

**Westinghouse UK**  
**AP1000® GENERIC DESIGN ASSESSMENT**  
**Resolution Plan for GI-AP1000-ME-01**  
**Squib Valve Concept and Design Substantiation**

MAIN ASSESSMENT AREA	RELATED ASSESSMENT AREA(S)	RESOLUTION PLAN REVISION	GDA ISSUE REVISION
Mechanical Engineering	PSA Fault Studies C&I	6	1

<b>GDA ISSUE:</b>	<p>While undertaking the GDA the availability of adequate arguments and evidence for the selection, system incorporation and qualification of the squib valve designs has been limited.</p> <p>Westinghouse is required to issue appropriate approved documentation that provides adequate arguments and evidence for their selection, equipment design, and associated system design.</p>
<b>ACTION: GI-AP1000-ME-01.A1</b>	<p>Generate and issue appropriate approved documentation that provides adequate arguments and evidence for the squib valve selection.</p> <p>ONR considers a GDA can not be completed without the design being finalised and the availability of auditable and approved design documentation that demonstrates the valve selection at the concept stage is ALARP.</p> <p>ONR's expectation is for Westinghouse to finalise their designs and provide the formal Summary Report, which is to include the appropriate arguments and evidence to demonstrate the squib valve selection is ALARP, with sufficient evidence of optioneering, and the design has followed a robust design process.</p> <p>With agreement from the Regulator this action may be completed by alternative means.</p>
<b>ACTION: GI-AP1000-ME-01.A2</b>	<p>Generate and issue appropriate approved documentation to justify the squib valve detailed component designs are able to achieve the safety case requirements and assumptions.</p> <p>ONR considers a GDA can not be completed, without the designs being finalised and the availability of approved design documentation that demonstrates the valve detailed component designs meets the safety case requirements.</p> <p>ONR's expectation is for Westinghouse to finalise their designs and provide the formal approved design justification, which includes the appropriate arguments and evidence that the valves' detailed component</p>

	<p>designs meet the safety functional requirements. With agreement from the Regulator this action may be completed by alternative means.</p>
<p><b>ACTION: GI-AP1000-ME-01.A3</b></p>	<p>Generate and issue appropriate approved documentation to justify that the squib valve interfacing system designs (e.g. supports, interfacing pipework etc.) are able to achieve the safety case requirements and assumptions. ONR considers a GDA can not be completed, without the designs being finalised and the availability of approved design documentation that demonstrates each valve is integrated into its associated system, and meets the safety case requirements. ONR's expectation is for Westinghouse to finalise their designs and provide the formal approved design justification, which includes the appropriate arguments and evidence that each valve is integrated into its associated system, and meets the safety functional requirements. With agreement from the Regulator this action may be completed by alternative means.</p>
<p><b>ACTION: GI-AP1000-ME-01.A4</b></p>	<p>Generate and issue appropriate approved documentation to demonstrate the surveillance and EMIT regime is able to achieve the safety case requirements and assumptions. Given the 60 year design life of the <b>AP1000</b><sup>®</sup> plant, and the inability to stroke the squib valves during in service inspections, ONR considers that Westinghouse needs to specify a robust surveillance regime to ensure that the squib valve designs are capable of delivering their safety functions in accordance with the requirements of the safety case. ONR's expectation is for Westinghouse to finalise their designs and provide the formal approved design justification, which is to include an adequate surveillance and EMIT regime specification that is commensurate to the <b>AP1000</b> NPP safety case and the safety role for each squib valve type. With agreement from the Regulator this action may be completed by alternative means.</p>
<p><b>ACTION: GI-AP1000-ME-01.A5</b></p>	<p>Westinghouse shall address the listed points, which have been identified as gaps in the safety justification of the squib valve designs as a result of undertaking the GDA from a Mechanical Engineering perspective:</p> <ul style="list-style-type: none"> <li>• Westinghouse shall demonstrate the FMEA for the final squib valve designs includes an independent technical reviewer.</li> <li>• Westinghouse shall generate and issue an</li> </ul>

	<p>ALARP justification that each squib valve type as proposed is adequate to achieve its safety functional requirements and its design intent, in terms of position indication during normal operation.</p> <ul style="list-style-type: none"> <li>• Westinghouse shall generate and issue an ALARP statement on how the bracket design achieves the design intent of a guard.</li> <li>• Westinghouse shall generate and issue an ALARP statement on how the 14 inch ADS squib valve design achieves its design intent without the requirement of a cover.</li> <li>• Westinghouse shall provide confirmatory evidence of the described poka yoke features within the 8 inch valve detailed drawings.</li> <li>• Westinghouse shall provide evidence that adequate arrangements are in place to control and manage the supply of the squib valves, and tolerances for the technical parameters of critical components.</li> <li>• Westinghouse shall provide evidence that the squib valve Equipment Qualification tests adequately demonstrate that each squib valve type is able to achieve its design intent.</li> </ul> <p>With agreement from the Regulator this action may be completed by alternative means.</p>
<p><b>ACTION: GI-AP1000-ME-01.A6</b></p>	<p>Westinghouse shall address the listed points, which have been identified as gaps in the safety justification of the squib valve designs as a result of undertaking the GDA from a Pyrotechnics perspective:</p> <ul style="list-style-type: none"> <li>• Westinghouse shall issue document (#35 (APP-PV70-GER-001)).</li> <li>• Westinghouse shall generate and issue the arguments and evidence regarding the following items:       <ul style="list-style-type: none"> <li>○ Justify why different rationales have been adopted to select the pyrotechnic substances for the initiator and booster.</li> <li>○ Demonstrate why good practice from aerospace is relevant within nuclear plants.</li> <li>○ Justify the choice regarding the binder; notably, a comprehensive and well-argued analysis and supporting evidence requires to be provided.</li> <li>○ Provide results of radiation exposure of the propellants, and the demonstration that reference environments used in the past are sufficiently similar to the environment expected</li> </ul> </li> </ul>

