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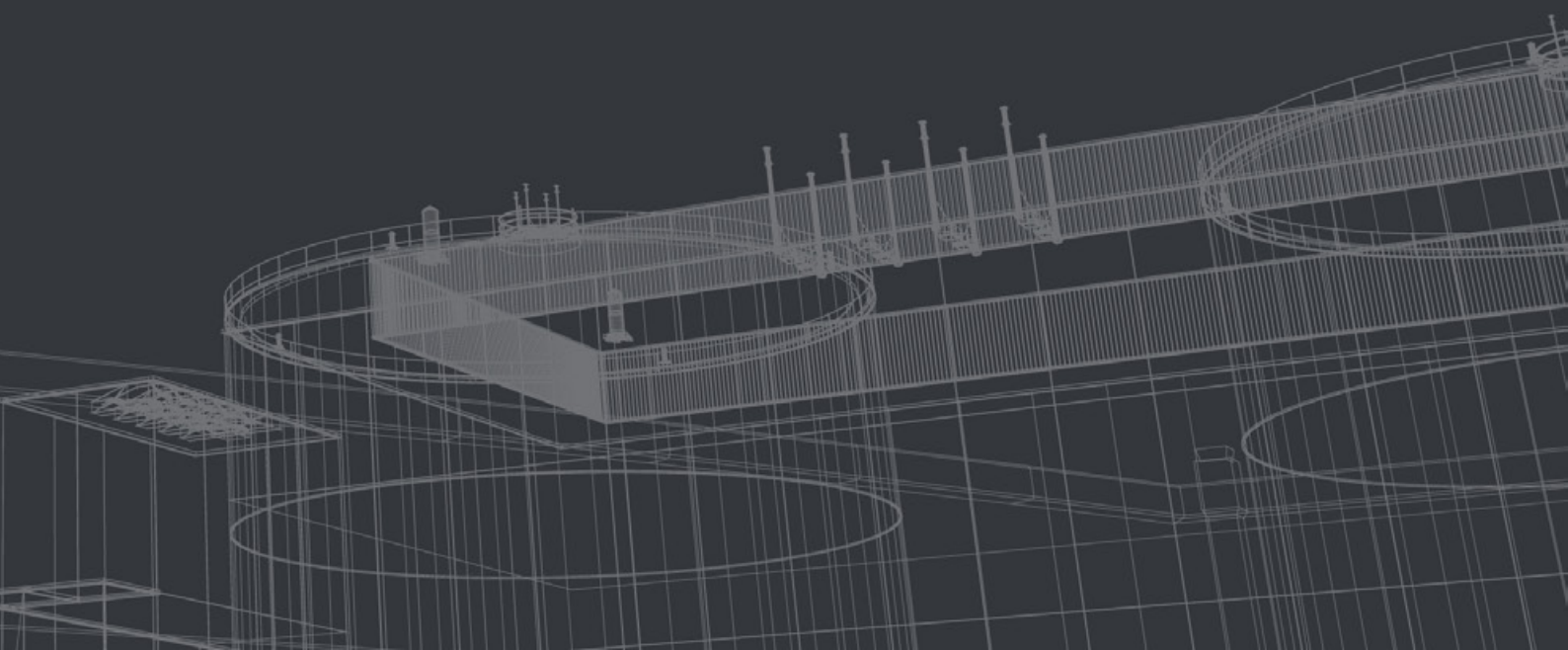
Lessons Fukushima 11032011

Lessons Learned and Checkpoints based on the Nuclear Accidents at Fukushima



Fukushima

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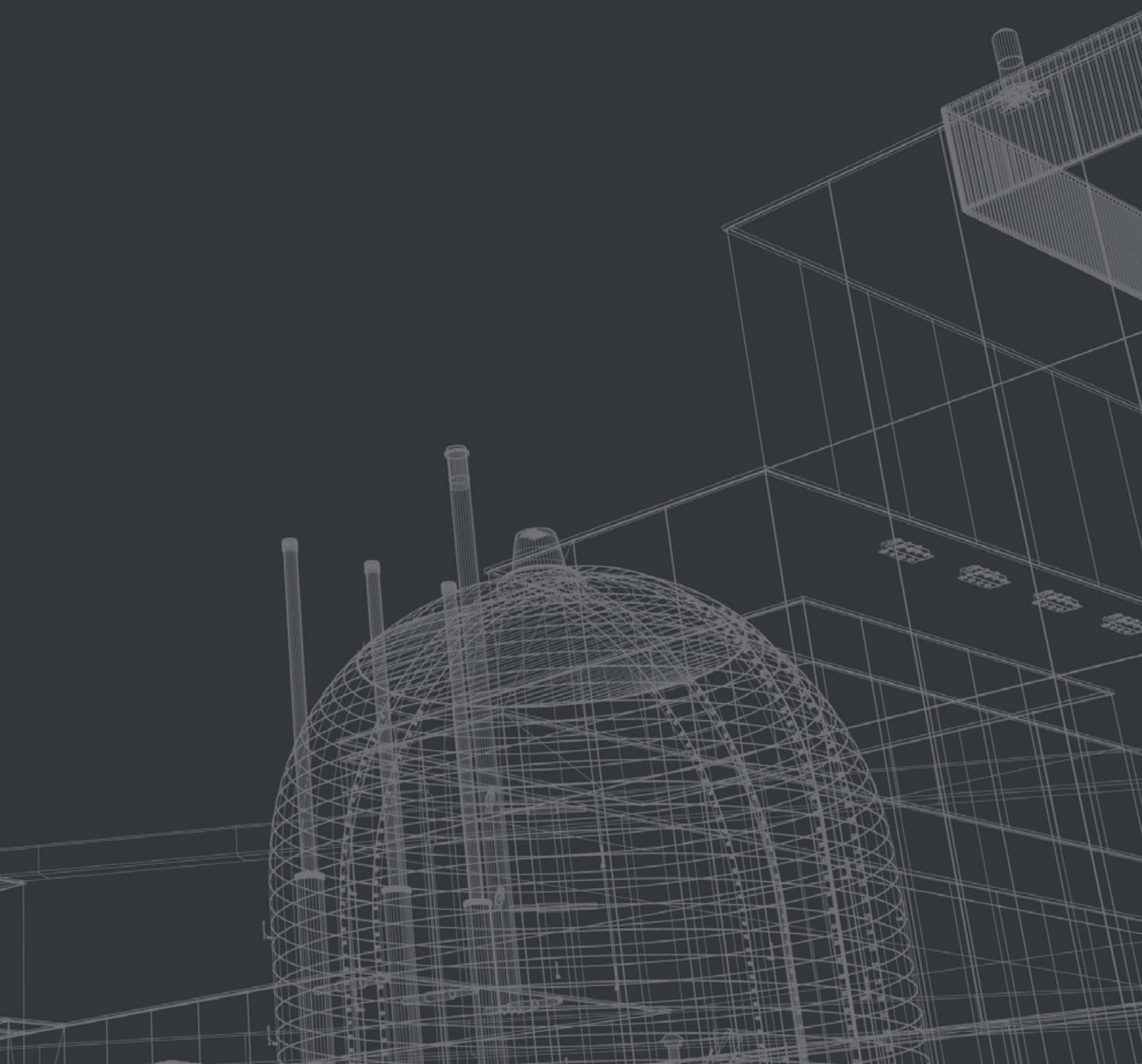
11.03.2011



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1 Introduction

The issue of “severe accidents” has played a key role in the supervisory activities of ENSI and its predecessor organisation, the HSK (Hauptabteilung für die Sicherheit der Kernanlagen, Principal Nuclear Safety Division), not merely since the reactor accident at Fukushima but for a long time before that event. The analysis of events in Switzerland and abroad, and examination of their significance for the Swiss nuclear power plants, are included among the standing obligations of the supervisory authority. After the accident at Harrisburg, for example, the HSK (as it then was) made it a requirement to back-fit autonomous emergency standby systems to cope with the effects of natural events such as earthquakes, flooding, storms and lightning, and of those due to human activity such as sabotage and aircraft crashes.

In response to the Chernobyl accident, the HSK developed a “Catalogue of measures against severe accidents” (MSU) which includes (but is not limited to) measures to prevent core damage as well as measures to mitigate the consequences of massive core damage. As a result of implementing the MSU, for example, systems to deal with large volumes of hydrogen in the containment were set up, as were systems for controlled and filtered venting of the containments.

For more than two decades, Probabilistic Safety Analyses (PSA) have been used in Switzerland to investigate core meltdown accidents in detail. Complex hazard analyses of external events (such as earthquakes) have been produced, and they are continuously adapted in line with the latest developments in science and technology.

