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September 26, 1984

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: Byron Generating Station Units 1 and 2
Braidwood Generating Station Units 1 and 2
Pump and Valve Operability
NRC Docket Nos. 50-454/455 and 50-456/457

References (a): April 4, 1983 summary of 1982 PVORT site audit.

(b): July 7, 1983 letter from E. D. Swartz to H. R. Denton.

Dear Mr. Denton:

This letter provides additional information regarding pump and valve operability at Byron and Braidwood stations. NRC review of this information is necessary to close Outstanding Item 4 of the Byron SER.

Reference (b) provided responses to a number of items which were not resolved during the 1982 Byron site audit by the pump and valve operability review team as described in reference (a). Additional information was requested during a conference call with the NRC Staff on August 7, 1984. Attachments A through E to this letter provide the requested information.

Please address further questions regarding this matter to this office.

One signed original and fifteen copies of this letter and the attachments are provided for NRC review.

Very truly yours,

T. R. Tramm

T. R. Tramm
Nuclear Licensing Administrator

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Attachments



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ATTACHMENT A

Diaphragm Valve - 1RY8028

**Concern 1:** Does Commonwealth Edison approve the static deflection test?

Response: Commonwealth Edison delegates the approval for these tests to Westinghouse, acting as CECo's agent. In addition, CECo performs periodic audits of Westinghouse to ensure that these responsibilities have been properly implemented and documented in Westinghouse's files.

**Concern 2:** Provide the frequency analysis for the valve body.

Response: As noted in our previous submittal on this valve, the natural frequency of RY8028 is below 33 Hz. The natural frequency of this valve as reported in ITT Grinnell Test Report No. 3864 is 12 Hz. Their qualification tests were conducted at 9.0g/9.0g/9.0g.

The above noted natural frequency and qualification levels have been factored into the Westinghouse piping analysis for Byron/Braidwood and were shown to be acceptable. The Grinnell Test Report and the Westinghouse analysis are maintained in the Westinghouse Engineering files in Pittsburgh and are available for audit.

ATTACHMENT B

Gate Valve - 1MS001A

Concern: The valve actuator safety margin based on the turbine room pressure (double-ended pipe break) versus actuator air pressure, does not assure valve operability.

Response: The original requirement for the functional test of valve 1MS001A was a supply of air from the reservoir to actuate the pilot valve which would provide a 55 psi differential pressure across the pilot valve. This reservoir is initially charged from the station instrument air system which will be operated at pressures of 80 psig or above and then is isolated.

Testing revealed that the pilot valve operation was not completely reliable when the reservoir was charged to 55 psig and would occasionally not complete its actuation. At 59 psig the valve was reliable. The total actuation time of valve 1MS001A is aproximately 3 seconds.

FSAR Section C.3.6 describes the pressurization assessment of the main steam valve rooms. A double ended rupture of the main steam line is not normally postulated in these areas because they are break exclusion zones but was postulated in the design basis to bound the structural pressurization effects. The maximum predicted pressure using conservative methods and accepted computer programs is a transient which peaks at 19.7 psig at less than one second after the break and then decreases.

As a result of these analyses and test results, a minimum effective differential pressure of 60.3 psi would be possible for a period of less than one second, based on full charging of the reservoir by instrument air supply. Since a margin of 1.3 psi is available even in this highly unlikely scenario, the design is considered adequate.

It should be noted that the failure of this valve to close because of environmental effects would not result in unacceptable degradation of the plant safety systems. In the event of losing two steam generators' capabilities due to a line break which affects both main steam isolation valves in one valve room and loss of function of a third steam generator due to a single active failure would result in one functional steam generator remaining available which is adequate to safely shutdown the plant.

