Health and Safety Executive

HEALTH & SAFETY EXECUTIVE
NUCLEAR DIRECTORATE
ASSESSMENT REPORT

New Reactor Build

EDF/AREVA EPR Step 2 PSA Assessment

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1. Introduction

This report deals with the Generic Design Assessment GDA Step 2 assessment of the Probabilistic Safety Analysis (PSA) approach detailed in the Submission (Ref 1) provided by EDF/AREVA for the EPR. The main conclusion is that EDF/AREVA have provided sufficient information to demonstrate that their PSA techniques are consistent with NII's Safety Assessment Principles (SAPs). This provides us with a sufficient degree of confidence to recommend that GDA Step 2 requirements have been met for the EPR.

2. ND Assessment

2.1 Requesting Party's Case

EDF/AREVA's report of their PSA is outlined in Chapter R of the submission. Chapter R itself is broken down into 5 sections, covering:

- R0 Objectives and Targets,
- R1 Methodology and Results
- R2 Level 2 PSA (plans) and Level 1+ Methodology and Results
- R3 Specific PSA Assessments looking at risk reduction categories
- R4 Internal and External hazards

Sub chapter R0 discusses the uses made of the PSA and these include design assist, consideration of the balance of the design, justification of test and maintenance activities and confirmation of robustness against hazards. R0 states that all reactor states are included and all types of internal and external hazards covered, it also enlarges on the numerical targets discussed in section 5.4 of Chapter E. Sub chapter R1covers initiating event analysis which is based largely on French experience and lists a fairly typical set of event groups. The way in which the Initiating event frequencies are determined is also discussed and EDF/AREVA state their use of an expert judgement process to establish the frequency of postulated IEs that have not occurred in preference to a Chi squared approach. The approach to Common Cause Failure (CCF) is also discussed. Sub chapter R2 describes the approach to level 2 PSA and reports on the existing level 1+ PSA. This latter essentially separates the level 1 core damage events into a limited number of plant damage states (PDS), 3 in this case, representing in-tact containment, late containment failure and early containment failure. The results of the level 1+ are also given in R2. Sub chapter R3 deals with specific PSA analysis of risk reduction features, termed RRC-As, as well as looking at accidents associated with the spent fuel pool and analysis of long term (>24hr) sequences. R4 deals with internal and external hazards, noting their inclusion or the intent to include (for site specific ones) and are as follows:

Internal Hazard	**External Hazard**
Pipe leaks and breaks	Earthquake
Failure of tanks, vessels pumps and valves	Aircraft crash
Internal missiles	Industrial environment, including transport - explosions

Dropped loads	External flooding
Internal explosions	Extreme weather (snow, wind, low and high temperatures, etc.)
Fire	Lightning and electromagnetic interference
Internal flooding	External hazards specific to the site

EDF/AREVA's Targets and preliminary results are:

Metric	**EDF/AREVA target /yr**	**Result/yr**
Core Damage Frequency (CDF) internal events	10^{-6}	$6.1x10^{-7}$
CDF ext hazards	$5x10^{-6}$	$5x10^{-7}$ (seismic) $7x10^{-8}$ (aircraft –FL3) 10^{-10} (industrial) $7x10^{-8}$ (extreme weather)
CDF internal hazards	10^{-6}	$6.4x10^{-8}$ (fire) $2x10^{-8}$ (flood) Others to be added
PDS 3 (core damage with early containment failure)	10^{-7}	$3.9x10^{-8}$

2.2 Standards and Criteria

In respect of PSA, Step 2 of the GDA guidance (Ref 2) requires the Requesting Party (RP), in section 2.6, to provide "An overview statement of the approach, scope, criteria and output of the probabilistic safety analysis". The GDA guide goes on to say that that HSE will undertake "an assessment directed at reviewing the design concepts and claims" and specifically in point 2.22 "the PSA approach".

Hence the PSA itself is not being assessed in Step 2; rather we are looking at high level claims on how the PSA SAPs will be met by the RP's submission. The Fault Analysis strategy Project Assessment Report (PAR) (Ref 3) identified SAPs FA.10 to FA.14 and NT. 7 to 9 as the relevant sections. The equivalent sections of the IAEA standards (Ref 4) and WENRA reference levels (Ref 5) have also been listed. The aim of the assessment at Step 2 is to see that appropriate claims have been made. The arguments and evidence supporting these claims will be assessed in Step 3 and beyond.

