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EU STRESS TEST: SWISS NATIONAL ACTION PLAN

FOLLOW UP OF THE PEER REVIEW
2012 YEAR-END STATUS REPORT

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2012 Year-End Status Report

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Introduction

The EU stress test is part of the review process which Switzerland initiated immediately after the reactor accident in Japan.

As a direct consequence of the Fukushima accident in Japan, the Swiss Federal Nuclear Safety Inspectorate ENSI issued three formal orders in which the operators of the Swiss NPPs were required to implement immediate measures and to conduct additional reassessments. The immediate measures comprised the establishment of an external emergency storage facility for the Swiss NPPs, including the necessary plant-specific connections, and back-fittings to provide external injection into the spent fuel pools. The additional reassessments, which were to be carried out immediately, focused on the design of the Swiss NPPs against earthquakes, external flooding and a combination thereof. Investigations on the coolant supply for the safety systems and the spent fuel pool cooling on the basis of first insights gained from the accident in Japan were also requested.

In addition to the aforementioned orders, and on the basis of the internationally accessible information, ENSI carried out an analysis of the events at Fukushima and published the results in four reports. These reports provide detailed descriptions of the causes, consequences and radiological impacts of the accident at Fukushima. They analyse the contributory human and organisational factors, and specify lessons that can be derived from this information together with 37 specific issues for further investigation.

In a fourth formal order on 1 June 2011, ENSI instructed the Swiss operators to take part in the EU stress test. The EU Commission adopted a specification regarding the content and time-frame for the EU stress test on 25 May 2011. For the purposes of the EU stress test, there was to be particular examination of the robustness of the NPPs in case of impacts beyond the design basis due to earthquakes, external flooding and extreme weather conditions, with consequential loss of power supply and heat sink, and the need for severe accident management actions. The operators of the Swiss NPPs submitted their reports promptly by 31 October 2011 and ENSI has reviewed them. Based on this review, on 10 January 2012 ENSI requested further clarification on plant specific issues (see chapter 8.2). Also on the basis of this review, ENSI produced the National Report which was delivered to the EU Commission on 31 December 2011. The peer review process was led by a team of seven senior supervision experts from EU countries and a senior manager from the EU Commission. The peer review process proceeded in three stages: the Desktop Peer Review, the Topical Peer Review and the Country Peer Review. From 1 January 2012 onwards, the Desktop Peer Review entailed an initial review of the national reports. All the reviewers had access to all the national reports and they were able to submit written questions to the supervisory authorities. The two-week Topical Peer Review began on 5 February 2012 in Luxembourg, with meetings on the three topics. The review of the Swiss National Report took place on 9 and 10 February 2012. As the result of the Topical Peer Review, a Country Peer Review Draft Report was drawn up for each country, including a summary of the results obtained by the review team and a list of points (open issues) for further follow-up by the review team during the Country Peer Review. In overall terms, eight new "open points" were identified which ENSI will follow up to further improve the safety of the Swiss NPPs.

Swiss "Action Plan Fukushima"

These open points together with the issues identified in the analysis of the events at Fukushima, are being processed according to their importance and urgency in a Swiss action plan, called "Action Plan Fukushima". This "Action Plan Fukushima" will be detailed on a yearly basis and describe ENSI's oversight activities related to Fukushima. ENSI has set the goal of investigating the identified issues and implement the derived measures

by 2017. For the update on the implementation of these open points, please refer to the yearly updates of the "Action Plan Fukushima" on ENSI's website.

Swiss National Action Plan within the framework of the ENSREG Action Plan

The Country Peer Review for Switzerland took place from 26 to 29 March 2012 in Switzerland and – at the request of the peer review team – included a visit to the Beznau NPP. The peer review was completed with a main report that includes final conclusions and recommendations. The country peer review at European level finally led to 17 country reports that include country-specific conclusions and recommendations. The reports were approved by ENSREG and the European Commission on 26 April 2012. In a joint ENSREG/EC statement the stress test report was accepted and it was agreed that **an ENSREG action plan would be developed to track implementation of the recommendations.** As part of the ENSREG action plan each national regulator has to generate a country-specific action plan. The following document is fulfilling this condition and represents the Swiss National Action Plan regarding the follow up of the Peer Review of the stress tests performed on European NPPs.

European Level Recommendations

European guidance on assessment of natural hazards and margins

ENSREG recommendation

Overall, the compliance of the European stress tests with the ENSREG specification was good with regard to compliance of the installations with their design basis for earthquake and flooding. However there was a lack of consistency identified with respect to natural hazards assessments where significant differences exist in national approaches and where difficulties were encountered with beyond design margins and cliff-edge effects assessments. Therefore: The peer review Board recommends that WENRA, involving the best available expertise from Europe, develop guidance on natural hazards assessments, including earthquake, flooding and extreme weather conditions, as well as corresponding guidance on the assessment of margins beyond the design basis and cliff-edge effects.

What has Switzerland done so far?

Switzerland is chairing WENRA and an active member of the Reactor Harmonization Working Group (RHWG) within which 6 sub-groups were created in response to the stress test results and the accident in Fukushima Dai-ichi NPP. Switzerland actively participates in all RHWG subgroups. One of the subgroups explicitly addresses natural hazards. See also chapters 1.1, 1.2, 1.7, and 1.8.

What will Switzerland do in the future?

The WENRA RHWG subgroup on natural hazards will publish a guidance document in 2013. Switzerland will start the implementation of the new or revised WENRA safety reference levels in its national legal framework as soon as the results are published.

Periodic Safety Review

ENSREG recommendation

The peer review demonstrated the positive contribution of periodic safety reviews as an efficient tool to maintain and improve the safety and robustness of plants. In the context of the peer review, this finding is especially relevant for the protection of installations against natural hazards. Therefore: The peer review Board recommends that ENSREG underline the importance of periodic safety review. In particular, ENSREG should highlight the necessity to re-evaluate natural hazards and relevant plant provisions as often as appropriate but at least every 10 years.

What has Switzerland done so far?

In Switzerland, the periodic safety review is mandatory every 10 years. Within the periodic safety review, the risk from external hazards is re-evaluated. As one of the lessons learned from the Fukushima accident, ENSI required a re-evaluation of severe weather conditions. In addition, a comprehensive research project on external flooding was initiated.

What will Switzerland do in the future?

It is planned that the PRP (re-evaluation of the seismic hazard, see chapter 1.1) will be finalized in 2013.

Containment integrity

ENSREG recommendation

The Fukushima disaster highlighted once again the importance of the containment function, which is critical, as the last barrier to protect the people and the environment against radioactive releases resulting from a nuclear accident. This issue was already extensively considered, as a follow-up of previous accidents, and possible improvements were identified. Their expeditious implementation appears to be a crucial issue in light of Fukushima accident. Therefore: Urgent implementation of the recognised measures to protect containment integrity is a finding of the peer review that national regulators should consider. The measures to be taken can vary depending on the design of the plants. For water cooled reactors, they include equipment, procedures and accident management guidelines to:

- *depressurize the primary circuit in order to prevent high-pressure core melt;*
- *prevent hydrogen explosions;*
- *prevent containment overpressure.*

What has Switzerland done so far?

See chapter 3.1.

What will Switzerland do in the future?

See chapter 3.1.

Prevention of accidents resulting from natural hazards and limiting their consequences

ENSREG recommendation

The Fukushima disaster has also shown that defence-in-depth should be strengthened by taking into account severe accidents resulting from extreme natural hazards exceeding the levels taken into account by the design basis and current safety requirements applicable to the plants. Such situations can result in devastation and isolation of the site, an event of long duration, unavailability of numerous safety systems, simultaneous accidents of several plants including their spent fuel pools, and the presence of radioactive releases. Therefore: Necessary implementation of measures allowing prevention of accidents and limitation of their consequences in case of extreme natural hazards is a finding of the peer review that national regulators should consider. Typical measures which can be considered are bunkered equipment to prevent and manage severe accident including instrumentation and communication means, mobile equipment protected against extreme natural hazards, emergency response centres protected against extreme natural hazards and contamination, rescue teams and equipment rapidly available to support local operators in long duration events.

What has Switzerland done so far?

All Swiss NPPs are equipped with special bunkered safety systems designed against extreme external events.

ENSI has requested a new safety case to demonstrate that the Swiss NPPs have adequate protection against the 10,000-year earthquake and the combination of this earthquake and a 10,000-year flooding. The necessary analyses were submitted by the licence holders and examined by ENSI. Several open points were identified that require further examination.

The existing strategies to cope with Station Blackout (SBO) scenarios have been extended. As a result, additional equipment has been installed or stored on the plant sites and the existing accident management procedures will be adapted accordingly.

A flood-proof and earthquake-resistant external storage facility is in place at Reitnau since June 2011 in order to strengthen the provision for accident mitigation. It contains various operational resources, in particular mobile motor-driven pumps, mobile emergency power generators, hoses and cables, radiation protection suits, tools, diesel fuel and boration agents. The storage facility at Reitnau is located on top of a hill and is accessible by road or by helicopter. The three independent storage buildings are constructed mainly as underground bunkers which are earthquake- and flood-proof.

On the basis of a report by ENSI, the Federal Council decided on 4 May 2011 to set up an official working group to review emergency preparedness measures in case of extreme events in Switzerland (IDA NOMEX). The report of IDA NOMEX was adopted by the Federal Council on 7 July 2012. It describes 56 organisational and legislative measures deemed to be necessary as a result of the review conducted. ENSI is responsible for implementing measures related to

- assistance for persons with severe radiation exposure,
- the availability of measurement and forecasting systems for NPPs in extreme events,
- the reference scenarios for emergency preparedness and
- the review of the emergency planning zones around NPP sites.

What will Switzerland do in the future?

The open points identified in the examination of flooding, earthquake and the combination of both will be followed narrowly.

The work on measures identified by IDA NOMEX will continue until 2016. In addition to the above mentioned measures, ENSI will be involved in the definition of different measures in the responsibility of other federal offices.

In February 2013, ENSI will publish its action plan "Fukushima 2013" which will contain an analysis of the handling of large amounts of radioactive water in case of a severe accident.

1 Natural hazards

1.1 Hazard Frequency

ENSREG recommendation

The use a return frequency of 10^{-4} per annum (0.1g minimum peak ground acceleration for earthquakes) for plant reviews/back-fitting with respect to external hazards safety cases.

What has Switzerland done so far?

As specified in Article 5 of the Ordinance on Hazard Assumptions and the Evaluation of Protection against Accidents in Nuclear Plants (SR 732.112.2), the safety of an NPP has to be demonstrated for natural hazards with an exceedance frequency 10^{-4} per annum.

The seismic hazard was reassessed by a SSHAC Level 4 study (as defined in NUREG/CR-6372) in 2004. This study is designated as the PEGASOS project. In order to reduce the uncertainty of the PEGASOS results (mainly with additional data), the PEGASOS Refinement Project (PRP) was initiated. Based on intermediate results of PRP, ENSI requested the licensees to demonstrate seismic safety. The corresponding safety cases were submitted and reviewed by ENSI in 2012. It could be demonstrated that all Swiss NPPs fulfil the requirements.

