Rooms

NTO-R-0166

Spear Report

XE-Prime

EP-1A

DRUM & SHIELD WORTH, THERMAL CALIBRATION, AND DOSIMETRY IRRADIATION

FEBRUARY 1969

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SPEAR Memo No. 1
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XE-PRIME

EP-IA

Subject: SUMMARY OF SPEAR ANALYSES

Experimental plan IA of the XE-Prime Test Series was successfully performed at ETS-1 on 20 February 1969. The objectives of this EP were:

a. Perform Thermal Calibration at 1 MW.

b. Perform Nuclear Autostart to 100 KW.

c. Measure S-1 Shield Worth.

d. Measure Integral Worth of Drums 1 and 7.

e. Irradiate Intermediate Power Dosimetry.

These objectives were all successfully met and no problems were discovered that would prevent running EP-IB or EP-II.

Criticality at an average drum bank position of 98.9° (normalized to 530°R ambient temperature) was attained at 1:00 P.M. PST This value includes a 1.01 correction factor to account for a known error in the indicated drum position. From an operational standpoint, the indicated drum position is satisfactory, however, drum system and reactor performance evaluations require a better indication of drum position. Voltage measurements across the drum positions feedback pot are planned for EP-IB (refer to Memo 9) to enable better determination of the drum position.

The drum bank worth (15° to 165°) of XE-Prime was estimated to be $7.83 from the integral drum roll out data. The span was predicted at $7.9 ± $0.2. Drum roll in data confirms this value. There was no significant difference in the worth of drum No. 1 when the side shield S-1 was in-place or removed.

From the two stable scrams the shutdown was estimated at $4.75 ± $0.10 from the 530° ambient critical drum bank angle. This is in good agreement with the value of $4.73 measured in EP-I.

The primary neutronics system in general performed satisfactorily during EP-IA. Some minor adjustments need to be made prior to the next test. The thermal calibration data was used to determine the absolute power level vs. indicated powers data. The integral actual power for EP-IA was 243.5 KW hr (876.5 MW sec) using the test stand average log indication and based on a thermal calibration power of 900 KW. The secondary neutronics system did not perform satisfactorily during EP-IA.

The measured S-1 shield worth was 2.67¢ compared to 3.5¢ predicted. The improvement in shield worth measurements during this EP compared to EP-I is attributed to holding the reactor critical throughout the test.

Particularly gratifying was the excellent performance of the narrow band data system. The majority of the problems are normal maintenance type and are less than might be expected from a facility the size of ETS-1. An Instrumentation system summary and list of anomalies is contained in Memo 3.

The wide band FM data system had 61% of its channels active for this EP. Except for some missing calibrations and a few spikes during the calibration cycle, the data was much improved from EP-1. A high frequency noise problem still exists with the channels going through Rack 14. Minor modifications are under way which will decrease the adverse effect of these noise signals.

Temperatures measured during thermal calibration operations showed good agreement with predictions and indicated a power of about 0.9 MW. Memo 7 (see CRD supplement) presents a detailed discussion of the thermal calibration test.

Three sets of transfer function data were successfully evaluated during EP-IA. The drums were perturbed in position control with sine inputs at subcritical (47.2^{o}) and critical (100 KW) conditions. The power was perturbed in power control at 100 KW with a -10 KW step, sine, and psuedo-random inputs. The Synchronous Heterodyne Interval Timer was used for the first time during EP-IA to input transfer function signals. This resulted in known correct input signals, and contributed to the excellent quality transfer function data obtained.

The scram profiles show excellent repeatability on a scram-to-scram basis with rate limiting occurring within approximately 10 degrees. There was little variation between high and log individual drum slew velocities, but the average velocity of 625^{o} per second is 25^{o} per second slower than the minimum value indicated in the functional requirement (750 $\pm$ 100) for closed loop scram. An explanation may be that EP-IA was conducted without actuator coolant.

The power controller was checked during the EP-IA test for evidence of limit cycling noted in EP-I. The power loop limit cycle again occurred and was examined during a 2 second period ramp from 1 KW to 1 MW. The maximum amplitude of the limit cycle was $\pm$ 19%. Performance was essentially as predicted and no anomalies were noted.

The drum position, Engine Log, and Test Stand Log averagers performed adequately during this EP.

The temperature averagers were evaluated. Since they operated over a range less than 10% of the full scale output, this evaluation was inconclusive. Observations were noted in both data processing and hardware performance for T.621, 622, 623 that could not be explained in the time available. (Averager output was not in agreement with input values). An investigation is under way to determine if there is a problem with these three temperature averagers.

The nuclear autostart performed as expected with no anomalies. Power loop closure occurred at the set point and the transition to power control was extremely smooth.

Following are the SPEAR recommendations from XE-Prime EP-IA.

1. Explain the measurement anomalies listed in Table II of Memo 3. OK

2. Adjust the linear gains and log offset voltages by the necessary factor so they would have indicated the power level held listed in Table 2 of Memo 2.

3. Verify that the ETC Gamma (N.844) power supply is turned on prior to EP-IB. OK

4. Replace the power supply of the low range fast fission detector (N.845) and determine the problem with the high range fast fission detector (N.846).

5. Adjust the buffer of linear no. 2 to permit full scale readings. OK

6. Resolve the indicated difference in drum position between the DVM values displayed in the control room and data system values. OK

7. SC647 (Period Scram) and SC620 (Emergency/Scram) Binary signals should be recorded on an oscillograph if possible.

8. Revise the temperature averager setup procedure to record the input/output signals at the averager chassis and on the DDS at the same time and require agreement of data before setup is considered complete.

9. Include the time and channel number of Log Power Channels which are automatically or manually rejected and/or reset on the LRE record sheet. OK

10. Investigate why a drum override occurred in power control mode, while resetting an individual drum from manual to power control and correct the problem with binary event channel BC662..E.

11. Install a pressure transducer, which will indicate the common pressure in the tube trailers connected to the 3200 GN_2 system.

SPEAR Memo No. 2
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cjd DCR / B / BSM

XE-PRIME

EP-IA

Subject: NEUTRONICS SYSTEM PERFORMANCE

INTRODUCTION

The ETS-1 neutronics systems were exercised with the reactor critical during EP-IA conducted on 20 February 1969. For the purpose of this memo, the neutronics system includes the following subsystems:

Permanent

Primary - Control and Diagnostic

1. BF_3 Startup Channels.
2. Linear Power Channels.
3. Engine Mounted Log Power and Period Channels.
4. Test Stand Log Power and Period Channels.

Secondary

1. ETC Gamma Detectors.
2. Fast Fission Detectors.

SUMMARY

The primary neutronics system in general performed satisfactorily during EP-IA. Some minor adjustments need to be made prior to the next test. The thermal calibration data was used to determine the absolute power level vs. indicated powers data. The integral actual power for EP-IA was 243.5 KW hr (876.5 MW sec) using the test stand average log indication and based on a thermal calibration power of 900 KW. The secondary neutronics system did not perform satisfactorily during EP-IA.

TECHNICAL DISCUSSION

A. System Performance

Primary Systems

1. BF_3 LCR Startup Channels

Startup channels No. 1 and No. 2 performed well throughout EP-IA and were used to obtain inverse multiplication data during the approach to criticality. Startup channel No. 3 power supply was not turned on because it was felt that the detector was wet and that the detector might be damaged. It has been dried out since EP-IA and is now operational.

2. Linear Power Channels

The performance of the three linear power channels was generally satisfactory during EP-IA. Linear No. 2 buffer gain was set incorrectly which prevented an indication of greater than 1.336 for each decade.

3. Engine Log Power Channels

The performance of the three engine log power channels was generally satisfactory during EP-IA, other than a difference in the LRE console meter and data. A minor adjustment is required to make the power levels of three channels agree. The channels are supposed to be adjusted prior to EP-IB so that they all would read 900 KW during the thermal calibration of EP-IA. Figure 1 shows the engine log channel during the initial portion of the thermal calibration.

4. Test Stand Log Power Channels

The performance of the three test stand log channels was generally satisfactory during EP-IA except for a difference between the LRE console meter and data. There was also a difference between the three channels at steady state power levels. It is planned to adjust these channels in the same way as the engine logs. Figure 1 shows the test stand log channels during the initial portion of the thermal calibration.

5. Engine and Test Stand Period Channels

The engine and test stand period channels performed satisfactorily during EP-IA. Figure 2 is a plot of the engine and test stand period channels during the power increase to 900 KW. It is seen that both channels are in good agreement.

Secondary Systems

1. ETC Gamma

The power channel did not perform properly during EP-IA due to signal conditioning problems. The range channel, however, worked correctly which indicates that the problem is not with the detector but in the signal conditioning to data.

2. Fast Fission Channels

N.845 did not perform during EP-IA due to an inoperable power supply. It is suggested that the power supply be replaced prior to EP-IB, if one is available, if not the power supply of N.846, which is the high range channel, should be used. N.846 did not operate during EP-IA but the problem associated with this detector is not known at this time.

Miscellaneous Systems

1. Averagers

Both log averagers appeared to work properly during EP-IA with no problems associated with rejection of the input channels. Rejection of engine log 1 and test stand 2 did occur following scram due to the differences in the dark currents of the detector being greater than .25 volts which is the rejection criteria.

2. Power Loop Closure

The power loop closure pot was set at zero and 10 divisions during EP-IA. The power loop closures occur at about 250 watts and 300 watts, respectively, which is correct for these settings.

3. Period Scram Check

The period scram was checked out during EP-IA with a period of 1 second selected and a power increase of 25% selected. The period scram did occur within the expected limits of the period scram detector. A detailed discussion of the period scram is made in SPEAR Memo No. 12.

B. Reactor Power Indications

The average power indication during the thermal calibration are shown in Table 1. It is seen that the linear and log channels indicated higher power levels than that determined by the thermal calibration power of approximately 900 KW.

The indicated power levels of each of the linear and log channels for various power level holds is shown in Table 2. Based upon the thermal calibration power level of 900 KW, it is recommended that the linear gains and log channel offsets voltages be adjusted by the necessary factor so they would indicate 900 KW.

Figures 3, 4, and 5 show, respectively, the linear power levels, the test stand log power levels, and the engine power levels during the .5 degree swing transfer function test.

C. Miscellaneous Calibrations

The following figure is presented for reference purposes:

Figure 6: Final Drum Position vs. Exponential Pot Setting for a Nuclear Autostart

RECOMMENDATIONS

1. Readjust the linear gains and log offset voltages as discussed in the section on reactor power indications.

2. Establish agreement between the LRE console meters and the Digital data system.

3. Verify that the ETC Gamma (N.844) power supply is turned on prior to EP-IB.

4. Replace the power supply of the low range fast fission detector (N.845) and determine the problem with the high range fast fission detector (N.846).

5. Adjust the buffer of linear no. 2 to permit full scale readings.

ANOMALIES

Data - None.

Instrumentation

Primary Neutronics

1. Startup channel No. 3 did not function.

Secondary Neutronics

1. ETC Gamma channel did not operate.

2. ETC fast fission chambers did not operate.

TABLE 1

AVERAGE POWER INDICATIONS

DURING THERMAL CALIBRATION

CHANNEL	INDICATED POWER	THERMAL CALIBRATION POWER
Linear Average (PWALIN)	950 KW	900 KW
Test Stand Avg Log (PWDTSL)	922 KW	900 KW
Engine Avg Log (PWAEL)	1203 KW	900 KW

TABLE 2

POWER INDICATIONS FOR VARIOUS POWER LEVELS

Approx. Power Level Held	100 W	300 W	1.0 KW	1.8 KW	77 KW	900 KW
Linear # 1	109 W	375 W	1.1 KW	2.02 KW	74.74KW	1007 KW
Linear # 2	101 W	327 W	0.98KW	-	67.22KW	909 KW
Linear # 3	100 W	343 W	1.02KW	1.87 KW	69.55KW	941 KW
TS Log # 1	88 W	297 W	.87KW	1.60 KW	58.24KW	792 KW
TS Log # 2	97 W	338 W	.98KW	1.80 KW	67.29KW	914 KW
TS Log # 3	113 W	398 W	1.16KW	2.16 KW	77.02KW	1042 KW
Eng Log # 1	112 W	364 W	1.07KW	2.32 KW	84.23KW	1120 KW
Eng Log # 2	137 W	466 W	1.36KW	2.87 KW	105.77KW	1418 KW
Eng Log # 3	94 W	312 W	.92KW	2.36 KW	82.88KW	1048 KW

