Iowa Electric Light and Power Company
November 4, 1985
NG-85-4801

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

Subject: Duane Arnold Energy Center
Docket No: 50-331
Op. License No: DPR-49
Masonry Wall Design - Inspection and Enforcement Bulletin 80-11
Reference: Letter, D. Vassallo to L. Liu, dated August 22, 1985
File: A-101a

Dear Mr. Denton:

This letter and its attachment provide our response to the above-referenced letter which requested us to reevaluate five masonry walls your staff found unacceptable. The letter requested that we reevaluate the walls in accordance with the staff position on the use of the Energy Balance technique or adopt an acceptable alternative. In discussions with our NRC Licensing Project Manager on October 25, 1985, we were given seven additional days beyond the 60-day response time to submit this letter.

The attached report concludes that walls 412-9 and 412-13 would remain elastic for seismic loads combined with sustained accident loads. Wall 200-7 was reevaluated using elastic methods in conjunction with refined loading criteria and was found to remain within working stress allowables. Therefore, we feel this response provides an acceptable alternative for these three walls.

Our review of the remaining two walls, 200-8 and 417-25, indicates that numerous conservative assumptions were made in our original IEB 80-11 reevaluation (Reference 1 of the attached report) as revised by Reference 2 of the attached report. We believe that further refinements in the seismic analysis of the Turbine Building (wall 200-8) and the Reactor Building (wall 417-25) would reduce the input to the masonry walls sufficiently to bring seismic stresses well within the elastic range. However, the cost of performing these new seismic analyses may be more than the cost of reinforcing the walls. Another possible solution is to relocate the safety related equipment mounted on these walls to another location. We believe that more engineering study is required to determine the best solution.

IE11

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We propose to perform this engineering study and inform you of our method of resolution and schedule for implementation by January 31, 1986.

Please contact this office should you have any questions.

Very truly yours,

R. W. McGaughy

Richard W. McGaughy
Manager, Nuclear Division

RWM/MJM/ta*

Attachment: DAEC Masonry Wall Response

cc: M. Murphy
L. Liu
S. Tuthill
M. Thadani
NRC Resident Office
Commitment Control No. 850300

Attachment to
NG-85-4801

REEVALUATION OF MASONRY WALLS QUALIFIED USING THE ENERGY BALANCE TECHNIQUE AT THE DUANE ARNOLD ENERGY CENTER

Five masonry walls at the Duane Arnold Energy Center were identified in our responses to Inspection and Enforcement Bulletin 80-11 (IEB 80-11) as having been evaluated using "Energy Balance" methods. It should be noted that there are two distinct energy balance methods. The first, the "Accident Energy Balance" (AEB) method, is used to evaluate structural response when subjected to impact or impulse (monotonic) type accident loads. The second method is a "Seismic Energy Balance" (SEB) method used for the evaluation of structural response when subjected to seismic (reversing type) loads. Both methods utilize inelastic strain energy to dissipate energy from external work and absorbed kinetic energy associated with the loading.

The main distinction between the two methods is that, for the SEB method, the seismic loads are the dominant loading and the structure is expected to undergo strain reversals. NRC consultants have questioned the application of this phenomenon of strain reversal in the evaluation of masonry walls. In the AEB method, all non-accident loads, including seismic, are treated as pseudo-static loads and the structure is allowed to exceed yield and come to a stable condition (controlled by a limit on the allowed ductility ratio for the loaded member). This non-cyclic use of energy balance techniques has been used by the industry for many years in the evaluation of accident loading on structural elements, and we understand that it is acceptable to the NRC.

DAEC masonry walls 412-9 and 412-13 were evaluated using the AEB method and shown to remain elastic under seismic loading. Therefore, they should not be listed with the walls evaluated by using the SEB method. Wall 200-7 has been analyzed for this submittal using elastic methods and the refined model described below. This analysis determined that wall 200-7 remains elastic and within working stress allowables.

For this submittal, walls 200-8 and 417-25 were reviewed with respect to the conservative assumptions made in the DAEC's original IEB 80-11 reevaluation (Reference 1) as revised by Reference 2 (hereafter referred to as the original IEB 80-11 reevaluation). This most recent review indicates that these walls would most likely remain elastic when subject to seismic loads.

