocouples) were made during the annual outage. The investigations were then completed but because of differences in the BWR design in Switzerland, it was not considered necessary to undertake hardware modifications or consider a new design basis accident.
- The reactor vessel head corrosion event at the Davis Besse NPP (USA) in 2002 generated considerable attention in the nuclear community. In this event, a significant amount of boric acid corrosion was detected caused by leakage from cracks in the control-rod nozzles. Both Swiss operators and the Inspectorate had previous experience of this phenomenon and so were already vigilant. A small head corrosion event caused by leakage had occurred in Switzerland in the early 1970s and 5 years before the above US event, cracks had been found and reported in the control nozzles of US plants. The Inspectorate had used this previous experience to strengthen the requirements for the periodic surveillance by plant operators of nozzle cracks and leakage control. Therefore, the Davis Besse event did not necessitate any additional action.
- The incident at Forsmark 1 NPP (Sweden) on 25 July 2006 also led to major investigations by the Inspectorate. The Inspectorate checked in detail aspects identified as being significant to the sequence of events. All Swiss NPPs carried out a comprehensive check of the technical and organisational measures used to deal with the

consequences of a similar type of event. The investigation results were published in a separate report and this is available on the Inspectorate's website. The investigations did not identify any deficiencies in technical and organisational precautions by Swiss NPPs designed to protect plants from the effects of grid disturbances. Nevertheless, the Inspectorate recommended that NPPs intensify simulator training for scenarios involving loss of redundancy in safety or information systems and signals in the control room.

The Annual Report of the Inspectorate includes information on selected events in Swiss NPPs and the use made of information from external operating experience.

Clause 8: Each Contracting Party shall take the appropriate steps to ensure that the generation of radioactive waste resulting from the operation of a nuclear installation is kept to the minimum practicable for the process concerned, both in activity and in volume, and that any necessary treatment and storage of spent fuel and waste directly related to the operation and on the same site as that of the nuclear installation take into consideration conditioning and disposal.

The Nuclear Energy Act includes the principle that the originator of radioactive waste is responsible for its safe management. Before an NPP is licensed, it must demonstrate that the waste generated by the facility can be safely and permanently managed and disposed of. The Radiological Protection Act and the Radiological Protection Ordinance stipulate that the volume of radioactive waste produced must be kept to the minimum possible. Under the Nuclear Energy Act, radioactive waste originating in Switzerland must be disposed of in Switzerland.

To ensure compliance with legal requirements during the licensing phase, plans for nuclear installations are subject to a critical review by nuclear safety authorities. During the construction and the operation of such installations, the Inspectorate's supervisory activities ensure compliance.

Each NPP stores the spent fuel discharged from the reactor on site for several years. The Nuclear Energy Act prohibits the reprocessing of spent nuclear fuel for a period of ten years starting on 1 July 2006. In the past, NPP operators had signed contracts with foreign companies for the reprocessing of some 1,139 tonnes of spent fuel. All spent fuel covered by these contacts had been shipped abroad by June 2006 and 1,070 tonnes had been reprocessed by the end of 2009. At present, spent fuel is also stored in transport and storage casks at the Central Interim Storage Facility, which started active operation in June 2001. The return of waste from foreign reprocessing facilities to the Central Interim Storage Facility started in 2002 and is proceeding on schedule. The Beznau NPP site also has an additional facility for the dry storage of spent fuel elements. It started active operation in April 2008. The Gösgen NPP site has a facility for the wet storage of spent fuel, which started operation in May 2008. A decision on future management (reprocessing or direct disposal) will be taken at a later date.

Fuel quality and plant cleanliness mean that the volume of radioactive waste generated at the NPPs is kept at a low level. The resultant waste is collected and segregated. Waste with such low activity levels that it is exempted from regulatory control is cleared for re-use or conventional disposal under the supervision of the Inspectorate. The conditions required for clearance are included in Annex 2 of the Radiological Protection Ordinance. The associated procedures are detailed in the Inspectorate's Guideline B04.

As a general rule, radioactive waste is conditioned as soon as practicable, mostly on site at an NPP or the Paul Scherrer Institute but in some cases externally at the Central Interim Storage Facility. Under the Nuclear Energy Ordinance, the Inspectorate must approve all procedures for the conditioning of radioactive waste. Approval is only granted if waste products comply with accepted storage criteria, meet the requirements of NAGRA, the disposal planning organisation and can be transported in compliance with the regulations on the transport of hazardous goods. Detailed requirements are documented in the Inspectorate's Guideline B05. Operational waste is stored on site under appropriate and adequate conditions. The requirements relating to the storage of radioactive waste and spent fuel are specified in the Inspectorate's Guideline R29. This guideline is due to be updated by the end of 2010 when it will become Guideline G04.