The external flooding analyses were redone in 2011 for flood levels with an exceedance frequency of 10^{-4} per annum. It could be shown that all Swiss NPPs fulfil the requirements.

All Swiss NPPs have conducted substantial seismic backfits since commissioning.

What will Switzerland do in the future?

Seismic hazard: It is expected that in 2013, the PRP project will be finalised and the final report will be submitted to ENSI. This will be followed by a regulatory review by ENSI and the publication of updated hazard assumptions. Based on these hazard assumptions, a final seismic proof has to be submitted for all Swiss NPPs.

External flooding: See chapter 1.7.

Extreme weather conditions: ENSI has requested licensees to update the extreme hazard analysis on extreme weather conditions such as extreme winds, tornados, extreme temperatures, heavy rain and deep snow at the 10^{-4} per annum return frequency. The ability of the plants to withstand these events has to be demonstrated.

1.2 Secondary Effects of Earthquakes

ENSREG recommendation

The possible secondary effects of seismic events, such as flood or fire arising as a result of the event, in future assessments.

What has Switzerland done so far?

Deterministic assessments: The regulatory guideline ENSI-G01 (Sec. 4.4.1) requires non-classified equipment to be qualified against earthquake where its failure has the potential to endanger functionality or integrity of classified equipment. Furthermore, in April 2011, ENSI requested a safety case for the dams which can potentially endanger NPPs. It had to be demonstrated deterministically that the 10^{-4} per annum earthquake would either not cause an uncontrolled release of water or that the flooding caused by instantaneous dam failure would not lead to an unmanageable safety threat at the NPP site. It could be shown that all Swiss NPPs fulfil the requirements.

Probabilistic assessments: The regulatory guideline ENSI-A05 (Sec. 4.6.2.1g) requires that conditional failure probabilities of mechanical interactions as well as seismically induced fires, explosions and floods be analysed in a seismic PSA. The same guideline (Sec. 4.6.2.2a) requires that other seismic hazards such as soil movement, industrial accidents or dam breaks be identified and discussed. These effects are investigated and included in the current PSA models where relevant.

What will Switzerland do in the future?

Deterministic assessments: Although the seismic robustness of the Wohlensee dam near the Mühleberg NPP could be demonstrated, some open issues were identified. The Mühleberg NPP provided the required answers which are currently under review by ENSI.

Probabilistic assessments: No further actions are necessary since the current process covers the recommendation.

1.3 Protected Volume Approach

ENSREG recommendation

The use a protected volume approach to demonstrate flood protection for identified rooms or spaces.

What has Switzerland done so far?

The reactor buildings and the buildings with the bunkered safety systems of all Swiss NPPs are flood protected. Furthermore, the flood protection of other safety relevant buildings was enhanced by the use of mobile flood barriers.

What will Switzerland do in the future?

No action is needed.

1.4 Early Warning Notifications

ENSREG recommendation

The implementation of advanced warning systems for deteriorating weather, as well as the provision of appropriate procedures to be followed by operators when warnings are made.

What has Switzerland done so far?

Dams and similar facilities with the potential to cause flooding at NPP sites have provisions in place to warn NPPs in case of large releases of water.

Moreover, due to the revision of the Ordinance on Alerting and Alarming (SR 520.12) and the Ordinance on Radio and Television (SR 784.401.11), the authorities and the public can be warned rapidly and selectively by radio and television not only by the public radio and television company but also by the numerous private stations.

What will Switzerland do in the future?

The implementation of the modified ordinances is either completed or well advanced.

Substantial investments in the communication infrastructure will be necessary in the forthcoming years. The Federal Office for Civil Protection is mandated to clarify the issue of financing communication systems on the basis of agreements between the federal government, the cantons and the operators of plants with nuclear, biological, and chemical hazard potential, and to apply for the necessary financial resources.

1.5 Seismic Monitoring

ENSREG recommendation

The installation of seismic monitoring systems with related procedures and training.

What has Switzerland done so far?

At all four Swiss NPP sites seismic monitoring systems were installed many years before the Fukushima accident in 2011. The relevant Swiss regulatory guideline HSK-R-16, created after consultation of the relevant USNRC regulatory guides, dates from February 1980. Refurbishments according to the state of the art have been made at all plants.

The operating procedures include rules how to react after general seismic alarm, OBE alarm or SSE alarm.

What will Switzerland do in the future?

ENSI is analysing the advantages and disadvantages of an automated shutdown of the plants after recognition of a seismic event by the seismic monitoring system (one of the open issues to be followed up after the EU stress test review).

1.6 Qualified Walkdowns

ENSREG recommendation

The development of standards to address qualified plant walkdowns with regard to earthquake, flooding and extreme weather – to provide a more systematic search for non-conformities and correct them (e.g. appropriate storage of equipment, particularly for temporary and mobile plant and tools used to mitigate beyond design basis (BDB) external events).

What has Switzerland done so far?

The regulatory guideline ENSI-A05 generally requires systematic and comprehensive walkdowns in the context of the development and update of a PSA, e. g. in the case of seismic PSA. EPRI-NP-6041-SL is one acceptable standard.

In 2012, ENSI conducted focused inspections of AM equipment. An important element of these inspections was the appropriate storage of mobile AM equipment to be used after an extreme earthquake or external flooding. In addition to the local mobile AM equipment, an external storage facility with AM equipment (e.g. diesel generators, fuel, pumps, hoses, and boron) was established at Reitnau in 2011. The external storage facility is bunkered and protected against external flood and earthquake.

Furthermore, all licensees have implemented a seismic housekeeping concept which is regularly inspected by ENSI.

What will Switzerland do in the future?

No need for further actions was identified.

1.7 Flooding Margin Assessments

ENSREG recommendation

The analysis of incrementally increased flood levels beyond the design basis and identification of potential improvements, as required by the initial ENSREG specification for the stress tests.

What has Switzerland done so far?

All the plants have sufficient margin over their design base floods. For two NPPs, ENSI required complementing the analyses by worst-case river blockage scenarios (log jam).

What will Switzerland do in the future?

Apart from the regulatory review of the river blockage analyses mentioned, it is foreseen to initiate a research project in order to generate new data to support the flood hazard assessment.

1.8 External Hazard Margins

ENSREG recommendation

The formal assessment of margins for all external hazards including, seismic, flooding and severe weather, and identification of potential improvements.

What has Switzerland done so far?

The EU stress test on the Swiss NPPs did show that there are considerable margins against the flood and seismic design basis hazard level (see chapter 1.1), taking into account a return frequency of the external hazards of at least 10^{-4} per year. Regarding the hazard from severe weather conditions, ENSI's assessment of such hazards was that the loads due to extreme winds, tornados, snowfall and rainfall are covered by other loads,

resulting for example from airplane crash or explosion. Nevertheless, ENSI required the operators of the Swiss NPPs to undertake further investigations on external hazards (see below).

What will Switzerland do in the future?

ENSI required the Swiss NPPs to submit a concept regarding proof of sufficient protection against severe weather conditions by the end of 2012. The investigations have to cover the hazards resulting from extreme winds, tornados, extreme air and river water temperatures, extremely heavy rain at the NPP site, loads from snow accumulation, and superposition of several extreme weather conditions. The hazards have to be derived from a return frequency of at least 10^{-4} per year. The probabilistic hazard analyses, as well as the proof of sufficient protection of the NPPs against these hazards, have to be submitted by the end of 2013, including submission of the existing margins (on flood hazard see chapter 1.7).

2 Loss of safety systems

2.1 Alternate Cooling and Heat Sink

ENSREG recommendation

The provision of alternative means of cooling including alternate heat sinks. Examples include steam generator (SG) gravity alternative feeding, alternate tanks or wells on the site, air-cooled cooling towers or water sources in the vicinity (reservoir, lakes, etc.) as an additional way of enabling core cooling.

What has Switzerland done so far?

Core cooling and residual heat removal at all Swiss NPPs is carried out by use of river water as a primary heat sink. In addition to these normal heat sinks, core cooling and residual heat removal at all Swiss NPP except the Mühleberg NPP can also be achieved by use of well water as an alternate ultimate heat sink. The well water systems are protected against severe external hazards and are part of the bunkered special emergency systems which has been realised in Switzerland since the 1990s. The Mühleberg NPP does not rely on well water as an alternate heat sink, but the cooling water supply is assured by separated independent cooling water intake structures for safety systems and special emergency systems. Furthermore, there is a hill water reservoir near the Mühleberg NPP which serves as an additional water source for core cooling. Nevertheless, the reviews which were carried out after Fukushima have revealed that there is a need to realize an additional alternate heat sink at the Mühleberg NPP.

What will Switzerland do in the future?

Because of the lack of sufficient ground water on site, an alternate or diversified ultimate heat sink does not yet exist at the Mühleberg NPP. There are diversified cooling water intake structures, but they all take water from the Aare river. In order to assure core cooling and residual heat removal in case of loss of the ultimate heat sink, ENSI ordered the Mühleberg NPP to implement a diversified heat sink that is independent from the Aare river by the end of 2017 (project DIWANAS). The Mühleberg NPP will follow this order by providing alternate cooling water to the special emergency system SUSAN from a protected well that is fed by the Saane River which is also in the vicinity of the Mühleberg NPP. After completion of the project DIWANAS at the Mühleberg NPP, the Swiss NPPs will fully comply with the ENSREG recommendations regarding alternate cooling and heat sink.

2.2 AC Power Supplies

ENSREG recommendation

The enhancement of the on-site and off-site power supplies. Examples include adding layers of emergency power, adding independent and dedicated backup sources, the enhancement of the grid through agreements with the grid operator on rapid restoration of off-site power, additional and/or reinforced off-site power connections, arrangements for black start of co-located or nearby gas or hydro plants, replacing standard ceramic based items with plastic or other material that are more resistant to a seismic event. Another example is the possible utilisation

of generator load shedding and house load operation for increased robustness, however, before introducing such arrangements the risks need to be properly understood.

What has Switzerland done so far?

According to the plant specific reports submitted within the EU stress test, all Swiss plants have – in addition to the three operational levels of external and station generator power supplies (including island mode in case of total loss of offsite power) – two independent safety layers of emergency power supplies that are 1E classified and qualified. In addition to the standard emergency power supplies (emergency diesel generators, hydro power station supplies), there are independent special emergency diesel generators protected against external events in bunkered buildings (all erected in the 1980s and 1990s).

Nevertheless additional safety layers 6 (local accident management power supplies) and 7 (accident management power supplies stored in an external storage facility, transportable by road or by helicopter) have been implemented. Additionally some plants have augmented their diesel fuel stocks to enhance the autonomy time locally at the plant itself. Contracts have been made to deliver additional fuel from large fuel storage facilities.

What will Switzerland do in the future?

The safety layers 6 and 7 will be optimised and extended (e.g. deployment of additional small emergency power units for dedicated systems like emergency communication systems, deployment of larger emergency power units to restore special emergency systems, optimisation of emergency procedures).

At one plant (the Beznau twin plant) a large project is going on to enhance the safety layer 4 (four emergency diesel generators, two for each plant unit, replacing hydro-generators that are not seismically qualified).