2.3 ND Assessment

Chapter R of the submission provides information on the scope, methodology, data and results of the level 1+ PSA carried out by EDF/AREVA. A full level 2 PSA is underway and is expected to be submitted for Step 3. R0 indicates that the PSA has been used to assist the design and help towards a balanced design and essentially meets the intent of FA.10 and FA.14. The PSA has been carried out specifically in support of the Flamanville 3 design, which is the variant EDF/AREVA have submitted to the GDA hence FA.11 ought to be met. The *break preclusion* approach adopted to large LOCA means EDF/AREVA have assumed very low frequencies and the justification of these will need to be scrutinised, as will the sensitivity of the results to such assumptions. The expert judgement methodology for assigning frequencies to postulated events that have not occurred yet will also need careful assessment. For FA.12, sub chapter R3 outlines some analysis associated with the spent fuel pool. This is encouraging, but no information appears to have been presented on other sources of radioactivity. This gap will need to be filled but there is a low likelihood that it will have a significant impact. The initiating event categories look to be fairly typical

of a PWR and we will need to look at the bounding process to see that it is inclusive and non-optimistic. The PSA itself is not available in English at this point of the process, but the information in Chapter R is sufficient to support an EDF/AREVA conclusion that a comprehensive PSA has been produced that accounts for component failure, CCF, human error etc and that it is an adequate representation of the plant as required by FA.13

The numerical results provided all show the French design targets to be bettered. EDF/AREVA acknowledge there is more to be done and the tentative nature of some of the results (e.g. seismic). Nevertheless there is nothing to suggest that more detailed UK specific analysis will fail to show that ND's NT 7, 8 and 9 to be met.

TQ EPR000003 (Ref 6) was issued asking for EDF/AREVA to say how they thought they had addressed ND SAPs. The response (Ref 7) for PSA is shown in the table below, and EDF/AREVA conclude that they comply with the requirements of the SAPs.

SAP/NT	**EDF/AREVA Claim:**
FA.10 Need for PSA	EPR design is considered to comply with the SAP PSA has been performed as an integral part of the EPR design. Results of the preliminary PSA analysis for the Flamanville3 which is the reference design for the UK EPR are given in SSER 2.R. The EPR project uses as a safety objective the IAEA 10^{-5}/yr CMF target for future reactors (all events). To meet this objective, the following breakdown of internal targets has been proposed for the purpose of PSA studies (see SSER 2.R.0): • core melt frequency due to internal events for power operation $<10^{-6}$/yr • core melt frequency due to internal events for shutdown states $<10^{-6}$/yr • core melt frequency due to internal hazards $<3\ 10^{-6}$/yr • core melt frequency due to external hazards $<5\ 10^{-6}$/yr A further probabilistic objective is that no class of events should make a disproportionate contribution to the core melt frequency to achieve a balanced design. Moreover, any major sequence contributing to the overall risk may be analysed in the framework of RRC studies. Preliminary results of the Level 1 PSA for internal events in SSER 2.R.1 show that the probabilistic objectives are achieved, and that the risk of core melt due to internal events is evenly divided between the five event groups: LOCA, secondary cooling system events, loss of offsite power supplies, loss of heat sink events and ATWS. Results of the preliminary hazards PSA presented in SSER 2.R.4 show the target for internal hazards is achieved, and the target for external hazards achieved to within a slight shortfall. A more comprehensive PSA analysis for the UK EPR will be presented in the SSER update to be submitted for Step 3 of GDA.
FA.11 Validity	The current French practice on operating plants in these matters intend to maximise the benefits from the series effect: the data update is performed on the basis of all operating feedback, the design and operation specificities are close to zero and, within the standard PSA model, the site dependant data are generally taken into account on an envelope basis. On the other hand, the use of PSA in day to day operation is quite low (e.g. no risk monitor). The major uses of PSA are concentrated on standard purposes: technical specifications, periodic safety reviews, operating feedback and incidents analyses… EDF will propose in due time to implement the same approach on the EPR worldwide standard. However, at the GDA stage, the available PSA tools enable both a site and a standard approach to be contemplated.

