MOTOR OPERATED VALVE TESTING AND EVALUATION

AT PERRY NUCLEAR POWER PLANT

(IE BULLETIN 85-03)

PERRY MOV TESTING AND EVALUATION

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PERRY MOV TESTING AND EVALUATION

I. INTRODUCTION AND BACKGROUND

A. Background

The Cleveland Electric Illuminating Company (CEI) presented the initi response to IE Bulletin 85-03, "Motor Operated Valve Common Mode Failures During Plant Transients Due to Improper Switch Settings" in letter PY-CEI/OIE-0206 L, dated May 14, 1986, which outlines the Perry program to assure MOV operability. Topics covered in this letter included IEB 85-03 items A. Design Basis, B. Motor-Operated Valve Control Switch Setting, C. Testing and D. Procedures. In addition, the valves to be tested along with their pertinent design data were listed.

CEI has participated in the BWR Owners Group (BWROG) Committee that has developed a BWR position for meeting the requirements of IE Bulletin 85-03. We have used the BWROG Final Report as a guideline document and Perry meets or exceeds the applicable requirements in the BWROG report.

A second response letter (PY-CEI/OIE-0263 L) was transmitted on January 16, 1987 to add additional valves and clarified that "CEI included all motor-operated valves in high pressure injection systems irrespective of normal valve position or safety actions."

B. Organization

In order to fulfill the requirements of the IE Bulletin, a Special Project Plan was instituted to best focus experienced personnel on determining and improving MOV operability. This plan was sponsored by the Manager of the Perry Plant Operations Department (PPOD). The MOV Task Group was comprised of the following personnel:

1. Special Project Coordinator from PPOD's Maintenance Section
2. Field Technicians
3. Work Planners
4. Spare Parts Evaluator
5. Nuclear Engineering Department Engineers (Mechanical & Electrical)
6. Quality Assurance Personnel

C. Scope of Work

The goal of the MOV Task Group was to establish acceptable operability and reliability of IEB 85-03 designated valves (Bulletin valves) at Perry. The Task Group's charter included:

- Improving and systematizing design changes,
- Spare parts planning,
- Performing thrust calculations used to adjust torque switches,
- Testing and troubleshooting,
- Dispositioning nonconformance reports,
- Reworking operators,
- Procedures and documentation.

The scope of work required to assure MOV operability includes procedure preparation and performance of calculations along with testing and maintenance activities. As stated in our initial response, procedures were in place to determine, control, implement and maintain the correct control switch settings, and testing activities were underway. These procedures are continuously being improved to reflect our testing experience.

Along with our procedure activities, a calculation methodology was developed as part of our overall program to determine torque switch settings and assure that maximum design differential pressure is taken into account.

Our testing activities were broken into two types of testing, static and dynamic. All Bulletin valves were static tested (without pressure and flow) to determine "as found" conditions relative to control switch setting and the overall valve operating condition. The valves were inspected to assure proper equipment qualification configurations were maintained and active components were in operating condition. The valves were tested using Motor Operated Valve Analysis and Test System (MOVATS) to determine the quantitative operating characteristics at the as-found switch settings. In addition, this test data was used to reset the limit and torque switches in accordance with our calculations and procedures.

Selected valves where also dynamically tested under flow and pressure to verify our switch setting methodology.

II. CALCULATION AND SWITCH SETTING METHODOLOGY

A. Calculation Methods

Thrust calculations are generated to attain a "target thrust" value that is used in field testing and torque switch adjustment of the subject valves. Cleveland Electric has acquired the vendor's calculation for thrust and related design basis information for use in determining MOV setpoints. In addition, hand calculations were performed in accordance with design procedures based on the Limitorque Selection Guide methodology. This calculation method conservatively takes into account a variety of "worst case" variables to provide sufficient margin for degradation in valve performance. Given the same design maximum differential pressure, the more conservative thrust value was selected between the vendor supplied data and the CEI calculation.

The "target thrust" value was then obtained by multiplying the selected value by 115% to provide an even greater safety margin for torque switch setting. In setting the torque switch, there is a +/- 10% tolerance applied to these values due to large differences in thrust values between possible torque switch settings. Settings may be applied at a higher value depending on design application.

This setting methodology is the best compromise to assure valve operability at maximum design loads, while minimizing valve degradation over expected life by staying well within the operator's and valve's allowable operating parameters.

B. Switch Setting Procedures

There are primarily two procedures used for the setting of MOV switches at Perry, General Electrical Instructions entitled "Motor Operated Valve Analysis and Test System (MOVATS) Testing" and "Limitorque Limit/Torque Switch Adjustment". The torque switch is set in accordance with the latter instruction, using the information gained from MOVATS testing and the calculated "target thrust".

The limit switch setting is documented by a combination of applicable design drawings and instructions. A brief description of the Perry procedures follows and is the basis for our limit switch settings.