2.3 DC Power Supplies

ENSREG recommendation

The enhancement of the DC power supply. Examples include improving the battery discharge time by upgrading the existing battery, changing/diversifying battery type (increasing resistance to common-mode failures), providing spare/replacement batteries, implementing well-prepared loadshedding/ staggering strategies, performing real load testing and on-line monitoring of the status of the batteries and preparing dedicated recharging options (e. g. using portable generators).

What has Switzerland done so far?

In the Swiss plants, not only the AC power is diverse, but also the DC power. That means that there are not only the usual redundant battery groups for the usual redundant safety trains, but also additional independent and redundant battery groups for the special emergency safety systems (bunkered, specially protected).

All battery groups for electrical loads important to safety in an emergency have been analysed with respect to the battery discharge time and their locations in the buildings. The result showed that, for safety equipment, battery life – before accident management power supply for recharging the batteries is available – is sufficient in all cases, and for equipment important to safety in most cases.

What will Switzerland do in the future?

Particular improvements have been planned which will be realised, and some are in the phase of investigation.

2.4 Operational and Preparatory Actions

ENSREG recommendation

Implementation of operational or preparatory actions with respect to the availability of operational consumables. Examples include, ensuring the supply of consumables such as fuel, lubrication oil, and water and ensuring adequate equipment, procedures, surveillance, drills and arrangements for the resupply from off-site are in place.

What has Switzerland done so far?

After the Fukushima accident, an external storage facility with three diesel generators, fuel, lubrication oil, cables, etc. was implemented. This equipment was tested during a shutdown period in one NPP. The test of this equipment was inspected by ENSI. Also on each of the four sites a lot of additional equipment was installed or is being stored. E.g. SAMG diesel generators in a power range of between 10 kVA and 1,000 kVA with the necessary equipment (cables, fuel, oil, lamps, etc.) are installed or stored at earthquake and flooding resistant places. The procedures for accident management (SAMG) have been revised and complemented.

In November and December 2012, ENSI inspected the relevant equipment for station blackout and for cooling the reactor and the spent fuel on all four sites. Also the original and the additional emergency connection points for electricity, water and pressurised air were part of the inspection.

What will Switzerland do in the future?

The procedures for deployment and testing of the accident management equipment will be completed by the NPPs and reviewed by ENSI in 2013.

2.5 Instrumentation and Monitoring

ENSREG recommendations:

The enhancement of instrumentation and monitoring. Examples include separate instrumentation and/or power sources to enable monitoring of essential parameters under any circumstances for accident management and the ability to measure specific important parameters based on passive and simple principles.

What has Switzerland done so far?

Accident instrumentation was installed long time before the Fukushima accident (part of the regulatory guideline ENSI-B12). Additional investigation had been made for SAMG instrumentation which is available in the main control and in the bunkered emergency control room. After the Fukushima accident, ENSI inspected this area and identified points that needed further investigation. For the spent fuel pool instrumentation (temperature and level measurement) the installation of new qualified equipment is under way.

What will Switzerland do in the future?

Additional investigations on hydrogen monitoring and treatment are in progress. Possible improvements of the SAM instrumentation will be analysed.

2.6 Shutdown Improvements

ENSREG recommendation

The enhancement of safety in shutdown states and mid-loop operation. Examples of improvements include, reducing or prohibiting mid-loop operation, adding dedicated hardware, procedures and drills, the use of other available water sources (e. g. from hydro-accumulators), requiring the availability of SGs during shutdown operations and the availability of feedwater in all modes.

What has Switzerland done so far?

The Swiss NPPs have procedures on the required availability of core cooling capacity in shutdown states and mid-loop operation. At the Gösgen NPP, the number of steam generators that have to be kept operational is specified depending on the status of the reactor pressure vessel, the primary system pressure and temperature. At the Gösgen NPP, maintenance is only allowed in one redundancy at the same time. Additionally, there is a requirement that at least one train of the special emergency residual heat removal system has to be operable during shutdown, which improves the reliability of core cooling during shutdown substantially. At the Beznau NPP, similar regulations are in place. Since a modification of the technical specification of the Mühleberg NPP it is required for the Swiss BWRs that – as a minimum – one complete safety train with core injection, residual heat removal and emergency power supply must be available during shutdown. As long as the vessel head is not removed, safety relief valves have to be operable to ensure safety injection.

In addition, SAMG in Switzerland covers all plant states, including shutdown (see chapter 3.8).

What will Switzerland do in the future?

ENSI's assessment of this issue is that the existing regulations regarding safety in shutdown mode and mid-loop operation are sufficient.

2.7 Reactor Coolant Pump Seals

ENSREG recommendation

The use of temperature-resistant (leak-proof) primary pump seals.

What has Switzerland done so far?

At the Gösgen, Leibstadt, and Mühleberg NPP, the primary pumps are inherently leak-proof after shutdown. At the Beznau NPP, seal water injection is necessary to prevent a reactor coolant pump seal LOCA.

What will Switzerland do in the future?

At the Beznau NPP, an additional, robust seal water system is planned to be installed by 2014, which will be part of the bunkered emergency system.

2.8 Ventilation

ENSREG recommendation

The enhancement of ventilation capacity during SBO to ensure equipment operability.

What has Switzerland done so far?

The need for ventilation of control panels or equipment necessary to provide cooling water and ventilation of main control rooms and emergency control rooms during SBO hat not yet been comprehensively reassessed by ENSI.

Effects of the loss of ventilation at the special emergency control rooms were tested. These tests showed that the operability of the equipment located in rooms of the special emergency bunkered systems, including control panels, is assured for at least several days.

During an extended SBO the necessary safety functions will be carried out by means of accident management measures (AMM), e.g. the use of fire water pumps or trucks, mobile diesel generators, and other means that have a relatively small waste heat production compared to the regular safety systems. According to ENSI's experience, conduction of AMM is possible without extra ventilation of such equipment. Regarding radiation protection aspects of the ventilation, no specific review was carried out so far.

What will Switzerland do in the future?

ENSI will assess the need for additional analyses on ventilation capacity during SBO.

2.9 Main and Emergency Control Rooms

ENSREG recommendation

The enhancement of the main control room (MCR), the emergency control room (ECR) and emergency control centre (ECC) to ensure continued operability and adequate habitability conditions in the event of a station black-out (SBO) and in the event of the loss of DC (this also applies to Topic 3 recommendations).

What has Switzerland done so far?

The emergency control rooms of the Swiss NPPs are designed to have a high level of protection. In 2012, ENSI conducted inspections at all Swiss NPPs regarding the habitability of and communication in emergency control rooms. The final assessments of these inspections are not yet available, as the operators will submit ENSI the concepts for assuring emergency control room habitability in February 2013.

Additional inspections on long time loss of power supply were made in each NPP at the end of the year 2012. The inspections covered the concept for managing such a situation, the relevant equipment on site, and the connection points for external emergency power supply equipment (e.g. the diesels stored at Reitnau) for reloading batteries etc.

What will Switzerland do in the future?

Depending on the results of the reviews of ECR habitability, ENSI will undertake further steps to ensure operability of these rooms.

2.10 Spent Fuel Pool

ENSREG recommendation

The improvement of the robustness of the spent fuel pool (SFP). Examples include reassessment/upgrading SFP structural integrity, installation of qualified and power-independent monitoring, provisions for redundant and diverse sources of additional coolant resistant to external hazards (with procedures and drills), design of pools that prevents drainage, the use of racks made of borated steel to enable cooling with fresh (unborated) water without having to worry about possible recriticality, redundant and independent SFP cooling systems, provision for additional heat exchangers (e. g. submerged in the SFP), an external connection for refilling of the SFP (to reduce the need for an approach linked to high doses in the event of the water falling to a very low level) and the possibility of venting steam in a case of boiling in the SFP.

What has Switzerland done so far?

ENSI reassessed SFP cooling, integrity, and instrumentation in the light of the Fukushima events. The reviews revealed potential for some improvements. ENSI therefore requested enhancing the reliability and robustness of the SFP cooling. The measures to be taken and the time frame for completion of the back-fitting measures are given below.

What will Switzerland do in the future?

ENSI ordered the following measures for enhancing SFP robustness:

- where not already available: back-fitting of two additional feed lines for SFP cooling without the need for entering the SFP buildings or rooms as an accident management measure (by 2012, at the Beznau NPP 2013)
- back-fitting of an accident-proof SFP level and temperature measurement instrumentation (1E qualification) for all Swiss NPPs (by 2014)
- improvement of the earthquake resistance and back-fitting of a venting duct to remove heat from the Beznau SFP storage building in case of boiling SFP water (by 2014)
- back-fitting of a new SFP cooling system that is qualified as safety system for the Beznau and the Mühleberg NPP (by 2015)
- back-fitting of a diversified heat sink at the Mühleberg NPP which serves also for SFP cooling (by 2017)

2.11 Separation and Independence

ENSREG recommendation

The enhancement of the functional separation and independence of safety systems. Examples include the elimination of full dependence of important safety functions on auxiliary systems such as service water and the introduction of an alternate source of cooling.

What has Switzerland done so far?

Physical separation and independence of safety systems has always been a design requirement for Swiss NPPs. Such requirements are stipulated in the Nuclear Energy Ordinance and in the regulatory guideline HSK-R-101, which was issued in Mai 1987 already.

Besides the separation of the redundancies of the safety systems, there are also bunkered special emergency systems which are fully separated from the normal safety systems and which are fed by a diversified heat sink, except for the Mühleberg NPP.

The ENSI review of the status of separation and independence of safety systems confirmed in general the high degree of separation, but showed a potential for improvement at the Mühleberg NPP.

What will Switzerland do in the future?

As mentioned in chapter 2.1, the Mühleberg NPP is required to implement a diversified heat sink by 2017. Furthermore, the ENSI review of separation and independence at the Mühleberg NPP revealed that at the lowest elevation of the reactor building there are several components including pumps of safety relevant systems that are separated only by distance. In case of internal flooding several systems could be affected simultaneously. ENSI therefore required the Mühleberg NPP to implement measures that reduce the internal flooding hazard substantially. Such measures include installation of additional valves in lines that have the potential to lead to a considerable flooding.

Furthermore backfitting of an additional safety system for core cooling and heat removal fully separated from the existing safety systems at the lowest elevation of the reactor building constitutes amongst others a prerequisite for the long term operation of the Mühleberg NPP.

As mentioned in chapter 2.2, the Beznau NPP enhances its emergency power supplies.

2.12 Flow Path and Access Availability

ENSREG recommendation

The verification of assured flow paths and access under SBO conditions. Ensure that the state in which isolation valves fail and remain, when motive and control power is lost, is carefully considered to maximise safety. Enhance and extend the availability of DC power and instrument air (e. g. by installing additional or larger accumulators on the valves). Ensure access to critical equipment in all circumstances, specifically when electrically operated turnstiles are interlocked.

What has Switzerland done so far?

