

**Westinghouse UK**  
**AP1000® GENERIC DESIGN ASSESSMENT**  
**Resolution Plan for GI-AP1000-SI-01**  
**Avoidance of Fracture**

MAIN ASSESSMENT AREA	RELATED ASSESSMENT AREA(S)	RESOLUTION PLAN REVISION	GDA ISSUE REVISION
Structural Integrity	-	4	0

<b>GDA ISSUE:</b>	<p>Avoidance of Fracture - Margins Based on Size of Crack-Like Defects</p> <p>Demonstration of defect tolerance and the absence of planar defects in the components for which the likelihood of gross failure is claimed to be so low it can be discounted.</p> <p>This requires integration of qualified non-destructive examinations during manufacture and analyses for limiting sizes of crack-like defects using conservative material fracture toughness properties.</p>
<b>ACTION: GI-AP1000-SI-01.A1</b>	<p>Support assessment of the fracture analysis approach by providing adequate responses to any questions arising from assessment by ONR of documents submitted during GDA Step 4 but not reviewed in detail at that time. A number of important fracture assessment reports arrived much later in the Step 4 assessment timeframe than had been originally planned. ONR undertook a high level review of the reports to gain confidence in the approach but was unable to undertake a full assessment within the timescales allowed for GDA Step 4. This GDA Issue Action has been created to support the full assessment of these reports.</p> <p>Activities by Westinghouse should comprise:</p> <ul style="list-style-type: none"> <li>• Provide adequate responses to questions arising from ONR assessment of documents submitted during GDA Step 4 or in response to this Action.</li> </ul> <p>With agreement from the Regulator this action may be completed by alternative means.</p>
<b>ACTION: GI-AP1000-SI-01.A2</b>	<p>Demonstrate that there are qualifiable inspection techniques capable of detecting the limiting defects with adequate margin in a representative range components for which the likelihood of gross failure is claimed to be so low it can be discounted.</p> <p>A number of the important reports on inspection qualification arrived much later in the Step 4 assessment timeframe than had been originally planned. As a result ONR has been unable to undertake a full assessment of all inspection qualification reports within the timescales allowed for GDA Step 4, but has undertaken a high level</p>

	<p>review of the reports where a full assessment was not possible in order to gain confidence in the approach, This GDA Issue Action has been created to support the full assessment of the reports not yet fully assessed.</p> <p>Activities by Westinghouse should comprise:</p> <ul style="list-style-type: none"> <li>• Provide adequate responses to questions arising from ONR assessment of documents submitted during GDA Step 4 or as a result of this action.</li> </ul> <p>With agreement from the Regulator this action may be completed by alternative means.</p>
<b>ACTION: GI-AP1000-SI-01.A3</b>	<p>Provide formalised proposals for additional materials testing to underpin the fracture toughness values used in the fracture analyses.</p> <p>Westinghouse have acknowledged that testing over and above the standard testing required by ASME will be required to underpin the fracture toughness values used in the fracture analyses, however formalised proposals for additional materials testing have not yet been provided.</p> <p>Activities by Westinghouse should comprise:</p> <ul style="list-style-type: none"> <li>• Provide formalised proposals for additional materials testing to underpin the fracture toughness values used in the fracture analyses.</li> <li>• Provide adequate responses to questions arising from ONR assessment of documents submitted during GDA Step 4 or as a result of this Action.</li> </ul> <p>With agreement from the Regulator this action may be completed by alternative means.</p>
<b>RELEVANT REFERENCE DOCUMENTATION RELATED TO GDA ISSUE</b>	
<b>Technical Queries</b>	TQ-AP1000-1255
<b>Regulatory Observations</b>	RO-AP1000-18 RO-AP1000-19
<b>Other Documentation</b>	<p>DCP_JNE_000108 (UN REG WEC 00101) DCP_JNE_000561 (UN REG WEC 000533) UKP-GW-GLR-004 Rev. 1 UKP-MV01-Z0R-100 Rev. 3 UKP-MV01-Z0R-101 Rev. 1 UKP-MV01-Z0C-100 Rev. 1 UKP-MB01-Z0C-004 Rev. 1 UKP-MV20-Z0C-100 Rev. 1 WDI-TJ-1047 Rev. 1 WDI-TJ-1048 Rev. 1 WDI-TJ-1051 Rev. 1 WDI-TJ-1054 Rev. 1 WDI-TJ-1055 Rev. 1 WDI-TJ-1057 Rev. 1 Note: Only most recent revisions of documents are</p>

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### Scope of work:

The key activities which will need to be completed to close this GDA Issue are:

- Provide adequate responses to any questions arising from assessment by ONR of documents whether submitted during GDA Step 4 but not reviewed in detail at that time or submitted as part of this GDA Issue.
- Update:
  - The structural integrity classification document (UKP-GW-GLR-004)
  - The weld ranking document (UKP-MV01-Z0R-100)
  - The flaw evaluations for the selected weld locations (UKP-MV01-Z0C-100, UKP-MB01-Z0C-004, UKP-MV20-Z0C-100)
  - The manufacturing NDT inspection plans, if required, to address ONR comments (WDI-TJ-1047, WDI-TJ-1048, WDI-TJ-1051, WDI-TJ-1054, WDI-TJ-1055, WDI-TJ-1057)
  - The NDT inspection plan development process document
  - The conclusion on avoidance of fracture resulting from the reconciliation between the fracture mechanics assessments and outcome of the NDT work on detection capabilities.
- Provide formalised proposals for additional materials testing to underpin the fracture toughness values used in the fracture analyses.

