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U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555

Gentlemen: ULNRC-1523

DOCKET NUMBER 50-483
CALLAWAY PLANT
SAFETY-RELATED MOTOR-OPERATED VALVE PROGRAM

References:
1) ULNRC-1387 dated October 17, 1986
2) C. E. Norelius letter to D. F. Schnell dated February 19, 1987
3) ULNRC-1456 dated March 5, 1987
4) C. E. Norelius letter to D. F. Schnell dated May 7, 1987

Reference 1 transmitted the Union Electric response to I&E Bulletin 85-03 which documented the MOVATS safety-related motor-operated valve (MOV) program. Provided herein as Enclosure 1, is the Union Electric response to the NRC staff questions as transmitted in reference 4.

Enclosure 2 to this letter is the Union Electric MOV program which is being resubmitted in a revised form to incorporate the information found in Enclosure 1. Revision bars in the margin annotate where changes to the program have been made.

If you have any additional questions, please contact us.

Very truly yours,

Donald F. Schnell

Donald F. Schnell

WEK/mat

Enclosures

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Donald F. Schnell, of lawful age, being first duly sworn upon oath says that he is Vice President-Nuclear and an officer of Union Electric Company; that he has read the foregoing document and knows the content thereof; that he has executed the same for and on behalf of said company with full power and authority to do so; and that the facts therein stated are true and correct to the best of his knowledge, information and belief.

By Donald F. Schnell
Donald F. Schnell
Vice President
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SUBSCRIBED and sworn to before me this 10th day of June, 1987.

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UNION ELECTRIC RESPONSE TO NRC QUESTIONS CONCERNING CALLAWAY PLANT SAFETY RELATED MOTOR OPERATED VALVE PROGRAM

Question 1: Referring to Enclosure 1 (Page 1) of the latest response of 3/05/87, note that the following statement appears in the second paragraph of the response to RAI Question 1:

"Due to the results of this (MOVATS') research, we have revised our submittal to no longer require one time delta-P testing in the open direction."

Referring to the response to RAI Question 6 on Page 5 of Enclosure 1, note that the MOVATS data base does not include globe valves with orifice sizes less than 1.75 or greater than 2.0 inches.

We note that four 4-inch motor-operated globe valves (HV-5,7,9,&11) are located in discharge lines of the AFW motor-driven pumps, and that two 1-1/2 inch motor-operated globe valves (HV-8813 & 8814B) are located in miniflow lines leading from the HHSI pumps to the RWST.

Will representative samples of these globe valves be delta-P tested in the open direction?

Response: The valve sizes, as listed in Question 1 above, refer to the piping line sizes in which the valves are located. This differs from the orifice size which is used for thrust calculations. The orifice sizes for the valves in question are as follows:

AL HV 5, 7, 9 & 11 - 2.00 inches
EM HV 8814 A&B - 1.875 inches
BN HV 8813 - 1.875 inches

Since these valves' orifice sizes are encompassed within the MOVATS data base, no differential pressure testing is deemed necessary.

Question 2: Please refer to Enclosure 2 (Page 3) of the latest response. Completion of revision of procedures for Phase II is scheduled for July 1, 1987. This date does not agree with the date of March 15, 1987 scheduled for Phase II on Page 6 of Enclosure 2.

Response: The correct date for completion of revision of procedures for Phase II is July 1, 1987.

Enclosure 1 to
ULNRC 1523

UNION ELECTRIC RESPONSE TO NRC QUESTIONS CONCERNING CALLAWAY PLANT SAFETY RELATED MOTOR OPERATED VALVE PROGRAM

Question 3: Please refer to Attachment A (Page 2) of the latest response. Justification 19 should replace Justification 1 for valves AL-HV-5, 7, 9, 11.

Response: The correct justification for Max Operating Differential Pressure is Justification #19.

Question 4: Please refer to Attachment B (Item II-B, pages 3 and 4) of the latest response. Where in the response are conditions and precautions addressed for intentionally backseating a valve electrically?

Response: The statement regarding the intentional electrically backseating of a motor-operated valve (MOV) will be deleted. Presently, Callaway does not electrically backseat any valves which are under the scope of this bulletin, nor is there any intent to electrically backseat these valves in the future.

Question 5: Several entries in Table 2 of Attachment B to the Union Electric submittal indicate that the actual closing force was greater than the calculated closing force (Log #15, 91, 92, 105, 109, 110, 111). Each of these should be explained in detail since the figures indicate that the formula used to predict closing force may have been unconservative in these cases.

Response: The log numbers listed in Question 5 are associated with Westinghouse gate valves with disk-to-stem pins. As previously stated in Enclosure 1 (Page 9) of the latest response (ULNRC-1456, dated 3-5-87), the test results indicate that the standard MOVATS equations do <u>not</u> apply to double disk and parallel disk gate valves or Westinghouse gate valves (with disk-to-stem pins) in the closed direction. As discussed in Attachment B (page 6) of the latest submittal, a representative sample of valves which fall into this category will undergo differential pressure testing. This data will be used to develop valve specific equations.

UNION ELECTRIC RESPONSE
TO NRC QUESTIONS CONCERNING
CALLAWAY PLANT SAFETY RELATED
MOTOR OPERATED VALVE PROGRAM

Question 6: At a meeting between NRC and Union Electric Co. on February 19, 1987 the question of motor control center (MCC) testing of the motor-operated valves was discussed at some length. The question of MCC testing after "adjustment" of valve stem packing was discussed and several alternatives were mentioned. Union Electric's current proposal is to do stroke time testing per ASME Section XI after adjusting of packing and then to check valve stem drag, as part of MCC testing, during refueling outages. As pointed out by the staff, such testing may not detect overtightening of packing during the interval between tests. Union Electric has not discussed this issue in their submittal. One of the Union Electric proposals made during the meeting was to limit packing loads to some predetermined value and to declare the valve inoperable if such a value were exceeded. However, the current Union Electric proposal involves no positive verification that the valve was left operable after packing loads are adjusted. The ASME Section XI stroke timing test is considered inadequate based on past experience. The Union Electric policy should be revised to provide the needed assurance of valve operability after any adjustment of valve stem packing or, for that matter, any substantial maintenance or adjustment of the valve assembly.

Response: Union Electric's policy regarding valve operability verification after minor maintenance (i.e. packing adjustment) will be to rely on the Section XI Code testing. Although Section XI stroke time testing is not considered the optimum form of operability verification following a packing adjustment, it is what is required by 10CFR Part 50 Section 50.55a(g). Union Electric feels that this possible deficiency should be addressed by going through the appropriate ASME Code committees and review process to revise the applicable code requirements. This will ensure that the proper reviews of additional cost to the industry, additional safety margin gained, etc., are performed.

CALLAWAY PLANT

SAFETY-RELATED MOTOR OPERATED
VALVE PROGRAM

The response to IE Bulletin 85-03 is organized into four phases which correspond to Action Items a, b, c, and d from Bulletin 85-03. These phases provide for: I) identification of valves to be included and verification of design basis for the operation of each valve (Action Item a.); II) development of policies and procedures for establishing correct switch settings (Action Item b.); III) switch adjustment, demonstration that the settings defined in Phase II above have been properly implemented, and demonstration that the valves will function properly under the maximum differential pressures expected on the valves during both normal and abnormal events within the design basis (Action Item c.); IV) preparation or revision of procedures for periodic testing and inspections to ensure that correct switch settings are determined and maintained throughout the life of the plant (Action Item d.).

Each phase of the program and the overall program schedule are described in the following summary.

Phase I - Identification of valves to be included and verification of design basis for the operation of each valve.

This phase of the program has been completed and the results have been transmitted to the Nuclear Regulatory Commission (NRC) via ULNRC-1309, dated May 14, 1986 (Reference 2). For completeness of the program, the information will be included here.

The Union Electric response to Action Item a. is based on methodology developed by the Westinghouse Owners Group (WOG) for member utilities (see WOG-86-168, Westinghouse Owners Group Safety-Related MOV Program Final Report, dated April 7, 1986). This methodology is based on the SNUPPS design for the high pressure injection system and auxiliary feedwater system. The fluid systems evaluation was used to determine the maximum operating differential pressure for all system operating modes and design basis events. The maximum operating differential pressure represents the maximum pressure producing capability of the system equipment for the system operating modes.

Attachment A, IE Bulletin 85-03 Valve Information, provides a list of the valves to be included and design information for operation of each valve. The information consists of:

A) MOV as listed by Callaway valve number.

B) Brief description of valve function.

C) Design E specification differential pressure for opening and closing as specified in the design equipment specification.

D) Maximum operating differential pressure for opening and closing as determined by the fluid systems evaluation.

E) A brief justification statement for the maximum operating differential pressures.

F) Results of a review to determine if Emergency Response Guidelines (ERGs) are consistent with the fluid systems operating assumptions.

Phase II - Development of policies and procedures for establishing correct switch settings.

This phase of the program defines the technical basis for establishing torque and limit switch setpoints. The technical basis for many of the setpoint policies to be used at Callaway have been obtained from MOVATS Incorporated. MOVATS utilized test results from many plants to establish and justify several alternate policies for torque, torque bypass, and limit switch setpoint adjustments. A description of the policies and technical basis which were supplied by MOVATS is included as Attachment B, Switch Adjustment Policies and Justifications.

Listed below are the switches for which Union Electric determined that setpoint policies were required for response to Bulletin 85-03. Also, listed are the policies which were not included in Attachment B.

A) Open Torque Switch
- See Attachment B

B) Open Limit Switch
- See Attachment B

C) Close-to-Open Torque Bypass Limit Switch
- See Attachment B

D) Open Indication Limit Switch
- The policy to be utilized at Callaway for the open indication limit switch will be to have the open indication limit switch set at the same point as the open limit switch. Each of the valves included in the Bulletin has an open limit switch and will be set per B) above.

E) Close Torque Switch
- See Attachment B

F) Close Limit Switch
- See Attachment B

G) Open-to-Close Torque Bypass Limit Switch
- See Attachment B

H) Close Indication Limit Switch

- The policy to be utilized at Callaway will be to have the close indication limit switch set at the same point as the close limit switch, if a close limit switch exists for the valve. If the valve is designed to close on torque, i.e. no close limit switch, the close indication limit switch will be set within 3% of valve travel from the fully closed position.

  In no case will the close indication limit switch be set at the same position as the close-to-open torque bypass limit switch. This is possible for all the valves in the bulletin since they all have four limit switch rotors instead of only two.

I) Control of Butterfly Valves
- See Attachment B

To accomplish Phase II of the program, first a review of the torque and limit switch configuration of each valve will be performed. If this review indicates that the current design cannot meet the switch setting policies stated above, an evaluation of current valve operability will be performed. For this initial evaluation of operability, all switches which affect the safety-related function of the valve will be assumed to be set properly, unless two or more switches which both affect safety-related functions, and are required to be set at different places, are on the same rotor, i.e. are set at the same position. For valves which fall into this category, the valves will be declared inoperable until an evaluation verifying operability is performed or the design can be modified to allow all switches affecting safety-related functions to be set per the above policies.

When review of the design indicates switches not affecting safety-related functions, cannot be set properly, design modification packages will be developed and the new design implemented at the first available outage that the valve can be worked.

Review of the design for each valve will be complete March 15, 1987.

Procedures for setting torque and limit switches are scheduled to be revised in accordance with the above policies by July 1, 1987. This is to allow time for the purchase of test equipment (which will be required to perform the switch settings as will be discussed in Phase III) and to allow time for training of appropriate personnel.

Phase III - Switch adjustment, demonstration that the settings defined in Phase II above have been properly implemented, and demonstration that the valves will function properly under the maximum differential pressures expected on the valves during both normal and abnormal events within the design basis.

This phase of the program begins with the actual adjustment of the switches using the policies established in Phase II. To facilitate measurement of such things as percent valve travel and thrust values of torque switch trip, which are needed in setting the switches, and to facilitate testing to prove operability, the MOVATS Signature Analysis Process will be utilized. To aid in the evaluation of our program and due to the many advances in valve signature analysis over the last few years, Attachment C, Description of MOVATS' Signature Analysis Process, has been included. Additional information regarding the operation and principles of MOVATS may be found in the American Society of Mechanical Engineers paper 84-NE-16 "Early Diagnosis of Motor Operated Valve Mechanical and Electrical Degradations", 12th Inter-Ram Conference for the Electric Power Industry report entitled "Update on Field Signature Testing of Motor Operated Valve Mechanical and Electrical Degradations", or by contacting MOVATS Incorporated, 2999 Johnson Ferry Road, Marietta, Georgia, 30062, telephone 404-998-3550.

Utilizing the Control Switch Signature discussed in Attachment C, all the limit switch setpoints discussed in Phase II can now be set and verified to be within the correct percent of valve travel by indication of actual switch trip setpoint in milliseconds of valve travel.

Utilizing the Stem Thrust Signature and Control Switch Signature discussed in Attachment C, the actual thrust values obtained at the open and close torque switch trip can be measured. These values are then compared to the policies specified in Phase II and adjusted appropriately.

Therefore, to perform the switch adjustments and demonstrate that the settings defined in Phase II have been properly implemented, MOVATS Signature Analysis will be performed locally at the valve in conjunction with switch adjustment. This initial MOVATS Signature Analysis will consist of as found stem thrust, motor load, and control switch signatures, stem thrust signature calibration, switch adjustments and as left stem thrust, motor load, and control switch signatures.

The final part of Phase III is to demonstrate that the valves will function properly under the maximum differential pressures expected on the valves during both normal and abnormal events within the design basis.