FA.12 Scope and extent	EPR design is considered to comply with the SAP The PSA presented in Chapter R of the Step 2 SSER considers internal events, internal and external hazards affecting the nuclear steam supply system as the dominant source of radioactive material in the plant. Initiating events cover all reactor states, including both at-power and shutdown conditions. For the Step 3 SSER, the PSA is being extended to cover events affecting the fuel building and events involving accidental release of radioactivity in the nuclear auxiliary building and effluent treatment building.
FA.13 Adequate representation	EPR design is considered to comply with the SAP As explained in SSER 2.R.1, the EPR PSA model accounts for random component failures, failure of components due to the initiating event, common cause failures, and equipment unavailability due to maintenance. Best-estimate methods and data are used for supporting transient analyses, accident progression analyses, source term analyses, and radiological analyses, as requested by the SAP. Reliability data are derived mainly from operational feedback from France and Germany, supplemented by the EG&G generic reliability database (see SSER 2.R.1.2.1). Initiating event frequencies are evaluated from operating feedback from French plants and international feedback. The PSA contains a comprehensive treatment human errors, which are allowed for in equipment unavailability analysis and in treating the probability of failure to execute requested actions (see SSER 2.R.1.2.3). In the PSA analysis that will be presented in Step 3 of GDA, an uncertainty analysis will be included. Hence risk results will be presented at a range of confidence levels, rather than as a central estimate of risk, a requested by the SAP.
FA.14 Use of PSA	EPR design is considered to comply with the SAP As far as design is concerned, and as stated in SSER 1.C.4.3, the EPR objectives of reinforcing defence in depth involved extensive use of probabilistic methods. PSA was used to quantitatively demonstrate implementation of the defence-in-depth concept as well as to show that a balance has been achieved between levels of protection and that the levels were independent of one another. PSA studies were performed at the design stage of the EPR to support the choice of design options, including the required level of redundancy and diversity of the safety systems. PSA was also used to select or reject changes to the main EPR design options during the Basic Design Optimisation Phase of EPR. With regard to the use of PSA during the plant life, see response to SAP FA 11 above.
Target 7	Not explicitly covered – But see response to FA 10
Target 8	Not explicitly covered – But see response to FA 10
Target 9	Not explicitly covered – But see response to FA 10

Other points for ND follow up in Step 3 and beyond:

- The bounding of event groups is not described in detail, ND will want to see that it is inclusive and non-optimistic
- There are no detailed results at this stage, so no indication of the adequacy of the treatment of uncertainty and sensitivity to assumptions
- The expert judgement method for initiating event frequencies will need to be assessed to ensure that it is robust
- The justification for assumptions on the exclusion of some types of CCF (R1 section 2.1.4) will need to be assessed
- More on non core sources (e.g. radwaste)

3. Conclusions

EDF/AREVA have provided an adequate overview of the approach, scope criteria and output of the level 1+ PSA they have produced. They have also provided results that can be reasonably extrapolated to give confidence that the SAPs NTs will be adequately addressed in Step 3.

Some points for future consideration (by ND) have arisen during this high level assessment and it has not been possible, or indeed appropriate to address them in Step 2. These will be picked up during our assessment in Step 3 and beyond.

4. Recommendations

HSE should accept that EDF/AREVA have provided sufficient information on the approach, scope, criteria and output of the PSA for Step 2 of GDA.

5. References

1. EDF/AREVA Safety, Security and Environmental Report, EPR0001. September 2007.

2. HSE Nuclear Power Station Generic Design Assessment – Guidance to Requesting Parties, Version 2, 16 July 2007

3. Step 2 Fault Analysis & PSA Strategy. AR07015.

4. IAEA Safety Standards Series – Safety of Nuclear Power Plants: Design – Requirements – No.NS-R-1

5. Western European Nuclear Regulators Association Reactor Safety Reference Levels, January 2007

6. TQ EPR000003.

7. EDF/AREVA response to TQ EPR000003.