“Severe Accident Management Guidance” (SAMG) – representing strategies to mitigate the effects of a core meltdown accident – was also introduced at an early stage; this written procedures, which is verified by the supervisory authority, provides the Swiss plants with optimal assistance for dealing with accidents. In overall terms, Swiss nuclear power plants have attained a very high standard in the area of severe accidents, as compared to other countries.

Moreover, the safety of the Swiss nuclear power plants is constantly reviewed as part of ongoing supervision activities, and especially in connection with the Periodic Safety Review (PSR) that is conducted every 10 years.

Nevertheless, the accident at Fukushima provides reasons to examine whether further improvements should be made to the existing assessment of precautions against severe reactor accidents, and whether any additional measures may need to be initiated for the protection of the general public.

In this report, ENSI presents the checkpoints which, on the basis of the analysis of the events at Fukushima, have been assessed as relevant for further improvements to nuclear safety and emergency protection in Switzerland. The analyses were carried out by an interdisciplinary team (the "Japan Analysis Team"). The checkpoints are derived from the knowledge gained as a result of analysing the behaviour of people, technology and organisations during the events relating to the accident. These "Lessons Learned" are set out in the Annexe to this Memorandum. They are based on the extensive investigations whose results were presented by ENSI in the reports entitled " Event sequences in Fukushima Dai-ichi and Dai-ni following the Tohoku-Chihou-Taiheiyou-Oki earthquake on 11.03.2011" and "In-depth Analysis of the Accident at Fukushima on 11 March 2011 With Special Consideration of Human and Organisational Factors" (both reports are posted on ENSI's website).

The measures relate to the areas of design, emergency management, experience feedback, supervision, radiation protection and safety culture. These areas are referred to in the following text as "Focus Areas", i.e. areas where action is required. Among other aspects, they focus on the checkpoints to optimise emergency protection in Switzerland. Some of these checkpoints are of an overriding character, so they fall primarily within the responsibility of the Federal government and the cantons, but they are also relevant for ENSI. At Federal level, therefore, the Interdepartmental Working Group to Review Emergency Protection Measures in case of Extreme Events in Switzerland (IDA NOMEX) was set up as long ago as 04.05.2011.

The implementation of measures required in the short term was initiated by corresponding directives from ENSI; part of this process has already been completed, while the medium- to longer-term measures will be incorporated into an action plan as part of ongoing supervision. The aims of implementing any measures that might result from the checkpoints are to continue increasing the safety of Swiss nuclear power plants even in case of infrequent events, to optimise emergency protection and to make further improvements to supervision by ENSI.

So far, no significant safety shortcomings have been identified in Swiss nuclear power plants on the basis of analyses of the accident sequences. There are no indications for the need to shut down according to the criteria of the DETEC (Department of Environment, Transport, Energy and Communications, UVEK) Ordinance on the Methodology and Boundary Conditions for Reviewing the Criteria for the Provisional Shut Down of Nuclear Power Plants (DETED Ordinance on the Methodology and the General Conditions for Checking the Criteria for the Provisional Taking out of Service of Nuclear Power Plants, abbreviated as: "Shut Down" Ordinance). The necessary improvement to the reliability of the cooling water supply at the Mühleberg nuclear power plant (NPP) was already implemented during the 2011 inspection shutdown.

2 Derivation of checkpoints from the “Lessons Learned” after the Fukushima accident

The checkpoints set forth in section 3 of this Memorandum are based mainly on knowledge gained from investigating the events relating to the accident in units 1 to 4 of the Fukushima Dai-ichi NPP (it was possible to bring the units of the Fukushima Dai-ni NPP into a safe condition and to stabilise them after the earthquake and the tsunami). This body of knowledge, referred to below as “Lessons Learned”, was developed by ENSI on the basis of analytical work and reporting on the accidents. The “Lessons Learned” are chiefly based on the following ENSI reports:

- “Event sequences in Fukushima Dai-ichi and Dai-ni following the Tohoku-Chihou-Taiheiyou-Oki earthquake on 11.03.2011”, Memorandum ENSI-AN-7614 Rev. 1 dated 26.08.2011
- “In-depth Analysis of the Accident at Fukushima on 11 March 2011 With Special Consideration of Human and Organisational Factors”, Memorandum ENSI-AN-7669 dated 29.08.2011

In addition, ENSI has examined other aspects linked to the accident:

- Legal basis of nuclear supervision in Japan
- Structure of the Japanese nuclear sector
- Failures of electrical supply and equipment due to the earthquake and tsunami
- Back-fitting measures on boiling water reactors with Mark I containment
- Results of the IRRS (Integrated Regulatory Review Service) Mission to Japan in 2007
- Measures based on the Fukushima accident in other countries with nuclear power plants

As the first step, ENSI’s “Lessons Learned” were assembled without further evaluation of their relevance for Switzerland and their applicability to conditions in this country. For this reason, the “Lessons Learned” (which are summarised in the Annexe to this Memorandum) do not as yet constitute an evaluation or selection of the findings in respect of their applicability to Switzerland.

The results of ENSI’s analyses were reviewed by external experts from Germany, France and the US. Knowledge gained and measures taken by organisations and supervisory authorities in other countries such as the IAEA, the Japanese government and the US supervisory authority (NRC) were adduced for the purpose of verifying the “Lessons Learned” that had been defined. The aim of this procedure was to ensure that the “Lessons Learned” for Switzerland are backed by a broad basis of expertise. After evaluating the relevant conditions in Switzerland, ENSI’s “Japan Analysis Team” used these verified “Lessons Learned” to develop the checkpoints, which it then assigned to six Focus Areas, according to the subject matter involved in each case.

2.1 Derivation and assignment of checkpoints

The “Lessons Learned” were assigned in advance to various Focus Areas, so that the checkpoints could be allocated to the relevant responsibilities and competences within ENSI, the Swiss nuclear power plants and the other institutions concerned. The Focus Areas represent specific areas of competence within ENSI which have always been elements of ENSI’s supervision of Switzerland’s nuclear plants.

The checkpoints can all be assigned to the six Focus Areas listed below. Safety culture is mentioned as the last Focus Area because its content impinges on all the other Focus Areas, given that it fosters and requires safety-oriented thinking and behaviour but does not establish new technical or organisational requirements:

- Design
- Emergency management
- Experience feedback
- Supervision
- Radiation protection
- Safety culture

2.2 Evaluation of checkpoints

In order to evaluate and specify the checkpoints, the "Japan Analysis Team" submitted the developed proposals to the sections of ENSI responsible for the relevant specialist areas. Another objective here was to examine (where relevant) how far the proposals had already been taken into account in current supervisory procedure, or whether any omissions were identified in the existing supervision of Swiss nuclear power plants which created a corresponding need for action. In particular, the aim was to examine whether proposed improvements or reviews had already been initiated as immediate measures on the basis of ENSI's directives. The following directives are involved:

1. ENSI's directive dated 18.03.2011: **measures due to the events at Fukushima**

- Immediate review of the design against earthquake and flooding in respect of shut down criteria
- Access to an external storage facility with additional resources to mitigate severe accidents by 01.06.2011
- As required: back-fitting of additional externally accessible connections for mobile emergency equipment by 31.12.2012
- Back-fitting of two physically separate feeds for the external supply of the spent fuel storage ponds by 31.12.2012
- Proof of diversified coolant supply, of the design of the cooling system for the spent fuel storage ponds, and of protection of spent fuel storage ponds located outside the primary containment, by 31.03.2011. A statement by ENSI on this subject was issued with the third directive dated 05.05.2011.

2. ENSI's directive dated 01.04.2011: **Procedural requirements for the review of design in respect of earthquakes and flooding**

- Redetermination of seismic hazard assumptions (intermediate step prior to completion of the PEGASOS Refinement Project, PRP) by 30.11.2011: proof of seismic stability based on the new earthquake catalogue of the SED (Swiss Seismo-logical Service), and on the seismic hazard assumptions which were redetermined when site data were recorded in connection with the PRP. By 31.03.2012: deter-ministic proof of ability to cope with the 10,000-year earthquake.
- Deterministic proof of ability to cope with the 10,000-year flood, by 30.06.2011. ENSI evaluated the proof submitted by the operators by 31.08.2011.
- Deterministic proof of ability to cope with the combination of an earthquake and the failure of the dam installations which would be triggered by the earthquake in the area of influence for the nuclear power plant, by 31.03.2012.