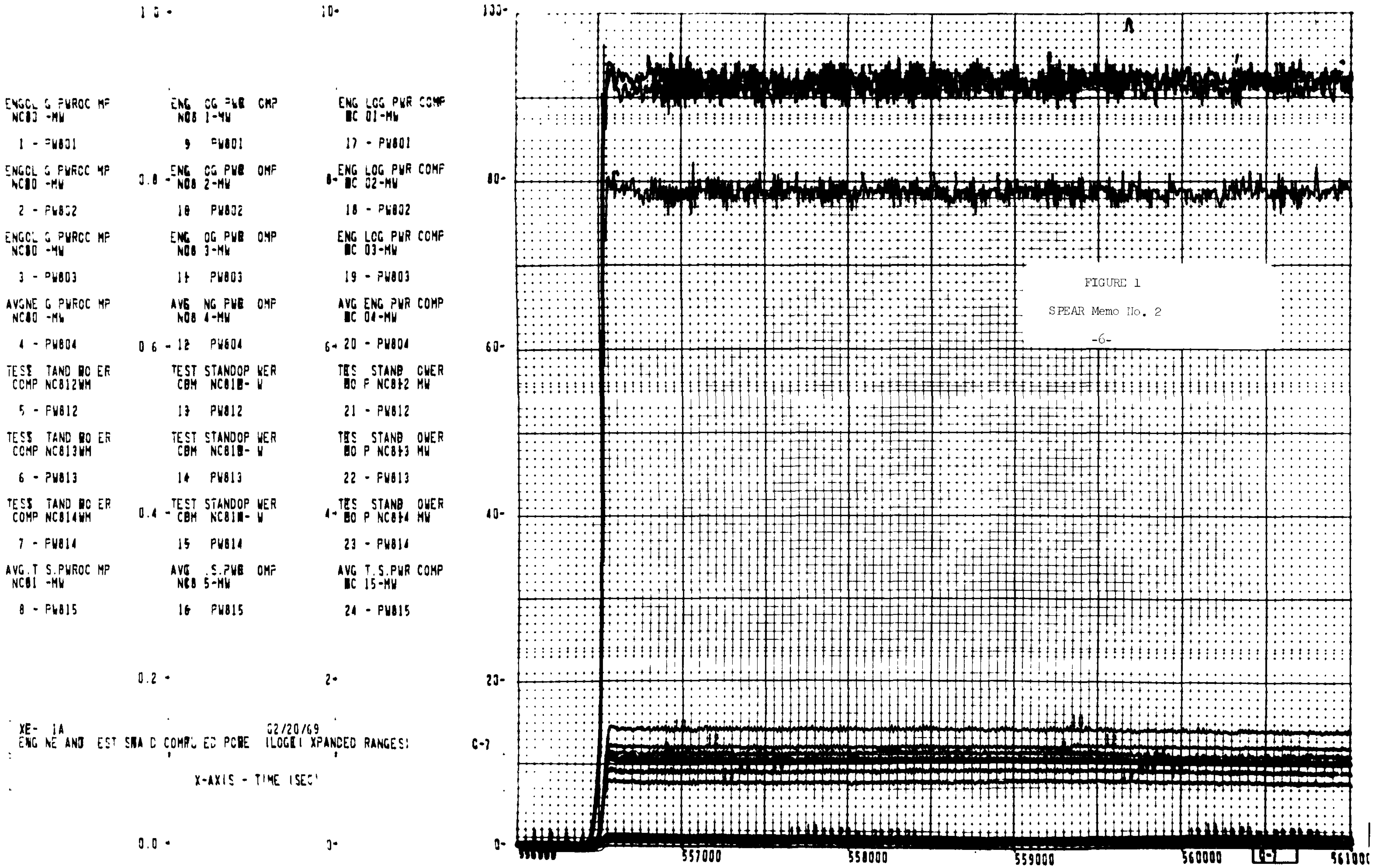

FIGURE 1

SPEAR Memo No. 2

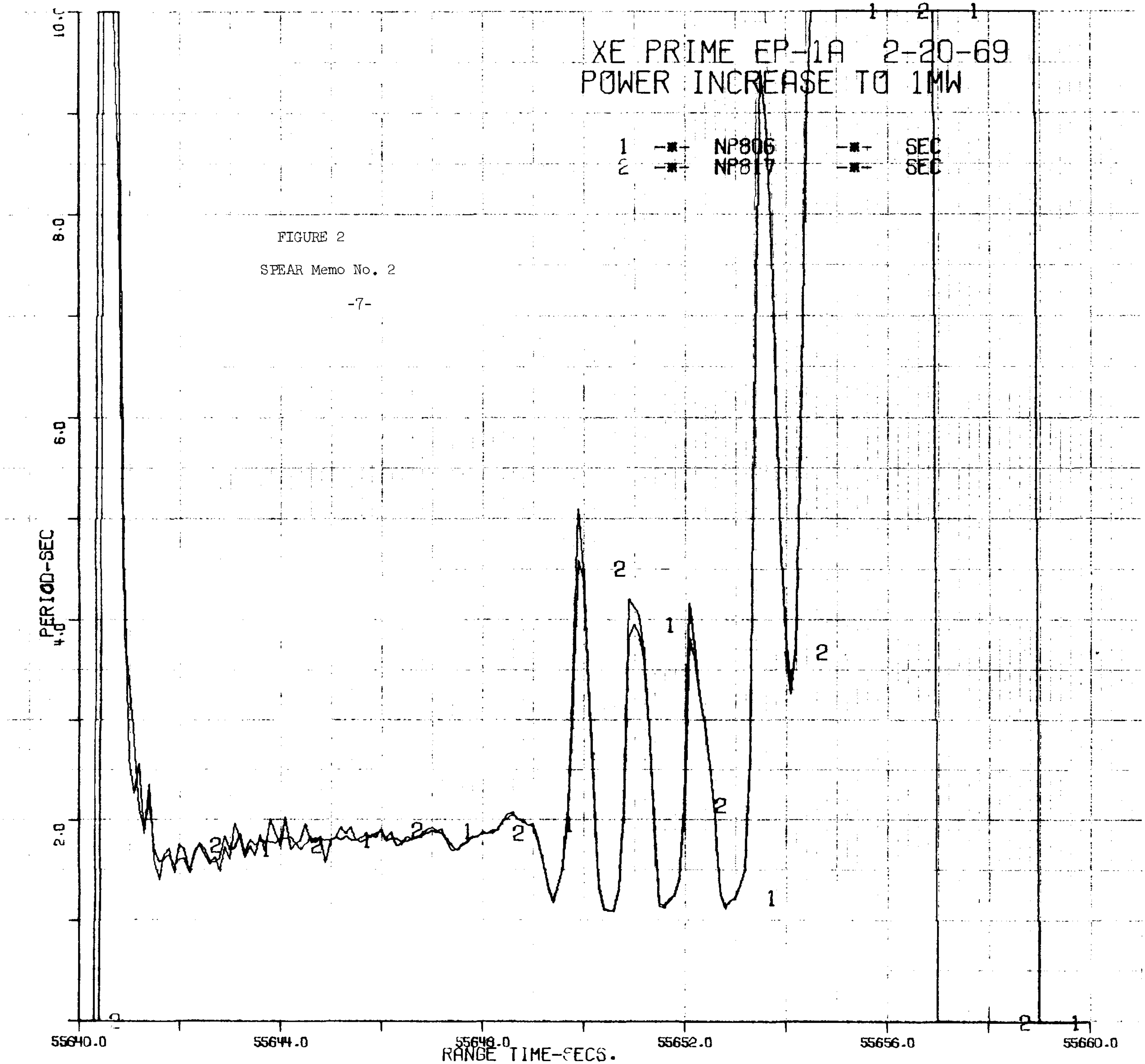

FIGURE 2

SPEAR Memo No. 2

-7-

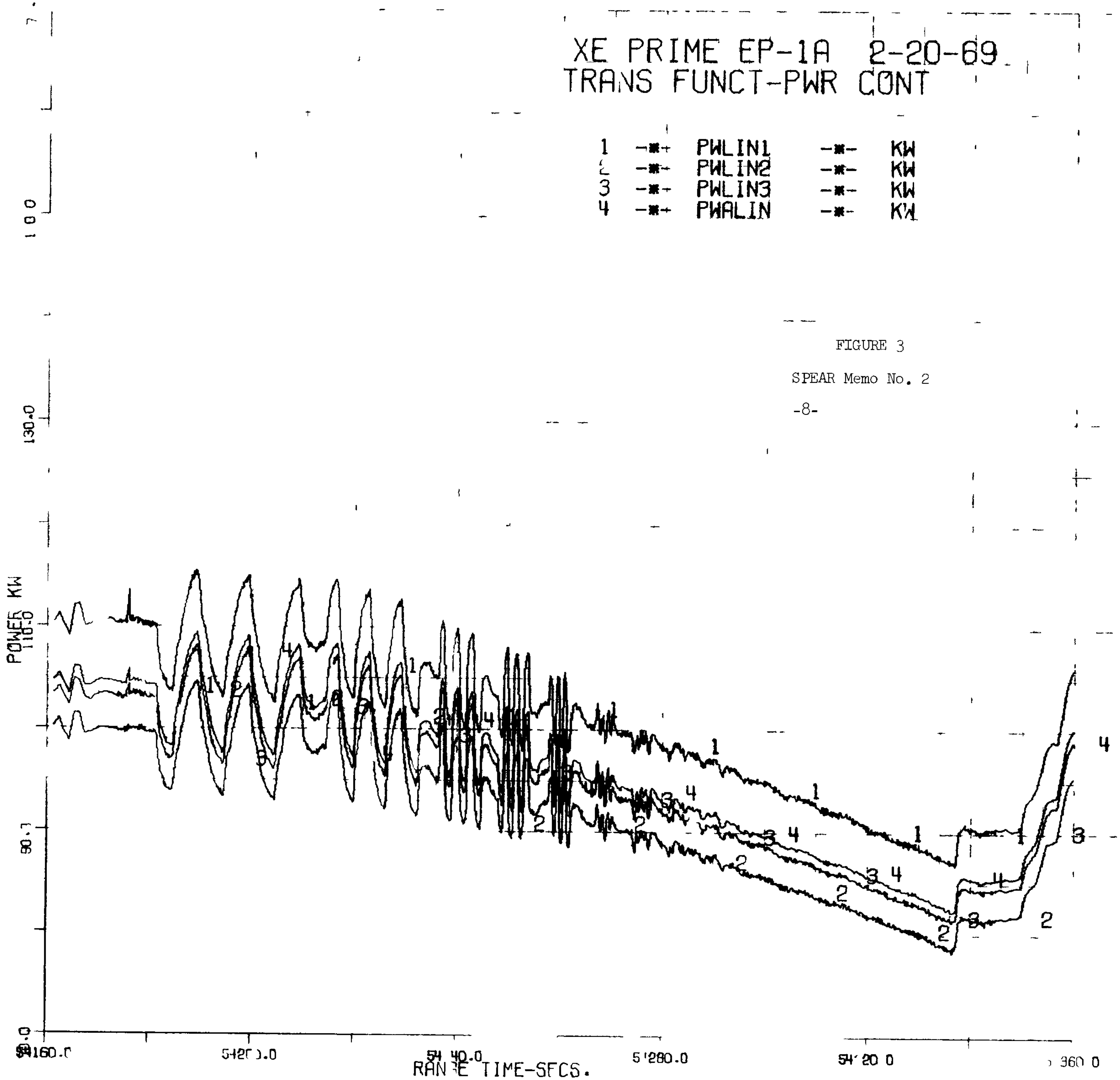

FIGURE 3

SPEAR Memo No. 2

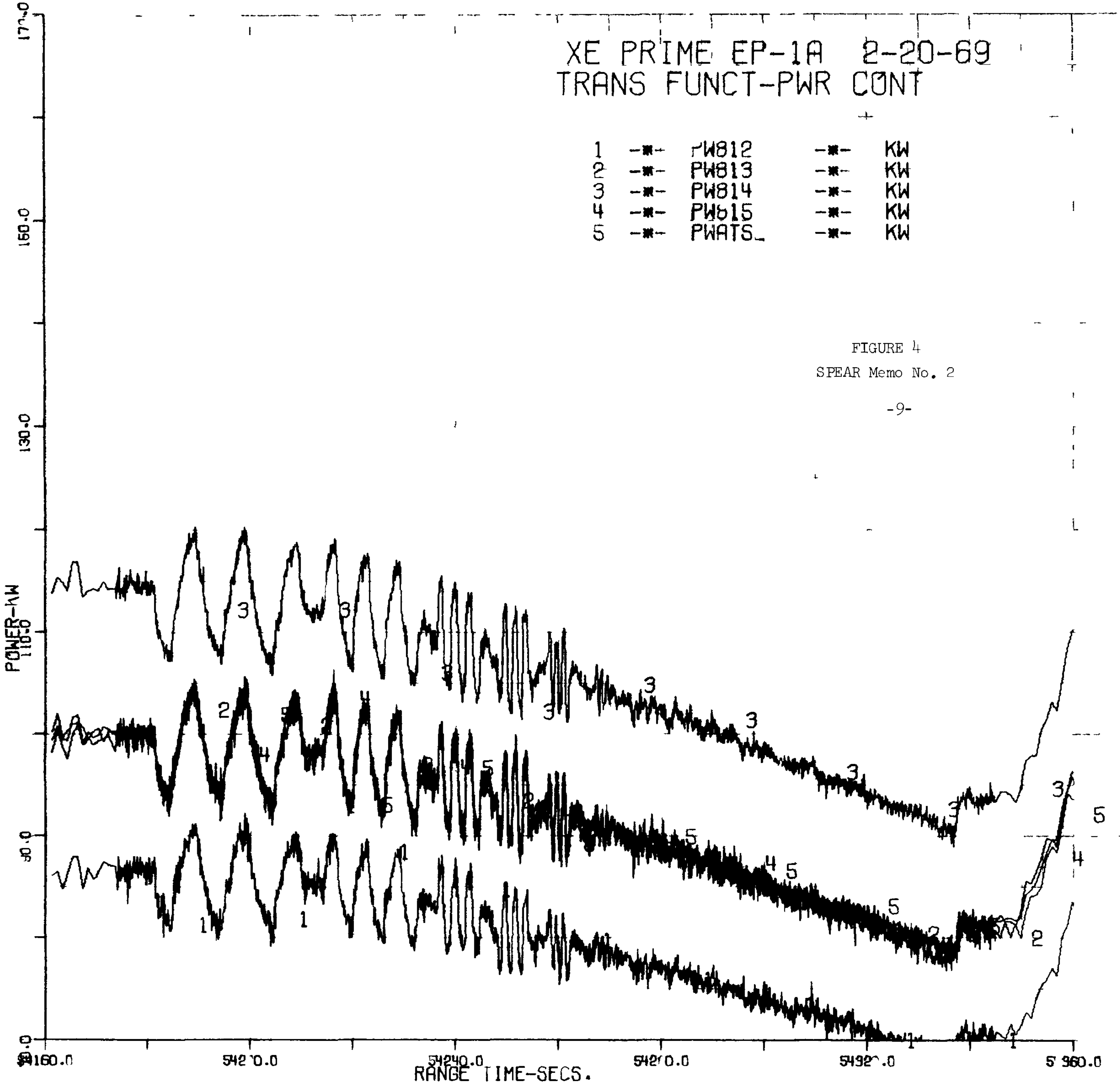

FIGURE 4

SPEAR Memo No. 2

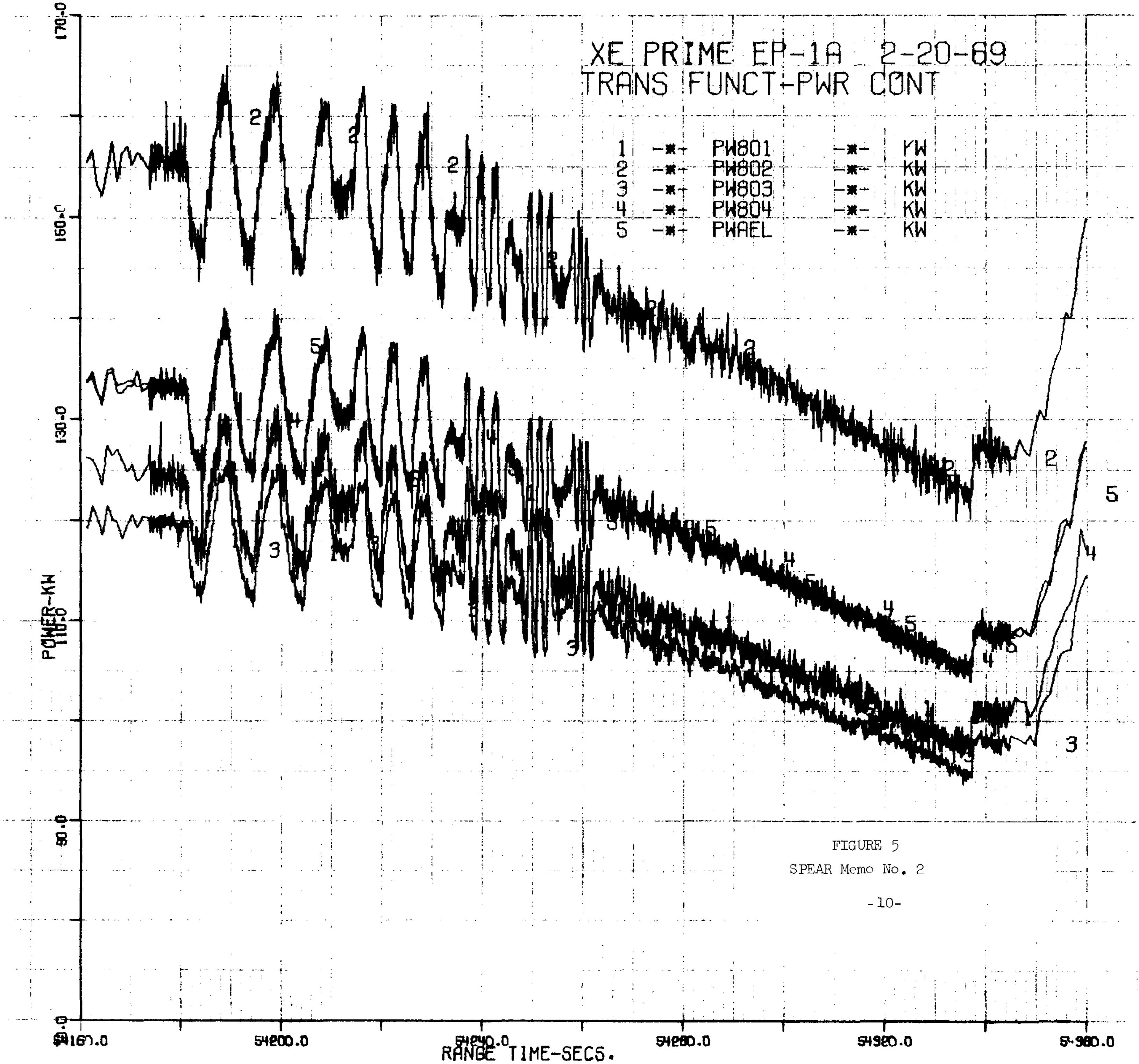

FIGURE 5

SPEAR Memo No. 2

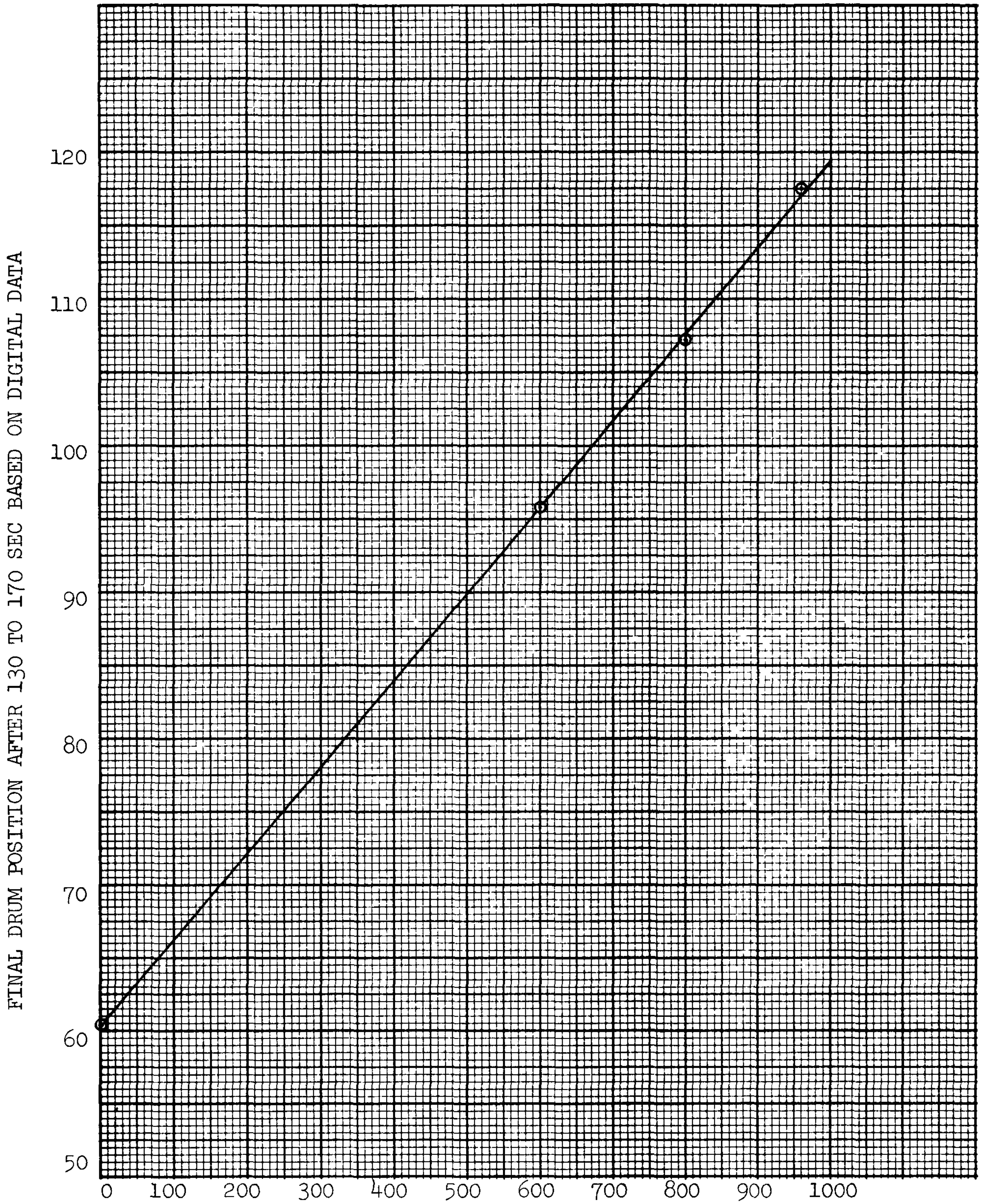

FIGURE 6

EXPONENTIAL POT DIVISIONS

FINAL DRUM POSITION VS EXPONENTIAL POT SETTING
FOR A NUCLEAR AUTOSTART

SPEAR Memo No. 3
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XE-PRIME

EP-IA

Subject: MEASUREMENT SYSTEM PERFORMANCE

SUMMARY

The narrow band data acquisition portion of the measurement system performed in an excellent manner with normal maintenance problems being far less than should be expected from a facility of this size.

The wide band FM data acquisition system had 61% of its channels activated. Except for some missing calibrations and some pulses during the calibration cycle, the data looked much better than it had previously. A detailed review of oscillograms, strip charts, and events channels was not completed because of time restraints. A system summary is presented in Table I.

TECHNICAL DISCUSSION

A slightly different format is being used to make this memorandum more useful in serving two functions. First, a Measurement System Review Summary is presented which will eventually show system trends over a period of several EP's so as to permit a rapid review of current system performance as related to previous tests. A brief description of the line items in Table I will be found at the end of the memorandum (Appendix A). Second, a table of data anomalies (Table II) is provided to alert the data user to data problems that would affect his various analyses. Lost data will be reported as well as data that contain irregularities which must be taken into consideration if meaningful data are to be obtained. Any other specific gross problem will be reported and discussed as deemed necessary. In this way, it is hoped that attention will be centered on overall data acquisition performance and data irregularities of which data users must be aware. The numerous small anomalies occurring in any test will be reported to NTO personnel for documented action. The exact method for reporting to and receiving reports from NTO has yet to be proceduralized.

Both the wide band (WB) and narrow band (NB) data acquisition systems have greatly benefited from the grounding work done at ETS-1 and from the silencing of noise generators found in Test Cell Building racks 12, 13 and 70. High frequency noise problems (predominently 100K HZ) still exist which may limit portions of the WB system. Minor modifications are under way which will decrease the adverse effect of these noise signals, but the overall effectiveness of the modifications cannot be determined until they are complete. The adverse effect of the recent wet weather may offset some of the gains realized since cable isolation resistances are dropping badly in some areas checked. Large random transients exist during some wide band calibration steps. If it can be shown that these transients are related to special manual calibration activities, they should cause little concern since they do not greatly affect the value of the calibrations. If, however, these transients are caused by equipment which might be operated during a test, the false data collected would be difficult to differentiate and separate from good data. The cause of the reported loss of wide band calibration signals has not as yet been determined.

A new procedure for providing a manual calibration of the data systems at the start of an EP has provided better calibration data for those special channels involved and will result in more accurate data. The additional documentation of channels requiring special treatment, having zero pressure calibration requirements, or which are known to be faulty prior to a test has greatly aided in the review of data. These documents must become more formalized, more complete, and constantly updated to provide the service for which they are intended. The completeness and accuracy of the datalog information has improved tremendously in the past two months. It still has some cases of missing, wrong, or incomplete information which is being corrected on a daily basis. The past concept of issuing an "As Run Datalog" containing only channels believed to be properly working at the start of an EP seems to be out of place in light of the size, complexity, cost, and the time involved in making the changes needed for various EP's. It would seem more functional for a separate memorandum or supplement to be issued within hours after each test to advise data users of channels known not to be functional at the beginning of or during an EP.

The selection of valid calibrations for the reduction of raw data to engineering units was accomplished by engineering personnel who participated in control room activities during the EP. This effort is so time consuming that extra attention should be paid to select prior to run day all special calibrations performed on R-3, R-2, or R-1. The selection of run day calibrations should be automated to such an extent that only the special run day calibrations need to receive detailed attention after the test.

CONCLUSIONS

The narrow band data acquisition system is ready for EP-IB. The wide band data acquisition system has been tremendously improved but has not yet been demonstrated at near capacity with the engine and facility systems in operation. Numerous documents must still be completed, corrected, and/or formalized. A procedure should be established for screening and assigning action items on data user reported anomalies. A feedback system reporting the results of these action items is a necessary part of such a procedure. The zero pressure calibration portion of NTO-SOP-0184 should be updated to reflect the latest test stand configuration and a section should be added to provide a zero pressure calibration of engine mounted transducers.

APPENDIX A

EXPLANATION OF ENTRIES IN MEASUREMENT SYSTEM REVIEW SUMMARY

1. AVERAGE NB NOISE - All ambient 2-sigma noise level values calculated in the Digital Data System Diagnostic Routine are summed and averaged, 9999 counts equals full scale. Exceptions to this are those channels whose noise level count exceeds 100 counts. The digital data system is currently so quiet that a noise level greater than 100 counts indicates a significant channel problem.

2. NUMBER OF NB CHANNELS SET UP - This is the number of narrow band channels believed to be set up and functioning properly at the start of an experimental plan and therefore not reported on the "Not Set Up" list provided by ETS-1 instrumentation personnel.

3. NUMBER OF NB CHANNELS REVIEWED - Time does not always permit the reviewing of all recorded data during the limited SPEAR effort. This value is an attempt to put the number of reported anomalies in its proper perspective.

4. % OF REVIEWED NB CHANNELS WITH LOST DATA - If data is irretrievably lost during an experimental plan, the corresponding channel is included in this calculation. If data can be salvaged by reprocessing or by using special data reduction techniques, it is not considered as lost and is not included. Channels having lost data or data requiring special data reduction techniques are listed in the Data Anomaly Table.

5. AVERAGE FM WB NOISE - All standard deviation noise level values derived from the Wide Band FM System Diagnostic Routine are summed, averaged, and doubled to provide a better comparison with the 2 sigma noise values calculated by the NB Diagnostic Routine. Exceptions to this are the same as for the narrow band system.

6. All definitions of the remaining line items are similar to those of the narrow band system as applicable to the indicated systems.

TABLE I

MEASUREMENT SYSTEM REVIEW SUMMARY

XE-P EP-	IA										
AVERAGE NB NOISE (COUNTS TAKEN FROM NB DIAGNOSTICS ROUTINE)	10										
NUMBER OF NB CHANNELS SET UP	864										
NUMBER OF NB CHANNELS REVIEWED	864										
PERCENT OF REVIEWED NB CHANNELS WITH LOST DATA	2.4										
AVERAGE FM WB NOISE (COUNTS TAKEN FROM WB DIAGNOSTICS ROUTINE)	28										
NUMBER OF FM WB CHANNELS SET UP	79										
NUMBER OF FM WB CHANNELS REVIEWED	79										
PERCENT OF REVIEWED FM WB CHANNELS WITH LOST DATA	11										
NUMBER OF OSCILLOGRAPH CHANNELS SET UP	36										
NUMBER OF OSCILLOGRAPH CHANNELS REVIEWED	0										
PERCENT OF REVIEWED OSCILLOGRAPH CHANNELS WITH LOST DATA	NA										
NUMBER OF STRIP CHART CHANNELS SET UP	81										
NUMBER OF STRIP CHART CHANNELS REVIEWED	0										
PERCENT OF REVIEWED STRIP CHART CHANNELS WITH LOST DATA	NA										

SPEAR Memo No. 3

TABLE II

MEASUREMENT ANOMALIES

XE-P EP-IA

ITEM	MEAS. NUMBER	MEASUREMENT DESCRIPTION	ANOMALY	COMMENTS
1	DF031..F	DCT H20 FLW CTL POS	100% cal step non-linearity exceeds 1%.	
2	DF032..F	DCT H20 FLW CTL POS	100% cal step non-linearity exceeds 1%.	
3	DP179..F	V3801 LH DWR ULL PCV-POS	100% cal step non-linearity exceeds 1%.	
4	DP248..F	V3801 LH DWR PG PCV-POS	100% cal step non-linearity exceeds 1%.	
5	DP447..F	UTS GN2 PRG FCV-POS	100% cal step non-linearity exceeds 1%.	
6	DP621..F	ETC GN2 PRG PCV-POS	100% cal step non-linearity exceeds 1%.	
7	DR110W.E	TURB BLOCKING VALVE	All cal 86 steps pegged minus full scale.	
8	DT708Y.F	STM LN LWR-VERT	No calibration.	
9	DT708Z.F	STM LN LWR-HOR/PARA TO DUCT	25% calibration step non-linear. Rest of cal good.	
10	E.805..E	DRUM ACT T-MTR CURRENT	No calibration.	
11	FE433..F	ENG PURGE FLOW	Apparent transducer failure occurred when PCV251 opened.	
12	LT011..F	V3401 PRO TNK-LVL	No zero pressure cal with which to reduce data.	
13	LT015..F	PROCESS H20 SPLY TNK-LVL	100% cal step non-linearity exceeds 1%.	
14	MG042..F	DCT INERT WALL-MIDPAN, CNTR	No calibration.	
15	MG703..A	TIE ROD STRAIN DC + AC	100% cal step non-linearity exceeds 1%.	
16	PT302..A	REFLECTOR INLET PLENUM	100% cal step non-linearity exceeds 1%.	
17	PT844..F	SHIELDS GN2 SPLY PRESS	No zero pressure cal with which to reduce data. SOP-0184 does not call out this channel as a zero pressure channel. Cal 86 slope and assumed (o) offset used to reduce data.	
18	PT846..R	4LH6 INTERFACE PRESSURE	No calibration.	
19	PX904..A	ZERO SUPP PT300..A REFLECTOR INLET PLENUM	No calibration.	
20	PX905..E	ZERO SUPP PT500..A SHIELD DOME END GAS	No calibration.	

TABLE II

MEASUREMENT ANOMALIES

XL-P EP-IA

ITEM	MEAS. NUMBER	MEASUREMENT DESCRIPTION	ANOMALY	COMMENTS
21	PX908..E	ZERO SUPP PT810..A TURB INLET LINE ENTR	No calibration.	
22	TX909..E	ZERO SUPP TE501..A SHIELD DOME END GAS	No calibration.	
23	T.910..E	DAS PROG TERM TEMP	No calibration. Not inhibited. Ambient levels on all cal steps.	
24	TE136..A	NOZZLE EXTERNAL WALL	Channel "0" and gain start drifting on cal 85 just before test.	
25	TE195..F	S2H20 TEMP	50%, 75%, and 100% cal step non-linearities exceed 1%.	
26	TE643..E	CORE ELEMENT	75% and 100% cal step non-linearities exceed 1%.	
27	TE698..A	CLUSTER EXIT GAS	No calibration. Slope of 1.0 and intercept of 0.0 used for data reduction.	
28	TE711.AE	TIE ROD MATERIAL	50%, 100% cal step non-linearities exceed 1%.	
29	TE723..N	T-STD NEUT 1 CANNISTER	Oscillatory Noise signal. 1.85 Hz oscillations superimposed on 0.07 Hz oscillation.	
30	TE886..A	PV FWD FLG GAM HT RT SEN	Zero shift greater than 1% between cal 85 and 86. 100% step shift of 25%. Gross non-linearities.	
31	TE958..A	DRUM ACT POTS	50%, 75%, and 100% cal step non-linearities greater than 1%.	
32	TX901..E	ZERO SUPP TE835..E TURB INLET	No calibration.	
33	TX906..E	ZERO SUPP. T.710..E AVG TIE ROD MATERIAL	No calibration.	
34	VC900..E	FUNCTION GENERATOR	No pre cal attempted. Post cal drifts.	

SPEAR Memo No. 3

TABLE II

MEASUREMENT ANOMALIES

XE-P EP- IA

ITEM	MEAS. NUMBER	MEASUREMENT DESCRIPTION	ANOMALY	COMMENTS
35	BC662..E	DRUM OVERRIDE	Event indication does not appear in data. Problem first detected in XEP EP-I	
36	DP517..R	LN CD SYS PCV-VLV POS	Digital data indicated 100% open for test after range time 36620 but valve was closed most of the time	
37	CP517.MR	LN CD SYS - MAN CTL POT	Digital data indicates 98% open for test after range time 36620 but pot was closed most of the time.	

SPEAR Memo No. 4
W. Howarth: cjd
WTH

XE-PRIME

EP-IA

Subject: SHIELD WORTH

SUMMARY

A comparison of measured and predicted S-1 shield worth is given in Table I:

TABLE I

S-1 SHIELD WORTH		
Shield	Measured	Predicted
Dry	1.82¢	0.75¢
Wet	0.85¢	2.75¢
TOTAL	2.67¢	3.5 ¢

Good agreement was obtained between measured and predicted shield worths. Holding the reactor critical throughout the test was the primary reason for the good worth measurements.

TECHNICAL DISCUSSION

The data was taken from TDC digital listings.

Table II lists the average drum bank position at different S-1 shield conditions. The average was calculated at one second increments over the time slice. The dry shield worth was calculated by subtracting the critical drum bank position measured when the shield was 30' from the engine from the critical drum bank position measured when the shield was in position. Similarly, the wet shield worth was calculated by subtracting the critical drum bank position when the shield was in position from the critical drum bank position when the shield was filled. A drum bank differential worth of 6.53 cents/deg conversion factor was used to calculate shield worth.

TABLE II

S-1 Shield	Time Slice	Avg. Drum Bank Position, Deg.
30' From Engine	48304-15	97.834
In Position	48765-74	97.555
Filled	49979-88	97.425

The 30' from engine drum average was not at critical position. The TDC reactivity calculation indicated the drum position was subcritical by one cent. The 30' from engine drum average given in Table II includes the one cent correction.

CONCLUSIONS

None

XE-PRIME

EP-IA

Subject: INTEGRAL DRUM WORTH

SUMMARY

The drum bank worth (15° to 165°) of XE-Prime was estimated to be \$7.83 from the integral drum roll out data. Drum roll in data confirms this value, but was not used in the drum span estimate. XE-Prime drum span was predicted at \$7.9 ± \$0.2. There was no significant difference in the worth of drum # 1 when the side shield S-1 was in-place or removed (effectively an ∞ distance from the reactor).

TECHNICAL DISCUSSION

Determination of the integral drum worth was complicated by the transient state of the reactor on the initiation of the drum rollout. The stable period observed after a drum rollout will be the actual reactivity of the system. If the reactor were subcritical by ρs, for example, and a drum were inserted, ρd, the observed period would correspond to $\rho d - \rho s$.

Two methods were employed to determine ρs:

1. The TDC calculated reactivity at the time of the drum rollout.

2. The difference between the actual 11 drum bank positions at the time of the drum rollout and the estimated critical 11 drum bank position.

The basic data, the net observed reactivity, $\rho d - \rho s$, is listed in Table 1. This reactivity was obtained from the period observed for the power increase using the average linear power channels. A typical power transient for a drum 1 rollout is shown in Figure 1 and Figure 2 is used to convert the observed period to reactivity.

The TDC calculated reactivity, ρs, listed in Table 1.1 was obtained from the TDC plot tape for EP-IA (1/20/69). Adding this shutdown to the net reactivity yielded the drum worth of 7 of the 8 experiments.

The results of the second method for obtaining drum worth are shown in Figures 3, 4, and 5. These figures show the net reactivity observed (Table 1) vs. the 11 drum bank angle at the time of each drum roll out. A correction to the observed 11 drum bank angle was added to account for the small temperature variation during the test. These corrections listed in

Table 2 are based on station 26 temperature changes and the observed change in critical bank angle with temperature. Applying this correction brings the 11 drum bank angle to an ambient temperature at 530° (as in EP-I).

The line fitted to the data in each of the figures has a slope of 6.0¢/deg. which is 11/12 times the differential drum worth measured in EP-I of 6.5¢/deg.

Table 3 summarizes the estimates of the 11 drum critical angle for the conditions at each experiment. Corrections are applied to account for the shield removal and the difference between the 11 (one drum at 15°) and 12 drum critical bank angles observed in the drum uniformity test (EP-I).

The drum worths picked off figures 3, 4, and 5 at their respective estimated 11 drum bank critical angles are listed in Table 1 under Method 2. It can be seen that the results for the integral drum worths by Methods 1 and 2 agree to within about 1¢.

To obtain the estimated drum span, two corrections were made. A factor of 0.988 was used to correct the drum worth from 15° - 172° to 15° - 165° based on the characteristic cosine drum worth curve. A second correction from the drum uniformity test (EP-I) was applied to normalize drums 1 and 7 to the average. This was obtained by taking the ratio of the average 11 drum bank critical position change as drum was rotated from 15° to 165° to the change noted for the specific drum. These results are summarized in Table 4. Note that the average worth of drum # 1 differs by only 0.2¢ after correction for the observed drum worth variations.

The results in Table 5 summarize the data on integral drum worth taken by the drum drop method. The experimental reactivity worth is based on the ratio of the power 15 seconds after a step decrease in reactivity to the initial power. Since it took some 4 seconds to roll the drum in, the power ratio was determined at 15 seconds from the time the drum passed ~ 90°. This leads to a rather large uncertainty of some ± 3.0¢ (assuming about ± 1.0 second uncertainty on the 15 second interval).

