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AEP:NRC:0966Q

Donald C. Cook Nuclear Plant Units 1 and 2
Docket Nos. DPR-58 and DPR-74
License Nos. 50-315 and 50-316
RESPONSE TO UNRESOLVED ITEM FROM
INSPECTION REPORT 50-315/91009 (DRS)
and 50-316/91009 (DRS):
MOTOR-OPERATED VALVE TEST ACCURACY

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

Attn: A. B. Davis

August 30, 1991

Dear Mr. Davis:

Inspection Report 50-315/91-009 (DRS) and 50-316/91009 (DRS) discussed the results of an inspection of our Generic Letter 89-10 (Motor-Operated Valve) program. The inspection report contained one unresolved item (50-315/91009-01 and 50-316/91009-01), that concerned testing of the OATIS motor-operated valve data acquisition system by Idaho National Engineering Laboratory. The information requested is contained in the attachment to this letter.

This document has been prepared following Corporate procedures that incorporate a reasonable set of controls to ensure its accuracy and completeness prior to signature by the undersigned.

Sincerely,

E. E. Fitzpatrick
Vice President

EEF/eh

Attachment

cc: D. H. Williams, Jr.
A. A. Blind - Bridgman
J. R. Padgett
G. Charnoff
NFEM Section Chief
NRC Resident Inspector - Bridgman

ATTACHMENT TO AEP:NRC:0966Q

INFORMATION REGARDING

IDAHO NATIONAL ENGINEERING LABORATORY TESTING

OF OATIS MOTOR-OPERATED VALVE DIAGNOSTIC EQUIPMENT

BACKGROUND

At the January, 1990 meeting of the Motor Operated Valve Users Group (MUG) a plan was developed for validation of vendor accuracy claims for Motor Operated Valve (MOV) diagnostic test equipment. The NRC provided funding for the validation effort, and Idaho National Engineering Lab (INEL) was selected to conduct the testing. The MOV diagnostic equipment utilized at Cook Nuclear Plant is the third generation Operations Analysis & Test Interpretive System (OATIS) developed by ABB Impell. The NRC audit of our Generic Letter 89-10 program (March 18-28, 1991) recognized that the OATIS III equipment accuracy is a significant portion of the overall program, and considered the review and submittal of the INEL test results an unresolved item (50-315/91009-01; 50-316/91009-01). The OATIS III equipment was tested at INEL the week of April 22, 1991, and an interim report with limited data was issued at the MUG summer meeting the week of July 29, 1991. Several data points from the INEL testing were outside the OATIS published instrument accuracy, and on that basis a Problem Report was originated within AEPSC on August 8, 1991. On August 16, ABB Impell originated a Nonconformance Report which will initiate their internal corrective action and reportability reviews. The MUG anticipates having a final report ready for issuance at the winter meeting during the first quarter of 1992, that will contain full stroke data and graphical overlays to compare INEL and vendor data.

SUMMARY OF RESULTS

Attachment 1 is a summary of the vendor's stated measurement accuracy for the OATIS III equipment. Attachment 2 provides a brief description of the OATIS III equipment, and compares close stroke thrust at torque switch trip and final load between OATIS and the INEL Motor-Operated Valve Load Simulator (MOVLS). Attachment 3 contains unedited comments from ABB Impell and INEL regarding the overall validation effort and test methodology. Attachments 1, 2, and 3 are taken directly from the MOV User's Group "Progress Report of the Validation Committee" dated July, 1991.

DISCUSSION OF RESULTS

The results in Attachment 2 are a time-based comparison of discrete points in the closing stroke of the MOVLS between OATIS III and the INEL standard. These results show deviations in thrust measurement which are large in magnitude, and apparently independent of test parameter manipulation. In evaluating this data, several limitations of the INEL testing must be considered:

1) The INEL MOVLS was designed to simulate operational and dynamic conditions such as line pressure, differential pressure and rate of loading. No comparison to static diagnostic test results was made.

2) The SMB-0-25 actuator selected for testing is not typical of those installed at Cook Nuclear Plant. Only 10% of the actuators in the Generic Letter 89-10 program are SMB-0 type, and only 3% are SMB-0 with a 25 ft-lb motor. In contrast, 64% of the actuators in our program are SMB-00 type.

3) A relatively small amount of data was taken, and limited to a single actuator type, stem configuration, spring pack, and gearing. Three different transducer combinations were stroked nine times at three different loading conditions, for a total of twenty-seven strokes.

4) Commentary from different vendors in the MUG Report challenged whether the upper bearing assembly of the MOVLS was defective, that the compressive loads on the stem did not allow for relubrication as may occur during normal valve operation, and that the stem lubricant used has demonstrated poor performance characteristics in the EPRI sponsored lubrication study. These factors will tend to degrade the torque to thrust conversion and introduce variability in the stem factor and friction coefficient.

Despite these limitations which may restrict the widespread applicability of the data, the INEL testing does provide valuable information for comparing equipment accuracy and variables associated with actuator repeatability. ABB Impell has purchased the DaDisp 2.01 software utilized by INEL for data analysis, and this has already proven to be a powerful tool for evaluation. Review of the INEL data by AEPSC, Cook Nuclear Plant, and ABB Impell has resulted in the following observations:

1) There are timing differences between OATIS and the INEL standard. This is a significant factor in the variability shown in Attachment 2, as was acknowledged by a representative of INEL during the recent MUG meeting.

2) OATIS consistently predicted thrust higher than that from the INEL MOVLS.

3) Measurement of spring pack displacement at the end of running load, torque switch trip, and final load is within OATIS published accuracy for all data points.

4) The data indicates improved accuracy from strain gage based systems compared to LVDT based systems measuring spring pack displacement, such as OATIS.

To address the timing difference, the INEL data was evaluated using an event based comparison rather than time based. The event based evaluation consists of comparing thrust values at defined signature events (end of running load, torque switch trip, and final load) that are extracted from the full stroke traces, rather than comparing thrusts at a given point in time. The event based evaluation is consistent with how OATIS is applied for conducting diagnostic testing in the field, and removes the inaccuracy induced by inconsistent time computations between INEL and OATIS. This evaluation resulted in substantial improvement, with 81% (22 of 27) of the INEL data points at torque switch trip falling within OATIS published instrument accuracies.