1. For valves that do have a safety function to open, the valve travels full open, but not to the point of backseating, by the limit switch. The open torque switch is not utilized thereby the control logic provides maximum torque in the safe direction.
2. For valves that do not have a safety function to open, a torque bypass limit switch is presently utilized in the circuit, to assure that the torque switch is not in the circuit until the valve is unseated. The bypass limit is set by evaluating the MOVATS signature trace.
3. For valves which do have a safety function to close, the torque bypass limit switch is designed and set so that either the limit switch or the torque switch will close the valve. The limit switch takes the valve closed while the torque switch seats the valve to a calculated and MOVATS tested thrust value. In the event there is a torque switch opening prior to closure, the limit switch will complete the closure cycle for the safety function.
4. For valves that do not have a safety function to close, the closing torque bypass limit switch is set to follow the open control limit switch (which is set to not backseat the valve). The closing torque bypass limit switch is only in the circuit momentarily and the stroke is completed by the torque switch since the valve is not backseated and no cracking force is needed to overcome seating forces.

Condition 3 above presents a unique design concern when there is no safety function to go open. Setting the open bypass limit switch after unseating of the valve may improperly set the corresponding close torque bypass switch on a two train limit switch design. For these valves there may be improper closed indication provided to the operator and the valve may not complete the closing cycle in the event of torque switch opening during the valve stroke (previously discussed in IEN 86-29, "Effects of Changing Valve Motor-Operator Switch Settings").

Our present procedure for setting limit switches minimizes this condition but does not eliminate it completely. Corrective actions are being taken to change the design by removing the open torque switch and associated bypass limit switch thus allowing the close limit rotor to be set just prior to torque switch operation. This design change will eliminate the potential problem of incorrect control room indication of valve position.

III. STATIC TESTING

Each Bulletin valve was static tested without flow. Attachment 1, "Valve Data Summary" details pertinent characteristics of the valves tested. The valves are presently tested in accordance with the General Electrical Instruction "Motor Operated Valve Analysis and Test System (MOVATS) Testing"; its forerunner (FTI-F04) was used previous to 6/86. These procedures were used to obtain "as-found" thrust values and obtain nameplate data.

Attachment 2 tabulates the pertinent as-found operating characteristics of the subject valves as summarized below:

VALVE PROBLEM SUMMARY	NO. OF OCCURRENCES	% OF OCCURRENCES
MOVs whose as-found condition was inoperable and could not have performed their intended safety function	3	12%
Significant MOV problems that left uncorrected could have potentially affected MOV operability	9	38%
<u>Specific As-Found Conditions</u> (for 24 valves unless noted)		
Unbalanced torque switch	16	67%
Bypass switch set incorrectly	11*	92%
Valve Backseated	0	0
Overthrust of valve or operator	7	29%
Underthrust compared to calculation	1	4%
Stroke times not to Technical Specification	0	0

* NOTE: Only 12 valves use an open bypass switch.

Torque Switch:

An unbalanced torque switch affects the torque applied to the valve when it operates in either the open or close direction. Depending on the extent of imbalance, the corresponding output can potentially put the valve in an overthrust condition. Because of this condition, it has been our practice to balance the torque switch after taking our as-found thrust values. An unbalanced torque switch was common (67%) as shown by the high percentage of occurrences.

Bypass Switch:

The most common occurrence of improper valve set-up is the open torque switch bypass limit switch setting. Without diagnostic signature traces it is very difficult to capture the point in time of complete unseating of the valve. This is especially true in the General Electric standard design when a two-train limit switch is utilized because of its effect on the close indication. Implementation of the design change that removes the open torque switch for safety-related valves will eliminate the need for this adjustment. The as-left condition will assure that the valve has the capability of opening without being restricted by torque switch operation.

Backseating:

Perry's procedures for MOV's do not allow backseating. The as-found condition of the bulletin valves revealed that no valves were backseated.

Overthrust:

Twenty nine percent of either the valves or operators had a potential for an overthrust condition. Each case of potential overthrust was evaluated using existing procedures and vendor correspondence, when required, as part of the disposition.

Underthrust:

One of the HPCS valves (1E22F0023) was found to be in a potential underthrust condition. In our operability assessment, both vendor and CEI calculations were compared. In addition, credit was taken for the valve vendor's hydrostatic testing and our preoperational testing, performed at pressure and temperature, in determining that the valve was operable. Subsequent dynamic test results confirm this conclusion. However, torque switch open and close settings were increased as shown in Attachment 2.

Stroke Times:

Valve 1E51F0063, RCIC steam supply inboard isolation, experienced failures during routine testing under flow and temperature in January of 1987. The failure was its inability to open causing fuses to operate and the eventual failure of two motors over a one month period. Other symptoms discovered during diagnostic testing (increasing pressure and temperature) was an increasing motor current near or exceeding nameplate during the closing stroke. During this period, field representatives from both the valve and operator manufacturers, along with experienced MOV test personnel from Davis-Besse, were brought in to analyze for root cause and inspect the disassembled valve and operator.