The following is a detailed description of this latest evaluation for the five identified walls:

Masonry Wall 412-9

A review of the original IEB 80-11 reevaluation indicates that this wall remains elastic under full seismic loads including sustained jet force due to pipe rupture. The wall behaves inelastically only in dynamic response to combined pipe impact and jet force associated with the pipe rupture load (this phase is a monotonic load event with a response duration of about 20 milli-seconds). After this "short-term" monotonic load, the system reverts to elastic response with no reversals having inelastic displacements and, therefore, no degradation to the structural system. This is an acceptable design/evaluation approach for any structural system subject to impact or impulse type loading.

Masonry Wall 412-13

A review of the original IEB 80-11 reevaluation indicates that this wall remains elastic under full seismic loads including sustained compartment pressurization due to pipe rupture loads. Higher stresses are indicated locally due to jet impingement loads, but these loads do not fully mobilize plastic behavior in this localized area of the wall and the wall remains essentially elastic (i.e., linear response) in this localized area. In addition, the localized impact and jet load area is immediately adjacent to a side boundary of the wall, and, consequently, even if a localized overstress in this area were to occur, it would have no effect on the stability of the wall. Use of the AEB analysis technique illustrated the masonry wall's ability to remain stable under the compartment pressurization, jet impingement and seismic loading.

Masonry Wall 200-7

For this report, a reanalysis was performed using working stress techniques in which a refinement of loads, seismic accelerations and boundary conditions resulted in elastic wall response while subjected to the seismic loading combinations.

For this reanalysis:

1. Wall attachment loads were deleted from the uniform wall load and were applied as forces and moments acting at their respective locations. In addition, the calculated wall weight of 75 lbs/sq. ft. was used instead of the "rounded-up" value of 80 lbs/sq. ft. used in the original IEB 80-11 reevaluation (8-inch thick wall with a grouted cell every 16 inches on center).

2. Seismic accelerations for the attachment loads were selected using floor response spectra for 1 percent of critical damping in the Design Basis Earthquake (DBE) loading combination (DAEC FSAR Table 3.7-1), versus 1/2 percent used in the original IEB 80-11 reevaluation.

3. The mass and stiffness of a column which supports a platform in conjunction with the masonry wall were modeled into the wall analysis. The original reevaluation modeled the attachment as a restraint, which resulted in a localized overstress of the wall.

The latest analysis, based on the refinements listed above, resulted in elastic behavior using working stress techniques and consequently there is no need to rely on the seismic energy balance technique for qualification.

Masonry Wall 200-8

A review of the original IEB 80-11 reevaluation of this wall indicates that the assumptions and modeling conditions used contain a large degree of conservatism with respect to the seismic response of the Turbine Building structure and consequently the masonry wall.

Current methods for selecting and modifying earthquake time histories, for use in the dynamic analysis of structures, yield time histories whose response spectra more closely fit the committed design response spectra (as defined in the FSAR). A substantial benefit in the reduction of building response could be achieved using a time history which has a better response fit.

In the original Turbine Building seismic analysis, the effects of radiation damping for the structure supported by soil were not included. In addition, the damping for all modes, including soil dominated modes, was limited to 5 percent of critical. Inclusion of radiation damping and using more appropriate damping values for soil dominated modes can reduce response accelerations on the order of 30 to 40 percent. Furthermore, the original seismic analysis used a damping factor of 2 percent of critical (as per FSAR Table 3.7-1, Operating Basis Earthquake [OBE] damping coefficients) for the bolted steel structure. Typical values of damping of bolted steel construction would be on the order of 7 percent to 10 percent of critical for the DBE response range. Consequently, the resultant floor response spectra are very conservative.

In addition, the following conservative assumptions were included in the original IEB 80-11 reevaluation:

1. All attachment loads were assumed to be responding at the peak of the floor response and were assumed all to be acting in the same direction at the same time. This phenomenon is highly unlikely and, therefore, the assumption is quite conservative.

