ENSREG Stress Tests Peer Review - Follow-Up to Country Visit to Spain
Visit to Trillo NPP - 13th September 2012

Background

As part of the Action Plan following completion of the ENSREG Stress Tests Peer Review process, follow-up fact-finding site visits have been undertaken. One of these visits has been held at Spain's Trillo NPP. The main objectives of these fact-finding visits were to:

- Facilitate information exchange with respect to measures taken, planned or under consideration at the site level to improve safety as a result of the Stress Tests and Peer Reviews, focusing mainly on the three Stress Tests topical areas (natural hazards, loss of safety systems and severe accident management).
- Identify good practices and noteworthy successes, as well as lessons learned or difficulties encountered implementing these measures.
- Promote cooperation and confidence-building between European countries.

The Terms of Reference for the follow-up site visits are limited to site activities and do not include reviews of progress against other Stress Tests Recommendations and Suggestions.

Trillo NPP

Trillo NPP is a single, three-loop pressurised water reactor (PWR), designed and supplied by the German company Kraftwerk Union Aktiengesellschaft (KWU). The nominal thermal power level is 3027 MWt, corresponding to a reactor power of 3010 MWt. The reactor first reached criticality on May 14th 1988, and the current licence is valid till 2014.

The plant is equipped with a four-train Emergency Core Cooling System (ECCS) to cope with design basis accidents, composed of a medium-high pressure injection system (11 MPa), a passive system consisting of 6 low-medium pressure injection accumulators (2.5 MPa each with a volume of 35 m^3 of borated water), and a low pressure injection system. Each train has its own independent Safeguard diesel generator. The cooling of the Spent Fuel Pool (SFP) is carried out by the ECCS, which has three trains capable of performing this function, one being the dedicated train.

Another important safety system is the Emergency Feedwater System, which provides an independent capability to inject water into the steam generators from an alternative water source. It has four trains; each train is equipped with a diesel motor which drives an emergency generator, and a pump which takes water from a dedicated pool.

Electrical power is obtained from the following: the main 400kV grid, which remains available following a generator trip thanks to the opening of the "generation breaker"; the main generator, for in-house consumption ("island" mode of operation); and supplies from the 220kV back-up grid, which is used in the event of failure of the other two supply routes. In addition, there is a further electrical supply route provided for the Safeguard and Emergency networks from a third off-site grid (132kV). This 132kV grid independent from the 400kV and 220kV power supplies, and is capable of taking the plant to, and keeping it in, a safe condition.

Trillo's main heat sink is via the Circulating Water System, which is a closed system with two natural-draught cooling towers. After a reactor trip, residual heat is removed through the steam generators, which are part of a closed loop discharging into the condenser. The ultimate sink for removing the residual heat from the reactor core at shutdown, cooling the SFP and cooling the auxiliary systems is the Essential Service Water System, which is fed by two large water ponds and cooled by forced-draught cooling towers.

The Containment Building is of the so-called Large Dry Containment type, with an approximate free volume of $59000m^3$. The building is made up of a self-supported steel sphere surrounded by a reinforced concrete structure (the "Annulus"), forming a double containment. This last building houses several of the plant's safety systems. The foundation slab is made of reinforced concrete and has a cavity where the reactor vessel is housed. The SFP is located inside the Containment Building.

As a result of the Stress Tests, significant safety improvements have been identified for extreme scenarios and are planned to be implemented in the Short (2012), Medium (2013-2014) or Long Term (before the end of 2016).

Natural Hazards

The current seismic margin of the plant for safe shutdown equipment corresponds to a "High Confidence of Low Probability of Failure" (HCLPF) capacity value of 0.2g (the safe shutdown earthquake used for the design basis was 0.12g), associated with certain components of the Safeguard electrical feed network. Modifications are being implemented in the safe shutdown paths to increase the minimum capacity to 0.3g. Also, the containment integrity and the SFP integrity (including fuel racks and the liner), and its cooling systems, are being upgraded to 0.3g where necessary. Further, the seismic capacity of the following equipment, considered in the strategies to address Station Blackout (SBO) and the management of severe accidents, is being reviewed to check if it can also be substantiated to 0.3g: seismic Fire Protection System (FPS) equipment; the secondary Bleed and Feed (SBF) dedicated pump and its adjacent structure; Electrical Building Battery Room ventilation systems; Main Control Room filtering and pressurisation system, passive autocatalytic (H_2) re-combiners (PARs); and alternative equipment for SFP cooling.