3. ENSI's directive dated 05.05.2011:

Statement on the reports dated 31 March 2011

- Measures shall be proposed in response to the plant-specific findings described by ENSI in the area of spent fuel storage ponds and coolant supply, by 31.08.2011
- Review of the design of the spent fuel storage ponds, buildings and cooling systems as per the procedural requirements stated in the ENSI directive dated 01.04.2011, by 31.03.2012
- Evaluation of protection against hydrogen explosions in the area of the spent fuel storage ponds, by 31.03.2012

4. ENSI's directive dated 01.06.2011:

Re-evaluation of the safety margins for nuclear power plants in the framework of the EU stress tests

- Obligation to participate in the EU stress test: Re-evaluation of the safety margins for earthquakes, flooding, power supply, supply of cooling water; review of the effectiveness of measures against severe accidents

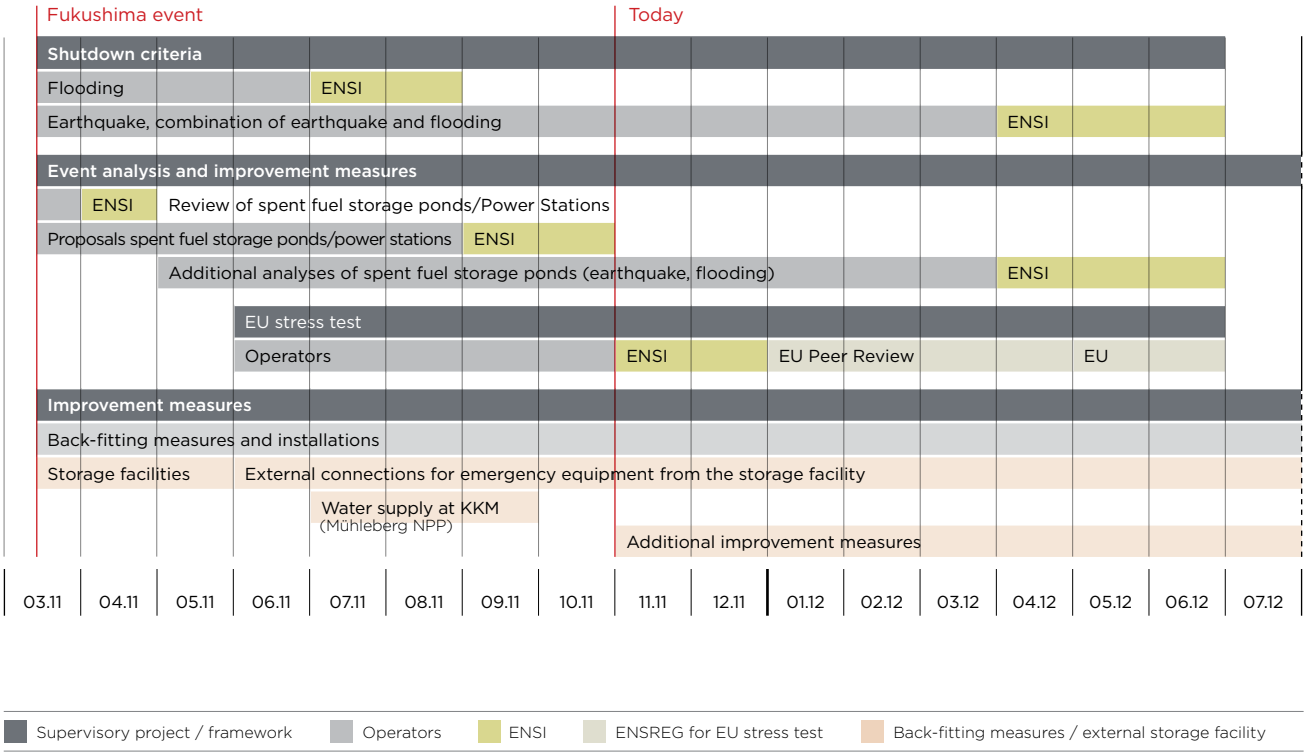

Figure 1: Overview of dates of directives and measures, 2011 / 2012

2.3 IDA NOMEX working group

On 04.05.2011, 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 is also represented, is to examine in the light of experience gained from Fukushima whether there is further need to take action regarding emergency protection in case of extreme events in Switzerland, and whether any new statutory and organisational emergency protection measures need to be taken. The IDA NOMEX working group consists of representatives of the cantons, the Federal Chancellery (BK) and the following departments: DETEC, EDI (Federal Department of Home Affairs, FDHA), EJPD (Federal Department of Justice and Police, FDJP) and VBS (Federal Department of Defence, Civil Protection and Sports (DDPS); it will review matters including the Emergency Protection Ordinance (Notfallschutzverordnung) and the Ordinance on Nuclear, Biological and Chemical Accidents and Natural Events (ABCN-Einsatzverordnung) in view of experience gained from the events in Japan following 11.03.2011. DETEC will probably report to the Federal Council on this work before the end of autumn 2011. The responsible departments will submit draft amendments to laws and ordinances to the Federal Council by mid-2012. The Swiss Federal Office of Energy (SFOE) is responsible for lead management and coordination of the working group.

In parallel with the findings determined by the Federal Council, the ENSI analysis has also derived checkpoints regarding the emergency protection measures implemented in Japan. Measures may need to be initiated in various areas of emergency management, such as means of communication, information provided to the general public, evacuation and the regulation of interfaces; such measures fall primarily within the areas of responsibility of the Federal government and the cantons. In this report, those checkpoints which are also considered under the auspices of the IDA NOMEX review are specially flagged as such. These are checkpoints 9, 10, 15, 17, 18, 20, 21, 22, 23, 24, 33 and 34.

2.4 Categorisation of checkpoints

From the complex events related to the accident at Fukushima, ENSI has derived 37 checkpoints which will help to achieve an additional increase in the safety of Swiss nuclear plants. The checkpoints were assigned to categories as follows, on the basis of the defence-in-depth concept:

Category I checkpoints to prevent accidents

Category II checkpoints to bring accidents under control, in order to prevent inadmissible release of radioactive substances

Category III checkpoints to mitigate the consequences of accidents

To date,
- 12 checkpoints have been identified in Category I,
- 9 checkpoints have been identified in Category II, and
- 16 checkpoints have been identified in Category III.

2.5 Processing status of checkpoints

The status of processing of the 37 checkpoints relates to the date of issue of this document.

- 13 checkpoints have already been implemented and/or initiated on the basis of the ENSI directives.
- 12 checkpoints will be followed up by IDA NOMEX or are dependent on IDA NOMEX.
- 6 checkpoints are already taken into account as part of ENSI's supervision activities.
- 4 checkpoints still have to be initiated.
- 2 checkpoints have already been completed.

The status of processing and/or implementation is reported separately for each individual checkpoint in the following section.

3 Presentation of checkpoints

In the following sections the checkpoints listed summed up, with their allocations to the six Focus Areas. The "Lessons Learned" on which the checkpoints are based are listed for each checkpoint.

3.1 Focus Area: Design

The "Lessons Learned" from the accident in Japan have generated the following issues in the Focus Area of the design of nuclear plant; ENSI will focus on processing and reporting on these issues, in addition to continuing its regular supervisory activities.

Checkpoint 1 (Category I)

The hazard assumptions for earthquake and external flooding, and also for extreme weather conditions, must be re-evaluated to take account of the latest knowledge.

Explanation:
Extreme weather conditions include, in particular, snow loads, temperatures, winds including tornado hazards, and heavy rain. This evaluation is being carried out in addition to the regular review of external hazard assumptions as part of the Periodic Safety Reviews (PSR). Extreme weather conditions for Switzerland were re-analysed recently by MeteoSwiss on behalf of ENSI. The results will be incorporated into further analyses.

This checkpoint was derived from "Lessons Learned" 6 and 18.

Implementation:
In connection with the ENSI directives of 18.03.2011, an additional targeted review was requested for earthquake and flooding, and for the combination of earthquake and flooding. These reviews are also elements of the EU stress test, which was ordered by ENSI on 01.06.2011.

Checkpoint 2 (Category I)

The control strategies for a long-lasting total power failure must be re-evaluated on the basis of knowledge gained from Fukushima.

Explanation:
This checkpoint was derived from "Lesson Learned" 32.

Implementation:
By its directive of 01.04.2011, ENSI obliged the Swiss nuclear power plants to submit appropriate proof regarding the 10,000-year earthquake and flood. In addition, this checkpoint is covered by the EU stress test, which was ordered by ENSI on 01.06.2011.

Checkpoint 3 (Category I)

A review must be carried out to determine whether the coolant supply for the safety systems and the associated auxiliary systems is guaranteed from a diverse source which is safe against earthquakes, flooding and contamination..

Explanation:
This checkpoint was derived from "Lesson Learned" 18.