2. The wall mass used was a "rounded up" value of 80 lbs/sq. ft. instead of the calculated value of 75 lbs/sq. ft.

3. The attachment loads were applied both as a uniform load added to the wall's uniform self weight and also as individual concentrated forces and moments applied at specific locations on the wall.

4. Seismic accelerations for attachments were based upon 1/2 percent of critical damping for the DBE loading conditions instead of 1 percent of critical damping which is permitted by the FSAR.

5. In addition to the above, material strengths for masonry and reinforcing steel are typically higher than the minimum specified design values used in the original IEB 80-11 evaluation.

At present, we cannot show that this wall would remain elastic by using the working stress method. We believe that it could be shown to remain elastic using this method if the conservative assumptions listed above were removed. However, this would require a new seismic analysis of the Turbine Building to determine the refined building response. The cost of a new seismic analysis could exceed the cost of reinforcing the walls or relocating the affected safety-related equipment. Therefore, additional engineering effort is required to determine the best solution.

Masonry Wall 417-25

A review of the original IEB 80-11 reevaluation of this wall indicates that the assumptions and modeling conditions used contain a large degree of conservatism with respect to the seismic response of the Reactor Building structure and consequently the masonry wall.

Current methods for selecting and modifying earthquake time histories, for use in the dynamic analysis of structures, yield time histories whose response spectra more closely fit the committed design response spectra (as defined in the FSAR). A substantial benefit in the reduction of building response could be achieved using a time history which has a better response fit.

In addition, the following conservative assumptions were included in the original IEB 80-11 reevaluation:

1. All attachment loads were assumed to be responding at the peak of the floor response and were assumed all to be acting in the same direction at the same time. This phenomenon is highly unlikely and, therefore, the assumption is quite conservative.

2. The wall mass used was a "rounded up" value of 80 lbs/sq. ft. instead of the calculated value of 75 lbs/sq. ft.

3. The attachment loads were applied both as a uniform load added to the wall's uniform self weight and also as individual concentrated forces and moments applied at specific locations on the wall.

4. Seismic accelerations for attachments were based upon 1/2 percent of critical damping, for the DBE loading conditions, instead of 1 percent of critical damping which is permitted by the FSAR.

5. In addition to the above, material strengths for masonry and reinforcing steel are typically higher than the minimum specified design values used in the original IEB 80-11 reevaluation.

At present, we cannot show that this wall would remain elastic by using the working stress method. We believe that it could be shown to remain elastic using this method if the conservative assumptions listed above were removed. However, this would require a new seismic analysis of the Reactor Building to determine the refined building response. The cost of a new seismic analysis could exceed the cost of reinforcing the walls or relocating the affected safety-related equipment. Therefore, additional engineering effort is required to determine the best solution.

References

1. Letter w/enclosure, L.D. Root (Iowa Electric) to J.G. Keppler (NRC), November 10, 1980 (LDR-80-335), Subject: Response to IE Bulletin 80-11, 180-Day Final Report, Revision 0

2. Letter w/enclosures, L.D. Root (Iowa Electric) to H. Denton (NRC), October 6, 1982 (LDR-82-264), Subject: Response to NRC Questions Raised in Conference Call of May 17, 1982 and 180-Day Final Report, Revision 1

JUSTIFICATION FOR THE CURRENT PURGE AND VENT VALVE T-RING SEAL PRESSURIZATION SYSTEM

Background

In responding to GL 84-09, we evaluated the T-ring seals on the purge and vent valves as potential oxygen sources. Each purge and vent valve has a T-ring seal system which is pressurized from the plant instrument air system which contains normal atmospheric concentrations of oxygen. The seals are qualified for the accident environment and the NRC requires their replacement at regular intervals (Ref. 1). For these reasons, failure of these seals was not considered as credible. However, the NRC expressed a concern that these T-ring seals could be potential oxygen sources. An additional evaluation has been made to determine the time available after seal failure for operators to take corrective action before the drywell oxygen concentration reaches the 5% flammability limit, beginning from an initial O_2 concentration of 4% (tech spec limit). This evaluation, in conjunction with a discussion of existing design provisions at DAEC, is used to justify the continued use of plant instrument air system for pressurization of the T-ring seals.