	<p>within <b>AP1000</b> reactors.</p> <ul style="list-style-type: none"><li>○ The relevance of the Summary Report, Appendix C in substantiating the pyrotechnics aspects.</li><li>● Westinghouse shall generate an argument that demonstrates that:<ul style="list-style-type: none"><li>○ Test data from carrying out initiator tests by others provides suitable reliability evidence for use with the <b>AP1000</b> design given the variance in the <b>AP1000</b> initiator design and the use of a binder.</li><li>○ Sufficient and relevant test evidence exists for the <b>AP1000</b> booster design to support its reliability claim.</li></ul></li><li>● Westinghouse shall clarify the relevance and purpose of Development Report 17399(01)DR to the ballistic analysis.</li><li>● Westinghouse shall provide:<ul style="list-style-type: none"><li>○ A review of the advantages and disadvantages of each considered initiator concept.</li><li>○ An explanation of the selection criterion for the initiator ignition concept.</li><li>○ The analysis to support the selection of each considered initiator concept.</li></ul></li><li>● Westinghouse shall generate and issue the justification that:<ul style="list-style-type: none"><li>○ Cartridges will not be liable to react to any electromagnetic environments, with adequate consideration to resonant harmonics that they will be exposed to throughout their life cycle.</li><li>○ EMIT requirements for EMI protection is suitable and adequate.</li></ul></li><li>● Westinghouse shall generate and issue the justification that all the relevant UK requirements for the design of cartridges and termination units have been adequately covered by the implementation of US standards and guidance.</li><li>● Westinghouse shall generate and issue the following documentation:<ul style="list-style-type: none"><li>○ Finalised requirements regarding the propellant neutron testing, by justifying the energy, the intensity, and the duration of exposure.</li><li>○ Qualification results, which includes the substantiation that actuators as proposed are adequate to achieve their safety functional requirements and their design intent.</li></ul></li><li>● Westinghouse shall provide the justification that C&amp;I faults do not impact the properties of the</li></ul>
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initiator bridgewire.

- Westinghouse shall generate and issue a further analysis to confirm that, in case of a fire in adjacent containment fire zones, the present design of cartridge peak temperature is maintained below the propellant auto-ignition temperature with an adequate margin. To date fires in surrounding rooms have not adequately considered.
- Westinghouse shall generate and issue comprehensive justification that:
  - - The safeguards that are provided within the termination units and cabinet interface modules are sufficient to reduce the spurious actuation probability at a level coherent with other potential sources of LOCA.
  - The absence of SADs within the pyrotechnic chain achieves the correct balance between the two competing demands of preventing spurious actuation of the squib valves, and yet ensuring they have a high reliability of actuation on demand to support the passive core cooling function.
- In respect of the electrical current values Westinghouse shall provide:
  - A review of the advantages and disadvantages of each considered value.
  - An explanation of the selection criterion for the electrical current value.
  - The analysis to support the selection of each considered option.
- Westinghouse shall generate and issue the justification that each squib valve termination unit type and terminal block is designed adequately to achieve its safety functional requirements and its design intent. This justification shall include:
  - The comprehensive list of safety and functional requirements, including surveillance monitoring requirements.
  - The detailed description of design solutions.
  - The qualification programme and its results.
  - The description of EMIT provisions required to maintain safety functions.

With agreement from the Regulator this action may be completed by alternative means.

<p><b>ACTION: GI-AP1000-ME-01.A7</b></p>	<p>Westinghouse shall address the listed points, which have been identified as gaps in the safety justification of the squib valve designs as a result of undertaking the GDA from a Surveillance and EMIT perspective:</p> <ul style="list-style-type: none"> <li>• Westinghouse shall provide the detailed evidence that an adequate visual inspection can be carried out on the 8 inch squib valve design.</li> <li>• Westinghouse shall explicitly capture in the consolidated PCSR the requirement that if a cartridge taken out of a plant fails its test then all cartridges from that batch should be replaced.</li> <li>• Westinghouse shall generate and issue the justification that electrical testing EMIT requirements result from a process which has considered and analysed each option, with a suitable selection rationale. This justification shall demonstrate specifically the following items: <ul style="list-style-type: none"> <li>○ Testing every 24 months is sufficient to prove a high level of availability of the safety system using squib valves.</li> <li>○ Insulation testing does not reduce the risk of failure.</li> <li>○ Electrical currents supplied by digital voltmeters always stay lower than the threshold defined in bridgewire resistance test.</li> <li>○ Reconnecting initiators to a circuit under voltage does not increase the risk.</li> </ul> </li> <li>• Westinghouse shall identify in the safety case that every cartridge subjected to a significant mechanical shock loading during its lifetime must not be used, as a safety requirement. As part of this, Westinghouse shall also define the acceptance parameters in respect of this criterion.</li> <li>• Westinghouse shall generate evidence of recommending an adequate surveillance and EMIT regime that is commensurate to the <b>AP1000</b> NPP safety case assumptions and the safety role of each squib valve type.</li> </ul> <p>With agreement from the Regulator this action may be completed by alternative means.</p>
<p><b>RELEVANT REFERENCE DOCUMENTATION RELATED TO GDA ISSUE</b></p>	
<p><b>Technical Queries</b></p>	<p>Various</p>
<p><b>Regulatory Observations</b></p>	<p>RO-AP1000-036</p>
<p><b>Assessment Reports</b></p>	<p>Step 4 - Mechanical Engineering Assessment of the Westinghouse <b>AP1000</b></p>