Implementation:
This was required on the basis of the ENSI directives dated 18.03.2011. In its directive dated 05.05.2011, ENSI ordered improvement measures based on the operators' analyses. Staggered failure of the ultimate heat sinks required for heat dissipation will be considered within the framework of the EU stress test, which was ordered on 01.06.2011.

Checkpoint 4 (Category I)

A review must be carried out to determine whether the requisite tightness of buildings containing important safety equipment is guaranteed in case of flooding of the site.

Explanation:
The escape of radioactive water into the environment must be prevented in the event of leaks within the plant. This means that the buildings must be watertight from the outside as well as the inside.

This checkpoint was derived from "Lesson Learned" 32.

Implementation:
This was already required on the basis of the ENSI directives dated 01.04.2011, and was essentially completed by ENSI's evaluation dated 31.08.2011. During its inspections, ENSI will also ascertain that the tightness of buildings from the inside to the outside is guaranteed.

Checkpoint 5 (Category I)

On the basis of experience gained from the Fukushima accident, another review must be undertaken to determine whether the availability of the instrumentation required to assess the condition of the plants is guaranteed adequately even in extreme situations.

Explanation:
The data are required in order to assess the situation and/or to initiate the requisite measures inside and outside the plant, and to communicate them. This also includes ensuring that control centres and onsite equipment are able to function in order to cope with severe accidents based on all the hazard assumptions under consideration.

This checkpoint was derived from "Lesson Learned" 23.

Implementation:
The review of instrumentation to monitor the spent fuel storage ponds was required within the directive dated 05.05.2011. The additional required incident overview displays are specified in ENSI guideline B12.

Checkpoint 6 (Category I)

A review must be carried out to determine whether control of leaks and long-term cooling of the spent fuel storage ponds are guaranteed in case of severe accidents.

Explanation:
This checkpoint was derived from "Lessons Learned" 19 and 33.

Implementation:
In the directive dated 05.05.2011, the licence-holders were required to submit improvement measures; these measures were submitted by 31.08.2011 and are being assessed by ENSI.

Checkpoint 7 (Category II)

A review must be carried out to determine whether the verifications regarding the prevention of hydrogen explosions should be extended to additional areas of the plants beyond the primary containment.

Explanation:
This checkpoint was derived from "Lesson Learned" 29.

Implementation:
This issue is dealt with as part of the EU stress test which was ordered on 01.06.2011. Further details were specified for the spent fuel storage ponds in the directive dated 05.05.2011.

Checkpoint 8 (Category II)

The design and operation of the systems for filtered venting of the containment must be reviewed again.

Explanation:
The systems for filtered venting installed in the Swiss nuclear power plants are intended to prevent overpressure failure of the primary containment during sequences of events involving a slow build-up of pressure. The requirements were incorporated in guidelines issued by the HSK (now: ENSI).

This checkpoint was derived from "Lesson Learned" 26.

Implementation:
The system for filtered venting is examined both in the EU stress test ("Measures and design to protect the integrity of the containment") and during ENSI's inspections of key points specifically related to knowledge gained from the Fukushima-Dai-ichi accident.

Checkpoint 9 (Category II) Covered by IDA NOMEX

It is necessary to carry out a new review of design against earthquake and flood of the monitoring network for automatic dose rate measurement in the vicinity of nuclear power plants (MADUK), in relation to experience gained from the Fukushima accident.

Explanation:
This checkpoint was derived from "Lesson Learned" 37.

Implementation:
The specific requirements for implementing this checkpoint will be defined on the basis of the knowledge acquired by IDA NOMEX.

Checkpoint 10 (Category III) Covered by IDA NOMEX

A review must be carried out to determine whether the emergency rooms and the substitute emergency rooms at the Swiss nuclear power plants still meet the requirements, based on the experience gained from the Fukushima accident.

Explanation:
Nuclear power plants must have suitable, seismically robust, appropriately protected, ventilated and well equipped emergency rooms and substitute emergency rooms which can also withstand external impacts such as earthquake or flooding. These rooms require adequate equipment, and must be of such a nature as to guarantee the health and radiological protection of on-site staff, and to ensure that they are accommodated and provided with supplies. The protected room for the ENSI emergency organisation (GENORA) must also be reviewed.

This checkpoint was derived from "Lessons Learned" 9, 16, 24 and 25.

Implementation:
Requirements regarding technical equipment for the emergency protection of nuclear plants are stipulated in ENSI guideline B12. Based on the knowledge acquired by IDA NOMEX, ENSI is to define the specific requirements for implementing this checkpoint.

Checkpoint 11 (Category III)

The access control system for nuclear power plants and the associated arrangements must be reviewed to determine the accessibility of rooms where intervention is required in case of severe accidents, while maintaining appropriate plant security. Monitoring of radiation protection must continue to be guaranteed in this context.

Explanation:
This checkpoint was derived from "Lesson Learned" 22.

Implementation:
This checkpoint has already been initiated and has been largely completed as part of the existing supervision activities, but with consideration given to the additional knowledge gained from the Fukushima accident.

3.2 Focus Area: Emergency Management

The need for a functioning emergency management system became clear during the progression of the accident at Fukushima-Dai-ichi, and it was evident that appropriate planning and precautions are also required for the extremely unlikely case of a severe accident. The operators of the Swiss nuclear power plants and ENSI have already taken extensive precautions in this regard as part of their emergency planning. As a practical example of the progression of a severe accident, Fukushima offers the opportunity to review the suitability and completeness of emergency planning in Switzerland at various levels and during various phases, and to introduce improvements where applicable.

Checkpoint 12 (Category I)

The emergency measures for heat dissipation in case of a complete failure of the cooling water supply must be reviewed and verified under conditions resulting from the destruction of the infrastructure and the power supply.

Explanation:
This checkpoint was derived from “Lesson Learned” 18.

Implementation:
By setting up the external storage facility (ordered by the directive dated 18.03.2011 and in place since 01.06.2011), resources were already made available for use in a situation of this sort in order to maintain the cooling function independently of the permanently installed safety systems. In addition, this checkpoint is an element of the EU stress test, which was ordered by ENSI on 01.06.2011.

Checkpoint 13 (Category I)

It is necessary to review how the alternative supply of water and power for emergencies is ensured.

Explanation:
The connections required for this purpose must be compatible and must be positioned so as to guarantee accessibility in case of internal as well as external impacts. The necessary actions must be included in the documentation of decision guidance for emergency management in case of severe accidents (SAMG, Severe Accident Management Guidance) and appropriate training must be provided on this aspect.

This includes restoration of the necessary power supply from the external grid, from a nearby power plant, from another unit at the site, or with a mobile emergency diesel generator from the external storage facility. For this purpose, the existing boundary conditions, including the envisaged periods of time, must be determined and compared to the terms of reference used for emergency planning.

This checkpoint was derived from “Lessons Learned” 18 and 22.

Implementation:
Additional supply options, e.g. to feed with extinguishing water, were already created some years ago in the Swiss NPPs in connection with the development of the SAMG. The directive dated 18.03.2011 ordered another review in the light of the accident at Fukushima

Checkpoint 14 (Category II)

It is necessary to examine the water resources that can be made available to feed the reactor pressure vessel, the spent fuel storage ponds and the containment.

Explanation:
The original purpose of use (e.g. as fire extinguishing water) must be taken into account in this context, and the ability to use the water in case of severe accidents must be defined.

This checkpoint was derived from "Lesson Learned" 34.

Implementation:
The available water resources have already been verified and they are already documented in the existing emergency procedures. As far as is known at present, no further measures are required.

Checkpoint 15 (Category II) Covered by IDA NOMEX

Emergency management must be reviewed to determine further potential for improvement.

Explanation:
Organisational emergency protection measures must take account of human and organisational factors in emergency management. In particular, these include the following aspects:

a Decision-making processes and pathways for dealing with emergencies.

b Qualifications and competences of the individuals involved in dealing with an emergency (including the decision-makers in particular).

c Consideration given to aggravated physical and mental working conditions in emergency plans and education/training for staff.

d Clarity regarding the roles and responsibilities of organisations involved in dealing with an emergency, including interfaces within and between the organisations.

This checkpoint was derived from "Lessons Learned" 8, 9, 11, 12, 15, 16, 28, 30 and 35.

Implementation:
This checkpoint is being implemented under the auspices of IDA NOMEX. The resultant specific requirements for nuclear plants are to be supervised by ENSI.

The allocation of roles and responsibilities for the emergency organisations, including the interfaces, is already being practised and reviewed as part of the regular emergency exercises.