Several exceptionally low worths were calculated (e.g. see Table 5 - RT - 50919.4). Low values were found to correlate well with time after reaching the 50 kw peak power occurring in the preceeding drum rollout experiment. Time delays of less than 200 seconds after the 50 kw excursion apparently do not permit the long lived delayed neutron precursors to stabilize sufficiently. It can also be seen that the data taken when the drum roll in is the initial experiment (at RT 47338.3 and 50340.5) is relatively accurate. It was also observed that the measured reactivity for a negative insertion (such as a drum roll in) is insensitive to small errors in the criticality of the reactor. Therefore, the reactivity difference between the drum bank position and the critical drum bank position was not added to the measured drum reactivity insertion.

TDC Data Evaluation

Integral drum worth summary Tables 1 and 5 include values calculated by the reactivity computer. For drum No. 1 the reactivity computed is within 2.5¢ of the best estimates of the drum worth.

Drum No. 7 is anomalous in all reactivity competitions. The high computed values for drum No. 7 are probably due to the proximity of the detectors. The detectors are seeing not only a general power rise (or fall) due to the reactivity insertion, but also the peripheral power variation due to drum motion. For either positive or negative insertions, the edge power change would appear to augment the actual reactivity change. This detector behavior was observed in the drum rollout measurements performed in E-MAD after central poison wire removal. Variations in the detector response of 6 to 14% were encountered depending on the source - detector - drum geometry. Proximity of the drum and detector gave the highest indicated reactivity change.

CONCLUSIONS

The drum span was precisely as predicted. The low value obtained for the differential drum bank worth in EP-I relative to the predicted value based on a $7.9 drum span might be explained by correlating previous NRX different bank worth/drum span data.

TDC reactivity calculations were extremely useful in all reactivity determinations in the SPEAR effort. It is becoming apparent that the reactivity calculations may be used directly in many cases; particularly near critical.

Some observations on the reactivity calculations:

1. The most indicative result was the accurate smoothing of the power transients during, for example, a drum roll out. The 65¢ insertion took place in some 5 seconds, and the reactivity rose to ~ 65¢ and stopped. This means that the erratic behavior of period measurements could be completely smoothed out by the reactivity computer.

2. The reactivity was correct after the reactor had been in the vicinity of critical for some time. This indicates a need for initialization of the program (precursor concentrations).

3. Development of the estimation of reactivity from source level to critical would be valuable. This would reduce the time required for initialization.

4. Shutdown measurements need improvement especially after a scram.

5. Noise pulses cause an inaccuracy in the calculated reactivity for about 1 second.

6. Reactivity feedback estimations should be added to the routine.

TABLE 1

SUMMARY OF INTEGRAL DRUM WORTH TEST DATA (15° to 172°)

DRUM	RANGE TIME	OBSERVED REACTIVITY $\rho d - \rho s$ (¢)	TDC CALCULATED REACTIVITY ρs (¢)	DRUM WORTH METHOD 1 (¢)	OBSERVED REACTIVITY ρs (¢)	DRUM WORTH METHOD 2 (¢)	TDC DRUM WORTH (¢)	AVG DRUM WORTH EXPERIMENTAL/ TDC
1 (S-1 removed)	47666.5	54.0	--	--	-10.3	64.3		64.0/65.2
	48006.4	55.5	- 8.0	63.5	- 8.8		65.2	
	50484.5	58.8	- 4.7	63.5	- 6.0		65.4	
1 (S-1 filled)	50792.1	54.0	- 9.7	63.7	-10.8	64.8	66.2	64.2/65.7
	51133.1	59.3	- 3.9	63.2	- 5.5		65.5	
	51581.0	64.5	- 1.1	65.6	- 2.6		72.1	
7 (S-1 filled)	52004.6	64.0	- 2.8	66.8	- 3.1	67.1	73.1	66.7/73.1
	52425.9	63.8	- 2.7	66.5	- 3.3		74.1	

TABLE 2

APPROXIMATE CRITICAL BANK ANGLE

CORRECTIONS FOR THE INTEGRAL DRUM WORTH TEST

TEST	RANGE TIME	AVERAGE STATION 3 TEMPERATURE (°R)	12 DRUM ** BANK CORRECTION(°)	11 DRUM BANK CORRECTION (°)
Drum 1	47666.5 - 86.5	513	+ 0.37	+ 0.40
Shield Removed	48006.0 - 26.0	515	+ 0.32	+ 0.35
Drum 1	50484.5 - 504.4	521	+ 0.20	+ 0.22
Shield In-Place	50792.1 - 812.1	525	+ 0.11	+ 0.12
	51133.0 - 153.0	522	+ 0.17	+ 0.19
Drum 7 *	51581.0 - 601.0	525	+ 0.11	+ 0.12
	52004.0 - 024.0	527	+0.06	+ 0.07
Shield In-Place	52425.9 - 445.9	530		

* Critical 12 Drum Bank Angle = 97.86°

11 Drum Bank Angle = 103.71°

** Approximate Temperature Coefficient = $\frac{0.022^\circ}{^\circ R}$ (Δ T_3

TABLE 3

11 DRUM CRITICAL BANK POSITION ESTIMATES

CONDITION	CRITICAL BANK ANGLE (530° AMBIENT TEMPERATURE) (°)	11-12 CRITICAL BANK ANGLE DIFFERENCE (°)	11 DRUM CRITICAL BANK ANGLE (ONE DRUM AT 15°) (°)
Figure 3 - Drum 1 Shield Removed	98.30	5.85	104.15
Figure 4 - Drum 1 Shield In-Place	97.86	5.85	103.71
Figure 5 - Drum 7 Shield In-Place	97.86	6.05	103.91

TABLE 4

TOTAL DRUM BANK WORTH

DRUM NUMBER	AVERAGE WORTH (¢)	CORRECTED FOR UNIFORMITY (¢)	CORRECTED TO 15° to 165° (¢)
1	64.2 (x1.027) =	65.9	65.1
2	66.7 (x0.99) =	66.1	65.3
	Avg Drum Worth 65.2 ¢ Drum Span (15° to 165°) $7.83		

TABLE 5

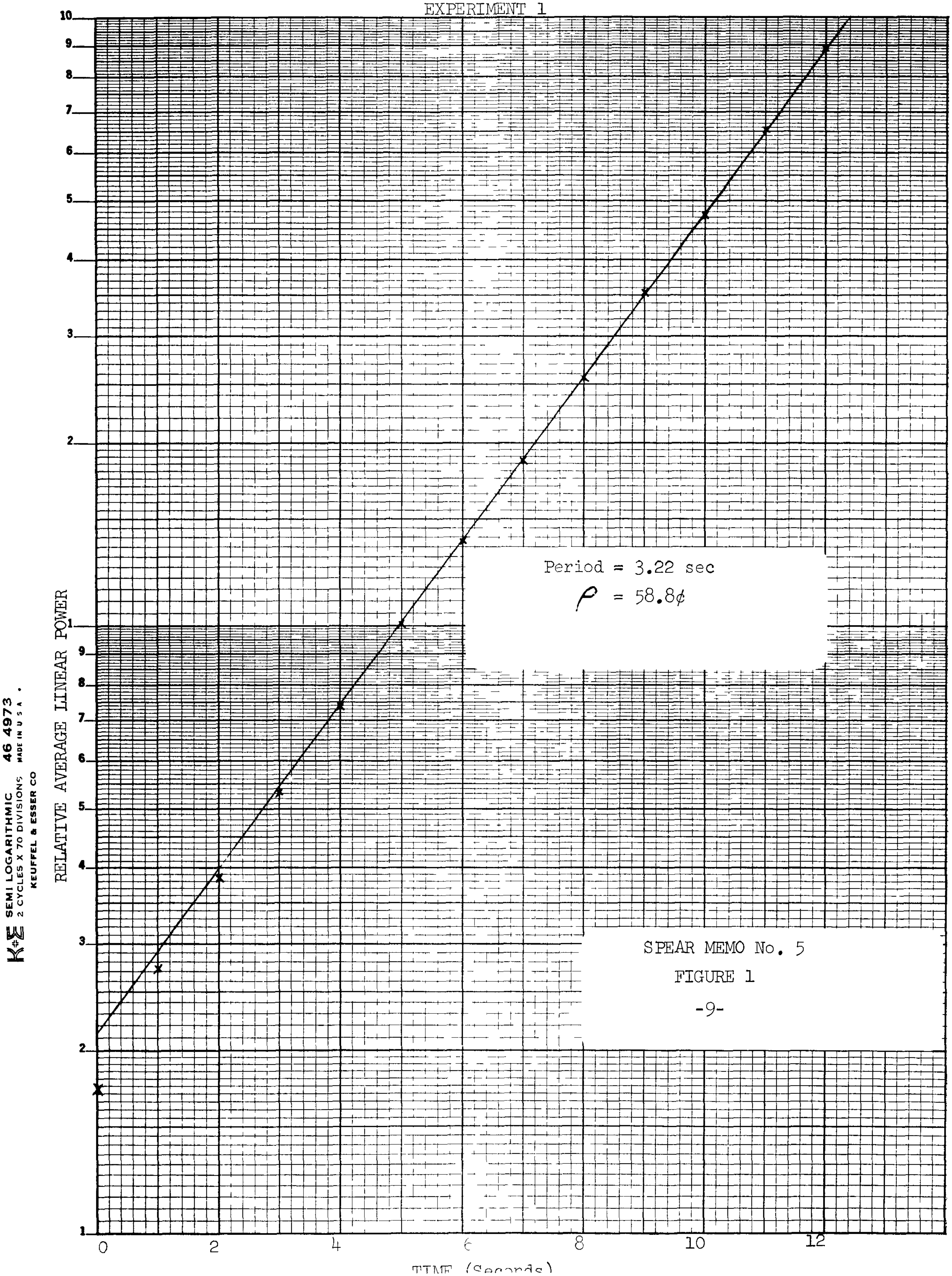
INTEGRAL DRUM WORTHS

ESTIMATED FROM THE DRUM DROP EXPERIMENTS

TEST	RANGE TIME	EXPERIMENTAL WORTH (¢)	APPROX TIME AFTER 50 kw (sec)	TDC WORTH (¢)	ESTIMATED AVERAGE DRUM WORTH (¢) EXPERIMENTAL/TDC
Drum 1	47338.3-53.3	- 64.2 ± 3	--	--	64.2/66.5
Shield Removed	47849.8-64.8	- 56.2	155	66.5	
Drum 1	50340.5-55.5	-67.5 ± 3		65.9	
Shield In-Place	50648.5-63.5	-60.0	145	65.0	
	50919.4-34.4	-57.8	105	64.7	67.5/65.2
Drum 7	51354.1-69.1	-65.2 ± 3	205	70.0	
Shield In-Place	51787.1-02.1	-65.0 ± 3	190	77.3	66.3/74.8
	52218.7-33.7	-68.8 ± 3	200	77.2	

TYPICAL POWER VARIATION FOR DRUM 1 ROLLOUT

EXPERIMENT 1



SPEAR MEMO No. 5

FIGURE 1

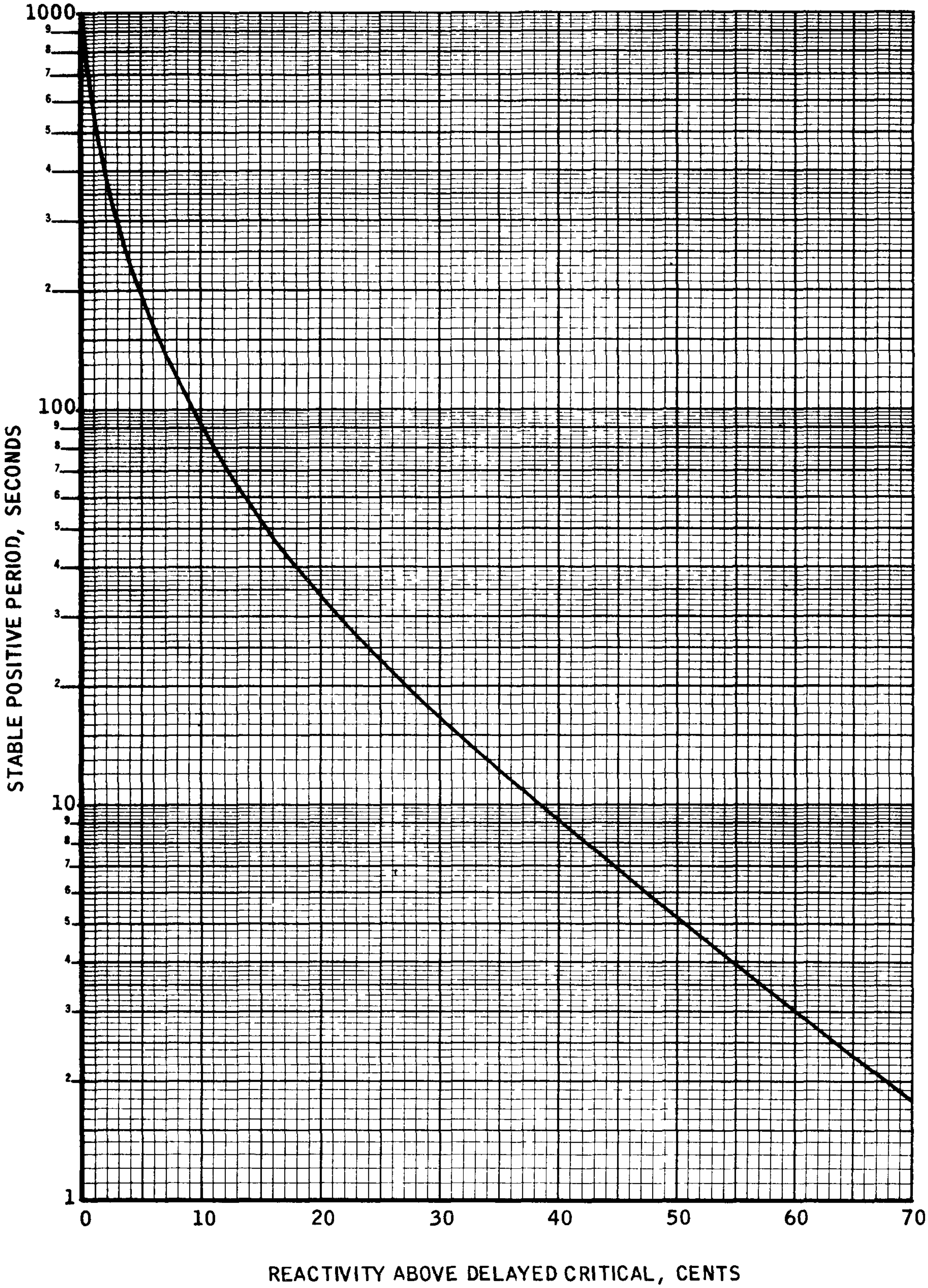
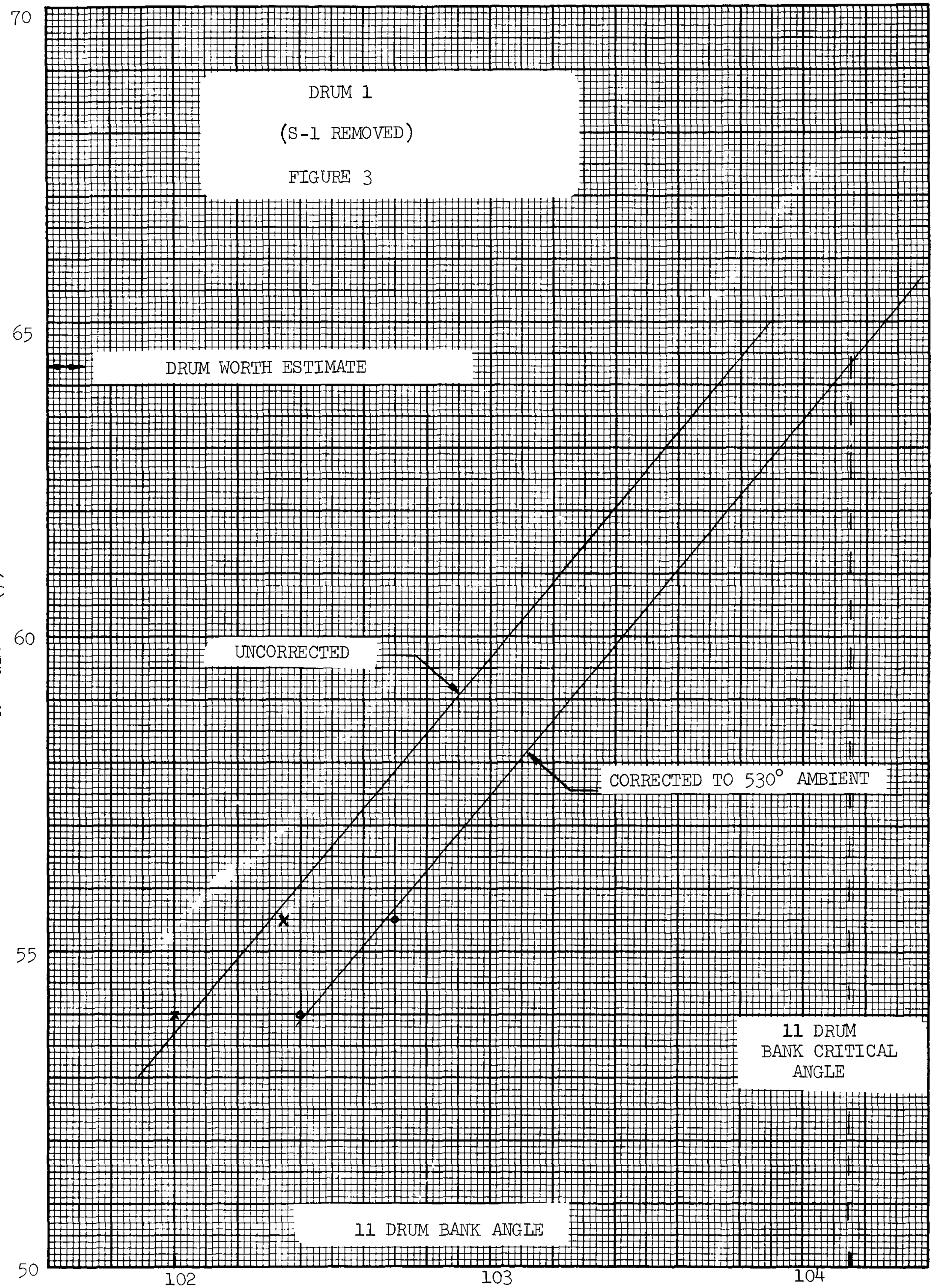
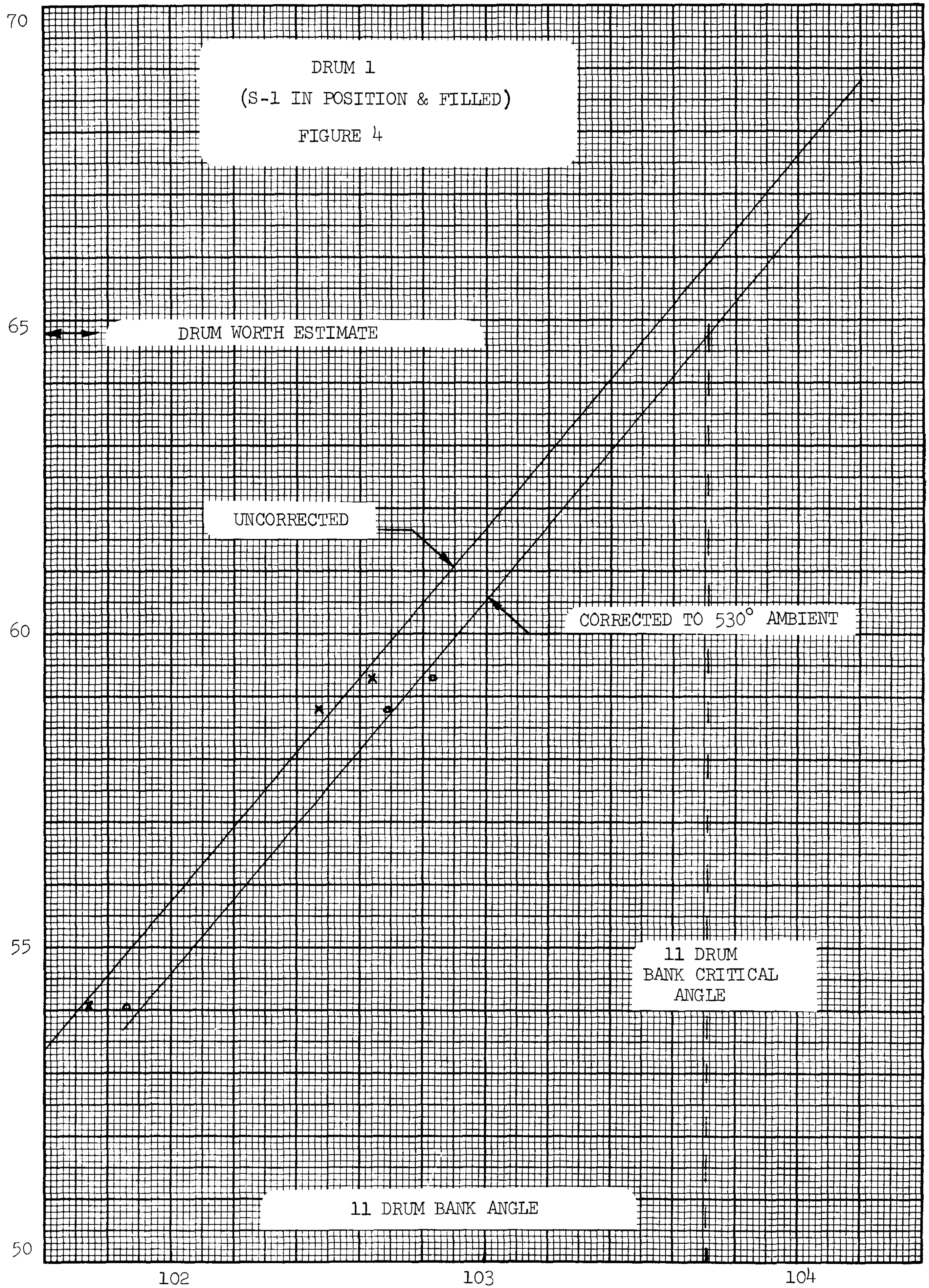


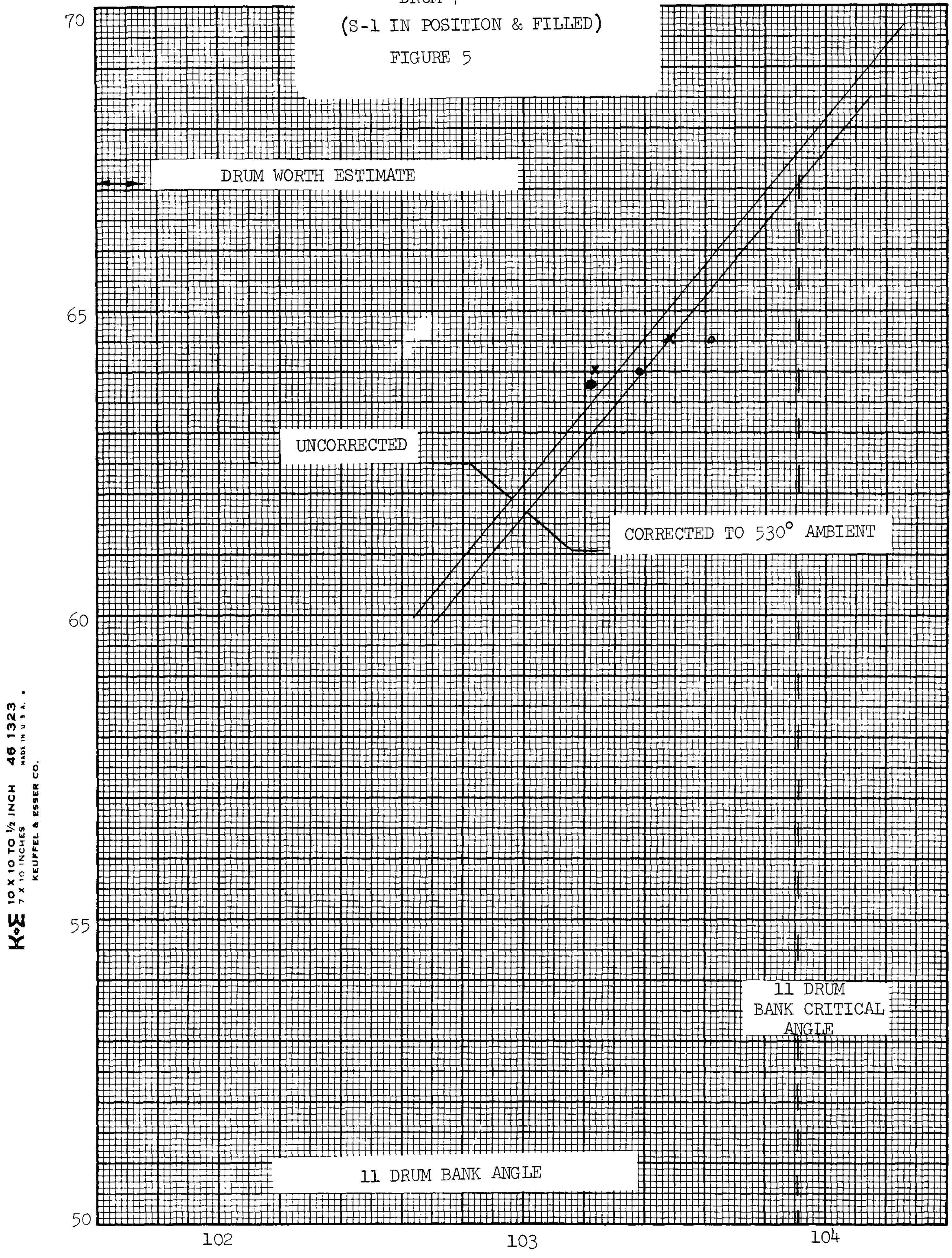
Figure 2 - Variation of Stable Positive Period with Reactivity above Delayed Critical


DRUM 1
(S-1 REMOVED)
FIGURE 3
70
65
60
55
50
DRUM WORTH ESTIMATE
REACTIVITY (¢)
UNCORRECTED
CORRECTED TO 530° AMBIENT
11 DRUM BANK CRITICAL ANGLE
11 DRUM BANK ANGLE
102
103
104



DRUM 1
(S-1 IN POSITION & FILLED)
FIGURE 4
70
65
60
55
50
DRUM WORTH ESTIMATE
UNCORRECTED
CORRECTED TO 530° AMBIENT
11 DRUM BANK CRITICAL ANGLE
11 DRUM BANK ANGLE
102
103
104

DRUM 7
(S-1 IN POSITION & FILLED)
FIGURE 5



SPEAR Memo No. 6
A. Mowery:cjd

XE-PRIME

EP-IA

Subject: CRITICALITY

SUMMARY

The critical drum bank angle at 530°R ambient temperature (similar to EP-I) was determined to be 98.9°. This angle includes a 1.01 correction factor to account for a known error in the indicated drum angle. EP-I critical bank estimate was 99.8° ± 0.35° indicating a possible 0.9° or 6¢ reactivity increase for EP-IA - a nominal variation.