Possible root causes analyzed at the time were:

1. Continuously energized shunt field of DC motor along with high ambient temperatures (approx. 140F) resulting in motor (shunt field) failure. Direct contact with the motor manufacturer at his facility has led to de-energizing the shunt fields.

2. Improperly adjusted limit switch along with a torque switch failure driving the disc hard into its seat.

3. Piston effect in the closing direction causing excessive current draw.

4. Process conditions (i.e. pipe thermal movement, steam condensation, etc.) resulting in mechanical binding of valve internals.

Pipe thermal movement was rejected as a contributor due to close proximity of component supports. Actual movements via lanyard pots were determined to be well within acceptable criteria and did not induce significant stresses in the valve assembly or result in body deformation such as seat contraction which could cause wedge binding.

Another process condition investigated was steam condensation in the piping downstream of 1E51F0063. The 10" diameter steam supply piping is sloped down from a vertical riser upstream of 1E51F0063 (F063) through 1E51F0064 to RHR stop valves 1E12F0052A&B.

During the time these motor failures were occurring, the steam piping collected condensate up to a level which caused overflow into a steam supply pipe to the RCIC turbine. During the period immediately following admission of steam into piping downstream of F063, the piping could have filled with enough condensate to cause bowing in the pipe due to differential temperatures (The combination of colder condensate in the bottom of the pipe and saturated steam would tend to cause a contraction at the pipe bottom and expansion at the top). Without some type of restraint downstream of F063, this condition could have induced a bending moment at the valve body and contributed to a potential binding between the valve seat and wedge.

While the above condition is credible, it was not a significant factor due to restraint from a guard pipe assembly downstream of F063. Actual measurements were not obtainable; however, the tight installation tolerances for internal guides between the process pipe and guard pipe would have restricted pipe deformation to extremely small amounts at F063. Subsequent to modification of F063, drain lines were added to the 10" diameter piping near stop valves 1E12F0052A&B, which precludes the buildup of condensate in this piping as described above.

It was concluded that neither thermal movement nor steam condensation were significant contributors to the motor failures of 1E51F0063. All of the above possible causes were vigorously pursued but none were conclusively the root cause. The valve operator was reworked, reassembled and installed.

By mid-March of 1987 the valve started to exhibit the same symptoms at operating pressure and temperatures, and the valve became stuck in the closed position. At this time a decision was made to make this valve a normally open alternating current MOV with the same characteristics as the 1E51F0064 outboard isolation valve. No unusual operating occurrences have occurred since this design change was implemented.

IV. DYNAMIC TESTING

A. Scope and Exceptions to Testing

The dynamic testing program demonstrated valve operability under design flow, temperature and pressure. Flow tests were performed on valves which would not place the HPCS or the RCIC systems in an unanalyzed or undesirable configuration. The following is a listing of valves and their tested direction (see Attachment 1 for valve descriptions):

1E12F0052A	Open and Close
1E12F0052B	Open and Close
1E22F0001	Close
1E22F0010	Open and Close
1E22F0011	Open and Close
1E22F0012	Open and Close
1E22F0015	Open
1E22F0023	Open and Close
1E51F0010	Open and Close
1E51F0019	Open and Close
1E51F0022	Open and Close
1E51F0031	Open and Close
1E51F0045	Open and Close
1E51F0046	Open and Close
1E51F0059	Open and Close
1E51F0063	Close
1E51F0076	Open and Close

The following exceptions to testing are explained below:

1. 1E22F0001 - This valve was tested in the close direction only. A limit switch on 1E22F0015 prevents 1E22F0001 from opening when F0015 is full open.

2. 1E22F0004 - The HPCS injection valve was not flow tested since it is good operating practice to minimize injections to the RPV and place as few thermal transients on the RPV nozzles as possible. During shutdown, it is not possible to properly control vessel level with the HPCS pump injecting.

3. 1E22F0015 - This valve cannot be tested closed under flow conditions since the only suction source is through the F0001 valve which cannot be opened until F0015 is closing. Testing F0015 in the closed direction risks starving HPCS pump suction and cavitation damage.

4. 1E51F0013 - The RCIC injection valve was not tested since it injects through the head spray nozzle and would result in moisture carry-over to the main and feed pump turbines.

5. 1E51F0063 - This valve was tested only in the closed direction. It was decided not to subject the associated piping to unnecessary transients. The identical outboard isolation valve, 1E51F0064, was evaluated on the basis of 1E51F0063 test results. A minor torque switch setting increase was initiated based on F063 test findings.

6. 1E51F0068 - Opening or closing the RCIC turbine exhaust isolation valve would subject the RCIC turbine to potentially damaging loads.

7. 1E51F0077 and 1E51F0078 - These valves would experience differential pressures only in the event of an accident which would pressurize containment. The static test provides sufficient test data to determine switch settings.