Checkpoint 16 (Category II)

ENSI has identified the following issues as checkpoints for improving emergency planning and emergency exercises:

a The decision-making guidance for emergency management in case of severe accidents (SAMG) at nuclear power plants, including the newly planned checkpoints to deal with severe accidents, must be reviewed on the basis of knowledge gained from the Fukushima accident. In this regard, it is particularly necessary to check:

- Whether adequate consideration is given to a Station Blackout (SBO) of long duration and the simultaneous occurrence of events in multiple-unit plants;

- Whether there is any need for measures, auxiliary resources and equipment that must be available to ensure that sub-criticality is maintained over the long term in case of severe accidents.

b Consideration given to incidents involving an SBO of long duration in the planning of emergency exercises.

c Examination of whether the procedures are trained often enough during emergency exercises. Particular attention should be focused here on a functioning interorganisation chain of communication across the various organisations.

Explanation:
The accident at Fukushima confirmed that wellprepared emergency procedures are necessary to enable speedy reactions – as appropriate to the situation – in order to cope with accidents.

This checkpoint was derived from "Lessons Learned" 9, 10, 16, 24, 28 and 35.

Implementation:
The Swiss NPPs have an extensive system of incident and emergency procedures, supplemented by the SAMG. ENSI considers that a new review against the backdrop of the events at Fukushima would benefit safety. This review should reevaluate the regulatory requirements (ENSI-B12) as well as the implementation of the SAMG in the plants.

As part of the implementation of the ENSI directive dated 18.03.2011, external emergency storage facilities were already set up for all NPPs in Switzerland on 01.06.2011. Among other items, stocks of boron compounds are kept in these facilities to ensure sub-criticality in the long term.

Checkpoint 17 (Category II) covered by IDA NOMEX

A review must determine whether and to what extent the communication facilities are designed with adequate redundancy and diversity.

Explanation:
In case of a power failure of long duration, it must be ensured that the communication facilities required to cope with the emergency are able to function.

For this checkpoint, it is also necessary to examine the locations where communication equipment is set up and the accessibility of such equipment in case of extreme natural events, so that communication with the responsible units is guaranteed.

Also as part of this checkpoint, it must be ensured that the staff required to deal with the accident can be summoned.

This checkpoint was derived from "Lessons Learned" 10, 14 and 25.

Implementation:
This checkpoint is being implemented under the auspices of IDA NOMEX. The resultant specific requirements for nuclear plants are to be supervised by ENSI.

Checkpoint 18 (Category III) covered by IDA NOMEX

At all times, it must be ensured that adequate staff are available to accomplish all necessary emergency management activities.

Explanation:
This includes ensuring that the necessary qualified staff are available not only to the licenceholders but also to ENSI and other involved authorities and institutions.

This checkpoint was derived from "Lesson Learned" 16.

Implementation:
This checkpoint is being implemented under the auspices of IDA NOMEX. The resultant requirements for nuclear plants are to be supervised by ENSI.

Checkpoint 19 (Category III)

Measures that increase the organisation's ability to react to unexpected events must be reviewed again on the basis of experience gained from Fukushima.

Explanation:
The general aim of the measures is to ensure that unforeseen events are virtually excluded. The review of NPP design to protect against external events was repeated for this purpose. Nevertheless, unexpected events or sequences of events cannot be totally ruled out.

This checkpoint was derived from "Lessons Learned" 1, 9, 10, 12, 15, 17, 18, 22, 23, 24, 25, 26, 28, 29 and 36.

Implementation:
Implementation of this checkpoint is to be clarified within ENSI.

Checkpoint 20 (Category III) covered by IDA NOMEX

Transmission of plant parameter data must be reevaluated with respect to an alternative, independent means of data transmission.

Explanation:
This also includes re-evaluation of whether the transmitted data are adequate to track and evaluate incidents. The term "data transmission" refers to the forwarding of the plant parameters that are used to track incidents to the necessary internal and external units.

This checkpoint was derived from "Lessons Learned" 8, 23 and 24.

Implementation:
The specific requirements are to be formulated by ENSI on the basis of knowledge acquired by IDA NOMEX.

Checkpoint 21 (Category III) covered by IDA NOMEX

The evacuation concepts must be reviewed, taking account of knowledge gained from the Fukushima accident.

Explanation:
This checkpoint was derived from "Lesson Learned" 14.

Implementation:
This checkpoint is being implemented under the auspices of IDA NOMEX.

Checkpoint 22 (Category III) covered by IDA NOMEX

Coordination with other international partners is required to determine whether and how an international network for central international emergency support can be set up.

Explanation:
The services to be provided in an emergency must be defined. Agreements must be reached with the participating institutions for this purpose.

This checkpoint was derived from "Lesson Learned" 12.

Implementation:
This checkpoint is being implemented under the auspices of IDA NOMEX. The resultant requirements for nuclear plants are to be supervised by ENSI.

Checkpoint 23 (Category III) covered by IDA NOMEX

A review must be carried out to determine whether the necessary information regarding forecasts of releases and radiation exposure is provided in a timely and continuous manner in case of an accident.

Explanation:
The correctness of the dispersion calculations must be reviewed, taking account of several potential sources (multiple-unit plants, spent fuel storage ponds).

This checkpoint was derived from "Lessons Learned" 10 and 14.

Implementation:
The specific requirements are to be formulated by ENSI on the basis of knowledge acquired by IDA NOMEX.

Checkpoint 24 (Category III) covered by IDA NOMEX

The following improvement measures were identified regarding information to be provided to the general public:

a It must be ensured not only that the requisite infrastructure and the necessary individuals and/or organisations and equipment are available for crisis communication, but also that the necessary means of communication are in place. The relevant precautions must be taken. Regular training must be provided on the associated procedures. This point also includes a functioning network of experts who are available to the media to supply neutral and objective information.

b Review to determine whether the organisational responsibilities for informing the public as well as the local authorities and support staff are clearly stipulated, and are uniformly understood by all involved parties.

c A review should be carried out to determine whether the timely communication of radiological effects, including calculated forecasts, is also ensured beyond Switzerland's borders.

Explanation:
This checkpoint was derived from "Lesson Learned" 14.

Implementation:
The specific requirements are to be formulated by ENSI on the basis of knowledge acquired by IDA NOMEX.

3.3 Focus Area: Experience Feedback

Checkpoint 25 (Category III)

It is necessary to examine the extent to which the release of non-nuclear hazardous substances in case of beycend design basis events could exert an additional influence on the accident progress, and which counter-measures are required.

Erläuterung:
This checkpoint was derived from "Lesson Learned" 39.

Implementation:
Implementation of this checkpoint has yet to be initiated.

In order to continue strengthening the feedback of experience as part of regular supervision activities, ENSI defines the following checkpoints under the key supervisory point of the "Learning organisation":

Checkpoint 26 (Category I)

The process of evaluating and examining the applicability of national and international operating experience must be optimised on the basis of knowledge gained from the Fukushima accident.

Explanation:
This checkpoint was derived from "Lesson Learned" 1.

Implementation:
As part of the change to its organisation as of 01.09.2011, ENSI has already taken the first step of combining the evaluation of national and international operating experience in one independent section.

Checkpoint 27 (Category II)

It must be guaranteed that the knowledge gained from national and international operating experience (the procedure for processing events) in the operators' organisations reaches all the relevant individuals and units (including those at group level).

Explanation:
According to ENSI guideline B03, the operators are already obliged to report the results of their event analyses to ENSI. However, it may be possible to improve the procedure.

This checkpoint was derived from "Lessons Learned" 2 and 15.

3.4 Focus Area: Supervision

This Focus Area comprises checkpoints that relate to supervision by ENSI in general, and in particular those which relate to the regulations. This area also includes efforts at international level to harmonise global supervisory requirements in the nuclear sector, and to have these requirements reviewed by international organisations.

Checkpoint 28 (Category I)

It must be ensured that internationally harmonised assessment standards for nuclear safety are established at a high level of safety.

Explanation:
In connection with international reviews, and especially as regards WENRA (Western European Nuclear Regulators Association), ENSI will continue its efforts to ensure that internationally harmonised assessment standards are applied at a high safety level.

This checkpoint was derived from “Lessons Learned” 1 and 15.

Explanation:
ENSI applies the WENRA reference levels and takes account of the IAEA standards.

In Europe, a first step was taken with Switzerland’s participation in the EU stress test, as ordered by ENSI on 01.06.2011.

Implementation:
The monthly reports inform ENSI about the external accounts of experiences feedback that are processed in the Swiss nuclear power plants, and about any checkpoints that are introduced. As part of the follow-up of the Fukushima accident, the procedure for experience feedback from the licence-holders must be re-evaluated.

