

Post-
Fukushima
accident

Spain

Peer review country report

Stress tests
performed on
European nuclear
power plants

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1 GENERAL QUALITY OF NATIONAL REPORT AND NATIONAL ASSESSMENTS

The accident at the Fukushima nuclear power plant in Japan on 11th March 2011 triggered the need for coordinated action at EU level to identify potential further improvements in Nuclear Power Plant(NPP) safety. On 25th March 2011, the European Council concluded that the safety of all European Union (EU) nuclear plants should be reviewed to provide comprehensive and transparent risk and safety assessments - the stress tests. The stress tests comprise three main steps: a self-assessment by licensees, an independent review of these assessments by the national regulatory body, and then a third phase of international regulatory peer reviews. The international peer review phase consists of three steps: an initial desktop review, three topical reviews in parallel (covering external initiating events, loss of electrical supply and loss of ultimate heat sink, and severe accident management), and seventeen individual country reviews.

The country review reports are one of the specific deliverables of the EU stress tests peer review process. They provide information based on the present situation with respect to the topics covered by the stress tests. They contain specific recommendations to the participating Member States for their consideration, good practices identified, and high-level information specific to each country and installation. The country review reports were initially drafted during the topical reviews based on the topical review discussions with the country involved and on generic discussions within each of the three topical review groups. Issues identified for each country during the topical reviews were identified for detailed follow-up discussions during the country reviews.

The current country review report was finalized at the end of the Country Review, after detailed discussions with the regulatory body of the reviewed country and a visit to a nuclear power plant. The report will form part of the Stress Tests Final Report combining the results of the three Topical Reviews and Country Reviews.

1.1 Compliance of the national reports with the topics defined in the ENSREG stress tests specifications

The national report “Stress Tests carried out by the Spanish nuclear power plants – Final Report” issued by the Spanish Nuclear Safety Council (CSN - Consejo de Seguridad Nuclear) addresses in a sufficient manner, most of the topics in the European Nuclear Safety Regulators Group (ENSREG) specifications for the Spanish fleet of Nuclear Power Plants (including the Pressurized Water Reactor (PWR) in dismantling phase and its dry spent fuel temporary storage) although the presentation does not formally follow the proposed structure.

Furthermore, the national report does not address fully to the extent specified cliff edge effects for earthquake, flooding and extreme weather. Further assessments are ongoing for these matters.

Despite this, the assessments performed have allowed the identification of strengths and potential opportunities for improvements to increase the robustness of Spanish NPPs.

1.2 Adequacy of the information supplied, consistency with the guidance provided by ENSREG

The information presented by the CSN is generally consistent with the guidance provided by ENSREG.

Within the topic of Earthquake, flooding and extreme weather conditions comprehensive information has been given with the exception of cliff edge effects.

Within the topic of loss of electrical power and ultimate heat sink, the national report is not fully consistent with the structure recommended by ENSREG, although in general the required information is presented. The information is adequately supplied by specific descriptions of the different plant designs provided at a reasonable level of detail. However, descriptions of different plant operational states, as well as some details (e.g. simplified diagrams of structures, systems and components, battery

recharge capabilities during Station Blackout (SBO)) were missing in the national report; these were provided during the peer review process.

Within the topic of Severe Accident Management, the information supplied in the national report, as explained and complemented at the horizontal peer review, addresses the reactor and the spent fuel pools (SFP) of the operating NPPs and the dry fuel storage of the NPP (José Cabrera) in the dismantling phase. AM (accident management) measures were presented and assessed. The assessments include the presentation of cliff edge effects (e.g. 2 to 33 h to battery depletion in total SBO scenarios, depending on the NPP and the assumptions), a discussion of the on-site emergency response plans, the procedural guidance, analyses of instrumentation performance, and proposals for improvement (e.g. additional analysis of organisational issues for accidents affecting both units on a site).

1.3 Adequacy of the assessment of compliance of the plants with their current licensing/safety case basis for the events within the scope of the stress tests

The national regulator has requested utilities to perform verification on compliance of the plants with their current design basis. CSN verifies these aspects by means of its continuous supervision and control programme and the periodic safety reviews that are conducted every ten years prior to the renewal of the operating licences.

The main objectives of the periodic safety review are to identify and analyze long term trends in plant operation,:

- to assess the ongoing programs for safety improvement (e.g., human & organizational factors, safety culture, operating procedures...)
- to assess plant safety versus state of the art in nuclear safety,
- to perform an aging management review, in all plants, (including a time limited aging analysis, if the plant will overpass 40 years of operation).

The content of the periodical safety review is included in the CSN Safety Guide 1.10 “Periodical Safety Reviews of Nuclear Power Plants”

In addition to the periodic safety review, the licensees have to present a new revision of their PSA for the license renewal. The PSA has to be updated after each refuelling outage (living PSA), but every ten year (within PSR) a complete revision has to be performed in order to include the new methodologies and updated plant models.

The country stated, that reports from the licensees conclude that the design bases and the licensing bases set for each facility are currently fulfilled. Deviations from the licensing bases have not been detected by regulator.

Concerning beyond-design basis accidents (and thus related to Accident Management (AM)) however, the national report does not clearly present an assessment of compliance with the related regulation(s). During the peer review process, additional information has been provided. Elements of AM are covered by the Spanish regulations as follows: The Spanish NPP were required in the earlier 2000s, as a result of Periodic Safety Review (PSR), to develop Severe Accident Management Guidelines (SAMGs), based on the results of probabilistic safety analyses and on generic guidelines issued by the design vendor (e.g. Westinghouse, KWU, GE). Also requirements on training, emergency exercises and procedures were established at that time. These regulations are briefly addressed in Sections 4.2.1.1 and 4.2.1.2. More recently, new directives have been sent by CSN to each NPP, associated with the most recent PSRs, aimed at reinforcing compliance of the Spanish plants with the Western European Nuclear Regulator Association (WENRA) accident management reference levels (RL).

Additionally the CSN had prepared for WENRA Harmonization process a Safety Instruction (to be published in the Official State Gazette). This was almost ready to be issued at the time of the Fukushima accident, but was postponed to allow the incorporation of lessons learned from the accident.

1.4 Adequacy of the assessments of the robustness of the plants: situations taken into account to evaluate margins

In the national report a treatment of margins can be found with a different level of detail.

The margins for seismic events and flooding have been assessed. Margins for extreme weather have not been quantified in the national report, except in the case of strong winds where the structures resistance beyond the design bases has been assessed.

Within the topic of Earthquake, flooding and extreme weather conditions, there is an extensive coverage of indirect effects of earthquakes. Cliff edge effects for external events have not been assessed, even though the assessment performed, following the Spanish selected approach to this problem, allows identifying strengths and opportunities for improvements in order to increase the robustness of the plants in those situations.

Within the topic of loss of electrical power and heat sink the information on - Loss Of Off-site Power (LOOP), SBO and combination of SBO and loss of Ultimate Heat Sink (UHS) is provided in different level of detail. Descriptions are not always sufficient for independent review. Nevertheless, results of assessment done by utilities and regulatory authority are assuredly presented.

Within the topic of Severe Accident Management, robustness can be considered to be represented by the time to escalations in the severity of the event associated with cliff edge effects in the accident progression (e.g. to battery depletion, core damage, etc.). Concerning the base case situation (total SBO) and the cliff edge effects chosen, the analyses of robustness of the Spanish NPPs appear adequate and the results reasonable. With respect to the assumed boundary conditions, more detailed information or analysis has been provided during the peer review as discussed in Section 4.3.

Finally, it is noted that current Spanish PSAs do not credit manual dis-latching (i.e. the removal of non-essential loads in accident conditions to preserve battery life). In the near future, CSN will carry out a detailed assessment of the time claimed for manual actions, the procedures, etc.

1.5 Regulatory treatment applied to the actions and conclusions presented in national report (review by experts groups, notification to utilities, additional requirements or follow-up actions by Regulators, openness,...)

There is clear evidence that regulatory engagement has been applied in the national report. CSN evaluation is systematically provided in separate chapters and additional work has been asked to the licensees.

CSN has taken a significantly proactive approach to the stress tests work and requested the licensees to analyse situation regarding events at Fukushima Daichi NPP. CSN requested information on actions performed in line of World Association of Nuclear Operators (WANO) recommendations, as well as issued Complementary Technical instructions regarding forthcoming specification on “stress tests”.

The planned time scheme for implementing the proposals of improvements - identified to gain additional margins - comprises the categories short-term (between January and December 2012), medium-term (between 2013 and 2014) and long-term (between 2015 and 2016).

Within the frame of loss of electrical power and heat sink CSN performed special inspections of systems related to LOOP, SBO and loss of UHS. All reports prepared by the utilities were evaluated by regulatory authority and results were summarized in the national report. Comments and assessments provided by regulatory authority in the national report are clear and provide useful extension to the information provided by the operator. Some aspects of assessments done by utilities are not fully understandable without Regulators comments. The regulatory treatment of the provided information and proposed actions are adequate.

Within the topic of Severe Accident Management, CSN concludes that the verifications and studies (which concern AM as well) that it has conducted confirm the existence of good margins that ensure that the safety conditions of the plants will be maintained beyond the cases contemplated in their design. Identified improvements or the need for further analyses have been assigned timescales for completion. AM-related examples of further work with assigned timescales include: analysis of the implementation of a system for providing alternative electricity supply to the control room emergency filtering units (short-term); analysis of the organisation and means available for managing

emergencies, and to size the organisational changes (medium-term); implementation of communication capacity improvements (long-term).

Overall, the regulatory body appears to have taken a proactive approach to the stress tests work. The review team considers the use of assigned time schedules as positive. Of course, the adequacy of the assignments can only be considered at a high-level in a review of this sort; with this caveat, the timescales seem broadly sensible.

Overall it is noted that the aftermath of Fukushima will require the implementation of important modifications to the plants, together with longer term work to contribute to the international effort to identify lessons learnt from the accident and to apply its implications in the Spanish plants. To be able to cope with the workload these activities will entail, the review team recommends that CSN's technical assessment human resources should be reinforced.