4.2 Description of Test

4.2.1 The valve to be used for the test was a prototype developed especially for use in installations subject to seismic limitations. A photograph of the valve is shown in Figure SF-1. Two minor differences to the production version of the valve may be observed. The photograph shows what is apparently an additional support for the yoke rod just below the body to bonnet flange joint. This lug does not support the rod in any way as it has been bored out so that it cleans the rod completely and there is about 1/8 inch clearance around the rod. In production versions this lug will not be used, the half bonnet with lugs at the top being the only intermediate support for the yoke rods. These ears serve the purpose of aligning the yoke and spring system with the seat and inhibit resonance of the yoke rods. The advantage of the half bonnet design is that it retains the inherent value of the Dresser controlled thermal expansion concept and provides a rigid and strong valve configuration.

The yoke rod also is shown with an increased diameter as it enters the bottom supporting ear. This will not be a part of production valves and has been shown by test to have no detectable effect on resonant frequency.

4.2.2 Some of the accelerometers used during resonance testing are visible in the photograph. These were moved to various positions during the test series and Figure SF-3 shows a typical configuration. The accelerometer positions are defined in Appendix IV of this report, which describes the instrumentation used.

ATTACHMENT C

Safety Relief Valve - 1MS013A

**Concern:** The applicant should submit a copy of the Phase 3 qualification test results and Section 4.2.1 of Seismic Report EMD 3901 for staff review.

Response: Attached are copies of the documentation requested above.

most simple being the straight line graph: $Y = 98 - 1.16\,x$ and the most accurate the polynomial $Y = 0.02\,x^5 - 0.11\,x^4 - 0.25\,x^3 + 3.42\,x^2 - 8.44\,x + 100.1$. The simple straight line shows apparent leakage at 98 percent of set pressure under static conditions but otherwise is an acceptable approximation.

5.3.5 The combined effect of simultaneous three axis vibration is problematical. A reasonable assumption is that leakage will first occur in the region indicated by Figure 13, followed by a low pop as defined in Figure 9.

6.0 PHASE III - Valve operability test

6.1 Summary of Test Results

6.1.1 The operation of the valve was completely satisfactory during all the tests. During this phase of this test, the valve survived through approximately 140 pops under vibration and showed no apparent damage at the end of the test.

6.1.2 The test conditions were considerably more severe than would be encountered during normal service life. The simulated reaction force was applied continuously throughout each test series at its full value of 18,500 pounds. The vibration input being specific rather than random and the acceleration forces used in the test were much greater than the valve would ever be subjected to in the field.

6.2 Description of Test

6.2.1 The test valve was mounted on the shaker table in the same way as for the previous test phases. The valve was to be subjected to steam pressure for this test series and so the table was thermally insulated as far as possible. The steam system is fully described in Appendix III of this report. In general the system consists of

6.2 Description of Test (Continued)

a main boiler comprised of 6.0 cu. ft. capacity steel cylinders heated by 18 K watt immersion heater in each cylinder. Make up water is supplied by two S.C. pumps of 40 cu. ins./min. capacity. The feed water is preheated by passing through a cylinder heated by 3 Kilowatts of external band heaters, in addition an 15 K watt immersion heater is fitted into the preheater which is activated when the pumps are delivering water. Main boiler steam is passed to the 1.5 cu. ft. tank attached to the underside of the shaker table, through four flexible 1/2" hoses. The tank is fitted with a condensate drain and safety valve set at 1,800 psig. The main boiler safety valve is set at 2,150 psig. Maximum steam capacity is about 2.5 lbs./min.

6.2.2 One problem with the system was the necessity to heat up the shaker table and valve assembly before the first test, the total weight of steel being in the region of 3,000 lbs. Many other problems were experienced and overcome during the development period prior to testing. The entire steam system was modified several times due to water level sensor, immersion heater and stop valve failures. Instrumentation presented difficulties because of the very rapid opening time of the valve with the modified disc holder and shroud system. The normal X-Y plotter system was too slow and so pressure and spindle movement were recorded using magnetic tape and the Biomotion data acquisition system and the strain gauges were recorded by B and H Oscillograph. Complete instrumentation data and calibration methods are described in Appendix IV of this report. The Biomation input was restricted to two channels to provide maximum definition over the two seconds of data acquisition time. The two

6.2 Description of Test (Continued)

variables measured and charted by X-Y plotter being inlet steam pressure and spindle movement. It was necessary to make the full ten inches of the chart x axis equal to two seconds in order to capture the lift and closing point of the valve. The opening stroke was virtually instantaneous but the closing cycle was much slower, dependent on initial steam supply conditions, but generally in the region of one second. The full X axis was expanded to cover a period of only 20 milliseconds (2 ms/inch) to examine the lift curve in more detail, this is discussed in Section 6.3.

