Office for Nuclear Regulation

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WESTINGHOUSE AP1000® GENERIC DESIGN ASSESSMENT

GDA ISSUE

DIVERSITY FOR FREQUENT FAULTS

GI-AP1000-FS-03 REVISION 0

Technical Area		**FAULT STUDIES**	
Related Technical Areas		Control and Instrumentation Probabilistic Safety Assessment	
GDA Issue Reference	**GI-AP1000-FS-03**	**GDA Issue Action Reference**	**GI-AP1000-FS-03.A1**
GDA Issue	Demonstration of functional diversity for frequent faults.		
GDA Issue Action	Implement the revised moderator temperature coefficients assumed in the ATWS analysis reported in UKP-GW-GLR-016 within the AP1000 safety analysis checklist document WCAP-9272-P-A. These should be referenced within the PCSR as the limits and conditions as the relevant core parameters identified by the fault studies for ultimate incorporation within the technical specifications for the AP1000 (see also GDA issue GI-AP1000-FS2). Alternatively, Westinghouse may wish to provide a revised analysis with parameters consistent with those presented in Chapter 4 of the DCD. With agreement from the Regulator this action may be completed by alternative means.		

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GDA Issue Reference	**GI-AP1000-FS-03**	**GDA Issue Action Reference**	**GI-AP1000-FS-03.A2**
GDA Issue Action	• Demonstrate protection for the excessive increase in secondary steam flow fault at full power for both the case with successful reactor trip and the case with failure of the reactor to trip due to either mechanical failure of the rods to insert or failure of the reactor protection system. Or • Propose design changes to provide protection against the excessive increase in secondary steam flow faults. In the European DCD and the UKP-GW-GLR-016, the analysis of excessive increase in secondary steam flow with failure to trip is limited to consideration of the condition II event, which limits flow increases to less than 10% at full power. Westinghouse has not presented any analysis for a more challenging excessive increase in secondary steam flow fault at full power. Westinghouse will need to demonstrate adequate diverse protection for such faults for both the case with successful reactor trip and for the case with failure of the reactor trip due to either mechanical failure of the rods to insert or failure of the reactor protection system. In particular, in the case of PMS failure, Westinghouse will have to demonstrate that there are adequate trip parameters on the diverse actuation system (DAS). Any design modifications identified as necessary will need to complete the six-stage modification process for inclusion in the PCSR. With agreement from the Regulator this action may be completed by alternative means.		

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Related Technical Areas	Control and Instrumentation Probabilistic Safety Assessment		
GDA Issue Reference	**GI-AP1000-FS-03**	**GDA Issue Action Reference**	**GI-AP1000-FS-03.A3**
GDA Issue Action	• Demonstrate the provision of diverse protection against rod misplacement faults including one or more dropped rods. Or • Propose design changes to protect against the consequences of such a fault. The analysis of these faults presented by Westinghouse assumes that although the protection and monitoring system (PMS) is unavailable the flux monitoring system remains available to the plant control system (PLS) and provides protection against these faults. This fails to demonstrate any diversity within the flux protection system. For this reason, Westinghouse are requested to provide explicit transient analysis using design basis analysis techniques for these faults to demonstrate that the diverse actuation system (DAS) is functionally capable of protecting against this fault. A modification to include the provision of a negative rate flux trip signal on the diverse actuation system (DAS) is to be considered as a possible ALARP measure. The design of any proposed modification will need to complete the six-stage modification process for inclusion with the PCSR. Note this action is also closely related to GDA issue GI-AP1000-FS.4. With agreement from the Regulator this action may be completed by alternative means.		

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Technical Area		**FAULT STUDIES**	
Related Technical Areas		Control and Instrumentation Probabilistic Safety Assessment	
GDA Issue Reference	**GI-AP1000-FS-03**	**GDA Issue Action Reference**	**GI-AP1000-FS-03.A4**
GDA Issue Action	Implement the proposed modification to provide a high hot leg temperature trip on the Diverse Actuation System to protect against the RCCA bank withdrawal fault at full power with failure of the PMS. Westinghouse has identified that a modification is required to provide a reactor trip signal on high hot leg temperature on the Diverse Actuation System. This is to protect against a RCCA bank withdrawal fault at full power with failure of the Protection and Monitoring System (PMS). The design for the proposed modification will need to complete the six-stage modification process for inclusion within the PCSR. With agreement from the Regulator this action may be completed by alternative means.		

