U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Issues Identified With Design Verification of AP1000 Squib Valves

Jeffrey Jacobson, NRO/DCIP

February 20, 2013

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Overall NRC Concern

- Need to implement a systematic engineering design process sufficient to identify critical parameters of the explosive system design and to establish acceptable tolerance ranges for each parameter

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

History

- Original concern cited during NRC Inspection of SPX, Copes-Vulcan in Feb. 2012 (Inspection Report 9990080/2012-201)
- Concern centered around lack of design verification of initiator
- Since that time, NRC concerns have broadened to the entire squib explosive system as additional information has been acquired during subsequent NRC inspections and as testing failures have been identified

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

History – (cont.)

- Verification activities to date have been insufficient to demonstrate acceptable reliability of complete squib valve system
  - PRA assumed failure rate of 5.8 E-04 or about 1 in 1500 (for whole system) based upon test data from dissimilar components
  - Current test data indicates these PRA assumptions may be invalid

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Design Verification

- Design verification is required by Criterion III of Appendix B to 10CFR Part 50 and involves:
  - Identifying design requirements (including reliability)
  - Defining critical parameters that need to be controlled and establishing acceptance criteria
  - Verifying through a combination of analysis or testing that the above design requirements have been achieved
  - Design verification function can not be passed on to commercial subcontractors without sufficient oversight

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Design Verification of Squib Valve Explosive System Should Include

- Interfacing plant systems for actuating valves (PMS and DAS)
- Initiator
- Cartridge
- Initiator/Cartridge Interface

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Interfacing Plant Systems

- Design of field run cabling/connectors
- Design of actuation circuitry
  - Westinghouse has taken appropriate corrective actions to address issues identified during NRC Inspections regarding the design of the field run cabling/connector system and the design of PMS and DAS actuation circuitry
  - Final field verification of cable design and installation to be completed

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Initiator

- Need to develop engineering basis for critical initiator parameters and effects of nuclear environment on initiator performance
  - Basis for acceptance criteria for stated critical parameters
  - Assessment of margin in stated critical parameters including effects of aging/radiation/accident environment
  - Testing to establish stated reliability targets
  - Closed bomb test may be insufficient to detect loss of margin due to environment

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Cartridge

- Established testing program and design reviews largely focused on cartridge output
- Need to perform testing/analysis/review of parameters critical to ensuring reliable cartridge ignition
- Root cause analyses performed for anomalous cartridge performance and for cartridge ignition failure did not identify or address breakdown in design verification process
- Closed bomb test may be insufficient to detect loss of margin in cartridge output

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Initiator/Cartridge Interface Considerations

- Need to develop engineering basis sufficient to ensure initiator will reliably ignite cartridge
  - Comparison of initiator output vs. cartridge ignition requirements
  - Assessment of physical arrangement and effect on ignition reliability
  - Consideration of aging/radiation/environmental effects on system performance
  - Margin assessment for critical parameters

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Initiator/Cartridge Interface Considerations – cont.

- Need to perform assessment of common cause failures
  - A failure similar to that exhibited during testing could potentially defeat redundancy of having multiple initiators and diverse safety actuation systems

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Conclusion

- These are complex issues that may require continued communication with the NRC to achieve successful resolution
- If not resolved these issues could ultimately challenge the ability to close out a number of related ITAAC