In 2012, ENSI conducted inspections in all Swiss NPPs in order to review the status of the provisions for coping with a long lasting SBO. One of the issues was the accessibility of rooms which are necessary for accident management. The operators demonstrated that access is possible in case of SBO and loss of motive and control power by using so called "intervention keys" that are available in the main control room and in the guard rooms. It was also verified that valves, e.g. steam generator blow-off valves, which are needed for residual heat removal or pressure relief, can be operated under SBO conditions, for example by manual actuation (crank handles) or by mobile accumulators. Regarding containment isolation, ENSI ordered the operators on 10 January 2012 to verify the robustness of the containment isolation. In this context the position of the isola-

tion valves in case of loss of motive and control power had to be checked. The results of these investigations had to be submitted by the end of 2012.

What will Switzerland do in the future?

The reports regarding the status of the containment isolation valves will be reviewed by ENSI in 2013. Further actions regarding this issue depend on the results of these reviews. During the extended SBO inspections carried out by ENSI, it was generally confirmed that access to critical equipment is available and that the required flow paths for core cooling and residual heat removal are assured. Apart from the reviews mentioned above, ENSI does not intend to take further steps regarding this ENSREG recommendation.

2.13 Mobile Devices

ENSREG recommendation

The provision of mobile pumps, power supplies and air compressors with prepared quick connections, procedures, and staff training with drills. Mobile devices are intended to enable the use of existing safety equipment, enable direct feeding of the primary or secondary side, allow extended use of instrumentation and operation of controls, allow effective fire-fighting, and ensure continued emergency lighting. The equipment should be stored in locations that are safe and secure even in the event of general devastation caused by events significantly beyond the design basis (this also applies to Topic 3 recommendations).

What has Switzerland done so far?

As a result of the Fukushima accident, ENSI required the operators of the Swiss NPPs to organise additional storage of accident management equipment at an external place. The goal was to store part of the accident management equipment – in addition to the extensive equipment on each NPP site – at a place that would not be affected by an earthquake or flood on site. As required, the operators set up a common storage facility and acquired equipment for severe accident measures. Since June 2011, this additional equipment is stored at the centralised storage facility Reitnau. The equipment comprises for example nine diesel motor driven pumps (2,000 to 4,000 L/min at 14 to 18 bar) and three diesel generators (400V, 50 Hz, 167 to 500 kVA), hoses, cables, tools and personal protection equipment.

The storage facility Reitnau is located on top of a hill accessible by road or by helicopter. The three independent storage buildings are earthquake and flood-proof underground bunkers.

What will Switzerland do in the future?

The operators intend to test the severe accident equipment stored at Reitnau during their regular emergency exercises and will adapt the devices if appropriate. ENSI inspects the inventory of the storage facility, the maintenance of units as well as emergency exercises.

2.14 Bunkered/Hardened Systems

ENSREG recommendation

The provision for a bunkered or "hardened" system to provide an additional level of protection with trained staff and procedures designed to cope with a wide variety of extreme events including those beyond the design basis.

What has Switzerland done so far?

All Swiss NPPs already have bunkered systems. The requirement for providing such a system, in addition to the original safety systems, was given in the regulatory guideline HSK-R-101 issued in Mai 1987. It is required in HSK-R-101 that shutdown of the reactor, core cooling and residual heat removal must be assured also in case of air plane crash, explosion, fire, and third party action. The requirements include the protection of such systems against external flooding and earthquake. A further requirement is the ability of the bunkered systems to perform the safety functions automatically during at least 10 hours without the need for any operator action. The bunkered systems shall have an equally protected control room and a diversified power supply. Therefore, there exists an additional set of bunkered special emergency diesels as a backup to the normal emergency power diesels, as well as a diversified set of core cooling and residual heat removal systems.

What will Switzerland do in the future?

As the Swiss NPPs do already fully comply with the ENSREG recommendation for hardened or bunkered systems, Switzerland has no intention to require further improvements regarding the special emergency bunkered systems.

2.15 Multiple Accidents

ENSREG recommendation

The enhancement of the capability for addressing accidents occurring simultaneously on all plants of the site. Examples include assuring preparedness and sufficient supplies, adding mobile devices and fire trucks and increasing the number of trained and qualified staff.

What has Switzerland done so far?

There is only one site with two units. There were emergency exercises over the last seven years involving both units simultaneously. In each of these exercises, the emergency organization was capable to manage the workload related to both units. In addition to the local mobile devices, there are procedures to deliver diesel fuel, boric acid, mobile generators, fire pumps, durable food and other accident management supplies from the external storage at Reitnau. SAMG is available for all operational modes.

What will Switzerland do in the future?

The licensees were requested to submit a general concept on the use of accident management equipment (local and from the external storage facility). The issues of multiple units at one site will be an element of the corresponding concept and ENSI-review.

2.16 Equipment Inspection and Training Programmes

ENSREG recommendation

The establishment of regular programs for inspections to ensure that a variety of additional equipment and mobile devices are properly installed and maintained, particularly for temporary and mobile equipment and tools used for mitigation of BDB external events. Development of relevant staff training programmes for deployment of such devices.

What has Switzerland done so far?

Staff training programmes are specified in the regulatory guideline ENSI-B10. Emergency staff have to have the knowledge and skills required for fulfilling their task pursuant to emergency preparedness regulations (rules of procedure), emergency instructions, Severe Accident Management Guidance (SAMG), etc. The required knowledge and skills specified in the regulations have to be trained and practised on a regular basis. ENSI regularly reviews the training programs.

According to Article 32 of the Swiss Nuclear Energy Ordinance, the licence holder must define systematic programmes for the maintenance of safety equipment and must implement the measures specified therein, in particular relating to maintenance, non-destructive in-service inspections, and periodic functional tests. Any deviation from the nominal condition must be corrected. Qualified procedures and equipment must be used for maintenance, inspection and repair tasks. They must be carried out by qualified personnel. All maintenance and repair work must be documented. The outcome has to be periodically evaluated. Programmes must be supplemented as necessary. The results from equipment inspection and the information from the relevant training programmes have to be reported to ENSI periodically. Maintenance programmes and qualification projects are assessed by ENSI or by technical support organizations.

ENSI has revised its regulatory guideline ENSI-B11 to extend the duration of emergency exercises to 24 hours.

What will Switzerland do in the future?

The training programme has to be reviewed and adapted periodically. If the annual emergency exercises show need for improvement, targeted training and further education measures have to be initiated.

The operators continue to test, maintain and exchange the severe accident equipment and material stored at the storage facility Reitnau on a regular basis. ENSI will inspect this periodically. Furthermore, mainly during emergency exercises, ENSI will inspect the training on the use of accident management equipment.

2.17 Further Studies to Address Uncertainties

ENSREG recommendation

The performance of further studies in areas were there are uncertainties. Uncertainties may exist in the following areas:

- *The integrity of the SFP and its liner in the event of boiling or external impact.*
- *The functionality of control equipment (feedwater control valves and SG relief valves, main steam safety valves, isolation condenser flow path, containment isolation valves as well as depressurisation valves) during the SBO to ensure that cooling using natural circulation would not be interrupted in an SBO (this is partially addressed in recommendation 3.2.10).*
- *The performance of additional studies to assess operation in the event of widespread damage, for example, the need different equipment (e.g. bulldozers) to clear the route to the most critical locations or equipment. This includes the logistics of the external support and related arrangements (storage of equipment, use of national defence resources, etc.).*

What has Switzerland done so far?

ENSI has required the licensees to provide analyses on boiling and hydrogen production in the spent fuel pools. The licensees have submitted their reports, and ENSI has started reviewing them.

On the external impacts on the spent fuel pools see chapter 2.10.

In response to the severe reactor accident in Fukushima the Swiss NPPs set up a joint external storage facility at Reitnau. The storage facility is earthquake and flood proof and contains additional means and equipment for deployment. The equipment stored exceeds the international standards. The external storage facility constitutes a supplementary pillar for accident management of Swiss NPPs and has been integrated into the emergency organisation of the respective plants. The equipment stored is permanently ready for deployment. The storage facility was designed and established in cooperation with the fire brigades, army and air force. All items are packed and prepared in a way that they can immediately be transported by land or air (helicopter) with the help of these response forces.

What will Switzerland do in the future?

The report of the interdepartmental working group IDA NOMEX set up by the Federal Council in the aftermath of the Fukushima accident has identified personnel and material resources for emergency management as an issue to follow up. Key issues are the responsibilities of the emergency partners concerning the provision of personnel and material for emergency management and the elaboration of proposals on how to remove the deficits in personnel and material resources.

3 Severe Accident Management

3.1 WENRA Reference Levels

ENSREG recommendation

The incorporation of the WENRA reference levels related to severe accident management (SAM) into their national legal frameworks, and ensure their implementation in the installations as soon as possible. This would include:

- *Hydrogen mitigation in the containment: Demonstration of the feasibility and implementation of mitigation measures to prevent massive explosions in case of severe accidents.*
- *Hydrogen monitoring system - Installation of qualified monitoring of the hydrogen concentration in order to avoid dangerous actions when concentrations that allow an explosion exist.*
- *Reliable depressurization of the reactor coolant system – Hardware provisions with sufficient capacity and reliability to allow reactor coolant system depressurization to prevent high-pressure melt ejection and early containment failure, as well as to allow injection of coolant from low pressure sources.*
- *Containment overpressure protection - Containment venting via the filters designed for severe accident conditions.*
- *Molten corium stabilization - Analysis and selection of feasible strategies and implementation of provisions against containment degradation by molten corium.*

What has Switzerland done so far?

WENRA: About 80% of the WENRA reference levels have been implemented into the Swiss regulation so far. Implementation of the reference levels related to SAM in the NPPs is considered to be completed.

Hydrogen mitigation in the containment: All Swiss NPPs have provisions against hydrogen in the containment (e.g. recombiners, igniters, N_2 inertization, mixing system). This is required by the (old) regulatory guideline HSK-R-103. In addition, comprehensive strategies (i.e., SAMG for all operational modes) are available to cope with hydrogen issues.

Hydrogen monitoring system: All Swiss NPPs are equipped with hydrogen monitoring systems. However, these systems are not qualified for severe accidents.

Reliable depressurization of the reactor coolant system: All Swiss NPPs have redundant and – except the Leibstadt NPP – diverse safety relief valves for depressurization of the reactor coolant system.

Containment overpressure protection: All Swiss NPPs are equipped with filtered containment venting systems designed for severe accident conditions.

Molten corium stabilization: All Swiss NPPs have implemented SAMG. There are strategies to cool the core melt inside or outside the vessel (depending on the plant) by flooding the containment or injecting water into the (failed) reactor pressure vessel (RPV).

What will Switzerland do in the future?

WENRA: Switzerland will continue the work on new regulatory guidelines in order to harmonize with the WENRA reference levels. In particular, the guideline dealing with design requirements for NPPs (ENSI-G02) will help to harmonize with the RLs in issues E and F.

Hydrogen mitigation in the containment: ENSI will require further improvements for (passive) hydrogen management at least in some of the plants.

Hydrogen monitoring system: Improvements of hydrogen monitoring system reliability under severe accident conditions are planned for all plants.

Reliable depressurization of the reactor coolant system: The Leibstadt NPP is planning to backfit two diverse, motor-operated safety relief valves to make feed and bleed operation more reliable.