8. 1E51F0510 - The Turbine Trip Valve's safety function is to close on spring actuation. The operator is used to reset the spring only. The operator was tested by MOVATS to determine limit switch operation and proper thrust to reset the spring.

B. Test Methods

Temporary Test Instructions were prepared for the majority of flow testing to adequately control test configurations, operating sequences and data gathering. The valves were tested using MOVATS test equipment to relate actual operator thrust along with its switch actuations and current characteristics. Along with the MOVATS data, an acoustic monitor was used in some cases in an attempt to capture that point in time when the valve opens/closes completely. With the thrust trace and the acoustic trace taken in the same time domain, the actual thrust required to open/close the valve was obtained. With actual thrust required to open/close the valve at pressure measured, adequate excess margin in thrust was verified (Attachment 3).

The valves were tested as close as possible to the maximum design pressure, but these values are sometimes difficult to achieve. Since flow testing measures performance under actual process conditions, it is preferred over hydro-testing because it takes into account all variables encountered in the open/close stroke. Hydrostatic testing only determined "cracking" thrust capabilities of the valve operator going open.

In those cases where maximum design pressure cannot be achieved, an extrapolation calculation can be made to derive margin over the designed pressure values. This calculation first solves for the remaining thrust (T remain) required to overcome the maximum delta P using the standard calculation method described in Section II.

T remain = Orifice Area X [Max delta P - Test Pressure] X Valve Factor + Piston Effect

Where Packing Load (not pressure dependent) is included in the test thrust below and Piston Effect is adjusted down to reflect only the remaining pressure differential.

Once T remain is known, the total designed thrust required [T required] to operate the valve is given by:

$$T_{required} = T_{test} + T_{remain}$$

T required is compared with the total tested rust at the given torque switch setpoint [T setpoint] to obtain the thrust margin [T margin]:

$$T_{margin} = T_{setpoint} - T_{required}$$

C. Test Results

The Dynamic test results are in Attachment 3. Each valve is shown to perform its design function at the maximum design differential pressure. The dynamic testing of these 17 valves has provided a high confidence level that our setting methodology assures adequate margin based on its built-in conservatism.

Those valves that were not dynamically tested will similarly perform their design function. There was a sufficient sampling of valves to prove our methodology. The methods described in this report are utilized in the setting of switches for safety-related MOV's at Perry.

V. CONCLUSIONS

The 24 Bulletin valves at Perry are capable of performing their intended function. This is based on the combination of our test findings, the evaluation of the data and continuing implementation of our program.

A. Continued Maintenance

CEI has an ongoing preventive maintenance program which encompasses motor operated valves. The primary document detailing these activities is a Preventive Maintenance Instruction entitled "Maintenance of Limitorque Valve Operators." This document establishes the standards for periodic examination and maintenance of MOV's and includes such items as:

1. Stem condition and lubrication
2. Cracks in working components
3. Lubricant sampling evaluation for proper substance properties and level.
4. Electrical properties inspected including motor meggering.

Special considerations must be applied to major modifications performed on MOV's to control thrust delivered. Included in major modifications are adjustments to packing due to leakage. This condition is controlled by procedure and provides for Engineering input to make packing adjustments. Typically, adjustment to packing requires additional MOVATS testing to verify proper thrust in accordance with our present program.

B. Lessons Learned

There were substantial "lessons learned" including these most significant:

1. Steam valves exhibit a different characteristic trace as compared to water valves, which makes it difficult to determine the actual point of flow stoppage.

2. An accurate means for determining valve flow in high ambient noise areas is needed for the industry. Our use of acoustic monitoring had limited success.

3. Dynamic flow testing can be a valuable procedure in determining actual valve performance and thrust margins.

4. Thrust values at the point of torque switch trip may be more meaningful than the total thrust. Generally, it appears as pressure goes up the amount of operator "coast" becomes less, which decreases the total thrust that was experienced during static testing.

5. Scheduling of testing activities is crucial and the scope of effort must be well defined.

6. The undertaking of a program of this magnitude resulted in positive management involvement, to assign a high priority and critical resources for the performance of MOV testing. Recognition of the importance of the program was vital to its satisfactory completion.