<b>Standards and Guidance</b>	SAPs – ECS.5, ERL series, EMT series, EQU.1; TAGs - Maintenance, Inspection & Testing SSCs
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<p><b>Scope of work:</b></p> <p>The ONR is requesting adequate arguments and evidence for the selection, system incorporation and qualification of the <b>AP1000</b> squib valve designs. This also includes the definition of an adequate surveillance and EMIT regime. Westinghouse is providing sufficient documentation via a number of documents as described below. All documents will be approved and verified following the Westinghouse procedure for, document control, and reflect the final squib valve design.</p> <p>APP-PV70-GER-002, “Squib Valve (PV70) and Squib Valve Actuator (PV98) Design Project Summary” (referred to as the “squib valve summary report” here after) will be updated to reflect the squib valve final designs from initial valve selection to equipment qualification testing and will link together the many evidentiary documents. This document provides the auditable trail showing that the squib valve design development project has followed Westinghouse’s robust design and development process.</p> <p>In addition to updating the squib valve summary report, Westinghouse will develop an independent safety case document for the AP1000 plant squib valves. This document will contain the detailed claims, arguments, and evidence for the squib valves implemented in the AP1000 plant.</p> <p>When the work starts to resolve this resolution plan, Westinghouse will provide a more detailed outline and description of each individual activity before that activity starts and then have discussions with the ONR to ensure that the scope and methodology is in-line with expectations.</p>
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<p><b>Description of work:</b></p> <p>Westinghouse document APP-PV70-GER-002, “Squib Valve (PV70) and Squib Valve Actuator (PV98) Design Project Summary” is the overarching document that pulls together and summarises all aspects of the squib valves from valve selection to final valve qualification. This document provides the auditable trail showing that the squib valve design development project has followed Westinghouse’s robust design and development process.</p> <p>The requests for additional information, justification, arguments and evidence listed in this GDA issue will be incorporated into the squib valve summary report. This will be done by modification of the squib valve summary report, addition of appendices to the squib valve summary report, modification of documents referenced in the squib valve summary report and the creation of new documentation that will be referenced in the squib valve summary report as appropriate.</p> <p>In addition to updating the squib valve summary report, Westinghouse will develop an independent safety case document for the AP1000 plant squib valves. This document will contain the detailed claims, arguments, and evidence for the squib valves</p>
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implemented in the AP1000 plant.

Westinghouse will address the GDA Issue actions as detailed below.

**A1:** Westinghouse has developed a squib valve design project summary report (APP-PV70-GER-002, "Squib Valve (PV70) and Squib Valve Actuator (PV98) Design Project Summary", Revision 0) that was transmitted to the ONR on 31 December 2010. This document provides a thorough summary of the use of squib valves in the **AP1000** design starting with their initial selection through their production including conceptual design, prototype testing, design finalisation, and production. Following ONR review and formal comment on APP-PV70-GER-002, Revision 0, Westinghouse will revise this document to incorporate comments as appropriate. In addition, Westinghouse will update this document to reflect the final valve designs, provide a summary of valve functional and separate initiator testing performed and outcomes of work related to the other actions of this GDA issue, particularly actions A5, A6 and A7.

The claims, arguments, and evidence (CAE) currently contained in the squib valve summary report will be put into a separate safety case document, which consists of high level claims and sub-claims. In total, there will be twelve sub-claims supporting four high level claims. The sub-claims and their supporting arguments and evidence will ultimately be incorporated into the squib valve safety case document in support of their associated high level claims. The sub-claims which pertain to the actions below have been noted in this plan to assist review of the evidence.

**A2:** There are a number of documents that provide safety justification for the squib valve designs and their components. The documents listed below will be updated to reflect the final squib valve designs. In addition, a number of new documents will be created in actions A5 and A6 of this GDA issue that will provide evidence and justification of the squib valve component designs. These are described in more detail in actions A5, A6 and below.

- The ASME Section III, Class 1 Code reports cover the pressure retaining parts for the three different squib valve designs. The ASME Code reports demonstrate the suitability of the squib valves for design loading in accordance with the ASME Boiler and Pressure Vessel Code, Section III, Division 1, Class 1, Nuclear Power Plant Components. These reports will be provided per the schedule as evidence in support of Sub-claim 2.2:
  - Document SPX 10.2.189 – 8" HP, Latest Revision
  - Document SPX 10.2.190 – 8" LP, Latest Revision
  - Document SPX 10.2.191 – 14", Latest Revision
- Westinghouse will issue a structural analysis report that covers the non-ASME code components of the squib valves. These components are analysed using standard engineering methods and techniques to justify design adequacy. These reports will be provided as evidence in support of Sub-claim 1.2
- APP-PV70-Z0-001 (Design Specifications for Squib (Pyrotechnic Actuated) Valves, ASME Boiler and Pressure Vessel Code, Section III Class 1 for Systems RCS/PXS) and APP-PV98-Z0-001 (Design Specification for Pyrotechnic Actuator



for ASME Boiler and Pressure Vessel Code, Section III Class 1 Squib Valves (PV70) ) will be updated to reflect the final squib valve design specifications. These reports will be provided as evidence in support of Sub-claims 1.1, 1.2, 2.1, 2.2, 3.1, 3.2, 4.1, and 4.2.

- The squib valve design project summary report (APP-PV70-GER-002, “Squib Valve (PV70) and Squib Valve Actuator (PV98) Design Project Summary”) is the audit trail providing the details of the development, design finalisation, and equipment qualification of the squib valves.
- The squib valve safety case (UKP-GW-GL-200, “AP1000 Squib Valve Safety Case”) provides additional justification that the valve components achieve their safety case requirements and assumptions.
- Westinghouse provided the prototype testing report (SPX document: 10.4.368, “FUNCTIONAL TESTING SQUIB (PYROTECHNIC ACTUATED) VALVE”, Revision 1) on 9 November 2010. This document provides successful testing results which verify adequate squib valve designs. It also contains the prototype test plans and the sensitivity analysis. Revision 2 of SPX 10.4.368 will be submitted in accordance with the schedule. This report will be provided as evidence in support of Sub-claim 1.1.
- Equipment Qualification Test Plans – Three equipment qualification test plans were provided in October 2010. (APP-PV70-T5-001, Revision 0; APP-PV70-T5-002, Revision 0; APP-PV70-T5-003, Revision 0) These test plans outline and define sufficient testing to confidently qualify the squib valves and their components. The final revision of the test plans will be provided as evidence in support of Sub-claims 2.1, 2.2, 3.1, 3.2, and 3.3.
- Equipment Qualification Summary Reports – These reports will provide evidence that the final valve designs have successfully completed equipment qualification and meet the specified requirements. These reports will be provided as evidence in support of Sub-claims 2.1, 2.2, 3.1, 3.2, and 3.3.
- To address the action of TQ-**AP1000**-929 related to showing that a leak in the 14” shear cap will be detected before it can break; Westinghouse will make LTR-AMLR-11-31 available for review which is a white paper on spurious actuation frequency of the Automatic Depressurization System Stage 4 Valves due to Internal Rupture.