Containment overpressure protection: There is ongoing work to improve the seismic capacity of the venting systems of two Swiss plants. In addition, the risk of hydrogen combustion in the venting system will be evaluated.

Molten corium stabilization: No actions are planned.

3.2 SAM Hardware Provisions

ENSREG recommendation

Adequate hardware provisions that will survive external hazards (e.g. by means of qualification against extreme external hazards, storage in a safe location) and the severe accident environment (e.g. engineering substantiation and/or qualification against high pressures, temperatures, radiation levels, etc), in place, to perform the selected strategies.

What has Switzerland done so far?

All Swiss NPPs have special bunkered emergency systems. They are in separate buildings, are designed against external events and have the capacity for beyond design accidents to some degree. In addition, there are instantly installable accident management systems for containment depressurization and flooding qualified against seismic hazards according to the regulatory guideline ENSI-G01 as well as local mobile accident management equipment like fire water trucks, mobile pumps, and diesel generators stored in seismic and flood proved locations on site. In addition, there is an external central storage facility at Reitnau with diesel generators, fuel, pumps, hoses, boron, etc. in a bunker with protection against external flood and earthquakes. This material can be transported to the sites by Swiss Army helicopter or road.

What will Switzerland do in the future?

According to the Swiss action plan "Fukushima 2013", ENSI intends to define overall qualification requirements for accident management equipment to enhance the provision against extreme external hazards.

3.3 Review of SAM Provisions Following Severe External Events

ENSREG recommendation

The systematic review of SAM provisions focusing on the availability and appropriate operation of plant equipment in the relevant circumstances, taking account of accident initiating events, in particular extreme external hazards and the potential harsh working environment.

What has Switzerland done so far?

All Swiss NPPs have special bunkered emergency systems for decay heat removal hardened against external hazards. These have been in place for decades and are well integrated into procedures and training. Beginning around the year 2000, SAM procedures involving mobile equipment were successively developed and reviewed by ENSI. Onsite accident management equipment (e.g. mobile pumps and diesel generators) and the related procedural guidance have been added between 2009 and 2012. As additional backup measure, the external storage facility Reitnau was added in 2011.

What will Switzerland do in the future?

See chapters 3.4, 3.5, and 3.6.

3.4 Enhancement of Severe Accident Management Guidelines (SAMG)

ENSREG recommendation

The enhancement of SAMGs taking into account additional scenarios, including, a significantly damaged infrastructure, including the disruption of plant level, corporate-level and national-level communication, long-duration accidents (several days) and accidents affecting multiple units and nearby industrial facilities at the same time.

What has Switzerland done so far?

SAMGs of Swiss NPPs are generally symptom-based and thus suitable to cover a comprehensive set of scenarios. Recently the use of mobile or accident management equipment to cope with an SBO received special attention, including focused inspections by ENSI. Effects of damage to infrastructure and communication systems are addressed by the official working group to review emergency preparedness measures in case of extreme events in Switzerland (IDA NOMEX). Multiple-unit issues at the Beznau NPP are dealt with as already mentioned under (see chapter 2.15). The industrial facilities most likely to threaten the safety of nuclear installations in Switzerland are natural gas pipelines. They are regarded to be insignificant both in deterministic and probablilistic safety analyses.

What will Switzerland do in the future?

Switzerland will develop a comprehensive accident management concept in the face of long-term infrastructure disruptions, especially an SBO. The work on the measures suggested by IDA NOMEX will continue.

3.5 SAMG Validation

ENSREG recommendation

The validation of the enhanced SAMGs.

What has Switzerland done so far?

The regulatory guideline ENSI B-12, Sec. 4.4.6, requires SAMGs to be validated by an emergency exercise. Furthermore, it is required that SAMGs be updated regularly according to the state of the art and the experience from emergency exercises. ENSI reviews the SAMGs within the context of periodic safety reviews and when inspecting exercises.

What will Switzerland do in the future?

Viability and usefulness of SAMGs will be continuously reviewed in periodic safety reviews and exercises.

3.6 SAM Exercises

ENSREG recommendation

Exercises aimed at checking the adequacy of SAM procedures and organisational measures, including extended aspects such as the need for corporate and nation level coordinated arrangements and long-duration events.

What has Switzerland done so far?

General emergency exercises take place every second year as prescribed by the regulatory guideline ENSI-B11. One of the four NPP sites, the National Emergency Operations Centre of Switzerland, state authorities, and any foreign authorities as specified in bilateral and international agreements are involved. Such a scenario necessarily involves offsite response and SAM as well.

On 4 May 2011, the Federal Council decided to appoint an official working group to review emergency protection measures in case of extreme events in Switzerland (IDA NOMEX). The remit of this working group, in which ENSI was also represented, was to examine in the light of the Fukushima accident whether further action is required regarding emergency protection in case of extreme events in Switzerland, and whether any new statutory and organisational emergency protection measures need to be taken.

What will Switzerland do in the future?

A revision of the regulatory guideline ENSI-B11 coming into effect at the beginning of 2013 allows ENSI to require staff emergency exercises lasting up to 24 hours. ENSI also recently required NPP operators to develop a comprehensive concept on SAM measure to cope with an SBO.

On 4 July 2012, the Federal Council acknowledged the report of the IDA NOMEX working group and issued tasks for the elaboration of organisational measures in the field of personnel and material for emergency management, improvement of the coordination and cooperation at national level and the clarification of responsibilities.

3.7 SAM Training

ENSREG recommendation

Regular and realistic SAM training exercises aimed at training staff. Training exercises should include the use of equipment and the consideration of multi-unit accidents and long-duration events. The use of the existing NPP simulators is considered as being a useful tool but needs to be enhanced to cover all possible accident scenarios.

What has Switzerland done so far?

The regulatory guideline ENSI-B11 requires plants to regularly organise exercises on all kinds of accident scenarios. The emergency training of NPP employees shall include SAMGs as stated in regulatory guideline ENSI-B12, Sec. 4.4.6b. Accidents involving core damage cannot be handled by standard NPP simulators. Therefore, for exercises with core damage scenarios, instrument data was calculated utilizing MELCOR/MELSIM with different scenarios according to timing of operator actions and loaded into the plant-specific simulator as well as the ADAM/ANPA system of ENSI.

Furthermore, the handling of accident management equipment is regularly trained (including items from the external storage facility at Reitnau).

What will Switzerland do in the future?

A revision of the regulatory guideline ENSI-B11 coming into effect at the beginning of 2013 will give ENSI the possibility to require staff exercises lasting up to 24 hours. Exercise scenarios integrating an increased deployment of equipment stored at the external storage facility at Reitnau are being considered.

3.8 Extension of SAMGs to All Plant States

ENSREG recommendation

The extension of existing SAMGs to all plant states (full and low-power, shutdown), including accidents initiated in SFPs.

What has Switzerland done so far?

The regulatory guideline ENSI-B12, Sec. 4.4.1c, already requires NPPs to cover all plant states including shutdown in their SAMGs and all of them are in compliance. SFPs are not required to be addressed in the SAMGs. But all SFPs are addressed in all Swiss NPPs by SAMG or accident management procedures. According to an issue identified in the ENSI report on lessons learned from the Fukushima accident, SFP safety was inspected in all Swiss NPPs. These inspections resulted in the implementation of a number of improvements concerning both hardware and procedural guidance.

What will Switzerland do in the future?

No further action is needed.

3.9 Improved Communications

ENSREG recommendation

The improvement of communication systems, both internal and external, including transfer of severe accident related plant parameters and radiological data to all emergency and technical support centre and regulatory premises.

What has Switzerland done so far?

In its concluding report, the official working group set up by the Federal Council in May 2011 (IDA NOMEX) raised among else the issue of the importance of redundant and failsafe communication systems.

In collaboration with Swiss federal authorities and the licensees the current state of the measurement and prognosis systems was assessed. Based on this analysis and the lessons learned from the Fukushima accident, the requirements for such systems were redefined.

What will Switzerland do in the future?

Following the conclusions of IDA NOMEX, tasks were assigned at the federal level to define the requirements on redundancy and reliability of communication systems, to implement the project for the optimization of the communication between partners in an emergency and to clarify the financing of such systems. Work on these tasks is currently scheduled up to the end of 2016.

Based on the defined requirements for measurement and prognosis systems a concept has to be developed and then has to be implemented.

3.10 Presence of Hydrogen in Unexpected Places

ENSREG recommendation

The preparation for the potential for migration of hydrogen, with adequate countermeasures, into spaces beyond where it is produced in the primary containment, as well as hydrogen production in SFPs.

What has Switzerland done so far?

The findings and lessons learned from the Fukushima accident in relation to hydrogen have so far been summarised by ENSI in its action plan Fukushima 2012. All Swiss NPPs are equipped with systems for hydrogen mitigation. The potential for hydrogen production in the spent fuel pools and the integrity of the containment venting system were required to be investigated by the NPPs.

What will Switzerland do in the future?

Within its action plan for 2013, ENSI will request the NPPs to investigate systematically the issue of migration of hydrogen. This investigation will also cover the ingress of hydrogen into adjacent rooms in the plant.

3.11 Large Volumes of Contaminated Water

ENSREG recommendation

The conceptual preparations of solutions for post-accident contamination and the treatment of potentially large volumes of contaminated water.

What has Switzerland done so far?

Retention reservoirs for the water used for fire-fighting are required by Swiss legislation. As a consequence of the latest periodical safety reviews, power plant operators have been requested to update their analyses and installed additional volume, if needed.

ENSI assessed the emergency preparedness to protect purification plants that draw drinking water out of rivers and lakes. ENSI required federal, cantonal and communal authorities to assess their emergency preparedness procedures in case of contaminated river water and to propose the improvements necessary.

What will Switzerland do in the future?

ENSI will work together with federal, cantonal and local authorities and power plant operators to improve procedures and adapt equipment, if needed.

In February 2013, ENSI will publish its action plan "Fukushima 2013" which will require an investigation of the handling of radioactive water in case of a severe accident.

3.12 Radiation Protection

ENSREG recommendation

The provision for radiation protection of operators and all other staff involved in the SAM and emergency arrangements.

What has Switzerland done so far?

ENSI required the NPP operators to assess the feasibility of accident management measures in the plants. Assuming a severe core melt, dose rates have been determined at critical places on site at places necessitating operator action in the case of emergency. As a consequence of the latest periodical safety reviews, power plant operators were requested to update their analyses.

Under standard conditions, at each NPP there are sufficient personnel, radiation protection equipment and dosimeters. In case that in a severe situation the material stored on the NPP site were not accessible, radiation protection kits for at least 70 people as well as radiation measurement devices and decontamination equipment is now stored in containers at the storage facility Reitnau.

What will Switzerland do in the future?

ENSI will routinely check radiation protection measures for severe accident situations in all Swiss NPPs, including rescue teams. In emergency exercises the preparedness for adequate radiation protection procedures in severe accident situations shall be demonstrated. This includes also the preparedness of local fire brigades, rescue teams, and the storage facility Reitnau.

3.13 On Site Emergency Centre

ENSREG recommendation

The provision of an on-site emergency centre protected against severe natural hazards and radioactive releases, allowing operators to stay onsite to manage a severe accident.