Callaway will utilize a test method developed by MOVATS which verifies the valves will function against differential pressure. This method breaks down the total thrust encountered during valve operation into two parts: thrust resulting from differential pressure, and thrust resulting from the valve itself (i.e, packing loads, friction, gear efficiency, etc.) The thrust resulting from the valve itself is easily measured and quantified using the MOVATS thrust signature. Then if the thrust resulting from differential pressure alone could be calculated and added to the measured valve running thrust, and the total was less than the thrust value at torque switch trip, we could be assured that the valve would operate under maximum differential pressure.

To perform this calculation, MOVATS has developed equations for different types of valves. Examples of these equations are shown in Attachment B under II-A and II-E. These equations have been verified by actual test data (shown on Table 2 of Attachment B) to bound cracking, seating, and unseating thrusts. The calculated thrust values will be verified to be less than the maximum allowable loading condition specified by the operator and valve supplier. We do not feel that additional differential pressure testing is needed to verify these equations unless one of the following conditions exist:

1) The industry data does not encompass the particular size of valve being evaluated.

2) The valve is of a unique or unusual design, such that the data base information would not apply.

3) Sufficient industry full or partial pressure test data is not available at the time of the plant test to validate the equation being used for thrust calculations. Sufficient test data to validate a given open or closed stem thrust equation is assumed if at least four (4) sets of pressure data exist for the same type and size of valve or twenty (20) sets for the same type but various sizes.

As the valve degrades, the running thrust value (without differential pressure) will increase. As it increases, the total thrust value (after adding thrust resulting from differential pressure) also increases. To ensure that this total thrust does not get higher than the torque switch setting, we will periodically monitor the running thrust. To facilitate this monitoring, MOVATS has developed a method of monitoring from the motor control center (MCC).

"Motor load" signatures will be obtained as described in Attachment C. Motor load is a measure of motor mechanical output power, and changes in motor load can be related directly to changes in stem thrust.

Motor load will be monitored during initial MOVATS testing and a motor load "thrashold" value will be estabiished to aid in determination of valve operability.

The motor load threshold value is determined by conservatively calculating the stem thrust required to overcome differential pressure and measuring the corresponding motor load value (see Attachment C for a more complete description of this process). The equations used for calculating the required stem thrust have been validated by many in plant tests (see Attachment B, Table 2).

Motor load values recorded during routine tests will be compared to the established threshold values. As long as the running motor load is less than the threshold, the operator is capable of delivering enough additional thrust to overcome the differential pressure condition. If the running motor load increases to the threshold value, the valve will be declared inoperable until repair and testing activities are complete.

Phase IV - Preparation or revision of procedures to ensure that correct switch settings are determined and maintained throughout the life of the plant.

As stated in the last paragraph of phase II, the procedures for setting torque and limit switches in accordance with Phase II policies are scheduled to be prepared or revised by July 1, 1987.

In addition, preventive maintenance procedures will be developed to periodically perform testing to ensure the switch settings are being maintained and that the valves are still capable of overcoming accident differential pressures to perform their functions. This periodic testing will consist of the following:

A) Motor load and control switch signature traces.

This test verifies the following:

- motor running load has not exceeded the previously determined "Threshold" value.
- cycle time has not changed by more than 0.5 seconds from previous test.
- close-to-open torque bypass limit switches are within original criteria (time of actuation and comparison to valve unseating).
- check for unusual geometry of motor power signature which could be indicative of developing degradations.
- check time difference between contactor drop-out time and control switch actuation and compare to previous data.
- compare final closing power value to previous test. A change of 20% may warrant further evaluation.

ATTACHMENT A
IE BULLETIN 85-03 VALVE INFORMATION

Callaway Plant Valve Number	MOV Description	Design (E-SPEC) ΔP Close	Design (E-SPEC) ΔP Open	Maximum Operating ΔP Close	Maximum Operating ΔP Open	Justification for Max Operating ΔP	ERG Confirmation Of Operating Assumptions
BN-HV-8806 A&B	Safety Injection Pump Suction from RWST	200	200	200	50	Open - 2 Close -1	Yes
EM-HV-8923 A&B	Safety Injection Pump Suction from RWST	200	200	200	50	Open - 2 Close - 3	Yes
BN-LCV-112 D&E	CVCS Pump Suction from RWST	200	200	200	50	Open - 4 Close - 4	Yes
BG-LCV-112 B&C	CVCS Pump Suction from VCT	100	200	100	100	Open - 5 Close - 5	Yes
EM-HV-8821 A&B	SI Pump Cross-Connect	1500	1500	1500	1500	Open - 15 Close - 14	Yes
EM-HV-8835	SI Pump Discharge Isolation	0	2750	0	1500	Open - 7 Close - 6	Yes
BG-HV-8105 BG-HV-8106	CVCS Normal Discharge Isolation	2750	2750	2750	2750	Open - 8 Close - 8	Yes
EM-HV-8803 A&B	BIT Inlet Isolation	0	2750	0	2750	Open - 9 Close - 6	Yes (See Table 1 Footnote 1)
EM-HV-8801 A&B	BIT Outlet Isolation	0	2750	0	2750	Open - 9 Close - 6	Yes (See Table 1 Footnote 1)
BN-HV-8813 EM-HV-8814 A&B	SI Pump Miniflow	2750	2750	1500	1500	Open - 11 Close - 10	Yes
BG-HV-8110 BG-HV-8111	CVCS Pump Miniflow	2750	2750	2750	2750	Open - 13 Close - 12	Yes

ATTACHMENT A
IE BULLETIN 85-03 VALVE INFORMATION

Callaway Plant Valve Number	MOV Description	Design (E-SPEC) ΔP Close	Design (E-SPEC) ΔP Open	Maximum Operating ΔP Close	Maximum Operating ΔP Open	Justification for Max Operating ΔP	ERG Confirmation Of Operating Assumptions
FC-HV-312	Mechanical Trip and Throttle	1275	1275	1220	1220	Open - 16 Close - 16	Yes
AL-HV-34, 35, 36	Suction from CST - All Pumps	150	150	17	17	Open - 17 Close - 17	Yes
AL-HV-30, 31,32,33	Suction from Essential Service Water	200	200	180	180	Open - 18 Close - 18	Yes
AL-HV-5, 7,9,11	Motor-Driven Pump Discharge Flow Control	1800	1800	1645	1645	Open - 19 Close - 19	Yes

JUSTIFICATIONS

1. This valve must be able to close to isolate the RWST from the discharge of the RHR pumps during the recirculating mode of operation, as a precautionary measure in the event of backleakage through check valve 8926A (or B). For this scenario, the ΔP across 8806A (or B) could be as high as the RHR pump discharge head ~200 psig.

2. This valve is normally open, and is closed only for stroke testing and/or pump isolation for maintenance. The valve must be able to open against a full RWST head of water. For Callaway, this is ~50 psig.

3. This valve must be capable of isolating (closing) one high head safety injection pump, given a passive failure in that train of ECCS. For this scenario, the ΔP across 8923A, B could be as high as the RHR pump discharge head ~200 psig.

4. Same as 8806A, B (for both close and open), except these valves are in the suction of the centrifugal charging pumps and not the high head safety injection pumps.

5. These valves must close on an "S" signal; the maximum ΔP across the valve is defined by the volume control tank at its design pressure (relief valve setpoint) of 75 psig plus elevation head of the VCT above the valves. This is estimated to be ~100 psig.

6. Valve is only closed when pump is not operating; no flow - no ΔP.

7. Pump testing on miniflow circuit, ΔP is determined by the miniflow head of high head safety injection pump ~1500 psig.

8. These valves must be able to isolate the RCS from the CVCS, with a maximum possible ΔP of ~ the shutoff head of the centrifugal charging pumps.

9. Given a miniflow test of the centrifugal charging pumps, the BIT isolation valves must be able to open with a ΔP ~ equal to the charging pump shutoff head.

10. Valves must close to isolate miniflow so that high pressure injection switchover to recirculation may proceed. In the worst case, the ΔP will be equal to the pump developed head on miniflow ~1500 psig.

11. Similar to 10, except valve must be able to open during miniflow testing of the high head safety injection pump.

12. Valves must close to ensure adequate high pressure injection flow (on "S" signal) against miniflow ΔP ~2750 psig.

13. Similar to 12, except valve must be able to open during miniflow testing.

14. Must be able to move to allow realignment to ECCS to recirculation mode, and for ECCS train separation. Delta-P could be as high as 1500 psig ~ equal to miniflow head of high head safety injection pump.

15. Must be able to open to allow train separation during the recirculation phase of ECCS operation. Delta-P same as closing.

16. Lowest steam generator safety valve set pressure plus 3 percent accumulation.

17. Static elevation head of the condensate storage tank.

18. Discharge head of the service water pumps at miniflow.

19. Motor driven pump discharge pressure at miniflow.

FOOTNOTE TO TABLE 1

1. The ERG guidelines to terminate safety injection (isolate the BIT), and return to normal charging are performed with the centrifugal charging pumps operating. This termination method reduces net RCS makeup in a controlled manner and maintains continuous reactor coolant pump seal injection. Since the charging pumps are operating, the BIT isolation valves must close against a ΔP. This ΔP could be large for some SI termination scenarios (RCS could be as low as 200 psi - ΔP could be as high as 2500 psi).

ATTACHMENT B

Switch Adjustment Policies and Justifications

This phase of the program defines the technical basis for establishing torque and limit switch setpoints. A given control switch may be set to a number of possible positions. The most appropriate setting will be selected and switch setting procedures revised after a review of the valve function, operator and valve design, and overall plant policies. The following are the setpoint methods and technical justifications that will be considered for implementation during the control circuit review process. In each case, the method to be used by Callaway on most valves will be identified.

II-A Open Torque Switches

The open torque switch acts to alert plant personnel of mechanical problems with the valve or operator. The torque switch also provides some element of protection if the open limit switch fails to open. Historical data has shown that open limit switch failures are extremely rare.

Typically, the open torque switch is set to actuate at a thrust value above the calculated unseating load (including maximum design differential pressure loads). During valve unseating, the initial load peak (cracking load) may be of a high enough level to cause the torque switch to trip. Because of this peak, the torque switch must be electrically bypassed during this phase of valve operation.

One acceptable approach (being evaluated by Callaway as a possible approach) is to eliminate the open torque switch from the control circuit. From a maintenance point of view, the "alerting" function of the open torque switch trip is not necessary if valve/operator condition is monitored using some other means to provide adequate indication of developing mechanical degradations (i.e., MOVATS' MCC System).

As an alternative (also being evaluated by Callaway), the open torque switch will be wired into the control circuit and set to trip at a value greater than the load calculated for valve unseating. To establish the torque switch setpoint, the opening thrust value for full differential pressure conditions must be established accurately. The following is an example of the equations for the opening thrust. The equations were developed by MOVATS and validated using full and partial pressure testing data.

THRUST CALCULATION EQUATIONS

Solid and Flex-Wedge Gate Valves*

Seat (Friction) Load (SL)= 0.3 x Delta P x Orifice Area

Wedging Load (WL)= 0.75 x Seat Face Load

Scaling Constant (SC)= 1.3

Opening Thrust against Delta P= SC (SL+WL)

Standard Globe Valves

Seat Face (Friction) Load (SL)= Delta P x Orifice Area

Scaling Constant (SC)= 1.3

Opening Thrust against Delta P= SC (SL)

*NOTE: These equations are not used if a careful review of valve drawings identifies unusual valve design features. In particular, the equations do not apply to double disk or parallel disk gate valves.

Unseating Thrust (Tu)= Running Load + Opening Thrust against Delta P

Running Load measured at point A on Figure 1.

After the unseating thrust (Tu) has been determined, it will be compared to the maximum allowable loading condition specified by the operator and valve suppliers. Valves which have the calculated unseating thrust (Tu) exceeding the maximum will be evaluated on a case by case basis. Corrective action may include such things as operator replacement, full pressure testing, lowering of the ΔP requirement, or a vendor approved extension of the operator rating.

After an acceptable unseating thrust has been determined, the torque switch setting will be adjusted to some valve above (Tu). Typically, the minimum acceptable value is 1.05 (Tu) after all expected instrumentation and equipment variation are taken into account. These variations are as follows:

Operator/Torque Switch Repeatability	- ±10% (Thrust loads less than 4000 lbs)
	- ±5% (Thrust loads greater than 4000 lbs)

MOVATS Instrumentation	Accuracy
50K Load Cell	±2% of load ±0.4% linearity
200K Load Cell	±1.9% of full scale
Nicolet Scope	±0.2% of Voltage Range (10V)
TMD Linearity	±0.6% of 10 Volt Scale

Combining these tolerances, torque switch trip points established as follows:

For stem thrust loads less than 4,000 lbs,

Tu (1.05 + 0.15) = 1.20(Tu) minimum setpoint setting

For stem thrust loads greater than 4,000 lbs,

Tu (1.05 + 0.10) = 1.15(Tu) minimum setpoint setting

In general, a target band of 1.20 - 1.30 Tu (loads less than 4,000 lbs) and 1.15 - 1.25 Tu (loads greater than 4,000 lbs) will be used to allow for field setting of the switches (See Figure 4).

After the open torque switch has been set, the thrust at the actual trip setpoint will be verified to be less than the maximum allowable loading condition specified by the operator and valve suppliers.

II-B Open Limit Switches

The open limit switch must be adjusted to prevent inadvertent backseating of the valve.

