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August 26, 1982

Docket Nos. 50-277
50-278

Mr. John F. Stolz, Chief
U.S. Nuclear Regulatory Commission
Operating Reactors Branch #4
Division of Licensing
Washington, DC 20555

SUBJECT: Peach Bottom Atomic Power Station, Unit 2 and 3, NRC Request for Additional Information on the Peach Bottom Containment Purge and Venting and Completion of NUREG-0737 Item II.E.4.2.

Ref: Letter from J. F. Stolz (NRC) to E. G. Bauer, Jr., (PECo.), dated July 7, 1982.

Dear Mr. Stolz:

In response to your request for additional information on the Containment Purge and Vent System and NUREG-0737 Item II.E.4.2. for the Peach Bottom Atomic Power Station review, Philadelphia Electric Company submits the attached summary report of our efforts and findings concerning this issue. This report should provide the information required to complete the NRC review.

With respect to the specific request for information identified in your letter:

Review Item 1 - Conformance to Standard Review Plan Section 6.2.4 Revision 1 and Branch Technical Position CSB 6-4 Revision 1;

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Enclosure 2 of the referenced letter requested the following in order to complete your review:

1) Information concerning the provisions made to insure that isolation valve closure will not be prevented by debris which could potentially become entrained in the escaping air and steam.

2) An analysis which demonstrates the acceptability of the provisions made to protect structures and safety related equipment located beyond the purge isolation valves.

Response:

The information presented as item 12 in the summary report describes the protective screens (Seismic Category 1) installed to prevent debris from disabling the valves. Item 16 of the summary report describes the efforts undertaken to demonstrate the acceptability of the system design.

Review Item 2 - Valve Operability: Requires further qualification information to be forwarded for review.

Response:

The summary report identifies various analyses (Items 1 thru 11) on all phases of valve operability as described in the enclosure "Guidelines for Demonstration of Operability of Purge and Vent Valves" received with your letter of September 27, 1979.

Review Item 3 - Safety Actuation Signal Override: Has been reviewed by the NRC and no further information was requested in this letter.

Review Item 4 - Containment Leakage Due to Seal Deterioration: Requests that we propose Technical Specification changes and provide details of a proposed test program.

Enclosure 1 of the referenced letter states "The purpose of the leakage integrity tests of the isolation valves in the

containment purge and vent lines is to identify excessive degradation of the resilient seats for these valves."

Response:

The Peach Bottom purge and vent valves utilize an inflatable T-ring seal design which has proven to be extremely reliable and leak tight over a period of many years. This particular design is very forgiving with respect to seal degradation, temperature changes, and leakage. By pressurizing the seal chamber, the elastomer seat is uniformly pressed against the periphery of the closed butterfly disc, thereby assuring very low rates of leakage. Review of the surveillance test results have confirmed this as a superior design feature.

The possibility of excessive seal degradation is further negated by the Peach Bottom preventive maintenance program which requires that the seals be replaced approximately every four years (3 refueling outages maximum).

In view of the above, we conclude that the present testing frequency of once per refueling cycle presently required by the Peach Bottom Technical Specifications is more than adequate to identify seal degradation and assure proper operation of the valves.

We have reviewed the sample Technical Specification (Enclosure 3) of the referenced letter against the Peach Bottom Technical Specification and have concluded that the existing specification provides the essential operability and surveillance requirements. For this reason we do not plan to request a Technical Specification change for this issue.

If you have any questions or require further information on the subject, please do not hesitate to contact us.

Very truly yours,

Attachment

cc: NRC - Site Inspector

Docket Nos. 50-277
50-278

SUMMARY REPORT

SUBJECT: Peach Bottom Atomic Power Station
Operability of Purge and Vent Valves

Introduction

Since receipt of a letter from the NRC to Philadelphia Electric Company in November of 1978, purge and vent valve operability has been the subject of a continual dialog between PECo., the NRC, architect-engineer (Bechtel), and purge and vent valve manufacturers (Fisher & WKM). A partial listing of relevant external correspondence is attached. This report is intended to summarize the results of this activity and to outline a course of action to resolve remaining issues.