What has Switzerland done so far?

All Swiss NPP have bunkered emergency buildings, which contain at least one train of safety systems and an emergency control room to monitor the plant conditions and control the plant. These buildings are designed to withstand external events and to protect operators against the radiological consequences of core damage accidents.

Moreover, all NPP sites are equipped with civil protection buildings to accommodate large numbers of persons.

In general, the given facilities in the Swiss NPP meet the ENSREG recommendation.

Following the Fukushima accident, ENSI has set up an action plan for the year 2012. One of the issues addressed in this plan focuses on the emergency centres on site. Aspects of short term operability and habitability of emergency rooms during nuclear accidents as well as ensuring communication with external organisations are being assessed.

What will Switzerland do in the future?

In 2012 ENSI required a long term operation concept after a core damage accident with large release for each NPP. In 2013, ENSI will be assess these concepts with regard to the existing emergency facilities and international standards.

3.14 Support to Local Operators

ENSREG recommendation

Rescue teams and adequate equipment to be quickly brought on site in order to provide support to local operators in case of a severe situation.

What has Switzerland done so far?

Since June 2011, the Swiss NPPs run a centralised storage facility for accident management equipment at Reitnau, which is located at a distance of between 50 and 120 km from the Swiss NPPs. The equipment has been carefully selected in type and number so that up to two NPPs may get the necessary assistance in severe accident situations. All the equipment is prepared for transportation by helicopter or road.

In case of a severe accident in one of the Swiss NPPs, the following rescue team are available with a few hours:

- Fire brigade: 2 brigades with each 25 persons to cover 2 shift operation
- Emergency power: 2 brigades with each 3 persons to build up external power supply
- Radiation Protection: 5 brigades with each 3 persons to cover the surveillance of the radiological situation

As the distances between the power plants are relatively short, this manpower is mainly recruited within the staff of the plants.

What will Switzerland do in the future?

The centralised storage facility at Reitnau will continue operation with regular tests and maintenance of the stored equipment. During emergency exercises in the NPPs the interfaces to the accident management equipment available at the plants, in their vicinity, and at the storage facility Reitnau will be tested.

3.15 Level 2 Probabilistic Safety Assessments (PSAs)

ENSREG recommendation

A comprehensive Level 2 PSA as a tool for the identification of plant vulnerabilities, quantification of potential releases, determination of candidate high-level actions and their effects and prioritizing the order of proposed safety improvements. Although PSA is an essential tool for screening and prioritising improvements and for assessing the completeness of SAM implementation, low numerical risk estimates should not be used as the basis for excluding scenarios from consideration of SAM especially if the consequences are very high.

What has Switzerland done so far?

As required by the regulatory guideline ENSI-A05, all Swiss NPP have to develop and maintain Level 2 PSAs covering all relevant accidents due to internal or external events in all plant states. While these are very prominent among the technical bases for the development of SAMGs (see regulatory guideline ENSI-B12), the document that initiated the development of SAMGs in Switzerland in the year 2000 (HSK-AN-3674) clearly disapproves of exclusion of scenarios due to low frequency of occurrence. Therefore, ENSI agrees with above statement.

What will Switzerland do in the future?

No action necessary.

3.16 Severe Accident Studies

ENSREG recommendation

The performance of further studies to improve SAMGs. Examples of areas that could be improved with further studies include:

- *The availability of safety functions required for SAM under different circumstances.*
- *Accident timing, including core melt, reactor pressure vessel (RPV) failure, basemat melt-through, SFP fuel uncovery, etc.*
- *PSA analysis, including all plant states and external events for PSA levels 1 and 2.*
- *Radiological conditions on the site and associated provisions necessary to ensure MCR and ECR habitability as well as the feasibility of AM measures in severe accident conditions, multi-unit accidents, containment venting, etc.*

- *Core cooling modes prior to RPV failure and of re-criticality issues for partly damaged cores, with unborated water supply.*
- *Phenomena associated with cavity flooding and related steam explosion risks.*
- *Engineered solutions regarding molten corium cooling and prevention of basemat melt-through.*
- *Severe accident simulators appropriate for NPP staff training.*

What has Switzerland done so far?

Studies with relevance to the SAMGs are continuously being performed. A typical example of this is the update of the radiological post-LOCA-study at the plant, requiring the evaluation of habitability with regard to ionizing radiation in all rooms that need to be accessed to perform actions required by the emergency procedures or are otherwise important for accident management, such as the main control room.

ENSI and the operators independently cooperate with domestic and foreign research institutions to increase knowledge on severe accident behaviour. Regarding staff training, accidents involving core damage cannot be handled by standard NPP simulators, but there have been exercises for which instrument data had been calculated utilizing MELCOR/MELSIM with different branches according to timing of operator actions and fed into the plant-specific simulator as well as the ADAM/ANPA system of ENSI.

What will Switzerland do in the future?

The activities mentioned above will be continued.

4 National Organizations

The regulatory framework in Switzerland clearly allocates responsibilities and specifies the functions of the authorities responsible for safety. In case of an emergency, specific legal provisions apply, defining the tasks of the competent authorities and of the operators of nuclear facilities. In the event of a radiological emergency, the Federal NBCN (nuclear, biological, chemical, and natural) Crisis Management Board is called into action. The NBCN Crisis Management Board consists of the directors of all federal offices concerned, including the ENSI director general. It assesses the overall situation, proposes the necessary measures to the Federal Council (government), ensures coordination with other authorities and the deployment of resources required to cope with the event (e.g. civil and military elements, expert support by laboratories). It runs a stand-by emergency service, the National Emergency Operations Centre (NEOC), which is responsible for alerting and informing the public and for initiating early countermeasures in the event of a radiological accident. This chapter focuses on the general organizational topics relevant for maintaining and enhancing nuclear safety. The communication in an emergency is described in chapter 5.

4.1 Review and Revision of Nuclear Laws, Regulations and Guides

The Swiss legal framework governing the safe use of nuclear energy is widely based on the IAEA Safety Standards. In 2005, ENSI started its comprehensive project to design a new regulatory framework. This process has progressed well over the past years. When drafting regulatory guidelines, the IAEA safety standards are systematically taken into account. The same applies to the WENRA reference levels.

ENSI will continue its efforts to complete the regulatory framework considering the current IAEA Safety Standards as well as the WENRA reference levels. As an example, the radiation protection ordinance is currently being revised with the objective of achieving full compliance with international standards.

4.2 Changes to Functions and Responsibilities of the Regulatory Body

In November and December 2011, ENSI underwent an IRRS mission. The IRRS team issued the following recommendations relevant for functions and responsibilities:

- "The government should consider providing ENSI with the authority to issue regulatory requirements."
- "The government should take appropriate measures to ensure conventional safety requirements are being supervised and complied with at all nuclear facilities and that there are effective interfaces between conventional, radiation and nuclear safety."
- "The government should evaluate the needs for building and maintaining competence of the parties that have responsibilities in relation to safety in the near, mid-term and long-term future. It should then adopt the appropriate strategy to fulfil those needs."
- "Government should ensure that relevant authorities, commissions and committees, for example the NSC (Nuclear Safety Commission), involved in nuclear safety matters, provide its recommendations

and advice directly to ENSI before it issues its final decision. This should be done in an open and transparent manner, in order to allow ENSI to make an informed decision."

- "The government should revise relevant legislation in order to provide ENSI with the authority to formulate binding conditions on nuclear safety, security and radiation protection. This should be fully reflected in various licences, orders or in their amendments whenever it is necessary before or after the issuance of the authorization."
- "The Government should change the legal framework in such a way that the threshold for prosecution should be commensurate with safety significance, in accordance with a graded approach. The legal framework should also – given the importance of openness and transparency for nuclear safety – allow prosecution of a licensee in order to avoid the detrimental effects of blame on an individual."
- "The government should ensure that the Swiss Authorities responsible for the transport of radioactive material operate a collaborative process for the timely exchange of information regarding authorisations, inspections and enforcement actions to provide coordinated and effective regulatory oversight."
- "The government should ensure that there is appropriate and effective regulatory oversight and enforcement authority for all activities relating to packages that are used to transport radioactive material when such activities are undertaken on a facility that is not regulated under NEA (Nuclear Energy Act)."

After the mission, ENSI has defined a set of actions to implement the IRRS recommendations and suggestions.

4.3 Reviews and Improvements to Aspects of National EP&R

On 4 May 2011, the Federal Council decided to appoint an interdepartmental working group to review emergency protection measures in case of extreme events in Switzerland (IDA NOMEX). The remit of this working group, in which ENSI was also represented, was to examine in the light of the Fukushima accident whether further action is required regarding emergency protection in case of extreme events in Switzerland, and whether any new statutory and organisational emergency protection measures need to be taken. On 4 July 2012, the Federal Council acknowledged the report of the working group IDA NOMEX and issued tasks for the elaboration of organisational measures in the field of personnel and material for emergency management, improvement of the coordination and cooperation at national level and the clarification of responsibilities. For a detailed description of the results see chapter 5.

4.4 Openness, Transparency and Communication Improvements

Since 2009, ENSI is as an independent body constituted under public law which reports directly to the government and is fully separated from the Swiss Federal Office of Energy. As a federal authority, ENSI is subject to the Federal Act on Freedom of Information in the Administration. According to this law, all ENSI documents are public with defined exceptions, for instance security-related information, personal data, or trade secrets. ENSI is able to exercise its authority to intervene in cases where nuclear facilities or activities may pose significant radiation risks. According to the Nuclear Energy Act, ENSI shall order all necessary and reasonable

measures aimed at preserving nuclear safety and security. In the event of an immediate threat, it may impose immediate measures that deviate from the issued license or order.

ENSI regularly informs the public about its activities. For instance, it organises regular meetings with stakeholders like the mayors of the emergency planning zones 1 and 2. In these meetings, all aspects of safety, including emergency preparedness and response (see chapter 5) are addressed.

In the past, ENSI made important decisions based on its own expertise and on the expertise of external experts. These decisions were published and then commented by external interested parties, e.g. federal commissions. The IRRS team recommended in 2011 that ENSI collect information from interested parties (e.g. commissions) before taking the decisions in order to avoid later questioning of ENSI's statements. This issue is handled in the framework of the resolution of IRRS recommendations.

ENSI has expanded its information activities. ENSI appreciates the operators' communication activities related to experience exchange at an international level (e.g. WANO, OSART).

All Swiss NPPs underwent OSART missions including a follow-up mission (the last follow-up mission took place in October 2012 at Mühleberg) and all of them have implemented the recommendations received in the OSART reports. All Swiss OSART reports are available to the public. All Swiss country reports for the Convention on Nuclear Safety (CNS) and the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management are published on ENSI's website as well. All Swiss NPPs are member of the WANO and have a schedule for periodic WANO Peer Reviews.

4.5 Human and Organizational Factors

In August 2011, ENSI published a first report on its preliminary analysis of human and organisational factors (HOF) in the Fukushima accident. Since then it continued to deepen the analysis. A follow-up report is planned (no definitive date is yet established for publication, though).