Typically, the open limit switch will be set at approximately 90% of stroke from the close-to-open position. It is recognized that the amount of stem travel after limit switch trip is influenced by the inertia of the MOV assembly, valve design, and delay in motor contactor drop out after actuation of the open limit switch. Therefore, a specific setpoint for the open limit switch cannot be established. Instead, the following process will be used:

The limit switch will be set initially for 90-92% of the full open stroke. The valve will then be cycled open and allowed to trip electrically. Plant personnel will then place the operator in manual and continue to open the valve using the handwheel. If the valve can be opened an additional amount past the trip and coast down position, the switch is set correctly. If the valve cannot be opened past the coast down position, it can be assumed that the valve has hit the backseat. In the unlikely event that the valve has inadvertently backseated, a MOVATS signature analysis test will be conducted and the stem loading and subsequent stem stress levels will be evaluated. The limit switch setting will then be reduced in 2% increments and the valve will be cycled and checked until it is verified that the disc is not coasting into the backseat.

II-C <u>Close-to-Open Torque Bypass Limit Switch</u>

The close-to-open torque bypass limit switch prevents torque switch actuation during the high loading condition normally experienced when the valve disc is "cracked" from its seat (Tc - see Figure 2). From a operational standpoint, many switch settings are acceptable, depending on utility operating and maintenance policies. Operator loading conditions during the opening cycle must be examined to understand technical justifications for each acceptable setting.

Figure (1) shows a typical stem thrust and control switch actuation signature for a valve going from the close-to-open position with zero differential pressure across the valve. Figure (2) is the same basic signature modified to show bypass switch actuation at 5-10% of valve stroke (based on stem movement). Historically, it is believed that the 5-10% switch setting would encompass the initial valve unseating. After the valve began to pass fluid, the high loading conditions would decrease rapidly. This theory was generally accepted even though full pressure and flow data were not available to validate such an assumption.

Figure (3) depicts a thrust signature from the same valve shown in Figure (2). The changes in the signature characteristics result from differential pressure across the valve. With the typical bypass switch setting of 5-10% of stroke, it is clear that the torque switch may not be bypassed during the full unseating process. However, Figure 3 demonstrates that the "cracking load" (Tc) occurs early enough in the open cycle that the 5-10% bypass encompasses this loading condition.

Data from tests with full and partial differential pressure conditions (Table 1) indicates that the cracking load condition occurs at less than 1% of valve stroke for globe and gate valves, even though the loading condition during unseating does not begin to decrease until as much as 15% of stroke.

Based on analysis of test data, the following are acceptable settings for the close-to-open torque bypass limit switch.

1) Three (3) percent of total valve stroke as measured from the point of stem motion. The three percent value ensures that cracking has occurred at the time of switch actuation though unseating may not be complete. To use the three percent setting, the open torque switch must be set in accordance with recommendations contained in Section II-A.

2) 5-10% of stroke will provide some additional margin for added stem loads due to buildup of foreign materials on the valve seat, etc. Bypass switch actuation will occur during or at the completion of valve unseating under differential pressure conditions.

3) The approach to generally be used by Callaway will be to use 20-25% of stroke to ensure that the entire unseating is bypassed. The advantages of this approach are the same as 1) and 2) above. In addition, the valve will most likely perform its intended function even if the torque switch is set improperly. If this option is selected, it should be recognized that the closed light will illuminate when the valve is 20-25% open on operators equipped with two-rotor limit switches. Operationally, this condition can be justified for many applications. Of course, the 20-25% setting will not affect position indicating lights if operators are equipped with four-rotor limit switches and the indicating light limit switches are on different rotors than the close-to-open torque bypass limit switch (which will be the case at Callaway).

4) 90-98% of stroke will have the same advantages as 1) through 3) above and will preclude stoppage of valve travel if large mechanical loads are encountered anytime during the opening stroke. 90 - 98% of stroke will still provide back up for the open limit switch.

5) 100% Bypass - With this option, the open torque switch is wired completely out of the opening circuit, thereby negating the need for the bypass switch (see II-A, Open Torque Switches, for guidance on this condition).

II-D <u>Open Indication Limit Switch</u>

See Phase II in body of this enclosure.

II-E <u>Close Torque Switch</u>

The closing torque switch ensures that sufficient loads are delivered to the valve stem to provide leak tight closure of the valve. Although certain types of valves and/or unusual closing requirements may dictate use of a limit switch for valve closure, the torque switch is the most common method for control during the closing stroke.

As with the open torque switch, the closed torque switch setting must be calculated accurately. To establish the torque switch setpoint, the closing thrust value for full differential pressure conditions must be established accurately. The following is an example of the equations for the closing thrust.

The equations were developed by MOVATS and validated using full and partial pressure testing data. When the closing stem thrust (Tu) has been established, the margins for operator, valve, and instrumentation variations (previously described) are applied to determine the target closed torque switch setting.

The following is an example of the equations for closing thrust.

THRUST CALCULATION EQUATIONS

Solid and Flex-Wedge Gate Valves*

Seat (Friction) Load	(SL)=	0.3 x Delta P x Orifice Area
Wedging Load	(WL)=	0.75 x Seat Face Load
Piston Effect	(PE)=	Delta P x Stem Cross Section Area
Scaling Constant	(SC)=	1.3

Closing Thrust against Delta P= SC (SL+PE)

Standard Globe Valves

Seat Face (Friction) Load	(SL)=	Delta P x Orifice Area
Piston Effect	(PE)=	Delta P x Stem Cross Section Area
Scaling Constant	(SC)=	1.3

Closing Thrust against Delta P= SC (SL+PE)

*NOTE: These equations are not used if a careful review of valve drawings identifies unusual valve design features. In particular, the equations do not apply to Westinghouse gate valves with pinned (hinged) disks.

As will be discussed in Phase III, the equations will not be relied upon if sufficient industry full or partial pressure test data is not available at the time of the plant test to validate the equation being used for thrust calculations. The present MOVATS data base does not include sufficient test results to validate MOVATS closing thrust equations for flex and solid wedge gates or globe valves with orifice diameters less than 1.75 inches or greater than 2.0 inches. Therefore, the testing program at Callaway will include differential pressure testing in the closing direction on representative valves. Utilizing this data specific equations will be developed. The equations will be considered accurate for a particular valve if pressure test data is provided by four valves

of the same type and size or twenty (20) valves of the same type.

When closing a valve, the final loading condition may be significantly higher than the closed torque switch trip setpoint. This difference is due to the inertia effects of the operator and valve assembly as well as variations in the motor contract drop-out time. Closing a valve without flow and pressure will result in the highest closure forces and the final forces must be evaluated against the operator and valve manufacturer's thrust limits.

II-F Closed Limit Switches

For valves that are controlled using a limit switch during closure, the final closure forces must be examined closely. These forces can vary widely depending on inertia, contactor drop-out time and valve design. Signature analysis techniques will be used to verify that the closure forces are acceptable when compared with operator and valve manufacturer's limits. In the long range program, any significant changes in contactor drop-out time will be noted and the impact on final stem loads will be monitored and evaluated.

II-H Closed Indication Limit Switch

See Phase II in body of enclosure.

II-G Open-to-Close Torque Bypass Limit Switches

Typically, the open-to-close torque bypass limit switch is of no operational concern because large hammerblow loading conditions do not occur during the initial phases of the closing cycle. For this reason, no specific requirements are placed on this switch setting relative to the valve stroke. Unless some other need is identified for positioning of this switch, the position that results from coast down of the motor after open limit switch actuation will be accepted.

II-I Control of Butterfly Valves

The guidelines for setting butterfly valve limit switches (and torque switches, where applicable) will be basically the same as previously discussed for other types of valves. There is one notable exception.

Normally, butterfly valves do not employ torque bypass switches. Bypass switches for the open torque switch will be considered when all of the following conditions exist:

1) Normal operating position of the valve is closed;

2) The safety position of the valve is open;

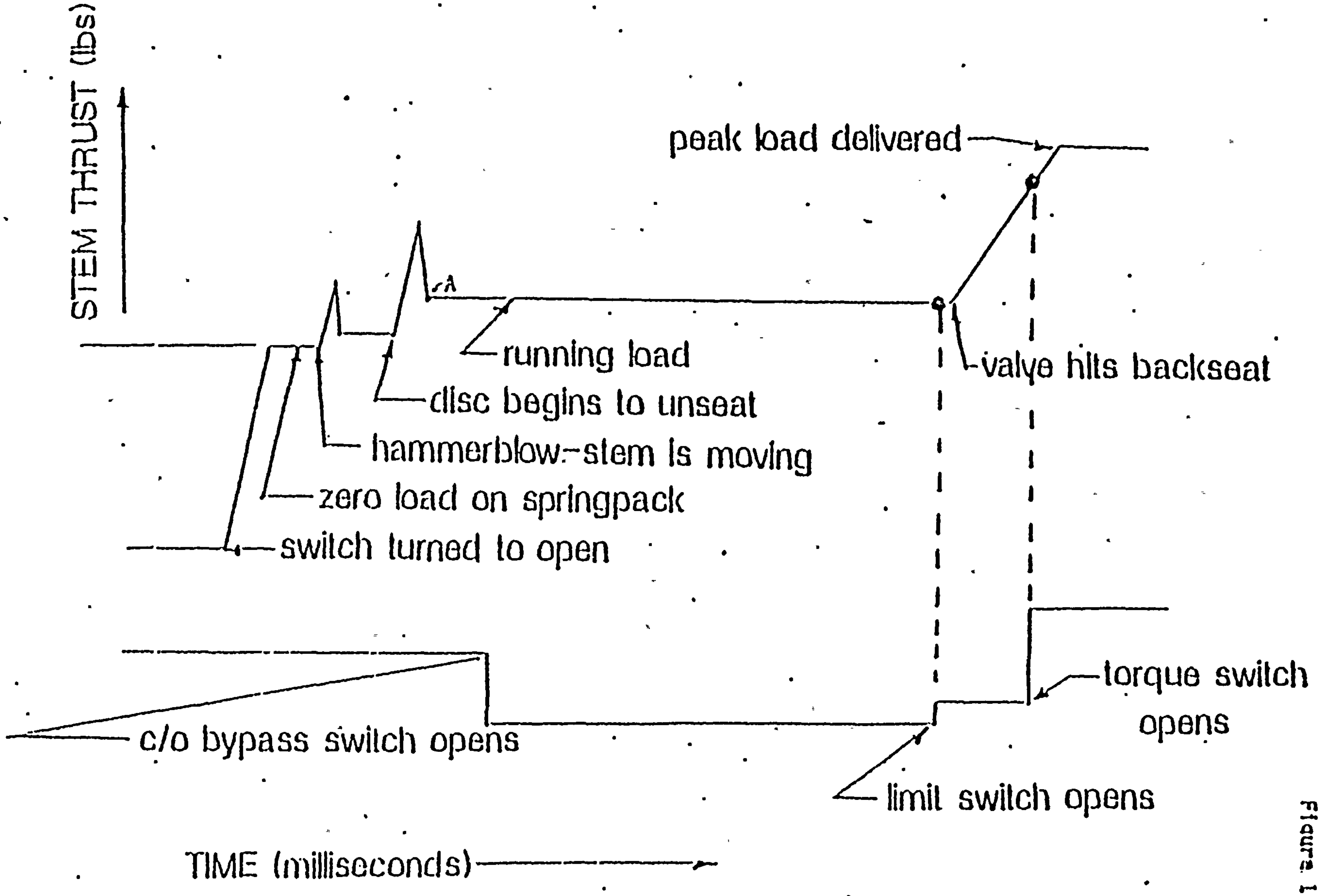
3) The valve is in a sea water or water environment such that foreign material build-up is of concern;

4) The valve is not cycled frequently enough to ensure that the foreign material build-up effects are negligible.

If all of the above conditions exist, then the open torque switch will be wired out of the control circuit or the close-to-open torque bypass limit switch will be set for approximately 98% of stroke.