6.2.3 Strain gauges were mounted on the valve inlet and outlet flange necks and recorded on the oscillograph. The spindle movement and the steam temperature in the tank mounted immediately under the valve was also recorded on the oscillograph.

6.2.4 The complete test installation was monitored and controlled from a large panel situated about twenty feet from the shaker table. This is shown in the photograph (Figure 15 ). A closed circuit television system was used to view the table because the system was completely enclosed in a safety screen of steel plate. The boiler system was also boxed in by steel plate as an additional safety precaution.

6.2.5 Steam pressure in the main boiler was brought up to about 1,300 psig and the valve and table system heated to saturation temperature at about 1,000 psig. The valve was then soaked at this temperature for one hour. After instrumentation calibration, the simulated reaction force was applied by two air cylinders which pulled down on the outlet elbow with a force of 18,500 pounds. All condensation was drained from the system. Vibration was started and then at the

6.2 Description of Test (Continued)

desired acceleration level, steam was passed from the main boiler to the table mounted tank. Immediately the valve popped, the steam supply was shut off. Tests were conducted at 10, 15, and 25 Hz. These frequencies are different from those specified in P.T. 52 Rev. 0 because it was found that 30 Hz was at the beginning of the resonance curve (ref. Section 5.2.3) and causes severe stressing. Accordingly, the 30 Hz was reduced to 25 Hz and the 20 Hz changed to 15 Hz. The maximum acceleration input level used in the tests was 6g. This was the maximum level attainable by the vibration equipment at 25 Hz and although only one complete record was made in the X axis at this force, the valve saw accelerations close to 6g several times until the equipment was finally adjusted to achieve maximum output. The single record was taken with the valve in the X axis and testing in the Y and Z axes followed. During testing in the Y axis the last of the strain gauges mounted on the inlet neck finally failed, due probably to the combination of heat and vibration. It was thought sufficient information had been obtained during the previous tests and so testing was continued.

6.2.6 When the Y axis test series was complete, the valve was popped statically with a lower base pressure in the table tank. The opening time was not affected, being still in the region of eight milliseconds. The pressure ramp was reduced from about 150 to 40 psi/second.

6.2.7 Another test which reduced the ramp speed even more was made by using the by-pass pressure time to pop the valve. There was no effect on the time of opening although the valve closed more quickly due to the reduced steam flow volume.

6.2.8 Description of Test (Continued)

The shaker table was disassembled and re-erected into the vertical (Z axis) configuration. All the tests performed in the horizontal axes were repeated in the vertical plane. A static test record was made between each change in frequency to check the effect of any change in popping pressure.

6.2.9 Shortly before the Z axis tests were completed, the four screws holding the special disc shroud sheared and allowed the shroud to come away from the disc holder. This was presumably caused by the repeated impact of the disc holder against the base of the cylindrical yoke support. In consequence the valve reseated at a very high velocity. The record of shot 91 shows this very clearly. There was apparently no other damage to the valve so the screws were replaced with stronger ones and the valve reassembled. The tests were completed successfully and the only effect of the screw failure was slight steam leakage at about 1,000 psig.

6.3 Test Results Phase III

6.3.1 Prior to steam testing but in the final Phase III configuration, photograph (16A), the valve was subjected to resonance surveys with and without the simulated reaction force applied. The first resonant peak was unchanged at 37 Hz. The plots of these tests are numbered Figure 16 through Figure 19.

6.3.2 Before vibration was started, the effect of the simulated reaction force load was measured by the strain gauges. The measured strains are tabulated in Figure 20. This procedure was repeated before several test shots in order to insure the strain gauges were still working properly. Gauges "A" and "C" were located at the inlet flange neck and "T" and "B" at the outlet neck. The measured strains at the outlet are questionable since T values are very low and B values are much higher than calculated strains. The inlet results seem good and give approximate stresses of 6000 psi.