### Description of work:

During Step 4 of GDA, a detailed assessment was carried out to determine the UK structural integrity classification of the primary components. The assessment concluded that the reactor pressure vessel (RPV), steam generator (SG), pressuriser, the main steam lines inside containment and dissimilar metals between ferritic vessels and austenitic safe ends should be classified as high safety significant, and austenitic welds between the safe ends and the reactor coolant loop piping should be classified as high integrity. As a result of this evaluation a sample of welds from these components were selected for which detailed fracture mechanics assessments and fatigue crack growth calculations were performed. Manufacturing NDT inspection plans for a sample of the welds were also generated. The manufacturing NDT inspection plans were reviewed and endorsed by an ENIQ Type 1 qualification body. The fracture mechanics and fatigue crack growth calculations were documented as follows: UKP-MV01-Z0C-100 (RPV and reactor coolant loop piping), APP-MB01-Z0C-004 (SG and main steam lines), and UKPMV20- Z0C-100 (pressuriser). The manufacturing NDT inspection plans were documented in the reports identified as WDI-TJ-XXXX, which are identified in the "Other Documents" box above.

Over the last years since the issuance of the iDAC to the **AP1000**<sup>®</sup> plant design in 2011, several developments impacting the present GDA issue occurred, both in support to business development efforts in other countries as well as in support of the construction

in China and in the US. The resolution of the GDA issue will thus integrate these recent developments.

The first development relates to further assessment of the impacts of postulated ruptures in leak before break pipes on the safety functions (reactivity control, protection of the primary system integrity, emergency core cooling, residual heat removal, containment function), three barriers to release (fuel cladding, reactor coolant pressure boundary, containment barrier), and essential structures which have been carried out. This assessment will be reflected in the review and through the potential update of UKP-GW-GLR-004 (**AP1000** plant UK Structural Integrity Classification).

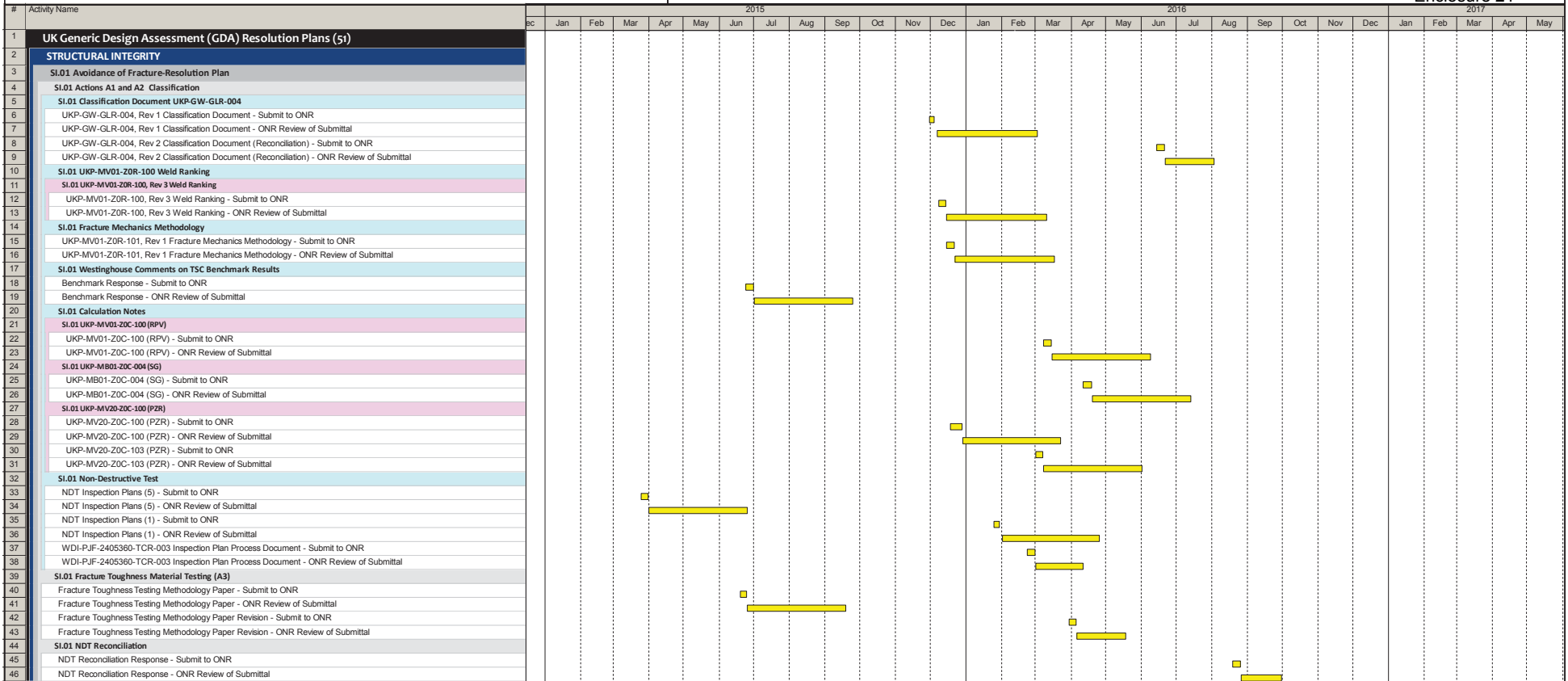
The second set of developments relates to design documents that have been updated to support design implementation and construction in China and the US. Design documents are used as input in the fracture mechanics and fatigue crack growth calculations which will consequently require to be updated. It is proposed to perform this update in parallel to ONR review of the general methodology used in these calculations. As this update is performed, the changes in classification of Class 1 SSCs, if any, identified during the update of UKP-GW-GLR-004 (**AP1000** plant UK Structural Integrity Classification) will be addressed and incorporated. This update thus entails an update of the weld / location ranking document as well as the fracture mechanics assessments that support the demonstration of the avoidance of fracture for representative sample locations. This update will be performed concurrently with the review and potential update of UKP-GW-GLR-004 (**AP1000** plant UK Structural Integrity Classification). Regarding the NDT aspects associated with the demonstration of the avoidance of fracture, the primary work to support closure of GDA issue will be to respond to questions and provide ONR with clarifications as the detailed assessment is undertaken.

