Office for Nuclear Regulation

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WESTINGHOUSE AP1000® GENERIC DESIGN ASSESSMENT

GDA ISSUE

JUSTIFICATION OF NOVEL FORM OF STRUCTURE FOR THE STEEL/ CONCRETE COMPOSITE WALLS AND FLOORS KNOWN AS CA MODULES

GI-AP1000-CE-01 REVISION 0

<table>
<tr><td>Technical Area</td><td colspan="3">CIVIL ENGINEERING</td></tr>
<tr><td>Related Technical Areas</td><td colspan="3">None</td></tr>
<tr><td>GDA Issue Reference</td><td>GI-AP1000-CE-01</td><td>GDA Issue Action Reference</td><td>GI-AP1000-CE-01.A1</td></tr>
<tr><td>GDA Issue</td><td colspan="3">Definition and justification of the novel design used for the steel/concrete composite system proposed for the CA modules within the nuclear island.</td></tr>
<tr><td>GDA Issue Action</td><td colspan="3">CONSOLIDATED SET OF DESIGN DOCUMENTS
The current set of documents submitted by Westinghouse range from high level documents to TQ responses. The UK Regulator requires a consolidated set of documentation to adequately describe the structure that is the basis of Westinghouse’s submission under the GDA process. This is to ensure any changes made after an iDAC/DAC is issued are easily identifiable.
This action requires Westinghouse to provide a consolidated set of formal documents that explicitly define the design submission. This should include, but not necessarily be limited to the following:
A single overarching document that summarises the structure submitted and the design methodology used for the UK GDA submission. This should draw together all the various submissions on the design methodology for the CA modules that have been submitted under GDA Step 4, and should include the UK Regulator additional requirements..
A document map and a list of the complete set of formal documents that define the structural layout, materials, form, the design methodology and the substantiation /calculations for the CA modules.
Adequate responses to any questions arising from assessment by ONR of documents submitted at the end of GDA Step 4 but not reviewed in detail at that time.
Sufficient drawings/mark ups to describe the structural layout and form of the CA Modules submitted under GDA.
With agreement from the Regulator this action may be completed by alternative means.</td></tr>
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Technical Area	**CIVIL ENGINEERING**		
Related Technical Areas	None		
GDA Issue Reference	**GI-AP1000-CE-01**	**GDA Issue Action Reference**	**GI-AP1000-CE-01.A2**
GDA Issue Action	ADDITIONAL ACCEPTANCE CRITERIA FOR OUT OF PLANE SHEAR CAPACITY For the current demand versus capacity utilisations for the majority of locations, the design method used is acceptable but is not universally applicable for higher utilisations. Therefore, additional limitations/acceptance criteria must be included in the GDA design methodology to limit the level of utilisation. This action requires Wesinghouse to provide additional acceptance criteria for the proposed design methodology to ACI 349-01 for out of plane shear, which shall include, but not be limited to, the following: • A reduction in the design value for Vc for the concrete contribution to shear strength, below the allowable value in ACI 349-01. Justification should be provided for the chosen limit of Vc. • Confirm the limit on Vc, above which shear reinforcement will be added (as stated in APP-GW-SUP-001) and provide design substantiation for the reifnrocement provided. The key design methodology document must therefore clearly state that this margin should not be encroached upon by future design development or changes. With agreement from the Regulator this action may be completed by alternative means.		

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<tr><td>GDA Issue Action</td><td colspan="3">ADDITIONAL ACCEPTANCE CRITERIA FOR IN-PLANE SHEAR CAPACITY WHEN CONSIDERED WITH OTHER LOADS

The current demand versus capacity utilisations, the design method used is acceptable but, it is not universally applicable to combinations of high in-plane shear, moment and axial load. Therefore, additional limitations/acceptance criteria must be included in the GDA design methodology.

This action requires Westinghouse to provide additional justification for the proposed design methodology for in-plane shear when combined with other loads, as follows:

1) Provide further calculations for in-plane shear to alternative codes:
JEAG 4618
draft AISC N690 App N9
any others deemed applicable by Westinghouse, including first principles.
in order to justify that the plates still have sufficient margin above the demand levels when these codes are used for design.

