COMPLEMENTARY SAFETY ASSESSMENTS FOR RESEARCH REACTORS FOR THE FRENCH NUCLEAR SAFETY AUTHORITY

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ABSTRACT

The “Autorité de sureté nucléaire” (ASN) requested licensees to undertake stress tests, called *complementary safety assessments* (CSA), of their installations on May 5th 2011, following the accident that occurred in Japan on March 11th 2011. Their mission consisted in providing feedback on the consequences of potential extreme events.

In this process, all the French facilities were divided into three categories of decreasing priority, depending on two main factors: on the one hand, their vulnerability to the various phenomena that led to the Fukushima accident, and on the other hand, the amount of radioactive elements that would be dispersed in the event of a failure of the safety functions. On the 79 high-priority facilities, only five of them are research or experimental reactors (including two currently shutdown or in decommissioning) and their operators (the “Comissariat à l’énergie atomique et aux énergies alternatives” (CEA) and the “Institut Laue Langevin”) submitted their reports to the ASN on September 15th 2011. Concerning the lower-priority facilities, including three other facilities (two research reactors operated by the CEA and a facility operated by ITER Organization) the deadline was September 15th 2012. Finally, the remaining facilities were not asked to submit a report yet, but they will have to do it later, mainly on the occasion of their next periodic safety review.

The analyses of the *cliff-edge effects,* that may occur in extreme situations (exceptional scale event, combination of several disasters...), led to the definition of a *hardened safety core* concept by the “Institut de radioprotection et de sûreté nucléaire” (IRSN). This *hardened safety core* of structures, equipments and organizational measures must ensure the ultimate protection of the concerned facilities in extreme situations : it is designed to prevent severe accidents (or curb their progression), limit large scale releases for extreme accidents, and enables the operating teams to perform emergency management. Therefore, the ASN asked licensees to propose a *hard core* of measures for each facility [1].

The specifics of CSAs for research reactors will hereby be highlighted and explained. A particular point will be made on the rules defining hard core dimensioning. To that end, the evaluation of baseline (seismic solicitations is quite representative as it needs to be set specifically. Another focus will also be proposed on the second batch of facilities report analysis, as a result of the expert meeting at the beginning of July 2013.

1. Introduction

The “Autorité de sureté nucléaire” (ASN) requested licensees to undertake stress tests, called *complementary safety assessments* (CSA), of their installations on May 5th 2011, following the accident that occurred in Japan on March 11th 2011. Their mission consisted in providing feedback on the consequences of potential extreme events.

In this process, all the French facilities were divided into three categories of decreasing priority, depending on two main factors: on the one hand, their vulnerability to the various phenomena that led to the Fukushima accident, and on the other hand, the amount of radioactive elements that would be dispersed in the event of a failure of the safety functions.

The specifics of CSAs for research reactors will hereby be highlighted and explained. A particular point will be made on the rules defining the *hardened safety core* dimensioning. To that end, the evaluation of baseline (seismic solicitations is quite representative as it needs to be set specifically). Another focus will also be proposed on the second batch of facilities report analysis, as a result of the expert meeting at the beginning of July 2013.

2. High priority facilities

Most of the 79 high-priority facilities considered in France are nuclear power reactors. Only five of them are research or experimental reactors (including two currently shutdown or in decommissioning) and their operators : the “Comissariat à l’énergie atomique et aux énergies alternatives” (CEA) and the “Institut Laue Langevin” (ILL) submitted their reports to the ASN on September 15th 2011. The facilities concerned are four experimental reactors of the CEA - OSIRIS[1], PHÉNIX[2], MASURCA[3] and the Jules Horowitz reactor[4] (RJH) – as well as the RHF[5] operated by the ILL.