Evaluation

During normal operation the DAEC primary containment is maintained with oxygen concentrations less than the technical specification limit of 4% by volume. The oxygen concentration is continuously monitored with an alarm set at 3.6%. To provide operational flexibility, the oxygen concentration during normal operation is maintained at approximately 2%. Therefore, the initial condition of 4% oxygen by volume used in this evaluation is considered conservative.

The T-ring seal material is ethylene propylene. This material is qualified for post-LOCA temperature, pressure and radiation environmental parameters applicable to the DAEC drywell conditions. The only failure mechanism which has been identified for this material is embrittlement due to aging. The estimated qualified life of the seals is 5 years, which is consistent with the evaluations made for ethylene propylene elastomers in ASCO solenoid valves. To ensure purge and vent valve operability, the T-ring seals are replaced at least every 4 years and valve leakage, a sign of seal failure, is tested every 3 months at the DAEC.

These seals are also found on the control valves in the torus-to-reactor building vacuum breaker system. While not required by the technical specifications, the seals in the vacuum breaker system will be replaced at intervals consistent with their above-mentioned lifetime, as part of our preventive maintenance program. The technical specifications do, however, require a quarterly operability check of the vacuum breaker system, at which time seal integrity will be checked by indirect methods. The surveillance procedures for the vacuum breaker system will be revised to incorporate this integrity check.

Thus, the primary failure mode in the seals, age-related failure, is very unlikely. In addition, since the primary containment oxygen concentration is normally monitored continuously during power operation, it is highly unlikely that failure of the seal system would go undetected.

Nevertheless, two independent evaluations have been performed to estimate conservatively the maximum leakage rate which could be associated with seal failure and hence the shortest time available to take corrective action. In addition, a third evaluation was performed to determine a more realistic leakage rate.

The following are the major assumptions used in these evaluations:

1. One of the six inboard inflatable T-seals develops a leak.

2. Air supply contains concentrations by volume of 20% oxygen and 80% nitrogen.

3. In order to maximize the airflow into the containment, the drywell pressure is assumed to be at 0 psig.

4. Air leakage entering the drywell sufficiently mixes due to natural and forced convections and by diffusion.

5. The calculated oxygen concentrations are maximized using a drywell pressure of 0 psig and temperature of 150F.

6. The initial oxygen concentration in the drywell is at 4%, the technical specification limit.

7. No credit is taken for nitrogen addition to reduce the oxygen concentration.

The first case evaluated an equivalent 1/8-inch diameter leak in a T-ring seal assuming the maximum air supply pressure (100 psig) at the T-ring seal. Normally, the pressure at the T-ring seal (after it developed a leak) would be less than 100 psig, because of the pressure losses in the tubing and across various components in the air supply lines. The estimated time required for oxygen concentration to reach 5% is approximately 5.3 hours.

The second case evaluated the restrictions due to the components of the T-ring seal system as shown in Figure 1. This evaluation assumed the air supply to be regulated at the minimum supply pressure of 80 psig and the flow control valve to be full open. In addition, the size of the seal leak was assumed to be large so as to not restrict the flow. The estimated time required for oxygen concentration to reach 5% is approximately 4.9 hours. This case shows the relative insensitivity of the calculation results to the assumed size of the seal leak.

In either case, operators would have sufficient time available to detect the leak and correct the problem.

In a more realistic case, the pressure drop across the many components within the seal system would limit the leakage rate significantly, thereby allowing the operator even more time to respond. The leak rate through a T-ring seal is principally dependent on the adjustment of the flow control valve. The Colorflow (see Figure 1) valve's function is to delay for a few seconds the pressure buildup within the seal chamber upon closing of the purge and vent valve. The Fisher control valve downstream from the Colorflow valve does not affect this time delay, as it has normally opened prior to the lever-actuated valve (labeled "A") opening to allow air into the seal system. The lever-actuated valve is triggered by the valve disc. Thus, air is not supplied to the seal system until the disc is almost closed. By this time, enough pressure has been applied to the Fisher valve to open it completely.