2 PLANT(S) ASSESSMENT RELATIVE TO EARTHQUAKES, FLOODING AND OTHER EXTREME WEATHER CONDITIONS

2.1 Description of present situation of plants in country with respect to earthquake

2.1.1 DBE

2.1.1.1 Regulatory basis for safety assessment and regulatory oversight)

The codes, guides and standards applied in Spain for the seismic evaluation and design are either based on site criteria of the USNRC 10CFR100 and the 10CFR50 or in the case of Trillo NPP on the German KTA 2201. The seismic classification of safety significant Systems, Structures and Components (SSCs) was carried out in accordance with USNRC Regulatory Guide 1.29 and ANSI-N 18.2.

Seismic Category I (SC I) SSCs have been designed to withstand the effects of the Design Base Earthquake (DBE) while remaining functional. Seismic Category II A (SC IIA) SSCs have been designed in accordance with the Spanish seismic resistance standard but additionally they are designed that in case of their failure they don't affect the function of any of the SC I SSCs. Seismic Category II SSCs have been designed in accordance with the Spanish seismic resistance standard. Their failure in case of an earthquake is acceptable.

2.1.1.2 Derivation of DBE

The original DBE assessments have been derived from deterministic hazard studies in the 1970s and early 1980s. Seismic Hazard Analysis (SHA) accounts for the strongest historical and instrumentally recorded earthquakes and increasing a safety margin to define the maximum intensity and associated Zero Period Acceleration (ZPA) of plant DBE. Site conditions are accounted for. The assessments were justified against updated earthquake catalogues in 2011.

The SHA performed has considered all information of seismic sources (faults and seismological data) available at the time of the licensing. An update of the SHA is planned to take into account the improved knowledge of seismic sources.

2.1.1.3 Main requirements applied to this specific area

The calculated seismic acceleration applicable to the sites of the Spanish nuclear power plants has been estimated between 0.05g and 0.08g; however, the value that has been used as the DBE at the different Spanish plants ranges from 0.10g to 0.20g (Peak Ground Acceleration - PGA at the free field) for the plants in operation, and is 0.25 g for the Jose Cabrera Individual Temporary Repository (ATI), the Temporary Spent Fuel Storage Facility . These values correspond to exceedance probabilities ranging from 2.8×10^{-4} to 2.6×10^{-5} (mean values). Exceedance probabilities higher than 10^{-4} /year are considered by the team to no longer be in line with current European practices, but at the time when the DBE were defined (licensing), only DSHA were available. However significant margins have more recently been demonstrated beyond the DBE for all plants (see next chapters).

2.1.1.4 Technical background for requirement, safety assessment and regulatory oversight

See previous chapters. Seismic safety assessment has been done mostly through deterministic approach and completed by a probabilistic approach for the seismic margin assessment.

The methodology used to establish the design basis earthquake (DBE) in each plant has been a deterministic procedure that evaluates the maximum historical earthquake at the site and then increases with a margin estimated to define the maximum intensity and associated Zero Period Acceleration (ZPA) of plant DBE.

The maximum design basis earthquake (DBE) adopted in the Spanish plants corresponds to that defined as "safe shutdown earthquake" (SSE) in the USNRC regulation (except Trillo NPP which is a German design). The DBE is the maximum earthquake that is considered reasonably might happen at a particular location. Its aim is to ensure, if occurs, the integrity of the pressure boundary of the reactor coolant, the reactor shutdown capability and maintaining it in safe conditions, and the ability to prevent or mitigate the consequences of accidents that could cause potential exposures to radiation outside the plant above the limits established by regulation.

Seismic design also considers an earthquake named OBE (Operating Basis Earthquake) in the USNRC regulation (except for Trillo plant), whose value is usually half of DBE. The OBE is associated with safety requirements to maintain the entire plant in operation.

Jose Cabrera ATI is classified as safety-significant, but not so the support slab on which the casks stand. The cask systems for storing spent nuclear fuel on reinforced concrete pads are installed as free-standing structures. Nevertheless the casks and the storage slabs of the ATI are seismically designed according to USNRC 10CFR72.103, and Nureg-1567 with a DBE with a PGA of 0,25g.

There is no automatic scram based on seismic instrumentation in Spanish NPPs, however there is an alarm in Control Room based on seismic instrumentation, and a procedure requesting to shutdown manually the reactor in case half of the SSE response spectra and earthquake Cumulative Absolute Velocity (CAV) according with USNRC 1.166 criteria are exceeded

2.1.1.5 Periodic safety reviews

Seismic safety improvements were assessed by means of specific analyses performed during the periodic safety reviews, and also through the different inspections carried out within the supervision and control processes carried out by CSN.

All plants have been conducting a review of external hazards, made under the "Integrated Programme for Performing and Use of Probabilistic Safety Assessment in Spain" and following the methodology described in NUREG-1407 of the USNRC.

In these studies external events are considered, particularly the risks from earthquakes, flooding, weather conditions, transport routes and nearby industries. An update of the SHA is planned to take into account the improved knowledge of seismic sources.

2.1.1.6 Conclusions on adequacy of design basis

The national report provides sufficient information to enable the conclusion that the design basis is consistent with international standards (see previous chapters). The CSN evaluation considers the content of the licensees' reports to be acceptable with regard to the seismic design bases. Nevertheless, in view of the progress made in recent years in site seismic characterisation methods and the experience gleaned at international level, the CSN will introduce a programme to update site seismic hazard characterization following the most recent International Atomic Energy Agency (IAEA) standards. Recent work on active faults, paleoseismology and the implementation of such data in SHA are available for Spain. An update of the SHAs to take into account the improved knowledge of seismic sources is planned. The analyses performed in Spain include a comprehensive analysis of the possible indirect effects induced by earthquake (explosions and fires, internal flooding caused by pipe breaks, damage on nearby infrastructure, sloshing in the Spent Fuel Pools (SFPs), effects of earthquakes on industries in the vicinity of their sites). The CSN has considered these analyses and their conclusions to be valid. Nevertheless, CSN evaluation concluded that further analyses should be carried out, and issued a Complementary Technical Instruction (CTI). These analyses should consider

the effects of pipe rupture (non seismic and seismic) that could lead to the release of large quantities of water in order to evaluate any need to improve the flood barriers.

Within the framework of the ongoing analyses it is suggested to consider in particular verifying that no common cause failure could occur (such as internal flooding of EDGs or other safety relevant SSCs due to damage to non seismically qualified SSCs).

An evaluation of the tsunami hazard at Vandellós NPP (located on the Mediterranean seashore and with tectonically active zones near the coast of Algeria that could generate some level of tsunami) has been performed and demonstrated the adequacy of the design basis.

2.1.1.7 Compliance of plant(s) with current requirements for design basis

The national report identifies that the licensees have confirmed that their plants are compliant with current requirements for design basis. All the plants have reviewed their SSCs design bases with respect to earthquakes. In addition, the licensees have reviewed the data on earthquakes that have occurred in the vicinity of the plants since the cut-off date considered in the DBE definition studies to 2011.

Licensees have formal processes to ensure the operability of the SSCs required to reach safe shutdown, among them the Operational Technical Specification (OTS) surveillance requirements, the Maintenance Rule, In-Service Inspection and seismic and environmental qualification requirements. These processes are regulated by CSN instructions within the framework of the integrated plant supervision and control system in force in Spain.

2.1.2 Assessment of robustness of plants beyond the design basis

2.1.2.1 Approach used for safety margins assessment

Seismic margin methodologies were applied according to the American Electric Power Research Institute (EPRI) and US-NRC standards, in order to determine the HCLPF seismic capacity of the plants. For this purpose a Review Level Earthquake (RLE) was established by the CSN in the initial analyses, corresponding to a PGA of 0.3g. The CSN considers this value as an adequate review margin for all Spanish plants independent from their seismic design basis. The safety functions considered have been established on the basis of EPRI NP-6041, NUREG/CR-4482, NUREG-1407. The seismic margins mentioned in the national report corresponds to the PGA values the SSCs required to reach and maintain safe shutdown (for 72 hours), including the functions of long-term emergency core cooling and containment isolation, considering two initiating events induced by the earthquake (loss of off-site power and small break LOCA). Within the stress test programme, the scope of the seismic margin analyses has been extended to include the SSCs required to guarantee the integrity and cooling of the spent fuel pool, and other safety relevant SSCs used to mitigate SBO and severe accident situations.

2.1.2.2 Main results on safety margins and cliff edge effects

Specific seismic IPEEE (Individual Plant Examinations for External Events) analyses were already performed in Spain for all operating plants. The final report of this IPEEE analyses accomplished by Spanish licensees was reviewed with the external support of US-NRC and LLNL (Lawrence Livermore National Laboratory). CSN mentions that the RLE corresponds to probabilities of exceedance ranging from 9.4×10^{-5} to 1.2×10^{-5} (mean value). The current lower HCLPF was assessed for all plants and is in all cases at least 50% above the DBE PGA values. Lower HCLPF ranges from 0.20 to 0.30 g.

The analysis performed shows that there is currently significant margin above the design bases. It does not strictly comply with the stress test specifications for the evaluation of cliff edge effects and associated possible weak points, which should be identified for each of the fundamental safety functions along with the corresponding earthquake severity.

2.1.2.3 Strong safety features and areas for safety improvement identified in the process

Where necessary, all the SSCs on the path of safe shutdown will be upgraded to 0.3 g.

The national report includes a rather comprehensive analysis of the possible indirect effects induced by an earthquake inside and outside the facility. It covers explosions and fires, internal flooding caused by pipe breaks, effects of sloshing in the SFPs and the UHS ponds, failure of dams and effects of earthquakes on industries in the vicinity of the sites.

2.1.2.4 Possible measures to increase robustness

Based on the information available and on the additional measures already decided or implemented, no further measures are suggested, except in the case of internal flooding where additional analysis are being carried out by the utilities and the need of improvements could be finally concluded

2.1.2.5 Measures already decided or implemented by operators and/or required for follow-up by regulators

In view of the progress made in recent years in site seismic characterisation methods and the experience gleaned at international level, the CSN is considering initiating a seismic hazard updating programme in accordance with the most recent IAEA standards. Within the framework of this seismic hazard update, it is suggested that this updated SHA should use the available geological and paleoseismological data characterizing the active faults of the Iberian Peninsula (see European SHARE project - 2010). Many of the faults included in that database have not produced earthquakes in historical times and therefore are not considered in current deterministic SHA. The importance of integrating paleoseismological data has particularly been shown for the area adjacent to the sites Vandellos II and Asco.

