TECHNICAL NOTICE

Risk of loss of heat sink for 29 nuclear reactors in the event of an earthquake

1. The heat sink components

The heat sink comprises all the equipment and systems used to take water from the sea or a river to contribute to cooling of the facilities and maintain them in a safe state, in both normal and emergency operating situations.

The main systems of the heat sink are located in the pumping station:
- the condenser circulating water system (CRF);
- the essential service water system (SEC);
- the raw water filtering system (SFI or CFI);

The pumping station also houses a part of the firefighting water production system (JPP), used to combat any fires liable to occur in the facility.

The pump room contains all the pumping means associated with several systems, generally situated in a sump.

2. The role of the various systems concerned

The essential service water system (SEC)

Via the component cooling system (RRI), the SEC system is used to cool equipment important for the safety of the reactor. The SEC system is said to be an "auxiliary" system comprising two redundant lines, each comprising two pumps and two exchangers. Each of these lines is capable of handling the necessary heat removal on its own.

Its safety role, via the RRI system, is to remove the residual heat from the fuel in certain post-accident situations (loss of coolant accident, steam line break) and when effecting and maintaining reactor cold shutdown. In normal operation and in the event of reactor outage, the SEC system also contributes to cooling a certain number of other equipment items, such as the reactor coolant pumps or the spent fuel pits.

The condenser circulating water system (CRF) or tertiary system

The role of the condenser circulating water system (CRF), which constitutes the tertiary system, is to use a condenser to cool the steam used to drive the turbine generator to produce electricity. Unlike the others, it does not have a safety function.

The raw water filtering system (SFI or CFI)

The SFI or CFI system provides filtering in the pumping station of the seawater or river water supplied mainly to the CRF system and the SEC system.

The firefighting water production system (JPP)

The JPP system supplies the site's entire firefighting network.

3. Circumstances of the event

The fire protection equipment, such as the JPP system, and raw water filtration equipment, such as the SFI and CFI systems, must comply with earthquake resistance requirements. They must also be regularly inspected during the course of preventive maintenance, to ensure that they are able to perform their functions in all situations when required, in particular in the event of an earthquake.

In 2009, EDF set up a preventive maintenance programme for the equipment constituting the fire protection network (JPP) for the 1300 MWe reactors. This programme requires that the piping protecting against the fire risk be monitored by means of external visual inspections, the aim of which is more specifically to detect corrosion, leaks, sweating or perforation of the pipes and their connection seals.

At the request of ASN, EDF carried out checks on the piping of the JPP system in the Belleville NPP in March 2017. Some of the results brought to light faster than expected deterioration. EDF therefore decided to expand the scope of the inspections to other sections of piping.

On 31 May and 14 June 2017, EDF carried out further, expanded inspections which brought to light the degraded condition of two sections of JPP system piping in this same NPP, with thicknesses less than the minimum thickness required on these pipes in order to guarantee their earthquake resistance. The deterioration observed was caused by corrosion and erosion phenomena.

Following the characterisation of this deviation, EDF took steps enabling it to qualify a repair solution for the JPP piping. Following this analysis, the temporary solution adopted by EDF was to replace the defective piping sections without delay, which entailed work lasting about ten days. This should be replaced within a few months by a final solution, the implementation of which will be inspected by ASN.

On 23 June 2017, EDF informed ASN of a first significant event rated level 1 on the INES scale for the reactors in the Belleville-sur-Loire NPP.

Given the safety implications of the total loss of heat sink, EDF set up a dedicated organisation on 5 July 2017 to characterise and process this event as rapidly as possible for all the reactors in operation. Thickness measurements were taken on the JPP, SFI and CFI piping of all the NPP reactors except for those which, owing to the configuration of their installation, entail no risk of internal flooding of the pumps on the SEC system, or which have no SEC pumps or piping susceptible to the corrosion phenomenon.

The results of this measurement campaign show that on 29 NPP reactors there is significant deterioration of the JPP, SFI and CFI piping which means that, in the event of a fracture following a maximum historically probable earthquake (MHPE)[1] the risk of flooding of the SEC system motors cannot be ruled out.

[1] The MHPE is conventionally associated with a return period of 1,000 years. This level of earthquake can be considered as the most intense "in human memory" identified in the region concerned. The MHPE is defined by repositioning the historical earthquake in the immediate vicinity of the site.

4. Potential consequences

The JPP, SFI or CFI piping concerned is situated in the premises of the essential service water system (SEC) pumping station for the reactors affected by this event. In the event of an earthquake, fracture of the piping concerned would lead to internal flooding in the premises of the SEC system pumping station and loss of the heat sink.

There are a number of water reserves on the NPP sites concerned, but not all of them were designed to withstand an earthquake:

- the steam generators auxiliary feedwater system (ASG) supply tanks;
- the SER and SED demineralised water tanks;
- the pumping station water tanks (SDP);
- the firefighting water tanks (JPP).

Moreover, these water reserves would become depleted, with the greater the heat to be removed, the more rapid this depletion.

The fracture of the JPP, SFI or CFI piping in the event of an earthquake could lead to the total loss of reactor cooling means. A situation such as this would be liable to lead to fuel melt and significant radioactive releases into the environment.

5. Processing of the deviation

In the same way as the repairs performed in the Belleville-sur-Loire NPP, temporary and permanent repairs have been initiated in the other twenty seven reactors concerned. The progress of the conformity work is to date as follows:

- 10 reactors have undergone temporary or permanent repair;
- 9 reactors are shutdown and are undergoing repairs which will be completed prior to their restart;
- 10 reactors, at present at power, have at least one earthquake-resistant essential service water train, with the second train undergoing repairs.

ASN has checked that the licensee has taken all necessary steps to deal with this event as rapidly as possible, more specifically ensuring that at least one train of the SEC system is in conformity for the reactors in operation. More particularly during the course of its inspections, ASN checks that the repairs are carried out satisfactorily. ASN will ensure that the licensee learns all relevant lessons from this event, notably with regard to improving preventive maintenance provisions.