From the two stable scrams the shutdown was estimated at $4.75 ± $0.10 from the 530° ambient critical drum bank angle. This is in good agreement with the value of $4.73 measured in EP-I.

TECHNICAL DISCUSSION

Some shift in the critical bank position was noted between the initial critical and the critical position after the integral drum worth test. This was attributed to a small temperature rise during the test period.

Historically, day-to-day reactivity shifts of ± 0.7° (2¢) have been observed from NRX-A2 through A6. The shift observed in XE-Prime is, therefore, not necessarily significant.

The measured shutdown at the end of the integral drum worth test was $4.80 (RT = 52600) and $5.00 after the thermal calibration test (RT = 56480). Drum bank angles were 98.4 and 102.7°, respectively, at the time of the scram. Adjusting to the ambient critical bank angle brings the two measurements to within 5¢ averaging about $4.75.

CONCLUSIONS

TDC reactivity calculations were required to determine the critical bank angle in many cases. To achieve a critical position within 0.1° would require that the observed period be higher than 600 seconds. This degree of resolution is not possible (or required) using the information displayed on the CTE console. One method to obtain an accurate critical position would be to use the TDC calculated reactivity values.

An alternate accurate method would be to purposely place the reactor on a 20 - 30 second period. Allow the power to increase 2 to 3 decades at a constant drum position. The critical angle can then be easily determined by calculating the reactivity from the power trace and using the differential drum bank worth to calculate the necessary reduction in the drum bank angle.

SPEAR Memo No. 9
J. Bock/V. Winter:cjd

XE-PRIME

EP-IA

Subject: DRUM POSITION CONTROL EVALUATION

SUMMARY

The indicated static error (Measured Exceeding Demanded) has been reduced from that first reported in SPEAR Report NTO-R-0164 (EP1 - SL2) Memo No. 16, but is still sufficiently outside the specified static accuracy of ± 1° so as to require further evaluation. An investigation is now being conducted to determine the accuracy of the drum position measured by the data system. The error is 1° at a drum position of 34 degrees to a maximum of 2.3° at a position of 102 degrees.

The relative tracking between individual drums shows a worst case error at 102° average drum position with a 1° spread between drums 2 and 11. This error is considered satisfactory.

Frequency response measurements were within tolerances, repeatable and showed a bandwidth of 1.5 cps with adequate gain and phase margin.

Drum profile during closed loop scram shows that a maximum slew velocity is achieved within 10 degrees and a rate of 625 degrees per second. This velocity is 25 degrees per second out of the nominal band of 750 ± 100 degrees per second. The individual slew velocities shows a maximum spread of approximately 15° per second.

Average drum actuator threshold maximum level measures between 0.325 and 0.370 degrees while responding to an increasing demand, and a maximum threshold between 0.400 and 0.470 degrees while responding to an Inward demand. There is no specification relating to drum threshold but is of interest to note a direct relationship to Power Controller limit cycling.

TECHNICAL DISCUSSION

This memo is concerned with the Static Accuracy and the dynamic control characteristics of the drum position control loop.

Sine wave responses in position control were measured at two different points in EP-IA: 1) At a sub-critical drum position of 47.2 degrees starting at 44073 seconds, and 2) At a drum position of approximately 101° starting at 54181 seconds.

Drum position dwells suitable for evaluation of static accuracy occurred several times during EP-IA.

1. Static Accuracy: In operation, a ganged drum position demand CC800 is compared against either feedback position potentiometer Cup "A" or "B" on each actuator, and the actuator changes position to minimize the error. The operator adjusts the ganged drum demand until he obtains

the desired averaged position. The static accuracy evaluation is made by comparing the ganged drum position demand with the computed average drum position.

The static error (Measured Exceeding Demanded) in the drum position control loop shows an error of 1° at a position of 34 degrees, to a maximum of 2.3 degrees at a position of 102 degrees. (See Figure 1 and Table 2). This error has been reduced from that previously reported due to a modification of the grounding system in and around racks 48 and 50.

The relative tracking capability and spread of individual drum positions at various average positions between 45° and 102° is shown in Figure 3 and Table 3. The worst case spread occurred at 102° with a 1.0 degree error between drums 2 and 11.

Although the computed average drum position (CAD) was compared to the ganged drum position demand (CC800) to realize the maximum deviation of 2.3°; the drum measured average position (D.800) and CC800 is shown in Figure 4 to illustrate the deviation. Channel 4 of this figure shows this variation as approximately 2.8°, but is not considered as accurate as the comparison of CAD and CC800.

A partial definition of the remaining error is shown in Table 1. This shows an apparent error between drum number 1 as recorded by the data system and the digital voltmeter readout on the ATE Console (See Figure 2). The DVM readouts were recorded during exponential potentiometer calibration between the range times of 40794 seconds and 41434 seconds. This error is between 1.4 and 1.8 degrees depending on drum position.

If this error is subtracted from the respective area of the curve shown in Figure 5, it would reflect a static drum inaccuracy of 0.15° at 60 degrees position to a maximum of 0.8° at 105 degrees position. This error is within the specified accuracy of ± 1 degree. This information has provided a basis for making an investigation of the data system which may resolve the question of static accuracy.

2. Frequency Response: Sine wave response in position control was measured at: 1) 47.2 degrees drum position as a range time of 44073 seconds, and 2) at 101 degrees drum position at 54181 seconds.

   a. Sub-Critical Response: The first transfer function measurements were made at 14 frequencies in the 0.1 to 16.0 cps range. The peak-to-peak demand was ± 0.5 degrees and ± 2.0 degrees for all frequencies above. Figure 6 shows the log magnitude and phase plots for the average position to demand with a ± 2 degree sine perturbation. The bandwidth is 1.5 cps with a phase angle of 113 degrees. There is an apparent plotting error in the scaling of phase angle. The AGC program 2909 did not subtract out the

180° phase shift in the drum demand integrator. Therefore, a plotted phase angle of 180 degrees should represent zero degrees. Figure 6 also shows that a meaningful signal to noise ratio exists up to 3 cps.

Figures 6 and 7 show a larger disagreement at roll-off frequencies between drum # 1 and the average than that reported in the last SPEAR memo.

Figures 8 through 21 are added as backup information and shows zero suppressed average drum position demand (CX902) versus average position error (CX902 minus DX902).

The transfer function measurement taken between the range times of 44363 and 44517 seconds were confined to a sine perturbation of ± 0.5 degrees. Figure 22 shows the response and phase angle of the suppressed average drum position measured (DX902). This figure also shows that a satisfactory signal strength to noise ratio exists only up to 1.0 cycles per second.

b. Drum Response (at Critical): The second set of transfer function measurements were for 14 frequencies in the 0.1 to 16.0 cps range using a peak-to-peak demand of ± 1.0 degrees, and 8 frequencies from 1.1 to 16.0 cps using a peak-to-peak demand of ± 2.0 degrees.

Figure 23 shows the log magnitude and phase plot for the average position to demand transfer functions for a ± 2.0 degree peak-to-peak sine perturbation. The bandwidth is 1.38 cps with a phase angle of 106 degrees. This measurement shows excellent agreement with the ± 2 degree measurement taken at a drum position of 47.2 degrees.

Figure 24 shows the log magnitude and phase plot for a ± 1.0 degree sine perturbation. The bandwidth is 0.84 degrees with a phase angle of 114 degrees.

The transfer function measurements taken during this test are in excellent agreement with those observed during EP-1. This data also compares favorably with the loop performance tests observed at E-MAD XE-Prime P-3 operations and at ETS-1 during XE-Prime P-9 tests.

3. Drum Profile During Scram: Several closed loop scrams were initiated during EP-1A. For purposes of discussion, three types of drum scrams were selected: 1) Fixed power scram from 1 KW, 2) Period scram from 100 watts, and 3) Manual scram from 50 KW.

A Fixed power scram occurred at a range time of approximately 46705.2 seconds. Figure 25 shows a slew velocity of 633° per second which was attained at a drum angle of 88 degrees.

A Period scram occurred at a range time of 46889.9 seconds. Figure 26 shows a slew velocity of 624° per second which was attained at a drum angle of 96 degrees.

A Manual scram was initiated at a range time of approximately 52610.4 seconds. Figure 27 shows a slew velocity of 625° per second which was attained at a drum angle of 92 degrees.

The scram profiles show excellent repeatability on a scram-to-scram basis with rate limiting occurring within approximately 10 degrees. The individual drum slew velocities show little variations between high and low, but the average velocity is 625° per second which is 25° per second slower than the Minimum value indicated in the functional requirement (750 ± 100) for closed loop scram. An explanation may be that EP-IA was conducted without actuator coolant.

4. Actuator Threshold: Drum Actuator threshold was measured utilizing the 0.1 cps sine response test of the Power Controller during the Range times of 53857 and 54003 seconds.

Figure 28 shows DX902 (zero suppressed Average Measured Drum Position) while Figure 29 shows CX902 (zero suppressed drum demand) and demonstrates clearly the Actuator threshold characteristics. By comparison of DX902 to NX902 (zero suppressed Average Test Stand Log power) during the intervals of threshold, there is a lack of loop control in the power controller.

The Measured thresholds while responding to an increasing demand were between 0.325 and 0.370 degrees, while the threshold was 0.400 to 0.470 degrees while responding to an inward demand.

CONCLUSIONS

1. Static Accuracy

It is suggested that further evaluation be accomplished to ascertain the difference between the digital voltmeter readout on the ATE console and the individual drum positions as entered into the data system.

The data currently being collected to improve the conversion of drum position counts to degrees may also bring the static accuracy within the specified limits. If this is not the case, additional evaluation is required.

2. SC647 (Period Scram) and SC620 (Emergency/Scram) Binary signals should be recorded on an oscillograph if possible.

3. Anomalies

None.

TABLE 1
Exponential Potentiometer Calibration

Exponential Pot Demand	Drum #1 (Data System)	Drum #1 (ATE Console)	Δ Drum Position
0 Divisions	60.3 Degrees	58.9 Degrees	1.4 Degrees
600 "	95.8 "	94.4 "	1.4 "
800 "	107.1 "	105.6 "	1.5 "
920 "	112.1 "	110.7 "	1.8 "
960 "	117.5 "	115.7 "	1.8 "

TABLE 2
STATIC ACCURACY EVALUATION

Range Time	Average Position (D.800)	Ganged Demand (CC800)	Position Average Calculated	Δ CAD-CC800
43671.6	47.9 Degrees	45.6 Degrees	47.1 Degrees	1.5 Degrees
45151.2	71.8 "	69.4 "	71.1 "	0.7 "
45451.2	85.1 "	82.4 "	84.6 "	2.2 "
46331.2	93.2 "	90.7 "	92.7 "	2.0 "
46549.7	104.9 "	102.1 "	104.4 "	2.3 "

TABLE 3
Variation of Individual Drum Position

Range Time	Ganged Drum Demand	Average Pos. Calculated	High Position	Low Position	Δ
43671.6	45.6 Deg.	47.1 Deg.	#4 (47.5)	#2 (46.6)	0.9 Deg.
45151.2	69.4 Deg.	71.1 Deg.	#10 (71.5)	#3, #8 (70.9)	0.6 Deg.
45451.2	82.4 Deg.	84.6 Deg.	#7 (85.0)	#8, #12 (84.3)	0.7 Deg.
46331.2	90.7 Deg.	92.7 Deg.	#7 (93.3)	#11 (92.4)	0.9 Deg.
41549.7	102.1 Deg.	104.4 Deg.	#2 (104.8)	#11 (103.8)	1.0 Deg.

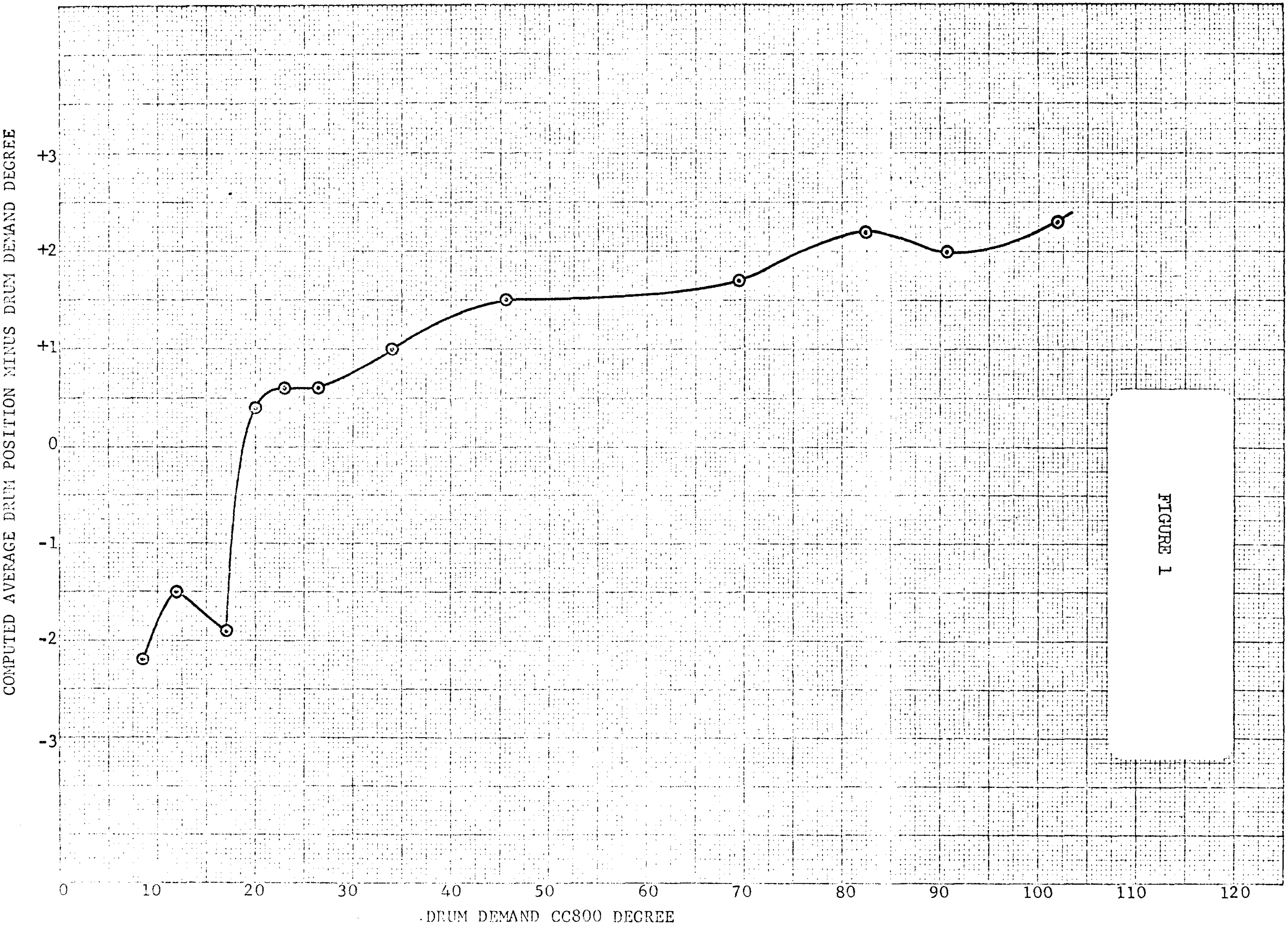
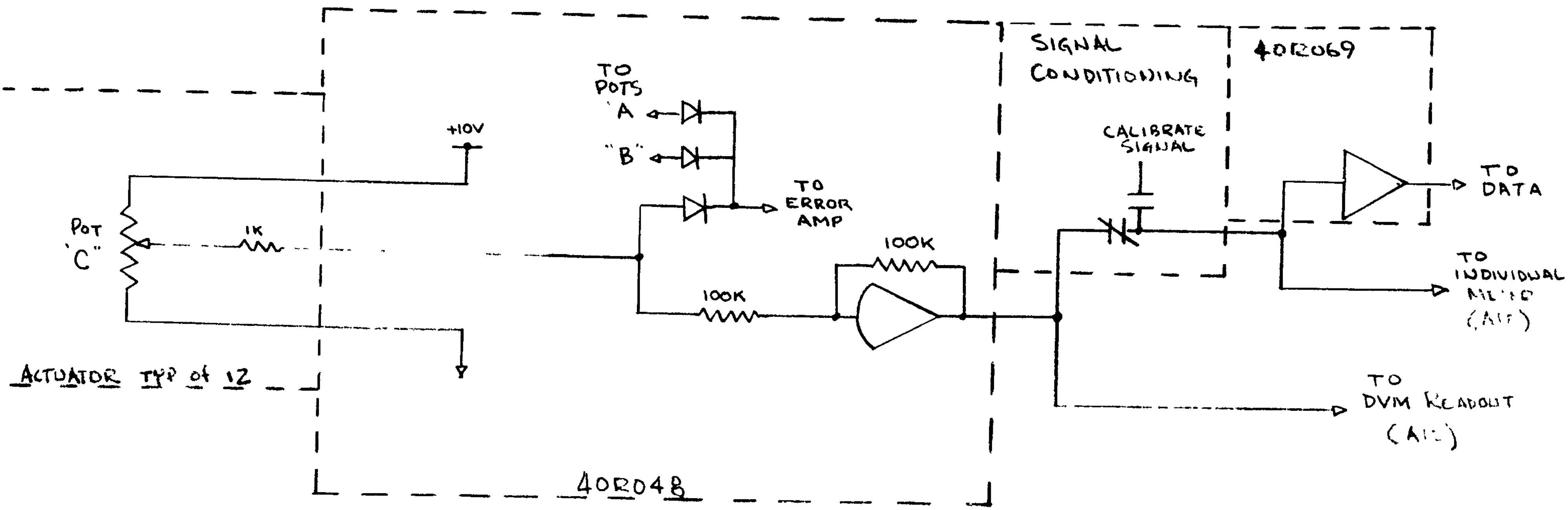

COMPUTED AVERAGE DRUM POSITION MINUS DRUM DEMAND DEGREE
+3
+2
+1
0
-1
-2
-3
0
10
20
30
40
50
60
70
80
90
100
110
120
DRUM DEMAND CC800 DEGREE

FIGURE 1

FIGURE 2



SIGNAL CONDITIONING
40R069
TO POTS
"A"
"B"
+10V
CALIBRATE SIGNAL
TO DATA
TO ERROR AMP
POT "C"
1K
100K
100K
TO INDIVIDUAL
ACTUATOR TYP of 12
TO DVM READOUT
40R048

DRUM POSITION CONTROL PLOT B

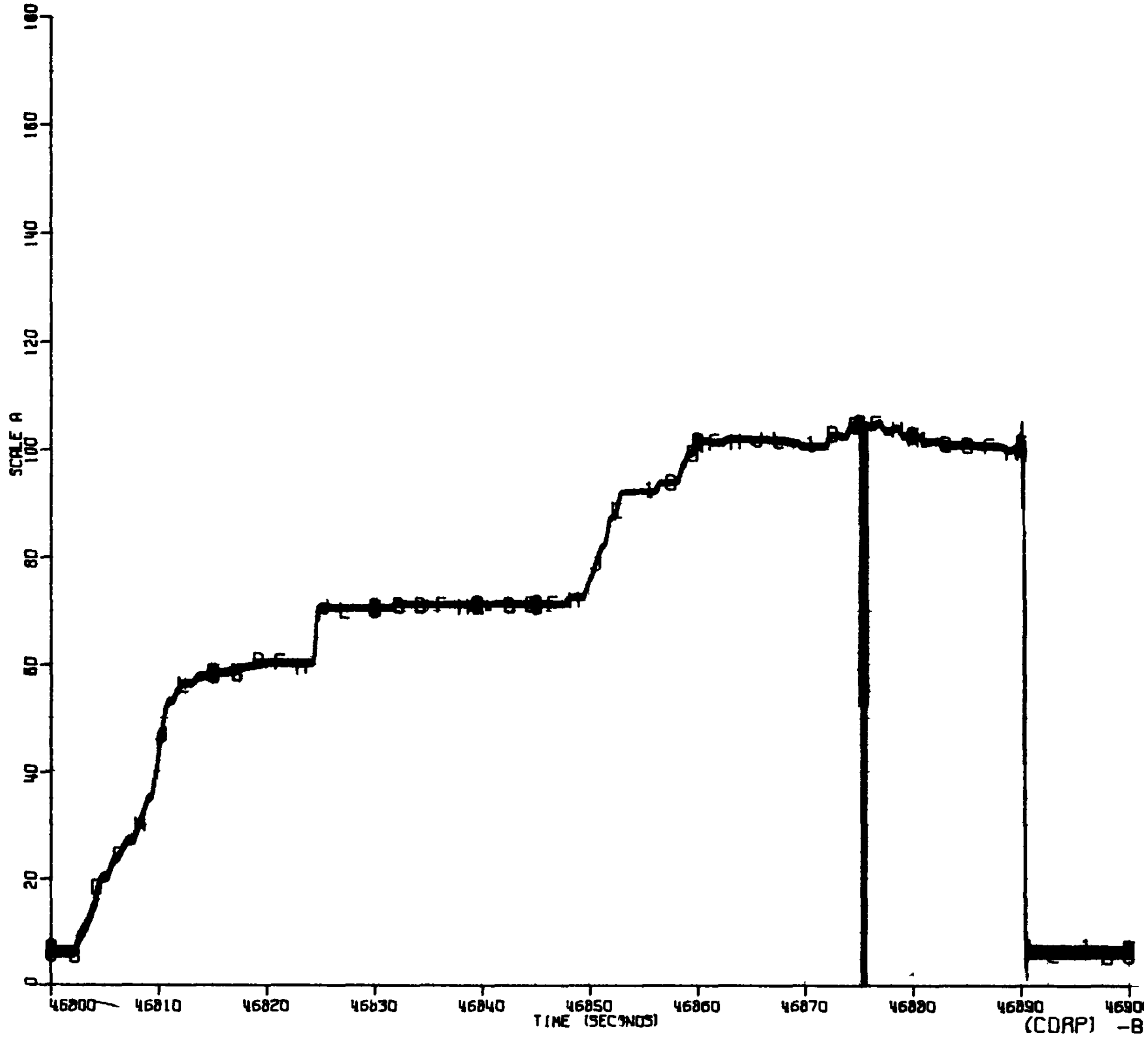
TEST NO. XEP EP-1A

DATE: 20 FEBRUARY 1969

FIGURE 3

SPEAR Memo No. 9

SCALE A	(DEGREES)	
1	DRUM MEAS. (AVG)	D.800..E
A	INDIV. DRUM POS.	D.801.AE
B	INDIV. DRUM POS.	D.802.AE
C	INDIV. DRUM POS.	D.803.AE
D	INDIV. DRUM POS.	D.804.AE
E	INDIV. DRUM POS.	D.805.AE
F	INDIV. DRUM POS.	D.806.AE
G	INDIV. DRUM POS.	D.807.AE
H	INDIV. DRUM POS.	D.808.AE
I	INDIV. DRUM POS.	D.809.AE
J	INDIV. DRUM POS.	D.810.AE
K	INDIV. DRUM POS.	D.811.AE
L	INDIV. DRUM POS.	D.812.AE



(CDRP) -B

DRUM POSITION CONTROL PLOT A

TEST NO. XE-P EP-1A

DATE: 20 FEBRUARY 1969

SCALE A (VOLTS)

1	DRUM DEMAND POT.	CC637..E

SCALE B (DEGREES)