It was also observed that OATIS consistently predicted higher thrust than that from the INEL standard, based on limited statistical evaluation. This was true even after the timing differences were normalized using the signature event comparison. The root cause of this phenomenon has been investigated, but no conclusions have been reached yet. In order to apply the INEL data to our thrust calculations, it has been decided to shift the OATIS accuracies upward by 4% of the given thrust range values. When this correction is applied, all 27 INEL data points fall within the revised OATIS accuracies at torque switch trip. ABB Impell is independently reviewing the INEL data, and may restate their published instrument accuracies as part of their Nonconformance Report evaluation.

MOV CAPABILITY ASSESSMENT

Cook Nuclear Plant has already completed a substantial amount of static diagnostic testing, and a limited amount of differential pressure testing of MOVs under the Generic Letter 89-10 program. This testing was based on thrust calculations which assigned target windows using the instrument accuracies published by ABB Impell for the OATIS III equipment. Additionally, NRC Inspection Report 50-315/91009(DRS);50-316/91009(DRS) caused us to reevaluate and revise our methodology for degraded voltage conditions and mispositioning. Therefore, it became necessary to assess the impact these changes had on the valves we have tested under the Generic Letter 89-10 program.

Using revised degraded voltage conditions, differential pressures, and diagnostic equipment accuracies, new target thrust windows were produced for

comparison to as-left values from diagnostic testing. In some cases, stem factor was also revised to reflect our review of the INEL test results and the refurbished condition of the actuators. This review showed that 93% (89 of 96) of the valves which have been tested under the Generic Letter 89-10 program have as-left torque switch trip settings which are greater than the minimum required for the new target thrust windows, and therefore are capable of performing their intended design function. Seven valves have as-left torque switch settings slightly below the new minimum target thrust. One of these seven valves was successfully tested at differential pressure during the 1990 Unit 2 outage, and passed with substantial margin. This result demonstrates the inherent conservatism of our thrust calculation methodology. By comparing the differential pressure results to the other six valves with low torque switch setpoints, we have determined that they will be capable of performing their design function and there is no need for immediate corrective action to reset the torque switches. Four of the six valves which have not been differential pressure tested are 4" diameter and less gate or globe valves with low design basis differential pressures (180 psid or less). The two remaining valves (2-FMO-201 and 2-FMO-203) are 14" diameter gates with design basis differential pressures of 1310 psid. These valves have torque switch settings which are only 1% below the new minimum target thrust. Based on the high inertial load which was measured during static diagnostic testing, it is judged these valves will close and perform their intended design function.

CONCLUSIONS

1) Review of the MOVs at Cook Nuclear Plant which have been tested under the Generic Letter 89-10 program has determined they are capable of performing their design function after consideration of revised degraded voltage conditions, differential pressures, and diagnostic equipment accuracies.

2) Future use of the OATIS III equipment at Cook Nuclear Plant will be based on instrument accuracies which account for the INEL test results. Pending completion of AAB Impell's review, we plan on applying the 4% of thrust range correction described herein.

3) We are evaluating the use of strain gage based diagnostic test equipment for the improved accuracy which was demonstrated during the INEL testing.

4) The torque switch settings for the six valves which are below the new minimum target thrust will be reset during the 1992 refueling outages.

5) AEPSC, Cook Nuclear Plant, and ABB Impell plan on continuing our review of the timing deviation and high thrust measurement bias in the OATIS III equipment, performing further review of the INEL data using the DaDisp software, and monitoring industry developments for further insights regarding diagnostic equipment accuracy and actuator repeatability.

ATTACHMENT 1

Summary of Vendor Claims for Measurement Accuracy

(Note: The values listed on this sheet have not been validated by the MUG)

Preparer: Eddy Sayed **Date of origination:** 2/19/91

Test Equipment Vendor / System: ABB Impell Corporation / OATIS III

Description of test method: Stem thrust is measured directly in the open direction into load cell. Spring pack deflection is measured in the closed direction and used to correlate thrust. Thrust values measured equate to seat thrust (values greater than running load). Clamp-on AC/DC current probes measure motor current. Alligator clips attach to limit and torque switches to monitor switch actuation.

Present Accuracy Specifications:

Parameter	Accuracy	Repeatability	Drift	Total	Field Variables (FV)
Thrust Sensr A	±	±	±	SEE ATTACHED	1,2,3,4
Thrust Sensr B	±	±	±	± %	
Torque	±	±	±	± %	
Stem Position	±	±	±	± %	
Motor Current	±	±	±	SEE ATTACHED	5,C
Motor Voltage	±	±	±	± %	
Motor Power	±	±	±	± %	
Time Base	±	±	±	± 0.0 µsec/min	B
Data Sample	-	-	-	1000 s/s/c	
Spring Pack Deflection	±	±	±	±0.01 inch	

Notes:

1: Accuracies are measured "end-to-end" (full loop accuracies).
2: "Total" accuracy specification includes the "units" (ie. %FS, %RDG, etc.).
3: Data sample rate units are "samples/sec/max channels"

Definitions:

Accuracy - A measure of the degree by which the actual output of a device approximates the output of an ideal device nominally performing the same function.
Repeatability - The closeness of agreement among repeated measurements of the output for the same value of input made under the same operating conditions over a period of time.
Drift - Gradual accuracy deviation in a given time period unrelated to input or environment.
Field Variables - Conditions which may affect equipment accuracy and are not accounted for in the accuracy statements above (ie. spring pack loading rate, non-standard stem threads, actuator mounting position, improper bolt torque, etc).

FV Notes:

1: Spring pack conditions: fatigue, gap, loading rate, grease, preload.
2: Stem / stem nut conditions: lubrication, non-standard threads, gap, packing load, stem speed.
3: Actuator conditions: mounting position, gear/bearing wear, lubrication, running load, bolt torque, torque thrust conversion.
4: General conditions: environment, line pressure during calibration, open calibration / close thrust correlation.
5: Motor conditions: voltage, frequency.