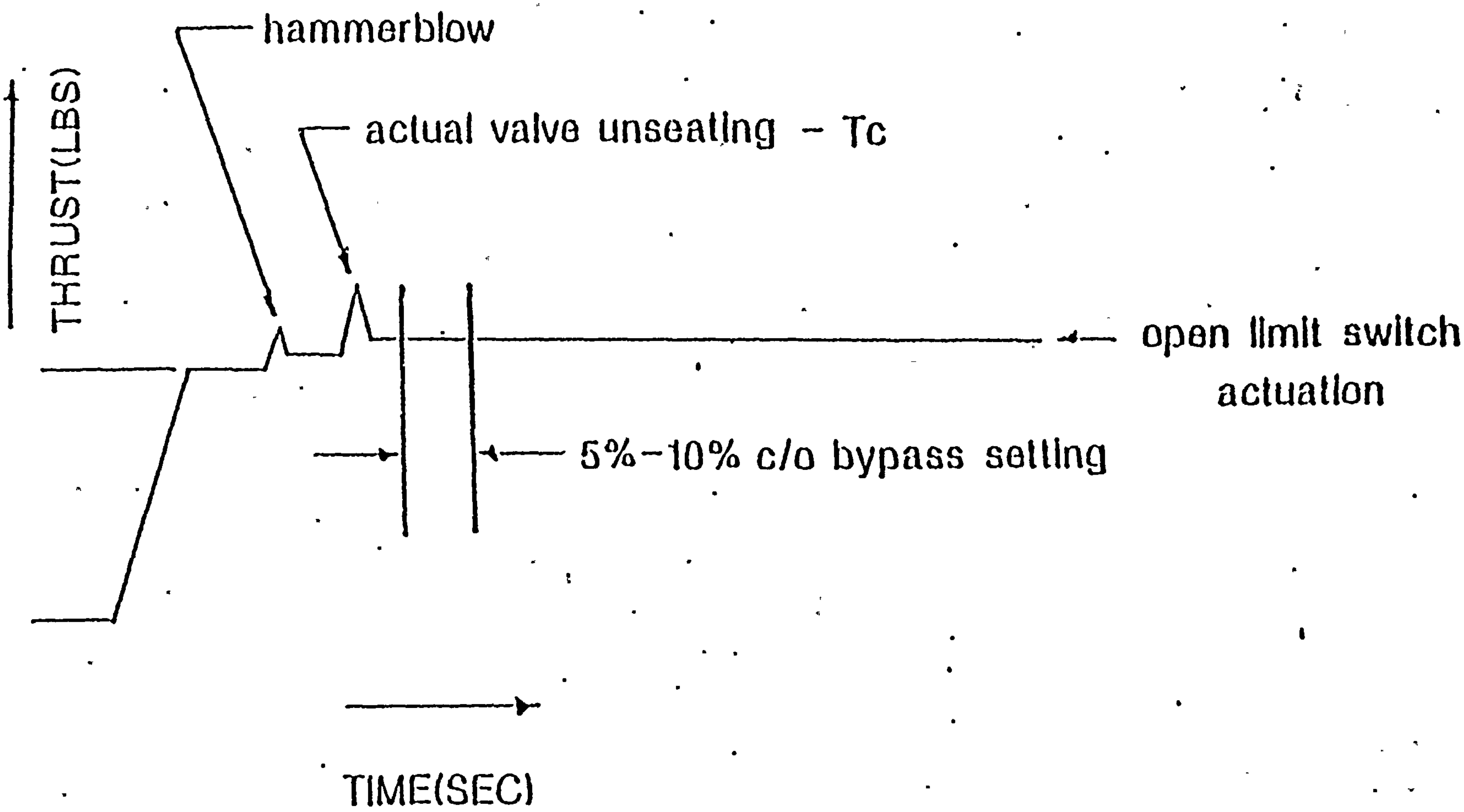
FIGURE 1

TYPICAL STEM THRUST AND CONTROL SWITCH ACTUATION SIGNATURES



Attachment 8
Figure 1

FIGURE 2

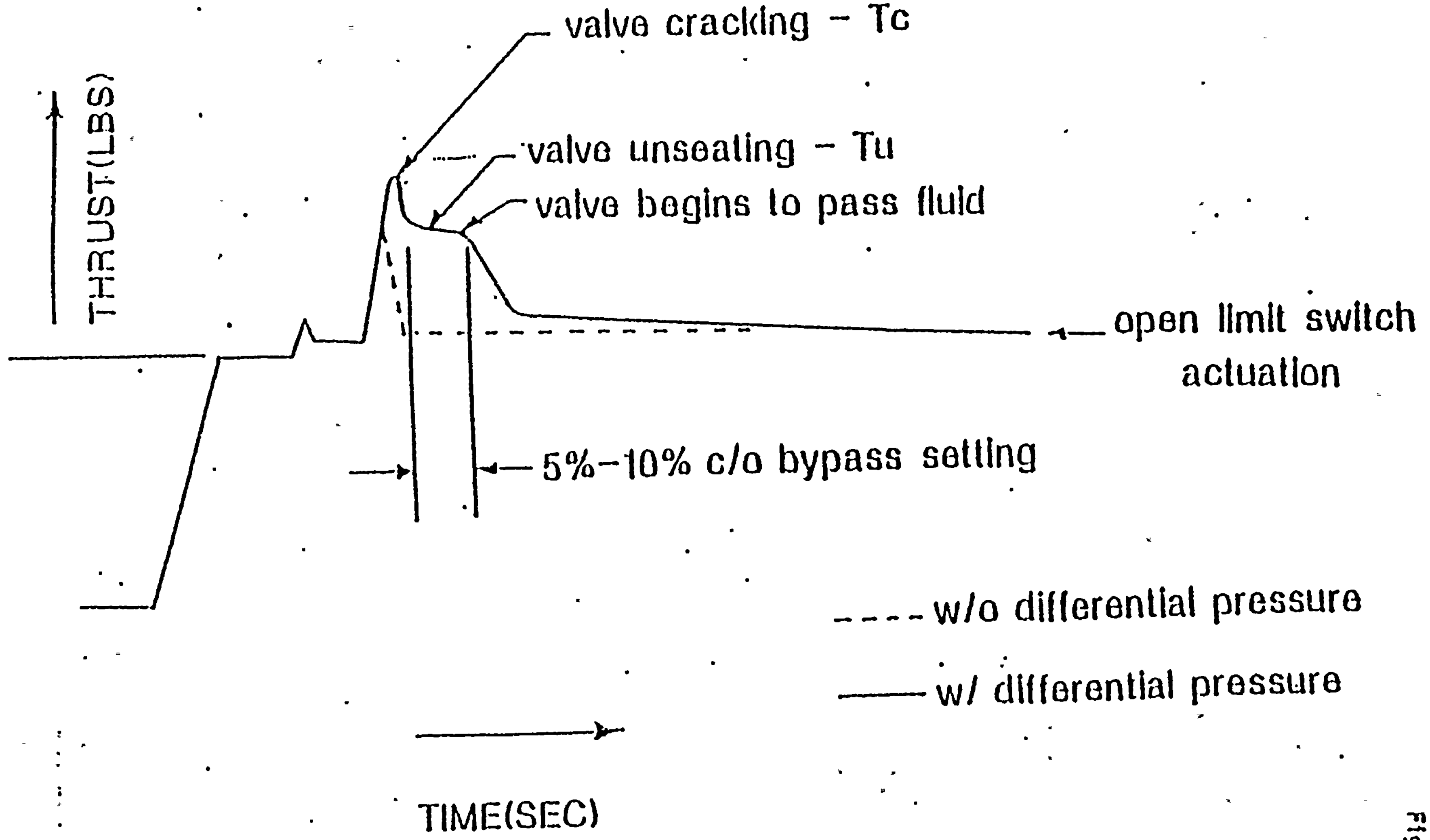


C/O STEM THRUST SIGNATURE

W/O DIFFERENTIAL PRESSURE

Attachment 8
Figure 2

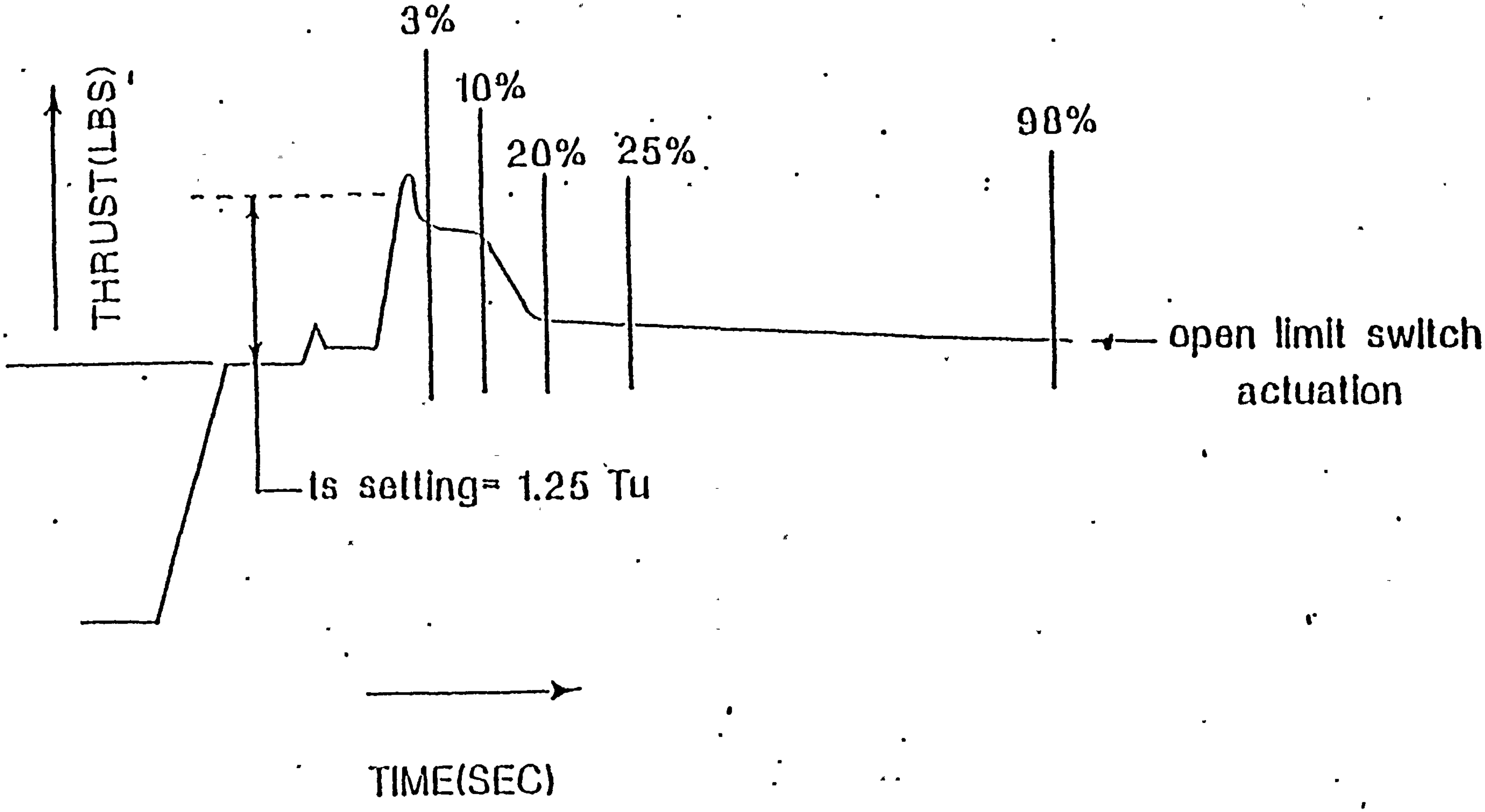
FIGURE 3



C/O STEM THRUST SIGNATURE

Attachment B
Figure 3

FIGURE 4



C/O STEM THRUST SIGNATURE

Attachment 3
Figure 4

FIGURE 5

LOAD CELL SUPPORT PLATE DIAGRAM

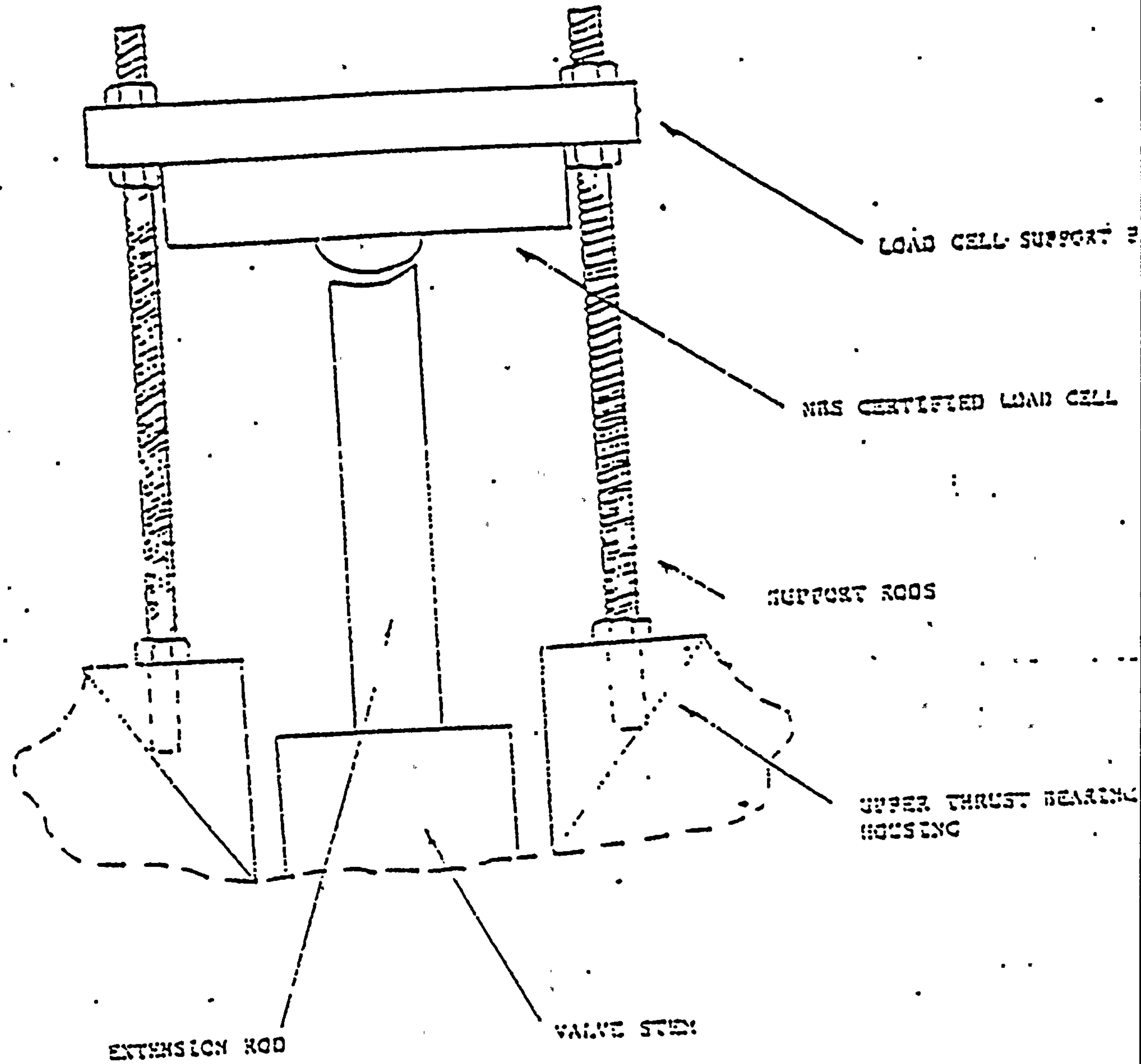
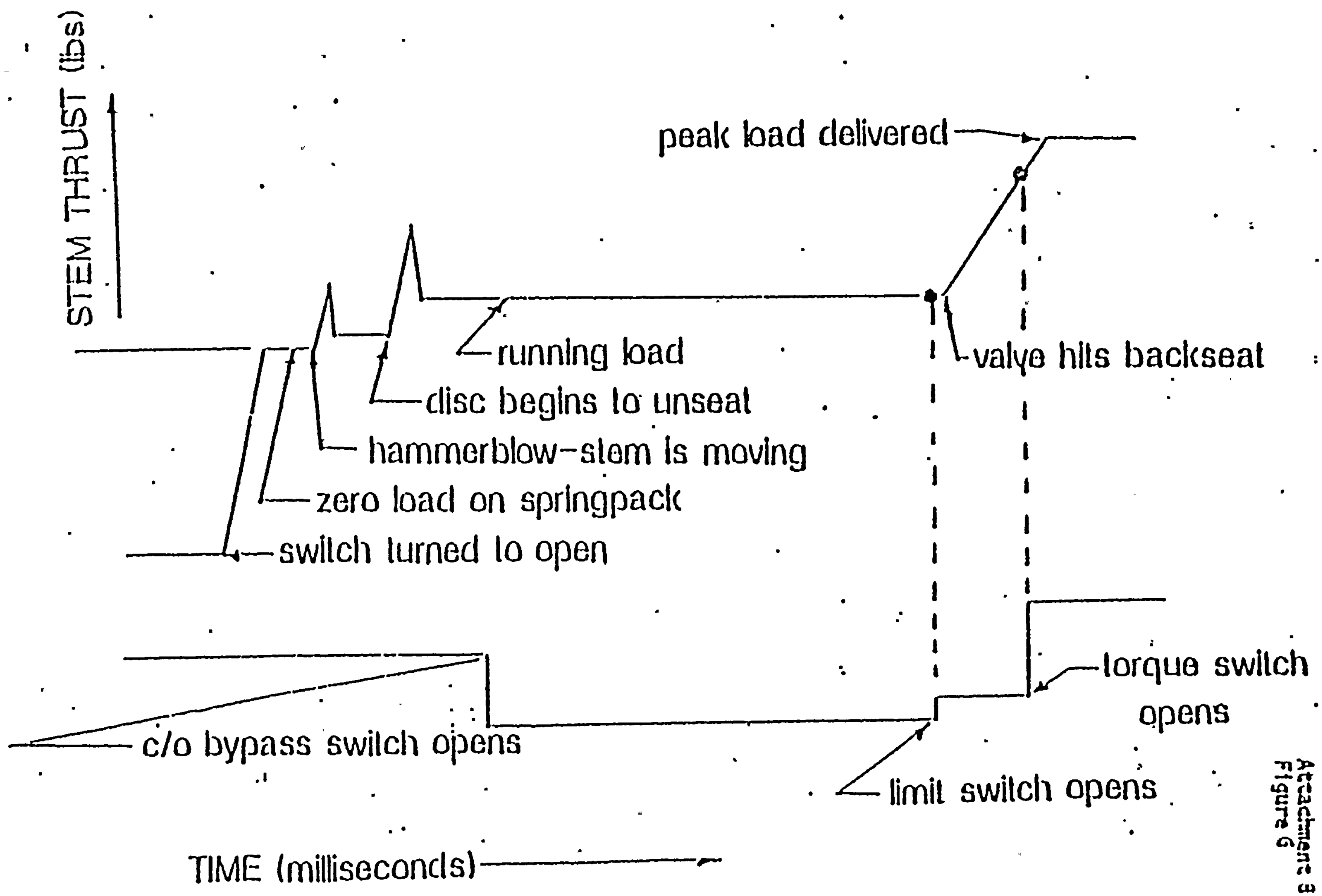


FIGURE 6.

TYPICAL STEM THRUST AND CONTROL SWITCH ACTUATION SIGNATURES



Attachment 3
Figure 6

FIGURE 7

Attachment 8
Figure 7

DETERMINING DELAY TIME

AND

MOTOR LOAD THRESHOLD VALUE

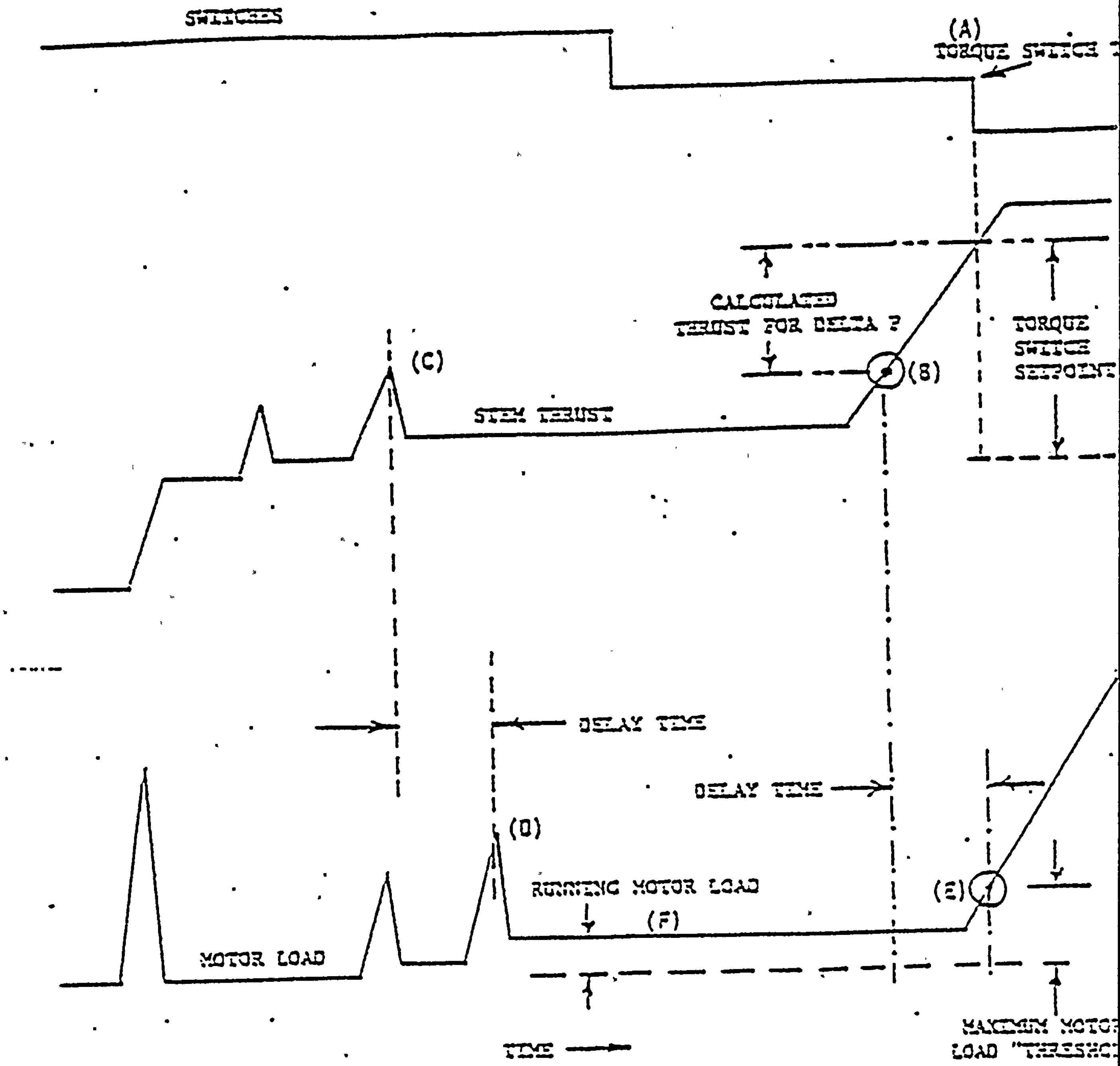


TABLE 1
CRACKING AND UNSEATING TIMES
AS PERCENT OF VALVE STROKE
(Arranged in Ascending Order)

NUMBER	CRACKING	UNSEATING w/DIFFERENTIAL PRESSURE
1	.10	.25
2	.12	.26
3	.13	.76
4	.13	1.05
5	.15	1.17
6	.15	1.32
7	.16	1.44
8	.19	2.21
9	.22	2.46
10	.22	4.78
11	.22	5.04
12	.27	5.22
13	.28	5.32
14	.29	5.7
15	.29	5.85
16	.33	7.5
17	.34	7.68
18	.36	7.89
19	.42	9.46
20	.46	9.53
21	.67	9.74
22	.68	10.8
23	.68	11.2

MOVATS DIFFERENTIAL PRESSURE TEST DATA

LOG NO.	TYPE	OPER SIZE	DELTA-P (PSIG)	STEM DIA. (IN)	ORIFICE AREA (SQ IN)	CALC OPEN	ACTUAL OPEN	CALC CLOSE	ACTUAL CLOSE	CRACK LOAD
1	FWG	000	1050	1.000	3.438	6652	4489	4873	ND	3500
2	FWG	00	54	1.887	13.250	5081	3455	3100	ND	2580
3	FWG	00	420	1.625	7.625	13089	11720	8612	ND	10174
5	FWG	000	100	1.125	5.761	1779	1688	1145	1014	ND
6	FWG	000	100	1.125	5.761	1779	1100	1145	1062	ND
7	FWG	1	650	2.000	8.000	22299	21250	15396	ND	ND
8	SWG	1	860	2.125	11.750	63645	41837	40333	ND	ND
9	SWG	1	935	2.125	11.750	69195	57702	43851	ND	ND
10	SWG	0	852	1.875	7.875	28322	20809	19242	ND	ND
11	SWG	1	850	2.125	11.750	62905	45199	39864	ND	ND
12	SWG	1	850	2.125	11.750	62905	36476	39864	ND	ND
13	SWG	00	900	1.625	6.000	17367	8015	12350	ND	ND
14	SWG	00	900	1.625	6.000	17367	6100	12350	ND	ND
16	FWG	00	2400	1.125	2.000	5145	880	6042	ND	1255
17	FWG	1	300	2.000	17.000	46474	32800	27781	ND	32800
18	FWG	00	1050	1.500	5.761	18680	11257	13086	ND	11257
19	FWG	00	700	1.500	5.761	12453	7344	8724	ND	7344
20	FWG	00	1050	1.500	5.761	18680	10733	13086	ND	10733
21	FWG	4	1075	2.500	14.500	121153	90541	76090	ND	90541
22	FWG	1	1050	1.500	5.761	18680	15700	13086	ND	16200