An evaluation was performed to determine the volume of the seal chamber and the resultant flowrate required to pressurize this volume in approximately two seconds. Using this value as the seal leakage rate, the estimated time required for the oxygen concentration to reach 5% is approximately 75 hours.

Justification for Keeping the Existing Design

Upon receipt of a high drywell oxygen alarm at 3.6%, the operator would use the normal nitrogen addition system to insert nitrogen into the containment to maintain the oxygen concentration below 4%. In addition, the operator would initiate action to determine the cause of oxygen inleakage. Guidance will be added to the present procedures stating that these seals are a potential source of the oxygen inleakage. As shown in Figure 1, a pressure indicator is installed on each valve and could be used to locate seal leakage. The local ball valve can then be used to isolate a seal leak. The above evaluation confirms that adequate time is available to detect the oxygen leak and isolate the seal.

The T-ring seal system on each of the redundant purge and vent valves on a given purge line is pressurized from an independent air compressor system which can be isolated locally at the valve. Also, the air inleakage problem would exist only if there is a leak in an inboard valve. The T-ring seal systems on inboard purge and vent valves 4300, 4307, and 4308 are pressurized from one train of control building H&V instrument air system, and the inboard purge and vent valve 4302 is pressurized from a second train of this air system. The operator is supplied by a separate air system than the seals (see Figure 1). The torus-to-reactor building vacuum breaker valves 4304 and 4305 are supplied by a common supply to both the operator and seal (see Figure 2). If a T-ring seal system on any one of the valves 4300, 4307, or 4308 develops a leak, the air supply would need to be isolated. However, the containment integrity would not be lost by this action. The outboard purge and vent valves 4301 and 4306 will remain pressurized. The same situation would be true for any postulated failures in the T-ring seal system for inboard valves 4302, 4304 and 4305.

From the above discussion, it is evident that the corrective actions could be taken in time to maintain the oxygen concentrations below flammability limits and the containment integrity is maintained at all times, even with the isolation of pressurization supply to the failed T-ring seal.

Based upon the above information, it is concluded that the existing T-ring seal pressurization system design at DAEC is adequate to protect the health and safety of the public.

References

1) Letter, M. Thadani to L. Liu, Amendment No. 100 to Facility Operating License No. DPR-49, May 22, 1984

