Health and Safety Executive

HEALTH & SAFETY EXECUTIVE
NUCLEAR DIRECTORATE
ASSESSMENT REPORT

New Reactor Build

GEH ESBWR Step 2 PSA Assessment

HM Nuclear Installations Inspectorate
Redgrave Court
Merton Road
Bootle
Merseyside L20 7HS

1. Introduction

This report deals with the Generic Design Assessment (GDA) Step 2 assessment of the PSA approach detailed in the PSR provided by GEH for the ESBWR. The main conclusion is that GEH has provided sufficient information to demonstrate that its 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 ESBWR.

2. ND Assessment

2.1 Requesting Party's Case

GEH's case is outlined in the PSR (Ref 1) and the major supporting document is the Design Control Document (DCD) (Ref 2) compiled to meet USNRC requirements. The DCD contains a large amount of information relevant to the UK, but there is not a one to one correspondence with ND requirements noted in the GDA guide (Ref 3) and our Technical Assessment Guide (TAG) on safety reports (Ref 4). The PSR is intended to bridge these gaps.

GEH addresses PSA in section 2.6 of the PSR. GEH claim to have carried out a comprehensive study (2.6.1 of the PSR) and to systematically analyse the complete range of anticipated initiating faults, internal and external initiators, and includes all modes of operation (2.6.2 of the PSR). The PSR goes on to discuss the various elements of the PSA. Section 2.6.5 of the PSR covers PSA methodology and section 2.6.6 gives an overview of the results. The methodology section covers initiating faults, accident sequence analysis, systems analysis, human reliability analysis, data analysis (initiating fault frequency, component reliability and common cause failure), quantification, containment performance (level 2) and consequence analysis (level 3).

All of the sections in 2.6 have copious references to the DCD and sampling of these links indicates that the stated support is there. The PSA (2.6.2 of the PSR) has been conducted in accordance with the ASME code (Ref 5) which is a recognised international standard and is broadly compatible with our own guidance.

GEH's Preliminary ESBWR Core Damage Frequency Estimates are:

Category	**CDF /year**
At-Power Internal Events	1.22×10^{-8}
At-Power Fire	1.21×10^{-8}
At-Power Flood	3.7×10^{-9}
Shutdown Internal Events	8.8×10^{-9}
Shutdown Fire	2.32×10^{-8}
Shutdown Flood	1.6×10^{-9}
TOTAL	6.16×10^{-8}

In response to Technical Query (TQ) ESBWR-000001(Ref 6), GEH provided a table of claims and location of supporting evidence for each of the SAPs listed in the TQ.

Standards and Criteria

In respect of PSA, Step 2 of the GDA guidance (Ref 3) 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 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 (FA) strategy Project Assessment Report (PAR) (Ref 7) identified SAPs FA.10 to FA.14 and NT. 7 to 9 as the relevant sections. The equivalent section of the IAEA standards (Ref 8) and WENRA reference levels (Ref 9) 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

The PSR describes a comprehensive Level 3 PSA, which at face value addresses ND requirements for completeness in terms of the lists of faults and hazards contained and the claimed coverage of all operating modes. In terms of the SAPs and NTs listed in the FA strategy report, the following summary claims, based on the TQ response (Ref 10), have been made:

SAP/NT	GEH Claim:
FA.10 Need for PSA	The ESBWR complies with FA.10. This is addressed in PSR Section 2.6 and in detail in Chapter 19 of the DCD and the ESBWR PRA (Ref. 3).
FA.11 Validity	The ESBWR complies with FA.11. The extant Issue 2 of the ESBWR PRA (Ref. 3) currently reflects the design as defined by Rev 3 of the DCD. Any design change control process encompasses any need to change the PRA. DCD Sub-section 19.4.2, describes the PRA update process
FA.12 Scope and extent	The ESBWR will comply with FA.12. The current PSA as described in PSR Section 2.6 and DCD Chapter 19 only covers core sources of radioactivity. Non-core sources of radioactivity will be discussed in the PCSR submission.
FA.13 Adequate representation	This is addressed in PSR Section 2.6 and detailed in DCD Chapter 19.The details that address this principle are provided in NEDO 33201 (Reference 3).
FA.14 Use of PSA	The ESBWR complies with FA.14. PSA has been used as an integral tool in the ESBWR design process from its beginnings and continues to provide design insights. Details are provided in Chapter 19 of the DCD and the ESBWR PRA (Ref. 3). The PSA will be handed over to the licensee.
Target 7	The ESBWR will be lower than the BSO target. PSR Section 2.2 compares the target to the calculated core damage frequency and on that basis alone concludes that the Basic Safety Objective (BSO) will be met. Even if conservative Design Basis assumptions are used (see Table 2.2-1 of PSR), the calculated fatality rate for a person at the site boundary would be ~2x10-8/yr. Updated analyses, using UK conditions, will be provided in support of the PCSR.
Target 8	The ESBWR will meet or better the BSO targets, even using Design Basis assumptions. DCD Chapter 15 discusses Infrequent Events, in which the sum of the probabilities of events with potential consequences is $3x10^{-4}$/yr and the exposure to a person at the site boundary is 1.6 mSv TEDE (see also Table 2.2-1 of PSR). That betters the frequency table. Even if DBAs are conservatively set at the upper limit of $1x10^{-4}$/yr the conservative consequence of 23 mSv whole body exposure to a person at the site boundary (see again Table 2.2-1 of PSR) betters the frequency table. Updated analyses, using UK conditions, will be provided in support of the PCSR
Target 9	The ESBWR will meet or better the BSO target. As noted in PSR Section 2.6, the probability of exposing a person located at the site boundary to a large release (defined as 250 mSv) is 2×10^{-9}/yr. Therefore, GEH is confident that the BSO goal for exposure to the population surrounding the plant which

	might lead to 100 deaths will be met. A specific assessment against Target 9 will require to be undertaken by the Licence Applicant once a specific site has been chosen.

GEH acknowledges that the PSR (and its references) does not fully meet FA12 in that non-core sources of radioactivity are not included. A commitment is given to address this in the PCSR. The claims GEH make for FA10, FA 11 and FA 13 appear to be reasonable. For FA14, the claim that the PSA has been used in the design process appears to be well supported.

GEH's PSR does not specifically address SAPs numerical targets 7, 8 and 9. It does however provide a reasonable argument that their current analysis can be extended for Step 3 to show that the targets are bettered.

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

- Linked event and fault tree approach is acceptable in principle but detailed modelling not assessed at this step.
- External events – we will want to review the evidence for screening out of external flood, snow loading etc.
- Intersystem CCF not modelled – we will need to look more closely at the rationale and at potential significance (their arguments look promising, but we will need to review in more detail).
- Transition modes of operation are discussed – good point, but need to see how they are included in step 3.
- Multiple Greek Letter method for CCF – acceptable in principle, use of generic CCF factors where there is no data (nothing wrong with this but expect to see arguments for this assignation of the factors and sensitivity/importance analysis that shows this does not lead to effectively hidden unrealistic claims on overall reliability).
- Evidence of the use of importance values – good point, and again we will want to explore this in step 3.
- Model convergence addressed – a good point; we will look at evidence later.
- Identification of significant human actions for task analysis.
- Component failure data – applicability is discussed, but not assessed during this step.

3. Conclusions

GEH has provided an adequate overview of the approach, scope criteria and output of the PSA. In addition to the PSA information, GEH has identified and given commitments to address specific gaps in the PSA, notably non-core sources of radioactivity, and to re-analyse the PSA consequences for comparison with SAPs numerical targets. Reasonable arguments have been advanced that give a strong indication that targets will be met or bettered.

Our high level assessment of the claims for adequacy of the PSA and its output does not indicate any fundamental cause for concern.

A number of points for future consideration 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 GEH has provided sufficient information on the approach, scope criteria and output of the PSA for Step 2 of GDA.

5. References

1. ESBWR –UK. Preliminary Safety Report. Step 2. 26A7403AA. Rev 0 August 2007

2. ESBWR Design Control Document. Rev 3. Feb 2007

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

4. T/AST/051 Guidance on the purpose scope and content of Nuclear Safety Cases. http://www.hse.gov.uk/foi/internalops/NSD/tech_asst_guides/index.htm

5. ASME Standard for Probabilistic Risk Assessment for Nuclear Power Plant Applications. ASME-RA-Sb-2005.

6. HSE TQ ESBWR-000001.

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

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

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

10. GEH Response to TQ ESBWR-000001 – “Compliance with HSE SAPs” 5 November 2007.