On the basis of the analyses performed for the RLE, the seismic capacity of all SSCs on the path to safe shutdown will be upgraded up to a PGA of 0.3 g for all Spanish plants. In order to increase the robustness of the plants, the licensee proposes to perform an analysis of the seismic vulnerability of the SBO equipment and of the most relevant equipment mentioned in the Severe Accident Management Guidelines and not contemplated in the current IPEEE, with a view to determine suitable actions guaranteeing a seismic margin of at least 0.3g for all required SSCs.

A new seismically and flood-resistant crisis emergency centre will be available in all sites.

The general post-earthquake inspection procedure is divided into two procedures: one contemplating immediate inspection in respect to shutdown and the other covering the inspection activities prior to start-up.

2.1.3 Peer review conclusions and recommendations specific to this area

The Design Basis has been explained and is considered to be consistent with international standards. There is a broad coverage of indirect effects of earthquakes, including effects on nearby hazardous industries, that could be seen as a good practice. Within the framework of the seismic hazard update claimed by CSN, it is suggested to consider to include geological and paleoseismological data characterizing the relevant active faults. There is evidence that a continuous improvement process by PSRs has been applied. The seismic margin assessment performed shows a significant margin beyond the design bases. In addition, the seismic capacity of all the SSCs on the path to safe shutdown and other safety relevant SSCs will be upgraded up to 0.3 g.

Beyond the improvement measures already implemented by the licensees or just claimed by CSN, no additional measures are suggested.

2.2 Description of present situation of plants in country with respect to flood

2.2.1 Design Basis Flood (DBF)

2.2.1.1 Regulatory basis for safety assessment and regulatory oversight

The codes, guides and standards applied in Spain for the flood evaluation and design are based on site criteria of the US-NRC. The general requirements used are the US NRC 10CFR 50 and 100. The specific basis for the design of nuclear power plants against floods are those included in USNRC R.G.1.59, R.G.1.102 and IAEA requirements and guides.

2.2.1.2 Derivation of DBF

DBF has been reevaluated taking into account the different phenomena which could produce severe flooding at the sites: intense local rainfall, overflowing of rivers and ravines, tsunamis, rising sea or groundwater levels. CSN mentions that the analysis of consequences of dam failures is undergoing a review in order to cross-check the dam failure criteria used by holders with those of the studies of Spanish Emergency Plan for dams. CSN has also requested additional analyses of the consequences of failure of the drainage system in some plants. Return periods associated with the Probable Maximum Flood (PMF) vary between 1000 and 10.000 years for the river flood scenarios. The reviewed DBF includes when applicable dam failure as an additional conservatism. All the Spanish plants, including those with lower PMF return periods, have judged that their DBF exceedance probabilities are around 10-5/year, following USNRC R.G. 1.59. The methodology used to establish the design basis flood (DBF) in each plant has been a deterministic procedure that evaluates the maximum historical flood at the site with an additional margin. Later, this procedure also was improved with the IAEA guides NS-G-3.4 and NS-G-3.5, and USNRC GL 89-22.

The design basis flood (DBF) adopted in the Spanish plants corresponds generally to that defined in the USNRC regulation and is considered to be the maximum flood that reasonably might happen at a particular location. Its aim is to ensure, if occurs, the integrity of the pressure boundary of the reactor coolant, the reactor shutdown capability and maintaining it in safe conditions, and the ability to prevent or mitigate the consequences of accidents that could cause potential exposures to radiation outside the plant above the limits established by regulation.

Except for Vandellós II and Trillo plants, the most critical flooding events correspond to the potential failure of upstream dams. In all cases it has been verified that said dams are capable of withstanding earthquakes greater than those adopted as the seismic design basis at every site; their seismic margins have been quantified. Additionally, licensees have analysed the consequences derived from dam failure, concluding that the flooding levels that would be reached at the plants affected by these events would be below the site grading elevation.

2.2.1.3 Main requirements applied to this specific area

See 2.2.1.2.

2.2.1.4 Technical background for requirement, safety assessment and regulatory oversight

The Licensees have considered the potential impact of external events on cooling water source (ultimate heat sink, primary and secondary). In particular the possibility of blockage (or clogging) in the water intake and outlet due to flooding has been analyzed, as well as the potential consequences and how to address or avoid them.

All Spanish plants have analyzed the potential flooding by rising water table but have not identified weaknesses or safety impacts. However, the CSN recently has required detailed analyses by a CTI on possible failures of drainage networks, both for groundwater and heavy rainfalls. For Almaraz and Asco NPP, an analysis of the effects of loss of the dewatering systems will be assessed in more detail by calculation, additional tests and inspections.

For heavy rain, original data was based on local regulations for conventional buildings, and has been reviewed more recently based on US-NRC guidelines and Probable Maximum Precipitation (PMP). The team notices the significant difference of return periods currently considered between the sites,

and suggest to consider adopting a consistent approach. CSN is reviewing the analyses recently provided by the Licensees and could consider further requirements on this if needed.

2.2.1.5 Periodic safety reviews

Flooding was reassessed by means of specific analyses performed during the periodic 10-yearly safety reviews, and also during the different inspections carried out, within the CSN's supervision and control processes.

2.2.1.6 Conclusions on adequacy of design basis

All the plants have reviewed their design bases in relation to external flooding for a wide range of flooding scenarios. The conclusions obtained by the licensees indicate that these design bases are adequately fulfilled and remains valid. The CSN evaluation considers the content of the licensees' reports to be acceptable as regards the external flooding design basis. The approach of defining flood design seems consistent with international standard. Potential flooding by rising water table has been analyzed without highlighting safety impacts at this stage, and further analysis of the effects of loss of dewatering systems at the relevant plants and of failure of the drainage systems are ongoing. It is suggested to consider adopting a consistent approach for the return periods associated to heavy rain scenarios at the different sites.

2.2.1.7 Compliance of plant(s) with current requirements for design basis

The national report claims that all the plants have reviewed their design bases in relation to flooding as a result of natural off-site events. The conclusions obtained by the licensees indicate that these design bases are adequately fulfilled. In addition, the licensees have assessed whether the selected magnitude of the design basis flood (DBF, Design Basis Flooding) continues to be valid.

CSN mentions that existing protections against flooding have been periodically inspected or subjected to specific inspection as part of the CSN supervision programmes.

2.2.2 Assessment of robustness of plants beyond the design basis

2.2.2.1 Approach used for safety margins assessment

The cliff edge considered on flooding levels has been the plant grading level in each site. For each site, the maximum flood level resulting either from river flooding or dam break has been assessed and compared to the plant grading level. For flooding due to heavy rainfall, the maximum expected rain flow has been compared to the flow capacity of the drainage systems.

2.2.2.2 Main results on safety margins and cliff edge effects

Actual grading level in each site has been considered as a virtual flooding cliff edge. The margins for river flood / dam break scenario is ranging from about at least 2 m (Almaraz, Asco and Garona) to more than 100 m (Trillo). For heavy rainfall scenarios, the analyses performed have showed significant margins compared to the drainage system flow capacity. For some sites, complementary studies are ongoing.

2.2.2.3 Strong safety features and areas for safety improvement identified in the process

The national report identifies proposals to increase the robustness, when deemed necessary.

2.2.2.4 Possible measures to increase robustness

It is suggested to consider improving the external flood volumetric protection of buildings containing safety related SSCs. An analysis of this issue by the Licensees is ongoing and possible safety improvements should be implemented where necessary.

2.2.2.5 *Measures already decided or implemented by operators and/or required for follow-up by regulators*

A number of analyses are still ongoing.

The licensees have proposed different improvements:

- Increasing capacity of downstream dams spillways.
- Reinforcing of water leak-tightness of building gates.
- Increasing the evacuation capacity in the drainage networks.
- Improvements to galleries with potentiality to induce in-leaks.
- Improving the hydrostatic resistance of seals in galleries connecting to buildings containing safety-related equipment.

Other measures are mentioned such as CSN request to document the analysis of the effects due to a possible failure of the drainage systems.

2.2.3 Peer review conclusions and recommendations specific to this area

DBFs have been explained and are considered to be consistent with international standards. The analyses cover a wide range of phenomena such as the effects of intense local rainfall, overflowing of rivers and ravines, tsunamis, rising sea or groundwater levels and rupture of dams. The design bases for external flooding of all the plants have reviewed. Both the licensees and the CSN conclude that they remains valid. Reevaluation of flooding hazard is part of the PSR process. Flooding design bases is also covered by CSN's supervision and inspection processes. The team notes that current good practices in Europe consider using DBF corresponding to exceedance probabilities of 10^{-4} /year or lower. Potential flooding by rising water table has been analyzed without highlighting safety impacts at this stage, and further analysis of the effects of loss of dewatering systems at the relevant plants is ongoing. It is suggested to consider adopting a consistent approach for the return periods associated to heavy rain scenarios at the different sites.

Margins above DBF are ranging from about at least 2 m to more than 100 m in the different sites. For heavy rainfall scenarios, the analyses performed have showed significant margins compared to the drainage system flow capacity. For some sites, complementary studies are ongoing. A number of proposals for concrete improvement of the robustness against external flooding is proposed.

It is suggested to consider improving the external flood volumetric protection of buildings containing safety related SSCs. An analysis of this issue by the Licensees is ongoing and possible safety improvements should be implemented where necessary.

2.3 Description of present situation of plants in country with respect to extreme weather

2.3.1 DB Extreme Weather

2.3.1.1 Regulatory basis for safety assessment and regulatory oversight

The approach applied has been developed in accordance with USNRC NUREG-1407. CSN required to all Spanish NPP in 1996 on the basis of USNRC Generic Letter No. 88-20 supplement 4 a systematic individual plant examination for severe accidents initiated by external events (IPEEE). Licensees identified which external hazards needed to be evaluated based on conservative screening analysis that included all potential external hazards. This analysis has been reanalyzed between the years 2008-2011. The external hazards considered have been: Seismic Events, High Winds and Tornadoes, External Floods , Transportation and Nearby Facility Accidents. Additional external risks have been assessed within the framework of the stress tests.