6.3.3 The lift and pressure data together with the additional strain recorded as the valve opened are tabulated in Figures 21 through 23. Not all the data is included in these tables because each shot was repeated three times and the results are consistent. Figure 21 contains the data for the X axis, figure 22 has the Y axis results, and figure 23 tabulates the data obtained during the vertical Z axis tests. The strain values shown in these tables are additional to the strain produced by the simulated reaction force shown in figure 20.

6.3.4 Popping pressure at various accelerations is plotted for the horizontal axis tests in figure 24. A scale on the right side of the graph shows the percentage relationship to static set pressure. These data have not been examined in the same detail as the air tests as the intent of the tests were basically to establish operability under vibration but it is clear that the pattern is the same. As the acceleration input increases the valve opens at a reduced pressure. Values for the steam tests are similar to those found using air. Figures 25 and 26 show the same thing for tests in the vertical direction.

6.3.5 The time to open was fairly constant throughout all the tests. It was generally in the region of 15 milliseconds or less. Shots 65, 65A and 65B were made at widely different pressure ramp speeds, 65 being about 125 psi/second and 65B showing no measurable increase in half of one second. The opening time did not change in these static shots. Several of the plots were replotted to a much higher rate time base, with the aid of the Biomation Unit. The standard base used was 200 milliseconds over the 10 inches of the X - Y plot and this was expanded to 20 milliseconds total. Only the initial opening stroke was visible on these plots. The shapes of the plots are very similar in all cases, static opening curves being compared with 6g shots in both the horizontal and vertical directions. Opening time was constant at 10 milliseconds. The amount of spindle movement or lift varried slightly in that the 6g traces showed about .050 inches less movement that the static shots.

6.3.6 Figure 27 shows a straight line graph which shows in much simplified form, the approximate percentage of the initial static set pressure at which a valve may open if it is subjected to vibration at or near the first resonance peak. To a lesser degree the graph also applies if one of the later peaks is approached.

Although all the information obtained from these tests, and also operating experience which is outside the scope of this report, was utilized to produce the plot, it is still only approximate and many other factors may cause leakage or popping below set pressure.

The valve seat condition is very important in this respect and an imperfect seat seal may cause leakage below the graph values even though it may be leak tight under static test.

7.0 Post Test Inspection

7.1 After all three phases of the test were completed the valve was completely disassembled and all critical components thoroughly examined for signs of wear or damage.

7.2 Disc - The disc was first visually examined for signs of damage to the seating area. Slight lateral scratching could be seen. It was then lightly lapped to check for flatness and showed signs of the inner lip dishing inwards. After a few minutes lapping the disc was flat so the dishing was very slight. The lateral scratches were removed by further lapping and the disc seat was die penetrant checked. No trace of cracks were found.

## Butterfly Valve - 1SX027A

Concern 1: Provide assurance that the Limitorque actuator torque is acceptable at minimum voltage requirements and/or that the Byron plants voltage supply cannot be less the 100% of the actuator voltage requirements.

Response: The required torque on the valve is 1180 ft-$lb_f$. The torque supplied by the Limitorque actuator is 1320 ft-$lb_f$. The motor is 33HP, 460V, 3 phase, 60Hz. The motor is specified to deliver full load at 75% voltage drop for infrequent periods (refer to the attached S&L Spec. F/L-2884, Article 307.2i).

Concern 2: Provide assurance that this valves critical soft parts are to be replaced at the end of their quailified lives and/or that they are able to withstand the postulated environmental conditions without exhibiting common mode failure effects.

Response: The critical soft parts on this valve (listed below) have been qualified for 40 years at the specified environmental conditions of 320$^{o}$F (3 minutes), 100 psig, and 2 x $10^8$ RADS.