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Technical Area		**FAULT STUDIES**	
Related Technical Areas		Control and Instrumentation Probabilistic Safety Assessment	
GDA Issue Reference	**GI-AP1000-FS-03**	**GDA Issue Action Reference**	**GI-AP1000-FS-03.A5**
GDA Issue Action	Demonstrate protection against a complete loss of forced flow fault as a result of perturbations in grid frequency for both the case with successful reactor trip and the case with failure of the reactor trip due either mechanical failure of the rods to insert or failure of the reactor protection system. In the Westinghouse submissions assessed, the analysis of complete loss of flow fault with failure to trip is limited to consideration of initial conditions associated with nominal full power conditions. Westinghouse has not presented any analysis considering the effect of grid perturbations on the initial reactor conditions. It is likely that in such circumstances, the reactor control system will attempt to increase power to compensate for any grid frequency reduction. This will perturb both the initial reactor power and the initial power distribution of the core including the axial offset. Westinghouse will need to demonstrate adequate diverse protection for such faults for both the case with successful reactor trip and for the case with failure of the reactor trip due to either mechanical failure of the rods to insert or failure of the reactor protection system. In particular, in the case of PMS failure, Westinghouse will have to demonstrate that there are adequate trip parameters on the diverse actuation system (DAS). Any design modifications identified as necessary will need to complete the six-stage modification process for inclusion in the PCSR. With agreement from the Regulator this action may be completed by alternative means.		

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Related Technical Areas		Control and Instrumentation Probabilistic Safety Assessment	
GDA Issue Reference	**GI-AP1000-FS-03**	**GDA Issue Action Reference**	**GI-AP1000-FS-03.A6**
GDA Issue Action	• Demonstrate the provision of diverse protection against loss of CVS following a normal reactor trip and xenon decay including demonstration of diversity to operator action. Or • Provide a consequence analysis demonstrating the acceptability of the design against HSE's accident frequency targets. After every reactor trip from full power there is an eventual decay in the level of xenon poisoning within the reactor core. The resultant swing in reactivity needs to be compensated for through increasing the boron concentration in the reactor to ensure an adequate shutdown margin. While the core make-up tanks (CMTs) and the in-containment refuelling water storage tank (IRWST) systems provide two diverse sources of borated water should the operator fail to ensure adequate shutdown margin using the Chemical and Volume control system (CVS), both these systems are also dependent upon operator action for actuation. Although timescales are long (many hours), this implies a combined human reliability of 1×10^{-7} per demand to meet the design basis target. For this reason, Westinghouse is to provide an ALARP study into the feasibility of automatically actuating the CVS to inject borated water after every reactor trip and for the CMTs to be automatically actuated following failure of the CVS. Alternatively, Westinghouse may wish to provide a consequence analysis of what would happen should the operator fail to ensure adequate shutdown margin. With agreement from the Regulator this action may be completed by alternative means.		

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Related Technical Areas		Control and Instrumentation Probabilistic Safety Assessment	
GDA Issue Reference	**GI-AP1000-FS-03**	**GDA Issue Action Reference**	**GI-AP1000-FS-03.A7**
GDA Issue Action	Analyse the homogenous boron dilution fault occurring in shutdown conditions with failure of the protection and monitoring system to demonstrate that there is diverse protection against the fault. This fault would be very difficult to detect should there be a failure of the flux instrumentation or the protection and monitoring system (PMS). For this reason, Westinghouse is to provide explicit transient analysis using design basis analysis techniques for this fault to demonstrate that the diverse actuation system (DAS) is functionally capable of maintaining adequate margin to departure from nucleate boiling. A modification to include the provision of a boron dilution block signal and a CMT actuation signal on the DAS (actuated by low doubling time and/or high source-range flux level) is to be considered as a possible ALARP measure. The design of any proposed modification will need to complete the six-stage modification process for inclusion within the PCSR. Westinghouse also needs to identify as a limit and condition for the reactor core design technical specifications the limiting moderator reactivity coefficients assumed in the analysis. With agreement from the Regulator this action may be completed by alternative means.		