2.3.1.2 Derivation of extreme weather loads

In general terms, the historical records at the site and its region were considered to design against extreme weather conditions. A probabilistic methodology was used as preliminary screening for

events different than earthquakes and flooding that constitute the specific scope of the stress tests. The screening out of external events performed to establish the design basis is based on a probability of occurrence of less than 10^{-5} per year, in accordance with the probabilistic methodologies included in the applicable IPEEE standards, NUREG/CR-2300, NUREG-1407, and its screening criteria, to attempt to establish other external events that might have a safety impact at each plant.. Events that are not screened out are then specifically analyzed, but applying the civil regulations in force. For example, an event is excluded if has a significantly lower mean frequency of occurrence than other events with similar uncertainties and could not result in worse consequences than those events; or if the event cannot occur close enough to the plant to affect it; or if the event is included in the definition of another event (as storm surges, included in external flooding). On performing the stress tests analysis, additional consideration has been given to: strong winds, electrical storms, hail, snow storms, extreme temperatures (high and low), freezing, drought, and forest fires. For each of these events the licensees have reviewed the original design basis and have assessed that the plant structures and components located in outdoor areas are adequately designed. Likewise, the scope of considered events has been expanded so as to include those events which have been previously screened but whose occurrence is still considered credible at each site. Proposed reinforcement measures are considered (for example, on lightning issues and others).

In the current analysis of extreme weather condition tornado is not considered. A specific study has been initiated recently by CSN to draw up a climatology regarding the occurrence of tornados in the areas surrounding nuclear facilities. This study is currently ongoing. Preliminary results show that the probability of a tornado occurring at plant sites would be 'low' or 'very low'.

Some common combinations of extreme weather conditions have been considered. Further detailed information on combined external events has been required to all NPPs by CSN and the additional analyses are ongoing.

Design temperatures were based on local construction regulation at the time of licensing and on vendor country regulation. Results showed by Licensees are being reviewed by CSN and some design temperatures could be adapted as a result. In all the cases, with initial high temperatures (inside the design bases) and after a loss of coolant accident, the ultimate heat sink (UHS) is designed to keep the necessary water inventory, without make-up (outside replacement of essential services water), for a period exceeding 30 days.

To calculate the wind speed design basis in some sites the exceedance frequency of 10^{-3} per year has been used, depending on the specific location of the site in accordance with the Spanish building standards at the time of the construction (MV-101).

2.3.1.3 Main requirements applied to this specific area

See 2.3.1.2.

2.3.1.4 Technical background for requirement, safety assessment and regulatory oversight

The probabilistic methodologies are basis for safety assessment and regulatory oversight. The potential phenomena have been screened, for each site, to discard those with negligible probability of occurrence (10^{-5} /year). It is recommended to consider improving the consistency between the return periods associated to the extreme design temperatures for the different sites, and in line with international standards.

2.3.1.5 Periodic safety reviews

The national report states that extreme weather is also included in PSR.

2.3.1.6 Conclusions on adequacy of design basis

The approach seems to be consistent in general with international standards. However, for extreme temperatures, it is recommended to consider improving the consistency between the return periods associated to the design extreme temperatures for the different sites, and in line with international standards.

2.3.1.7 Compliance of plant(s) with current requirements for design basis

The national report identifies that the licensees have confirmed that their plants are compliant with current requirements for design basis. CSN ascertains, that the conclusions drawn by the licensees concerning design requirements are generally considered acceptable and that in some cases additional studies are requested to the licensees, and in other cases the analysis by CSN is still ongoing.

2.3.2 Assessment of robustness of plants beyond the design basis

2.3.2.1 Approach used for safety margins assessment

As a general method and regarding extreme weather conditions, the safety margins are assessed by comparing in each case the design basis applied and maximum historical records obtained at the site. In some cases the plants have not yet finished the corresponding analysis or a detailed quantification of these margins has not been clearly determined by the licensees; CSN will require more information on this respect to the plants.

2.3.2.2 Main results on safety margins and cliff edge effects

The national report claims that the design criteria applied and the margins estimated are reasonable, although in certain cases, such as the margins with respect to extreme temperatures, the results submitted are still being reviewed by the CSN. The national report does not give information about the results of the margins available and cliff edge effects, except in the case of strong winds and water and snow loads; in these cases, the structures resistance beyond the design bases has been assessed.

2.3.2.3 Strong safety features and areas for safety improvement identified in the process

The insofar necessary assessments of CSN are still ongoing.

2.3.2.4 Possible measures to increase robustness

For extreme temperatures, it is recommended to consider improving the consistency between the return periods associated to the design bases for the different sites, and in line with international standards.

2.3.2.5 Measures already decided or implemented by operators and/or required for follow-up by regulators

There are some improvement measures ongoing and others will be required by the CSN.

2.3.3 Peer review conclusions and recommendations specific to this area

A probabilistic methodology has been used as preliminary screening for events different than earthquakes and flooding that constitute the specific scope of the stress tests based on a probability of occurrence of 10^{-5} per year, in accordance with internationally recognised standards.

According to the appraisals of CSN the analyses show that sufficient margins are available. For extreme temperatures, it is recommended to consider improving the consistency between the return periods associated to the design bases for the different sites, and in line with international standards.

Additional analyses are ongoing.

3 PLANT(S) ASSESSMENT RELATIVE TO LOSS OF ELECTRICAL POWER AND LOSS OF ULTIMATE HEAT SINK

3.1 Description of present situation of plants in country

3.1.1 Regulatory basis for safety assessment and regulatory oversight

In Spain there are NPPs of US and of German origin. For NPPs of US origin, USNRC (United States Nuclear Regulatory Commission) requirements are used, i.e. relevant sections of US Code of Federal Regulation (CFR). For the design of the main requirements, the General Design Criterion number 17 (“Electric power systems”), Regulatory Guide 1.9 (“Application and Testing of Safety-Related Diesel Generators in Nuclear Power Plants”), IEEE Std 387, Regulatory Guide 1.32 (“Criteria for power systems for Nuclear Power Plants”) and IEEE Std 308 have been applied. For Station Blackout (SBO), the contents of 10CFR50.63 (“Loss of all alternating current power”) and of Regulatory Guide 1.155 (“Station Blackout”) were applied.

The national report does not indicate the requirements for Trillo NPP of KWU (Germany) design nevertheless the country explained, that besides legal requirements of the country the standards and codes (KTA) of origin country are applied.

3.1.2 Main requirement applied to this specific area

The national report and additional explanations indicate some specific requirements applied in design bases of particular systems:

- The specific requirements due to impact of wind and ice-coating for off-site grid;
- At least two independent connections of plant to main grid;
- LOOP is already included in design basis of NPP;
- SBO is addressed in design as special case (except Trillo NPP);
- Safety internal NPP electrical distribution: 2 x 100% redundancy (4 x 50% in Trillo), Class 1E, Seismically qualified;
- At least 7 days (except Trillo, applicable KTA standards requires 72 hours) of autonomous operation is required for emergency diesel generators (DGs) in NPPs;
- At least for 30 days ensured possibility for heat removal.

3.1.3 Technical background for requirement, safety assessment and regulatory oversight

Spain uses deterministic as well as probabilistic analysis to assess safety of NPPs and both of them were used performing “stress tests”.

3.1.4 Periodic safety reviews

During periodic safety review (PSR) the issues linked to LOOP, SBO and loss of UHS features are analysed in the light of changes of safety requirements, ageing and new information on safety analysis, including re-analysis of site specific conditions. For example hardware modifications as an implementation of results of PSR have already been implemented in the area of improvement of train isolation, electrical protection of DC systems, improvements in offsite power supply incoming circuits, protection against lightning and installation of additional flow cooling water measurements for all cooled systems. Results and measures for improvement taken after PSR are plant specific. The measures have been established as conditions for licence renewal.

3.1.5 Compliance of plants with current requirements

The loss of off-site power is design basis event for all Spanish nuclear power plants. The additional loss of the safeguards DGs (SBO with loss of the ordinary back-up AC power sources) is also an event contemplated in the design basis of the five Spanish nuclear power plants of USA companies design,

since it was included as an extension of the initial design basis during the process of compliance with the regulations on Station Blackout (SBO). The SBO for Trillo NPP (Germany KWU) was addressed within the general framework of requirements to reduce the vulnerability of the plants to severe accidents, nevertheless the modifications to increase robustness of the plant during SBO are foreseen. It was concluded that the Spanish NPPs are fully compliant with current requirements.

3.2 Assessment of robustness of plants

3.2.1 Approach used for safety margins assessment

The national report summarizes the results of the regulatory review of the licensee reports. It describes in general the design provisions for each NPP concerning off-site and on-site power supply and heat sink and after that gives more detailed analysis for each plant.

In the frame of “stress tests” utilities verified current capabilities to respond to the proposed events, to identify the time necessary to implement relevant measures and the autonomy of the equipment used to prevent a serious accident and unacceptable consequences for the population. Finally an assessment on the degree of robustness of the plants was done.

3.2.2 Main results on safety margins and cliff edge effects

• Power Supply features

Spain indicated many options to supply electric power for on-site demand:

- main grid (at least 2 external grid connections);
- possibility of NPP to operate in “house load” regime (for Trillo NPP only);
- dedicated power supply from neighbouring hydropower stations in case of need of recovery from a grid collapse (for all NPPs);
- redundant and qualified back-up DGs (so-called safeguard DGs in case of Trillo NPP, and emergency DGs in case of the remaining NPP);
- alternative emergency DGs (all NPPs except Garona NPP; separated from emergency DGs, for all NPPs diverse by cooling option – except Cofrentes, where all DGs are cooled by essential service water system;
- DC power from batteries.

There are two redundant electric systems (2x100%; 4x50% in Trillo) with back-up DGs on every NPP. These electric systems are safety Class 1E and seismically qualified.

The operator of the national electricity grid in accordance with procedure gives the priority to power NPPs to recover power after black out. Power supply from hydropower stations will be tested regularly.

• Heat sink features

Primary heat sink is provided by natural draught cooling towers (Trillo and Cofrentes NPPs), river (Santa María de Garoña NPP), river boosted by a natural draught tower (Ascó NPP), sea (Vandellós II) or water reservoir (Almaraz NPP). The heat sink for spent nuclear fuel storages (dry type) at José Cabrera NPP and Trillo NPP sites is the atmosphere.