Design of PBAPS Systems:

The Containment Atmospheric Control System (P&ID M-367, FSAR Figure 5.2.7) and Containment Atmospheric Dilution System (P&ID M-372, FSAR Figure Q14.6.5) are utilized to control the containment atmosphere during normal plant operations and post-LOCA, respectively. The portions of these systems used for containment venting are shared. All gases vented from the primary containment are processed through the HEPA and charcoal filters of the Standby Gas Treatment System (FSAR Section 5.3.3) prior to release in accordance with the plant Technical Specifications.

The torus and drywell are each provided with large purge and vent lines for rapid deinerting during shutdowns, ventilation during outages, and rapid inerting during startups. These lines are each provided with two, normally closed, system isolation valves. The 6" and 18" butterfly valves used for this service are designed to maintain a tight seal against design post-LOCA containment pressures. These isolation valves may be operated from the control room during normal plant operation and are automatically closed upon receipt of a containment isolation signal. The containment isolation signal to these valves cannot be bypassed or over-ridden.

In addition to the above large vent lines, the torus and drywell are each provided with small makeup and vent lines for atmospheric control during plant operation and post-LOCA. These small lines are either 1" or 2" in diameter. Each is provided with 2-1" isolation valves (either 2 globe valves or a globe and a check). The valves used in this service are designed for rapid closure (less than 5 sec.), and a tight seal against design post-LOCA containment pressures. The globe isolation valves may be operated from the control room during normal operation and are automatically closed upon receipt of a containment isolation signal. For post-LOCA combustible gas control these small vent line isolation valves may be opened by taking the reactor mode switch out of the RUN position and utilizing keylocked bypass switches. This override of the isolation signal is alarmed in the control room.

Technical Specifications:

The present Technical Specifications for PBAPS require that the containment atmosphere oxygen concentration be reduced to less than 4% within 24 hours of placing the reactor in the RUN mode and maintained in this condition during operation. Deinerting is permitted 24 hours prior to a shutdown (see Tech. Spec. 3.7.A.5). Purging of the primary containment must be through the Standby Gas Treatment System whenever primary containment integrity is required (see Tech. Spec. 3.8.C.9).

In addition, all containment isolation valves are required to be operable, or in the isolated position during power operation (Tech. Spec. 3.7.D). Surveillance testing is required during each operating cycle to confirm operability, closure time, and leak rates for containment isolation valves (Tech. Spec. 4.7.A.2.f and 4.7.D.1.a). The specified maximum closure time for the purge and vent isolation valves is 5 seconds.

Operating Experience:

It has been necessary to periodically vent the PBAPS containments during normal plant power operation to control containment pressure, maintain a torus-to-drywell differential

pressure, and/or maintain an inert atmosphere. Torus-to-drywell differential pressure maintenance has been discontinued per agreement with the NRC (Safety Evaluation supporting Amendment Nos. 41 and 40). Presently, venting for pressure control and maintenance of an inert atmosphere is required only when the Instrument Nitrogen System (P&ID M-333, FSAR Figure Q10.4.1) is out of service and plant Instrument Air is being utilized as a backup, or when other system leakage causes pressurization. These conditions are encountered infrequently. In most cases, intermittent venting through the small lines is sufficient. On some occasions, however, it has been necessary to cycle the large butterfly valves to provide sufficient control. When this is done, the gas is released in batches by opening the inner, and then the outer valve. At least one of the 18" butterfly valves in each vent line remains closed at all times during this operation.

Rapid purging through the 18" lines for inerting or deinerting takes bet[illegible] 5 to 8 hours if the valves are fully open. Restriction [illegible] valves to less than 40° open, as described below, has approximately tripled purge times. This operation is performed only for outages requiring containment access.

Surveillance testing experience indicates that the assumed 5 second closure times are conservatively long. The 1" isolation valves actually close in less than 1 second. The 18" butterfly valves typically close in about 3 seconds.

Operability Evaluation:

Normal Power Operation:

A December 1978 study by the Mechanical Engineering Division indicated that continued "unlimited purging" was fully justified during all operational modes except startup and shutdown. Any limitation on controlled venting through the small lines, or through the large lines when releases are "batched" was determined to be unwarranted. The above determination was based

on a review of the existing design against Standard Review Plan 6.2.4 and Branch Technical Position CSB 6-4.

Subsequent investigations indicated that detailed seismic analyses of the small purge and vent valves manufactured by WKM had not been performed. The NRC was advised that analyses were being performed to verify the adequacy of the design.