**A3:** Westinghouse has now completed and can be made available for review, piping analysis reports for the piping associated with the squib valves. (APP-RCS-PLR-030, APP-PXS-PLR-030, APP-PXS-PLR-010, APP-PXS-PLR-020) These reports demonstrate that the piping and associated supports are adequately designed:

1. Evaluate the as-designed piping system based on the ASME III.
2. Determine the locations, type, orientation, and spatial requirements for pipe supports connected to the building or structural frame.
3. Confirm that safe shutdown earthquake (SSE) seismic design requirements are

met.

4. Ensure proper design interface with structural steel piping modules.

Westinghouse will insure that these documents include parameters and aspects of the design as documented in the design reference point. These documents will be provided as evidence in support of Sub-claim 3.1.

**A4:** The ASME OM Code specifies the surveillance regime to ensure that the squib valve designs are capable of delivering their safety functions in accordance with the requirements of the safety case. Further justification will be developed which will address the ONR's comments during the Step 4 assessment. Westinghouse will be including some of the aspects of action A7 in the safety case document in support of Sub-claim 4.4.

**A5: Gaps in the safety justification**

1. The squib valve failure modes and effects analysis will be reviewed to verify that it is consistent with the final valve designs. This review will include an independent technical reviewer. APP-PV70-GRA-001, "AP1000 Squib Valve Failure Modes and Effects Analysis (FMEA)" will be revised as appropriate. If the review and update of the document warrants design modifications, Westinghouse will evaluate those modifications for inclusion via the Westinghouse design change process. This document will be provided as evidence in support of Sub-claim 4.4.
2. Westinghouse will perform an evaluation to demonstrate that the squib valve position indication designs are ALARP. If warranted by the ALARP justification, Westinghouse will implement design changes as necessary. This evaluation will be incorporated into the squib valve summary report as evidence in support of Sub-claim 4.1.
3. Westinghouse will perform an evaluation to demonstrate that the 14-inch squib valve position indication switch bracket design is ALARP. If warranted by the ALARP justification, Westinghouse will implement design changes as necessary. This evaluation will be incorporated into the squib valve summary report as evidence in support of Sub-claim 1.2.
4. Westinghouse will perform an evaluation to demonstrate that the 14-inch squib achieves its design intent without incorporation of a cover and is ALARP. If warranted by the ALARP justification, Westinghouse will implement design changes as necessary. This evaluation will be incorporated into the squib valve summary report as evidence in support of Sub-claim 1.2.
5. Westinghouse will make the necessary assembly drawings that detail the poka yoke features of the 8-inch squib valves available for review. These documents provide evidence in support of Sub-claim 4.1.
6. Westinghouse provides a detailed definition of the squib valve designs via the valve design specifications. The design specifications define the critical features and parameters of the designs and also the information required to be provided in

the valve data package with each valve. The final valve design specifications (APP-PV70-Z0-001 and APP-PV98-Z0-001) will be made available for review as described in Action 2. In addition, a representative example of a final valve data package can be made available for review to show how the critical information is recorded. The Sub-claims which are supported by the design specifications are identified in A2; the example final valve data package will provide evidence in support of Sub-claim 4.4.

7. Westinghouse will provide the final equipment qualification summary reports. These reports will demonstrate that the valves meet their design intent as tested per the equipment qualification test plans. These reports will be provided as evidence in support of Sub-claims 2.2, 3.1, and 3.2.

#### **A6: Squib Valve Pyrotechnics Aspects**

1. Westinghouse will issue and make available for review APP-PV70-GER-001, "Report On Squib Valve Shape Charge Device"
2. Sub-actions a, b and c: Westinghouse will clarify and justify the rationale for selecting the pyrotechnic substances used in the **AP1000** squib valve design. Also, Westinghouse will justify the use of relevant good practice, including that of the aerospace industry, in the development of squib valves for the nuclear industry along with the removal the binder. These aspects will be included in the squib valve summary report or in a standalone document(s) that will be referenced from the squib valve summary report. These justifications will be provided as evidence in support of Sub-claim 4.3.

Sub-action d: Westinghouse is qualifying the **AP1000** squib valve propellants to the radiation levels expected in the various valve locations within the plant. This will be provided in the equipment qualification summary report(s).

For sub-action e, Westinghouse will clarify and state that the information presented in Appendix C (Operating Plant Experience) of the squib valve summary report is just supplementary information instead of a claim on the squib valves. This clarification will be incorporated into the summary report as evidence in support of Sub-claim 4.3.

3. Westinghouse will perform initiator testing to justify the margin claims of the squib valves. This work will enhance and substantiate the Appendices A and B of the squib valve summary report. The test results can be made available for review. These test reports provide evidence in support of Sub-claim 1.2.
4. Westinghouse confirms that report 17399(01)DR transmitted on 21 February 2011 titled, "DEVELOPMENT REPORT PYROTECHNIC CARTRIDGES FOR SQUIB VALVES WESTINGHOUSE **AP1000** NUCLEAR REACTOR" is the report that has been informally referred to as the "Ballistics Report". This report supplies evidence in support of Sub-claim 1.1.
5. Westinghouse will enhance the ALARP argument related to the squib valve

ignition mode to include more detail in the comparison of various ignition options and the ultimate mode selection. The squib valve safety case document will include this ALARP argument as evidence in support of Sub-claim 1.1.

6. Sub-action a: Westinghouse provided a response to an earlier GDA query on this subject which was provided in DCP\_DCP\_001842. Westinghouse will further justify the assumptions in this analysis with the second assumption being the key to the overall adequacy of the response. The second assumption will be shown to be bounding and applicable to **AP1000** design or an alternate justification will be provided. This work may be completed in a separate document; however, it will be linked to DCP\_DCP\_001842. This justification will be incorporated into the squib valve safety case document to provide evidence in support of Sub-claim 2.1.

Sub-action b: See the resolution plan for action A7.3 below. The document created to address action A7.3 includes EMIT activities related to squib valve EMI. The electrical testing requirements not only address verification of general electrical characteristics, but the testing methodology also insures verification of the robustness of the EMI related aspects of the squib valves including justification.