In regard to indirect aspects of a seismic event, internal fire, explosions and flooding have been analysed and the need for additional verification on the credit given to non-seismic flooding detection instrumentation and barriers, particularly in the analysis of ruptures in the Annulus Building, has been identified.

Most aspects of the external flooding risk at Trillo can be disregarded due to the site's location and features. However, flooding from torrential rain has been re-analysed to take both meteorological data up to 2010 and recent standards into account. The site drainage network has three independent discharge points, with a capacity of more than 170% of the maximum assumed value of precipitation and consequently there should already be good overall margins in this regard. Nevertheless, improvements are being done in order to prevent the possibility of minor local flooding in specific areas *(implementation by end of 2012*).

The team underlines that:

- The goal of a (high) Peak Ground Acceleration (PGA) of 0.3g for most of the safety relevant systems and components in a region with low seismicity is considered to be good practice.
- The non seismic qualification of the fire brigade building is an issue that should be considered for further study

Loss of Safety Systems

The plant is able to withstand a loss of offsite power for more than 72 hours by utilising electrical supplies from the Safeguard Diesel Generators. If these are unavailable, power supplies to the internal emergency network can be maintained by the Emergency Diesel Generators for at least 24 hours.

For the extreme case of a total loss of power including unavailability of the four Emergency Diesel Generators, improvements have been implemented for disconnecting unnecessary 220V DC loads, in order to extend the time of availability of essential safety functions including the remote control of SBF operation. Further improvements are planned. These include back-fitting portable diesel generators to supply power to essential services and a SBF procedure with instructions for local operation of steam generator inlet valves from rooms in the Annulus Building.

The main improvements to Trillo's capability to cope with an extended SBO are as follows:

- Test of power supply recovery from the hydro-power station (*completed successfully*).
- Test (*completed successfully*) and procedures for manual SBF and manual local valve opening in the flow path or local regulation of pump speed (*Implementation by end of 2012*)
- Procedures for the disconnection of unnecessary 220V DC loads to increase the battery discharge time to around 16 to 18 hours (*Implementation Completed*)
- A mobile diesel pump to transfer water from the Essential Service Water System ponds, from the Recirculation Water System or from the Pretreated Water System to the Emergency Feedwater System tanks, to the SFP or to the ECCS tanks (*Implementation by June of 2013).*
- A mobile diesel generator (DG2), with a connection to the 380V AC emergency supplies, to feed batteries, ventilation systems and to valve actuators. (*Implementation by end of 2016*)
- A mobile diesel generator (DG1) to power one mobile electrical pump, which provides make-up supplies to the primary injection and the SFP, and to power two other mobile electrical pumps for water transfer operations. (*Implementation by end of 2013)*
- Improvements to the seismic resistance (to 0.3g) of certain equipment to increase margin e.g. the alternate diesel-driven feedwater pump. (*Implementation by end of 2013)*
- New portable lighting (*Implementation by end of* 2012).
- Upgraded communications systems (*Implementation by end of* 2015)
- New portable power supply for instrumentation (*Implementation by June 2013*)

- Improved SBF pump fuel and Safeguard diesel generators oil reserves *(Implementation by end of 2012 and by end of 2014, respectively)*
- New vehicle for fuel transfer (*Implementation by end of 2012*)

In addition, to address an SBO coincident with a loss of ultimate heat sink, the above list will be complemented by the following improvements:

- Options to use other sources of water in the event of loss of the Essential Service Water system by means of flanged connections, portable pumps and hoses (*Studies Completed*).
- Enabling the local operation of steam generator inlet valves from rooms in the Annulus Building (*Implementation completed*)
- Design modifications to keep the piston check valve bypass valves closed during Residual Heat Removal (RHR) operation and so prevent potential leakage in the RHR suction line (*Implementation completed*)
- Enabling local manual opening of Accumulator Isolation Valves (needed in accidents during shutdown states) (*Implementation almost completed*)
- Alternative electrical supplies for the Accumulator Valves from the Uninterruptable Services Busses (*Design by end of 2013 and final Implementation by 2014*)
- Additional analysis for containment isolation (*Implementation by end of 2013*)
- Improvements to the back-up pneumatic system to allow for the injection of air from independent compressed air bottles (which will guarantee the opening of the main Steam Dump Isolation Valves at low pressures if the pilot valves are unavailable because of DC power loss). (*Implementation by end of 2014*)