Ultimate, or alternative, heat sink (UHS) is provided by ponds and cooling towers (Trillo, Vandellós II and Ascó NPPs), by spray ponds (Cofrentes and Almaraz NPPs) or by river (Santa María de Garoña NPP).

UHS guarantees 30 days cooling capabilities. UHS in all plants is safety category and seismically qualified, with two redundant cooling trains that deliver water from UHS to the heat exchangers needed to be cooled. UHS is protected from possible flooding by rivers or sea. Possible clogging of intake filters at Almaraz NPP and Garoña NPP is taken into account.

An additional alternative heat sink mentioned in the national report is the atmosphere by secondary bleed and feed (for Pressurised Water Reactor (PWR)), by Isolation Condenser (Santa María de Garoña NPP) or by containment venting before core degradation (for boiling water reactor (BWR)).

• Loss of power supply (LOOP)

LOOP is a design basis event for all NPPs of Spain. There is a possibility to supply power by stationary on-site back-up DGs (from 2 up to 4 DGs per unit, depending on site) for at least seven days, taking into account stock of fuel, lubricants and cooling capabilities. There is possibility to prolong operation time of DGs using additional diesel fuel stocks (from redundant tanks or boiler system) in Trillo, Cofrentes and Garoña NPPs. CSN confirms that availability of power supply in all NPPs is ensured for seven days. Priority is given to the restoration of off-site power. It should be stressed that the operator of the national electricity grid for the recovery of power in the event of a zero voltage condition in the grid, according to procedures gives priority to power nuclear power plants. In addition, the preferential restoration of external power supply from the nearby hydro power station is formalised in procedures. Periodical testing is being currently implemented.

- **Station Blackout (SBO)**

SBO with only loss of the ordinary back-up AC power sources is addressed in licensing basis of 5 NPPs of USA companies design. SBO in Trillo NPP case was addressed as beyond design event, as it was required in Germany.

- **SBO with loss of the ordinary back-up AC power sources.**

All NPPs except single Santa María de Garoña NPP have diverse DGs, which can be assumed as operating under defined conditions. These ensure maintenance of safety functions performance. It may be stressed that Santa María de Garoña NPP has one passive system for cooling the reactor.

Two NPPs have a single diverse DG for 2 units, rendering the management of the situation where both units are affected more difficult (alignment alternatively to one and then the other unit for Almaraz NPP, special connections to both units for Asco NPP).

Taking into account all available stocks all DGs dedicated for LOOP, SBO and loss of UHS has enough fuel, lubrication oil and cooling capability, at least 7 days of operation is guaranteed.

- **SBO with loss of permanently installed ordinary and diverse back-up AC power sources**

During total SBO only the batteries are available. The times for depletion of batteries are reported from 2 to 4 hours according to design. Based on evaluation, taking into account shedding, expected time of operation of batteries is from 16 to more than 24 hours. It could be concluded that all units have possibility to use DC power from batteries for a few hours with possibility to extend this time by implementation of procedural measures by disconnecting non-essential loads.

Various plant operational states (including the shutdown states) have been analyzed in the licensees' reports. Additional information regarding coping times was provided during peer review.

The possibilities to ensure cooling of reactor core were reported during peer review:

- PWR reactors of Westinghouse design: auxiliary feedwater + steam relief to atmosphere; primary depressurization; compensation of inventory of reactor coolant system by accumulators;
- Trillo NPP: emergency feedwater + steam relief to atmosphere; primary depressurization; compensation of inventory of reactor coolant system by accumulators;
- BWR-Cofrentes: operation of RCIC (or SRV-Fire Protection System) system + containment venting;
- BWR-Garoña: operation of Isolation Condenser; or HPCI (or SRV-Fire Protection System) systems + containment venting.

It should be stressed that by the dislatching of unnecessary DC loads, the consumption of DC power can be significantly reduced.

Moreover, the possibility of manual operation of turbine-driven pumps and relief valves without DC power to remove residual heat from reactor core has been analyzed in all the cases and already tested in some plants. For example, in Almaraz NPP the procedures for manual operation of turbine driven pumps and relief valves without DC are prepared, validated and tested, necessary portable equipment is available, staff is trained and the process of implementation is nearly finalized. Possibility to use manually operated means is available for all NPP, limited scope of additional instrumentation and control is maybe needed, nevertheless in some cases further analysis are ongoing to ensure that these dedicated manual actions can be performed in unfavourable working conditions.

There are various time constrains such as time to dry out of steam generators (depending on technology), to reactor core uncover, to vessel failure, to containment failure. The reported time to

beginning of core uncover if to assume most probable situation, is estimated from 31 to 42 hours, depending on NPP, not taking into account proposed additional measures for SBO (reactor coming from power operation). Coping times for SBO during outages, when reactor vessel is opened were not indicated in the national report. During peer review the coping times were reported for Trillo, Cofrentes and Garona NPPs. Time to core damage is from 1,5 hour to 11 hours.

- **Loss of Ultimate Heat Sink (UHS)**

The features to provide cooling, which are different depending on NPP technology, are analysed and described taking into account possible operational conditions.

If loss of primary heat sink is assumed, all NPPs are provided with cooling water by the UHS through redundant and qualified service water systems, which assures maintenance of cooling at least for 30 days. In the particular case of Garoña NPP, primary and ultimate heat sinks are based on the same river. If both primary and ultimate UHS are lost the possibilities to maintain cooling of reactor core were reported during peer review:

- PWR reactors of Westinghouse design: auxiliary feedwater + steam relief to atmosphere; primary depressurization; compensation of inventory of reactor coolant system by accumulators and Hydrostatic Pressure Pump;
- Trillo NPP: emergency feedwater + steam relief to atmosphere; primary depressurization; compensation of inventory of reactor coolant system by accumulators and extra-borating system;
- BWR-Cofrentes: operation of HPCS, RCIC (or SRV-Fire Protection System) systems + containment venting;
- BWR-Garoña: operation of Isolation Condenser; or HPCI (or SRV-Fire Protection System) systems + containment venting.

The analysis of availability of water stocks on site is provided and possibility to use non borated water for cooling was analyzed as well. In some cases exhaustion of available water stock is mentioned as cliff-edge. The national report indicates critical times for each NPP, such as provision of water from accumulators, which are depended on technology and operational regime. Measures to increase safety capabilities are discussed as well.

- **Loss of UHS & SBO**

The comprehensive analysis on combination of loss of UHS and SBO was performed. Various operational regimes were taken into account. It was concluded that consequences of such combined event are generally similar to the case of SBO with loss of permanently installed ordinary and diverse back-up AC power sources. Measures to increase safety capabilities were presented during peer review.

In relation to the use of the isolation condenser (IC) system in the Garoña plant, in the light of the failure / possible mistakes / design features of Fukushima, the NPP and also the regulatory authority has performed a specific detailed review. The IC failure occurred in Fukushima after the external flood, is not applicable to Garoña. According to the studies and evaluations performed (in Topic 1), the batteries and the DC buses would not be affected by the floods to be considered in the site. Additionally, foreseen actions to increase plant robustness will facilitate the recovery from hypothetical system isolation.

- **Cooling of Spent Nuclear Fuel Pools**

The national report analyses spent nuclear fuel pools (SFP) cooling issues for all NPPs. The analysis is provided separately in the parts of the national report coping with accident management. The cooling possibilities and times to cope with loss of cooling are determined. Each NPP has redundant possibilities to cool SFP under design basis conditions. The possibilities to cool SFP under beyond design basis conditions are comprehensively analysed within accident management procedures. The means of cooling of SFP are very different in NPPs as they are of different design. The means encompass systems, particularly devoted for cooling of SFP, other water supply systems, possible water stocks, fire protection systems. Times until boiling depends on the plant and operational mode and varies from 3,45 hours to 10 hours when the full core is moved to the SFP, or from 12 up to 23 hours for more frequent cases, e.g. just after refuelling outage . The times until uncover of fuel varies

from 37 up to 96 hours or from 100 up to 288 hours respectively taking into consideration the same conditions mentioned above.

For all NPPs the analysis are available to prove usage of non-borated water will not cause criticality issues.

3.2.3 Strong safety features and areas for safety improvement identified in the process

The strong features to ensure power supply for on-site demand and cooling capability in Spanish NPPs can be mentioned:

- organisational measures to restore power supply to NPP with priority to them;
- organisational and technical measures to restore power supply directly from hydropower stations;
- possibility to use turbine-driven pumps and atmospheric discharge valves to cool reactor core and possibility to operate such equipment manually (without any AC/DC power);
- in many cases – diverse ultimate heat sink capabilities;
- usage of risk-informed applications such as the “Maintenance Rule” or the “Risk Monitor” for maintenance activities management.

The operators and Regulatory authority identified areas for improvement. Measures to address them are listed in section 3.2.5.

3.2.4 Possible measures to increase robustness

Utilities proposed various additional measures to improve the robustness of the plants in scenarios linked to loss of power with the priority objective of providing complete autonomy to address SBO type events for at least 24 hours with the equipment existing at the site, and 72 hours with only light equipment provided from off site. Measures are proposed to reinforce on-site electricity supply by means of autonomous equipment, to improve the capability to recover off-site electricity supply from nearby hydroelectric stations, to extend the battery depletion time and to address complete loss of batteries. The robustness of the current plants is planned to be enhanced by measures, specified in Section 3.2.5 below.

3.2.5 Measures already decided or implemented by operators and/or required for follow-up by regulators

The following proposals for improvement are applicable to all the installations:

- Improvement of protocols for dedicated electrical supply from hydroelectric stations located in the vicinity of the site and performance of periodic tests in this respect;
- Availability on site of autonomous electricity generating groups;
- Analysis, and where appropriate testing of the capacity to provide water feed for the primary/secondary via the turbine-driven pumps (if included in the design of the plant), even in the event of unavailability of direct current for their control;
- Availability on site of autonomous motor-driven pumps for the injection of water to the primary and/or secondary and be able to perform water or fuel make-up in critical tanks, to delay cliff edge effects and to give more time for restoration of power supply;
- Additional portable instrumentation for performance of the manual control manoeuvres required in the event of complete loss of the batteries;
- Improvements to the communications systems (on-site and off-site) to address situations implying loss of the corresponding electrical feed systems;
- Improvements to the lighting systems to address prolonged loss of electrical supply events;
- Design modifications required to make available connection points for autonomous electrical and mechanical equipment;
- Preparation of relevant procedures and training of personnel according to these procedures.