These calculations should consider all the coincident loads present for each critical loadcase, such as those described in other actions of this pGI. These calculations should also include the symmetric sharing of in plane shear stress used by these codes.

2) Following the above, provide the limitations on combined loadings (e.g. moment and axial load) for which the Westinghouse methodology of asymmetric sharing of in-plane shear stress is applicable.

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Technical Area	**CIVIL ENGINEERING**		
Related Technical Areas	None		
GDA Issue Reference	**GI-AP1000-CE-01**	**GDA Issue Action Reference**	**GI-AP1000-CE-01.A4**
GDA Issue Action	ADDITIONAL SUBSTANTIATION OF SHEAR CONNECTION Provide the following substantiation with respect to the shear connectors: • Justify that the strength reduction factor of 0.75 for shear studs taken from ACI 349-01 B.4.4 is appropriate and provide sensitivity of this. • Justify the 125kips capacity for the channel acting as a shear lug, calculated to B.4.5.2 of ACI 349-01. Also justify the length of the channel (8inches) used in calculating the bearing onto the concrete. • Justification for omission of any tension force in the shear studs (resulting from restraining the plate) is required, and, if a tension force is required, the effect on the stud shear capacity needs to be considered. • Provide calculations for the development length to justify the shear for the full range of wall thicknesses and incorporating the outcomes of the above. If the development length is smaller than the lesser of three times the wall thickness or 9 feet, a first-principles approach that considers shear flow and locally applied forces in the horizontal and vertical direction may be acceptable. With agreement from the Regulator this action may be completed by alternative means.		

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<tr><td>GDA Issue Action</td><td colspan="4">JUSTIFICATION OF CONNECTIONS FOR CA MODULES
Westinghouse is required to submit the final concept details for a sample of generic connections for the CA Modules. This should include detail drawings and calculations. The calculations should clearly state the failure mechanisms of the connections considered and the effects on the ductile behaviour of the whole structure.
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Related Technical Areas		None	
GDA Issue Reference	**GI-AP1000-CE-01**	**GDA Issue Action Reference**	**GI-AP1000-CE-01.A6**
GDA Issue Action	JUSTIFICATION OF THE ABILITY OF SC TO WITHSTAND THERMAL LOADCASE Westinghouse is required to justify how the thermal analysis models transient thermal effects, such as environmentally induced transients and how these are combined with other mechanical loads in the design load cases. Westinghouse is also required to provide further justification that vapour pressure within the CA modules resulting from high thermal loading will not affect the structure's ability to perform its safety function (refer to action A7). With agreement from the Regulator this action may be completed by alternative means.		

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<tr><td>GDA Issue Action</td><td colspan="3">JUSTIFCATION OF THE ABILITY OF SC TO WITHSTAND FIRE
Westinghouse is required to provide evidence on the effect of fire on the CA Modules generally, not only where they are claimed as fire barriers.
The effect of fire on the CA Modules needs to be quantified, such that the risk to structures supporting Category 1 nuclear safety plant can be assessed, Specifically:
• Loss of the faceplate – the level of fire that will achieve this and the resulting effect on the load carrying capacity of the remaining structure need to be quantified.
• Build up of vapour pressure inside the wall due to fire. Westinghouse considers this a local effect but ONR believes this is not the case for a full room burn.
• Overall response of the whole structure to the temperatures in the fire, i.e. combination of induced thermal moment with other loads and deflections.
The response to GI-AP1000-IH.1.A1 will be key in answering the above. However, IH.1.A1 specifically refers to walls and floor claimed as fire barriers. This action is concerned with the structural stability of all the CA Modules following a potential fire. Therefore, a quantification of the fire magnitude that the structure can withstand without structural collapse shall be provided.
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<tr><td>GDA Issue Action</td><td colspan="3">LONG TERM RELIABILITY
Westinghouse is required to provide further substantiation on the long term reliability as follows:
• Assess the effects on the calculation of HCLPF for the in-containment CA Modules, based on the completion of actions A2 to A4 of this GDA Issue.
• Provide any other relevant reliability calculations, e.g. similar to Eurocodes.
With agreement from the Regulator this action may be completed by alternative means.</td></tr>
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