ATTACHMENT 1
VALVE DATA SUMMARY

VALVE MASTER PARTS LIST NUMBER	VALVE MANUFACTURER	VALVE TYPE	VALVE SIZE IN.	VALVE RATING LBS.	MAXIMUM DESIGN ΔP-PSID	ACTUATOR SIZE	MOTOR RPM	OUTPUT SPEED RPM	VALVE FUNCTION	REMARKS
1. 1E12F0052A	BORG-WARNER	GLOBE	10	1500	1040	SMB-2	1700	16.7	RHR STEAM LINE ISOLATION	
2. 1E12F0052B	BORG-WARNER	GLOBE	10	1500	1040	SMB-2	1700	16.7	RHR STEAM LINE ISOLATION	
3. 1E22F0001	ANCHOR-DARLING	GATE	16	150	90*	SMB-00	1700	23.6	CONDENSATE STORAGE TANK TO HPCS PUMP SUCTION	* MAX. DESIGN PRESSURE DIFFERENT FROM PREVIOUS RESPONSE
4. 1E22F0004	ANCHOR-DARLING	GATE	12	655	1575	SB-3	3365	67.3	HPCS TO RPV OUTBOARD ISOLATION	
5. 1E22F0010	ANCHOR-DARLING	GLOBE	10	900	1575	SMB-4	1730	20	HPCS TO RECIRCULATE TO CONDENSATE STORAGE TANK	
6. 1E22F0011	ANCHOR-DARLING	GLOBE	10	900	1575	SMB-4	1730	20	HPCS TEST RETURN TO CONDENSATE STORAGE TANK	
7. 1E22F0012	ANCHOR-DARLING	GATE	4	900	1575	SB-0	3400	102.7	HPCS MIN. FLOW TO SUPPRESSION POOL	
8. 1E22F0015	ANCHOR-DARLING	GATE	24	150	90*	SB-1	3450	90.8	HPCS SUCTION FROM SUPPRESSION POOL	* MAX. DESIGN PRESSURE DIFFERENT FROM PREVIOUS RESPONSE
9. 1E22F0023	ANCHOR-DARLING	GLOBE	12	900	1575	SMB-4	1655	11.8	HPCS TEST TO SUPPRESSION POOL	
10. 1E51F0010	BORG-WARNER	GATE	6	300	75	SMB-00	1900	38.8	PUMP SUCTION FROM CONDENSATE STORAGE TANK	DC OPERATED
11. 1E51F0013	BORG-WARNER	GATE	6	1500	1400	SMB-1	1900	59.1	RCIC INJECTION SHUT-OFF VALVE	DC OPERATED
12. 1E51F0019	ROCKWELL	GLOBE	2	1500	1400	SMB-000	1900	52	RCIC MIN. FLOW TO SUPPRESSION POOL	DC OPERATED
13. 1E51F0022	BORG-WARNER	GLOBE	4	1500	1400	SMB-0	1900	29	TEST BYPASS TO CONDENSATE STORAGE TANK	DC OPERATED
14. 1E51F0031	BORG-WARNER	GATE	6	300	75	SMB-00	1900	38.8	RCIC SUPPRESSION POOL SUCTION ISOLATION	DC OPERATED

ATTACHMENT 1
VALVE DATA SUMMARY

VALVE MASTER PARTS LIST NUMBER	VALVE MANUFACTURER	VALVE TYPE	VALVE SIZE IN.	VALVE RATING LBS.	MAXIMUM DESIGN ΔP-PSID	ACTUATOR SIZE	MOTOR RPM	OUTPUT SPEED RPM	VALVE FUNCTION	REMARKS
15. 1E51F0045	BORG-WARNER	GLOBE	4	1500	1177	SMB-0	1900	29	STEAM SUPPLY TO RCIC TURBINE	DC OPERATED
16. 1E51F0046	ROCKWELL	GLOBE	2	1500	1400	SMB-000	1900	52	TURBINE LUBE OIL COOLING WATER SUPPLY	DC OPERATED
17. 1E51F0059	BORG-WARNER	GATE	4	1500	1400	SMB-00	1900	55.7	TEST BYPASS TO CONDENSATE STORAGE TANK	THIS VALVE WAS INADVERTENTLY OMITTED FROM PREVIOUS RESPONSES - DC OPERATED
18. 1E51F0063	BORG-WARNER	GATE	10	1500	1177	SB-1	3405	106	STEAM SUPPLY LINE ISOLATION TO RHR CONDENSING HEAT EXCHANGER (INBOARD)	SEE TEXT FOR HISTORY OF THIS VALVE.
19. 1E51F0064	BORG-WARNER	GATE	10	1500	1177	SB-1	3405	106	STEAM SUPPLY ISOLATION (OUTBOARD)	
20. 1E51F0068	BORG-WARNER	GATE	12	300	30	SMB-0	1900	32.7	TURBINE EXHAUST TO SUPPRESSION POOL	DC OPERATED
21. 1E51F0076	ROCKWELL	GLOBE	1	1500	1177	SMB-000	1700	12.5	BYPASS FOR F063	
22. 1E51F0077	ROCKWELL	GLOBE	1.5	1500	30	SMB-000	1700	25	VACCUM BREAKER ISOLATION	
23. 1E51F0078	ROCKWELL	GLOBE	2	1500	30	SMB-000	1700	12.5	VACCUM BREAKER ISOLATION	
24. 1E51F0510	GIMBEL MACHINE WORKS	GLOBE	4	900	0*	SMB-000	900	N/A	TURBINE TRIP AND THROTTLING	* MAX. DESIGN PRESSURE DIFFERENT FROM PREVIOUS RESPONSE