2	DRUM DEMAND	CC800..E
3	DRUM MEAS (AVG)	D.800..E
4	DRUM ERROR (X10 O- CEN.)	10(CC800..E -D.800..E)+90

EVENTS

A	DRUM POS. CONT.	SC608..E
B	POWER CONT.	SC610..E
C	TEMP. LOOP CLOSURE	BC655..E
D	DRUM OVERRIDE	BC662..E

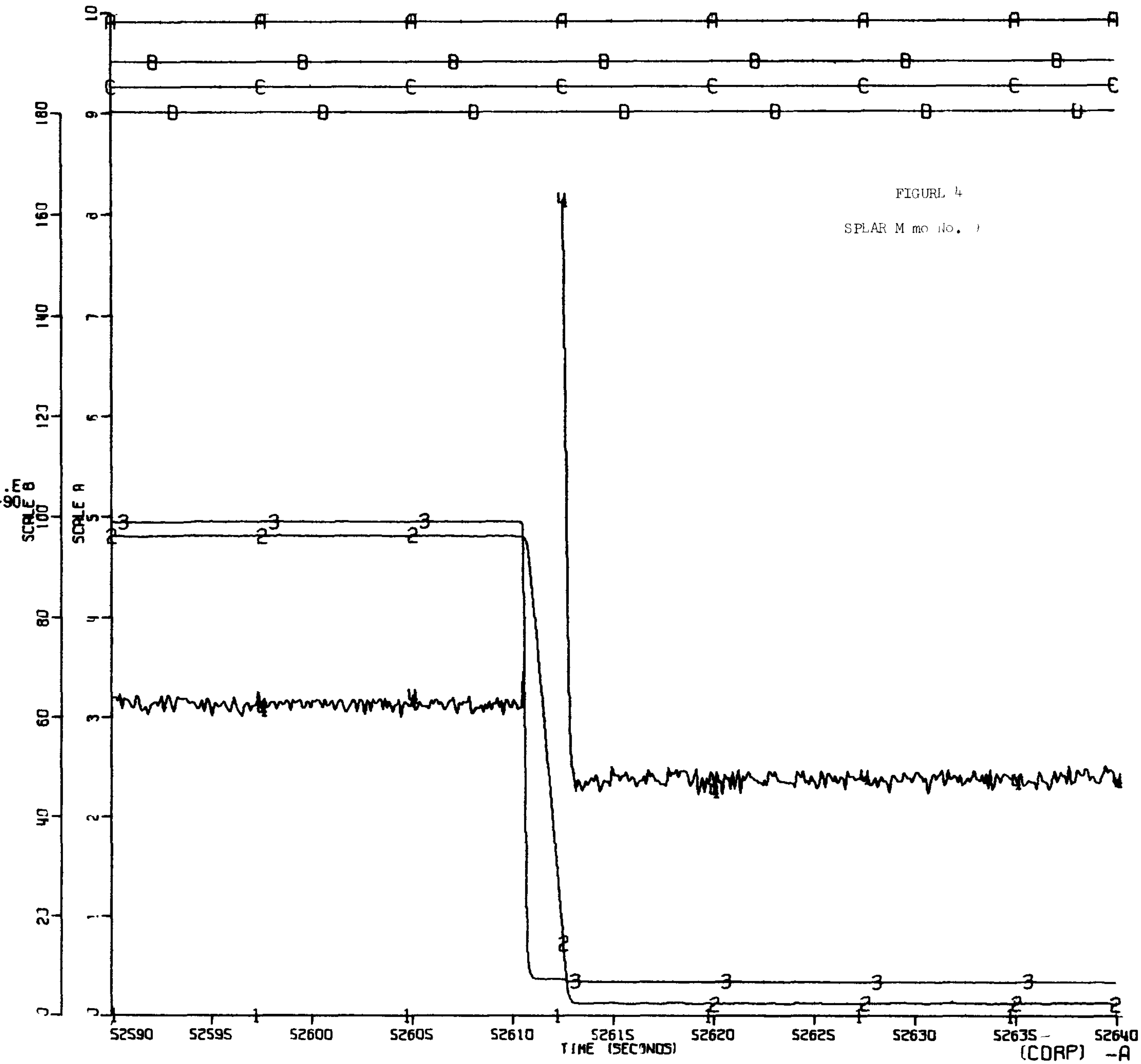
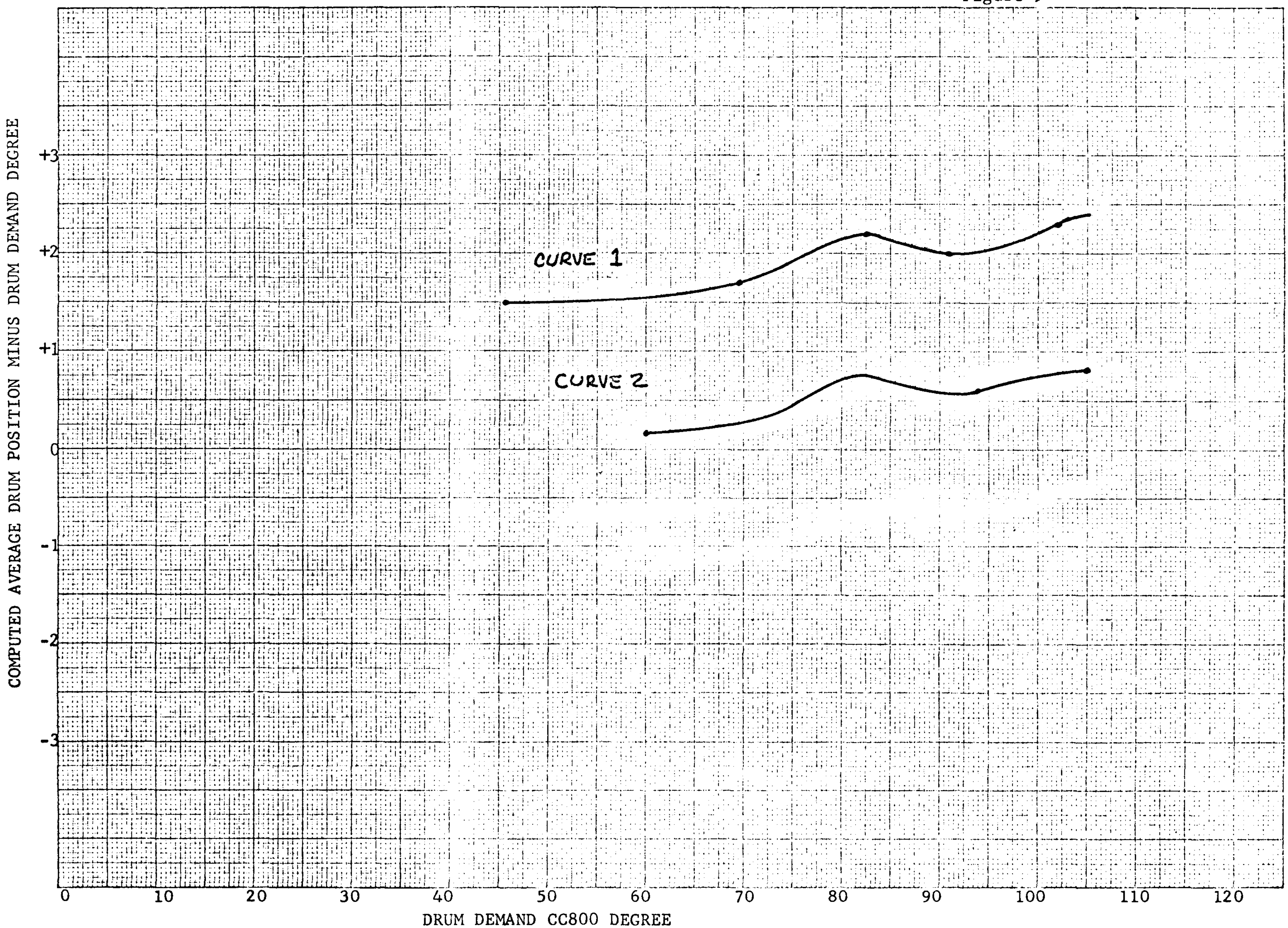
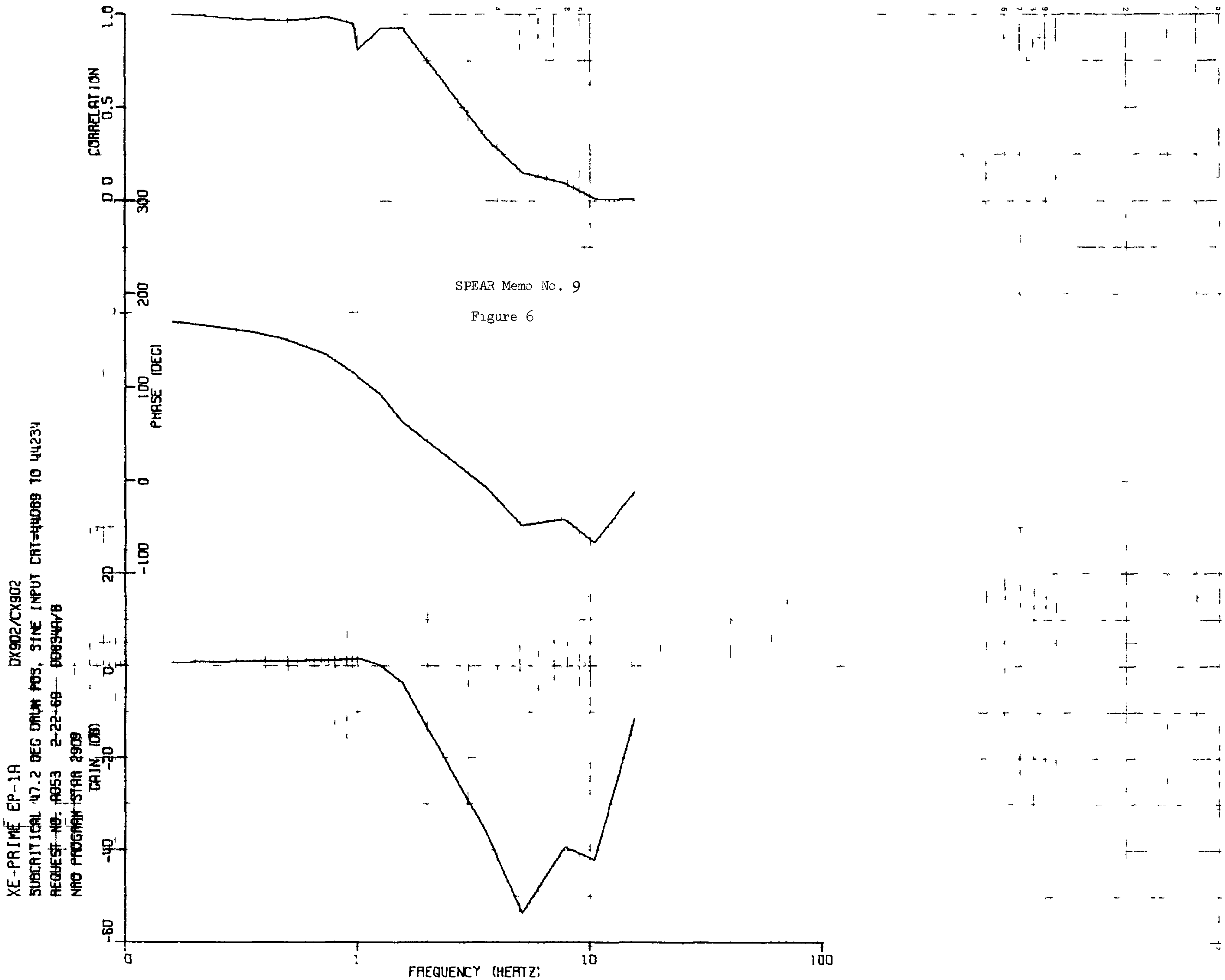


Figure 5



SPEAR Memo No. 9

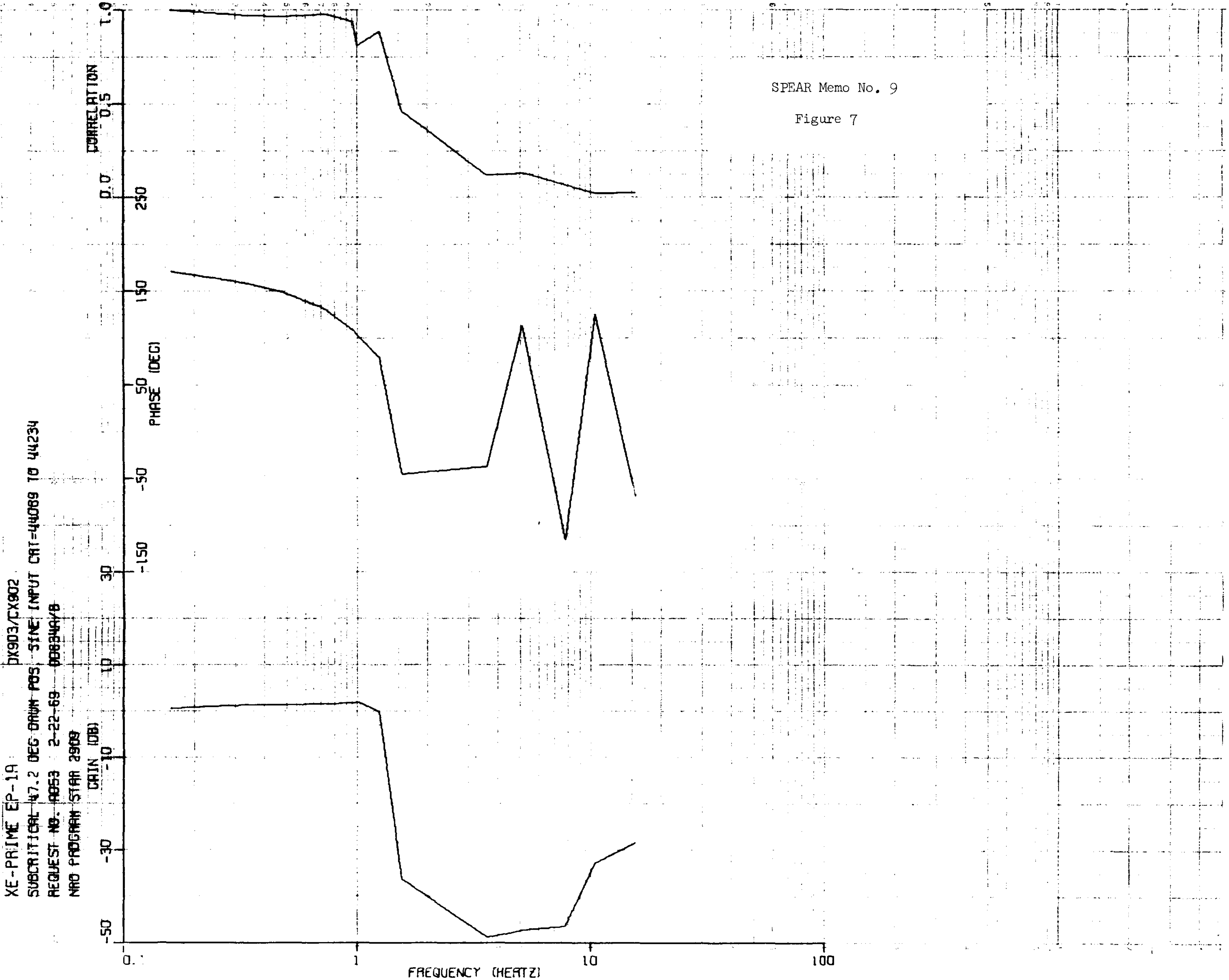


SPEAR Memo No. 9

Figure 6

SPEAR Memo No. 9

Figure 7



SPEAR Memo No.

Figure 8

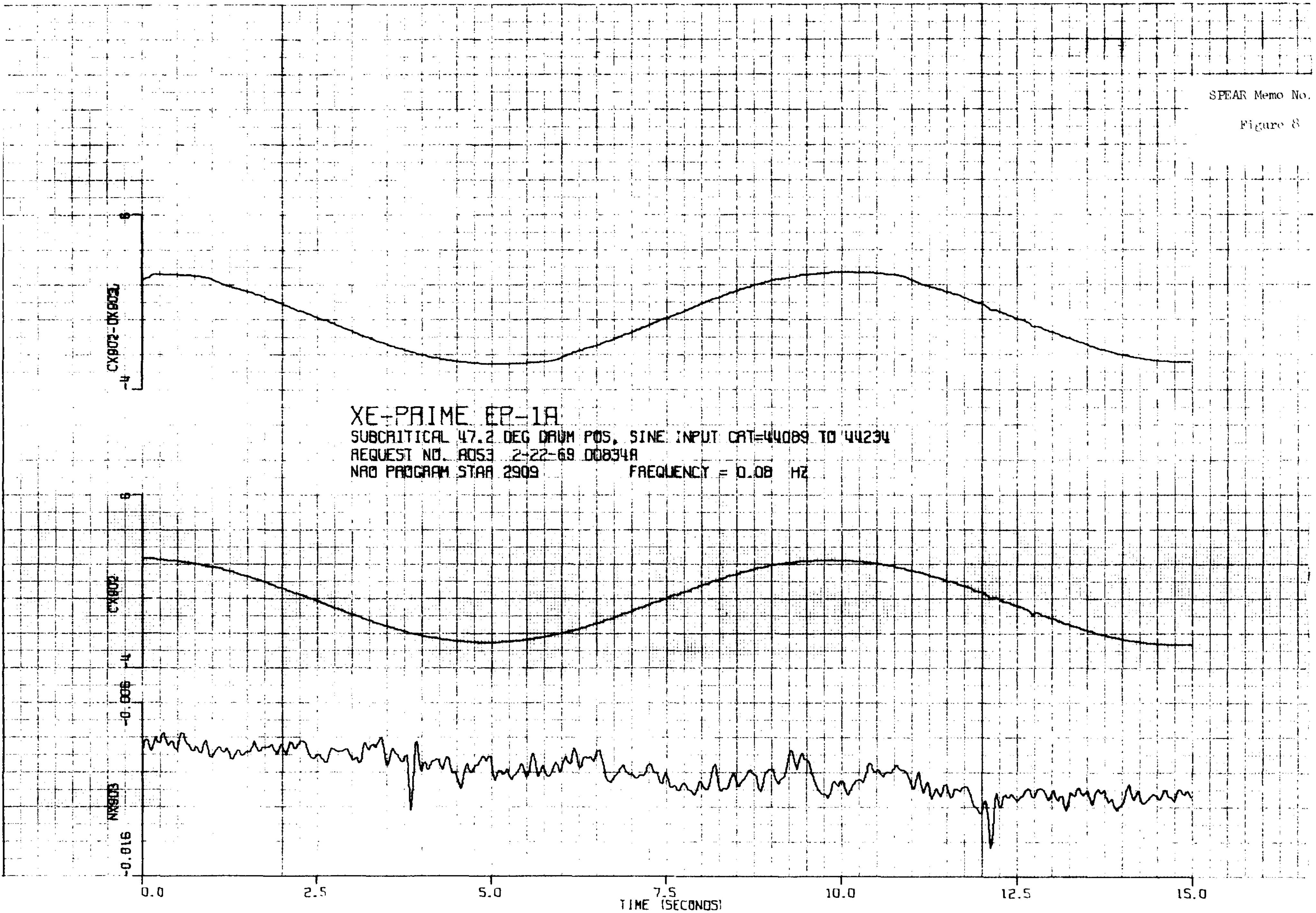


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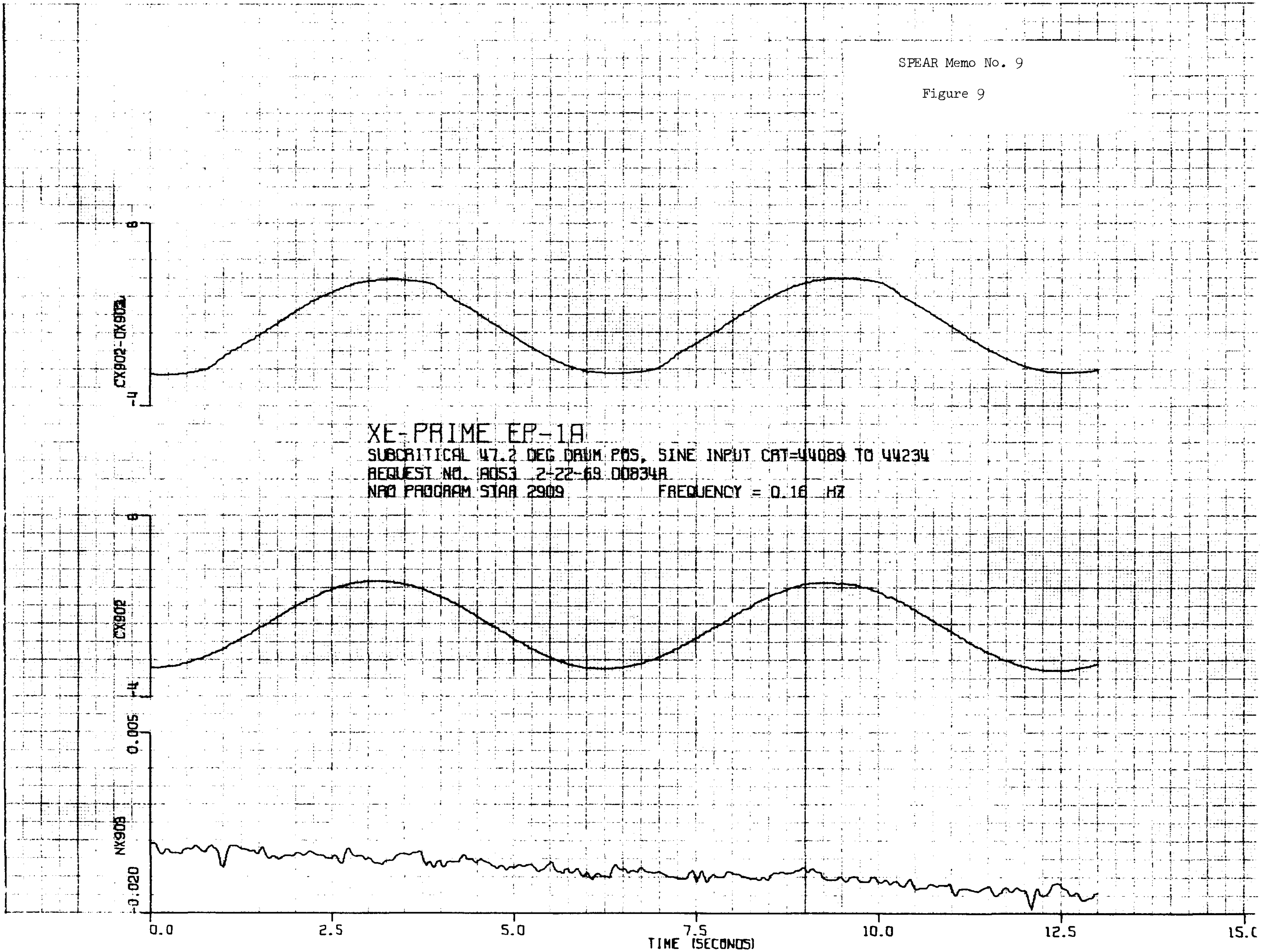
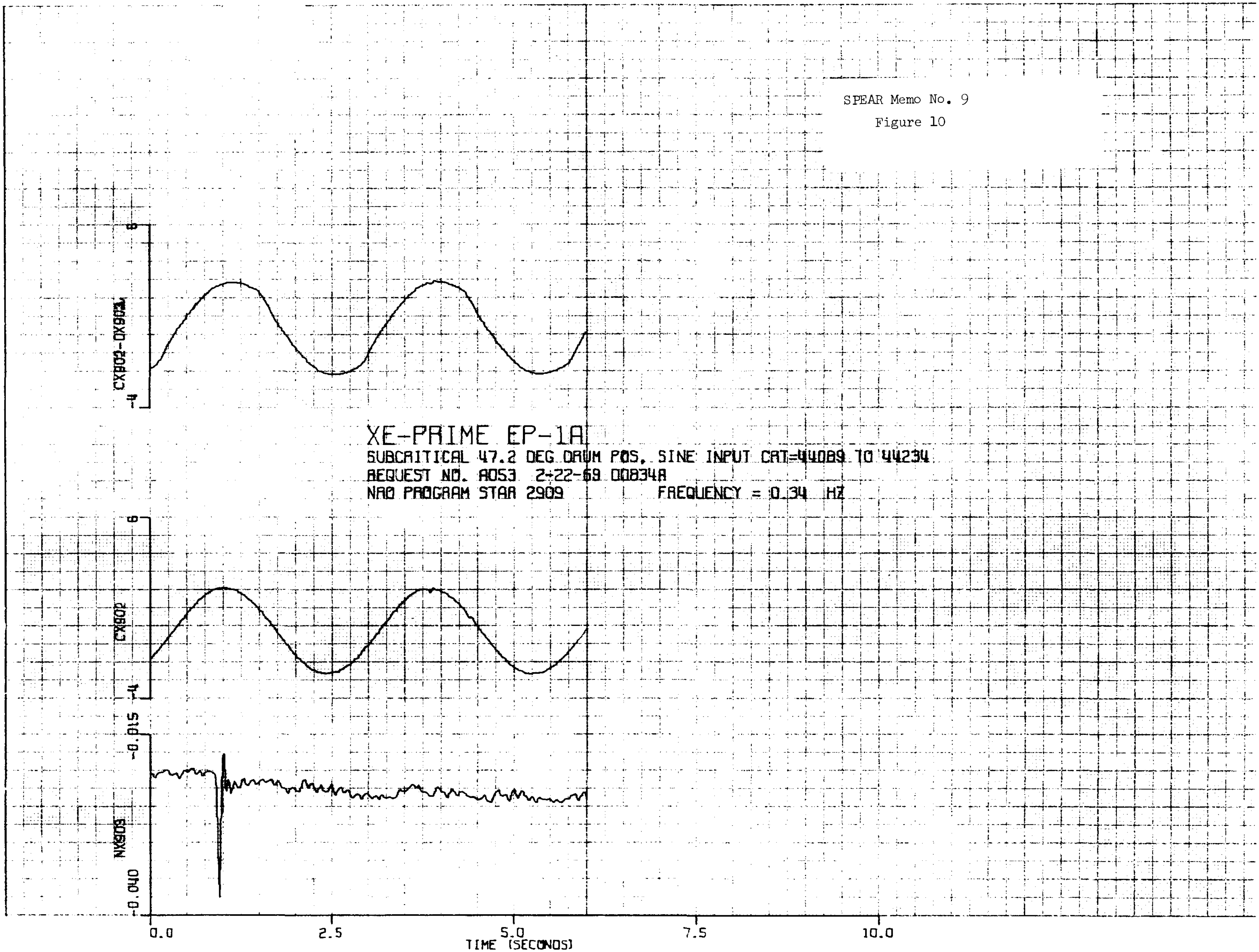
Figure 9



