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DCP/NRC0984
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Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555

ATTENTION: T. R. QUAY

SUBJECT: AP600 RESPONSE TO REQUESTS FOR ADDITIONAL INFORMATION

Dear Mr. Quay:

Enclosed is the Westinghouse response to an NRC request for additional information (RAI) pertaining to the squib valve failure rate used in the AP600 PRA. Specifically, the response to RAI 720.376 is provided. The OITS number associated with this RAI is 5124.

This response closes, from the Westinghouse perspective, the RAI. The Westinghouse status column in the OITS will be changed to "Action N." The NRC should review the response and inform Westinghouse of the status to be designated in the "NRC Status" column of the OITS.

Please contact Cynthia L. Haag on (412) 374-4277 if you have any questions concerning this transmittal.

Brian A. McIntyre

Brian A. McIntyre, Manager
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jml

Enclosure

cc: J. M. Sebrosky, NRC (Enclosure)
N. J. Liparulo, Westinghouse (w/o Enclosure)

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Enclosure to Westinghouse
Letter DCP/NRC0984

August 11, 1997

Question: 720.376

In the latest revision of the PRA, the failure rate of IRWST check valves was changed from 1E-6/hr to 2E-7/hr. Same is true for the failure rate of explosive (squib) valves (changed from 3E-3/d to 5.8E-4/d). These changes, which are not backed up by adequate data or analyses, have a significant impact on the focused PRA results. In addition, common cause failure data either are not available (e.g., squib valves) or could be much higher than those used in the AP600 PRA (e.g., check valves). The staff needs to understand the bases for the above mentioned changes in previously used data in the PRA. Following a telephone conversation with the staff, Westinghouse submitted data (obtained from Sandia National Laboratories) valves. The Sandia data, however, are for a specific design of standardized mini-valves used in weapons systems. Please explain how the Sandia data can be applied to AP600 squib valves.

Response:

Numerous discussions have taken place between Westinghouse and the staff on the failure rate of the IRWST check valves. These discussions occurred during telecons and meetings, and via submitted material by Westinghouse. The submitted material includes responses to other RAIs on this check valve failure rate topic and the AP600 PRA data information package (Westinghouse letter DCP/NRC0833, April 25, 1997). Since Westinghouse has provided justification for the PRA treatment of IRWST check valves in these responses, this RAI will not reply to the comments about the IRWST check valves failure rate.

The response to this RAI is directed at explaining how the Sandia data can be applied to the AP600 squib valves.

Failure Rate of Squib Valves

The change in the failure rate of squib valves was made to better reflect the reliability of these valves from data gathered from the general industry on valves built with the same technological base. The ALWR URD (Rev. 5&6, 12/93) suggests a squib valve failure rate of 3E-3/d, which is based upon the motor-operated valve failure rate (see URD page A.A-42). The change in squib valve failure rate for the AP600 PRA was made by taking into account the failure rate of the motor-operated valve (3E-3/d), knowing fully well that the squib valves are simpler and more reliable than motor-operated valves, and combining this failure rate with failure rates derived from data on squib valves from Sandia Laboratories using geometric averaging technique.

To understand why the motor-operated valve reliability data is not applicable to squib valves (also called pyrotechnic valves), it is necessary to first discuss pyrotechnic valve technology to distinguish it from the motor-operated valve technology. When the differences are understood, it will be obvious that first, the technologies are different and secondly, the reliabilities are different.

Pyrotechnic Valve Technology

The pyrotechnic technology which encompasses the design, development, testing and production of propellant and explosive actuated devices for military aircraft, munitions, space and missile applications began in the 1950s. Their simplicity and reliability have made it possible for the technology to find applications in commercial safety systems, such as fire protection, activating emergency valves (stand-by liquid control systems) in boiling water reactor nuclear power plants, emergency parachute opening, aircraft emergency doors, and automotive air bags.