23	FWG	1	750	1.500	5.761	13342	11820	9347	ND	14560*
24	FWG	1	1050	1.500	5.761	18680	12959	13086	ND	12959
25	FWG	1	1100	1.500	5.761	19569	13096	13709	ND	13096
26	FWG	00	900	1.500	5.761	16011	9656	11216	ND	9656
27	FWG	00	1050	1.500	5.761	18680	13584	13086	ND	13584
28	FWG	00	1275	1.500	5.761	22682	14148	15890	ND	14148

FWG - Flexible Wedge Gate Valves
SWG - Solid Wedge Gate Valves
ND - No Data Obtained

* Log. No. 23 and 162 are the same valve at different ΔP's. This valve's operation is suspect due to conditions it has been operated under.

TABLE 2
Sheet 1 of 3

LOG NO.	TYPE	OPER SIZE	DELTA P (PSIG)	STEM DIA. (IN)	ORIFICE AREA (SQ IN)	CALC OPEN	ACTUAL OPEN	CALC CLOSE	ACTUAL CLOSE	CRACK LOAD
29	FWG	0	100	1.5	10	5360	4661	3293	ND	4661
31	FWG	000	105	2.25	8.021	3621	3002	2612	ND	3002
32	FWG	1	361	2.0	8.125	12774	11379	8774	ND	11379
34	FWG	000	100	1.25	5.761	1779	1600	1176	ND	ND
43	FWG	00	2180	1.125	2	4674	3650	5488	ND	3650
70	FWG	000	151	1.25	10	8094	5126	4866	4450	4817
162	FWG	1	350	.5	5.761	6227	6040	4362	ND	10620 *
15	WFG	1	160	1.375	7.625	4986	3000	3158	5836	3025
91	WFG	00	2720	1.125	2.62	10008	7247	9234	11237	6833
92	WFG	00	2474	1.125	2.62	10100	6688	9319	10264	6688
96	WFG	000	2700	1.125	2.62	9935	8396	9166	ND	7577
97	WFG	00	2700	1.125	2.62	9935	10607	9166	ND	9100
98	WFG	00	2750	1.25	3.44	17444	5864	14355	10805	5540
99	WFG	00	2700	1.25	3.44	17127	4333	14094	6906	4267
100	WFG	00	2650	1.25	3.44	16810	4971	13833	ND	5116
103	WFG	00	2650	1.25	3.44	16810	7715	13833	11960	7715
104	WFG	00	2625	1.25	3.44	16651	4230	13703	10587	4230
105	WFG	00	1500	1.25	3.44	9515	4859	7830	10165	4859
106	WFG	00	1500	1.25	3.44	9515	7124	7830	7099	7124
109	WFG	00	1470	1.25	3.83	11559	6939	8950	12585	8750
110	WFG	00	1500	1.25	3.83	11795	6871	9133	14382	5699
111	WFG	00	1475	1.25	3.44	9536	4350	7700	7730	4350
35	GLB	STM-2500	1470	1.5	2.125	6777	5628	10154	6941	ND
37	GLB	00	1470	0.81	1.625	3963	2825	4948	1705	ND
40	GLB	00	1350	1.25	2.75	10424	9161	12578	10590	9030
50	GLB	000	1950	0.938	2	7964	1800	9715	ND	ND
51	GLB	00	1490	0.875	2	6085	3060	7250	ND	ND
83	GLB	00	1360	1.25	2.75	10501		12671	11417	ND

FWG - Flexible Wedge Gate Valves
WFG - Westinghouse Gate Valves with pinned stem-to-disk
GLB - Globe valves

TABLE 2
Sheet 2 of 3

* Log. No. 23 and 162 are the same valve at different ΔP's. This valve's operation is suspect due to conditions it has been operated under.