In 2012, ENSI conducted technical discussions with each NPP on the implications of the Fukushima accident and the following political decision to phase out of nuclear energy for their safety culture.

Moreover, ENSI initialised a process of self-reflection on its own regulatory culture and its effect on the licensees' nuclear safety and safety culture.

5 Emergency Preparedness and Response and Post-Accident Management

On the basis of a report by ENSI, the Federal Council decided on 4 May 2011 to set up an official working group to review emergency preparedness measures in case of extreme events in Switzerland (IDA NOMEX). The report of IDA NOMEX was adopted by the Federal Council on 7 July 2012. It describes 56 organisational and legislative measures deemed to be necessary as a result of the review conducted. ENSI is responsible for implementing measures related to

- assistance for persons with severe radiation exposure,
- the availability of measurement and forecasting systems for NPPs in extreme events,
- the reference scenarios for emergency preparedness and
- the review of the emergency planning zones around NPP sites.

Switzerland will continue to deal with the mandates defined in the IDA NOMEX report approved by the Swiss Federal Council. ENSI will mainly work on the reference scenarios and the emergency planning zone concept, but will be involved in several other measures.

Based on its action plan "Fukushima 2012", ENSI performed inspections of the Emergency operations facilities in all NPPs. The approaches and methods for the source term estimation were also examined.

In February 2013, ENSI will publish its action plan "Fukushima 2013" which will continue to deal with the open points identified in the lessons learned report of ENSI.

6 International Cooperation

This chapter focuses on Switzerland's international contractual obligations and cooperation activities which are considered to be relevant in the context of the Fukushima accident and the lessons learned from it. In light of this accident, Switzerland decided to further increase its engagement and contributions to strengthening the global nuclear safety regime.

ENSI is represented in more than 70 international committees. The majority of these bodies are part of the International Atomic Energy Agency (IAEA) and the Nuclear Energy Agency (NEA) of the OECD. ENSI furthermore actively participates in international organisations: chairing the Western European Nuclear Regulators' Association (WENRA), chairing the European Nuclear Security Regulators Association (ENSRA), as an observer in the European Nuclear Safety Regulators' Group (ENSREG) together with the European Nuclear Energy Forum (ENEF), as a member of the Heads of the European Radiological protection Competent Authorities (HERCA), and as a member of the European Union Clearinghouse as well as in the Network of Regulators of Countries with Small Nuclear Programmes (NERS).

In November 2011, Switzerland hosted an Integrated Regulatory Review Service (IRRS) mission by the IAEA. This peer review mission on the governmental, legal and regulatory framework for safety had already been initiated prior to the Fukushima accident.

6.1 Strengthening the Peer Reviews of CNS and of Missions

All Swiss NPPs underwent Operational Safety Review Team (OSART) missions including the Follow-up missions. In October 2012 the Mühleberg NPP subjected itself to an OSART mission. All Swiss NPPs also underwent at least one World Association of Nuclear Operators (WANO) mission at their own initiative.

Switzerland was the first Western country to request a mission by an IAEA International Regulatory Review Team (IRRT). The mission took place in 1998, the follow-up mission in 2003. The ENSI Ordinance stipulates that ENSI "subject itself periodically to a review by external experts regarding its compliance with the requirements of the IAEA". Therefore, ENSI is legally obliged to regularly host IRRS missions. The last mission to Switzerland took place in November 2011, including issues dedicated to the lessons learned from the Fukushima event (Swiss response to the event, formal orders issued by ENSI, creation of an external storage facility, participation in the EU stress tests and NPPs reassessment). Furthermore, ENSI experts so far have participated in sixteen IRRT and IRRS missions to other countries and chaired two of these missions. At the international level, ENSI encourages the conduct of international peer reviews.

6.2 Optimisation of the Global Safety Regime

As a consequence of the Fukushima accident, Switzerland advocates strengthening the global system for nuclear safety. The background for this position is the call for mandatory IAEA review missions to all countries with NPPs to assess their regulatory framework and activities as well as their NPP's siting, design and operation. Furthermore, Switzerland aims for more transparency in the reporting on the CNS meetings and the review missions, by calling for mandatory publication of the review results. The IAEA Action Plan on Nuclear Safety, which was endorsed by the IAEA General Conference of September 2011, includes these elements on a

non-mandatory basis and is considered to be a first step towards the effective strengthening of the global nuclear safety regime.

At the Second Extraordinary Meeting of the Convention on Nuclear Safety that was held in August 2012, Switzerland proposed various amendments to the Convention. To accommodate those, a working group entrusted with the task of strengthening the Convention was established. Switzerland will actively participate in this working group and will focus on efforts aimed at strengthening the multilateral nuclear safety regime. ENSI reaffirmed this position during the Fukushima Ministerial Conference on Nuclear Safety in December 2012.

6.3 Strengthening Communication Mechanisms through Regional and Bilateral Cooperation

Switzerland has signed bilateral treaties on the early notification and mutual assistance in case of a nuclear emergency with all neighbouring countries. Based on these treaties, bilateral commissions of the nuclear safety authorities were established which usually meet once a year. These bilateral commissions also exchange operational and regulatory experience and cooperate in emergency preparedness and response matters. The French-Swiss and the German-Swiss commissions comprise dedicated sub-commissions for this topic.

Incidents and accidents in Switzerland are reported to the IAEA Incident and Emergency Centre (IEC) by using the Unified System for Information Exchange in Incidents and Emergencies (USIE). In case of a serious incident or an accident in a Swiss nuclear installation, the national emergency response organisation is mobilised according to the Emergency Protection Ordinance and the Ordinance on the Organisation of Operations in Connection with NBCN Events, defining the governmental bodies responsible for mitigation of the accident, their duties and communication lines (see chapter 5). According to the Convention on Early Notification of a Nuclear Accident and corresponding bilateral agreements with Switzerland's neighbouring countries, the IAEA and the authorities of Germany, France, Italy and Austria are notified instantly. Switzerland is part of the EMERCON and ECURIE information systems.

An automatic dose rate monitoring and emergency response data system has been installed for all NPPs in Switzerland. The data is transmitted online to ENSI, the National Emergency Operations Center and – regarding the Leibstadt and Beznau NPPs which are close the German border – also to the responsible authorities in Germany. This data is also transmitted to EURDEP, the European Radiological Data Exchange Platform of the European Commission. ENSI's radiological prediction results are provided to the National Emergency Operations Centre and to the German authorities.

6.4 Effectiveness of Experience Feedback Mechanisms

The Swiss Nuclear Energy Act, the Nuclear Energy Ordinance and regulatory guidelines include requirements on the notification of events. The Nuclear Energy Ordinance also requires each plant to form a group that investigates events, defines corrective actions and follows through their implementation to prevent events from reoccurring. The insights from these events, as well as from international events, must be reported to ENSI at least every three months. In addition, operators are legally obliged to review their NPP design after every INES-1-event in their own plant or after any INES-2-event in another NPP in Switzerland or abroad.

Accordingly, ENSI issued an order to all NPP operators one week after the nuclear accident in Fukushima. This order was followed by three further others, regarding the procedure and deadlines for the design reviews, the

first measures to be taken based on the preliminary results of the reviews and the reassessment of the safety margins in the framework of the EU stress test.

ENSI reviews domestic and international operating experience. The review of operating experience may result in regulatory action and, as appropriate, in requirements to the operator. The yearly assessment of the safety situation at each Swiss NPP is based on the operating experience. This systematic safety assessment, which includes findings from inspections as well as from event investigation, is for instance used to focus the inspections on a particular aspect in the following year, representing a true feedback of operating experience into the regulatory actions.

ENSI issues an annual report compiling information on regulatory safety research, lessons learned from events in foreign NPPs, international cooperation and current changes and developments in the basics of the nuclear regulatory process. In some cases, e.g. for incidents of global interest or with main relevance to Swiss NPPs, ENSI prepares reports on its examination and response actions (e.g. the report on the event at Forsmark 1 on 25 July 2006, four reports on the analysis of the Fukushima accident).

Nuclear incidents in Switzerland are reported to the International Reporting System for Operating Experience (IRS) jointly operated by the IAEA and the NEA. ENSI is a member of the NEA Working Group on Operating Experience, the NEA Working Group on Inspection Practices and the European Network on Operational Experience Feedback (EU Clearinghouse). Sharing of operating and regulatory experience is also a constant agenda item of the bilateral commission meetings with the neighbouring states and of the meetings of the Network of Regulators of Countries with Small Nuclear Programmes (NERS), currently comprising eleven countries.

On a bilateral level, inspectors of the French Nuclear Safety Authority regularly participate in so-called cross inspections in Swiss NPPs and vice versa. For instance in autumn 2011, ENSI inspectors participated in inspections at the French Fessenheim and Bugey NPPs which are located close to the Swiss border. These inspections focused on Fukushima issues like earthquake resistance, flooding protection, loss of power and ultimate heat sink, emergency preparedness and response.

6.5 Strengthening and Expanded use of IAEA Safety Standards

The Swiss legal framework governing the safe use of nuclear energy is widely based on the IAEA Safety Standards. In 2005, ENSI started its comprehensive project to develop a new regulatory framework. This process has progressed well over the past years. When drafting guidelines, the IAEA safety standards are systematically taken into account. ENSI will continue its efforts to complete the regulatory framework considering the current IAEA Safety Standards. As an example, the radiation protection ordinance is currently being revised with the objective of achieving full compliance with international Standards.

ENSI is actively involved in the IAEA's committees for the drafting of the IAEA Safety Standards and thereby contributes to their strengthening. In fact, ENSI is represented in the Nuclear Safety Standards Committee (NUSSC), in the Radiation Safety Standards Committee (RASSC), in the Transport Safety Standards Committee (TRANSSC) and in the Waste Safety Standards Committee (WASSC).

7 National conclusions and activities

7.1 Fukushima Action Plan

After the accident in Japan's Fukushima Dai-ichi NPP on 11 March 2011, the Swiss Federal Nuclear Safety Inspectorate ENSI ordered immediate measures for a review of the safety of the Swiss NPPs. In parallel, an interdisciplinary team of experts from ENSI (the "Japan Analysis Team") reconstructed the events of the accident and subjected them to in-depth analysis. The results were presented to the public in two reports at the end of August 2011. The third report on the Fukushima accident outlines how Switzerland can continue to optimise the safety of its own NPPs on the basis of experience gained in Japan. Swiss NPPs do not display any significant shortcomings as regards safety. Nevertheless, on the basis of knowledge gained from Fukushima, ENSI has investigated whether further optimisation of the existing assessment of precautions against severe reactor accidents is required, and whether any additional measures need to be initiated in order to protect the population. In order to identify the potential for optimisation, ENSI defined 37 issues to be followed within the "Action Plan Fukushima". The "Action Plan Fukushima" is effective from 2012 onwards and will be annually updated until completion of the measures. The "Action Plan Fukushima" for 2012 covers 29 issues related to a number of subjects: earthquakes, flooding, extreme weather conditions, lengthy loss of power supplies, loss of the ultimate heat sink and coolant supply, containment venting and hydrogen management, emergency management at national level in Switzerland, safety culture, experience feedback, international supervision and cooperation, and the external storage facility at Reitnau. Twelve of these issues are related to the work started on the basis of the report by the official working group IDA NOMEX. Another eight open points were added in the "Action Plan Fukushima" from the Swiss National Report for the EU stress test. Three of them relate to seismic protection. Two are concerned with emergency management. Single points deal with protection in case of flooding, extreme weather events and loss of power supplies. Processing of the identified issues from the "Action Plan Fukushima" and open points is due by 2017. To achieve this goal, ENSI will update the "Action Plan Fukushima" annually and will report on the status of work. The list of open points and issues will be continuously reviewed on the basis of the latest knowledge, and will be updated as necessary.