ATTACHMENT 2
VALVE PROBLEM SUMMARY REPORT
AS-FOUND CONDITION

N/A - NOT APPLICABLE
I - INDETERMINATE

VALVE MASTER PARTS LIST NUMBER	UNBALANCED TORQUE SWITCH	OPEN BYPASS SWITCH SET CORRECTLY	VALVE BACK-SEATED	OVER-THRUST VALVE	OVER-THRUST OPERATOR	UNDER-THRUST	AS-FOUND TS SETTING O, C, MAX	AS-LEFT TS SETTING O, C, MAX	VALVE FOUND OPERABLE	REQUIRED STROKE TIME SEC.	STROKE TIME SEC.	REMARKS
1. 1E12F0052A	YES	NO	NO	NO	NO	NO	2.5, 2.5, 3.5	2.5, 2.5, 2.5	YES	N/A	56.48	
2. 1E12F0052B	YES	NO	NO	NO	NO	NO	3.0, 2.5, 3.5	2.0, 2.0, 2.5	YES	N/A	56.14	MOVEMENT BETWEEN THE BONNET AND THE OPERATOR WAS OBSERVED AND REWORKED
3. 1E22F0001	YES	NO	NO	NO	NO	NO	1.25, 1.5, 5.0	1.0, 1.0, 1.0	YES	N/A	70.76	TORQUE SWITCH WAS UNBALANCED, DECLUTCH TRIPPERS WERE IMPROPERLY ADJUSTED.
4. 1E22F0004	YES	N/A	NO	YES	NO	NO	1.5, 1.5, 3.0	1.5, 1.5, 3	YES	27	10.52	OVERTHRUST WAS IN OPEN DIRECTION INTO THE LOAD CELL DUE TO UNBALANCED TORQUE SWITCH.
5. 1E22F0010	NO	NO	NO	YES	NO	NO	2.25, 2.25, 3.75	1.75, 1.75, 2.25	YES	N/A	43.1	
6. 1E22F0011	YES	NO	NO	YES	NO	NO	1.5, 1.5, 3.75	1.75, 1.75, 1.75	YES	N/A	49.3	OVERTHRUST WAS IN THE OPEN DIRECTION INTO THE LOAD CELL DUE TO UNBALANCED TORQUE SWITCH.
7. 1E22F0012	YES	NO	NO	YES	NO	NO	1.5, 1.5, 3.0	1.0, 1.0, 1.0	YES	5	4.38	
8. 1E22F0015	YES	NO	NO	YES	NO	NO	1.5, 1.5, 2.5	1.0, 1.0, 1.0	YES	24	21	
9. 1E22F0023	YES	NO	NO	NO	NO	YES	1.5, 1.5, 4.0	2.0, 2.0, 2.0	YES	180	55.1	
10. 1E51F0010	YES	N/A	NO	NO	NO	NO	1.75, 1.75, 2.75	1.0, 1.0, 2.0	YES	N/A	18.92	
11. 1E51F0013	YES	N/A	NO	NO	NO	NO	2.5, 2.5, 3.5	2.5, 2.5, 3.5	YES	15	9.6	
12. 1E51F0019	NO	N/A	NO	NO	YES	NO	1.5, 1.0, N/A	1.0, 1.0, 1.5	YES	5	3.51	DAMAGED DECLUTCH TRIPPER FINGER AND WORM GEAR
13. 1E51F0022	NO	NO	NO	NO	YES	NO	2.0, 2.0, 3.25	1.75, 1.75, 2.0	YES	N/A	11.42	TORQUE SWITCH SETTING DID NOT CORRESPOND TO DWGS.- SHOULDER LOCKNUT WAS OVERTHIGHTENED CAUSING EXCESSIVE PRELOAD ON SPRING PACK.
14. 1E51F0031	YES	NO	NO	NO	NO	NO	2.0, 2.0, 2.75	2.0, 2.0, 2.75	YES	30	18.62	
15. 1E51F0045	YES	N/A	NO	NO	NO	NO	2.25, 1.5, N/A	2.0, 2.0, 2.0	YES	N/A	11.78	CLOSE TORQUE SWITCH SETTING FOUND NOT PER DESIGN