LOG NO.	TYPE	OPER SIZE	DELTA P (PSIG)	STEM DIA. (IN)	ORIFICE AREA (SQ IN)	CALC OPEN	ACTUAL OPEN	CALC CLOSE	ACTUAL CLOSE	CRACK LOAD
93	GLB	00	2725	1.125	1.875	9781	6000	13303	7845	6000
94	GLB	00	2750	1.125	1.875	9871	5420	13425	8241	5420
95	GLB	00	2560	1.125	1.875	9189	5000	12497	7580	5000
101	GLB	00	2750	1.125	1.875	9871	6861	13425	6891	6140
102	GLB	00	2710	1.125	1.875	9728	6184	13230	6636	6184

GLB - Globe valves

TABLE 2
Sheet 3 of 3

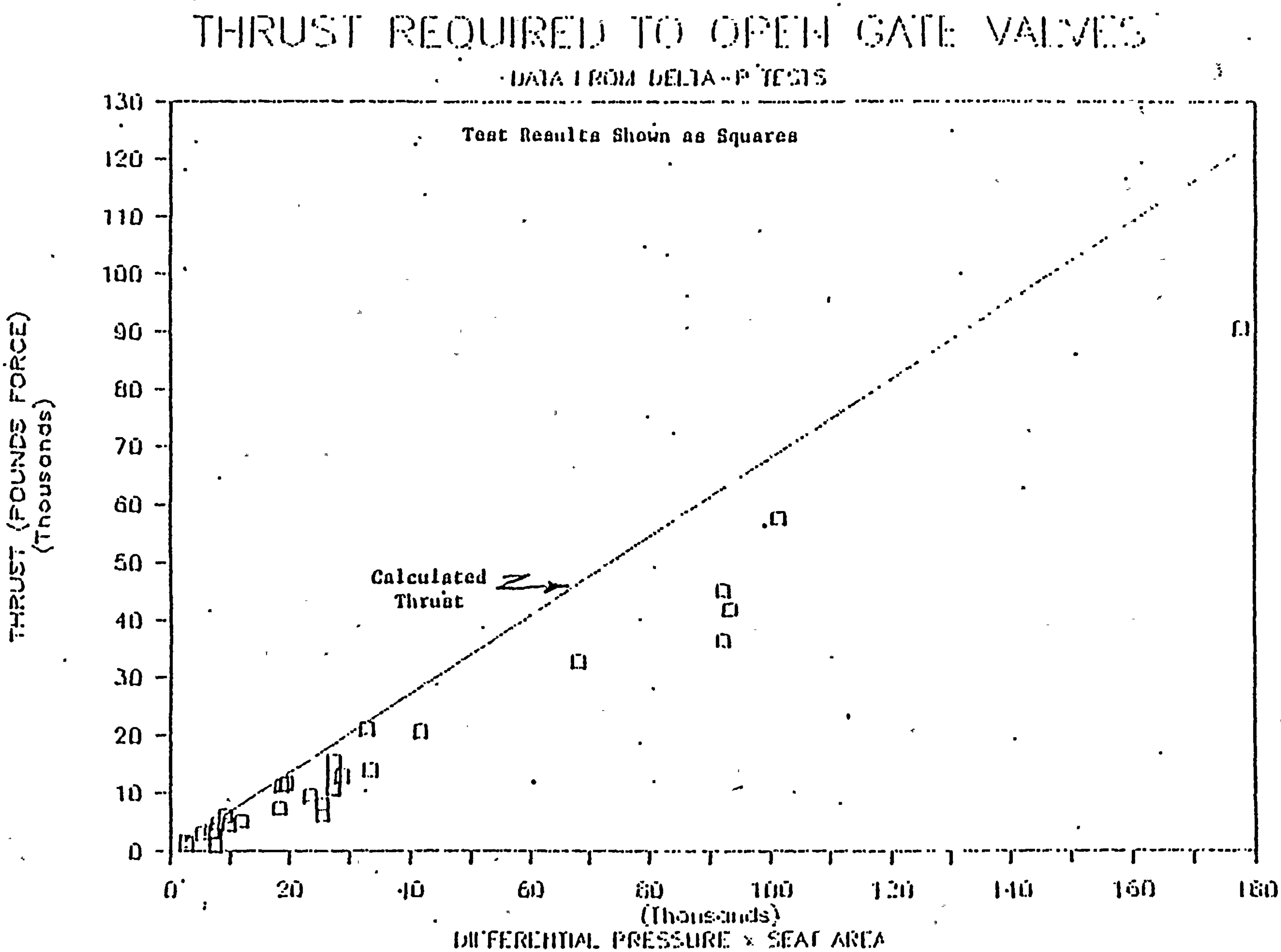

THRUST REQUIRED TO OPEN GATE VALVES
DATA FROM DELTA-P TESTS
Test Results Shown as Squares
Calculated Thrust
THRUST (POUNDS FORCE) (Thousands)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
0
20
40
60
80
100
120
140
160
180
(Thousands)
DIFFERENTIAL PRESSURE x SEAT AREA

