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Subject: **Response to Portion of NRC Request for Additional Information Letter No. 67 Related to ESBWR Design Certification Application – Nuclear Boiler System – RAI Number 3.9-171**

Enclosure 1 contains GE's response to the subject NRC RAI transmitted via the Reference 1 letter.

If you have any questions or require additional information regarding the information provided here, please contact me.

Sincerely,

Kathy Sedney for

James C. Kinsey
Project Manager, ESBWR Licensing

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Reference:

1. MFN 06-378, Letter from U.S. Nuclear Regulatory Commission to David Hinds, *Request for Additional Information Letter No. 67 Related to ESBWR Design Certification Application,* October 10, 2006

Enclosure:

1. MFN 07-208 – Response to Portion of NRC Request for Additional Information Letter No. 67 Related to ESBWR Design Certification Application – Nuclear Boiler System – RAI Number 3.9-171

cc:	AE Cubbage	USNRC (with enclosures)
	DH Hinds	GE (with enclosures)
	RE Brown	GE (w/o enclosures)
	eDRF	0000-0066-6230/1

Enclosure 1

MFN 07-208

Response to Portion of NRC Request for

Additional Information Letter No. 67

Related to ESBWR Design Certification Application

Nuclear Boiler System

RAI Number 3.9-171

NRC RAI 3.9-171

The depressurization valves and other squib valves employ squib explosives to actuate the valves open. The proper actuation depends on a high rate and high total amount of energy release to generate very localized heat and pressurization to break the tension bolt which normally holds the valve disk closed. Provide information regarding how the squib explosives are qualified to ensure proper rate and total amount of energy release for proper valve actuation, under limiting environmental and aging conditions. Are there a lower acceptable rate and total amount of energy release which ensure that the valves properly actuate, and could lower rates than these values result in melting or loss of pressure boundary integrity of upper valve parts, or would this simply result in failure of the valves to open? Provide information regarding the sample IST of the squib explosives which demonstrates that the rates and total amounts of energy release are acceptable.

GE Response

The depressurization valve (DPV) provides an example of how new pyrotechnic-actuated valves are developed and qualified for the ESBWR. The ESBWR Design Control Document (DCD), Revision 3, Tier 2 Subsection 6.3.7 lists Reference 1: GEFR-000879 "Depressurization Valve Development Test Program Final Report," dated October 1990. In the summary of this report it is stated that "*Over seventy booster assemblies underwent radiation, accelerated thermal, and steam aging. Subsequent test firings confirmed the target qualified life of these non-metallic components for use of the DPV in the predicted and postulated environments…*" The report contains a number of cross-references and among these is the "Development Test Procedure for Initiator/Booster Assembly – Pyronetics Part Nos. 3579/113250" (OEA/Pyronetics Document No. 4-3579, Rev. B). The test procedure is a manufacturer's proprietary document that provides the method for testing the initiator/booster assembly of the DPV and the acceptable test performance criteria. The performance test involves activating an assembly inside a closed explosives test chamber and measuring the time to achieve initial detonation pressure and the average peak pressure. The successful test records initial detonation pressure within the prescribed time limit and achieves an average peak pressure within the range of the manufacturer's nominal actuation pressure value plus-or-minus a pressure tolerance band value.

These proprietary criteria were determined by the DPV development program to provide reliable valve actuation at nuclear boiler system pressures from 1,500 psig to 1 psig while still meeting all other DPV design and performance criteria. It is anticipated that the IST requirements for the DPV will require some routine testing of the initiator/booster assembly on a programmatic schedule similar to the testing program used for licensed BWR squib valves of the standby liquid control system (SLCS). The DPV initiator/booster assembly test would be modeled after and use the acceptance criterion provided in the manufacturer's development test procedure.

Therefore proper rate and quantity of gas generation by the pyrotechnic actuator is demonstrated by testing. This testing has established both upper and lower limits for gas generation (actuator energy release), which assures reliable operation of the actuator mechanism to open the valve. The established test acceptance criteria from the valve development and qualification program is expected to be applied to each new lot of production material and actuators to ensure the design criteria are met by factory testing. Lot testing of chemical compounds used to manufacture pyrotechnic devices is also a commonplace practice. This testing provides a pre-manufacturing quality control check that the compound lot is correctly formulated to deliver the required burn rate and gas volume. Factory testing of production lots may also be applied to other components such as testing samples of DPV nipples to measure the shear energy required to remove the caps. This sort of testing also does not require a pyrotechnic device, and could use a pneumatic, hydraulic, or electric-powered test bench instead.

From the DPV example, it is also a criterion of the overall valve assembly design to be able to be test fired and rebuilt several times during its service life. The heat from the pyrotechnic charge is mostly absorbed by the actuator subassembly cylinder wall and cap with very little consumed by the piston/plunger motion (chamber volume expansion) due to the short stroke. The actuator subassembly exterior surface is designed and manufactured with a pattern of fins to air-cool the subassembly. Should a pyrotechnic device under perform, the result may be generation of either less total energy/gas or an energy/gas release at too slow a rate. In the worst-case failure, the mechanism to break the tension bolt and drive the plunger that causes the shear of the nipple cap would fail. Since the subassembly is designed for several cycles of the pressure and temperature load of a maximum pyrotechnic device detonation, the heat and pressure of a slow-burn failure would only result in the gradual dissipation of this energy through the actuator external fins.

At some intermediate failure condition, the piston/plunger might break free of the tension bolt, but either fail to separate the nipple cap or only partially separate the cap. In the DPV design, the actuator subassembly is not part of the Code pressure boundary. Only the nipple, the interior surface of which is the only wetted portion of the valve, is designed and credited as pressure boundary under Code rules. Since the function of the DPV is to cause the pre-engineered breach of the reactor coolant pressure boundary under specific initiation conditions (i.e., by ADS logic), the opening of the valve requires that the pressure boundary be purposefully "failed." Thus, the condition of the non pressure-retaining portions of the valve after activation, including the actuator subassembly, is not relevant to the pressure boundary of the DPV.

This condition is not the same for other pyrotechnically actuated valves such as those planned for the SLCS or GDCS activation functions. These valves will need to be of a design and manufacture such that the pressure boundary extends from the valve inlet to the valve outlet including the valve bonnet. Pressure integrity, as defined under the ASME Code, will apply to the valve pressure boundary (generally consisting of that portion with wetted interior surfaces) both before and after actuation. This may require, for example, that the valve bonnet holding the pyrotechnic actuator subassembly have some form of fluid interface sealing provision. Design alternatives might have the valve's actuator subassembly fully external and separate from the valve body, and used to operate some form of mechanical linkage. Qualification for pyrotechnic actuator valve designs will be in accordance with the requirements described in DCD Tier 2, Section 3.9, and as discussed in other RAI responses including 3.9-1, 3.9-44, 3.9-65, 3.9-103, 3.9-106, 3.9-107, 3.9-160, 3.9-161, and 3.9-169.

In-service testing is performed according to an in-service program schedule at regular intervals to ensure capability of the pyrotechnic actuators is maintained from fabrication through both shelf-life (replacement material and component storage) and/or installed service life. This testing need not rely only on testing whole valves, instead the pyrotechnic devices can be separately tested using the method and criteria based on the original valve qualification as described above.

DCD Impact

No DCD changes will be made in response to this RAI.