ATTACHMENT 2
VALVE PROBLEM SUMMARY REPORT
AS-FOUND CONDITION

N/A - NOT APPLICABLE
I - INDETERMINATE

VALVE MASTER PARTS LIST NUMBER	UNBALANCED TORQUE SWITCH	OPEN BYPASS SWITCH SET CORRECTLY	VALVE BACK-SEATED	OVER-THRUST VALVE	OVER-THRUST OPERATOR	UNDER-THRUST	AS-FOUND TS SETTING O, C, MAX	AS-LEFT TS SETTING O, C, MAX	VALVE FOUND OPERABLE	REQUIRED STROKE TIME SEC.	STROKE TIME SEC.	REMARKS
16. 1E51F0046	I	N/A	NO	I	I	I	1.0, 1.0, 1.5	N/A, 1.0, 1.5	YES	N/A	3.07	TORQUE SWITCH REMOVED AND BALANCED PRIOR TO TESTING
17. 1E51F0059	YES	NO	NO	NO	NO	NO	1.25, 1.25, 1.25	1.5, 1.5, 1.5	YES	N/A	4.3	STEM NUT NOT ADEQUATELY TIGHT AND DECLUTCH TRIPPERS NOT PROPERLY ADJUSTED
18. 1E51F0063	YES	N/A	NO	NO	NO	NO	1.0, 1.0, 2.5	2.75, 2.75, 2.75	NO	20	8.38	AS-FOUND TS SETTING FOR DC OPERATOR-AS-LEFT TS FOR AC OPERATOR - SEE TEXT FOR COMPLETE EXPLANATION
19. 1E51F0064	YES	N/A	NO	NO	NO	NO	2.5, 2.5, 2.5	2.75, 2.75, 2.75	YES	20	8.48	
20. 1E51F0068	NO	N/A	NO	NO	I	NO	2.75, 2.75, 2.75	1.75, 1.75, 1.75	YES	60	46.30	CLOSING LIMIT INCORRECTLY SET
21. 1E51F0076	I	YES	I	I	I	I	2.0, 1.5, 2.0	1.0, 1.0, 1.5	NO	15	11.5	VALVE STEM WAS FOUND BROKEN DUE TO THE INCORRECT SPRING PACK. VALVE WAS REPLACED AND OPERATOR REWORKED.
22. 1E51F0077	YES	N/A	NO	NO	NO	NO	1.0, 1.0, 5.0	1.0, 1.0, 1.0	YES	22.5	4.98	
23. 1E51F0078	I	N/A	I	I	I	I	2.5, 2.0, 3.5	N/A, 1.0, 2.0	NO	N/A	10	VALVE OPEN PARTIALLY AND MECHANICALLY BINDED. DISASSEMBLY REVEALED DECLUTCH TRIPPER LEVER BROKEN, FINGERS BENT AND A BAD WORM SHAFT BEARING. REPLACED THESE COMPONENTS AND TORQUE SWITCH.
24. 1E51F0510	YES	N/A	NO	NO	NO	NO	1.75, 1.75, N/A	1.75, 1.75, 1.75	YES	N/A	10	THIS VALVE'S SAFETY FUNCTION IS TO CLOSE ON SPRING ACTUATEION. THE MOTOR OPERATOR IS USED TO LATCH THE SPRING ONLY.
TOTAL	17 UNBALANED TORQUE SWITCH	11 OPEN BYPASS SET INCORRECTLY	0 BACK-SEATED VALVES	5 OVER-THRUST VALVE	2 OVER-THRUST OPERATOR	1 UNDER-THRUST			3 VALVES INOPERABLE			

N/R - NOT REQUIRED
N/A - NOT AVAILABLE

ATTACHMENT 3
DYNAMIC TEST REPORT

VALVE MASTER PARTS LIST NUMBER	TARGET THRUST LBS.	FLOW STOPPED SATISFACTORY	VALVE OPEN UNDER TEST PRESSURE	STROKE TIME SATISFACTORY	TEST PRESSURE PSIG	THRUST REQUIRED TO STOP FLOW LBS.	THRUST REQUIRED TO OPEN VALVE	ESTIMATED CLOSING THRUST MARGIN OVER MAX DESIGN DELTA P AT SETTING (%)	REMARKS
1. 1E12F0052A	57,007	YES	YES	N/R	920	N/A	N/A	10	FLOW INSTRUMENT TRACES INDICATED THAT FLOW WAS STOPPED PRIOR TO TORQUE SWITCH TRIP BUT THE EXACT THRUST VALVE COULD NOT BE DETERMINED BECAUSE OF TIME DOMAIN DIFFERENCES.
2. 1E12F0052B	57,007	YES	YES	N/R	920	N/A	10,200	12.5	DYNAMIC TEST RESULTED IN A MINOR INCREASE IN TORQUE SWITCH SETTING BASED ON TEST RESULTS TO PROVIDE ADDITIONAL MARGIN.
3. 1E22F0001	7,929	YES	N/A	N/R	50	N/A	N/A	44	VALVE WAS TESTED GOING CLOSE ONLY. TEST DATA WAS INCORRECT DUE TO IMPROPER SET-UP.
4. 1E22F0010	131,452	YES	YES	N/R	1400	86,745	109,500	58	DYNAMIC TEST WAS PERFORMED NEAR MAXIMUM DESIGN PRESSURE WHICH RESULTS IN ACTUAL THRUST MARGINS.
5. 1E22F0011	131,452	YES	YES	N/R	1400	100,169	101,800	37	DYNAMIC TEST WAS PERFORMED NEAR MAXIMUM DESIGN PRESSURE WHICH RESULTS IN ACTUAL THRUST MARGINS. THE VALVE WAS FOUND WITH A CRACKED YOKE DURING THE TEST.
6. 1E22F0012	10,793	YES	YES	YES	1400	N/A	9,634	25	THIS IS A FOUR (4) SECOND OPERATED VALVE WHICH MAKES EXACT FLOW STOPPAGE DIFFICULT TO DETERMINE. THE VALVE WAS TESTED NEAR MAXIMUM DESIGN PRESSURE
7. 1E22F0015	13,585	N/A	YES	YES	50	N/A	9,703	42	THIS VALVE WAS TESTED IN THE OPEN DIRECTION ONLY. THIS OPERATOR DOES NOT CONTAIN AN OPEN TORQUE SWITCH AND CAN PROVIDE THE FULL CAPACITY OF THE OPERATOR. THE CLOSING MARGIN IS ESTIMATED FROM THE AS-FOUND CLOSE TMD READING.
8. 1E22F0023	177,301	YES	YES	YES	1400	84,573	152,931	92	DYNAMIC TEST WAS PERFORMED NEAR MAXIMUM DESIGN PRESSURE WHICH RESULTS IN ACTUAL THRUST MARGINS.
9. 1E51F0010	2,625	YES	YES	N/R	10	890	1,826	170	THIS VALVE HAS A MAX DELTA P OF 75 PSI AND ITS OPERATOR/VALVE IS VERY CONSERVATIVELY DESIGNED.