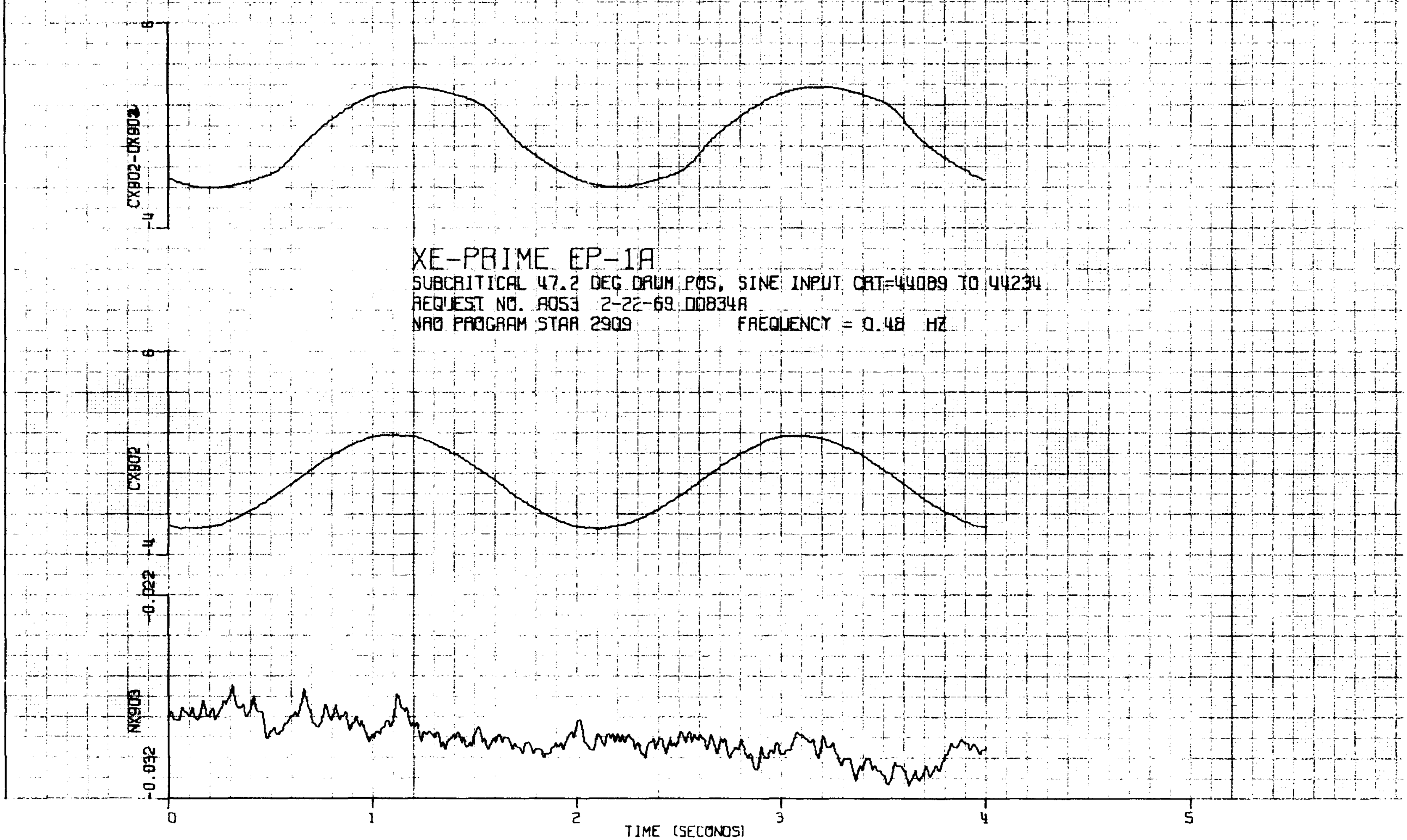
SPEAR Memo No. 9

Figure 10



SPEAR Memo No. 9

Figure 11



SPEAR Memo No. 9

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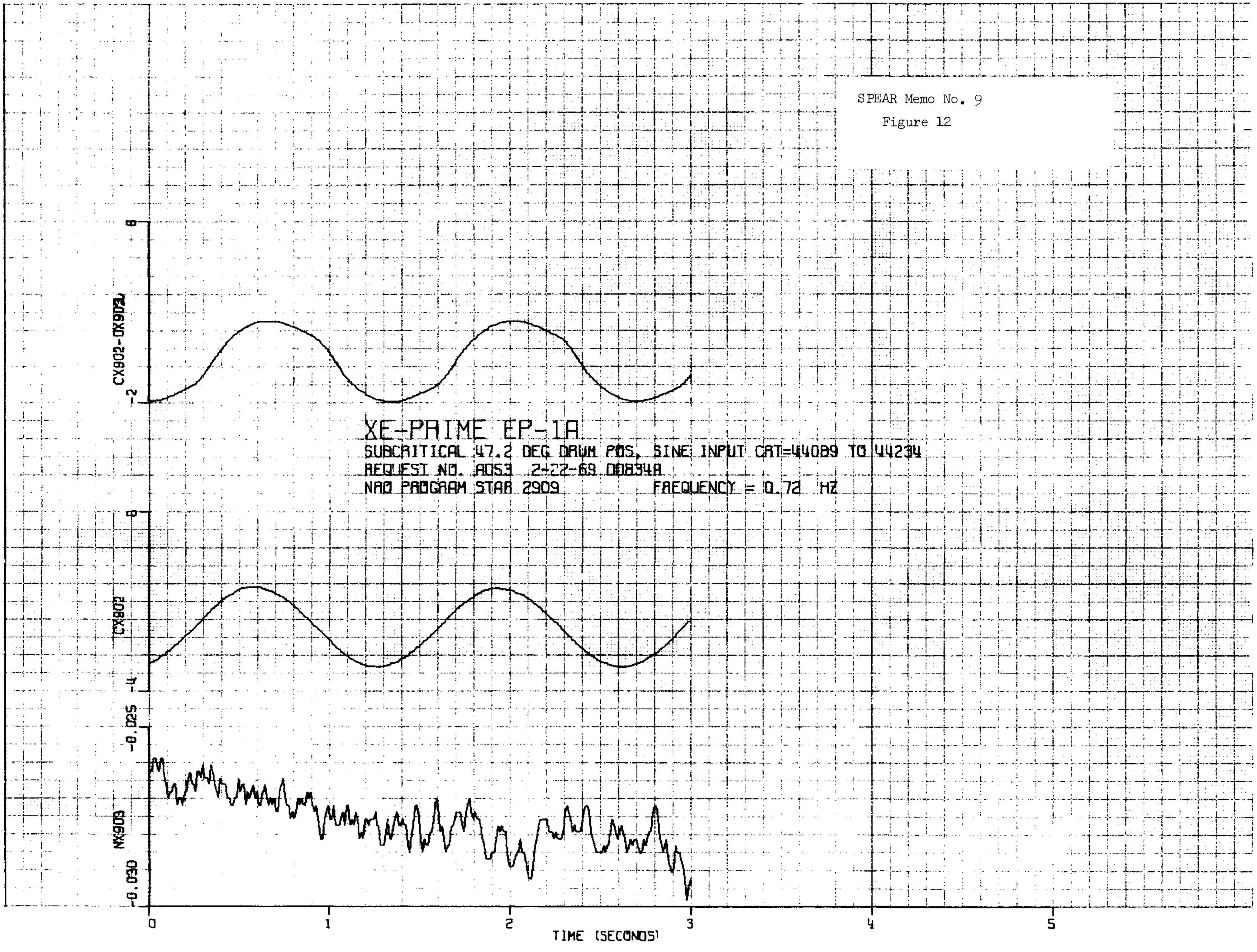

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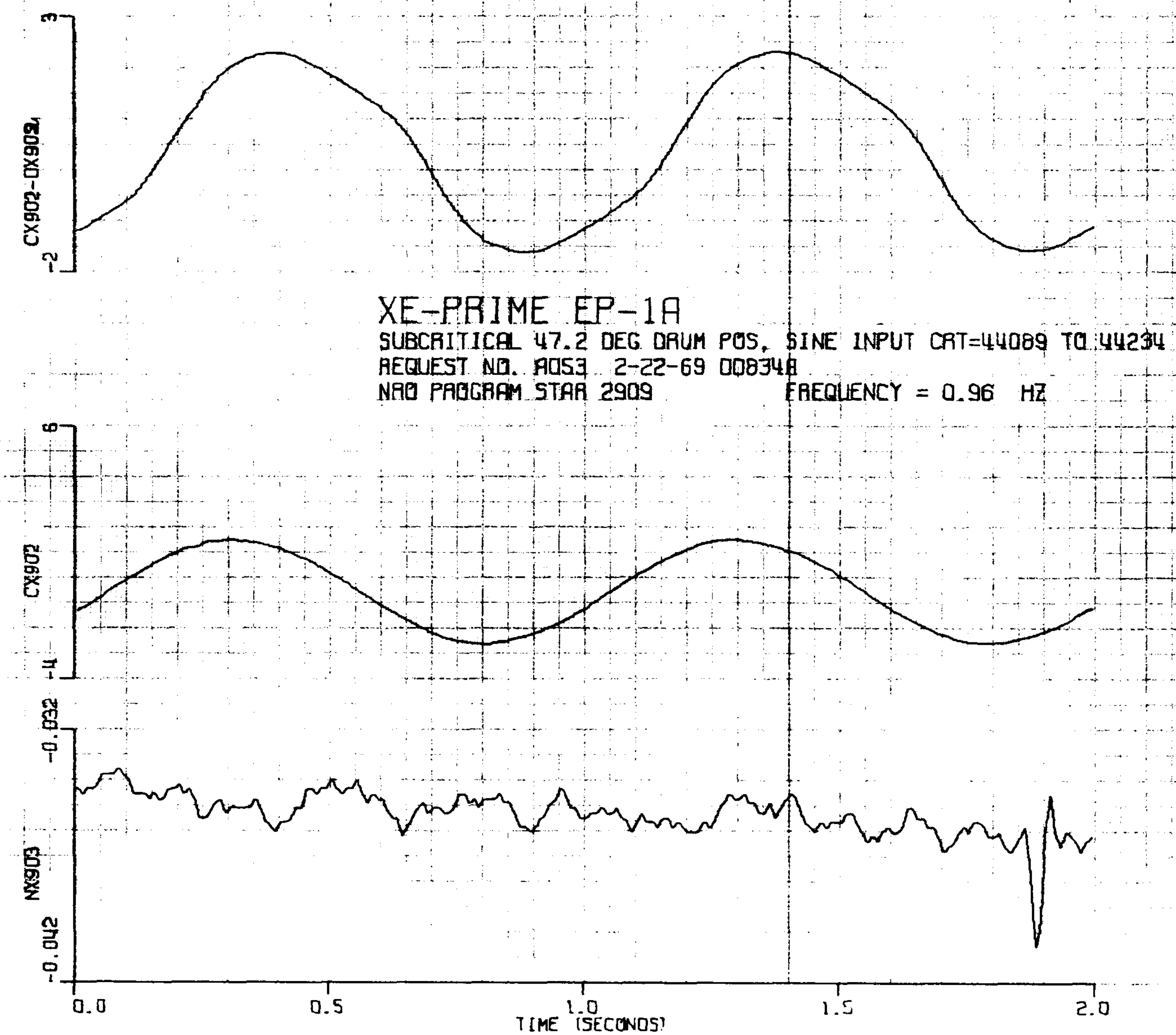
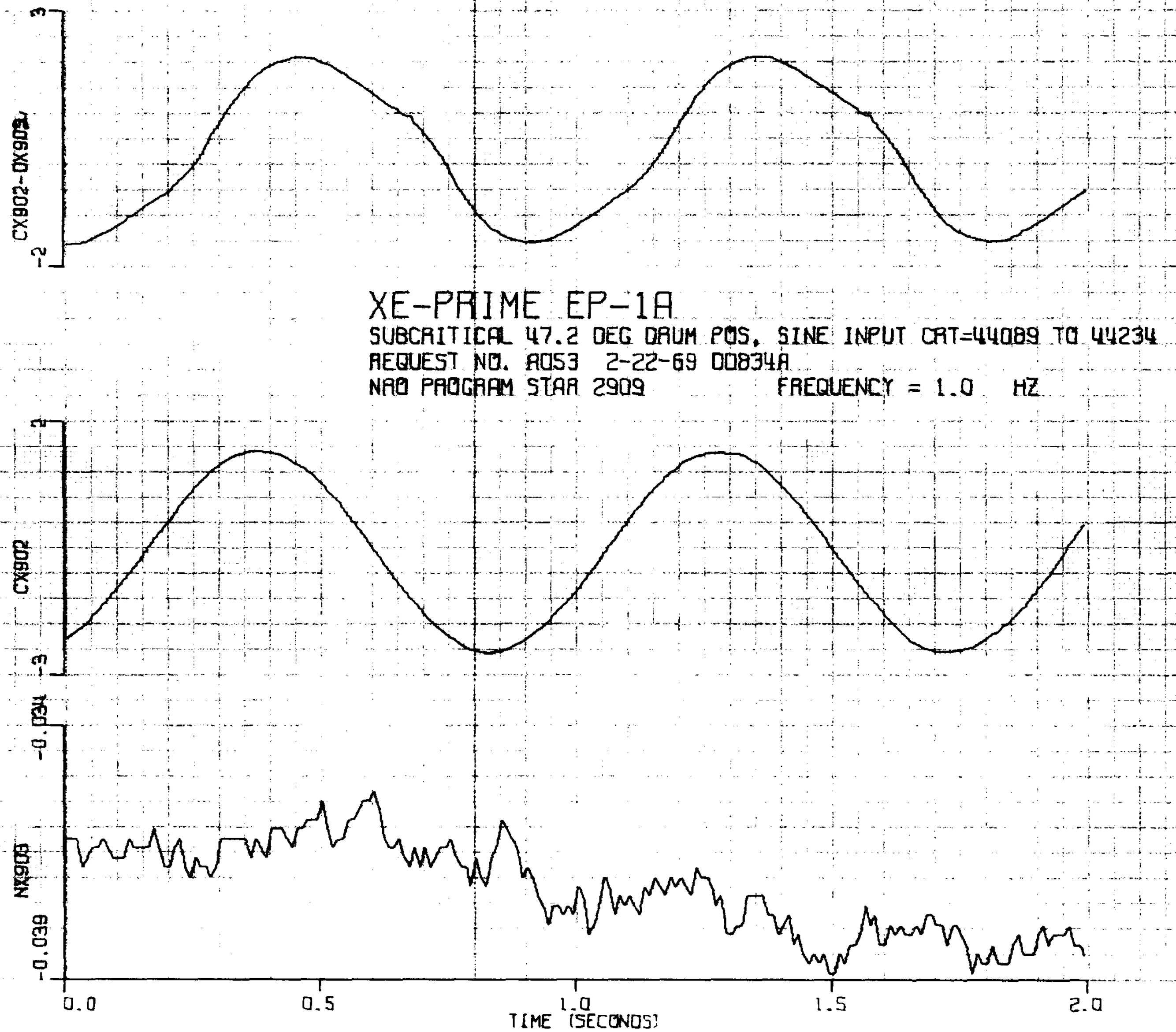
Figure 13