The basic principle for a normally closed squib valve is as follows:

> The valve housing employs a securely confined propellant which, when triggered electrically, creates a pressure wave in a chamber that accelerates an integral ram or plunger that shears a diaphragm or seal cap to open a flow path. The pyrotechnic valve has only one moving part which is the ram. This contrasts sharply with the motor operated gate valve which has many moving parts; namely, the motor, the gear assembly, the stem and the gate (disc). The simplicity of explosively actuated valves is, therefore, apparent. The squib valve technology is the same whether the valve is small (less than 0.1 inch flow path) as used in some aerospace applications or in larger nuclear applications such as used in the Boiling Water Reactor (BWR) Stand-by Liquid Control Systems (SLCs) where they are used to provide back-up capability for reactivity control in the event of failure of the normal operating systems. For each application, the design begins with the fact that high pressure has to be developed by propellant-generated gases in the actuator. The energy of the reacting gases in the actuator results in the motion of the plunger. The energy transferred to the moving plunger is dissipated by shearing a seal cap to open the valve to flow. Also, the energy required to shear the seal cap is usually estimated by integrating a shear force developed on the cap during the operation. To assure operability, the energy embodied in the plunger must be greater than the energy needed to shear the seal cap. The described scheme forms a coherent engineering method for the design of pyrotechnic valves. For each application regardless of size, therefore, the designer employs the same technique to size the valve components while taking into account the flow path size, the system operating pressure and temperature, the hydrostatic test pressure and the valve material properties to develop an acceptable design. The same approach will be employed in the design of the AP600 pyrotechnic (squib) valves.

Reliability of Squib Valves

The design simplicity of pyrotechnic valves is reflected in their reliability and their finding increasing application in commercial safety systems (e.g., nuclear safety, fire safety, automobile airbags, etc). Because the squib valve design has only one moving part (the ram or plunger) as against many moving parts for MOVs (i.e., the motor, the gearing unit, the stem assembly and the gate/disc), the reliability of pyrotechnic valves is higher than the reliability of MOVs which was used as a lower bound value (3.0E-3/d) in the URD reliability data for pyrotechnic valves. This reliability is also less subject to maintenance variations. For mechanical systems, in general the more dynamic and independent subsystems in a system the lower the reliability of the overall system. Thus, the reliability of squib valves with one simple moving part is higher than the reliability of MOVs with its many complex moving parts.

A review of data derived from the aerospace, nuclear industry and general industry shows that pyrotechnic valves are very reliable devices. The data below was extracted from various sources:

Source	Application	History
Conax Buffalo Corp. Buffalo, NY	Nuclear applications in BWRs	> 3000 valves supplied over the years with no failures
Pacific Scientific Chandler, Arizona	Aerospace and Military	> 25,000 valves tested over the years with no failures
OEA, Inc. Denver, Colorado	Aerospace, Automotive	> 600,000 tested over the years with no failures > Millions shipped for automotive applications

The experience of the nuclear industry with MOVs, indicates a failure rate of approximately 3E-3/d. This suggests that, if MOVs were subjected to the same number of tests as presented above for pyrotechnic (squib) valves, some failures would have been expected from such a large test population. It is, therefore, reasonable and conservative to include the MOV reliability data together with related squib valve reliability data to arrive at an expected reliability value for the AP600 squib valves. Geometric averaging technique, which was employed, is a reasonable approach for managing data with scatter to reduce the influence of out-liers.

Applicability of Sandia Laboratories Data to AP600 Squib Valves

The staff contends that the Sandia data are "for a specific design of standardized mini-valves used in weapons systems." A review of the squib valve models furnished by Sandia for military applications shows that the valves are not standardized in size, pressure class or function. However, as stated earlier in this response, the technology used to design squib valves is the same regardless of size, pressure class or function. The same technology is used whether the valve has a flow path of 0.1 inch or a flow path of 7 inches. In the same way, the technology for motor-operated gate valves is the same for MOVs. The MOVs are not all the same size or all the same pressure class or used in the same application. Because the technology base is the same for MOVs, it is customary to aggregate their specific failure rates to arrive at a composite failure rate (3E-3/d) for this valve type. For the same reason, the Sandia data derived from various sized squib valves are applicable to AP600 squib valves.

PRA Revision: None.