In reference 5), we advised the Commission that additional operability analyses would not be performed on the 1" air-operated globe valves. These valves have been designed and tested for rapid closure against pressures significantly higher than they would see following a LOCA. The valves in the drywell purge lines have been demonstrated to close in less than 5 seconds against a differential pressure of 1135 psig, and those on the torus against 110 psig. These are substantially greater than the maximum post-LOCA pressures of 42 psig in the drywell and 26 psig in the torus (see FSAR Figure 14.6.10). It was further stated that a seismic analysis of these valves had recently been completed with satisfactory results and that the stainless steel seating surfaces of these valves would not be subject to degradation when exposed to a post-accident environment.

Start-up and Shutdown:

A review of the design of the 6" and 18" butterfly valves with the manufacturer (Fisher) indicated that they might not close if subjected to DBA-LOCA differential pressures while in their full-open position. High stress levels would be experienced in the area of the stem-to-disc connection. In addition, it was determined that the air supply to the inflatable seals used in these valves was not safety-grade or seismic.

The NRC was immediately notified of these findings (reference 3), the valves were blocked closed, and a seismic air supply provided. Subsequent efforts were directed at determining the maximum allowable valve opening, providing a permanent seismic air supply which would not hamper operational flexibility, providing mechanical stops for positive valve position control,

and further evaluations of operability. These considerations are discussed throughout the following text.

The following specific discussions correspond to issues in the NRC's "Guidelines for Demonstration of Operability of Purge and Vent Valves" transmitted to PECo, with reference 4) and "Request for Additional Information" transmitted with reference 7):

1. Valve Closure Rate Versus Time - The butterfly valves are designed to close from their full-open position in less than 5 seconds. In accordance with the discussion in 2), below, the valves have been limited to a maximum of 40° open. Fisher has advised us that test results indicate that an assumption of a constant rate of closure from this position to the closed position is conservative. This assumption has been used in the determination of acceptable valve openings.

2. Flow Direction Through Valve; Δ p Across Valve - Fisher has provided a tabulation of allowable Δ p for the 6" and 18" valves for flow into the flat and into the hub. In determining allowable pressure drops across a particular butterfly valve at various angles of the disc, Fisher used classical "mechanics of materials" type equations to calculate stress levels at various worst-case locations in the valve assembly (specifically, various locations along the valve shaft). Their analysis addressed all of the different states of shear and stress which are applicable to the loading conditions defined. Fisher has confirmed the dynamic torque factors which are utilized in their analyses by testing. Code allowable stresses were assumed to be the limits of operability.

   Since the valves are installed at random with regard to direction of flow, allowable values for the most limiting combination (18" valve, flow into hub) have been integrated with the DBA LOCA drywell pressurization curve to determine an acceptable valve opening limit. This analysis indicates that the valves will close

against design pressures if they are limited to 40° open. All valves were initially limited to less than this opening by adjustment of their air supply regulators. Mechanical stops have subsequently been installed to provide a more positive means of control.

3. Single Valve Closure - Two butterfly valves are provided in series in each purge and vent line. Closure of a single valve has been assumed to be the limiting condition for analysis. Flow disruptions due to the simultaneous closure of an upstream valve could conceivably cause undesirable stresses on the shaft-to-disc connection of the downstream valve. However, Fisher's evaluation has indicated that this condition is less severe as a result of sharing the pressure drop between the two valves.

4. Containment Back Pressure Effects - All PBAPS butterfly isolation valves are located outside of containment. Thus, containment pressure on the valve operator can not exist and there will be no effect on the closing torque margins of these air operated valves.

5. Adequacy of Accumulator - An accumulator is not utilized to assure valve closure. These valves are spring loaded to close on loss of instrument air. A high pressure nitrogen cylinder is utilized as a source of safety-grade air for each inflatable seal. The controls are designed such that gas from this cylinder is utilized only when the instrument air line pressure drops below 75 psig. Alarms are provided to indicate loss of seal pressure.

6. Torque Limiting Devices - The PBAPS butterfly valves do not utilize torque limiting devices since they are equipped with air operators.