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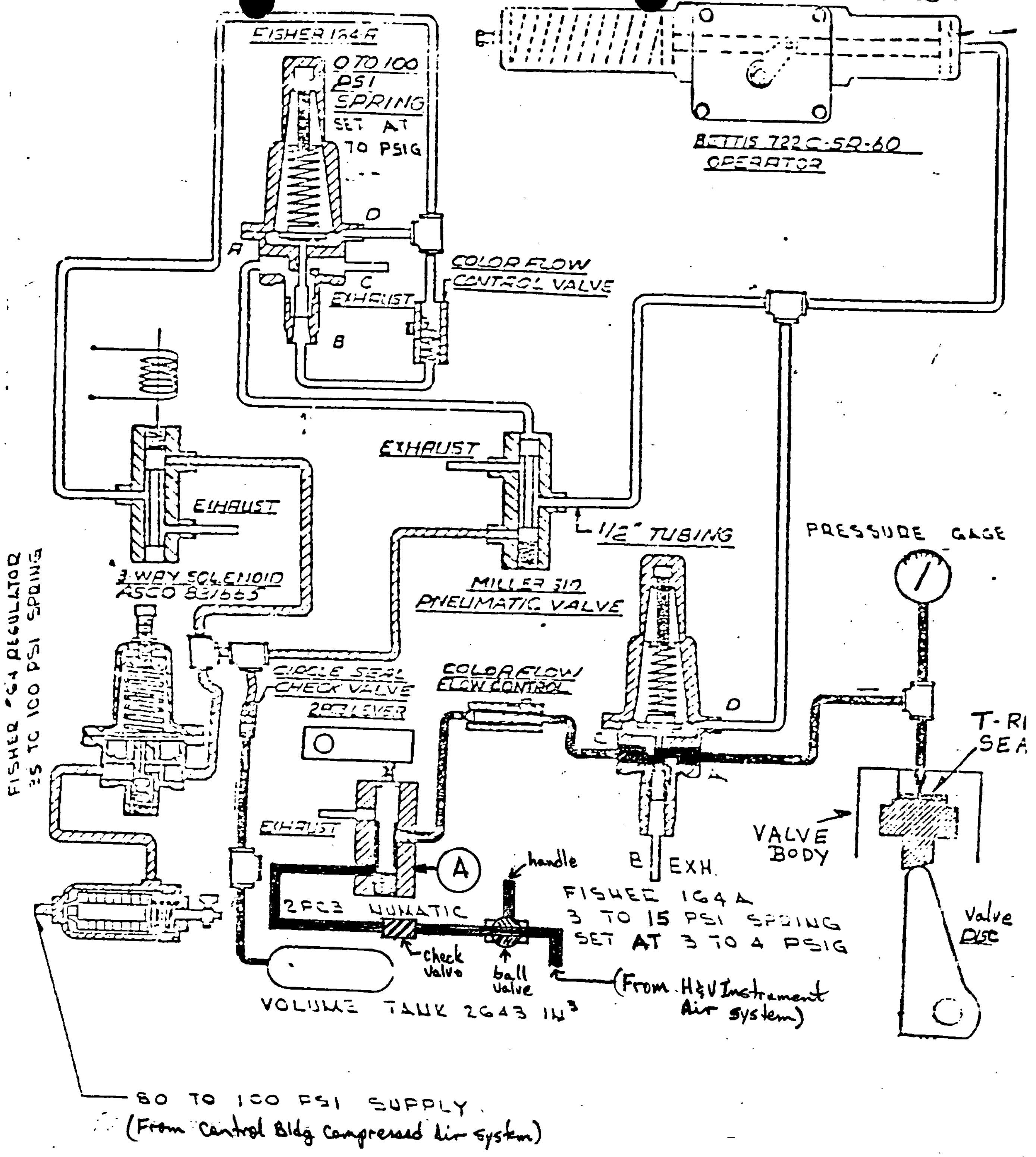

NORMAL CLOSED POSITION OR ELECTRICAL FAILURE SHOWN BY CROSS SECTION AND SHADED LINES. AIR FAILURE SHOWN BY SHADED LINES ONLY