7. Westinghouse will evaluate and compare the codes and standards used to design the cartridges and termination units properly encompass the applicable UK requirements (codes, standards, and regulations). This work may be completed in a separate document and linked to the squib valve safety case document. This comparison will provide evidence in support of Sub-claim 4.5.
8. See action A2. The squib valve equipment qualification summary report will provide the whole qualification results including the definition and justification for all test parameters and requirements.
9. Westinghouse will provide evidence that the application of currents at or below the no-fire current have no impact on the bridge wire or that these current levels can't be generated by C&I failures. This justification will be incorporated into the squib valve safety case document. Action 6 item 3 provides some supporting evidence to support this item.
10. Westinghouse will demonstrate that there is sufficient margin to the propellant auto-ignition temperature in fire scenarios. This will include consideration of fires in adjacent rooms and show that the analysis is representative of the final squib valve design. This justification will be incorporated into the squib valve safety case document as evidence in support of Sub-claim 2.1.
11. Sub-action a: This action will be addressed in part by the revision of UKP-DAS-GLR-001, "United Kingdom **AP1000** Basis for the Safety Case of the 7300 Series Based Diverse Actuation System". This document is being updated as part of the response to GDA issues GI-**AP1000**-C&I-01 and GI-**AP1000**-C&I-02. As part of this revision, the DAS squib valve circuitry will be described and evidence

presented to support adherence to appropriate SAPs including design details, testing, qualification data and substantiation of reliability claims. The **AP1000** PSA will be reviewed to verify that the DAS squib valve circuitry reliability is properly incorporated into the squib valve spurious actuation probability.

Related to the PMS, Westinghouse will submit an ADS Blocker/Containment Recirculation Squib Valve Basis for the Safety Case document. This document will be developed as part of GI-**AP1000**-C&I-04 and will provide claims, arguments and evidence to support the addition of an ADS Diverse Actuation Interlock (APP-GW-GEE-2411) which is an outcome of the C&I assessment undertaken in GDA. The document will provide a full deterministic and probabilistic assessment to demonstrate that the risk of serious consequences as a result of spurious ADS operation due to a failure on the PMS is below the design basis sequence cut-off frequency of  $10^{-7}$  per year while ensuring the reliability of ADS to perform its important safety function has not been significantly affected.

The potential for spurious actuation beyond the areas covered by GI-**AP1000**-C&I-01, GI-**AP1000**-C&I-02, & GI-**AP1000**-C&I-04 will be addressed within the squib valve safety case document.

12. Sub-action b: Westinghouse will justify that the **AP1000** squib valve actuation train(s) have an appropriate balance between preventing spurious actuation and providing high reliability to fire on-demand without Safety and Arming Devices (SADs) contained within the pyrotechnic chain or evaluate design changes if appropriate. This evaluation will be will be incorporated into the squib valve safety case document as evidence in support of Sub-claim 2.1.
13. Westinghouse will provide a comprehensive ALARP justification of the selection of electrical current values related to the actuation of the squib valves. This evaluation will be will be incorporated into the squib valve safety case document as evidence in support of Sub-claims 1.2 and 2.1.
14. For the DAS, Westinghouse will provide APP-GW-GEE-2286, "Changes to Diverse Actuation System (DAS) Voting Logic and Associated Architecture" and APP-GW-GEE-2287, "Changes to Diverse Actuation System (DAS) Platform Implementation." These DCPs formally document design changes needed to substantiate the safety case argumentation and evidence for the DAS.

Westinghouse will then provide a revision of UKP-DAS-GLR-001, "United Kingdom **AP1000** Basis for the Safety Case of the 7300 Series Based Diverse Actuation System" (BSC). This document is being updated as part of the response to GDA issues GI-**AP1000**-C&I-01 and GI-**AP1000**-C&I-02.

- a. Further substantiation to the claims, arguments and evidence related to IEC standard compliance and key SAPs identified in the initial issuance of the BSC.
- b. The BSC will provide substantiation that the proposed architecture design

permits a channel to be taken out of service for test and/or maintenance and the DAS will still meet its intended reliability target.

- c. The BSC will include a description of the system, breaking it down such that the major elements can be identified (such as input/output and logic cards). Included will be the demonstration of adequacy for each of these elements (including identification of revisions) as well as the DAS as a whole. The BSC will identify production excellence arguments and identify the independent confidence building measures.
- d. The BSC will include a description of the project QA arrangements, e.g. ISO 9001; this should include a clear description of the interface to the DAS supplier (and any other suppliers). The BSC will also include an outline of the DAS supplier QA arrangements.
- e. The BSC will identify available supporting analysis such as hazards analysis, FMEAs, reliability analysis, MTBF values, environmental qualification, etc. link them to claims made and the demonstration of fitness for purpose of the system.
- f. The BSC will identify the design process by which the individual components will be brought together and integrated as a system.
- g. The BSC will substantiate that the automatic DAS remains in service during reactor power operation including meeting the requirements for maintenance and proof testing.
- h. The BSC will substantiate that the automatic and manual DAS meets their reliability targets.
- i. The BSC will provide further evidence on how the DAS meets the UK position with respect to ALARP.
- j. The BSC will describe and identify the basis for remote DAS controls and associated displays. This includes a description and basis for manual DAS-based squib valve controls.
- k. The BSC will provide a clear and coherent description of the external and internal DAS power supply architecture along with the substantiation of the safety claims made on them.
- l. The BSC will include a preliminary programme plan for the completion of the DAS design. The plan will include the identification of subsequent BSC issuances covering key DAS design stages along with key design and site milestones.

For the PMS, Westinghouse will submit an ADS Blocker/Containment Recirculation Squib Valve Basis for the Safety Case document. This document is being developed as part of GI-**AP1000**-C&I-04. and will provide a minimum of the

following:

Further substantiation to the claims, arguments and evidence related to IEC standard compliance and key SAPs identified in the initial issuance of the BSC.

The BSC will include a description of the system, breaking it down such that the major elements can be identified (such as input/output and logic cards). Included shall be the demonstration of adequacy for each of these elements (including identification of revisions) as well as the circuitry as a whole. The BSC will identify production excellence arguments and identify the independent confidence building measures.