ATTACHMENT 3
DYNAMIC TEST REPORT

N/R - NOT REQUIRED
N/A - NOT AVAILABLE

VALVE MASTER PARTS LIST NUMBER	TARGET THRUST LBS.	FLOW STOPPED SATISFACTORY	VALVE OPEN UNDER TEST PRESSURE	STROKE TIME SATISFACTORY	TEST PRESSURE PSIG	THRUST REQUIRED TO STOP FLOW LBS.	THRUST REQUIRED TO OPEN VALVE	ESTIMATED CLOSING THRUST MARGIN OVER MAX DESIGN DELTA P AT SETTING (%)	REMARKS
10. 1E51F0019	6,210	YES	YES	YES	1,000	N/A	N/A	10	THIS IS A FOUR (4) SECOND OPERATED VALVE WHICH MAKES EXACT FLOW STOPPAGE DIFFICULT TO DETERMINE. THIS IS A SPRING OPERATED DIAPHRAM VALVE TO GO OPEN.
11. 1E51F0022	21,123	YES	YES	N/R	1,000	11,495	3,855	20	CLOSING THRUST WAS EXTRAPOLATED TO ESTIMATE MARGIN OVER MAX DESIGN DELTA P.
12. 1E51F0031	2,625	YES	YES	YES	10	1,127	3,763	330	THIS VALVE HAS THE SAME CHARACTERISTICS AS 1E51F0010 AND IS VERY CONSERVATIVELY DESIGNED.
13. 1E51F0045	19,129	YES	N/A	N/R	900	N/A	N/A	40	THIS IS A STEAM VALVE WHICH EXHIBITS DIFFERENT TEST CHARACTERISTICS WHICH MAKE ACTUAL FLOW STOPPAGE DIFFICULT TO DETERMINE. VALVE NOT TESTED GOING OPEN.
14. 1E51F0046	6,210	N/A	YES	N/R	29	N/A	N/A	14	VALVE WAS TESTED GOING OPEN ONLY. TEST DATA WAS INCORRECT DUE TO IMPROPER SET-UP.
15. 1E51F0059	9,350	YES	YES	N/R	1,010	7,564	4,554	10	DYNAMIC TEST RESULTED IN A MINOR INCREASE IN TORQUE SWITCH SETTING BASED ON TEST RESULTS TO PROVIDE ADDITIONAL MARGIN.
16. 1E51F0063	35,981	YES	N/A	YES	920	N/A	N/A	34	VALVE NOT OPEN UNDER FLOW. SEE TEXT FOR EXPLANATION. FLOW DATA WAS LOST DUE TO EXTREME TEMPERATURE DURING TEST AFFECTING TEST EQUIP.
17. 1E51F0064	35,981	N/A	N/A	YES	N/A	N/A	N/A	25	FLOW TEST WAS NOT PERFORMED BUT WAS EVALUATED AGAINST ITS IDENTICAL VALVE 1E51F0063. A MINOR TORQUE SWITCH SETTING INCREASE WAS INITIATED BASED ON ITS TEST FINDINGS.
18. 1E51F0076	2,672	YES	YES	YES	920	N/A	N/A	55	FLOW INSTRUMENT TRACES INDICATE THAT FLOW WAS STOPPED PRIOR TO TORQUE SWITCH TRIP BUT THE EXACT THRUST VALUE COULD NOT BE DETERMINED BECAUSE OF TIME DOMAIN DIFFERENCES. THIS IS A SPRING OPERATED DIAPHRAGM VALVE TO GO OPEN.