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[1] The OSIRIS pool-type reactor has an authorised power of 70 megawatts thermal (MWth). It is primarily intended for technological irradiation of structural materials and fuels for various power reactor technologies. It is also used for a few industrial applications, in particular the production of radionuclides for medical uses, including molybdenum 99. Its critical mock-up, the ISIS reactor with a power of 700 kWth, is essentially used for training purposes

[2] PHENIX is a fast neutron sodium-cooled reactor; CEA submitted the final shutdown and decommissioning authorisation application for this reactor in late 2011.

[3] The MASURCA reactor is a critical mock-up, whose construction was authorized by a decree dated 14th December 1966, and is intended for neutron studies, mainly on the cores of fast neutron reactors and for the development of neutron measurement techniques.

[4] The RJH pool-type reactor will be able to carry out activities similar to those performed today with the OSIRIS reactor. It will however comprise a number of significant changes with regard to both the possible experiments and the level of safety

[5] The high flux reactor (RHF) at the Institut Laue Langevin (ILL) in Grenoble, is a research reactor designed to supply neutrons, used primarily for experiments in solid physics, nuclear physics and molecular biology. The maximum power of the reactor is 58.3 MWth.

The analyses of the *cliff-edge effects* for all the high priority BNIs, that may occur in extreme situations (exceptional scale event, combination of several disasters...), led to the definition of a *hardened safety core* concept by the “Institut de radioprotection et de sûreté nucléaire” (IRSN). This *hardened safety core* of structures, equipments and organizational measures must ensure the ultimate protection of the concerned facilities in extreme situations : it is designed to prevent severe accidents (or curb their progression), limit large scale releases for extreme accidents, and enables the operating teams to perform emergency management. Therefore, the ASN asked licensees to propose a *hardened safety core* of measures for each facility [1].

ASN issued additional instructions in the light of the conclusions of the stress tests, in its resolutions of 26th June 2012. In addition to the common request applicable to all BNIs, for the definition and implementation of a *hardened safety core* of material and organisational measures to control the fundamental safety functions in extreme situations, the main requests are the following for the CEA reactors:

- to move the fissile material from the MASURCA facility to a facility with a satisfactory seismic design before December 31st 2013, as the CEA promised to do on several occasions; Due to industrial delays, the expected end of the move is now before the end of 2014.
- to improve the PHENIX reactor regarding flooding or sodium fire control risk;
- to improve the loss of cooling risk for the OSIRIS reactor;
- to improve the risks of flooding and loss of cooling as well as the seismic behaviour of the Jules Horowitz reactor.

For the ILL, following the analysis made of the operator’s report, it was asked to create a new emergency management rooms during the 2013-2014 winter outage and several new systems to allow emergency cooling and the mitigation of radioactive releases.

The *hardened safety core* for all high priority BNIs was studied by the IRSN and ASN’s permanent group of experts. This group gave its comments upon IRSN report at the beginning of April 2013. These comments, IRSN report and ASN analysis are the based of regulatory decisions with technical prescriptions for the *hardened safety core* of all high priority facilities.

For the ILL, due to the beginning of the 2013-2014 winter outage in September, the regulatory decision that prescribes the rules to consider for the design of the *hardenedy safety core* was the first sent to the operator for comments and remarks at the end of July 2013. The operator had no comment, and the *regulatory decision* is currently (9th to 14th September 2013) put on the ASN webpage for public discussion, with and expected official publication attended before the end of September.

For the *hardened safety core*, it is asked to consider a reference spectrum for the design with a return period above 10 000 years with a high level of confidence (and around 30 000 years). For the new parts of the *hardened safety core,* the use classical rules of design codes is required. For the existing ones, when rules of design codes are not possible to apply for the verification, it is asked to use as much as possible realistic and deterministic methods.

For the CEA, the regulatory decision that imposes a loading level to consider (with a seismic spectrum that has the same properties as the one considered for the RHF) and the rules that has to be considered for the design of the *hardened safety core* will be published in late 2013, with the feedback ASN regulatory decisions that apply to ILL (see above) and to French nuclear power reactors.