Finally, Westinghouse has responded to TQ-**AP1000**-1255, which links the manufacturing inspection plans to the fracture mechanics calculations. Based on feedback from ONR, Westinghouse has provided supplemental information to support this response. This information was captured in DCP\_JNE\_000572 (UN REG WEC 000544). The key information from these responses has been captured in Chapter 20 of the **AP1000** plant PCSR. These documents will be updated in accordance with the outcome of the updates and reviews of both the fracture mechanics related and the NDT related documents.

In order to completely address the GDA issue, Westinghouse recognises that, for HSS components, in addition to undertaking detailed fracture mechanics assessment and performing qualified manufacturing inspections there is a need to perform additional material testing beyond what is required by the ASME code to support the fracture toughness values assumed in the fracture mechanics analysis. During GDA, it has been agreed upon that an outline of the additional material testing for the HSS components should be developed. The initial Westinghouse proposal is outlined in DCP\_JNE\_000561, which was provided to ONR on 28 March, 2011. Through interaction with ONR, Westinghouse anticipates there will be a need to revise this proposal and provide additional details such as those identified in the draft Step 4 report to satisfactorily address this action.

<b>Schedule/ programme milestones:</b>
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Please see the following page for the schedule.
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**Methodology:**

**Action 1:** The methodology for performing the fracture mechanics assessment is based on R6. The methodology for the specific application of the R6 procedure to **AP1000** components is documented in UKP-MV01-Z0R-101.

**Action 2:** The manufacturing inspection plans developed are based on the guidelines for preparation of technical justifications as described in ENIQ Recommended Practice 2.

**Action 3:** The fracture toughness testing for HSS materials is based on the ASME code with additional fracture toughness testing to be specified to validate the manufactured components exhibit the fracture toughness assumed in the fracture mechanics assessments.

**Methodology will address comments raised by the ONR during Step 4.**

**Justification of adequacy:**

**Action 1:** The fracture mechanics analysis provided is based on a developed approach that has already been reviewed by ONR and found to be generally acceptable. The results of this analysis generally demonstrate that limiting defect sizes will be detectable for the sample of welds analysed based on an informed weld ranking process.

**Action 2:** The manufacturing inspection plans developed are based on an industry recognised methodology and have been reviewed and endorsed by an independent inspection body. This provides confidence that further ONR review is likely to also find the plans acceptable.

**Action 3:** The additional fracture toughness testing that will be proposed for HSS materials will support the fracture toughness values assumed in the fracture mechanics analysis for the HSS components. The feedback from ONR on the current proposal highlights that the approach proposed is positive and a resolution can be reached. This provides confidence that a revised proposal can be made which will be deemed adequate.

Timely closure of the actions defined in this Issue will be reached through maintaining quality interaction with ONR and using existing processes to assure closure of open items.

**Impact assessment:**

Resolution of this GDA Issue has the potential to impact Chapter 20 of the PCSR. The results of the fracture mechanics assessments, the manufacturing inspection plans, and the additional material testing are captured in Chapter 20 of the PCSR. Based on the resolution of this Issue updates to the PCSR may be required.