Valve Seat - E.P.T.
Shaft Bearing - Fiberglass Epoxy, Nylon
Shaft Seal - John Crane 187 (Asbestos-Graphite)

Ordinary maintenance and surveillance will ensure scheduled change-outs of parts that may degrade for normal mechanical wear.

306.5 Valves shall function smoothly without sticking, rubbing, vibration or scouring on opening and closing.

306.6 The pneumatic cylinder lubrication system, if required, shall be provided for each valve for remote operation from a station approximately 100 ft. from cylinder. Lubricant shall be phosphate ester compound fire resistant fluid (Shell S.F.R. Fluid C, Shell Oil Co.) or equivalent.

306.7 Rod seal and piston seal shall be bubble tight when leak tested at 110 psig.

306.8 Operation shall be designed for a minimum of 1000 operating cycles/year without any maintenance or seal packing replacement for four years.

306.9 Air cylinders shall be provided with 115 V ac solenoid control valves. Solenoid coils shall meet requirements specified in Article 307.3 of this Specification.

307. <u>ELECTRICAL REQUIREMENTS</u>

307.1 General:

a. Electrical equipment associated with valves shall be capable of satisfactory and reliable operation in the environmental conditions specified for a 40 year service life. It is the Contractor's responsibility to determine whether or not the components and equipment specified herein are suitable for the environmental conditions specified. If not suitable, he shall propose alternates which can withstand the specified conditions.

b. Valves shall be furnished with motor operators, air operators with solenoid pilots, hydraulic actuators, or solenoid actuators as required by the valve data sheets.

c. Electrical equipment designated as Class 1E on the valve data sheets shall be qualified in accordance with the requirements of IEEE-323-1974. Documentation shall be provided in accordance with Environmental Qualification Documentation for Class 1E Equipment (Att. E). Amd.1

307.2 Motor-Operated (MO) Valves:

a. Valve motor operators shall be Limitorque Type SMB, as manufactured by the Limitorque Corporation, and shall meet the requirements of Form 1810, as modified below.

b. Valve ac motors shall be rated at 460 V, 3-phase, 60 Hz. Motor performance curves shall be furnished for each motor rating.

c. Valve motor operators, their components and insulation shall be suitable for satisfactory and reliable operation in ambient conditions and radiation levels specified.

d. Valve operator stem nuts shall have a positive locking feature for preventing its loosening during valve travel.

e. Valve operators shall have four-train, geared limit switches.

f. Reversing motor starters will be furnished by the Purchaser

g. Where specified, position transmitters shall be selsyn-type. Slide wires are not acceptable.

h. The schematic diagram for valve control shall be as shown in Drawing ES-96 for ac motors.

i. Each valve operating unit shall have ample horsepower capacity and torque to seat its valve and maintain tight shutoff and unseat the valve, under the maximum rated pressure-temperature conditions on the upstream side of seat and atmospheric pressure on other side. Motor operators shall be sited to stroke the valve within the specified time at the maximum design differential pressure at the rated voltage ± 10% and shall deliver full load (running torque, not seating torque) without damage when the voltage drops to 75% of rated voltage for infrequent one minute intervals.

j. Contractor shall be fully responsible for each of the following requirements for each motor-operated valve:

j1. Deleted

j2. Deleted

j3. Deleted

Amd.2

j4. Identify the maximum allowable torque switch settings (Open and Close).

j5. Provide a nameplate on the motor operator which contains at least the below listed information:

j5.1 Motor operator serial number.

j5.2 Maximum allowable torque switch settings (Open and Close).

j5.3 Initial factory settings (Open and Close).

j6. All information concerning torque switches shall be submitted separately to the Consulting Engineers and shall be correlated with motor operator serial number, valve serial number and valve ID number.

ATTACHMENT E

## Auxiliary Feedwater Pump - 1AF01PB-1

Concern: Approval of the diesel qualification test at Southwest Laboratories by the applicant.

Response: The diesel driver for the auxiliary feedwater pump is in a mild environment and the environmental qualification of this component is still under testing at Southwest Labs. The qualification program is now scheduled to be completed in February, 1985. Seismic qualification of the diesel driver is complete.