Developments and Conclusion

Clause 1: Under the new Ordinance on the Federal Nuclear Safety Commission, the advisory role of the Federal Nuclear Safety Commission in the licensing process focuses more on fundamental aspects of nuclear safety compared with the role undertaken by the previous commission.

Clauses 2 and 3: The Inspectorate is preparing a guideline harmonizing the Technical Specifications for NPPs.

Clause 6: The Inspectorate has introduced new reportability criteria for events. The criteria are more closely linked to the Technical Specifications for each NPP. This reflects the fact that the safety significance of a finding depends on the design of a specific plant, particularly on the degree of redundancy for the relevant function. In addition, the former national event rating scale was abolished in a minor revision to the Nuclear Energy Ordinance,

Clause 8: New storage facilities are now operational at 2 NPP sites.

Switzerland complies with the obligations of Article 19.

Outlook

In the coming years, Switzerland will continue its efforts to provide a regulatory body, legal framework and regulatory guidelines, which are fully compatible with IAEA Safety Standards and harmonised with the safety requirements of the Western European Nuclear Regulators Association – and in some areas, it will exceed international standards.

In the next reporting period, three of Switzerland's NPPs will have been operating for more than 40 years. As a result, the regulatory oversight of these plants will need to focus more on the specific issues arising from long-term operation. The Nuclear Energy Act specifies that nuclear installations must be backfitted, where necessary with the latest state of backfitting technology. In addition, it requires backfitting in excess of that if this further reduces risk and is reasonable. This principle has triggered a number of large backfitting projects in Swiss NPPs, each of which requires careful supervision by the Inspectorate.

The tasks of the Inspectorate have also evolved since the submission of three applications for new NPP site licences. The Inspectorate must now build up the resources required to assess the applications for NPP construction licences. Provided that these new-build projects meet safety requirements, the final decision on projects will be taken by the people in a referendum.

The process to select a site for the disposal of radioactive waste in deep geological formations in Switzerland is continuing and will also need a substantial effort by the Inspectorate in the next reporting period.

The Swiss Federal Nuclear Safety Inspectorate will continue to refine its Integrated Oversight Strategy in response to the increase in tasks to be undertaken by the regulatory body and the complexity of the oversight required for the long-term operation of existing NPPs and new build projects. This will ensure that the Inspectorate obtains a comprehensive view of the safety of each installation and can recognise signs of deteriorating performance as early as possible. It will also enable the Inspectorate to focus its resources on issues of relevance to safety and it is a fundamental strategic objective of the Inspectorate to ensure that the conditions required for the safety of operating plants exist despite the additional workload arising from the new-build projects.

Appendices

- Appendix 1: List of abbreviations used in the present report
- Appendix 2: List of the Inspectorate’s guidelines currently in force

Appendix 1: List of abbreviations used in the present report

ADAM	Accident Diagnostics, Analysis and Management System
ALARA	As Low As Reasonably Achievable
ANPA	Emergency Response Data System
ASP	Ageing Surveillance Programme
BWR	Boiling Water Reactor
BWROG	Boiling Water Reactor Owners Group
ECCS	Emergency Core Cooling System
ECURIE	European Community Urgent Radiological Information Exchange
ENSI	Swiss Federal Nuclear Safety Inspectorate (Eidgenössisches Nuklear-sicherheitsinspektorat)
EOP	Emergency Operating Procedures
EOR	Emergency Organisation Radioactivity
GDC	General Design Criteria
HLW	Low-Level Waste
HOF	Human and Organisational Factors
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
INES	International Nuclear Event Scale
INEX	International Emergency Exercise
IRRS	Integrated Regulatory Review Service
IRS	Incident Reporting System
ISO	International Standards Organisation
L/ILW	Low-Level and Intermediate-Level Waste
LWR	Light Water Reactor
MADUK	Automatic Dose Rate Monitoring System
MTO	Man Technology Organisation
MOX	Mixed oxide
NDE	Non-destructive Evaluation Methods
NEA	Nuclear Energy Agency
NPP	Nuclear Power Plant
NRC	Nuclear Regulatory Commission
OECD	Organisation of Economic Co-operation and Development
OHSAS	Occupational Health and Safety Assessment Series
OSART	Operational Safety Review Teams (IAEA)
PEGASOS	Probabilistic Assessment of Seismic Hazard for Swiss NPP Sites
PRP	PEGASOS Refinement Project
PSA	Probabilistic Safety Analysis
PSI	Paul Scherrer Institute, a research institute
PSR	Periodic Safety Review
PWR	Pressurised Water Reactor
RHR	Residual Heat Removal
SAMG	Severe Accident Management Guidance

SAR	Safety Analysis Report
SER	Safety Evaluation Report
SIA	Swiss Society of Engineers and Architects
SRL	Safety Reference Levels (WENRA)
SSC	Systems, Structures and Components
Sv	Sievert
WANO	World Association of Nuclear Operators
WENRA	Western European Nuclear Regulators Association
WOG	Westinghouse Owners Group

Appendix 2: List of the Inspectorate's guidelines presently in force

Status: July 2010

Languages: All guidelines are originally written in German; guidelines denoted by e or f have also been translated into English or French. In the case of guidelines denoted by an asterisk only the title has been translated into English.