3. Lower priority facilities

For the second batch of facilities considered to be lower priority, including six CEA research facilities and the ITER[6] thermonuclear fusion facility the deadline was September 15th 2012. Among them, two research reactors operated by the CEA (CABRI[7] and ORPHÉE[8]) and a facility operated by ITER Organization. The *support functions*, in other words the material or organisational means common to all the BNIs, on the Cadarache and Marcoule sites will also be assessed. The *support functions* include military BNIs that are not under the surveillance of the ASN, and that requires a cooperation with the *defence nuclear safety authority*.

ASN's permanent group of experts gives its comment about IRSN report based on studies by the licensees in the beginning of July. Based on this works, ASN will impose technical prescriptions in following regulatory decisions.

For the CABRI reactor, no *hardened safety core* is identified. Some of the key components of the facility need to be more precisely studied under extreme loading. For ORPHÉE, which stays in the great suburb of Paris, the *hardened safety core* proposed by the CEA is satisfactory and a *regulatory decision* will fixed the level of seism to consider for the design of this *hardened safety core.* For ITER the preliminary work done by the licensee to identify a *hardened safety core* is satisfactory. Some other extreme situations have to be considered. Regarding the current state of conception and construction of ITER, another examination will be performed before the tokamak assembling process (expected in 2015).

4. Other facilities

Finally, the remaining facilities have not been asked to submit a report yet, but they will have to do it later, mainly on the occasion of their next periodic safety review. Among them, X were research reactors operated by the CEA (EOLE and MINERVE[9], PHEBUS[10],…). All of them

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[6] The ITER project is an experimental installation, which purpose is scientific and technical demonstration of controlled thermonuclear energy obtained with the magnetic confinement of a deuterium-tritium plasma, during long-duration experiments with a significant power level (500 MW for 400 s).

[7] The CABRI reactor, created on 27th May 1964, is mainly used for experimental programmes aimed at better understanding nuclear fuel behaviour in the event of a reactivity accident.

[8] The ORPHÉE reactor, with an authorised power of 14 MWth, is a pool-type research reactor, using heavy water. as the moderator.

[9] The ÉOLE critical mock-up reactor is intended for neutron studies of light water reactor cores. It can be used to reproduce a high neutron flux using experimental cores representative of pressurised or boiling

have limited safety stakes. A project of regulatory decision is currently presented to the public on the ASN web page, and the publication is attended for the end of September.

5. Conclusion

The installations regulated by the ASN, and among them the research installations, differ widely in size. However, the laws applied to all the BNIs are the same, and the ASN try to have the same process for all of them. Regulating the safety and radiation protection of these installations as a whole and on comparing practices per type of installation in order to choose the best ones and thus encourage operating experience feedback remains the priority of the ASN. It is in this spirit priorities were defined for the submittal of the stress test reports concerning the nuclear facilities other than power reactors. A prior analysis was conducted to assess the risks in the light of the experience feedback from the Fukushima Daiichi accident and the *potential source term*. Given the diversity of the nuclear fleet, each facility must be studied individually. These studies are completed by a set of inspections targeted on topics related to the Fukushima Daiicchi accident (*e.g*. decision making in alert situation, weather forecast, flooding, mobile pumping resources…).

6. References

[1] *Complementary Safety Assessments of the French Nuclear Installations (CSA)*, December 2011 report, French Nuclear Safety Authority.
http://www.french-nuclear-safety.fr/index.php/content/download/34059/251667/file/Complementary-safety-assessments-french-nuclear-safety.pdf

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water power reactors. The MINERVE reactor is devoted to the measurement of cross sections by sample oscillation, enabling variations in reactivity to be measured. Based on the conclusions of CEA's strategic review of the continued operation of these installations, CEA would cease operation of these two reactors by 2019 years.

[10] The PHÉBUS test reactor is intended for studying the severe accidents that could affect pressurised water reactors. Clean-out and decommissioning of the experimental systems used in the last experiment have been continuing since 2004.