The CSN considers the analyses performed by the licensees and the improvement measures proposed to be basically adequate.

As regards those accidents that might be initiated in the plant shutdown situation, the CSN evaluation has identified the need to generally analyse an additional potential improvement to address situations in which a complete loss of power might occur during the shutdown conditions. In this respect, the utilities are required to analyse the capacity to recover containment integrity in those cases.

Concerning loss of ultimate heat sink the analyses performed by the utilities conclude that these scenarios are bound by the complete loss of alternating current supply (on and off site), for which reason the improvement proposals are the same as those indicated for this event. The CSN evaluation considers this conclusion to be acceptable.

The utilities have proposed measures for improvement of capabilities to cope with cooling of spent nuclear fuel pools. These measures are various and NPPs dependant. Typically measures for improvement of relevant instrumentation and control as well as for water injection capabilities are proposed. In every case evaluation of regulatory authority is given.

3.3 Peer review conclusions and recommendations specific to this area

The national report indicates that comprehensive complementary safety analysis has been done by the utilities for all NPPs. Measures are proposed to increase safety capabilities in case of LOOP, SBO and loss of UHS, without any external support, and have been assessed (mainly analytically) by the regulatory authority.

As a reaction to the Fukushima event, the utilities and Regulatory authority also carried out inspections on all structures, systems and components relevant to LOOP, SBO and loss of UHS. As a result of these inspections, analysis and working meetings measures to improve safety of the plants in respective areas is now planned and prioritized.

Some measures (for example, linked to manual operation of steam driven pumps and relief valves for heat removal without DC power), were decided to be applied. The possibility of manual operation of turbine-driven pumps and relief valves without DC power to remove residual heat from reactor core have been analyzed in all the cases and already tested in some plants.

The CSN has included, in the order issued in March 2012, the main licensee provisions, complementary aspects and additional requirements.

The peer review team considers that the planned actions, in some cases already implemented or in the process of being incorporated, are in accordance with ENSREG specifications, and welcomes the exchange of information among Spanish NPPs.

The peer review team appreciates that some NPPs have already implemented some of their proposed measures (e.g. portable emergency equipment in the control room for communications or lighting in an SBO) and suggests CSN to follow up this topic with the remaining NPPs.

The Regulatory authority, and also the NPPs, should complete the implementation plan of improvement measures as well as consider the conclusions and significant international recommendations regarding to Fukushima event.

4 PLANT(S) ASSESSMENT RELATIVE TO SEVERE ACCIDENT MANAGEMENT

4.1 Description of present situation of plants in Country

4.1.1 Regulatory basis for safety assessment and regulatory oversight

Following the US regulatory practice, severe accident management was not included in the licensing bases of the Spanish NPP. In the late nineties CSN started to consider this issue in PSR. As a result, SAM was included in subsequent plant licence renewals, with requirements for SAMGs based on the results of PSAs and on the generic guidelines prepared by the design vendors. Additional requirements for training of the personnel and exercising accident management guidelines were also established at that time.

Recently, new directives have been sent by CSN to each NPP, associated to the latest PSRs, with the objective of reinforcing the compliance of the Spanish plants with the WENRA AM reference levels.

These directives include requirements for hydrogen control, containment filtered venting, and containment flooding strategies.

CSN has also drafted a comprehensive set of requirements for AM with the aim of anchoring AM within the legal framework on nuclear safety in Spain. These will be published as a CSN Instruction entitled “Emergency Operating Procedures and Severe Accident Management” and will, among other requirements, include the relevant WENRA RLs. The process for issuing this CSN Instruction will start in May 2012 and is expected to be finished at the end of the year or the first quarter 2013.

4.1.2 Main requirements applied to this specific area

As already outlined, elements of AM are covered by the Spanish regulations on training and procedures. In addition, further regulatory requirements related to AM are included in the following:

- Conditions and Complementary Technical Instructions (ITC) associated to the Authorization renovations: for procedural and analysis of SAM issues
- CSN Instruction IS-11 (“Licenses to Operators in Nuclear Power Plants”) and IS-12 (“Requirements regarding the qualification and training of site and external non-licensed personnel in the area of nuclear power plants”): for training
- CSN Safety Guide 1.9 (“Emergency Drills and Exercises in NPP”): for exercises and drills

4.1.3 Technical background for requirement, safety assessment and regulatory oversight

CSN notes:

- the verification of the design and licensing bases is subject to a continuous supervision and control programme by the regulator and authorizations for continued operation every ten years related to PSRs; and
- (concerning AM) CSN’s verifications reveal the existence of good margins that ensure that the safety conditions of the plants are maintained beyond the cases contemplated in the plant designs.

As a result of the most relevant aspects identified in probabilistic safety assessment (PSA) in Spain, the licensees have been introducing design modifications and procedures and maintenance practices improvements which have entailed a significant strengthening of the plants’ capabilities to respond to transients and accidents. With regard to the stress tests, the PSA at full power was used for topics 1 and 2, e.g. to sift through credible extreme events.

4.1.4 Periodic safety reviews (regularly and/or recently reviewed)

As mentioned before the Spanish PSR are conducted according to the CSN Safety Guide “Periodic Safety Reviews of the Nuclear Power Plants” GS 1.10. The review of issues concerning Accident Management has been included in the topics covered by chapter 4.7 of this guide. They typically cover, among other aspects, EOP and (although not explicitly mentioned in the GS 1.10) Severe Accident Management Guidelines (SAMG) programs. During the evaluation of CSN to PSR, for granting the Authorizations, several conditions have been imposed in relation with AM, e.g. the requirement (released in June 2010) for analysing the possibility of backfitting the Almaraz NPP with passive autocatalytic re-combiners (PARs) for hydrogen control in the containment. The review team would recommend to address AM more directly in the Safety Guide on the content of the PSR.

In connection with a PSR, the licensee is required to submit a PSA for Levels 1 and 2 for power and shutdown operation. The scope of the Level 1 PSA includes so-called on-site events, internal fires and internal flooding for full-power operation, and on-site events for low-power and shutdown operation. The predicted core damage frequencies (reflecting this scope) range from 4.29E-6 (Cofrentes) to 5.07E-5 (Vandellós) per year. The scope of the Level 2 PSA includes on-site events (except for Garoña, which includes internal flooding as well) during full-power operation. The predicted major early release frequencies (reflecting this scope) range from 4.9E-8 (Garona) to 3.3E-7 (Ásco) per year.

4.1.5 Compliance of plants with current requirements (national requirements, WENRA Reference Levels)

A comprehensive set of requirements for AM, anchored with the legal framework on nuclear safety, does not yet exist in Spain, though the process for achieving this is well in hand, including the issuing of the CTI mentioned above just before the country visit. In addition, relevant requirements for elements of AM, namely for training and procedures, were already addressed in the regulations prior to the Fukushima accident.

Once the new CSN Instruction mentioned in chapter 4.1.1 is published., Spanish regulatory requirements will fully include accident management aspects of the WRL.

4.2 Assessment of robustness of plants

4.2.1 Adequacy of present organizations, operational and design provisions

4.2.1.1 Organization and arrangements of the licensee to manage accidents

Aspects concerning this subject are addressed in the national report under the heading of Planning for accident management. This planning is intended to work in accordance with the On-Site Emergency Response Plans (ERP). Plant-specific aspects, e.g. concerning the routes of access to the site, are presented as well.

The common proposals (serving improvements), identified by the licensees, include:

- the setting-up of a working group bringing together all the plants to analyse the human resources required to reinforce their emergency organisations (this analysis will take into account, among other things: accessibility, human resources, times available),
- the setting-up of new on-site Alternative Emergency Management Centres (AEMC) at each plant,
- the setting-up of an Emergency Support Centre (ESC), common to all the plants, with back-up equipment located at a Centralised Store and available to be deployed and operated by an Intervention Unit ready to act at the sites in 24 hours,
- the review of existing mutual assistance procedures for emergency situations, in order to bring them into line with the new needs for support and the exchange of human and material resources, and
- analyses with a view to improving the availability of the communications systems in the scenarios postulated in the present stress tests.

Furthermore, plant-specific proposals are made, e.g. an additional shift auxiliary operator (Ascó, Vandellós II).

CSN assesses the proposals as positive and additionally requires:

- the consideration of simultaneous accidents in both units of one site,
- detailed analyses of the feasibility of carrying out local actions,
- a review of the feasibility of assigning more than one function to be performed, probably simultaneously, to a specific job post in the emergency response organisation ,
- the submission to the CSN for its approval, of a report containing the improvement plans, including those for strengthening emergency response organisations, and
- a detailed specification indicating the available resources, the management of these resources and of the ESC etc.

Furthermore, based on internationally accepted standards, CSN has recently established a single national approach concerning reference dose levels for the personnel intervening in an emergency. This is based both on the national regulations for emergency and for radiation protection as well as on relevant international standards (IAEA) and recommendations (ICRP). Plant-specific requirements have also been made by CSN, e.g. an analysis that should include the times during which the access routes could remain unusable following an earthquake or flooding, and the compensatory measures foreseen during this period (Cofrentes, Garoña, Trillo and Ascó).

With regard to routine exercises and inspections of the AM organization, CSN explained during the peer review that, according to its Safety Guides 1.3 (“On-Site Emergency Response Plan in NPP”) and

1.9 (“Emergency Drills and Exercises in NPP”), the SAMGs should be exercised at least once per year, and the licensee reports from these exercises checked by CSN inspectors.

The review team considers that the proposals, especially the setting-up of a working group to analyse important factors like human resources and times available, will serve to increase the robustness of the plants to control or mitigate severe accidents. In particular, the regular training and inspection of SAMGs reflects good practice. The peer review team’s sample review of the CSN inspection documentation from SAMG exercises suggested a good standard is being achieved.