Checkpoint 29 (Category I)

Greater importance should also be accorded in the international sphere to the recommendations resulting from international reviews (IRRS, OSART (Operational Safety Review Team)) and from the regular Periodic Safety Reviews (PSR). The transparency of ENSI's supervision and of the operators' safety-related activities must be increased.

Explanation:

As part of its collaboration with IAEA, ENSI advocates the conduct of international reviews as a binding requirement. In this context, ENSI will undergo a review by an international team of experts under the direction of the IAEA (Integrated Regulatory Review Service, IRRS) for the second time in November 2011 (after the first such review in 1999). However, the findings from the international review should also be processed in the light of the accident at Fukushima. In addition, ENSI has undertaken to participate in the EU stress test.

Moreover, ENSI has enhanced the transparency of its own activities – especially as regards measures following the Fukushima accident – by stepping up its public relations work.

WANO, the World Association of Nuclear Operators, offers its members peer reviews so that operating experience can be exchanged.

This checkpoint was derived from "Lessons Learned" 1 and 20.

Implementation:

ENSI had already initiated the 2011 IRRS mission prior to the Fukushima accident. OSART missions have been carried out in all Swiss nuclear power plants. WANO peer reviews are conducted regularly at the initiative of the operators. Participation by Swiss nuclear power plants in the EU stress test was ordered by ENSI on 01.06.2011.

Checkpoint 30 (Category II)

ENSI is reviewing the significance of the lessons from the Fukushima accident for its supervision.

Explanation:

This relates to the following aspects in particular:

a Review of regulatory documents (in particular the ENSI guidelines) to determine whether they cover all the relevant lessons from the accident at Fukushima.

b Review of ENSI's supervisory strategy in the light of knowledge gained from the Fukushima accident.

This checkpoint was derived from "Lessons Learned" 4 and 11.

Implementation:

This checkpoint has been partially initiated, and its implementation must be integrated into ongoing changes to the regulatory documents. The change to ENSI's organisation that was already planned prior to Fukushima was implemented on 01.09.2011, with the inclusion of the newly-gained knowledge.

3.5 Focus Area: Radiation Protection

For the Focus Area of radiation protection, checkpoints have been identified relating to the deployment of staff, the monitoring of surrounding areas to determine releases of radioactivity, and the management of radioactive waste in case of severe accidents.

Checkpoint 31 (Category III)

Additional emergency resources must be kept in readiness for radiation protection in case of severe accidents.

Explanation:
The emergency resources must be stored in a manner which protects them against earthquake and flooding, and which ensures that they are accessible. Resources for monitoring radiation protection and the necessary protective equipment must be kept in readiness in the external storage facility, in addition to the resources available within the power plant.

This includes the availability of sufficient personal dosimeters and protective equipment, taking account of measures to guarantee that such equipment will function in case of a power failure of long duration, and resources for iodine prophylaxis; these requirements apply to the plant's own staff, third party staff, and to the staff of the emergency and rescue forces.

This checkpoint was derived from "Lessons Learned" 13 and 16, 17.

Implementation:
An external emergency storage facilitiy was already set up for all NPPs in Switzerland on 01.06.2011, on the basis of the ENSI directive dated 18.03.2011.

Checkpoint 32 (Category III)

It is necessary to examine whether the emission and immission measurements in place on the power plant sites in order to determine the substances released due to activities are guaranteed in case of loss of offsite power (LOOP) or in case of an emergency.

Explanation:
This also includes a concept for substitute measurements in case of a total power failure of long duration which takes account of the experience gained from the Fukushima accident.

This checkpoint was derived from "Lesson Learned" 37.

Implementation:
This checkpoint has yet to be initiated.

Checkpoint 33 (Category III) covered by IDA NOMEX

It is necessary to examine the extent to which the availability of the meteorological data required for dispersion calculations is guaranteed in case of extreme natural events.

Explanation:
The meteorological data required for dispersion calculations must be available in case of severe accidents that result from extreme natural events such as earthquakes or flooding. A concept for substitute measurements should ensure that dispersion calculations can still be carried out in case of a total power failure of long duration.

This checkpoint was derived from "Lesson Learned" 37.

Implementation:
ENSI is to define the specific requirements for the implementation of this checkpoint on the basis of knowledge acquired by IDA NOMEX.

Checkpoint 34 (Category III) covered by IDA NOMEX

It is necessary to stipulate arrangements for dealing with contamination in the area surrounding nuclear plants following severe accidents.

Explanation:
In case of soil contamination, it is necessary to examine which resources are suitable to curtail the contamination and to limit its effects. In case of deployment, the necessary resources must be available within appropriate periods, or must be kept in readiness. These resources may include binders (spray resins, cement), covering materials (to fix or cover loose contamination) and cleaning equipment (suction equipment, pumps, grippers and grabs, etc.).

For the case of personal contamination, it is necessary to examine whether the requisite resources and arrangements are also adequate for larger groups of people.

This checkpoint was derived from "Lesson Learned" 13.

Implementation:
ENSI is to define the specific requirements for the implementation of this checkpoint on the basis of knowledge acquired by IDA NOMEX.

Checkpoint 35 (Category III)

It is necessary to examine how to deal with large volumes of contaminated water, radioactive waste or environmentally hazardous substances in case of severe accidents.

Explanation:
The stipulated procedures must be integrated into emergency management. It is necessary to examine how the necessary technical resources can be made available in case of deployment, and whether resources should be kept in readiness.

This checkpoint was derived from "Lessons Learned" 38 and 39.

Implementation:
This checkpoint has yet to be initiated.

Checkpoint 36 (Category III)

As part of the emergency planning for severe accidents, it must be ensured that sufficient radiation protection staff are available on site.

Explanation:
In the stressful situations that must be expected, dose measurements at short notice and safety-oriented planning of work must continue to be possible, in order to protect the plant staff.

This checkpoint was derived from "Lesson Learned" 17.

Implementation:
This checkpoint has yet to be initiated.

3.6 Focus Area: Safety Culture

The accident at Fukushima-Dai-ichi has once again demonstrated that safety culture must be given high priority in the operators' organisations. ENSI regards this issue as very important in connection with its supervision, as reflected (for example) in the specialist discussions on safety culture that are conducted at regular intervals. Taking account of impressions gained from the Fukushima accident, it is nevertheless necessary to examine whether new knowledge has been gained in the area of supervision that could enable better development of the safety culture in the operators' organisations.

Checkpoint 37 (Category I)

The knowledge gained from the Fukushima accident must be taken into account in the programmes to foster and develop the safety culture in Swiss nuclear power plants.

Explanation:
Knowledge about safety culture gained from critical consideration of the Fukushima accident is reviewed during the regular "Specialist discussions on safety culture" with the Swiss licence-holders. Moreover, aspects of safety culture are also covered by regular supervision in the area of People and Organisation. The following aspects require particular attention here:

a Continuous improvement of safety.

b Measures to foster a good safety culture, especially in the areas of maintenance management and change management.

c Prioritisation of safety amid the conflicting interests of politics, safety and costeffectiveness.

A review is also required to determine whether the events in Fukushima have yielded new findings which relate to the safety-oriented development of organisations and which have not yet received adequate consideration in previous supervisory practice, in ENSI's regulations or in ENSI's strategy.

This checkpoint was derived from "Lessons Learned" 1, 2, 3, 7, 15, 21 and 27.

Implementation:
During the specialist discussions on safety culture and the regular supervision of organisational aspects, ENSI will brief itself on progress with the ongoing promotion of the safety culture.

As part of the forthcoming planning of supervision, a key point will be defined for the purpose of implementing checkpoints in the area of the management system.

The licence-holders keep ENSI continuously updated about measures relating to safety culture by means of monthly and/or annual reports. These measures are also covered by the PSR.

4 Further procedure

4.1 Implementation of checkpoints

The implementation of the checkpoints derived from the “Lessons Learned” will help to continue improving the safety of the Swiss nuclear power plants: the aim is to carry out the inspections and tests and to implement any resultant measures in the timeframe until 2015.

Measures of particular significance for safety were introduced immediately after the accident at Fukushima, e.g. by the directive dated 18.03.2011 regarding examination of the design of Swiss nuclear power plants to withstand extreme natural events such as those which led to the accident at Fukushima.

Those checkpoints still outstanding will be taken into account in the upcoming planning of supervisory activities, and will be coordinated across ENSI’s entire organisation. For the coming years, ENSI will define key implementation points according to their importance for safety in each case, and will take these as the basis for its detailed planning of supervisory work.