7. Piping System Effects - The effects of piping system discontinuities on flow distributions has been analyzed by our architect-engineer (Bechtel). It has been

determined that all but two valves per unit will be subjected to even flow distributions. Velocity profiles for the valves with uneven flow distributions were provided to the valve manufacturer (Fisher).

Fisher has advised that valves AO-2520 and 3520 are oriented such that the non-uniform fluid profile will not produce an additional torque on the valve disc since both "wings" of the disc (as split by the stem) will be subjected to the same flow. They have also advised that the non-uniform flow profile to which valves AO2520 and 3505 will be subjected will assist valve closure.

8. Effect of Disc and Shaft Orientation - The effect of shaft orientation relative to the fluid mixture egressing from the containment was considered to be relevant only in those cases where the valves would see uneven flow distribution. This is discussed in 7., above. The effect of disc orientation was considered in the determination of allowable valve opening per 2., above.

9. Seismic Design - A seismic analysis of the butterfly valve assemblies was performed by Fisher in 1974. This analysis considered normal operating loads plus loading due to seismic acceleration. In 1979 Bechtel was requested to review their original piping seismic analysis for 2 of the 18 purge and vent valves to confirm that allowable valve accelerations would not be exceeded. The results indicated that problems did not exist. A 100% check was subsequently requested. This review indicated the need for several pipe support modifications to limit valve accelerations to acceptable levels. This condition was reported to the NRC and corrective actions taken immediately.

Fisher has provided confirmation that the addition of mechanical stops will not adversely affect the seismic design of the valves. The seismic design of the safety grade air supply systems has been reviewed by Bechtel.

Seismic qualification documentation for components in the air supply systems was supplied by Fisher.

10. Seal Integrity - A tabulation of expected normal and post-LOCA environmental conditions was provided to Fisher for their evaluation of longterm seal integrity. The seals in these butterfly valves are routinely replaced approximately every 4 years in accordance with the manufacturer's recommendations. The ethylene propylene seal material used in these valves has been qualified for use in numerous safety-grade applications for radiation doses up to $\sim 5 \times 10^6$ Rads (γ) which is greater than the 2×10^6 Rads predicted for PBAPS. Test data furnished by a manufacturer of elastomeric seals indicates that this material would experience between 28 and 47% compression set at 10^7 Rads (γ).

Typically, only gamma radiation has been considered a hazard to elastomeric seals since they are usually enclosed in metallic grooves. In this particular application, however, a portion of the T-ring inflatable seal will be exposed to the containment atmosphere and thereby subjected to substantial beta irradiation ($\sim 8 \times 10^8$ Rads). We have thus far been unable to find any work done on the effects of the exposure of elastomers to beta radiation. Because of the low energy level of beta radiation, it is felt that any effects will be shallow surface phonomena that will not materially alter seal effectiveness.

The above described compression set phenomena may also occur due to temperature changes. As temperature increases the seal ring material attempts to expand but, due to the restrictive design, "thermal stresses" are developed in the seal. Over a period of time, the seal retains some permanent set which is assumed to be caused by polymer crosslinking. Then as the temperature is reduced, the seal material contracts resulting in less sealing compression, which tends to reduce its tight shut-off capability. This compression set phenomena will not be a problem for the Peach Bottom valves because the inflatable T-ring seal maintains a constant

and uniform sealing compression. In addition, the seal has been designed for tight shutoff against a constant differential pressure of 62 psig. This is substantially higher and of much longer duration than the predicted containment pressure response.

The design of the T-ring inflatable seal makes it particularly forgiving with respect to seal degradation, temperature changes, and leakage. By pressurizing the seal chamber, the elastomer seal is uniformly pressed against the periphery of the closed butterfly disc thereby assuring very low rates of leakage. It is therefore felt that continued seal replacement at approximately 4 year intervals (maximum 3 refueling outages) will provide sufficient assurance of seal integrity.

11. Design for Compressible Flow - The butterfly valves used at Peach Bottom have been designed considering the effects of compressible flow. Fisher's philosophy concerning the effects of compressible flow is presented in ISA Transaction Vol. 8, No. 4 entitled "Effect of Fluid Compressibility on Torque in Butterfly Valves" written by Floyd P. Harthun. The method used by Fisher to determine dynamic torque results in conservative loading conditions for stress and sizing calculations.