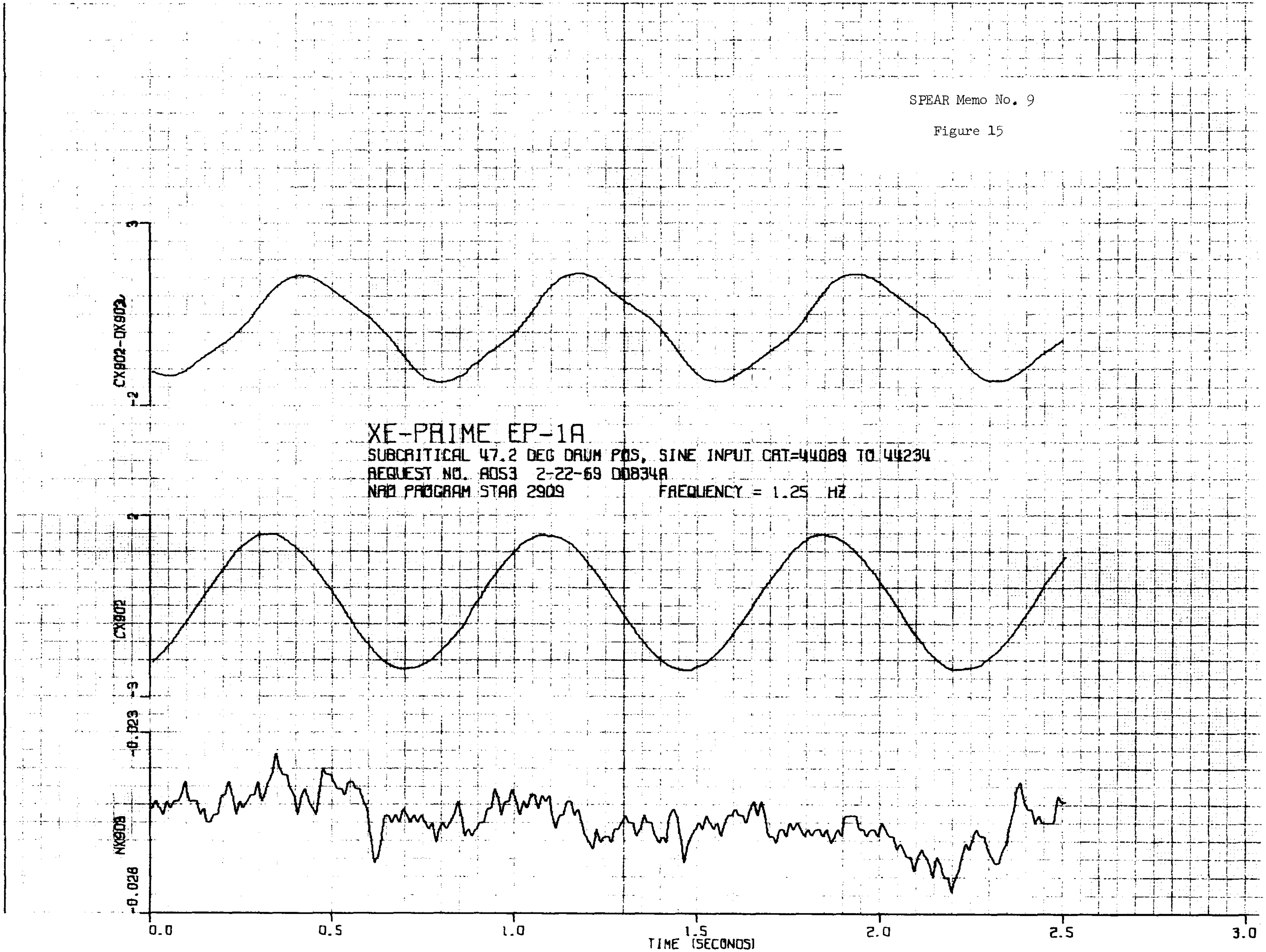
SPEAR Memo No. 9

Figure 14



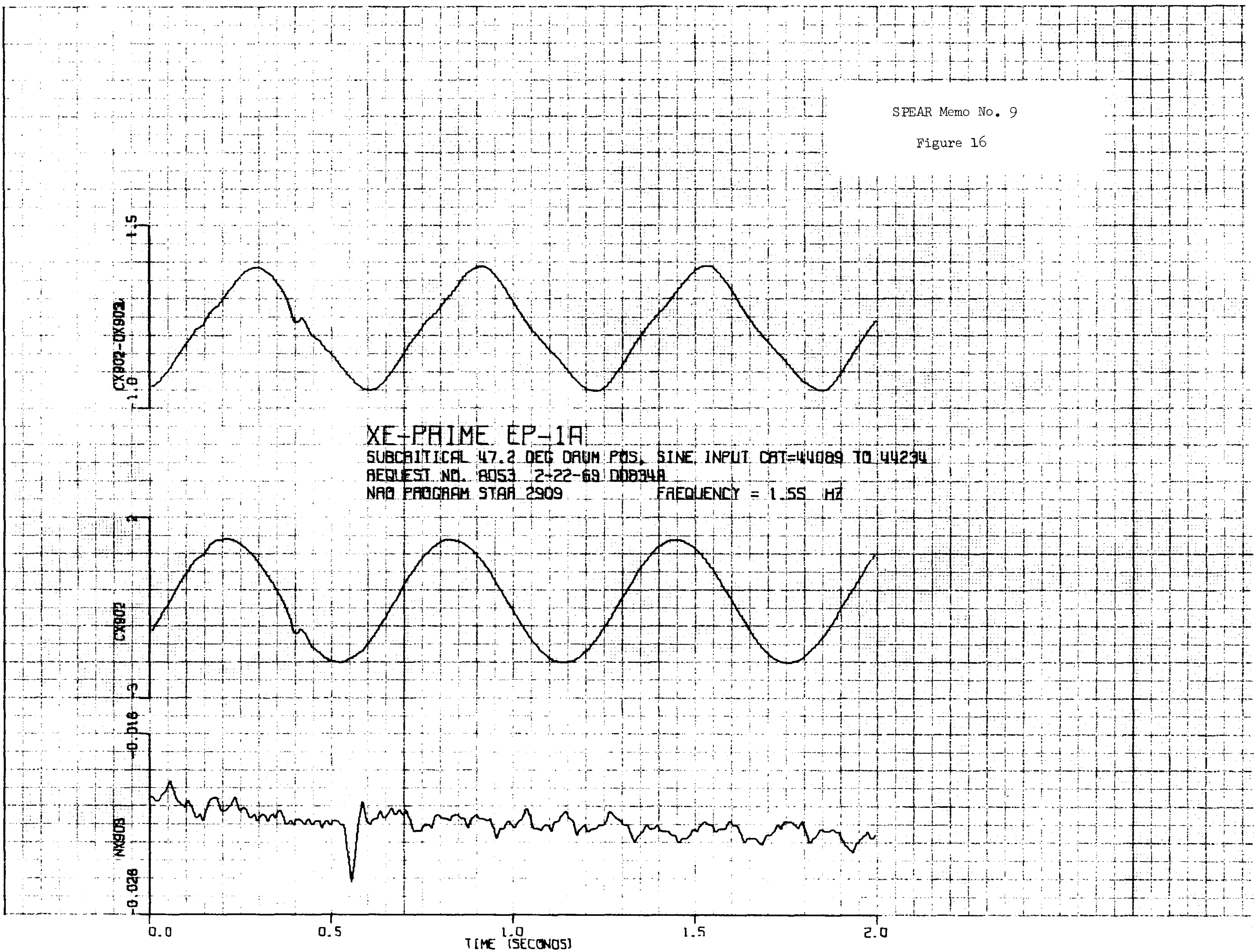
SPEAR Memo No. 9

Figure 15



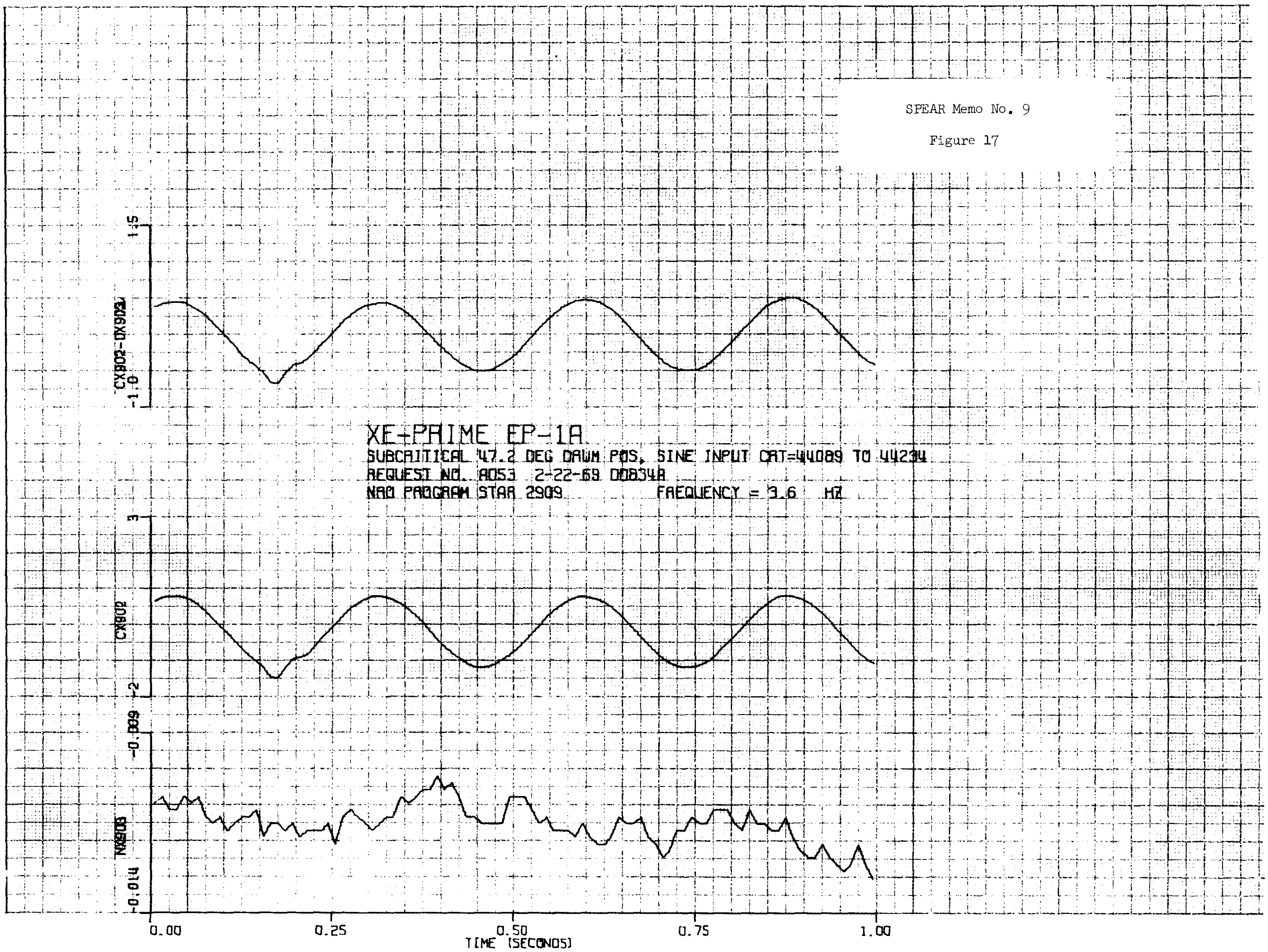
SPEAR Memo No. 9

Figure 16



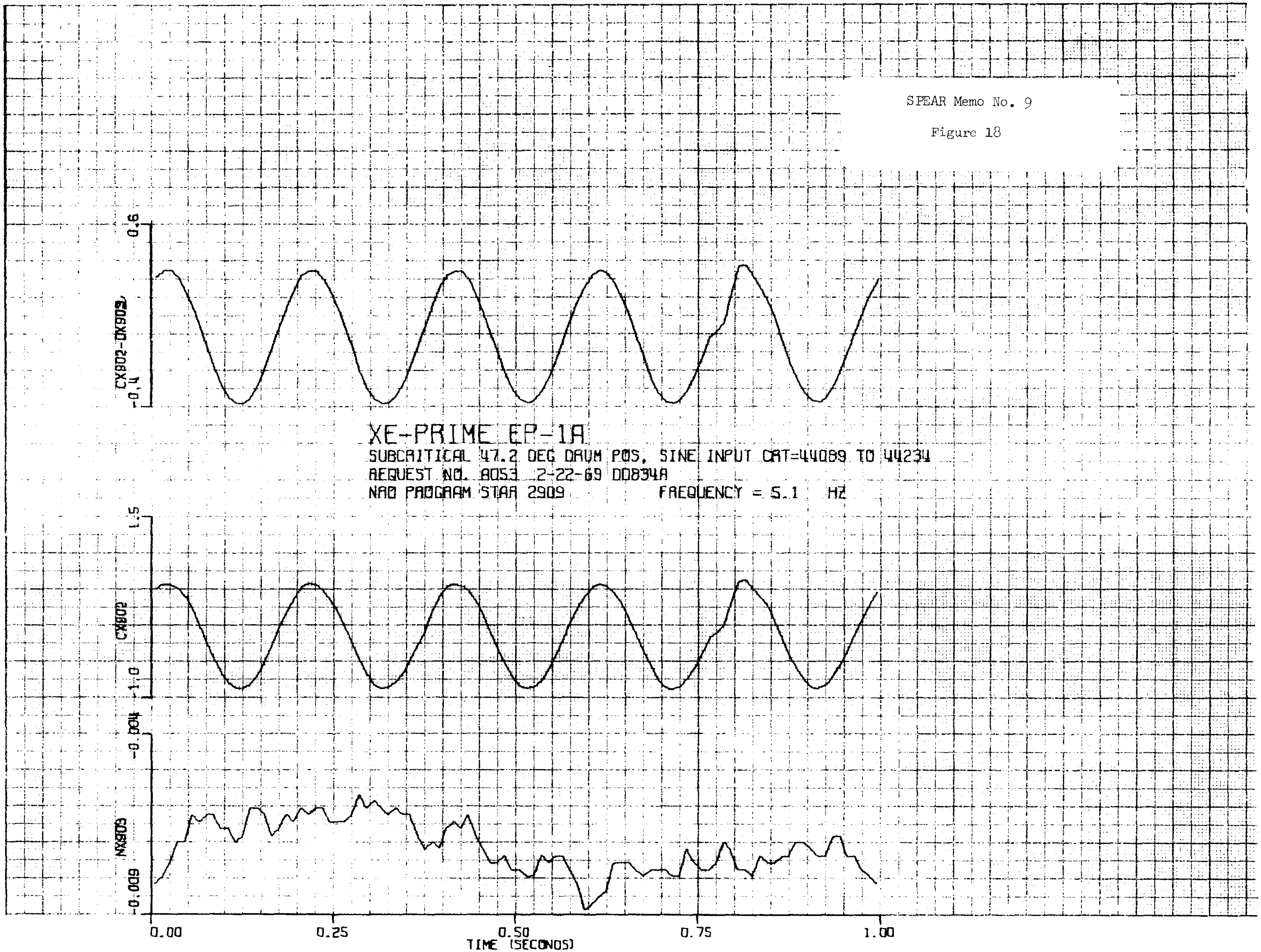
SPEAR Memo No. 9

Figure 17



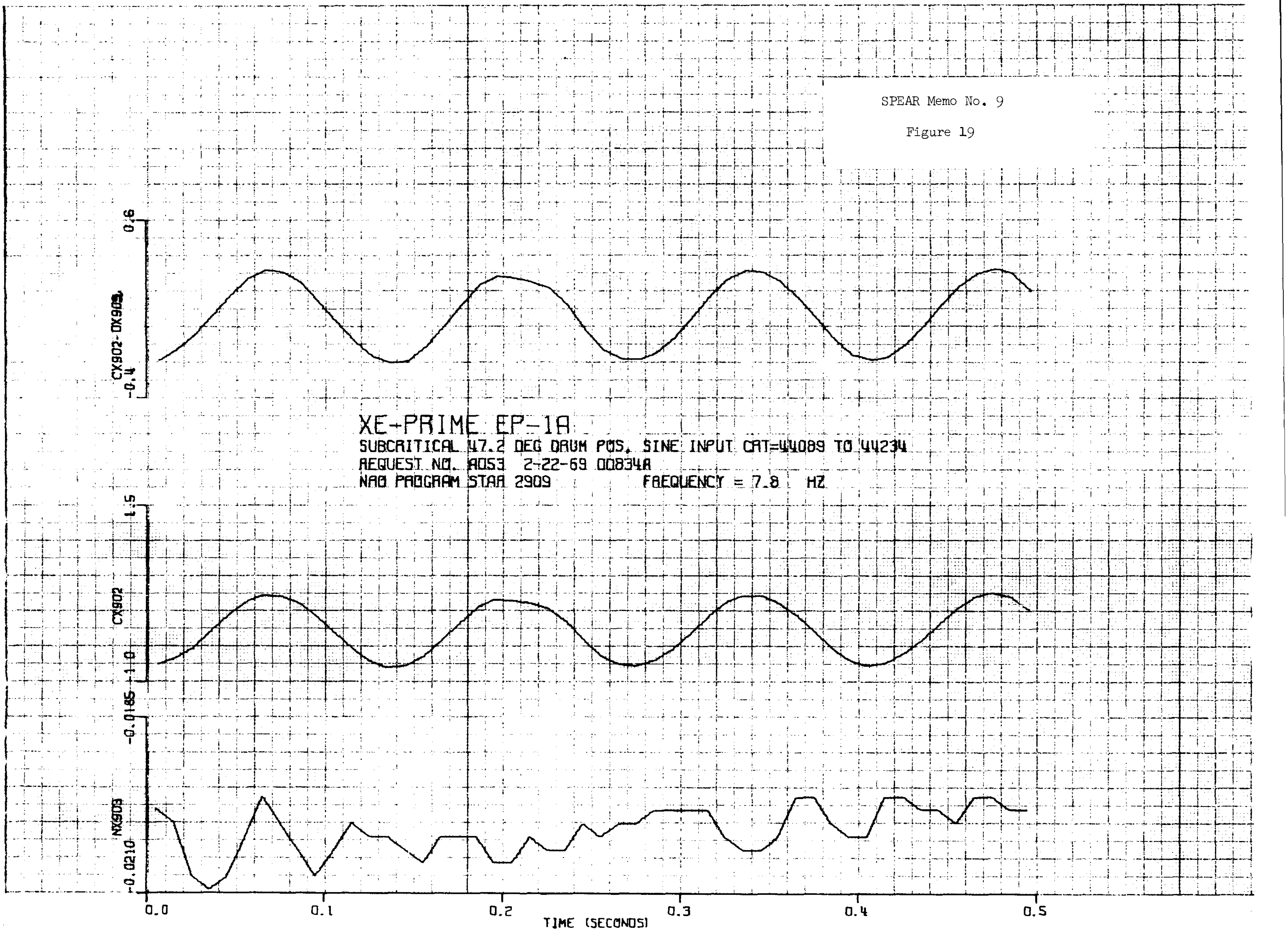
SPEAR Memo No. 9

Figure 18



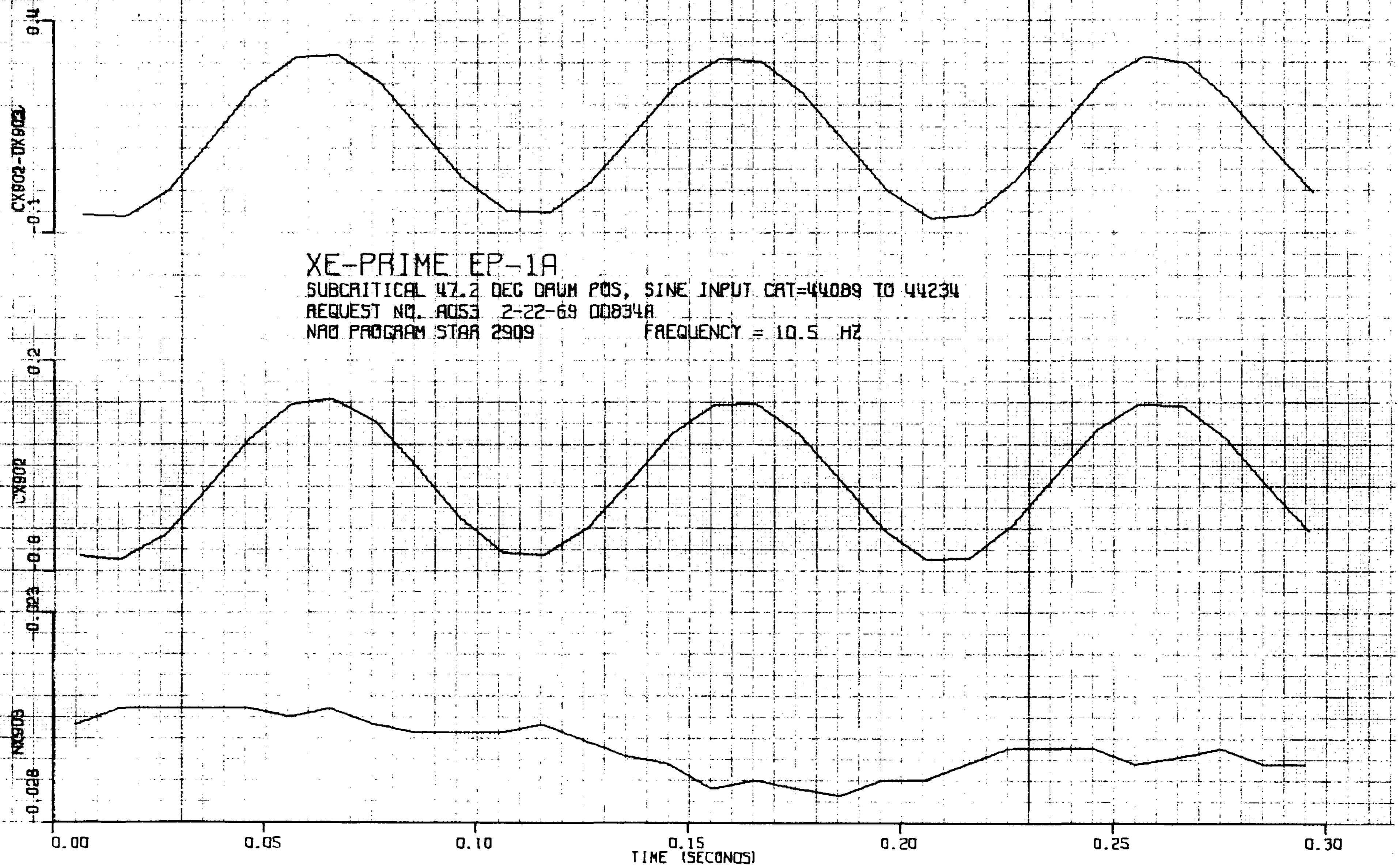
SPEAR Memo No. 9

Figure 19



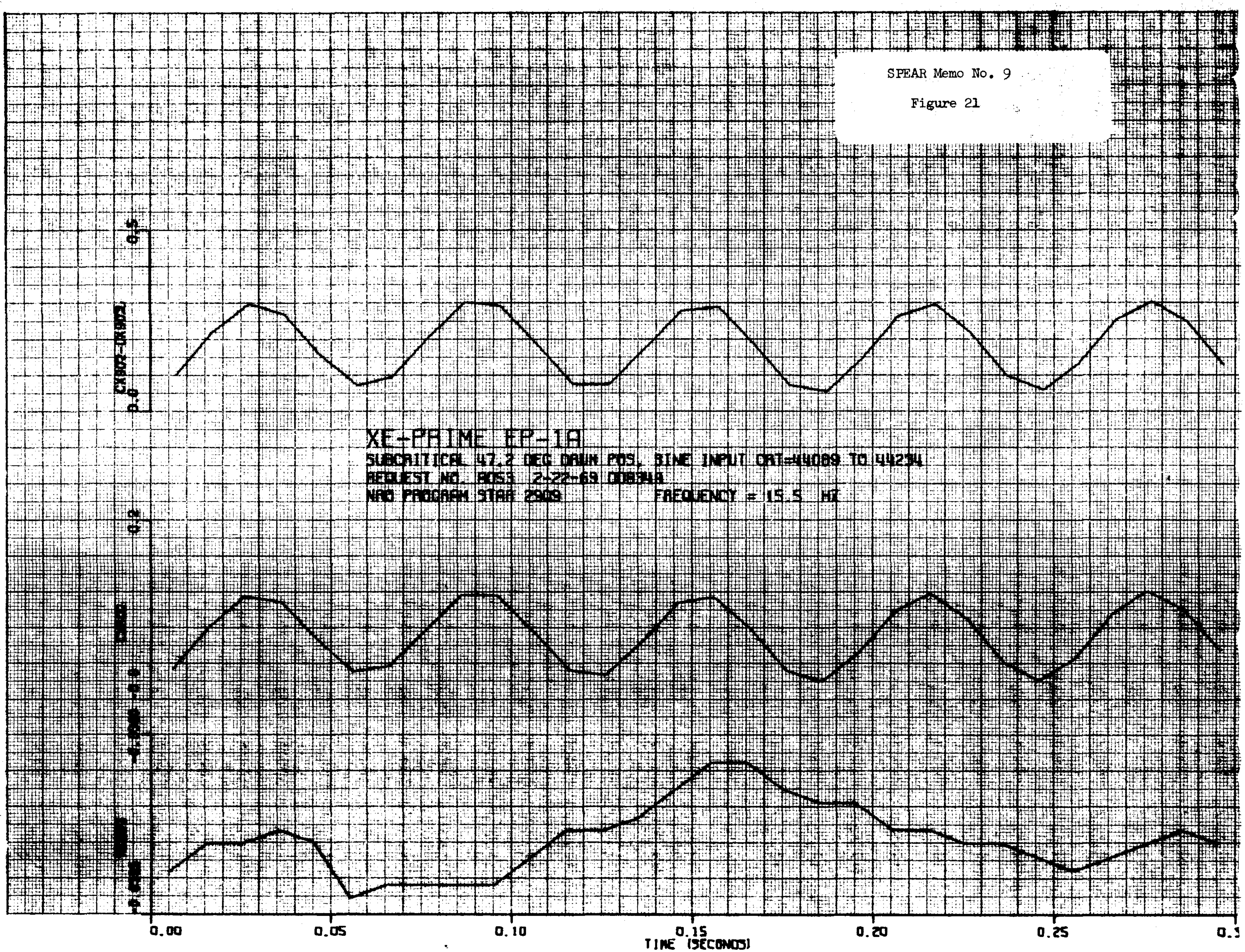
SPEAR Memo No. 9

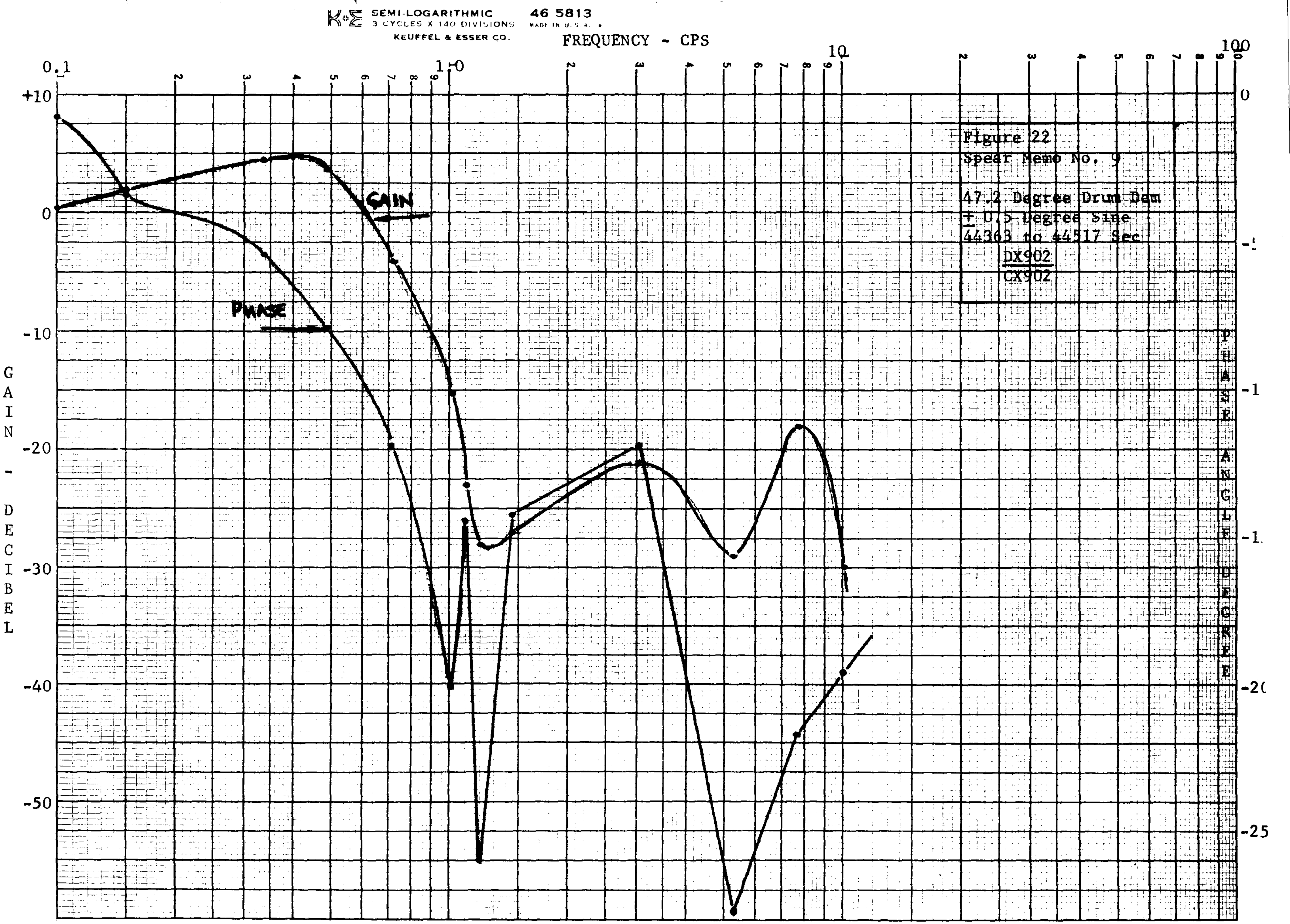
Figure 20



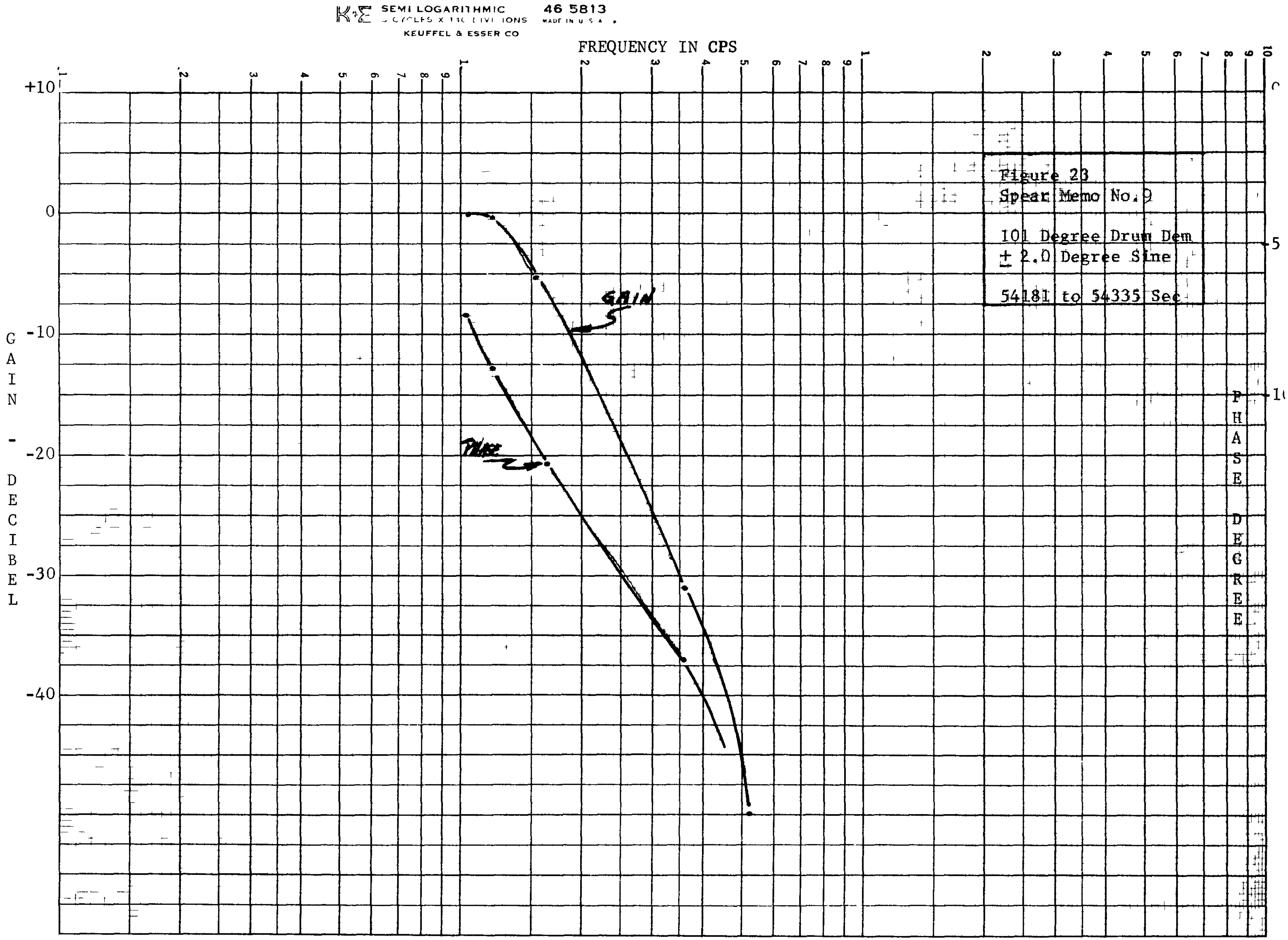
SPEAR Memo No. 9

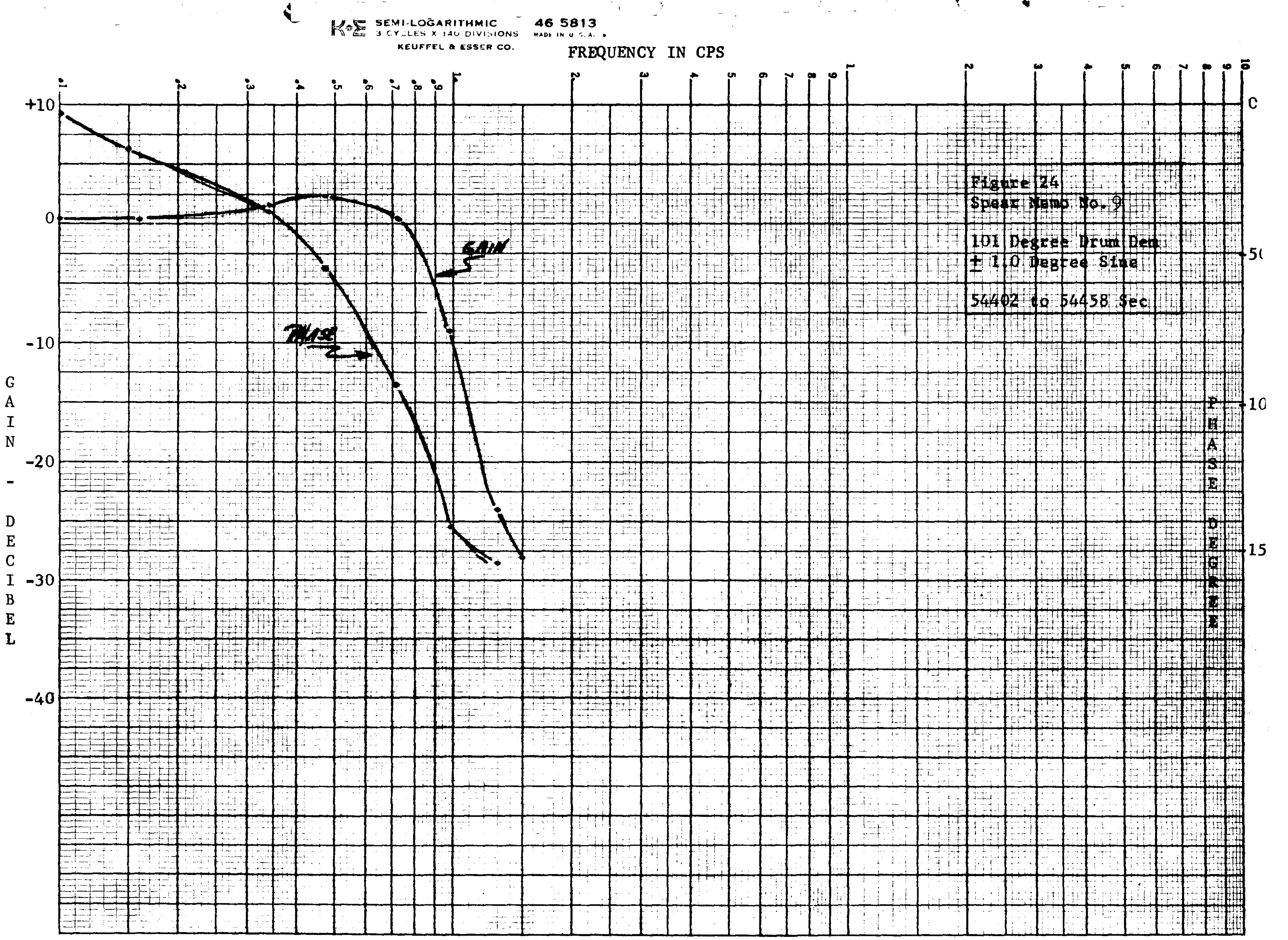
Figure 21





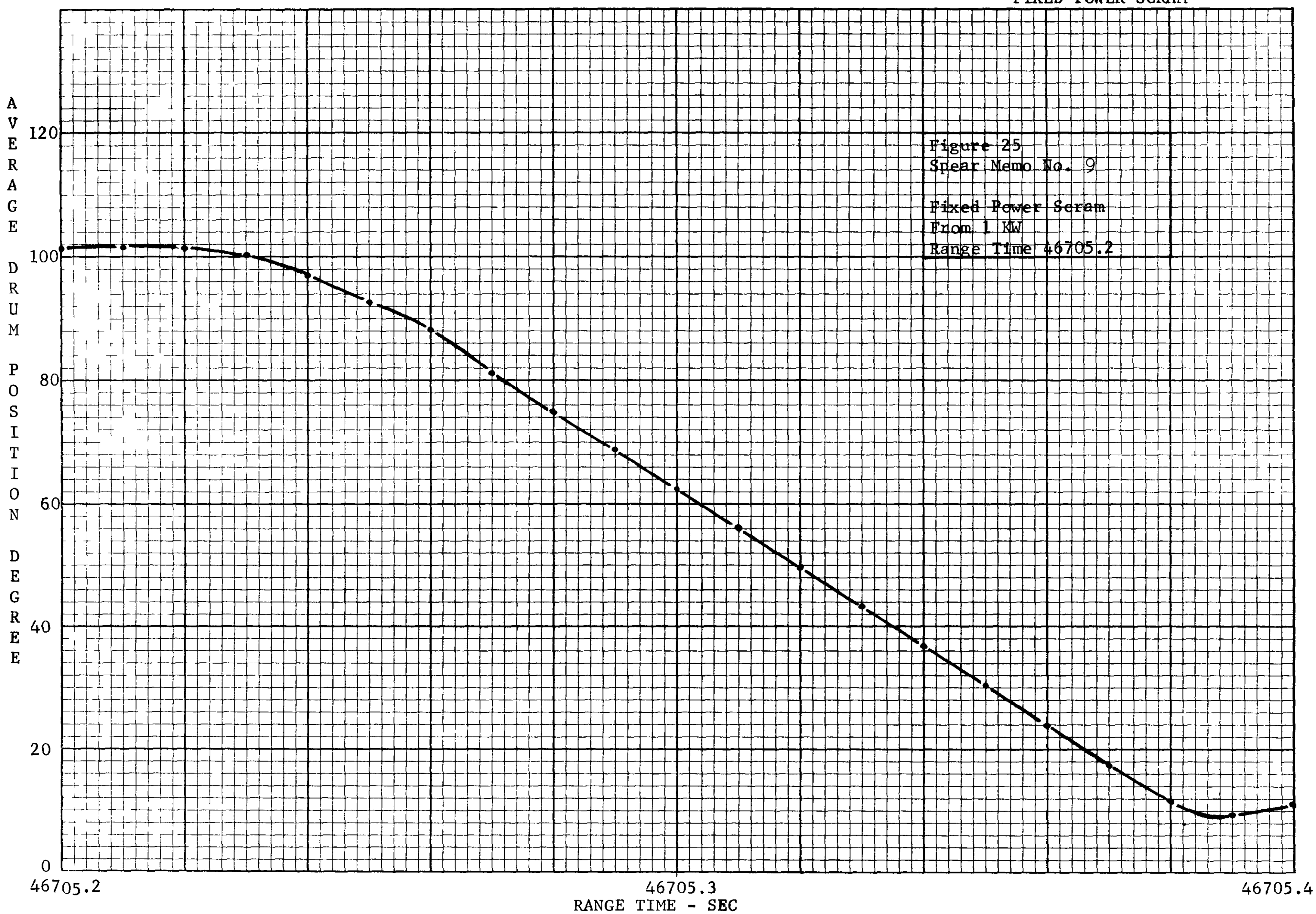
SEMI-LOGARITHMIC 46 5813
3 CYCLES X 140 DIVISIONS
KEUFFEL & ESSER CO.
FREQUENCY - CPS
0.1
1.0
10
100
+10
0
-10
-20
-30
-40
-50
GAIN - DECIBEL
PHASE ANGLE DEGREE
GAIN
PHASE
Figure 22
Spear Memo No. 9
47.2 Degree Drum Dem
± 0.5 Degree Sine
44363 to 44517 Sec
DX902
CX902


K+E SEMI LOGARITHMIC 46 5813
KEUFFEL & ESSER CO
FREQUENCY IN CPS
GAIN - DECIBEL
PHASE DEGREE
+10
0
-10
-20
-30
-40
GAIN
PHASE
Figure 23
Spear Memo No. 9
101 Degree Drum Dem
± 2.0 Degree Sine
54181 to 54335 Sec



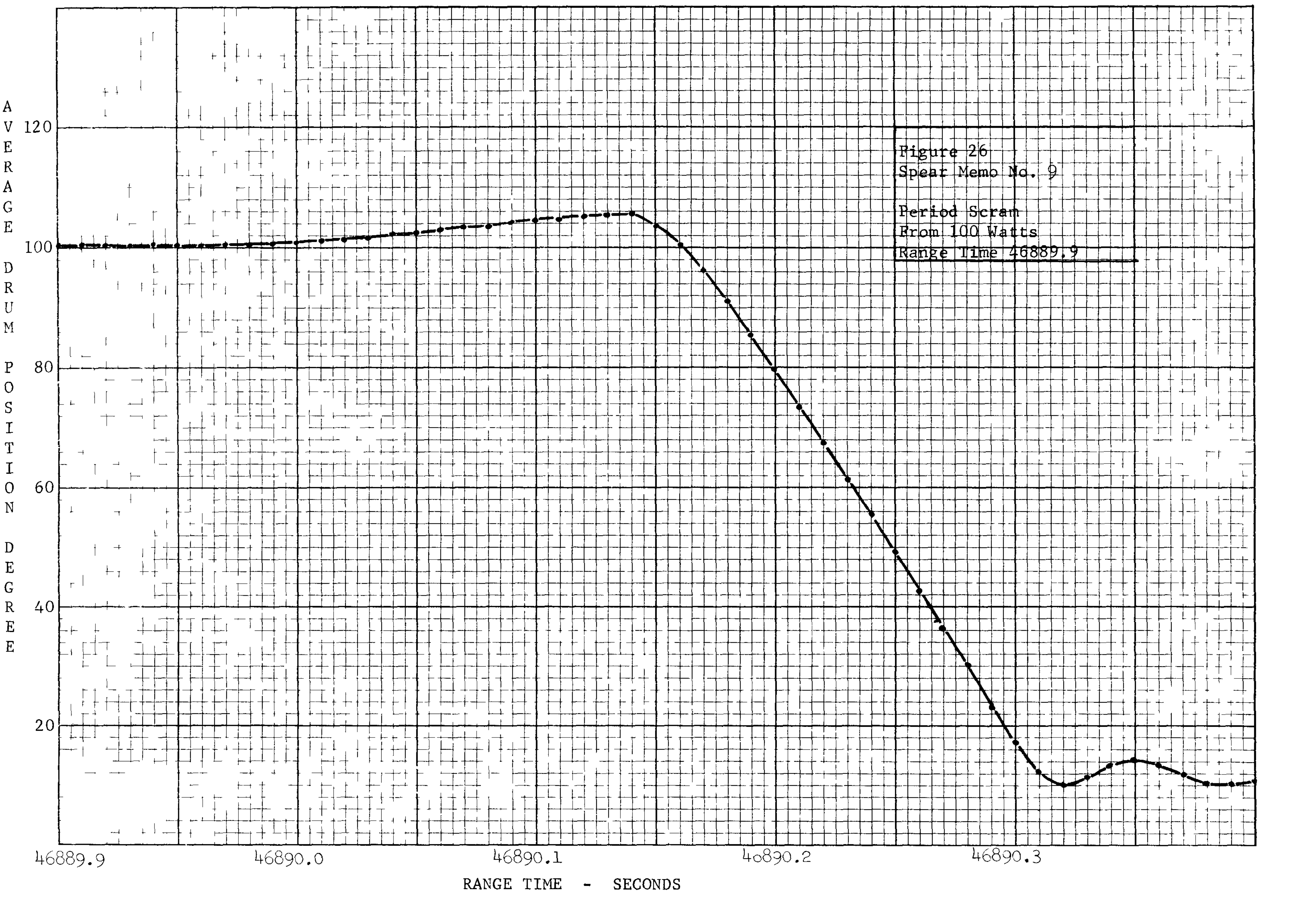
K+E SEMI-LOGARITHMIC 46 5813
3 CYCLES X 140 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.
FREQUENCY IN CPS
.1 .2 .3 .4 .5 .6 .7 .8 .9 1. 2. 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9 10
+10
0
-10
-20
-30
-40
GAIN - DECIBEL
PHASE DEGREE
50
10
15
GAIN
PHASE
Figure 24
Spear Memo No. 9
101 Degree Drum Den
± 1.0 Degree Sine
54402 to 54458 Sec

FIXED POWER SCRAM

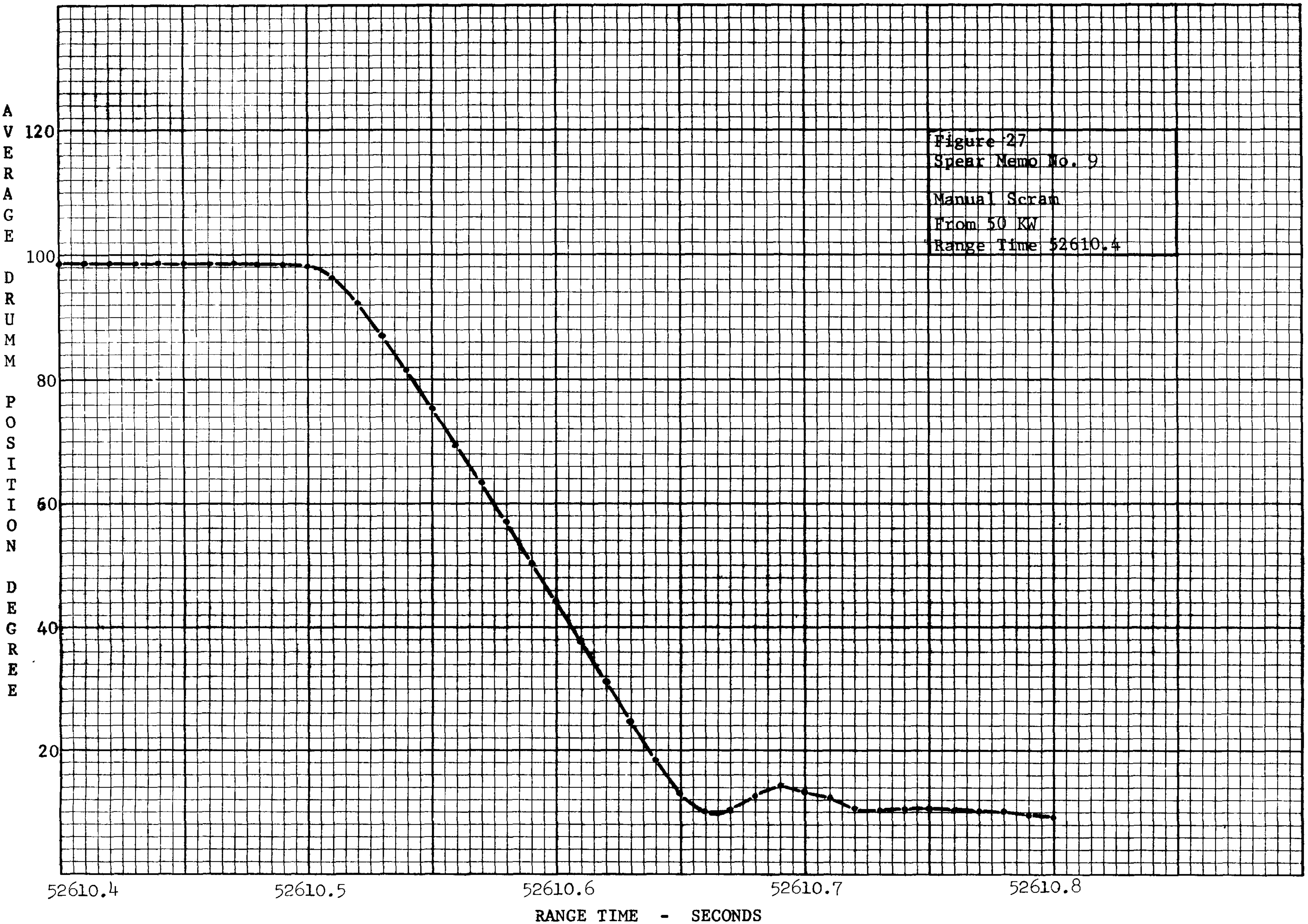


K+E 10 X 10 TO THE INCH 0070 7 X 10 INCHES MADE IN U.S.A. KEUFFEL & ESSER CO [redacted]

PERIOD SCRAM

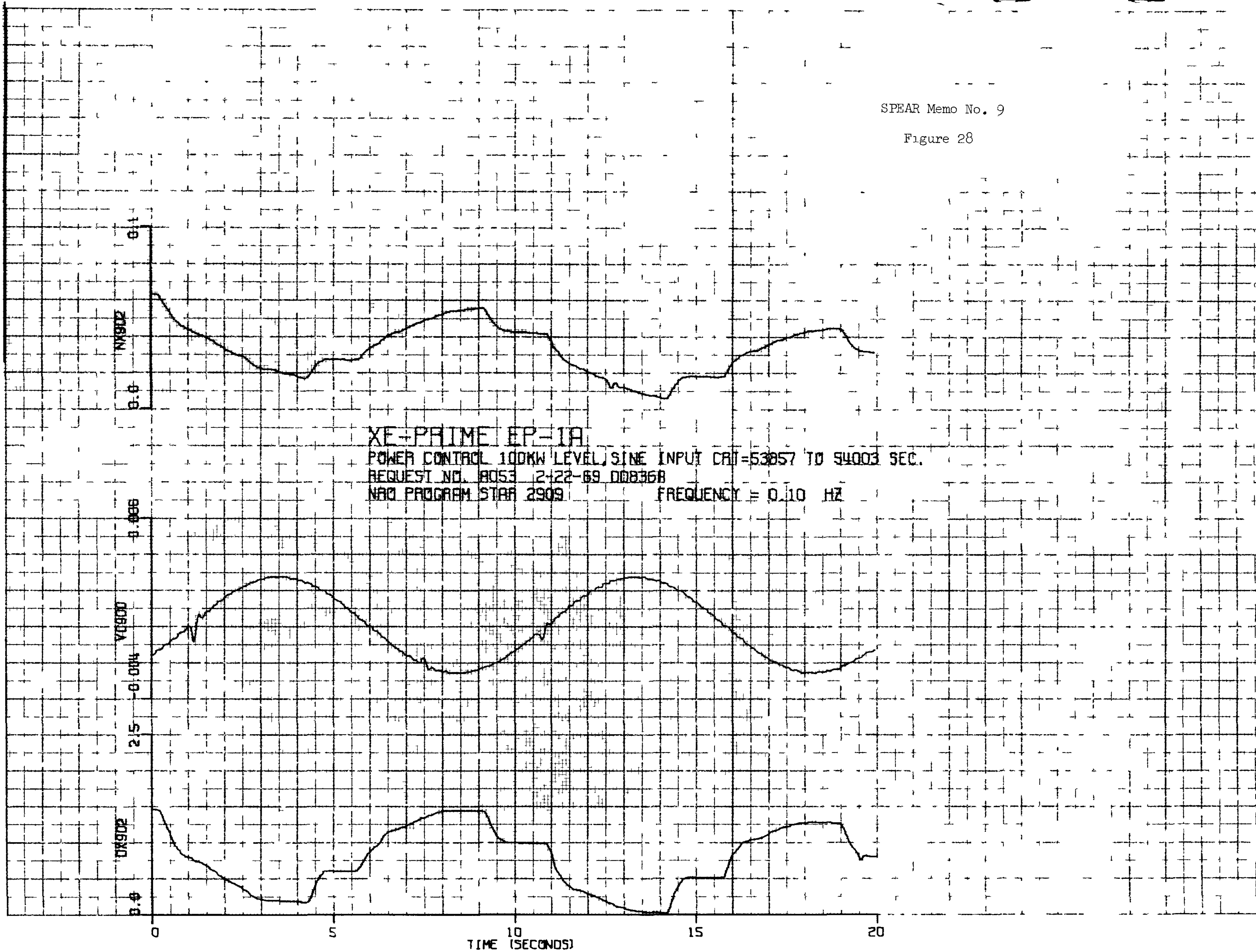


MANUAL SCRAM



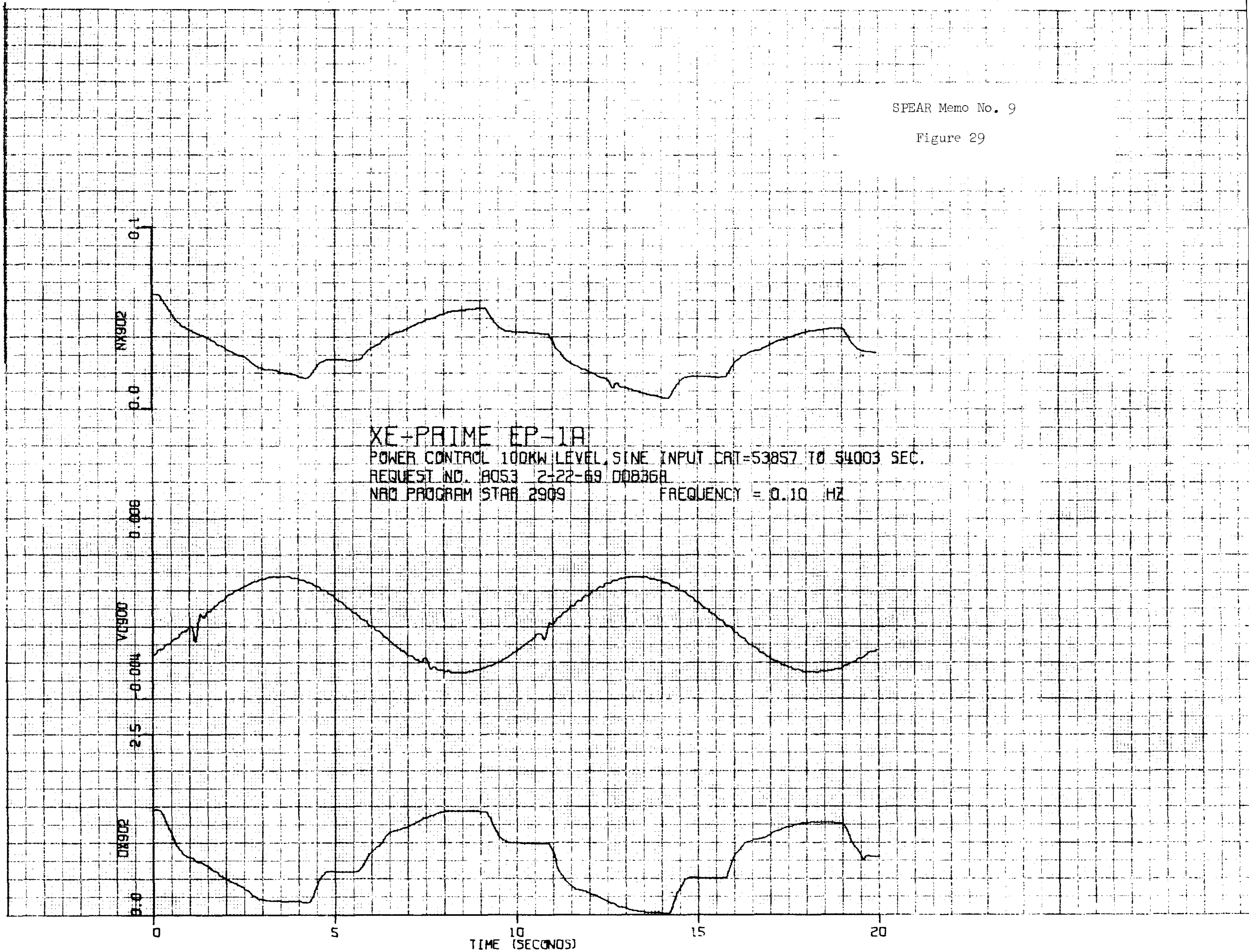
[redacted] [redacted]

Figure 28



SPEAR Memo No. 9

Figure 29



SPEAR Memo No. 10
R. D. Pfremmer/L. Mackey
cjd

XE-PRIME

EP-IA

Subject: POWER CONTROLLER

SUMMARY

The power controller was checked during the EP-IA test for evidence of limit cycling noted in EP-I, for performance of the demand generator, and for static and dynamic accuracy. The power loop limit cycle (noted in Memo # 15, EP-I SPEAR Report) again occurred and was examined during a 2 second period ramp from 1 KW to 1 MW. The maximum amplitude of the limit cycle was ± 19%.

The performance of the power demand generator was also evaluated from data obtained during this same portion of the test. The performance was acceptable.

The static accuracy of the power control loop was checked from data at two different points in the test. This provided checks at 1.8 KW and 1 MW. In both cases, the accuracy was within specifications. The transfer functions taken during the autostart test at 100 KW, in power control were used for evaluation of dynamic accuracy.

Power Loop Limit Cycle

During range times 55640 to 55655, power was increased 3 decades (from 1 KW to 1 MW) on a two second period. This test was performed to verify that a scram would not be obtained on a 2 second period.

On the curve of Figure 1, data channel 1 is the power demand in volts and curve 2 is the measured power in log watts. If the power demand curve is converted to log watts (Log Watts = $\frac{CC629}{1.25} + 1.74$) the demand and measured are in close agreement.

As seen from the plot of Figure 1, the power loop limit cycle was not present during the first two decades of power increase. This is because during the first two decades the drums are moving (data channel 6) to a position to establish the two (2) second period. During the third decade of power increase the limit cycle is present. The minimum period obtained during the limit cycle is 0.36 seconds which compares to a predicted minimum period of 0.5 seconds. This prediction appeared in Reference (1). The limit cycle amplitude in linear power level is ± 19% compared to a predicted level of 16%. The limit cycle amplitude in drum position is ± 0.25 degrees compared to a predicted amplitude of ± 0.3 degrees. The frequency of the limit cycle oscillation is 0.8HZ compared to a predicted frequency of 1.0HZ. These predictions appear in Reference (1).