4.2 Ongoing observation of the Fukushima event

The analysis of previous severe accidents has shown that it can take several years to record all the details and to evaluate them. For example, access to the reactor of the stricken Three Mile Island nuclear power plant was not possible until years after the accident. ENSI therefore expects the collection of facts about the Fukushima accident to continue for a long time to come. As time goes on, further “Lessons Learned” will probably be derived from these facts, and more measures to improve safety at the Swiss NPPs will follow. Accordingly, the checkpoints summarised here should be regarded as another interim step in ENSI’s analysis of the Fukushima accident.

ENSI will continue to obtain and review information about the Fukushima accident, and to incorporate the resultant knowledge into its own supervision activities. Where indicated, ENSI will issue new directives or initiate other measures.

5 Annexe: Brief summary of “Lessons Learned”

ENSI has carried out a comprehensive analysis of the nuclear accident at Fukushima and has published the results in two reports (see section 2). The investigations have revealed a series of organisational and technical shortcomings which caused the accident and/or aggravated its damaging effects. The knowledge gained from the analyses completed by ENSI is summarised here in 39 condensed “Lessons Learned”. These involve not only ascertained facts but also hypotheses which ENSI has derived from the available information (as at August 2011). The sequence of Lessons Learned is not determined by their content, but is the result of the in-depth analysis mentioned above.

Lesson Learned 1

Shortcomings in the development of a learning organisation

Experience from national and international events was not given sufficient attention. According to the 2007 IRRS mission to Japan, events that received no public attention, as well as events outside Japan, did not lead to improvement measures in the Japanese nuclear power plants.

Lesson Learned 2

Deficient corporate culture

It appears that a corporate culture became established in the operator’s organisation which favours falsification and concealment.

Lesson Learned 3

Downgraded safety because of cost-effectiveness considerations

In its 2010 annual report, the operator’s company wrote that the frequency of equipment inspections was reduced as part of a cost-cutting programme.

Lesson Learned 4

Lack of independence for the supervisory authority (NISA)

NISA was part of the Ministry of Industry (METI, Ministry of Economy, Trade and Industry). This resulted in conflicts of interest and non-transparent decision-making structures.

Lesson Learned 5

Structural defects in the overall supervisory system

The roles and responsibilities of the Japanese supervisory bodies were not clearly defined.

Lesson Learned 6

Inadequate depth of supervision

The supervisory authority carried out no examination (or only a superficial examination) of safety against tsunamis before the plant was built and during its operation; this was the greatest failure.

Lesson Learned 7

Deficiencies in the operator’s safety culture

Safety reviews were omitted or even falsified. The consequence of this was deficient management of maintenance.

Lesson Learned 8

Deficiencies during the decision-making

The feed of sea water should have been initiated at an earlier stage. Inadequate communication (due to various reasons) between the operator's company, the supervisory authority and the government (Prime Minister) impeded timely decision-making. The plant parameters required for decision-making were not continuously available.

Lesson Learned 9

Inadequate preparation of emergency measures

In Japan, emergency measures were prepared by the operators on a voluntary basis. The existing emergency plans displayed various defects: inadequate emergency procedures for technical decision-making guidance in case of severe accidents (Severe Accident Management Guidance, SAMG); faulty communication plan; delayed provision of external emergency assistance; inadequate consideration given to simultaneous destruction of the entire infrastructure; staff, including emergency team, insufficiently prepared for an event of this scale. Back-fitting of diversified additional systems to cope with external events may only have been undertaken on a partial basis in Japan.

Lesson Learned 10

Overburdened staff

SAMG measures to mitigate the impact of a severe accident were not adequately implemented, so extensive releases occurred over long periods.

Lesson Learned 11

Regulatory shortcomings

The emergency measures to deal with severe accidents were not adequately stipulated in the relevant laws and regulatory documents.

Lesson Learned 12

Shortcomings in emergency planning by the authorities

The local crisis team was not ready to deploy, and/or was overburdened; in addition, there were communication problems among all the parties involved. Moreover, the coordination of international assistance was not adequate.

Lesson Learned 13

Inadequate radiation protection measures

As a consequence of the flooding, personal dosimeters and protective equipment were not available for the staff in sufficient quantities.

Lesson Learned 14

Inadequate information for the public

The public was informed about the expected development of exposure to radiation and contamination either inadequately, or too late.

Lesson Learned 15

Hazards of group dynamics

During the period of operation preceding the accident, risks were underestimated, warnings and facts were disregarded, and it is possible that "groupthink", complacency and overconfidence developed within the operator's management teams.

Lesson Learned 16

Stressful working conditions

The accident entailed exceptional physical and mental stress for the staff, exacerbated by insufficient knowledge of the actual situation as the accident evolved.

Lesson Learned 17

No knowledge of the radiological situation

Coping with the crisis was made more difficult because the radiological situation was unclear, especially in the initial phase of the accident.

Lesson Learned 18

Inadequate design to withstand external events

The operator is responsible for the safety of its plant. Its assumptions regarding the magnitude of the maximum credible earthquake as well as the frequency and height of tsunamis were too low. The design of the plants, which was based on these assumptions, was therefore inadequate. The extent to which proof of appropriate tsunami design was examined by the supervisory authority is not clear.

As a result of the inadequate design, there was flooding of the emergency diesel generators, the auxiliary cooling water system and the decay heat removal systems. This flooding led to a total and long-lasting failure of the installed power and cooling water supplies, and to the failure of heat removal.

The single air-cooled diesel generator in unit 6 of Fukushima-Dai-ichi was the only one that was still ready to operate, and it was possible to make subsequent use of this generator to deal with the accident in units 5 and 6.

Lesson Learned 19

Defects in structural design

The positioning of the spent fuel storage ponds in the upper sections of the reactor buildings made it difficult to initiate the necessary emergency measures. In addition, the lines connecting the buildings (e.g. cable and pipe ducts) were not tightly sealed, enabling the escape of contaminated water or venting gases from the reactor building.

Lesson Learned 20

No obligation for safety reviews

Despite international reviews (in connection with the WANO and OSART missions) and the Periodic Safety Review (PSR), weak points regarding safety were not rectified by the Japanese bodies. Not least, this was because the improvement measures specified by WANO (World Association of Nuclear Operators) are commitments entered into by the operator itself – and, moreover, they are not transparent to outside observers. The experts from OSART (Operational Safety Review Team) drew up their recommendations on behalf of the IAEA, but there is no direct obligation on the licence-holders to implement the checkpoints. In the case of the PSR, the internationally valid requirements were implemented to differing degrees.

Lesson Learned 21

Unfavourable and incorrect action by the operator

Due to a technical regulation requiring compliance with a maximum shutdown cooling gradient, the manual shutdown (probably of one train) of the emergency condenser for unit 1 took place ten minutes after the occurrence of the earthquake. The valves of the emergency condenser were later closed locally, without the knowledge of the shift leader. As a result, the emergency condenser was no longer available to deal with the accident at a later stage.

Lesson Learned 22

Restoration of supply equipment was hindered

The implementation of emergency measures (SAMG) was made more difficult due to impeded accessibility resulting from damage to plant components and rooms (debris), as well as power failures following the tsunami. Connections for the mobile power supply equipment had to be set up from scratch, and they did not work at first. The provision of the sea water feed may have posed technical problems.

Lesson Learned 23

Failure of electrical equipment

Failures of the lighting and plant instrumentation occurred due to the total failure of the emergency electrical power supply system in units 1, 2 and 4. These plants had to be operated under the most difficult conditions. For example, there were failures of the filling level indicator for the reactor pressure vessel.

Lesson Learned 24

Local ambient conditions hinder emergency measures

The ambient dose rate in the control rooms rose sharply (with very sharp temporary increases), so the number of operators had to be reduced and all the operators had to be evacuated at times. Comparable conditions affected the emergency room (the workplace of the emergency staff on site). Here too, the radiological conditions, the deterioration in communication conditions and the failure of the lighting imposed constraints on the ordering and implementation of emergency measures.

Lesson Learned 25

Communication equipment was not ready to operate

In some cases, the means of communication for the emergency staff and for the transmission of instructions were not initially ready to operate. As well as the external (fixed) telephone and mobile telephone networks, this also applied to internal communication equipment for the NPP at Fukushima Dai-ichi.

Lesson Learned 26

Problems with venting

There were difficulties with carrying out venting of the containment. The electrical actuators for the valves were no longer available as a result of the power failure. Operation from the control room therefore ceased to be possible. Manual local operation of the valves was prevented because access to the components was impeded. In addition, excessive ambient dose rates meant that the opening of the valves had to be interrupted several times.

Lesson Learned 27

Shortcomings in maintenance

Unofficial sources suggest that important safety equipment was not adequately maintained. It is not possible to give a conclusive assessment of the accuracy of these suggestions.