Other Notes:

A: Repeatability and drift variables fall within the stated total accuracy value.
B: Negligible error.
C: Current values represent the value selected on the signal conditioning unit. The range on the current probe remains set at 200 amp for any motor current value from 0-200 amp. Accuracy values are based upon manufactures claims for a range setting of 200 amps. Based on calibration results, the actual accuracy values are reduced to approximately the accuracy value at the 200 amp range throughout the entire range. (i.e. Simpson = 4.13% from 0-200 amp, Fluke = 2.24% from 0-200 amp)

Additional Data Sheet Space

Preparer: Eddy Sayed **Date of origination:** 2/19/91
Test Equipment Vendor / System: ABB Impell Corporation / OATIS III

Parameter	Accuracy	Repeatability	Drift	Total	Field Variables (FV)
Thrust Range					
4000 lbs	±	±	±	±16.8 % RNG	
8000 lbs	±	±	±	±9.4 % RNG	
14000 lbs	±	±	±	±10.1 % RNG	
24000 lbs	±	±	±	±8.2 % RNG	
45000 lbs	±	±	±	±6.4 % RNG	
70000 lbs	±	±	±	±8.1 % RNG	
140000 lbs	±	±	±	±6.4 % RNG	
200000 lbs	±	±	±	±6.2 % RNG	
Simpson Current range					
10	±	±	±	±80 % RNG	
20	±	±	±	±40 % RNG	
50	±	±	±	±16.4 % RNG	
100	±	±	±	±8.06 % RNG	
200	±	±	±	±4.13 % RNG	
Fluke Current range					
10	±	±	±	±40 % RNG	
20	±	±	±	±20 % RNG	
50	±	±	±	±8.06 % RNG	
100	±	±	±	±4.12 % RNG	
200	±	±	±	±2.24 % RNG	

FV Notes:

6: ____________________

7: ____________________

8: ____________________

9: ____________________

10: ____________________

Other Notes:

D: ____________________

E: ____________________

F: ____________________

ATTACHMENT 2

3.2 ABB IMPELL

3.2.1 EQUIPMENT DESCRIPTION

The OATIS MOV test system is designed around a portable Personal Computer (PC). Data is input by the user or collected by transducers and transferred to the PC through a signal conditioning unit known as the Back Pack. The PC is preconfigured with the OATIS MOV software package and a special Analog to Digital (A/D) acquisition card. The A/D card is located in a expansion chassis mounted at the rear of the PC. It gathers data with a twelve-bit resolution and stores the data in the PC's internal memory.

The OATIS MOV Back Pack consists of five separate signal conditioning cards, an output card, an output display device, and a triple output power supply. The signal conditioning cards are designed to isolate the incoming signal from its corresponding transducer and minimize the level of background noise generated by the surrounding environment. Each card contains a self test circuitry to verify operation.
The five cards are:

Card	Transducer	Parameter
LVDT	Linear displacement	Spring Pack Disp.
Strain Gauge	Compression Load Cell	Stem Thrust
Current	Current Probe	Motor Current
Limit Switch	Test Leads	Control Switch Trip
Torque Switch	Test Leads	Control Switch Trip

The Output card produces high level analog signals that are compatible with the A/D card in the PC and allows manual or automatic selection of stroke direction.

The Output Display indicates LVDT zero position adjustment, Load Cell calibration check, Current probe adjustment and power supply output.

Stem thrust is measured directly in the open direction into a load cell. Spring pack deflection is measured in the closed direction and used to correlate stem thrust. Thrust values measured equate to seat thrust (values greater than running load). Clamp-on AC/DC current probes measure motor current. Alligator clips attach to the limit and torque switches to monitor switch actuation

3.2.2 DIFFICULTIES/ABNORMALITIES

a. Testing for the first series of nine tests was performed with the Limit Switch Auto Control Switch being manually manipulated for the Open and Closed direction. The Limit Switch card sensitivity was adjusted and the next eighteen tests were conducted with the switch in auto.

b. Zero time reference for the OATIS testing was taken at the opening of limit switch contact number four. Due to the sensitivity problems encountered contact switch four was not able to be monitored during the first nine tests.

c. Current readings for the first nine tests were changed to zero for both the final open and close direction after the data was recorded.

d. After the first nine tests the INEL spring pack transducer was bumped from a zero setting. The data for the next eighteen tests must be zeroed to obtain the actual reading.

OATIS (IMPELL) TEST DATA

S/N #1

OPEN TO CLOSE STROKE

VENDOR STROKE NUMBER	INEL STROKE NUMBER	TORQUE SWITCH SETTING	DESIRED MEASUREMENT	VENDOR READ	INEL READ	INEL BAND MIN	INEL BAND MAX	DEVIATION FROM INEL	PERCENT DEVIATION	ACCUM LEVEL (INCH)	ACCUM PRESS (PSIG)	LOAD CLASS	SENSOR TYPE
A1	A1	1.25	T. S. TRIP	9890	13827	13682	13972	-3792	27.7	9.5	25	L	LVDT/
			FINAL	17570	16122	15977	16267	1303	8.0				LOAD CELL
A2	A2	1.25	T. S. TRIP	9820	11284	11139	11429	-1319	11.8	9.5	50	L	LVDT/
			FINAL	17750	15722	15577	15867	1883	11.9				LOAD CELL
A3	A3	1.25	T. S. TRIP	10130	15375	15230	15520	-5100	33.5	9.5	90	L	LVDT/
			FINAL	17570	15331	15186	15476	2094	13.5				LOAD CELL
A4	A4	1.75	T. S. TRIP	15150	16847	16702	16992	-1552	9.3	5	50	M	LVDT/
			FINAL	24130	20310	20165	20455	3675	18.0				LOAD CELL
A5	A5	1.75	T. S. TRIP	15760	13502	13357	13647	2113	15.5	5	100	M	LVDT/
			FINAL	24650	19744	19599	19889	4761	23.9				LOAD CELL
A6	A6	1.75	T. S. TRIP	15490	11914	11769	12059	3431	28.5	5	170	M	LVDT/
			FINAL	26390	11961	11816	12106	14284	118.0				LOAD CELL
A7	A7	2.25	T. S. TRIP	27510	20311	20166	20456	7054	34.5	0.75	50	H	LVDT/
			FINAL	39750	21154	21009	21299	18451	86.6				LOAD CELL
A8	A8	2.25	T. S. TRIP	28080	20317	20172	20462	7618	37.2	0.75	100	H	LVDT/
			FINAL	37350	21240	21095	21385	15965	74.7				LOAD CELL
A9	A9	2.25	T. S. TRIP	27950	22674	22529	22819	5131	22.5	0.625	190	H	LVDT/
			FINAL	28640	23087	22942	23232	5408	23.3				LOAD CELL

