REGULATORY OBSERVATION

REGULATOR TO COMPLETE

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Related RQ / RO No. and CM9 Ref: (if any)**:**	RQ-UKHPR1000-0227 CM9: 2020/100764 RQ-UKHPR1000-0308 CM9: 2019/215263 RQ-UKHPR1000-0425 CM9: 2019/253025 RQ-UKHPR1000-0576 CM9: 2020/83398
Observation title:	Suitable and sufficient Level 2 PSA for UK HPR1000
Lead technical topic: 15. Probabilistic Safety Analysis	**Related technical topic(s):** 2. Civil Engineering 19. Severe Accident Analysis

Regulatory Observation

Background

As per international standards, the objectives of a Probabilistic Safety Analysis (PSA) are to determine all significant contributing factors to the radiation risks arising from a facility or activity, and to evaluate the extent to which the overall design is well balanced and meets probabilistic safety criteria where these have been defined. The Level 2 PSA aims to provide the leakage pathways and the source terms from the various fuel damage sequences identified in the Level 1 PSA. Effectively, the Level 2 PSA identifies, evaluates and quantifies loads on the containment structure that can occur as a result of a severe accident.

Based on the review of the submitted Level 2 PSA [1], the associated model, and the supporting documentation, four RQs were raised by ONR. The full responses to the RQs were assessed and interactions with the requesting party were also held to understand the views of the Requesting Party (RP). Based on the assessment conducted to date, ONR is of the opinion that a number of specific shortfalls remain which will require more focussed effort by the RP to resolve in order to ensure a suitable and sufficient level 2 PSA is produced during GDA. These shortfalls are discussed in this regulatory observation and relate to:

- Definition of Large Releases
- Release category definitions and interface with the Level 3 PSA
- Containment fragility and supporting analysis
- Phenomenology analysis supporting the containment event tree modelling
- Equipment survivability
- Level 2 PSA ALARP review

The objective of this Regulatory Observation (RO) is to state ONR's expectations on a suitable and sufficient Level 2 PSA and provide guidance on the required actions for an effective resolution of the observation.

Relevant Legislation, Standards and Guidance

ONR's Safety Assessment Principles (SAP) [2], of which FA.12 states that:

Fault analysis: PSA	Scope and extent	FA.12
PSA should cover all significant sources of radioactivity, all permitted operating states and all relevant initiating faults.		

Where the offsite consequences are potentially significant, such as for an operating power reactor, the PSA should be at least to level 2 and include all external events (including beyond design basis events that could realistically lead to a significant offsite release (see also SAPs paragraph. 618).

Further guidance is provided in the associated Technical Assessment Guide: NS-TAST-GD-030 [3], inspectors must be able to form an opinion on adequacy of the Level 2 PSA and demonstration of ALARP based on results of the Level 2 PSA.

IAEA Specific Safety Guide, Development and Application of Level 2 Probabilistic Safety Assessment for Nuclear Power Plants [4], is also of relevance.

Regulatory Expectations

ONR expects the RP to produce and document a suitable and sufficient Level 2 PSA, which is aligned to relevant standards and guidance as appropriate. To date, ONR have identified the following specific shortfalls which will need to be resolved:

Definition of Large Release

TAG 30 [3] Appendix A1-3 lays out an expectation that the basis for the definition of 'large release' is presented and explained. ONR accepts that there is not a widely accepted criterion for 'large release' internationally. However, this would not exempt the RP from presenting a rationale and showing how that rationale leads to the grouping of release categories into 'large vs. non-large' that has been used in the PSA. Currently, the RP presents a list of release categories, with inadequate explanation. It is conceded that the lack of a standardised international approach gives the RP more flexibility in their approach to defining 'large release'. It is noted that a clear definition of 'large release' would assist in substantiation of the adequacy of the analysis performed and presentation of results. On occasions, the size of a release pathway (e.g., leak versus rupture of the containment, diameter of a non-isolated release pathway) or timing/duration of release may lead to classification of some release categories (or contributors to unrefined release categories) being reclassified as 'not large'.

The TAG expectations in relation to 'large release' are also similar to the requirements in the ANS/AMSE Level 2 PRA standard – e.g. supporting requirements under high level requirements ST-A and ST-D (documentation).

Release category definitions and interface with the Level 3 PSA

ONR notes that the RP has not included warning time (for emergency response actions) in the initial list of release category attributes. It is considered relevant good practise to consider the warning time attribute and disposition (as included or not included) and provide reasoned basis for its inclusion or exclusion from the release category definitions. Generally, a reasoned, documented approach is similarly expected for the other release category attributes. International guidance too refers the abovementioned high level requirements e.g. ANS/ASME trial use Level 2 standard (under requirements for source term) as well as Table 7 of IAEA SSG4 [4].

Containment fragility and supporting analysis

The regulatory expectations on containment performance analysis are presented in detail in the Table 1-3.3 of TAG-30 [3].