4.2.1.2 Procedures and guidelines for accident management

Procedural and guidance documentation for AM includes SAMG in the GE and Westinghouse NPPs, and the Operating Manual and AM Manual in the KWU NPP (Trillo). These guidance documents:

- were implemented in accordance with the practices of the country of origin, USA and Germany, respectively,
- are part of the Spanish regulatory system,
- are required through specific conditions or CTIs associated with renewals of the operating licence and, regarding training, established in CSN Instruction IS-12 (“Requirements regarding the qualification and training of site and external non-licensed personnel in the area of nuclear power plants”), and
- are currently addressed, with respect to the development and maintenance, within the scope of the systematic supervision processes of the CSN.

Concerning areas of improvement, the Trillo licensee plans the development of symptom-based SAMG for mitigation of the consequences of severe accidents and maintenance of containment integrity. This is because the approach in its Accident Manual is focussed on prevention and needs to be enhanced to consider means of accident mitigation. In addition, CSN requires that shutdown operating conditions should be integrated in this development project.

In the context of the existing SAMG in the GE and Westinghouse NPPs, CSN requires the licensees to complete their analyses of the management of the severe accidents that occur from shutdown operating conditions. During the peer review CSN clarified that there is not currently a requirement from CSN to develop the SAMG for shutdown states and AM procedures for the mitigation of SFP accidents, but it is going to be requested of the licensees. The shutdown PSA Level 2 is ongoing (e.g. to include low power and shutdown states) and will be available in the medium term (2013-2014), after which the scope of the SAMGs will be expanded.

The review team assesses it as positive that the existing AM procedures and guidelines were implemented in accordance with the practices of the country of origin (and in consultation with the relevant Owners Groups) and that their development and maintenance is currently included within the scope of the systematic supervision process by CSN. Nevertheless, the improvements for shutdown states and SFP (see below) identified are considered necessary – CSN’s intent to introduce expanded SAMGs once the appropriate analyses are completed is strongly supported.

4.2.1.3 Hardware provisions for severe accident management

Hardware provisions in place for severe accident management include:

- passive autocatalytic re-combiners (PARs) in the Trillo NPP and
- dedicated containment venting systems in the BWR NPPs.
- flanges and connections for mobile pumps to inject into the vessel, spent fuel pool and containment (Cofrentes),
- various provisions for AM measures including secondary Bleed & Feed (Trillo), the alignment of an alternative diesel generator (DG-3) to serve both units (Ascó), the alignment of auxiliary feedwater with suction for the other water sources (Westinghouse PWR)
- options (including via the relief valve of a steam generator) for the depressurization of the reactor coolant system (RCS).

The list of improvements, based on the proposals by the licensees and the evaluation of CSN, includes:

- Installing diverse systems for injecting water into the reactor vessel (high and/or low pressure), the steam generators or the containment building.
- Installing passive autocatalytic re-combiners (PARs) at those plants that do not have them yet.
- Installing a filtered venting system in the containment building, with the exception of one licensee, which requests the opportunity to analyse this in more depth.
- Applying additional measures to know, in the event of a total loss of direct current, the essential parameters that are required in severe accident strategies.
- Applying measures to prevent core damage sequences with high pressure in the reactor.
- Applying measures to boost the ability to implement containment flooding strategies.
- Reinforcement of the electrical power supply to the Main Control Room ventilation system.

Furthermore, various plant-specific proposals are made, e.g. the development of primary feed and bleed (Trillo), or the analysis of reactor cavity flooding strategy (Ascó and Vandellós II).

The envisaged improvements address important issues including the prevention of high-pressure core melt, containment base-mat melt-through, containment failure due to over-pressure and hydrogen explosion. The review team shares CSN's position that the envisaged improvements are appropriate and that they will strengthen the plants' ability to face up to severe accidents and to mitigate their consequences.

Two Westinghouse NPPs seem to have inconsistent positions concerning the injection of non-borated into the RCS. While the Almaraz NPP will establish a precaution in its procedures in order to ensure that only borated water is supplied to the RCS, the Ascó plant considers it to be preferable to inject water, even if it does not contain boric acid, than not to inject. CSN considers this aspect to be an open issue that deserves further analysis. More generally, CSN is going to require the Spanish NPP to consider the issue of water quality and chemistry, when defining strategies for RCS and containment injection.

4.2.1.4 Accident management for events in the spent fuel pools

This section addresses the SFPs of the operating plants and very briefly the dry fuel storage (12 Holtec International HI-STORM 100Z-type casks) of the NPP (José Cabrera) in the dismantling phase.

In case of accidents involving loss of inventory and/or SFP cooling, the licensees identify the resources available, normal and alternative, for cooling of and the supply of water to the SFP.

Depending on the plant, several backup methods to add coolant to the SFP are provided and included in the procedures. Pipes or external lines extending into the pool are equipped with siphon breakers or check valves to prevent drainage.

The licensees analyzed the times available prior to boiling and before different levels of water are reached (to uncovering of the fuel assemblies) in the event of total loss of cooling and for different thermal loads in the SFP. The problem of possible re-criticality of the fuel, if the pools contain borated water and replenishment had to be performed using non-borated water, has also been analyzed.

As regards loss of SFP cooling accidents, the licensees have calculated the dose rates at the edge of the pool on the basis of the level of water above the fuel assemblies in order to identify the loss of shielding capacity and its repercussion on accessibility for the performance of recovery actions.

The licensees plan to develop specific procedures that, depending on the data provided by the SFP instrumentation (level, temperature, area radiation), allow to take preventive measures that will assure later cooling or water replenishment (i.e. valves opening, fire-fighting hoses deployment, etc).

Generally speaking, CSN will request:

- the radiological protection aspects - to be considered in the local manual actions foreseen in the event of loss of pool cooling accidents - should be incorporated in written procedures; and
- the conditions that would compromise the performance of manual interventions (water level or time) should be identified and specific actuations should be contemplated to reduce doses in the local manual actions foreseen.

As regards the phenomena associated with the processes of degradation of the fuel in the pools following its being uncovered, the licensees point out that they will participate in the activities and analyses to be performed by EPRI in relation to this issue. EPRI's programme extends to 2014 and

aims to gain in-depth insight into the phenomena and the possible releases that would occur following this event. CSN considers it adequate not to establish any additional improvement in relation to this issue at this time, since it would be advisable first to progress the analysis of these phenomena. CSN however suggests that to address accidents involving prolonged loss of the ultimate heat sink and of electricity supply, the SFP temperature, level and area radiation instrumentation should have an adequate range (in the case of level, to the bottom of the SFP), should be seismically classed (and should have an indication available in the control room. Furthermore, there should be portable instrumentation available for the case of loss of all power sources.

CSN assesses that the licensees' proposals generally meet its current requirements but that they will later need to verify the details at implementation. The licensees propose to provide their plants with portable equipment to replace the inventory of water in the pool, along with the portable instrumentation required for adequate control of these manoeuvres. Some licensees also mention that they are studying the possibility of incorporating resources to allow for spraying of the spent fuel assemblies if they were to become uncovered.

Given accidental blockage of passive cooling of the José Cabrera dry fuel storage, it would take at least 5 days until a limit situation concerning temperature and pressure would occur. The proposals of the licensee include the development of procedures for returning the affected casks to the vertical position if they are turned over.

The review team assesses it as positive that SFP cooling problems are addressed so far by existing AM measures and that further improvements are proposed in this area. CSN stated that in some of the future strategies that are going to be implemented by operators, local actions could be needed (for instance, connection to hoses). A detailed characterization of the future strategies is not yet available but, local actions and the accessibility/habitability issues (due to radiological and other limitations) will be taken into account in their design.

The licensees describe that specific analysis will be / were carried out in relation to accumulation of hydrogen in other buildings outside the containment area. CSN specifies that this analysis will have to consider in detail possible escape routes for hydrogen and the dynamics of propagation in different rooms of the buildings adjoining the containment area. These analyses have been required taking into account the hydrogen generated inside containment as a result of core degradation in the in-vessel and ex-vessel phases. Regarding the possible hydrogen generation from the SFP, this is one of the issues included in the SFP degradation phenomena that will be studied in the programme of activities that are being carried out by EPRI (the Spanish licensees are committed in their reports to closely follow this project); potential hydrogen generation and its consequences should be included in this project and in the NPPs application of its results.

For Santa Maria de Garoña NPP the possibility of hydrogen explosion in the containment is ruled out because of nitrogen inertization. Usually this condition is not valid during refuelling outages, so specific analyses with respect to refuelling outages might be appropriate. This issue will be analyzed in the shutdown severe accident management analysis required by the CSN.

The existing procedural guidance related to SFP accidents is limited, by the moment, to preventive strategies. Further procedural guidance for mitigation of consequences during fuel degradation is part of the currently ongoing EPRI project. The Spanish licensees are committed in their reports to closely follow this project. In parallel, CSN will follow the international efforts in this field.

Overall, the review team supports the proposals for better developed arrangements for addressing severe accidents in SFP. However, in view of the spent fuel from decades of operation present in the pools of some of the plants, CSN's current strategy of focussing only on preventive AM measures (i.e. to keep the fuel submerged), and postponing any decision on mitigating AM measures (e.g. installing measures and providing SAMGs for addressing hydrogen production) pending the outcome of EPRI's project analysing these matters, is considered by the review team to have the potential to lead to unnecessary delays.

4.2.1.5 Evaluation of factors that may impede accident management and capability to severe accident management in multiple units case

The factors that may impede AM addressed in the national report include:

- radiation at various places of work (control room, technical support centre, vicinity of SFP),

- degraded access to the site in case of accidents initiated by external events,
- loss of DC power after battery depletion,
- accumulation of hydrogen in and outside the containment, and
- seismic impacts (e.g. in the context of the containment venting system of the BWR plants).

Related analysis results are presented, e.g. need to evacuate the emergency support centres, and proposals for improvement are derived, e.g. to construct alternative emergency management centres. Another example is the proposal to improve the seismic resistance of the diesel-engine pump providing make-up to the steam generators (identified for Trillo).

Concerning a potential unavailability of the Technical Support Centre (TSC), CSN explained during the peer review that the AEMC proposed for each plant (see Section 4.2.1.1) would have several functions, one of them to be redundant to TSC.

The issues addressed associated with accidents simultaneously affecting multiple units per site include:

- the need to extend the analysis of the emergency organisation and resources to address accidents affecting multiple units (requirement by CSN);
- the feasibility of aligning one DG to support two units (analyses by the Almaraz and Ascó licensees).