OATIS (IMPELL) TEST DATA

S/N #2

OPEN TO CLOSE STROKE

VENDOR STROKE NUMBER	INEL STROKE NUMBER	TORQUE SWITCH SETTING	DESIRED MEASUREMENT	VENDOR READ	INEL READ	INEL BAND MIN	INEL BAND MAX	DEVIATION FROM INEL	PERCENT DEVIATION	ACCUM LEVEL (INCH)	ACCUM PRESS (PSIG)	LOAD CLASS	SENSOR TYPE
B1	B1	2.25	T. S. TRIP	25652	21935	21790	22080	3572	16.2	0.625	50	H	LVDT/
			FINAL	30030	28352	28207	28497	1533	5.4				LOAD CELL
B2	B2	2.25	T. S. TRIP	25922	22776	22631	22921	3001	13.1	0.625	100	H	LVDT/
			FINAL	30940	29141	28996	29286	1654	5.6				LOAD CELL
B3	B3	2.25	T. S. TRIP	26093	24241	24096	24386	1707	7.0	0.625	190	H	LVDT/
			FINAL	26510	23958	23813	24103	2407	10.0				LOAD CELL
B4	B4	1.75	T. S. TRIP	15250	12299	12154	12444	2806	22.5	5	50	M	LVDT/
			FINAL	22940	19435	19290	19580	3360	17.2				LOAD CELL
B5	B5	1.75	T. S. TRIP	15959	11919	11774	12064	3895	32.3	5	100	M	LVDT/
			FINAL	23010	19228	19083	19373	3637	18.8				LOAD CELL
B6	B6	1.75	T. S. TRIP	15347	12375	12230	12520	2827	22.6	5	170	M	LVDT/
			FINAL	23180	19453	19308	19598	3582	18.3				LOAD CELL
B7	B7	1.25	T. S. TRIP	9815	6151	6006	6296	3519	55.9	9.5	25	L	LVDT/
			FINAL	17720	14426	14281	14571	3149	21.6				LOAD CELL
B8	B8	1.25	T. S. TRIP	9815	5790	5645	5935	3880	65.4	9.5	50	L	LVDT/
			FINAL	17720	13871	13726	14016	3704	26.4				LOAD CELL
B9	B9	1.25	T. S. TRIP	9987	6801	6656	6946	3041	43.8	9.5	100	L	LVDT/
			FINAL	17720	14238	14093	14383	3337	23.2				LOAD CELL

OATIS (IMPELL) TEST DATA

S/N #3

OPEN TO CLOSE STROKE

VENDOR STROKE NUMBER	INEL STROKE NUMBER	TORQUE SWITCH SETTING	DESIRED MEASUREMENT	VENDOR READ	INEL READ	INEL BAND MIN	INEL BAND MAX	DEVIATION FROM INEL	PERCENT DEVIATION	ACCUM LEVEL (INCH)	ACCUM PRESS (PSIG)	LOAD CLASS	SENSOR TYPE
C1	C1	1.25	T. S. TRIP	8934	5257	5112	5402	3532	65.4	9.5	25	L	LVDT/
			FINAL	14860	15229	15084	15374	−224	1.5				LOAD CELL
C2	C2	1.25	T. S. TRIP	9200	4625	4480	4770	4430	92.9	9.5	50	L	LVDT/
			FINAL	16110	14096	13951	14241	1869	13.1				LOAD CELL
C3	C3	1.25	T. S. TRIP	9200	7254	7109	7399	1801	24.3	9.5	100	L	LVDT/
			FINAL	16330	7278	7133	7423	8907	120.0				LOAD CELL
C4	C4	1.75	T. S. TRIP	14030	10302	10157	10447	3583	34.3	5	50	M	LVDT/
			FINAL	20590	18765	18620	18910	1680	8.9				LOAD CELL
C5	C5	1.75	T. S. TRIP	14030	10051	9906	10196	3834	37.6	5	100	M	LVDT/
			FINAL	20270	18690	18545	18835	1435	7.6				LOAD CELL
C6	C6	1.75	T. S. TRIP	13410	11797	11652	11942	1468	12.3	5	170	M	LVDT/
			FINAL	20680	19580	19435	19725	955	4.8				LOAD CELL
C7	C7	2	T. S. TRIP	17530	14582	14437	14727	2803	19.0	1	50	H	LVDT/
			FINAL	24110	22478	22333	22623	1487	6.6				LOAD CELL
C8	C8	2	T. S. TRIP	17920	14629	14484	14774	3146	21.3	1	100	H	LVDT/
			FINAL	24530	22861	22716	23006	1524	6.6				LOAD CELL
C9	C9	2	T. S. TRIP	18160	17693	17548	17838	322	1.8	1	170	H	LVDT/
			FINAL	18480	17216	17071	17361	1119	6.4				LOAD CELL

OATIS (IMPELL) TEST DATA AVERAGES

DEVIATION (PERCENT)

LVDT/ LOAD CELL

DATA USED	STROKES	DATA POINT	MIN	MAX	AVE % DEV
ALL STROKES	27 STROKES	T. S. TRIP	1.8	92.9	29.9
	27 STROKES	FINAL	1.5	120.0	25.9