7.2 IRRS Mission to Switzerland

In November 2011, Switzerland hosted an Integrated Regulatory Review Service (IRRS) mission of the IAEA. This peer review mission on the effectiveness of the governmental, legal and regulatory framework for safety had already been initiated prior to the Fukushima accident.

The IRRS mission noted good practices in the Swiss system and also made recommendations and suggestions to improve the regulatory infrastructure. The scope of the mission covered the Swiss nuclear regulatory framework for all types of nuclear-related activities regulated by ENSI. The mission was conducted from 20 November to 2 December 2011, mainly at ENSI in Brugg. The team held extensive discussions with ENSI staff and visited all Swiss NPPs.

The IRRS team highlighted several good practices of the Swiss regulatory system, including the following:

- ENSI requires Swiss nuclear operators to back-fit their facilities by continuously upgrading equipment and safety procedures and adopting current technology to maximize nuclear safety.

- ENSI demonstrates openness and transparency by posting significant documents on its website, including reports on safety research, applicable lessons from foreign NPPs, and safety assessments for all Swiss NPPs.
- ENSI's comprehensive and user friendly management system enables the regulator to work effectively and efficiently to oversee Swiss nuclear safety.

The IRRS team also made recommendations to improve the Swiss regulatory system, including the following:

- As ENSI was established as an independent regulatory body in 2009 as part of a revised government framework, the Swiss government should actively monitor how this new framework is working and make improvements as needed.
- ENSI needs the authority to set conditions for licensing nuclear activities and to issue regulatory requirements.
- The Swiss regulatory framework should continue evolving its graded approach to safety, and further develop its inspection efforts in all areas, especially in waste, decommissioning and transport.

8 Implementation of activities

8.1 Recommendations to Switzerland from the Peer Review Country Report

Extreme weather recommendation

ENSREG recommendation

The peer review team recommends considering the assessment of margins with respect to extreme weather conditions exceeding the design bases, e.g. by extending the scope of future PSRs.

What has Switzerland done so far?

In 2012, ENSI has defined the specifications for analyses on the protection against extreme weather conditions, including combinations thereof, to be performed by the licensees. Meteoswiss has delivered the raw data for the assessment.

What will Switzerland do in the future?

The operators have to deliver their reports before the end of 2013. Subsequently ENSI will evaluate the licensees' reports in 2014.

Severe Accident Management

ENSREG recommendation

It is recommended that the regulator assesses the opportunity of requiring more reliance on passive systems for hydrogen management for severe accident conditions. It is also recommended that the regulator considers further studies on the hydrogen management for the venting systems.

What has Switzerland done so far?

ENSI has started discussing the boundary conditions for further analyses to be conducted by the licensees. The need for passive autocatalytic recombiners has also been studied.

What will Switzerland do in the future?

ENSI will request all Swiss licensees to provide additional studies and identify possible backfitting measures. After evaluation of the licensees reports a decision on hardware and procedural measures will be taken.

8.2 Open Points Derived from the EU Stress Test Swiss National Report

ENSI has derived eight open points which may lead to further improvement measures within the EU stress test. ENSI plans to complete the processing of all these points by 2017.

Open point 2.1

ENSI will follow up the question as to whether in the Swiss nuclear NPPs automatic scrams should be triggered by the seismic instrumentation

What has Switzerland done so far?

As stated in the Swiss report for the EU stress test the Swiss NPPs do not have an automatic scram actuation based on seismic instrumentation.

ENSI has started preliminary discussions on the issue. The objective of such discussions is the detailed analysis of the current situation in the Swiss NPPs and the clarification of pros and cons of an automatic scam triggered by the seismic instrumentation.

What will Switzerland do in the future?

The Regulatory Body ENSI will set up in 2013 a working group to investigate the necessity to implement in NPPs automatic scrams triggered by the seismic instrumentation.

As a basis for the decision-making process, also the international practice should be taken into account. Once the information is collected and structured, ENSI will issue an evaluation report. Based on these results a back-fitting demand could be sent to the licensees, if necessary.

Open point 2.2

In respect of seismic proof that has still to be supplied, ENSI will follow up, for all Swiss nuclear NPPs, on a more detailed examination of the seismic robustness of the isolation of the containment and the primary circuit.

What has Switzerland done so far?

This issue was addressed in the ENSI order issued on 10 January 2012. ENSI has asked the licensees to evaluate in detail the seismic robustness of the containment and primary circuit.

The operators have submitted their reports to ENSI, which have been partly evaluated during the assessment of the plant protection against earthquake (ENSI evaluation report issued July 2012).

What will Switzerland do in the future?

ENSI will complete the evaluation for all the NPPs by issuing evaluation reports in the course of 2013. Possible further actions will be decided upon in 2013.

Open point 2.3

ENSI will follow up on measures to improve the seismic stability of the containment venting systems in case of beyond-design basis accidents for the Gösgen and the Leibstadt NPP.

What has Switzerland done so far?

This issue was addressed in the ENSI order issued on 10 January 2012. ENSI has asked the licensees of the Gösgen and the Leibstadt NPP to evaluate in detail the seismic robustness of their filtered containment venting systems. The licensees have submitted their analyses.

What will Switzerland do in the future?

ENSI is currently evaluating the input received and will issue corresponding reports in the course of 2013. A decision on possible backfitting measures or further actions will be made in 2013.

Open point 3.1

ENSI will follow up on the impacts of a total debris blockage of hydraulic engineering installations at the Beznau, Gösgen and Mühleberg NPP.

What has Switzerland done so far?

The operators have delivered their reports to ENSI. ENSI is reviewing the analyses of the licensees with the help of external experts.

What will Switzerland do in the future?

A statement on the licensees' reports will be issued by ENSI in the course of 2013. Further actions if needed will be decided based on such statements.

Open point 4.1

ENSI will follow up for all Swiss NPPs on the proofs of protection against extreme weather conditions, including combinations thereof.

What has Switzerland done so far?

In 2012, ENSI defined the specifications for the analyses to be performed by the licensees. Meteoswiss has delivered the raw data for the assessment.

What will Switzerland do in the future?

The operators have to deliver their reports before the end of 2013. Subsequently ENSI will evaluate the licensees' reports in 2014.

Open point 5.1

ENSI will follow up for all Swiss NPPs on the development of a comprehensive strategy for the targeted deployment of the mobile accident management emergency diesels in order to secure selected direct current or alternating current consumers in the long term under total SBO (resp. SBO) conditions.

What has Switzerland done so far?

The Swiss NPPs are characterised by a robust design against total SBO with multi-layered defence levels. Nonetheless, the licensees have equipped an external storage facility (see chapter 2.12) with mobile accident management emergency diesel generators which can be transported on site via helicopter and plugged to predefined connection points. Additionally, all licensees have equipped their plants with supplementary mobile diesel generators (partially with fixed installation place but not connected).

ENSI has conducted topical inspections on all four sites in order to check the new accident management equipment, the deployment strategy, the procedures and connection points. The analysis of the inspection results is still in progress.

What will Switzerland do in the future?

Based on the results of the topical inspections, ENSI will evaluate the need for further actions.

Open point 6.1

From the point of view of risk minimisation, ENSI will follow up for all Swiss NPPs on the extent to which the current deployment strategies for the venting systems in severe accidents should be retained.

What has Switzerland done so far?

On venting strategies, ENSI has received recommendations about the use of passive means for hydrogen control as well as on the issue of inertisation of the filtered containment venting system piping as a result of the Country Peer Review. As a consequence, ENSI has started discussing the boundary conditions for further analyses to be conducted by the licensees. The need for passive autocatalytic recombiners has also been studied.

What will Switzerland do in the future?

ENSI will issue a request to all Swiss licensees for additional studies and possibly backfitting measures. After evaluation of the licensees reports a decision on hardware resp. procedural measures will be taken.

Open point 6.2

ENSI will follow up for all Swiss NPPs on whether restoring containment integrity during shutdown in the case of a total SBO represents a time-critical measure.

What has Switzerland done so far?

The issue has been retained for further analyses.

What will Switzerland do in the future?

A detailed analysis of total SBO is foreseen also for low power and shutdown states. Depending on the results, measures could be envisaged.

List of acronyms

AM	Accident Management
BDB	Beyond Design Basis
CNS	Convention on Nuclear Safety
DC	Direct Current
EC	European Commission
ECC	Emergency Control Centre
ECR	Emergency Control Room
ECURIE	European Community Urgent Radiological Information Exchange
EMERCON	early notification system for nuclear emergencies operated by the IAEA and based on the Convention on Early Notification of a Nuclear Accident
ENEF	European Nuclear Energy Forum
ENSI	Swiss Nuclear Safety Inspectorate
ENSRA	European Nuclear Security Regulators Association
ENSREG	European Nuclear Safety Regulators Group
EP&R	Emergency Preparedness and Response
ERS	Expert Group for Reactor Safety
EU	European Union
HERCA	Heads of the European Radiological protection Competent Authorities
HOF	Human and Organisational Factors
HSK	former name of ENSI
IAEA	International Atomic Energy Agency
IDA NOMEX	inter-departmental working group to review emergency preparedness measures in case of extreme events in Switzerland
IEC	Incident and Emergency Centre
INES	International Nuclear and Radiological Event Scale
IRRS	Integrated Regulatory Review Service
IRRT	International Regulatory Review Team (former IRRS)
NBCN	Nuclear Biological Chemical Natural
NEA	Nuclear Energy Agency
NERS	Network of Regulators of Countries with Small Nuclear Programmes
MCR	Main Control Room
NEOC	National Emergency Operations Centre
NGO	Non-Governmental Organisation
NPP	Nuclear Power Plant
NUREG/CR	Reports by Contractors of the United States Nuclear Regulatory Commission
OECD	Organisation for Economic Co-operation and Development
OSART	Operational Safety Review Team
PRP	Pegasos Refinement Project
PSA	Probabilistic Safety Assessment
RHWG	Reactor Harmonization Working Group
RPV	Reactor Pressure Vessel
SAM	Severe Accident Management

SAMG	Severe Accident Management Guideline
SBO	Station Black Out
SSHAC	Senior Seismic Hazard Analysis Committee
SFP	Spent Fuel Pool
SG	Steam Generator
USIE	Exchange in Incidents and Emergencies
WANO	World Association of Nuclear Operators
WENRA	Western European Nuclear Safety Regulators Association

Schweizerische Eidgenossenschaft
Confédération suisse
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ENSI-AN-8124
Published 31.12.2012