The current containment and supporting analysis, seems to focus only on ascertaining the containment rupture mode. However, it is a regulatory expectation [3] that the models used to characterise the loss of containment integrity (e.g. the models used for thresholds and / or leak before break) are explicitly stated and justified. It is also considered relevant good practise to include analysis of leakage from the containment as well as rupture of the containment. The possibility to reach a conclusion that leakage of the containment rather

than rupture is not ruled out, but it would need to be justified on the basis of sound and well documented analysis. It was also noted through interactions with the RP, that in the containment model some discontinuities and regions of potentially higher localised stress may not have been modelled in detail, as it is a global model to assess the 'rupture mode' of failure. Adequacy of the modelling performed should be justified by the RP. The regulatory expectation is that improved modelling is carried out, as necessary.

Phenomenology analysis supporting the Containment event tree modelling

The regulatory expectations on the accident progression modelling (or containment event trees) in Level 2 PSA are presented in TAG 30 [3] Appendix 1-3.4. It is an expectation that all potentially significant severe accident phenomena should be subject to a detailed probabilistic analysis. The analyses performed should always take account of the context in which the phenomena occur, i.e. the detailed evaluations as needed could be performed using boundary conditions that are representative of the accident sequences in which the modelled phenomena occur.

It would be appropriate to generate probability values which are plant/design specific, in order that the PSA is capable of providing plant/design specific insights. For example, an analysis of steam generator and hot leg creep rupture may indicate not only the relative probability of each of these occurring but also the detailed location at which a failure may occur. Should there be a credible probability of a hot leg nozzle (junction between vessel and hot leg) for creep rupture (captured through creep analysis resulting in an estimate of probability), it may impact where water inventory from the vessel discharges to e.g. to the reactor pit. Such a scenario may have knock-on effects on the accident progression.

In the modelling of the accident progression wherever arguments are embedded based on conservatism or otherwise, the values used need appropriate justification commensurate that of the overall claim on the design of the HPR1000 being of advanced generation III. The justifications are expected to be more detailed and based on a discussion of the physical processes involved and the response of engineered structures and safeguards to severe accident conditions.

It is an regulatory expectation that all rationales used in developing probability estimates and performing screening or prioritisation of phenomena need to be properly documented and presented so that ONR can assess their validity.

International guidance too refers to the expectation that phenomena would be analysed in detail on a plant/design specific basis to support quantification of a Level 2 PSA. See paragraphs 5.25 to 5.31 of IAEA SSG4 [4].

Equipment survivability

Regulatory expectation on equipment survivability is presented in TAG 30 [3] Appendix 1-3.4. ONR expects a structured assessment of the survivability (or operability) of equipment credited in the containment event trees. The results of this assessment may identify equipment which will not survive certain severe accident stresses or it may conclude that most or all equipment will continue to operate, in either case, appropriate analysis and/or justification is expected to support the development of a realistic PSA model.

The international guidance too presents the requirements towards equipment survivability analysis e.g. IAEA SSG4 [4] (page 34 and 35), which states: *The effect of the environmental conditions resulting from a severe accident on the survivability of components and systems credited within the Level 2 PSA model should also be assessed and, as appropriate, taken into account. Environmental impacts may include temperature, pressure, humidity and radiation conditions, as well as effects derived from energetic events (e.g. short term temperature and pressure spikes or impulse loadings from detonations or steam explosions).*

Level 2 PSA ALARP review

It is ONR's expectation in TAG 30 [3] that '*a demonstration that the risk of radioactive release for the NPP is ALARP is included*'. The ALARP review and discussion related to Level 2 PSA in the submission by the requesting party, was found to be inadequate.

It is ONR's expectation that a detailed discussion of accident contributions to the overall Level 2 PSA risk metrics, including an identification of vulnerabilities, opportunities for improvement of human response or other ALARP measures. For example, if human failure events are significant contributors to risk then a potential for

improvements to procedural guidance or severe accident management guidance would need to be addressed as ALARP measures. On occasions, priorities or cues for actions can be modified to make critical actions more reliable. A structured analysis and supporting discussion of these and other items is expected.

References

[1] Internal Events Level 2 PSA, CGN, 2018, CM9 2018/378858
[2] ONR, Safety Assessment Principles for Nuclear Facilities 2014 Edition, Rev. 1, January 2020. http://www.onr.org.uk/saps/index.htm
[3] ONR, NS-TAST-GD-030, Probabilistic Safety Assessment, Rev. 6, June 2019. http://www.onr.org.uk/operational/tech_asst_guides/index.htm
[4] IAEA, Specific Safety Guide No. SSG 4, Development and Application of Level 2 Probabilistic Safety Assessment for Nuclear Power Plants, 2010. www.iaea.org

Regulatory Observation Actions

RO-UKHPR1000-0047.A1 – Produce and document a suitable and sufficient Level 2 PSA

In response to this Regulatory Observation Action, GNSL should:

- Produce appropriate analysis and justifications to address all the shortfall discussed in the RO relating to:
    - Definition of Large Releases
    - Release category definitions and interface with the Level 3 PSA
    - Containment fragility and supporting analysis
    - Phenomenology analysis supporting the containment event tree modelling
    - Equipment survivability
    - Level 2 PSA ALARP review
- Document the analysis and justifications in a revised Level 2 PSA to be submitted as part of Step 4 assessment to ONR.

Resolution required by '*to be determined by General Nuclear System Resolution Plan*'

REQUESTING PARTY TO COMPLETE

Actual Acknowledgement date:	
RP stated Resolution Plan agreement date:	