TABLE 2
FIGURE 2

THRUST REQUIRED TO CLOSE GATE VALVES

DATA FROM DELTA-P TESTS

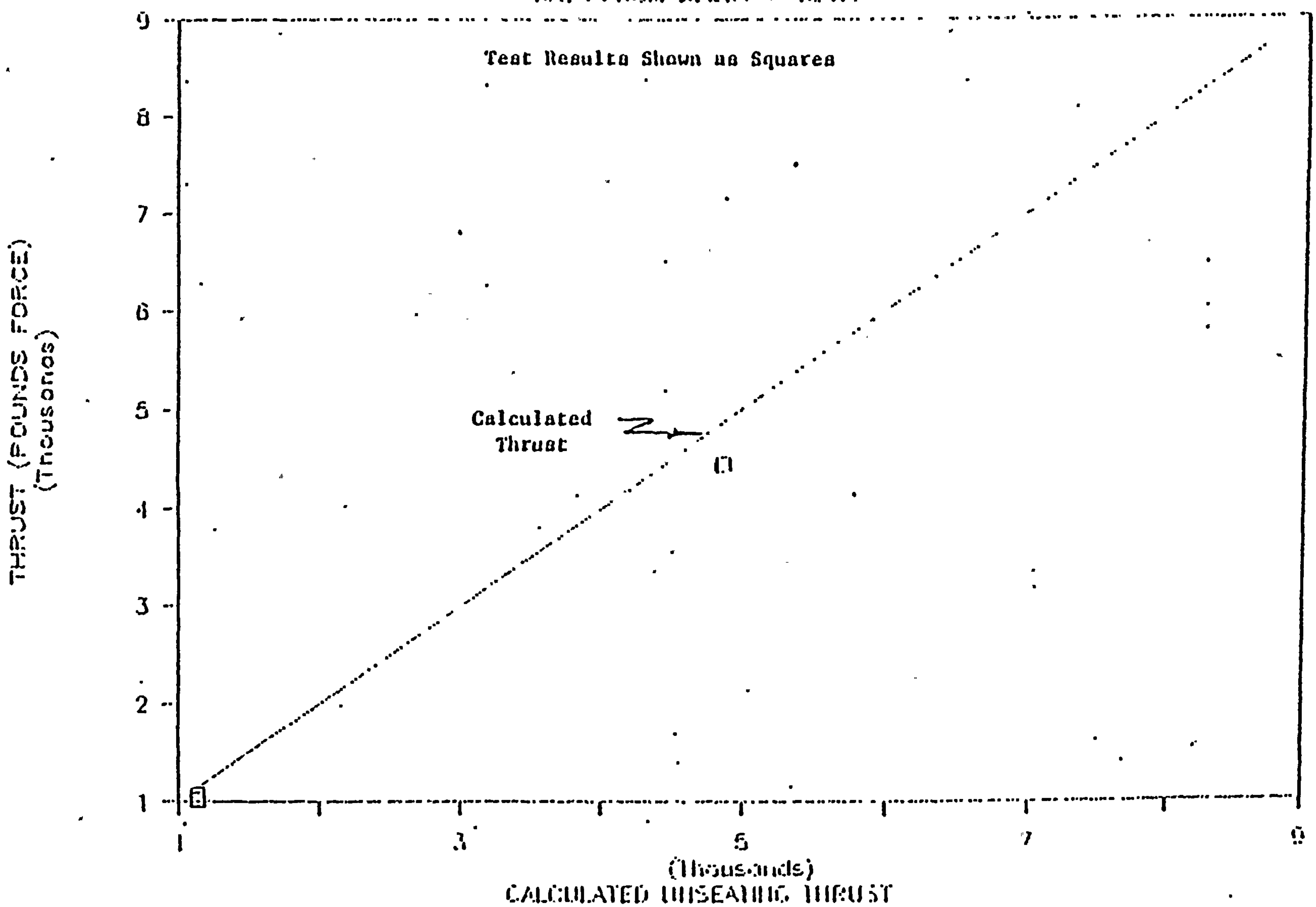


TABLE 2
FIGURE 3

THRUST REQUIRED TO OPEN GLOBE VALVES

DATA FROM DELTA-P TESTS

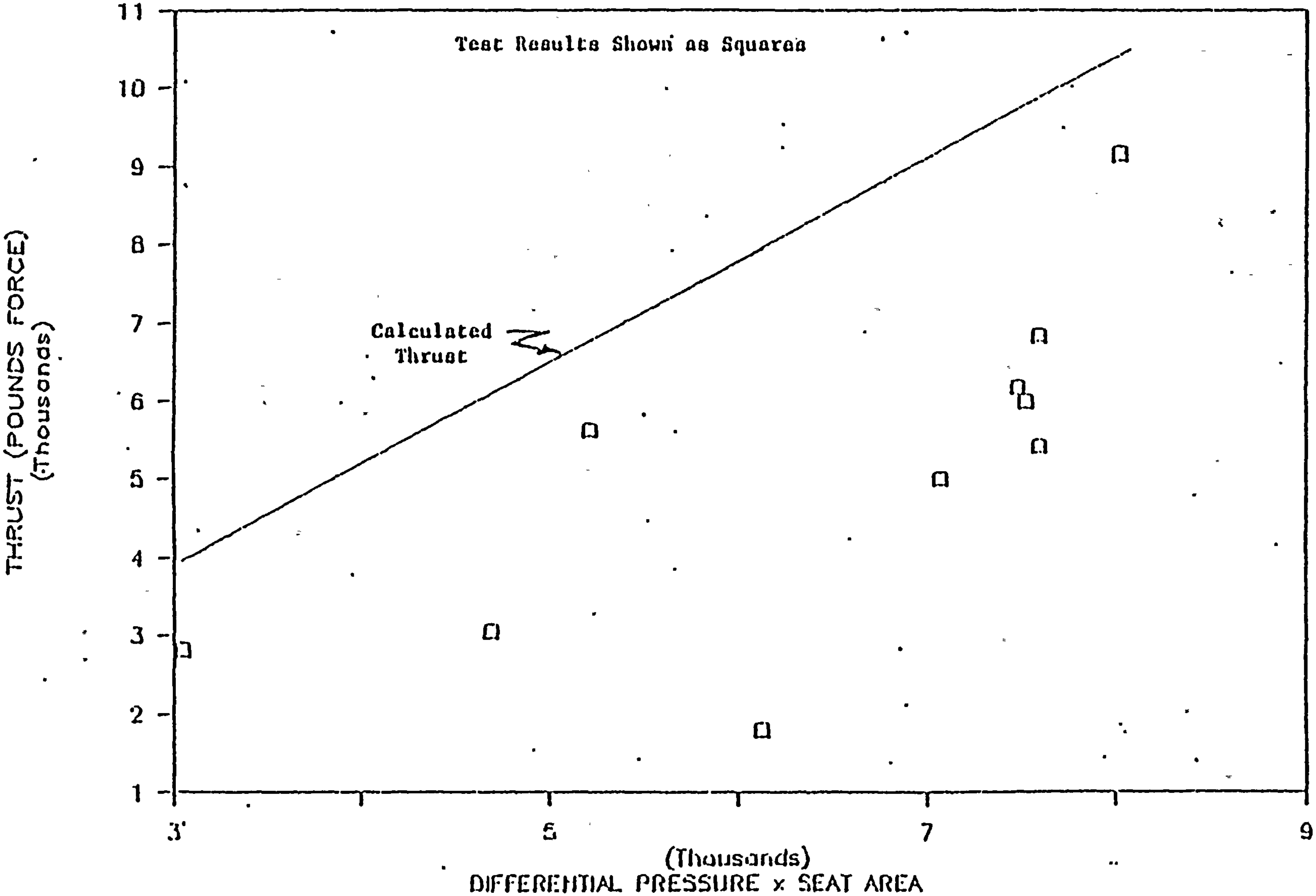


TABLE 2
FIGURE 4

February 26, 1987
Attachment B

THRUST REQUIRED TO CLOSE GLOBE VALVES

DATA FROM DELTA-P TESTS

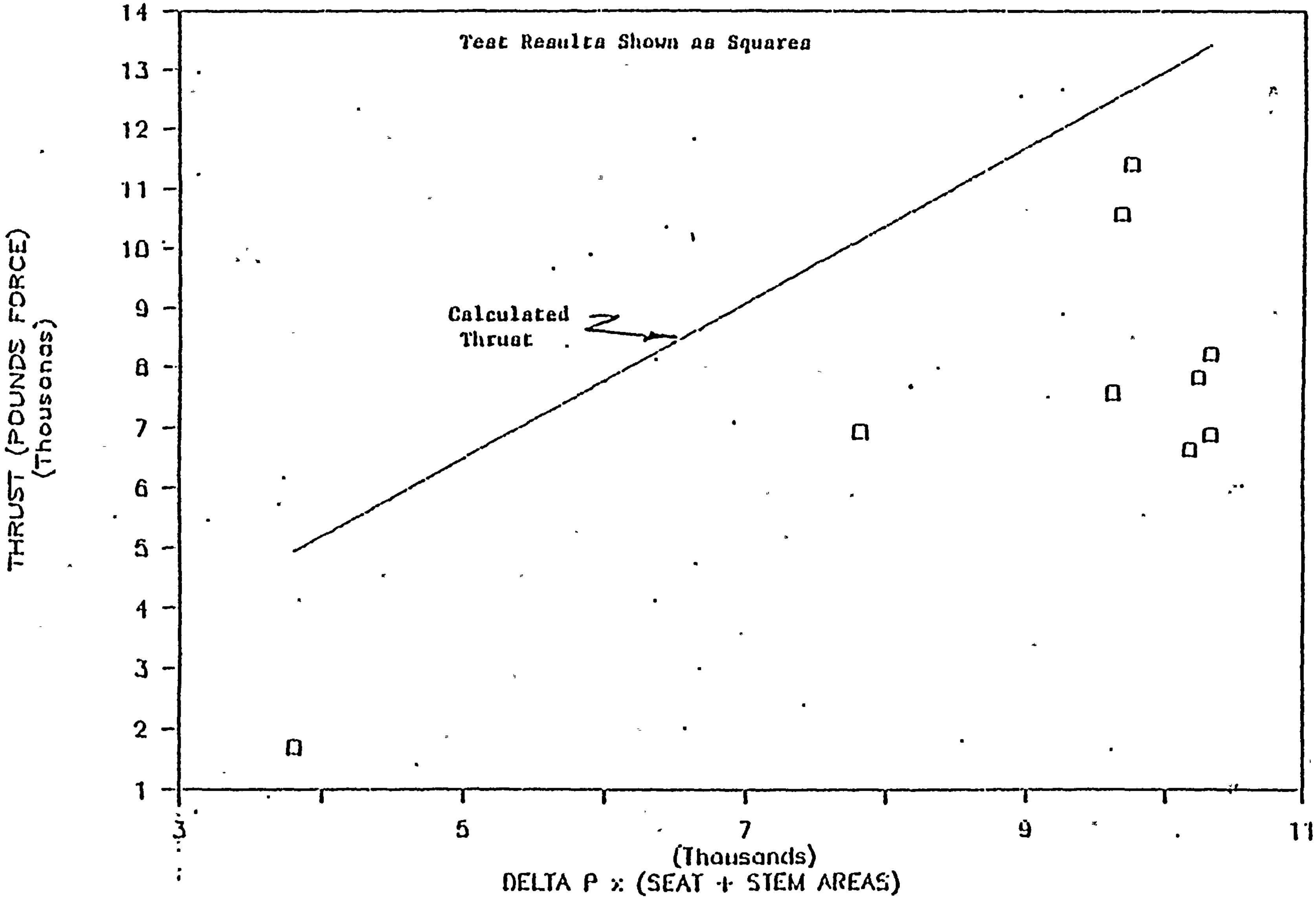
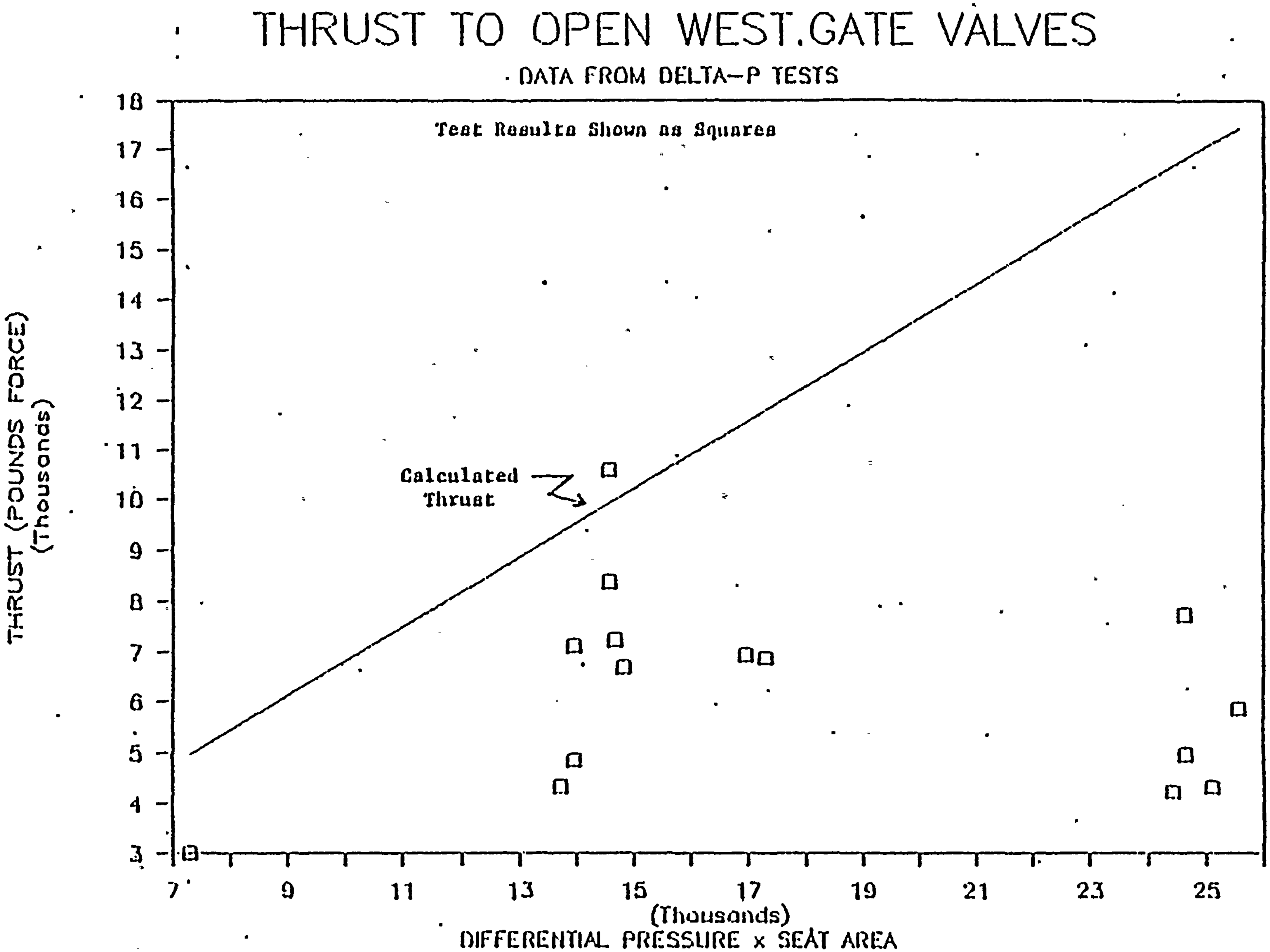


TABLE 2
FIGURE 5

February 26, 1987

Attachment B



ROCHESTER GAS AND ELECTRIC CORPORATION

GINNA STATION PORV BLOCK VALVE REPLACEMENT PROGRAM

ATTACHMENT C.6

A copy of Rotork Catalog Section 2, "Electric Motor Performance Data for "A" Range Actuators and Rotork letter dated April 27, 1989

rotork

Catalog section 2
Publication number AE2/0 1
Date of issue 12/81

Electric motor performance data for 'A' Range actuators

ATTACHMENT C.6
p. 1 of 5

Performance requirements
The operating torque of the average motorized valve essentially features the following four points.

1 Torque at the open position is low, as there is no differential pressure, and gland friction force is the largest constituent.

2 The closing torque only begins to rise substantially as throttling takes place when the valve is about three quarters shut.

3 The closing force rises sharply with the last few turns as the valve seats.

4 If the valve has remained shut for long periods, wedging, corrosion or the 'flow', of soft seats may require a higher momentary unseating force than was necessary to shut the valve. As no continuous running is possible on normal on/off duties, the motor need only be 15 minute rated to cover normal valve travel times of 1–5 minutes, and this will also give a generous allowance for inching on manual regulating duties.

The essential requirements of a motor to meet these needs are:—

a A high stalling torque in comparison with that required to operate and seat the valve, to be available at high speed for unseating in combination with a lost motion hammerblow effect, achieved by allowing the motor to reach full speed before the drive is taken up.

b A relatively high starting torque to enable the valve to be inched when the backlash is taken up.

The graph shows the Rotork motor speed/torque characteristic, designed to meet these performance requirements. It provides the highest possible stalling torque at high speed while providing a starting torque which is at least 80% of it. The torque available to seat the valve is shown as actuator rated torque, and it can be seen that the stalling torque gives a safety margin of up to 2:1 to ensure unseating, even if the voltage is low. (The stalling and starting torques vary approximately as the square of the voltage).

In order to prevent valve damage in the event of incorrect wiring, particularly reversed phase rotation when torque and limit switches are rendered useless, it is important that the motor should produce this characteristic without too much kinetic energy, i.e. the rotor should be long and thin rather than short and fat. The short time rating which enables more punch to be packed into a smaller frame is therefore also desirable for mechanical reasons.

Motor Performance Data
For any three-phase motor of any valve actuator from any source there are only three pieces of information which are factual, because they can be measured. They are locked rotor current, locked rotor torque and stalling torque. The first only is of any use to the customer, the others are part of the actuator maker's responsibility in selecting the motor in the first place. Quoting locked rotor current only is not very helpful for the selection of cables, fuses and control gear, where data is required on the ordinary full loading running condition of an ordinary motor drive. To satisfy this requirement, an arbitrary basis for presentation must be chosen.

The seating torque, for which the actuator must be rated mechanically, is only required for a very brief period; the time rating has to relate to the average load of a valve which, in our experience is about 33% of seating torque. There are particular exceptions like regulating butterfly valves which may require a very high opening torque during travel but will be assisted in closing, and lubricated plug valves which may need a higher proportion of torque through travel, but as a generalisation the 33% figure is quite conservative. If this is then worked out mechanically into horsepower and listed as the nominal horsepower it will be found that the locked rotor current is much higher than that quoted for the equivalent conventional motor of the same horsepower. The virtue of the horsepower figure is therefore only that it is independent of a supply voltage.

Rotork Published Motor Currents
Rotork, therefore publishes the following three currents for actuators at any specified voltage.

1 Locked Rotor (starting)
Maximum current demanded, lasting for three cycles only (see oscillogram) during normal starting unless the motor is stalled. Locked rotor current should be used for sizing cables, to ensure that the voltage drop does not exceed approx 15% during starting.

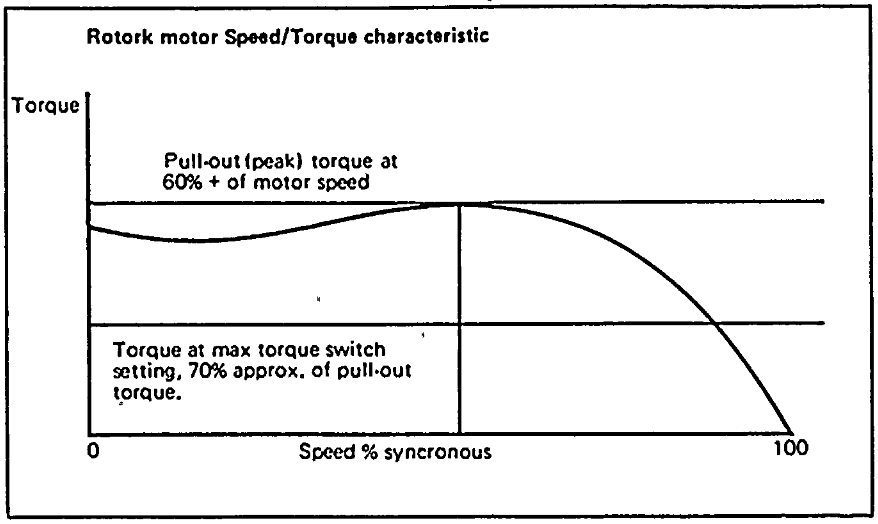
2 Rated Torque (seating)*
Current corresponding to maximum seating torque, which is also a brief duration at the end of valve stroke. It should be used for selection of fuses and thermal trips where required. See page 8.