The BSC will include a description of the project QA arrangements based on the Westinghouse QMS. This will include a clear description of the interface to the circuitry supplier (and any other suppliers). The BSC will also include an outline of the circuitry supplier QA arrangements.

The BSC will identify available supporting analysis such as hazards analysis, FMEAs, reliability analysis, Mean Time Between Failures (MTBF) values, environmental qualification, etc. link them to claims made and the demonstration of fitness for purpose of the system.

In particular, the BSC will provide further justification to the reliability analysis and MTBF values declared in the initial issuance of the BSC. Both calculated values and usage data will be used to substantiate the MTBF values.

The BSC will identify the design process by which the individual components will be brought together and integrated as a system.

The BSC will provide further evidence on how the ADS blocker meets the UK position with respect to ALARP.

The BSC will provide a full deterministic and probabilistic assessment to demonstrate that the risk of serious consequences as a result of spurious ADS operation due to a failure on the PMS is below the design basis sequence cut-off frequency of  $10^{-7}$  per year while ensuring the reliability of ADS to perform its important safety function has not been significantly affected.

The BSC will demonstrate that adequate protection is provided or propose possible design changes to reduce the initiating frequency of the spurious operation of the containment recirculation squib valves and/or provide additional protection. In particular, should Westinghouse choose to implement the blocker device in a similar manner to that applied on the ADS valves then the safety case needs to recognise that the effectiveness of the blocker device may be limited by the reliability of the CIM and so additional protection may well be required. The safety case needs to provide a full deterministic and probabilistic assessment to demonstrate that the risk of serious consequences following spurious operation of the recirculation valves is below the design basis sequence cut-off frequency of  $10^{-7}$  per year while ensuring the reliability of recirculation valves to perform their

important safety function has not been significantly affected.

The BSC substantiation will include an evaluation of the ADS 1 to 4 valve spurious operation rates (accounting for sensor failure and PMS test and maintenance activities).

These documents will cover the squib valve actuation aspects of the DAS and PMS. The safety cases identified above will provide evidence in support of Sub-claim 2.1.

#### **A7: Squib Valve Surveillance and EMIT**

1. The Squib Valve Instruction Manual (APP-PV70-VMM-001) will contain the detailed steps to perform a visual inspection of the 8-inch squib valves. See the plan for action A4.
2. The requirement that all cartridges from a batch should be replaced if any cartridge from that batch fails its test after being removed from a plant is currently captured in the squib valve safety case document. Westinghouse will explicitly capture this in the PCSR.
3. A report shall be generated and submitted to address electrical testing requirements of the squib valves. The report will include recommendations/requirements for both the installation contractor and the plant owner to comply with to assure full functionality of the squib valves under all design basis events. It will also address testing frequencies, insulation testing, continuity testing and other forms of non-destructive evaluations. Installation of the valves will be detailed and include Quality Assurance requirements and the level of oversight required for electrical testing. Spurious actuations, potential failures and industry experiences will be fully considered for this report. The following items will be specifically addressed in this report or in a separate justification for the report:
  - a. Testing every 24 months is sufficient to prove a high level of availability of the safety system using squib valves.
  - b. Insulation testing does not reduce the risk of failure.
  - c. Electrical currents supplied by digital voltmeters always stay lower than the threshold defined in bridge wire resistance test.
  - d. Reconnecting initiators to a circuit under voltage does not increase the risk.

The test report will provide evidence in support of Sub-claims 1.2 and 2.1. The justification will provide evidence in support of Sub-claim 4.1.

4. Westinghouse will document the criteria for maximum mechanical shock loading for squib valve cartridges before which they must not be used. This will be included in the squib valve safety case document, as evidence in support of Sub-claim 4.1, and in the PCSR.



5. Westinghouse will provide justification to show that the planned surveillance and EMIT regime defined in the ASME OM Code is in-line with the safety case assumptions. This will be included in the squib valve safety case document as evidence in support of Sub-claim 4.4.

**Schedule/ programme milestones:**

Please see the following page for the schedule.

