Hitachi-GE Nuclear Energy, Ltd.
UK ABWR GENERIC DESIGN ASSESSMENT
Resolution Plan for RO-ABWR-0079
(UK ABWR Internal Hazards Turbine Disintegration Safety Case)

RO TITLE:	UK ABWR Internal Hazards Turbine Disintegration Safety Case	
REVISION :	0	
Overall RO Closure Date (Planned):		31st May, 2017
REFERENCE DOCUMENTATION RELATED TO REGULATORY OBSERVATION		
Regulatory Queries	RQ-ABWR-0769	
Linked ROs	-	
Other Documentation	-	

Scope of work :

Background

As part of GDA Step 3, Hitachi-GE presented its approach to the UK ABWR Turbine Disintegration Safety Case in the Topic Report on Internal Missiles Rev. 1, May 2015. ONR assessed this report and RQ-ABWR-0769 was raised (TRIM Ref. 2016/63463). The RQ summarised concerns on the proposed methodology, claims and arguments, ALARP and optioneering studies. During GDA Step 4, the safety case for turbine disintegration has been discussed in a number of Internal Hazards (IH) L4 meetings, where Hitachi GE presented progress to date (SE-GD-0455, SE-GD-0494, and SE-GD-0515) in response to ONR's concerns. ONR believe that Hitachi GE has made limited overall progress in this area and that the concerns are largely outstanding. The ONR expectations were reiterated and presented within RO-ABWR-0079.

Scope of Work

This Resolution Plan presents the actions and milestones required to address the Regulatory Observation (RO) (RO-ABWR-0079) regarding the UK ABWR Turbine Disintegration Safety Case.

Description of work:

RO-ABWR-0079.A1

A1.1 Clearly define and substantiate the number of missiles generated by a turbine disintegration event, and impact with buildings, during DB and BDB events.

Hitachi-GE will provide:

- Justification for the claim that the HP turbine failures will not cause the ejection of high energy missiles

from the casing, and that the LP turbines are the only source of high energy turbine missiles.

- Justification and substantiation for the credible failure modes of the LP turbines. The considered failure modes will includes, but not limited to following as needed :
    - Brittle failure due to propagation of defects, giving rise to normal overspeed failure.
    - Ductile failure due to failure of overspeed protection, giving rise to runaway overspeed failure. For each disc, calculations of rotational speed at which tensile strength will be exceed and ductile failure will occur.

- For each failure mode, the number of high energy missile fragments ejected will be derived and justified. The range of plausible missile ejection velocities and ejection angles will also be substantiated with consideration for AV series in the SAPs.

- A review of the GDA plot plan will be performed to determine which turbine missile fault sequences result in damage to each building (and SSCs) within the Design Basis (DB), and which fault sequences can be considered to be Beyond Design Basis (BDB) as explained within ONR Safety Assessment Principles [Ref-1]

  To be specific, Hitachi-GE will consider Design Basis fault (Tb disc disintegration) with a frequency of > 10^{-5}/yr, and Beyound Design Basis fault with a frequency less than 10^{-5}/yr according to the following SAP FA.2 para 628:

  628. Initiating faults identified in Principle FA.2 should be considered for inclusion in this list, but the following need not be included:

  (a) faults in the facility that have an initiating frequency lower than about 1 x 10-5 pa;

  Fault sequences (Turbine missile impact to building) will be analysed as Design Basis up to > 10^{-7}/yr, and below the frequency they will be qualified as Beyond Design Basis according to SAP para 631.

  631 Sequences with very low expected frequencies need not be included in the DBA. Judgement should be exercised in this regard, but for high hazard facilities, a fault sequence frequency of 1 x 10-7 pa would be a typical cut-off when applying design basis techniques.

A1.2 Develop a robust deterministic safety case

Hitachi-GE will:

- Develop a deterministic safety case for Design Basis turbine missile impact events identified in the ROA1. This will demonstrate the continued availability of fundamental safety functions through redundancy of design following loss of equipment from Design Basis missile impact faults sequences. Delivery of fundamental safety function will be described through backup systems for the only Beyond Design Basis (BDB) events if it is identified in ROA1 and the backup building can be credited in the BDB missile case. Furthermore, robust turbine design to prevent turbine disintegration (e.g. turbine trip systems, vibration monitoring system, etc.) will be also described to enhance the safety case.
- Consider consequential hazards such as fire, flooding, steam release which could also occur following a turbine disintegration event in Design Basis turbine missile impact events.
- Address common cause failure (e.g. “Loss of all RCW” or “Loss of all RSW” [Ref-2] as bounding faults) and cliff edge effects (e.g. If a building impact affects multiple divisions in the sensitivity case which induces more severe impact, to show the remaining safety features such as Backup Building or to show that the occurrence frequency is negligible.)
- Identify the plant states in which the turbine disintegration hazard is present (i.e. power operation) and equipment unavailability.
- Present appropriate claims, arguments and evidence.

- Present defence in depth arguments (i.e. mobile safety equipment as last leg of safety case).

A1.3 Provide an ALARP demonstration

Hitachi-GE will:

- Demonstrate ALARP of the proposed GDA site layout* with regard to the risk due to the turbine disintegration hazards. The demonstration will consider all of the factors which affect the relative positions of each of the GDA buildings and structures
- The demonstration will consider measures such as separation, redundancy, structural strengthening of buildings and other protection measures to demonstrate risk from turbine disintegration is reduced ALARP.

  *NOTE: The scope of this ALARP demonstration is only GDA site layout described in chapter 9 of UK ABWR PCSR. The demonstration will not commit any particular site layout in future site licensing.

Summary of impact on GDA submissions:

The Submission date of Topic Report on Turbine Disintegration Safety Case is extended from 20th December to 31st March.

Programme Milestones/ Schedule:

See attached Gantt Chart (Table 1)

Reference:

[Ref-1] "Safety Assessment Principles for Nuclear Facilities" (2014 Edition Revision 0).
[Ref-2] "Topic Report on Fault Assessment" (GA91-9201-0001-00022, UE-GD-0071 Rev.4, March 2016).

Table 1 RO-ABWR-0079 Gantt Chart

UK ABWRInternal Hazards Turbine Disintegration Safety Case Resolution Plan for RO-ABWR-0079			
Level	Action Title	Start	Finish
1	Regulator's Issues of RO		
1.1	ONR issue of RO	28-Nov-16	9-Dec-16
1.2	Hitachi-GE acknowledge RO	5-Dec-16	9-Dec-16
1.3	Hitachi-GE issue Resolution Plan	12-Dec-16	16-Dec-16
1.4	Regulator's confirm credibility of Resolution Plan	19-Dec-16	23-Dec-16
1.5	Regulator's publish RO and Resolution Plan	2-Jan-17	13-Jan-17
2	Action A1.1 - Substantiation of DB and BDB events	12-Dec-16	27-Jan-17
3	Action A1.2 - Development of Robust Deterministic Safety Case	30-Jan-17	31-Mar-17
4	Action A1.3 - Demonstration of ALARP	27-Feb-17	31-Mar-17
5	Regulator's Closure of RO		
5.1	Regulator's assessment	3-Apr-17	28-Apr-17
5.2	Regulator's publication of RO closure letter	1-May-17	12-May-17