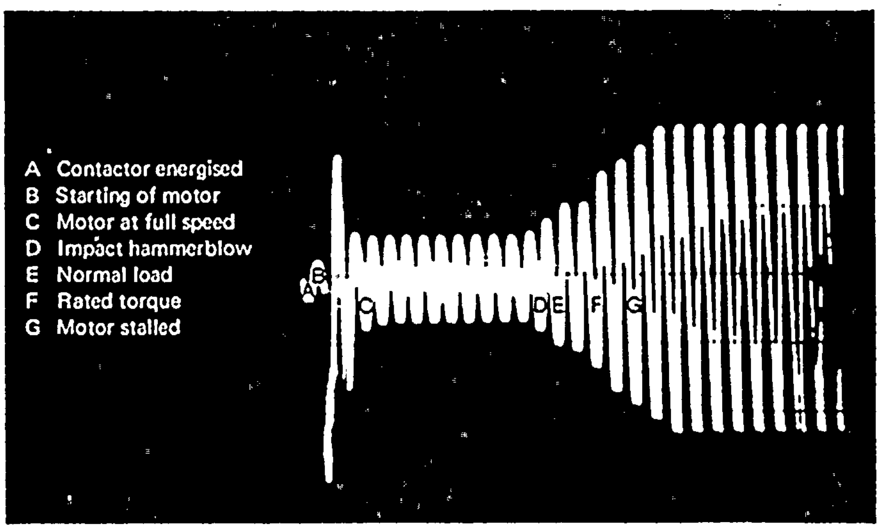
3 Average Load
Corresponds to 33% of maximum seating torque, and should be used for sizing motor control gear. See page 8.

In addition, a nominal horsepower is listed (independent of voltage). The figure gives the equivalent size of a conventional motor which would draw approximately the same locked rotor and average load currents.

The following data is approximate and applies to standard 15 minute rated class B insulated motors for normal power supplies as specified.

* Torque at maximum torque switch setting.





rotork

Catalog section 2
Publication number AE2/0 (Imp)
Date of issue 12/81

Performance summary for electric actuators
Imperial units

ATTACHMENT C.6
P. 2 of 5

Mechanical data

Actuator size	Flange reference	Maximum stem diameter inches Rising	Non-rising	Thrust rating lbf	Limit switch turns range*	Handwheel ratio Standard	Optional	Dimension sheet number Syncropak	Syncroset
7A	1	1	¾	5000	1·5 to 100 or	direct	—	AE2/1.1	AE2/2.1
7AZ	1	1¼	1	5000	12·5 to 400	direct	—	AE2/1.1	AE2/2.1
7AB	1	—	—	500		direct	—	AE2/1.2	AE2/2.2
11A	1	1	¾	5000	1·5 to 100 or	direct	—	AE2/1.1	AE2/2.1
11AZ	1	1¼	1	5000	12·5 to 400	direct	—	AE2/1.1	AE2/2.1
11AB	1	—	—	500		direct	—	AE2/1.2	AE2/2.2
13A	1	1	¾	10000	1.5 to 100 or	direct	direct	AE2/1.1	AE2/2.1
13AZ	1	1¼	1	10000	12.5 to 400		(enlarged 18" diam)	AE2/1.1	AE2/2.1
14A	2	1½	1¼	15000	1·5 to 100 or	direct	10:1	AE2/1.3	AE2/2.3
14AZ	2	2	1½	15000	25 to 800	direct	10:1	AE2/1.3	AE2/2.3
16A	2	1½	1¼	15000	1·5 to 100 or	direct	10:1	AE2/1.4	AE2/2.4
16AZ	2	2	1½	15000	25 to 800	direct	10:1	AE2/1.4	AE2/2.4
30A	3	2⅛	1¾	25000	2 to 160 or	direct	15:1	AE2/1.5	AE2/2.5
30AZ	3	2⅝	2	25000	25 to 800	direct	15:1	AE2/1.5	AE2/2.5
40A	5	2½	2	50000	2 to 160 or	direct	10:1 or	AE2/1.6	AE2/2.6
40AZ	5	3	2¼	50000	25 to 800	direct	20:1	AE2/1.6	AE2/2.6
40AR	4	—	2	—		direct		AE2/1.7	AE2/2.7
70A	5	2¾	2¼	50000	2 to 160 or	15:1	30:1	AE2/1.8	AE2/2.8
70AZ	5	3¼	2⅞	50000	33 to 1000	15:1	30:1	AE2/1.8	AE2/2.8
70AR	4	—	2¼	—		15:1	30:1	AE2/1.10	AE2/2.10
90A	6	2¾	2¼	75000	2 to 160 or	15:1	45:1	AE2/1.9	AE2/2.9
90AZ	6	3¼	2⅞	75000	33 to 1000	15:1	45:1	AE2/1·9	AE2/2·9
90AR	4	—	2¼	—		15:1	45:1	AE2/1.10	AE2/2.10
91AR	4	—	2¼	—	33 to 1000	15:1	30:1	AE2/1.11	AE2/2.11
95A	6	2¾	2¼	100,000	2 to 160 or	15:1	45:1	AE2/1.12	AE2/2.12
95AZ	6	3¼	2⅞	100,000	33 to 1000				

* Actuators will be provided with the lower turns range unless the turns required by the valve are specified, in which case the higher turns range will be provided for specified turns exceeding the following:

For	7A/11A/13A	39 turns
	14A/16A	49 turns
	30A/40A	59 turns
	70A/90A	69 turns
	91AR/95A	69 turns

Refer to Rotork for applications where valve travel time exceeds 10 minutes or for turns exceeding maximum listed.

Flange data

Reference	Number of bolts	UNC bolt size inches	PCD inches	Outside dia. inches
1	4	⅜	4	4 15/16
2	4	⅝	5½	7⅛
3	4	¾	6½	8¼
4	4	⅝	10	11⅞
5	8	⅝	10	11⅞
6	8	¾	11¾	13¼

ATTACHMENT C.6
p. 3 of 5

For 575V 60Hz 3ph power supply

Actuator size	rpm	Rated* torque lbf ft	Motor poles	Approximate current amps			Average load			
				Locked rotor	Rated torque	Average load	Nominal hp	Nominal kW	Power factor	Efficiency %
7A, AZ & AB	21	25								
	29	25	4	1.7	.9	.4	.13	.1	.49	51
	43	23								
	57	20								
	86	20	2	3.8	1.4	1.0	.25	.19	.40	50
	115	16								
11A, AZ & AB	21	50								
	29	50	4	3.7	1.2	1.0	.24	.18	.39	47
	43	45								
	57	40								
	86	40	2.	5.1	1.75	1.4	.38	.29	.40	50
	115	32								
13A & AZ	29	80								
	43	80	4	5	2.6	1.45	.5	.82	.49	52
	57	70								
14A & AZ	21	120	4	7	2.8	1.8	.6	.43	.45	67
	29	120								
	43	100								
	57	80								
	86	80	2	10	3.0	2.1	1.1	.8	.55	71
	115	60								
	173	45								
16A & AZ	21	225	4	14	4.8	3.0	1.2	.9	.48	63
	29	225								
	43	190								
	57	150								
	86	150	2	17	5.3	3.6	1.8	1.3	.54	70
	115	110								
	173	80								
30A & AZ	21	400								
	29	400	4	24	6.0	3.8	2.0	1.5	.56	71
	43	375								
	57	300								
	86	300	2	40	10.5	5.5	3.6	2.6	.68	72
	115	240								
	173	190								
40A, AZ & AR	21	750								
	29	750	4	40	11.0	6.0	3.4	2.5	.57	73
	43	625								
	57	500								
	86	500	2	59	18	7.5	5.9	4.4	.65	82
	115	400								
	173	300								
70A, AZ & AR	21	1100	4	58	17	8	4.4	3.3	.56	74
	29	1100								
	43	950								
	57	750								
	86	750	2	80	21	13	7.8	5.8	.6	75
	115	550								
	173	475								
	230	400								
90A, AZ & AR	21	1500								
	29	1500	4	70	21	12	7.2	5.4	.57	79
	43	1250								
	57	1000								
	86	1000								
	115	750	2	124	31	17.5	12	9.0	.65	81
	173	640								
	230	540								
91AR	173	1000	2	166	67	21.6	21	15.6	.79	87
	230	1000								
95A & AZ	29	2200	4	70	22	13	7.8	5.8	.57	78

* Torque at [illegible]

Rotork Sealed Valve Actuators

Rotork Controls, Inc.
19 Jet View Drive
Rochester
New York 14624

telephone (716) 328-1550
telex 6854116
cables Rotork Rochester
telefax 716-328-5848

rotork

your reference

our reference

date

April 27, 1989

ATTACHMENT C.6
p. 4 of 5

Rochester Gas & Electric Corporation
89 East Avenue
Rochester NY 14649

Attention: Mr. Cong Pham

Subject: Rotork Motors

Dear Mr. Pham:

Thank you for your interest in our products. We discussed earlier your requirement for rating our motors in foot pounds. We do not rate our motors in foot pounds as we feel we sell a machine which provides a foot pound output.

We have come up with a small formula to try and obtain a rating for your comparison purpose. We hope this is of some use to you. Please feel free to contact us if you require more information.

Regards,

Pete Kundin
Northeast Regional Sales Manager

PK/nar

Enc.

rotork

ATTACHMENT C.6
p 5 of 5

16A size Actuator, 57 rpm:

Rated: 150 foot pounds

Motor Ratio: 60:1

Efficiency: 45%

Mechanical Advantage: 27

Motor Torque Foot Pounds = 150 ÷ 27 = 5.5 foot pounds

30A size Actuator, 57 rpm:

Rated: 30 foot pounds

Motor Ratio: 60:1

Efficiency: 50%

Mechanical Advantage: 30

Motor Torque Foot Pounds = 300 ÷ 30 = 10 foot pounds

ROCHESTER GAS AND ELECTRIC CORPORATION

GINNA STATION PORV BLOCK VALVE REPLACEMENT PROGRAM

ATTACHMENT C.7

Limitorque Rating Sheet SMB/HMB Design, SEL-9, Sheet 1 of 2

LIMITORQUE

RATING SHEET
SMB/HMB DESIGN

	SMB-000	HMB-00 SMB-00	HMB-0 SMB-0	HMB-1 SMB-1	HMB-2 SMB-2	HMB-3 SMB-3
2 PC. NUT MAXIMUM STEM	1 3/8"	1 3/4"	2 3/8"	2 7/8"	3 1/2"	5"
2 PC. NUT MAXIMUM BORE KEYWAY	1 1/8" 1/4" x 3/32"	1 1/2" 3/8" x 1/8"	1 7/8" 1/2" x 3/16"	2 7/16" 5/8" x 7/32"	2 7/8" 3/4" x 1/4"	4 1/4" 1" x 3/8"
1 PC. NUT MAXIMUM	1 1/2"	2"	2 3/4"	3 1/4"	3 7/8"	5 3/4"
1 PC. NUT MAXIMUM BORE KEYWAY	1 1/4" 1/4" x 1/8"	1 3/4" 3/8" x 3/16"	2 5/16" 5/8" x 7/32"	2 3/4" 5/8" x 7/32"	3 1/4" 3/4" x 1/4"	4 3/4" 1 1/4" x 7/16"
RATIO RANGE AND MAX. TORQUE RATING (Self-Locking)	33.5 - 136 90'#	23.0 - 109 250'# 114 - 184 190'#	26.4 - 150.8 500'# 158.3 - 247 340'#	27.2 - 171.6 850'# 191.7 - 234 625'#	26.2 - 82.5 1800'# 84.8 - 150 1250'# 153 - 212.5 950'#	43.9 - 95.5 4200'# 98.6 - 132.8 3300'# 138.4 - 186.4 2800'#
RATIO RANGE AND MAX. TORQUE RATING (Non-Locking)	12.5 - 30.6 90'#	9.7 - 22.0 250'#	11.2 - 26.1 500'#	11.6 - 25.6 850'#	10.6 - 25.5 1800'#	11.1 - 37.3 4200'#
SEATING THRUST	8,000#	14,000#	24,000#	45,000#	70,000#	140,000#
MOTOR RANGE (Max. Ratio For Stall)	* 2'#/U ** 5'#/68	5'#/U 7 1/2'#/U 10'#/102 * 15'#/65 ** 25'#/44	7 1/2'#/U 10'#/U 15'#/150 * 25'#/114 ** 40'#/63	10'#/U 15'#/U 25'#/171 * 40'#/106 * 60'#/79	15'#/U 25'#/U 40'#/150 60'#/117 * 80'#/82	40'#/U 60'#/U 80'#/U 100'#/143 * 150'#/118

NOTES: SMB-00, 65'# torque or greater supplied with 4.37:1 handwheel gear ratio
3600 RPM motors may be used for torque seating on all units except where noted (*)
* 3600 RPM motors may be used for position seated valves.
** 1800 RPM motor only, for either torque or position seating.

U-Unlimited ratios.

SEL-9
SHEET 1 OF 3
REV. 2 6/2/75

ATTACHMENT C.7
p. 1 of 1

ROCHESTER GAS AND ELECTRIC CORPORATION

GINNA STATION PORV BLOCK VALVE REPLACEMENT PROGRAM

ATTACHMENT C.8

MOVATS, Inc. Engineering Report - E.R.1.0, "Differential Pressure Thrust Calculation Methodology", Rev. 0, June 20, 1988