Activity Name	2015												2016											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	
<b>BL6 -02262016 - UK Generic Design Assessment (GDA) Resolution Plans (51)</b>																								
<b>MECHANICAL ENGINEERING</b>																								
<b>ME.01 Squib Valve Concept &amp; Design Substantiation-Resolution Plan</b>																								
<b>ME.01 Submittals Ready for ONR Review</b>																								
<b>ME.01 Squib Valve Design Evolution</b>																								
Squib Valve Design Evolution - Present to ONR for Review																								
<b>ME.01 (A1) APP-PV70-GER-002 -Rev.0 - Squib Valve Summary Report</b>																								
(A1) APP-PV70-GER-002 - Rev 0 - Squib Valve Summary Report-Submit to ONR																								
(A1) APP-PV70-GER-002 - Rev 0 - Squib Valve Summary Report-ONR Review of Submittal																								
<b>ME.01 (A2) SPX 10.4.368 - Functional Testing Squib (Pyrotechnic Actuated) Valve, Rev.1</b>																								
(A2) SPX 10.4.368 - Functional Testing Squib (Pyrotechnic Actuated) Valve, Rev.1-Submit to ONR																								
<b>ME.01 (A2) Structural Analysis Report for 14" Squib Valve, Non-ASME Code Components</b>																								
(A2) Structural Analysis Report for 14" Squib Valve, Non-ASME Code Components-Submit to ONR																								
<b>ME.01 (A6) APP-PV70-T5-002 -Rev.3(EMI) Test Proc.-Squib Valv. Initi. &amp; Connect.</b>																								
(A6)APP-PV70-T5-002-Rev.3(EMI) Test Proc.-Squib Initi. & Connt-Submit to ONR																								
<b>ME.01 (A2) LTR-AMLR5-11-31 - White Paper on Spurious Operation</b>																								
(A2) LTR-AMLR5-11-31 - White Paper on Spurious Actuation-Available for ONR Review																								
<b>ME.01 (A2) APP-PV70-T5-003 -Rev.0-Qual. Plan-QME-1-2007 Qual. 8" &amp; 14" Squib Valv.</b>																								
(A2) APP-PV70-T5-003 -Rev.0-Qual. Plan-QME-1-2007 Qual. 8" & 14" Squib Valv.-Submit to ONR																								
<b>ME.01 (A6) APP-PV70-GER-001 Report Squib Valve Shape Charge Device</b>																								
(A6) APP-PV70-GER-001 Report Squib Valve Shape Charge Device-Available for ONR Review																								
<b>ME.01 (A2) APP-PV70-T5-001 -Rev.3-Qual. Plan for Safety Squib Val. Acts &amp; Elect. Connect.</b>																								
(A2) APP-PV70-T5-001 -Rev.3-Qual. Plan-Safety Squib Val. Acts & Elect. Connect.-Submit to ONR																								
<b>ME.01 (A6) Ballistic Report-17399(01)DR</b>																								
(A6) Ballistic Report-17399(01)DR-Available for ONR Review																								
<b>ME.01 (A2) APP-PV70-Z0-001 - Rev.6 Pyrotechnic Actuated Squib Valve</b>																								
(A2) APP-PV70-Z0-001 - Rev.6 Pyrotechnic Actuated Squib Valve-Available for ONR Review																								
<b>ME.01 (A6) APP-GW-GEE-2286 Changes to DAS Voting Logic &amp; Associated Arch.</b>																								
(A6) APP-GW-GEE-2286 Changes to DAS Voting Logic & Associated Arch.-Submit to ONR																								
<b>ME.01 (A6) APP-GW-GEE-2287 Changes to DAS Platform Implementation</b>																								
(A6) APP-GW-GEE-2287 Changes to DAS Platform Implementation-Submit to ONR																								
<b>ME.01 (A3) APP-RCS-PLR-030-Available for Review</b>																								
(A3) APP-RCS-PLR-030-Available for ONR Review																								
<b>ME.01 (A3) APP-PXS-PLR-030-Available for Review</b>																								
(A3) APP-PXS-PLR-030-Available for ONR Review																								
<b>ME.01 (A3) APP-PXS-PLR-010-Available for Review</b>																								
(A3) APP-PXS-PLR-010-Available for ONR Review																								
<b>ME.01 (A3) APP-PXS-PLR-020-Available for Review</b>																								
(A3) APP-PXS-PLR-020-Available for ONR Review																								
<b>ME.01 (A2) APP-PV98-Z0-001 - Rev.1 Pyrotechnic Actuator</b>																								
(A2) APP-PV98-Z0-001 - Rev.1 Pyrotechnic Actuator-Available for ONR Review																								
<b>ME.01 Submittals WORKING - ECS Scheduled Finishes</b>																								
<b>ME.01 (A2, A5) APP-PV70-VDR-101001 (SPX 10.2.191-14"), Re v 0</b>																								
(A2, A5) APP-PV70-VDR-101001 (SPX 10.2.191-14"), Rev. 0-Available for ONR Review																								
<b>ME.01 (A2, A5) APP-PV70-VDR-102000 (SPX 10.2.189-8" HP), Rev. 0</b>																								
(A2, A5) APP-PV70-VDR-102000 (SPX 10.2.189-8" HP), Rev. 0-Available for ONR Review																								
<b>ME.01 (A2, A5) APP-PV70-VDR-102001 (SPX 10.2.190-8" LP), Rev. 0</b>																								
(A2, A5)APP-PV70-VDR-102001 (SPX 10.2.190-8" LP), Rev. 0-Available for ONR Review																								
<b>ME.01 (A2,A5, A6) APP-PV70-VBR-002 Equipment Qualification Summary Report- 8"</b>																								
(A2,A5, A6) APP-PV70-VBR-002 8" Equipment Qualification Summary Report-Submit to ONR																								
<b>ME.01(A2,A5, A6) APP-PV70-VBR-004 Equipment Qualification Summary Report- 14"</b>																								
(A2,A5, A6) APP-PV70-VBR-004 14" Equipment Qualification Summary Report-Submit to ONR																								
<b>ME.01 (A5) Equipment Qualification Data Package</b>																								
(A5) Equipment Qualification Data Package-Available for ONR Review																								
<b>ME.01 (A5) Quality Release and Data Package (xxx-PV70-VQV-xxx)</b>																								
ME.01 (A5) Quality Release and Data Package (xxx-PV70-VQV-xxx)-Available for ONR Review																								
<b>ME.01 (A2) APP-PV70-VDR-012 Structural Analysis Report- 8" Squib Valve, Non-ASME Code Components</b>																								
(A2) APP-PV70-VDR-012 Structural Analysis Report- 8" Squib Valve, Non-ASME Code Components-Available to ONR for Review																								
<b>ME.01 (A6) Squib Valve Initiator Margin Testing Reports</b>																								
(A6) Squib Valve Initiator Margin Testing Reports-Available for ONR Review																								
<b>ME.01 (A7) Squib Valve Instruction Manual (APP-PV70-VMM-001)</b>																								
(A7) Squib Valve Instruction Manual (APP-PV70-VMM-001)-Submit to ONR																								
<b>ME.01 Receive Updated FMEA from SPX</b>																								
Receive Updated FMEA from SPX-Available for ONR Review																								

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Activity Name	2015												2016											
	ec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
<b>ME.01 Bruceton Test Reports</b>																								
Design Substantiation Testing-Submit to ONR																								
<b>ME.01 Submittals UK Specific</b>																								
<b>ME.01 Independent Review of FMEA (APP-PV70-GRA-001)</b>																								
Independent Review of FMEA-Available for ONR Review																								
<b>ME.01 (A7) Electrical Testing Requirements Report</b>																								
(A7) Electrical Testing Requirements Report-Submit to ONR																								
<b>ME.01 AP1000 Squib Valve Safety Case (UKP-GW-GL-200)</b>																								
<b>Finalize Safety Case Document UKP-GW-GL-200</b>																								
UKP-GW-GL-200 - Submit to ONR for Review																								
UKP-GW-GL-200 - ONR Review of Draft																								
<b>Summary Report Update (APP-PV70-GER-002 Rev 1)</b>																								
APP-PV70-GER-002 - Submit to ONR for Review																								
APP-PV70-GER-002 - ONR Review of Draft																								

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### **Methodology:**

Westinghouse document APP-PV70-GER-002, "Squib Valve (PV70) and Squib Valve Actuator (PV98) Design Project Summary" is the overarching document that pulls together and summarises all aspects of the squib valves from valve selection to final valve qualification. This document provides the auditable trail showing that the squib valve design development project has followed Westinghouse's robust design and development process.