S/N #1	9 STROKES	T. S. TRIP	9.3	37.2	24.5
	9 STROKES	FINAL	8.0	118.0	42.0
S/N #2	9 STROKES	T. S. TRIP	7.0	65.4	31.0
	9 STROKES	FINAL	5.4	26.4	16.3
S/N #3	9 STROKES	T. S. TRIP	1.8	92.9	34.3
	9 STROKES	FINAL	1.5	120.0	19.5

LOW LOADING	9 STROKES	T. S. TRIP	11.8	92.9	46.7
	9 STROKES	FINAL	1.5	120.0	26.6
MED LOADING	9 STROKES	T. S. TRIP	9.3	37.6	23.9
	9 STROKES	FINAL	4.8	118.0	26.2
HIGH LOADING	9 STROKES	T. S. TRIP	1.8	37.2	19.2
	9 STROKES	FINAL	5.4	86.6	25.0

ATTACHMENT 3

4.2 ABB IMPELL

ABB Impell Corporation has reviewed the MOV Users Group (MUG) Subcommittee on Test Equipment and Method Validation report "Progress Report on Equipment Validation". ABB Impell Corporation is currently performing a detailed evaluation of the data available from the testing of OATIS at INEL. In comparing the Preliminary Report with the detailed evaluation, two items have been identified which require consideration.

4.2.1 ITEM 1 - TIME DEVIATIONS

The statement on Signal Conditioning Delays provided in the Progress Report does identify the possibility that variations of time exist and may result in differences between vendor and INEL thrust values. It also specifies that the evaluation of the impact on vendor to INEL comparisons is beyond the scope of the preliminary report. During the detailed evaluation, it has been determined that a discrepancy in time does exist between INEL and OATIS. The impact of the time discrepancy is quite significant and was evaluated along with additional methods of comparison for applicability to test data.

Although there may be additional means of performing comparisons of the data as determined by the INEL standard and OATIS diagnostic equipment, the two most logical appear to be time referenced and event referenced.

<u>INEL Time Referenced Method</u>

The use of point to point comparison at an instant in time removes the inaccuracy associated with transducer output interpretation (signature analysis). If the comparative time computations between standard and test were negligible, then this method would provide highly accurate comparisons of thrust. Deviation in the time calculations, which may affect displayed time between the standard and test, will have proportional effects on the thrust comparisons. As a result any thrust comparisons made in a time reference based method will include error induced by deviations in time from the standard. While this time discrepancy may be of importance during any comparisons or evaluations of time, its impact on thrust determination may be negligible and only induced by the method of comparison.

<u>Signature Event Referenced Method</u>

The use of event comparisons removes the inaccuracy induced by inconsistent time computations. It does induce error associated with event evaluations. As technicians are responsible for the evaluation of transducer waveforms, and the waveforms can vary during similar event occurrence, an

inaccuracy associated with misinterpretation or inconsistent interpretation is induced. This inaccuracy is variable but can be minimized through consistent and defined interpretation techniques.

Method Comparison

While both of the comparison methods are valid and have merit, one must be chosen for continued use during evaluation of data. The time referenced method may incorporate error which is unrelated to thrust and cannot be controlled. The event method introduces error which may be variable and based on subjective evaluation. If the time references and presentations are compatible, then a time referenced method would yield the more accurate and consistent results. An evaluation of the time reference compatibility was performed to determine applicability of the INEL method.

Time Comparison Between INEL Standard and OATIS

The method of comparison utilized by the MOV Users group, Test Equipment and Method Validation Committee, Test Plan 91-1 is based on time. Comparisons are made and evaluated through system time comparisons of event (Torque Switch Trip, Final Load) activities. To review the accuracy of this thrust comparison, an evaluation of variance between INEL monitored Torque Switch Trip times and OATIS Torque Switch Trip times, as normalized to the INEL time reference, was performed.

Evaluation of the compared data leads to the following conclusions:

- The times deviated by a mean value of 0.049 seconds with a standard deviation of .058 seconds.
- In 85.2% of the test cases the OATIS normalized torque switch trip times were larger than the INEL torque switch trip times.

While the time evaluation performed indicates that there is some deviation between OATIS and the INEL standard; it was inconclusive whether this is the result of overall discrepancies or deviations of the OATIS torque switch or limit switch indication values. If the discrepancy is due to misrepresentation of switch trip time or a time shift between transducer representations, then the resulting error would greatly impact the accuracy of thrust reported at switch trip. However, if the discrepancy is an overall variance between OATIS and the standard, and all OATIS transducer responses are represented on a consistent time scale, then the impact will

be isolated to time referenced comparisons. All representations by OATIS will not be affected and only the representation of time may be in question.

To determine the cause of this apparent time discrepancy it was necessary to evaluate additional data which can provide isolation of time deviations. If the representation of switch indication were invalid, then it should be expected that comparisons of relative spring pack displacement at torque switch trip would be discrepant. It was determined that the variations measured between INEL spring pack displacement at INEL torque switch trip and OATIS spring pack displacement at OATIS torque switch trip are all within reputed equipment accuracies. The lack of variation in measured displacement may not be representative of switch indication accuracy, however, either;

- the INEL standard and OATIS are equal in time variance,
- the OATIS measurement of spring pack displacement is out of tolerance and the time variance makes it appear acceptable, or
- the variation lies in the computational deviations of time. To further investigate the cause of time variance, a comparison of overall stroke times was performed.

The result of stroke time comparisons indicate that stroke time deviation averaged .072 seconds and the time discrepancies are not limited to switch trip indication but are present throughout data display.

Conclusions On Method Analysis

From this evaluation, the time discrepancy bounds the entire signature region. As this is the case the more appropriate method of thrust comparison would be signature event analysis. While the use of an event base method will correctly ignore overall time discrepancies, and reflect any misrepresentations in switch trip indication, it will induce error associated with data interpretation. The impact of this error can be minimized through consistent analysis techniques and definitions.