Lesson Learned 28

Delays for technical reasons

There may possibly have been delays in supplying sea water, because it was impossible to reduce pressure in the reactor pressure vessel. In addition, the volume flow rate of the cooling water that was supplied was not adequate, given the decay heat power that was still present.

Lesson Learned 29

Inadequate precautions against hydrogen explosions

It was not foreseen that explosions could occur in the reactor building due to leakages of hydrogen from the containment. Accordingly, no provision was made for measures to prevent hydrogen explosions in the reactor building outside of the containment.

Lesson Learned 30

Bottlenecks relating to equipment and staff for the emergency measures

Implementation of the emergency measures was made more difficult because the units were not independent of one another in terms of equipment and systems. This situation included jointly used pipe and cable ducts, supply of compressed air, emergency diesel generators and common exhaust air stacks. There were also staffing overlaps between the units. This may have caused staffing bottlenecks when it came to dealing with the accident.

Lesson Learned 31

Inadequate power supply

The power supply was inadequately designed to withstand external events, and was insufficiently diversified.

Lesson Learned 32

Inadequate protection of safety equipment

The tsunami impaired many items of safety equipment that were required to deal with the incident. Sediment may have clogged the cooling water intakes, and the air intakes on the buildings may have caused water penetration.

Lesson Learned 33

Deficient cooling of the spent fuel storage ponds

A failure of the cooling system for the spent fuel storage ponds was previously regarded as a minor risk, because spent fuel assemblies generate comparatively little heat, and the period and technical possibilities for restoring the cooling system were considered to be non-critical. At Fukushima, however, there were long delays and technical difficulties with restarting the cooling system because of severe damage to buildings and the accumulation of accidents in multiple plants.

Lesson Learned 34

Insufficient reserves of water

It is possible that no major internal reserves of water were available to feed the reactor pressure vessel, because the supply of sea water was started as early as 12.03.2011.

Lesson Learned 35

Insufficient reserves of boron

It is possible that no major reserves of boron were available, because – according to press reports – deliveries of boron from the US started only a few days after the occurrence of the event.

Lesson Learned 36

Availability of passive systems under accident conditions

With regard to unit 2, TEPCO and NISA drew the conclusion that the Reactor Core Isolation Cooling System probably continued to operate even after the battery capacity was exhausted (for approx. 30 hours). This means that operation without the control technology equipment that was actually required was still possible and expedient under the conditions of an extreme accident.

Lesson Learned 37

Environmental monitoring was impaired

Adequate radiological monitoring of the environment was impossible directly after the accident, because the earthquake and the tsunami had damaged and/or destroyed the relevant equipment and systems.

Lesson Learned 38

Inadequate disposal of water

Large quantities of radioactively contaminated water were generated during the accident. The responsible parties had – and still have – major difficulties with the intermediate storage, cleaning and disposal of this water and with avoiding its discharge into the sea and/or the soil.

Lesson Learned 39

Hazardous substances

In addition to the release of radioactive substances, there were releases of other substances (e.g. oils, lubricants and corrosion protection agents) which posed a hazard to the health of the public and to the ecosystem.

6 List of abbreviations

BEB	Spent Fuel storage ponds
BK	Federal Chancellery
EDI/FDHA	Federal Department of Home Affairs (FDHA)
EJPD/FDJP	Federal Department of Justice and Police (FDJP)
GENORA	Protected room for the ENSI emergency organisation
HSK	Principal Nuclear Safety Division
IAEA	International Atomic Energy Agency
IDA NOMEX	Interdepartmental Working Group to Review Emergency Protection Measures in case of Extreme Events in Switzerland
IRRS	Integrated Regulatory Review Service
NPP	Nuclear power plant
MADUK	Monitoring network for automatic dose rate measurement in the vicinity of nuclear power plants
MeteoSwiss	Federal Office of Meteorology and Climatology
METI	Ministry of Economy, Trade and Industry (Japan)
MSU	Catalogue of measures against severe accidents
NFO	Emergency organisation
NISA	Nuclear and Industrial Safety Agency (Japan)
OSART	Operational Safety Review Team
PEGASOS	Probabilistic Seismic Hazard Analysis for Swiss Nuclear Power Plant Sites
PRP - PEGASOS	PEGASOS Refinement Project
PSA	Probabilistic safety analysis
PSR	Periodic Safety Review
RPV	Reactor pressure vessel
SAMG	Severe Accident Management Guidance
SBO	Station Blackout
SED	Swiss Seismological Service
TEPCO	Tokyo Electric Power Company
U.S. NRC	United States Nuclear Regulatory Commission
VBS/DDPS	Federal Department of Defence, Civil Protection and Sports (DDPS)
UVEK/DETEC	Federal Department of Environment, Transport, Energy and Communications (DETEC)
WANO	World Association of Nuclear Operators
WENRA	Western European Nuclear Regulators Association

Fukushima

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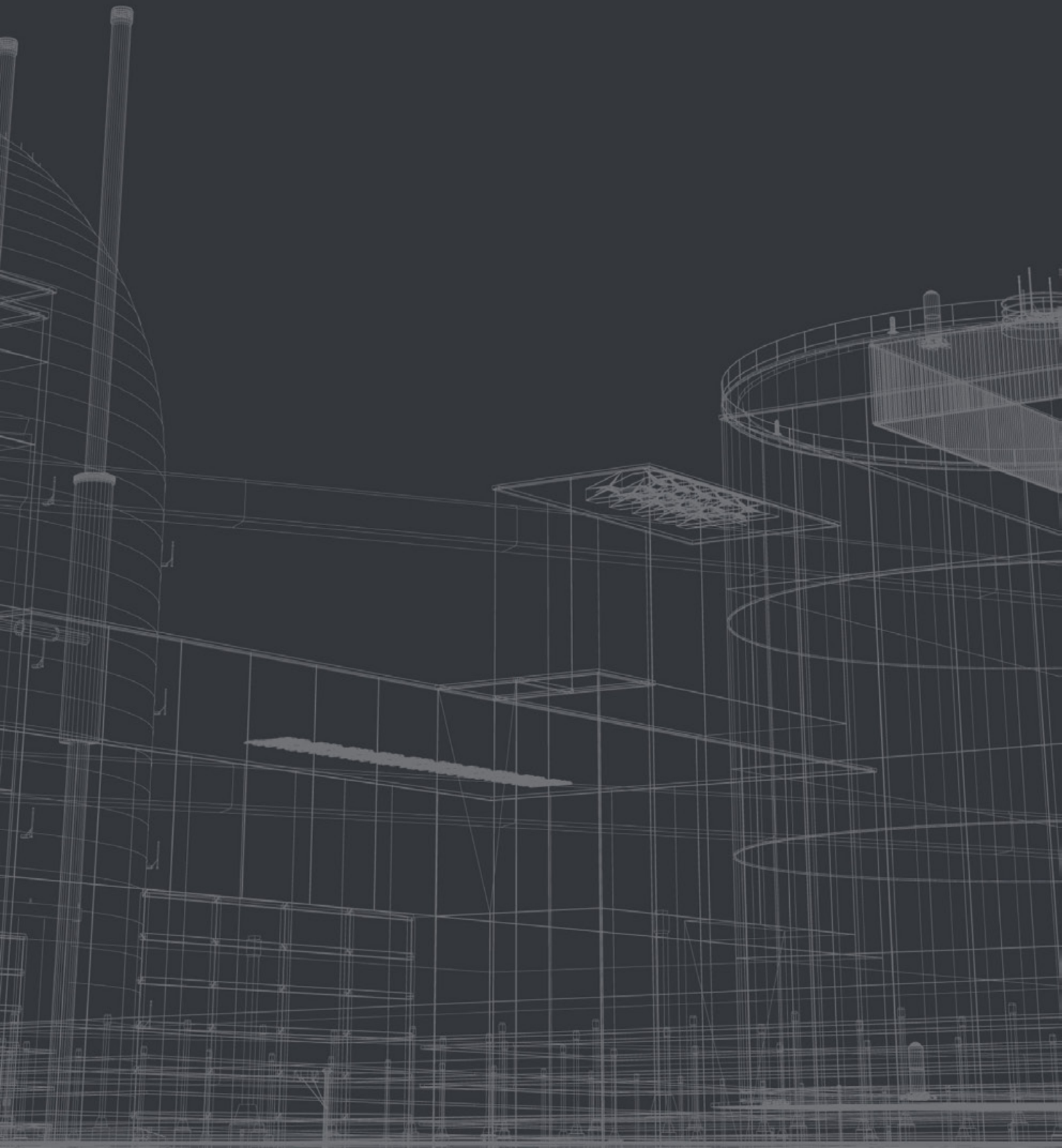

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