The squib valve summary report will be update to reflect the final squib valve designs. All of the existing evidentiary documents will be updated to reflect the final squib valve designs.

In addition to updating the squib valve summary report, Westinghouse will develop an independent safety case document for the AP1000 plant squib valves. This document will contain the detailed claims, arguments, and evidence for the squib valves implemented in the AP1000 plant.

The requests for additional information, justification, arguments and evidence listed in this GDA issue will also be incorporated into the squib valve summary report. This will be done by modification of the squib valve summary report, addition of appendices to the squib valve summary report, modification of documents referenced in the squib valve summary report and the creation of new documentation that will be referenced in the squib valve summary report as appropriate. .When the work starts to resolve this resolution plan, Westinghouse will provide a more detailed outline and description of each individual activity before that activity starts and then have discussions with the ONR to insure that the methodology is in-line with expectations.

The squib valve summary document is referenced in Chapter 17 of the PCSR providing a coherent, auditable trail through the squib valve selection and design. The squib valve safety case document will also be referenced by the PCSR to provide the claims, arguments, and evidence for the squib valves in the AP1000 plant. The methodology for each specific action and sub-action of this GDA issue is described in the Description of Work section.

### **Justification of adequacy:**

There are a large number of documents that will address this GDA Issue. As described above, some of these documents have already been supplied for ONR assessment, some documents will be updated, and others are planned to be delivered. Once produced or updated, this collection of documents provides comprehensive arguments and evidence to support the selection, development, testing and final qualification of the **AP1000** squib valves. Numerous ALARP studies will be performed to assess various aspects related to squib valves. Westinghouse is also providing adequate justification of the squib valve interfacing system designs and robust surveillance and EMIT strategy.

As described above, Westinghouse document APP-PV70-GER-002, "Squib Valve (PV70) and Squib Valve Actuator (PV98) Design Project Summary" is the overarching document that pulls together and summarises all aspects of the squib valves from valve

selection to final valve qualification. This document provides the auditable trail showing that the squib valve design development project has followed Westinghouse's robust design and development process.

The squib valve summary report will be update to reflect the final squib valve designs. All of the existing evidentiary documents will be updated to reflect the final squib valve designs.

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The requests for additional information, justification, arguments and evidence listed in this GDA issue will also be incorporated into the squib valve summary report. This will be done by modification of the squib valve summary report, addition of appendices to the squib valve summary report, modification of documents referenced in the squib valve summary report and the creation of new documentation that will be referenced in the squib valve summary report as appropriate. This addresses the ONR request to issue appropriate approved documentation that provides adequate arguments and evidence for their selection, equipment design, and associated system design.

When the work starts to resolve this resolution plan, Westinghouse will provide a more detailed outline and description of each individual activity before that activity starts and then have discussions with the ONR to insure that the methodology and adequacy is in-line with expectations.

The squib valve summary document is referenced in Chapter 17 of the PCSR providing a coherent, auditable trail through the squib valve selection and design. The squib valve safety case document will also be referenced by the PCSR to provide the claims, arguments, and evidence for the squib valves in the AP1000 plant. The methodology for each specific action and sub-action of this GDA issue is described in the Description of Work section.

#### **Impact assessment:**

- PCSR
- APP-PV70-GER-002, "Squib Valve (PV70) and Squib Valve Actuator (PV98) Design Project Summary"
- UKP-GW-GL-200, "UK AP1000 Squib Valve Safety Case"
- The ASME Class 1 Code reports
  - Document SPX 10.2.189 – 8" HP
  - Document SPX 10.2.190 – 8" LP
  - Document SPX 10.2.191 – 14"

- Structural analysis report that covers the non-ASME code components
- APP-PV70-Z0-001 (Design Specifications for Squib (Pyrotechnic Actuated) Valves, ASME Boiler and Pressure Vessel Code, Section III Class 1 for Systems RCS/PXS)
- APP-PV98-Z0-001 (Design Specification for Pyrotechnic Actuator for ASME Boiler and Pressure Vessel Code, Section III Class 1 Squib Valves (PV70))
- Prototype testing report (SPX document: 10.4.368, "FUNCTIONAL TESTING SQUIB (PYROTECHNIC ACTUATED) VALVE")
- Equipment Qualification Test Plans
  - APP-PV70-T5-001
  - APP-PV70-T5-002
  - APP-PV70-T5-003
- Final equipment qualification summary report(s)
- LTR-AMLRs-11-31 which is a white paper on spurious actuation frequency of the Automatic Depressurization System Stage 4 Valves due to Internal Rupture
- Piping analysis reports for the piping associated with the squib valves
  - APP-RCS-PLR-030
  - APP-PXS-PLR-030
  - APP-PXS-PLR-010
  - APP-PXS-PLR-020
- APP-PV70-GRA-001, (**AP1000** Squib Valve Failure Modes and Effects Analysis (FMEA))
- Final design drawings of 8-inch squib valves to demonstrate poka yoke features
- Final valve data package
- APP-PV70-GER-001, (Report On Squib Valve Shape Charge Device)
- Report 17399(01)DR, (DEVELOPMENT REPORT PYROTECHNIC CARTRIDGES FOR SQUIB VALVES WESTINGHOUSE **AP1000** NUCLEAR REACTOR)
- Report to evaluate and compare the codes and standards used to design the cartridges and termination units properly encompass the applicable UK requirements
- UKP-DAS-GLR-001, (United Kingdom **AP1000** Basis for the Safety Case of the 7300 Series Based Diverse Actuation System)
- ADS Blocker/Containment Recirculation Squib Valve Basis for the Safety Case

document

- Squib Valve Instruction Manual (APP-PV70-VMM-001)
- Master Submission List
- Roadmap