4.2.2 ITEM 2 - GENERIC APPLICABILITY

While the results of this test should be considered as valuable and informative, they should not be considered as the basis for the establishment of revised tolerances. The MUG validation has been designed for determining the

conformance/nonconformance of results to a specific test and not to establish equipment tolerances for all ranges and applications. A small population sample (one set of MOVLS specifications) and a limited number of cycles at any specific test condition impose finite limitations on evaluation of this data.

In addition to the Items noted, ABB Impell and OATIS users are continuing with detailed data evaluation to determine the most applicable analysis and applications of the INEL testing. The results of this analysis will be reconciled with MOV programs of OATIS users upon completion of data evaluation. ABB Impell does note that the limited data sample provides analysis restrictions in the areas of rate of loading and stem factor repeatability. Review of the wealth of data as collected by INEL throughout equipment validation, may prove insightful and provide the industry with a better understanding of these phenomena. The review of this data could be initiated by release of all the INEL MOVLS obtained data to public domain.

INEL COMMENTS

The INEL's role in the MUG validation was one of service. We did not make policy or enforce it. All vendors chose to test at our facility and they accepted the risks knowingly. Policy and outcome remarks should be reserved for MUG.

Many comments concern event timing and measured values. Timing is critical when evaluating measurements at some event during the stroke such as torque switch trip. Measurement channels with signal processing time delays or transducer response time variations may overestimate the torque and/or force available. With timing delays, measured values of force and torque include momentum effects that may not respond the same at higher loadings. The real question is how accurately a vendor can determine event timing with respect to his system's time response. Small errors in the timing scale itself are trivial, as long as the sequential spacing and the relationship of the event to time is maintained.

Several vendors questioned the INEL stem torque measurements. The INEL typically looks at the torque balance across the operator. The spring pack force multiplied by the effective moment arm length gives the input torque. The difference between this and the measured stem torque is equal to the losses in the operator and the losses not accounted for in the calibrations (e.g. MOVLS lower thrust bearing). Figure 1 shows the INEL torque spring pack force measurement for a typical MOVLS closure stroke. Figure 2 shows the INEL stem torque measurement for the same stroke. By dividing the stem torque measurement by the spring pack force measurement we can determine the apparent moment arm length. Figure 3 compares this apparent moment arm length with the theoretical length obtained from Limitorque. The two curves lie on top of one another indicating no significant losses between input and output torque. Figure 4 shows the difference between input torque (measured spring pack force times moment arm length) and output torque (INEL stem torque measurement). This data shows that essentially there is no error due to losses in the operator or lower thrust bearing. This relationship remains constant from the lowest to the highest MOVLS loadings, convincing us that the MOVLS stem torque measurement methodology is sound.