12. Debris Entrainment - Design features were originally not provided at Peach Bottom to ensure that purge and vent valve closure would not be prevented by debris which could potentially become entrained in the escaping air and steam. Fisher has suggested that screen mesh with 3/8" to 1/2" holes be provided. Accordingly, protective screens have been installed on the inner end of each containment purge and vent penetration. The screens are of seismic Category I design and located at a distance of at least several pipe diameters from the inner side of each inboard isolation valve.

13. Leak Testing During Operation - Local leak rate tests of all the purge and vent valves are currently performed

during each refueling outage in accordance with the requirements of 10 CFR 50, Appendix J and the Plant Technical Specifications. The capability to leak rate test the purge and vent valves during reactor operation currently exists. Such testing would have to be performed by pressurizing between the inner and outer valves. Testing of the inner valve in its nonaccident direction will give conservative or equivalent leak rates to testing in the accident direction for this type of valve.

14. Leak Rate vs. Δp - The inflatable seal ring utilized in the Peach Bottom purge and vent valves provides a design whose leakage is not sensitive to differential pressure across the valve but, rather, the relationship between seal supply and valve differential pressure. The seal supply pressure is maintained at a minimum of 75 psig which is more than 1.5 times greater than the maximum post-LOCA drywell pressure.

15. Limitation on Purge Time - In accordance with the requirements of reference 1), the use of the large volume purge path during operation has been limited to 90 hours per year. This limitation, in conjunction with the extended duration of purging due to limited valve opening, has caused some operational difficulties and may cause more significant problems in the future, depending on the number of times drywell access is required during any given year. Leakage inspections are performed while the vessel is pressurized during shutdown and startup operations. Once the current 90 hour limit is reached, inerting and deinerting will have to be accomplished while the unit is shutdown, thus extending the duration of all subsequent outages and precluding inspections. As a result, we have undertaken an evaluation of valve modifications which will allow greater opening percentages. In addition, evaluations of the radiological consequences of a range of LOCA's during purge operations are being completed in order to justify a less stringent limit.

16. Effects on Downstream Safety-Related Equipment - Gases being vented from the Peach Bottom primary containment are transported through duct-work to the Standby Gas Treatment System (SGTS) for filtration prior to release. Our Architect-Engineer (Bechtel) has completed an analysis of the pressure surge that the SGTS duct and filters could be exposed to if a DBA-LOCA were to occur while the large diameter (18") vent valves were fully open. The pressure differential across the filters was determined to be limiting and was calculated to exceed the differential for which the filters were designed. A later analysis, assuming 40° open valves, has demonstrated that acceptable pressures are encountered. However, filter effectiveness following such an event would be somewhat questionable due to the amount of moisture absorbed on the charcoal filters. We have thus undertaken a probabilistic assessment of the significance of potential damage. This effort has been completed to the point that we can conclude that there will be no increase in risk above WASH-1400 if duct failure does not occur. Further evaluations are continuing to support the same conclusion even with assumed duct and/or filter failure.

PEACH BOTTOM ATOMIC POWER STATION
PURGE AND VENT VALVES
REFERENCES

1) T. A. Ippolito (NRC) letter to E. G. Bauer (PECo) dated 11/29/78 - notice of problem, transmittal of SRP.

2) S. L. Daltroff (PECo) letter to T. A. Ippolito (NRC) dated 1/2/79 - response to reference 1).

3) W. T. Ullrich (PECo) letter to B. H. Grier (NRC) dated 3/5/79 - LER on valve closure and seismic air supply.

4) D. G. Eisenhut (NRC) letter to all LWR's dated 9/27/79 - transmittal of guidelines for demonstration of operability.

5) J. W. Gallagher (PECo) letter to D. G. Eisenhut (NRC) dated 10/25/79 - evaluation of large valves expected to be completed by about 4/30/80.

6) T. A. Ippolito (NRC) letter to E. G. Bauer (PECo) dated 10/22/79 - request for confirmation of operating limits and verification studies.

7) T. A. Ippolito (NRC) letter to E. G. Bauer (PECo) dated 1/2/80 - long term items (debris, leak testing, SGTS overpressure).

8) NEDO-24577, Mark I Containment Program - Plant Unique Load Definition Reports, April 1979.

9) NEDO-24708, Additional Information Required for NRC Staff Generic Report on Boiling Water Reactors, August 1979.