Note: All guidelines are available on the ENSI website (www.ensi.ch).

Guideline	Title of Guideline	Date of current issue
G03/e	Specific design principles for deep geological repositories and requirements for the safety case	2009/4
G05*	Transport and storage containers for interim storage	2008/4
G07/f	Organisation of nuclear installations	2008/4
G11*	Safety-classified vessels and piping: Planning, manufacturing and installation	2010/5
G13*	Radiation protection measuring devices in nuclear installations: Concepts, requirements and testing	2008/2
G14*	Calculation of radiation exposure in the vicinity due to emission of radioactive substances from nuclear installations	2009/12
A01*	Requirements for deterministic accident analysis for nuclear installations: Extent, methodology and boundary conditions for technical accident analysis	2009/7
A04*	Application documents for modifications in nuclear power plants requiring a permit	2009/9
A05/e	Probabilistic Safety Analysis (PSA): Quality and Scope	2009/1
A06/e	Probabilistic Safety Analysis (PSA): Applications	2008/5
A08*	Analysis of source terms: Extent, methodology and boundary conditions	2010/2
B02*	Periodical reporting for nuclear installations	2010/2
B03*	Reports for nuclear installations	2008/12
B04*	Clearance of materials and areas from controlled zones	2009/8
B05*	Requirements for conditioning of radioactive waste	2007/2
B06*	Safety-related classified vessels and piping: Maintenance	2010/5
B07*	Safety-related classified vessels and piping: Qualification of non-destructive testing	2008/9
B11/f	Emergency exercises	2007/11
B12/f	Emergency preparedness in nuclear installations	2009/4
R-4*	Supervisory procedures for the construction of nuclear power plants, project engineering of structures	1990/12
R-6*	Safety-related classification, classification limits and procedures for construction of equipment in nuclear power plants with light-water reactors	1985/5
R-7*	Guideline for the area of radiation protection of the nuclear power installations and the Paul Scherrer Institute	1995/6
R-8*	Structural safety for nuclear power plants, Swiss Federal supervising procedures for construction work	1976/5

Guideline	Title of Guideline	Date of current issue
R-11*	Aims in radiation protection for normal operation of nuclear installations	2003/5
R-12*	Collection and reporting of doses of personnel exposed to radiation in nuclear installations and the Paul Scherrer Institute	1997/10
R-16*	Seismic installation instrumentation	1980/2
R-23*	Maintenance, inspections, replacements, repair and modification of electrical equipment in nuclear installations	2003/1
R-27*	Selection, training and examination of operational staff requiring a licence in nuclear power plants	1992/5
R-29*	Requirements for interim storage of radioactive waste	2004/3
R-30*	Supervisory procedures for construction and operation of nuclear installations	1992/7
R-31*	Supervisory procedures for construction and backfitting of nuclear power plants, 1 E classified electrical equipments	2003/10
R-35*	Supervisory procedures for construction and modification of nuclear power plants, systems technology	1996/5
R-37*	Acknowledgment of radiation training and further education in the supervisory area of HSK	2001/7
R-39*	Collecting data of radiation sources and material testers in nuclear installations	1990/1
R-40*	Filtered containment venting of light-water reactors. Design requirements	1993/3
R-46*	Requirements for the application of computer-based instrumentation and control important to safety in nuclear power plants	2005/4
R-48*	Periodic safety review of nuclear power plants	2001/11
R-49*	Requirements important to safety for security of nuclear installations	2003/12
R-50*	Requirements important to safety for fire protection in nuclear installations	2003/3
R-51*	Ageing management for mechanical and electrical equipment and structures in nuclear installations	2004/11
R-60*	Supervision of fuel element production	2003/3
R-61*	Supervisory procedures when using nuclear fuel and control-rods in light-water reactors	2004/6
R-101*	Design criteria for safety systems of nuclear power plants with light-water reactors	1987/5
R-102*	Design criteria for the protection of saferty equipment in nuclear power stations against the consequences of airplane crash	1986/12
R-103*	On-site severe accident measures	1989/11

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