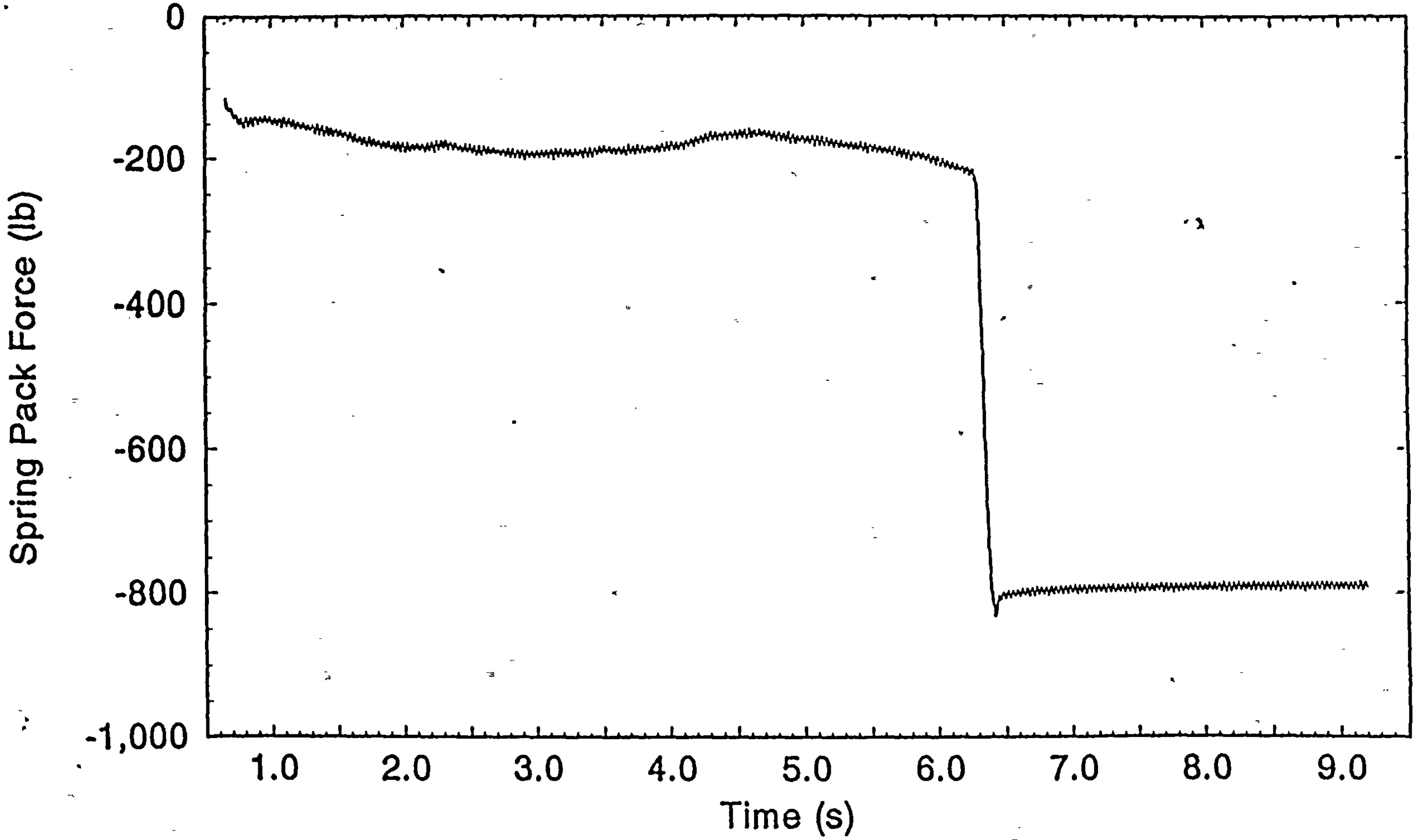

Figure 1. *Torque spring pack force*

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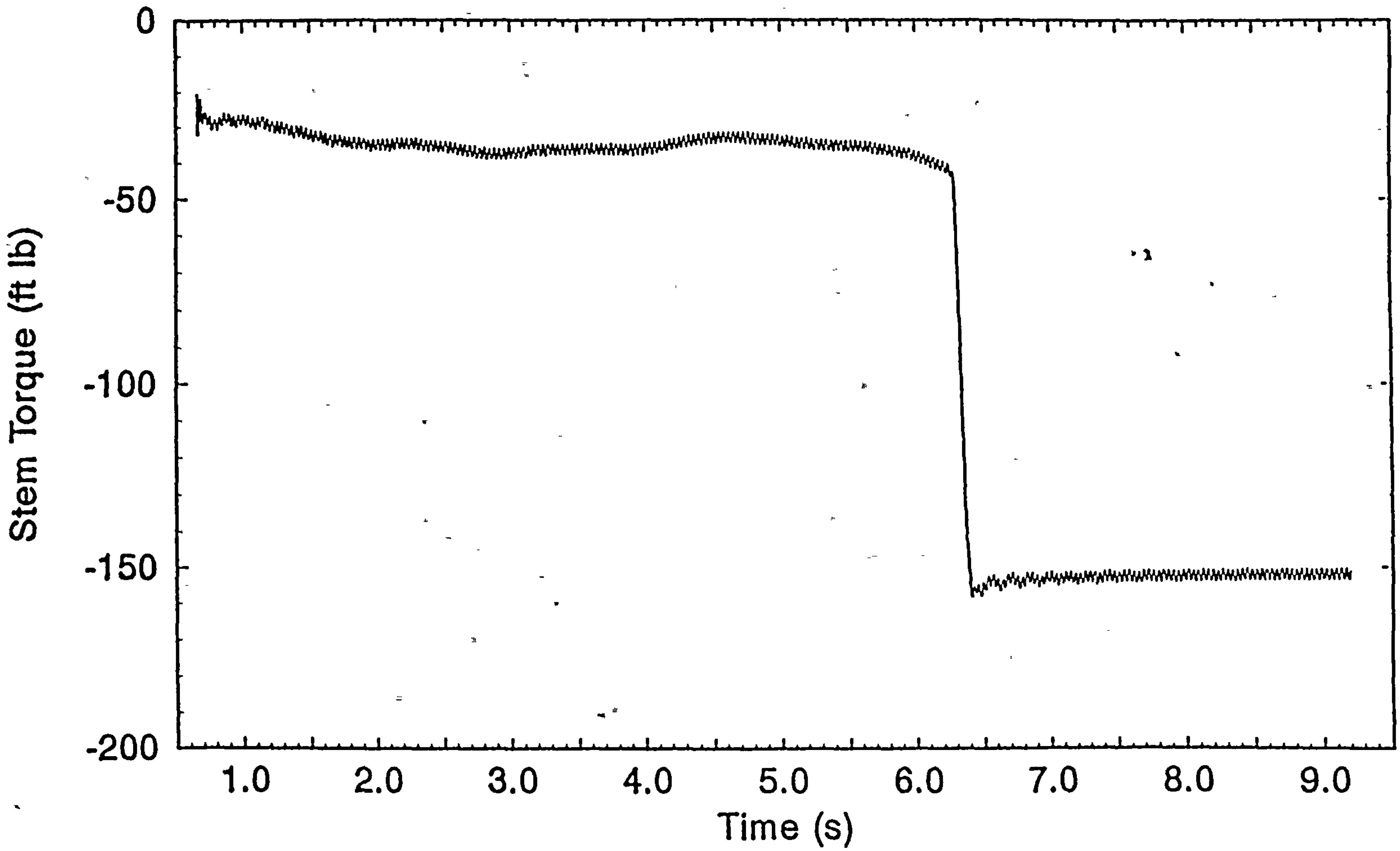