The team noticed that:

- A noteworthy success has been obtained in the development of procedures for manual actions in case of extended SBO, including load dislatching and manual valve operation, as well as the subsequent testing and training of the operating personnel to apply them (even though some activities are still pending and some difficult aspects remain to be addressed, including the radiological impact of these manual actions)

- The good practice linked to prior testing of procedures under development (through which it was discovered that four people are needed to open an Accumulator Isolation Valve rather than the envisaged two) and seismic upgrading of accident management equipment (e.g. alternate diesel-driven feedwater pump).

Severe Accident Management

Further specific Severe Accident measures being implemented at Trillo include:

<u>Accident Management</u>

- The creation of an Alternative Emergency Management Centre (AEMC) on site (*Provisional centre by end of 2013 and new AEMC operational by end of 2015*),

- The creation of a new centralised Emergency Support Centre common to all Spanish nuclear plants *(Implementation by end of 2013)*
- Improvements in the area of communications *(Analysis completed, Implementation as part of the new AEMC by end of 2015)*
- In-depth human resources re-analyses *(Implementation by end of 2013)*

Radiological Protection

- Improvements in control room habitability (*Analysis Completed)*: Safeguard power supply to MCR filtering system *(Implementation by end of 2013)*
- Guidelines for the protection of field operators *(Implementation by end of 2013)*
- Enlargement of the gamma radiation detector network *(Implementation by end of 2014)*

Fuel and Core Damage

- Implementation of containment filtered venting *(design work to be completed by the end of 2013 for implementation by end of 2016*)
- Development of plant-specific Severe Accident Management Guidelines (SAMGs) focussing on mitigation as well as preventative actions (including strategies for flooding the containment) *(Implementation by end of 2016)*
- Analysis of instrumentation qualification requirements in severe accidents; *(Completion by end of 2016)*
- Analysis of potential for H_2 to accumulate outside containment *(Completion by end of 2013)*
- Analysis of severe accidents initiated during shutdown *(Completion by end of 2014 in parallel with Level 2 Shutdown PSA, and implementation in parallel with SAMG 2016)*
- Re-analysis of the robustness of containment isolation devices in severe accident conditions *(Completion by end of 2014)*
- Reinforcement of SFP make-up (and spray) and instrumentation (*Implementation linked with SBO mobile diesels and pumps*)
- Modifications to implement primary bleed and feed strategy (*Implementation in 2013 refuelling outage)*:

The team points out that:

- Good Practice: PARs were installed at Trillo during the late 1990's and are also qualified for severe accident conditions. The licensee is however open to making any further improvements arising from developing good practice identified at other plants.
- The licensee may be faced with some difficulties to complete the SAMG improvements within its stated timescales. The current SAMGs are mainly focused on preventive measures (as is the case for most of the German plants) and further steps need to be undertaken to establish a complete set of mitigating generic guidelines for PWR-KWU design. This work is being carried out in cooperation

with the relevant owners' group and so the timescales for its completion are not completely within Trillo's control.

- The licensee has already made impressive progress since the Fukushima accident in enhancing its capabilities to address a severe accident, including a significant investment in providing primary bleed and feed capability, as required by CSN prior to the Fukushima. There however remains a significant amount of work left to do and achieving the ambitious timescales the licensee has set itself could be a challenge. Nevertheless the overall success of this work will depend on completing these improvements within reasonable timescales.

Overall Review Conclusions

The licensee has a good, open and positive working relationship with the regulatory body and, in keeping with this, has agreed on a safety enhancement programme (that includes all the stress tests recommendations) to a very ambitious timeframe. The review team recognises the important measures that have already been taken and supports the planned improvements foreseen.

Given the relative remoteness of Trillo's location, the talents and experience of the site's emergency teams and supporting technical staff will likely be key factors in successfully addressing a severe accident. The review team was impressed by the technical knowledge, judgement and commitment of the licensee staff we met and stress the importance of continuing to maintain such high standards.

The schedule for the implementation of the planned improvements is considered appropriate, but highly demanding. In this context, it may prove difficult to finish all the planned modifications on time, taking into account the needs for design, procurement, implementation, testing and personnel training.