NOTE:
SHADED AREA INDICATES PRESSURE IN LINES

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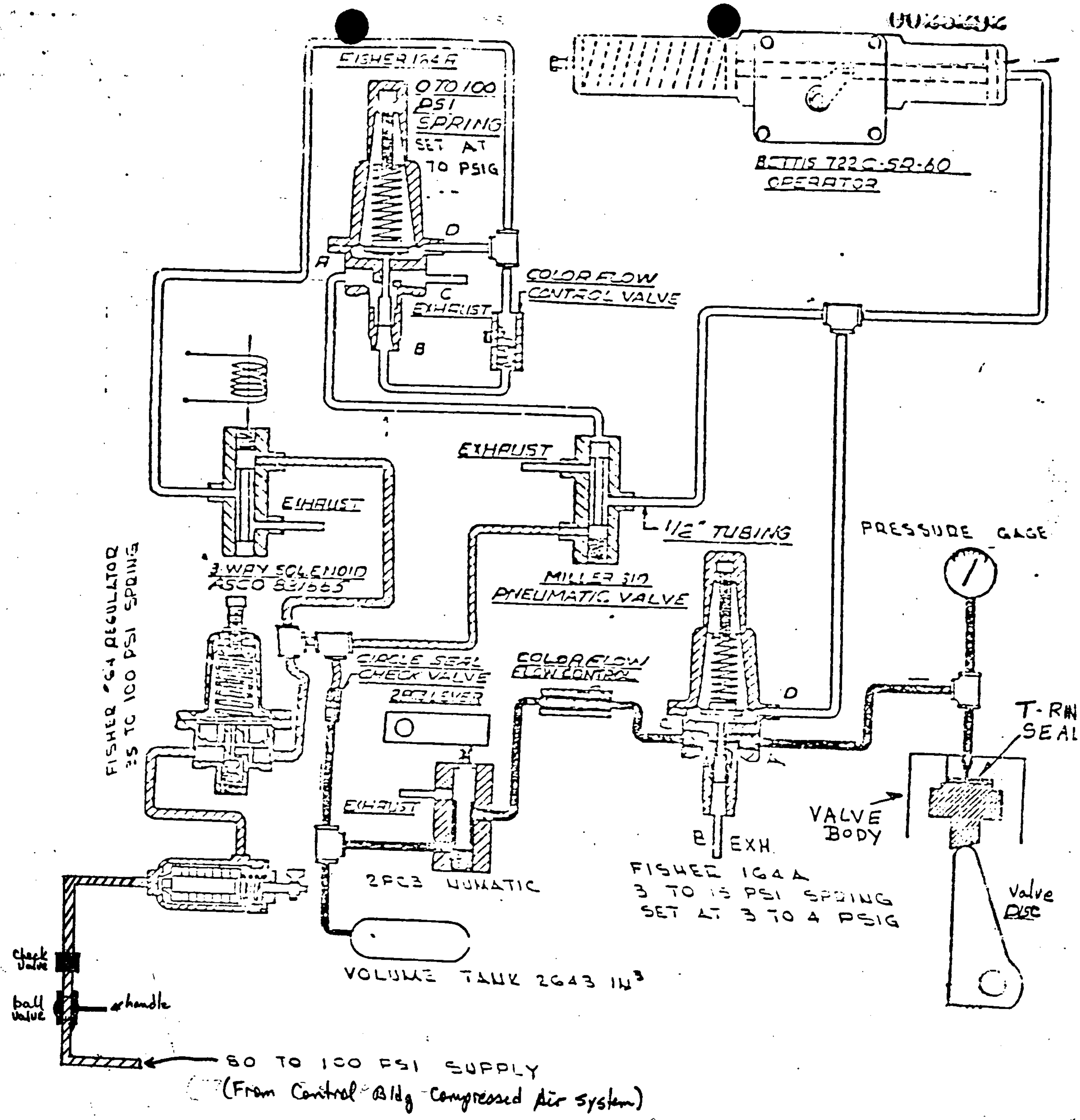
18" HLS-BF-C7-Item 1.13-C7-4302, 7884-M-111D
18" HLS-BF-C7-Item 1.14-C7-4303, 7884-M-111D

TAG NOS.: 18" HLS-BF-C7-Item 1.15-C7-4305, 7884-M-111D
18" HLS-BF-C7-Item 1.16-C7-4307, 7884-M-111D
18" HLS-BF-C7-Item 1.17-C7-4308, 7884-M-111D
PO NO.: 87880-73-74-75-76-77-78-79
CUSTOMER PO NO.: 7884-M-111D Rev. 0

FIGURE -1



NORMAL CLOSED POSITION OR ELECTRICAL FAILURE SHOWN BY CROSS SECTION AND SHADED LINES. AIR FAILURE SHOWN BY SHADED LINES ONLY

NOTE:
SHADED AREA INDICATES PRESSURE IN LINES

SERIAL NOS.: 166584; 166585; 166586; 166587; 166588; 166589; 166590
TAG NOS.: 18" [illegible]-C7-Item 1.11-C7-[illegible], 7894-M-111D
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18" [illegible]-C7-Item 1.13-C7-[illegible], 7894-M-111D
18" [illegible]-C7-Item 1.14-C7-[illegible], 7894-M-111D

TAG NOS.: 18" [illegible]-C7-Item 1.15-C7-[illegible], 7894-M-111D
18" [illegible]-C7-Item 1.16-C7-[illegible], 7894-M-111D
18" [illegible]-C7-Item 1.17-C7-[illegible], 7894-M-111D
PO NO.: 87880-73-74-75-76-77-78-79
CUSTOMER PO NO.: 7894-M-111D Rev. 0

FIGURE -2