Figure 2. Stem torque

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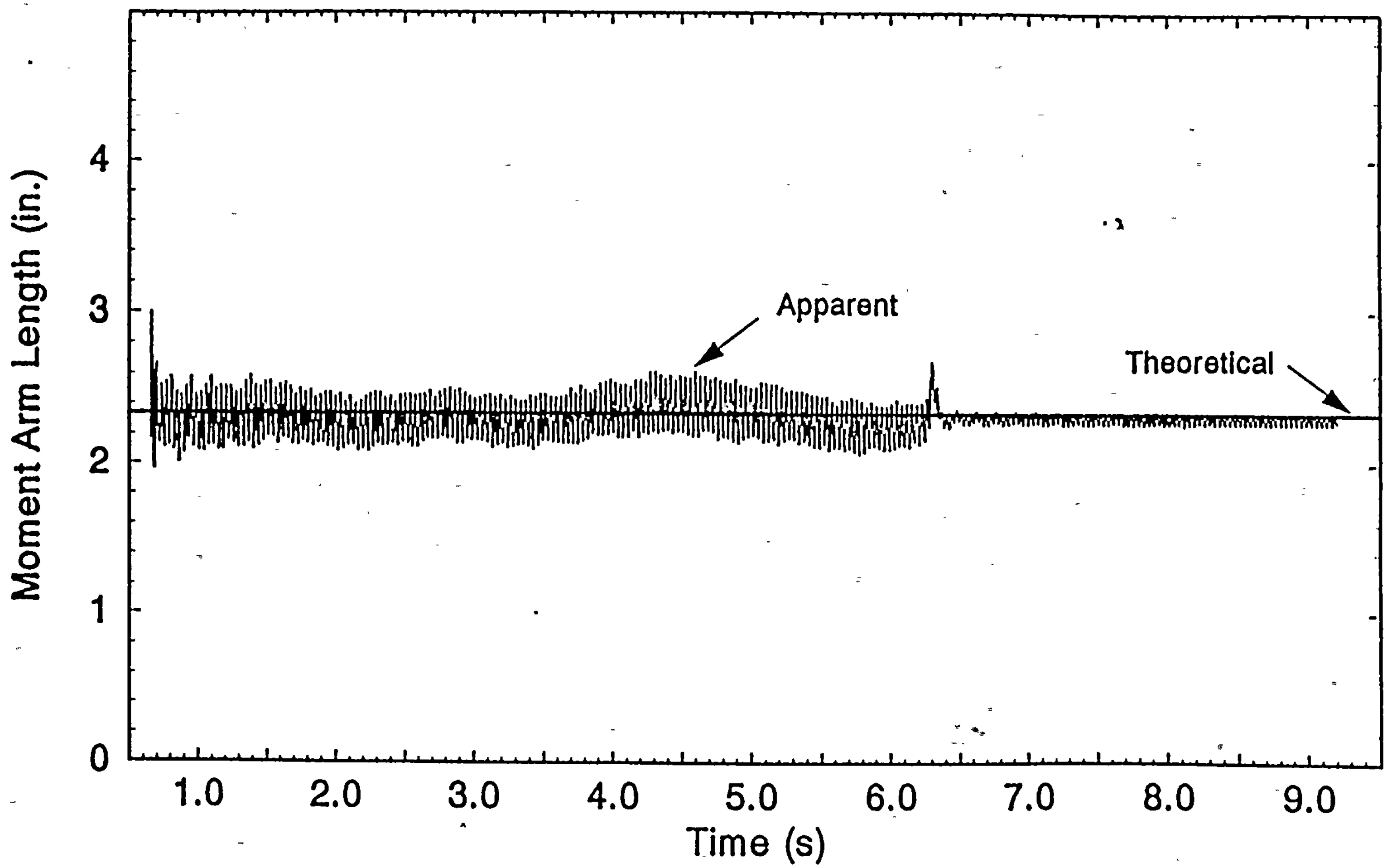

Figure 3. Apparent vs theoretical moment arm length

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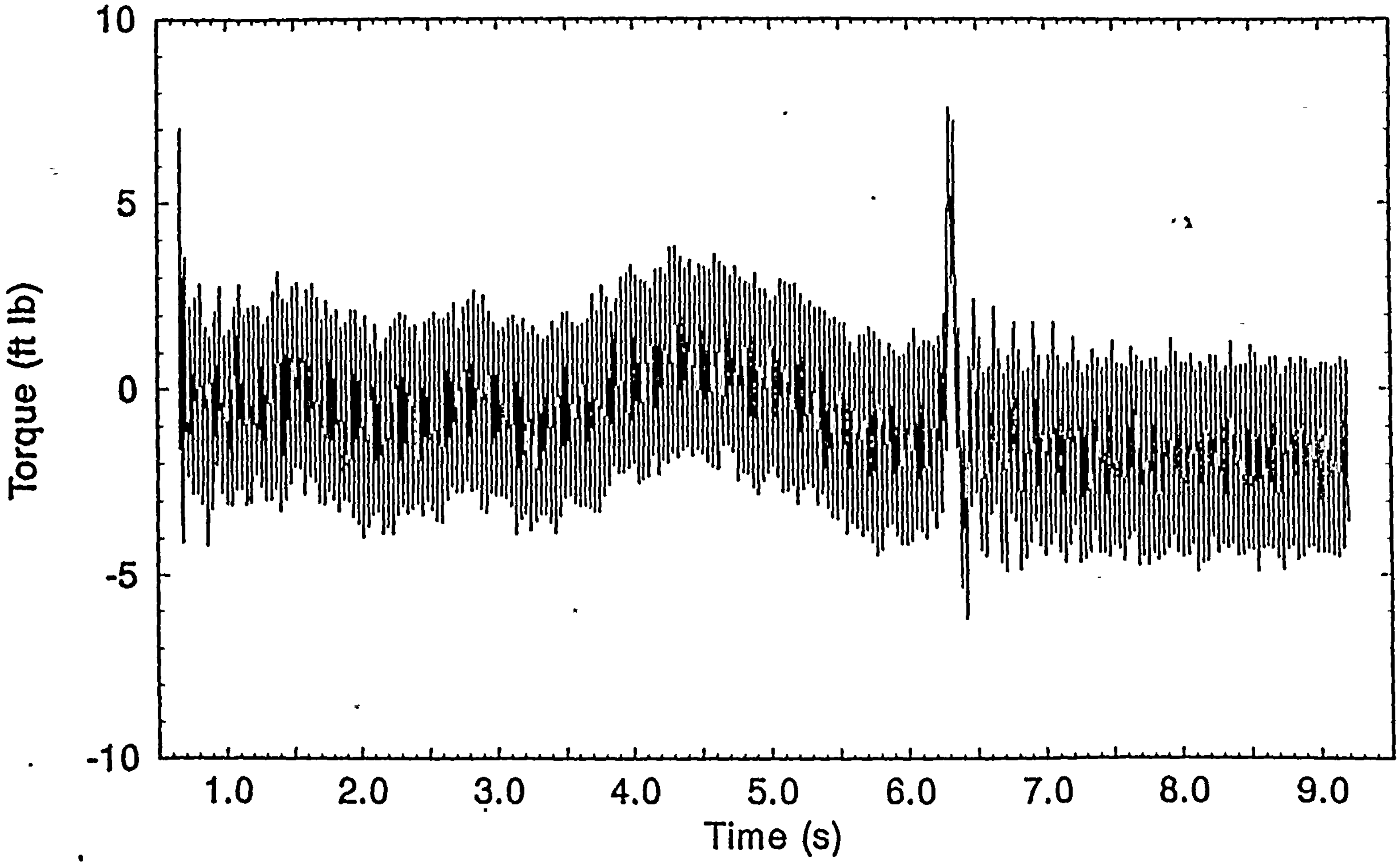

Figure 4. Input vs output torque error

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