The review team considers this subject is adequately addressed in national report within the scope of the stress tests. A comprehensive assessment of impeding factors is usually made in the PSA. However, the PSA studies in Spain do not include the full scope of external events. In this context, the national report states that assessments of other external events (via the IPEEE process) have been carried out. However, these assessments do not cover degradations (induced by the external impact) of the equipment required for AM.

Furthermore, CSN has requested analyses to address the issue of whether there is sufficient time available to restore containment integrity in the case of an accident during shutdown states when the containment hatch is open. For total and extended SBO situations, the analysis of this issue has been required to Spanish Operators (finalization: 31/12/2013). Additionally, in application of the “Generic Guide for Shutdown Safety”(reference UNESA CEN-30, March 2011; developed as a result of the efforts of a Task Group with the participation of the Spanish utilities (UNESA) and the CSN), NPPs have to guarantee the closure time of the containment in order to avoid potential fission product releases. This Guide has been accepted by CSN as a generic guideline to manage shutdown safety in Spanish NPPs, and provides the basis for the development of the plant-specific guidelines (acceptance letter from CSN to UNESA: 25th April 2011; implementation plan for the NPPs specific guidelines: refuelling outages in 2011 and 2012).

4.2.2 Margins, cliff edge effects and areas for improvements

Concerning margins and cliff edge effects, the positions set out in Sections 1.4 and 4.1.5 apply. Potential areas for improvements are addressed in Sections 4.1.4, 4.2.1 and 4.2.3. Current plant features of Spanish NPPs assessed as important by the review team are highlighted below.

4.2.2.1 Strong points, good practices

- Permanent connection allowing alternate SFP makeup without entering the SFP area (Trillo).
- Possibility, given the success of operator actions including the disconnection of unnecessary loads, of >24 h core cooling via steam-driven pump operation in total SBO scenarios (GE and Westinghouse NPPs).
- The planned setting-up of a working group bringing together all the plants to analyse the human resources required to reinforce their emergency organisations (this analysis will take into account, among others: accessibility, human resources, times available).
- Generic SAMGs are verified and validated by supporting calculation, analysis and exercises.
- Proposals for a national ESC with “plug and play” equipment designed to be used at any Spanish NPP.

- The plans for improvements include the confinement and treatment of large liquid wastes resulting from severe AM.
- Provision for containment cooling from the outside by the annulus building ventilation (Trillo).

4.2.2.2 *Weak points, deficiencies (areas for improvements)*

- No filtered containment venting system.
- No SAMG in Trillo.
- No passive autocatalytic hydrogen re-combiners (GE NPP Cofrentes and Westinghouse NPPs)
- CSN's safety guide on the content of periodic safety reviews does not explicitly include accident management as a topic.
- External events are currently out of the scope of the PSA.
- No commitment at present for SAMGs for hydrogen mitigation in SFP accidents

4.2.3 Possible measures to increase robustness

4.2.3.1 *Upgrading of the plants since the original design*

This subject is addressed in Sections 1.5, 4.2.1 (4.2.1.2 for AM organization and planning, 4.2.1.2 for procedures and guidelines for AM, 4.2.1.3 for hardware provisions for AM, 4.2.1.4 for AM for events in the SFP).

The AM-related improvements implemented after start of power operation and before the Fukushima accident include:

- SAMG (GE and Westinghouse NPPs) and AM Manual (Trillo);
- third power supply train (Trillo);
- passive autocatalytic hydrogen re-combiners (Trillo);
- control valve to improve the option for remote manual control of IC operation (Santa María de Garoña); this valve is DC powered;
- dedicated system for containment venting in the BWR plants (no dedicated system in the Westinghouse plants).

4.2.3.2 *Ongoing upgrading programmes in the area of accident management*

Details on this subject concerning are not explicitly presented in the national report. Examples of currently ongoing improvements are however listed in the preceding sections.

4.2.4 New initiatives from operators and others, and requirements or follow up actions from Regulatory Authorities: modifications, further studies, decisions regarding operation of plants

4.2.4.1 *Upgrading programmes initiated/accelerated after Fukushima*

24 inspections (4 at each of the 6 nuclear power plants in operation) were carried out by CSN addressing earthquakes (determination of seismic margins), potential on-site flooding caused by earthquakes, events involving a SBO, events involving the loss of the heat sink, severe accidents in the reactor, and accidents in the SFP. CSN has already sent each licensee a Complementary Technical Instruction that will collect the conclusions that have been drawn from this process.

The related proposals for requirements on AM-related improvements are presented above (Sections 4.2.1.1 to 4.2.1.4). In summary, they concern:

- additional AM measures (portable pumps and DGs, capability to perform local manual actions of critical AM systems and/or components included in procedures, alternative supply to critical AM instrumentation, filtered containment venting, passive hydrogen re-combiners, etc.),
- organisational and logistic aspects (e.g. setting-up a new on-site Alternative Emergency Centre in each NPP and creating an emergency response centre common to all NPPs),

- additional procedural guidance (for the management of severe accidents initiated during shutdown operation, for manual operation of equipment in cases of loss of d.c., etc.),
- additional analysis (e.g. on the leak-tightness capacity of the containment isolation valves, on the potential effects of containment flooding strategies on the ESC important for AM, on the effects of severe accident conditions in containment on the critical AM instrumentation and on organisational issues in accidents with both units affected per site), and
- habitability and accessibility (e.g. power supply system in the emergency control room filter units).
- Reference dose levels for the personnel intervening in an emergency: CSN has recently established comprehensive, consistent and homogeneous reference levels for all onsite intervening personnel during an emergency. These criteria are consistent with reference levels defined for off site intervening personnel..

A plan to implement them has been elaborated by CSN (see Section 1.5).

4.2.4.2 *Further studies envisaged*

The implementation of the improvements identified from the EU stress test is scheduled as already outlined in Section 1.5; e.g.:

- the analyses tracking and control of doses to the workers and of radioactive emissions will be completed jointly by all the plants and are expected to be finished by June 2012
- Research by EPRI into AM strategies in SFPs
- completion of the construction or the modification of the existing structures is scheduled for the long term (2015-2016)

4.2.4.3 *Decisions regarding future operation of plants*

As noted above PSRs are conducted every ten years prior to the renewal of the operating licence. The stress tests have not given rise to any issues that draw into question CSN's previous decisions to recommend renewing these licences at the previous PSRs.

4.3 Peer review conclusions and recommendations specific to this area

The review team assesses that the proposals for improvements made by the licensees and CSN indicate a high level of both expertise in the field of AM and awareness with regard to beyond-design accidents.

Existing design features combined with existing AM measures reveal the existence of time margins for the control or mitigation of severe accidents in Spanish NPPs. However, the assumptions underlying these margins (e.g. 30 to 40 h until the core uncovers in a total SBO scenario) may deserve verification (see Section 1.4). In particular, the values quoted to the review team seemed low for one plant (Trillo) and long for another (Almaraz); these values suggest an inconsistent approach to the analyses. It is recommended that these possible inconsistencies be understood in order to ensure an appropriately robust approach is taken at all plants (while taking into account the differences among technologies). In particular, a good understanding of the assumptions that have been made with regard to these values (e.g. what loads need to be disconnected to extend battery lives, what manual operations are needed for ensuring AM measures are successful, when supplies of consumables need to be refreshed etc) is an essential input to, for example, human factors analysis of AM tasks.

The review team considers that the improvements identified by the licensees and CSN will all be important in increasing the robustness of the plants. In support of these, the following recommendations made by the peer review team, should be considered:

- complete the establishment of a comprehensive set of requirements for accident management integrated within the Spanish legal framework, as initiated so far by the work on the instructions on emergency operating procedures and severe accident management;
- include accident management as an explicit topic in CSN's safety guide on the content of the periodic safety review;

- develop severe accident management guidance (SAMGs) for accidents initiated during shutdown operation and accelerate plans to include SAMGs addressing mitigating aspects for spent fuel pools;
- fully include external events in probabilistic safety assessments including assessments of reliability of accident management under such conditions

In addition to these points the reviewers would like to encourage CSN, in view of its extensive expertise, competence and experience in this topic, to take a more prominent role in the ongoing international discussions aimed at developing good practice in severe accident management. In addition to the more obvious benefits, such participation will ensure that safety related improvements are made earlier on Spanish NPPs than might otherwise be the case.

Acronyms

AEMC	Alternative Emergency Management Centre
AM	Accident Management
ATI	Individual Temporary Repository (Almacenamiento Temporal Individualizado)
BWR	Boiling Water Reactor
CSN	Nuclear Safety Council (Consejo de Seguridad Nuclear)
CTI	Complementary Technical Information
DBE	Design Base Earthquake
DBF	Design Base Flood
DG	Diesel Generator
ENSREG	European Nuclear Safety Regulators Group
EOP	Emergency Operation Procedures
EPRI	(American) Electric Power Research Institute
ERP	Emergency Response Plans
ESC	Emergency Support Centre
EU	European Union
HCLPF	High capacity Low probability of Failure (Seismic Margin)
HPCI	High Pressure Core Injection System (ECCS subsystem; GE design)
IC	Isolation Condenser
ICRP	International Commission on Radiological Protection
IAEA	International Atomic Energy Agency
IPEEE	Individual Plant Examinations for External Events
LOCA	Loss of Coolant Accident
LOOP	Loss Of Off-site Power
NPP	Nuclear Power Plant
OTS	Operational Technical Specification
PAR	Passive Autocatalytic Re-combiners
PGA	Peak Ground Acceleration
PSA	Probabilistic Safety Analysis
PSR	Periodic Safety Review
PWR	Pressurized Water Reactor
RCIC	Reactor Core Isolation Cooling
RLE	Review Level Earthquake
SAMG	Severe Accident Management Guidelines
SBO	Station Blackout
SFP	Spent Fuel Pool
SHA	Seismic Hazard Analysis
SRV	Safety Relief Valve
SSCs	Systems, Structures and Components
TSC	Technical Support Centre
UHS	Ultimate Heat Sink
UNESA	Unidad Eléctrica (Spanish utilities association)
US-NRC	United States Nuclear Regulatory Commission
WANO	World Association of Nuclear Operators
WENRA	Western European Nuclear Regulator Association
ZPA	Zero Period Acceleration