After the final power level of 1 MW was obtained the limit cycle is not seen to be present in Figure 1. This is because the drums are still moving back to the critical angle and the limit cycle is not yet established. The linear power curves of Figure 2 show that the limit cycle is present during the 1 MW hold. The amplitude of the oscillation varies from essentially zero to a maximum amplitude of ± 0.9% of linear power.

The performance of the power controller during steady state and 2 second period is essentially as predicted. The minimum period (0.36 seconds) obtained during the 2 second period ramp is acceptable since the amplitude of the power oscillation (± 19%) is well below the 100% power interval which can be set in the period scram circuit.

Power Demand Generator

The power demand generator was evaluated during a ramp from 1 KW to 1 MW which was conducted on a 2 second period. Figure 1 shows the demand and measured log power traces during the ramp. These are data channels 1 and 2. The demand ramp channel was checked against the theoretical ramp rate for a 2 second period and it was accurate to within 3%.

The roundoff at the end of the ramp is due to diode limiting on the demand amplifier. A slight shortening of period was noted just prior to entering this region.

The 1 MW power level was held for 829 seconds with less than 10 millivolts drift in the power demand integrator.

Log Power Controller Accuracy

The static accuracy was determined as in EP-I (see Memo # 15) by comparison of CC629, the demanded signal voltage and NC815 which is the LOGWATT calculation from the measured signal. Two points in the test were selected to evaluate controller static accuracy. These were a stable 1 MW power level attained during the Thermal Calibration and Dosimetry Irradiation Test. The other was a 1.8 KW power level attained during the Drum Integral and Shield Worth tests.

The static accuracy as evaluated at the two power levels are shown on Table 1. At 1 MW the accuracy is quite good (less than 1%). At 1.8 KW the accuracy is not as good but is within the ± 2% specified in Reference (2).

The dynamic accuracy of the power controller was also evaluated from transfer functions made during the EP-IA test. These transfer functions were run after the Autostart with the system in Log Power control at 100 KW. Figure 3 shows the comparison of these data with the predicted values for the power loop response test. The EP-IA data has a bandwidth of .9HZ which is slightly less than the predicted band width of 1 HZ. Due to the circuitry used for sine wave injection the test response is not the same as the power controller which has about a .5HZ band-width.

Further dynamic data were extracted from the EP-IA data by use of a Nichols chart. The gain and phase margins for the log power response test were 12 db and 55 degrees respectively. Although these figures are not directly applicable to the power loop because of transfer function manipulation in the log power test circuit, it can be seen that the test data is in good agreement with the predicted performance out to the bandwidth of the power control loop.

CONCLUSIONS

The power controller performance was as predicted in Reference (1) and (2) during EP-IA and no anomalies were noted.

REFERENCE (1): 7820:M6295 (NRO), "Modified Power Control Loop Compensation" dated 9/17/68.

REFERENCE (2): NDC124, "Control System, Reactor, X-Engine", section 3.4.3.1.

TABLE 1

POWER CONTROLLER

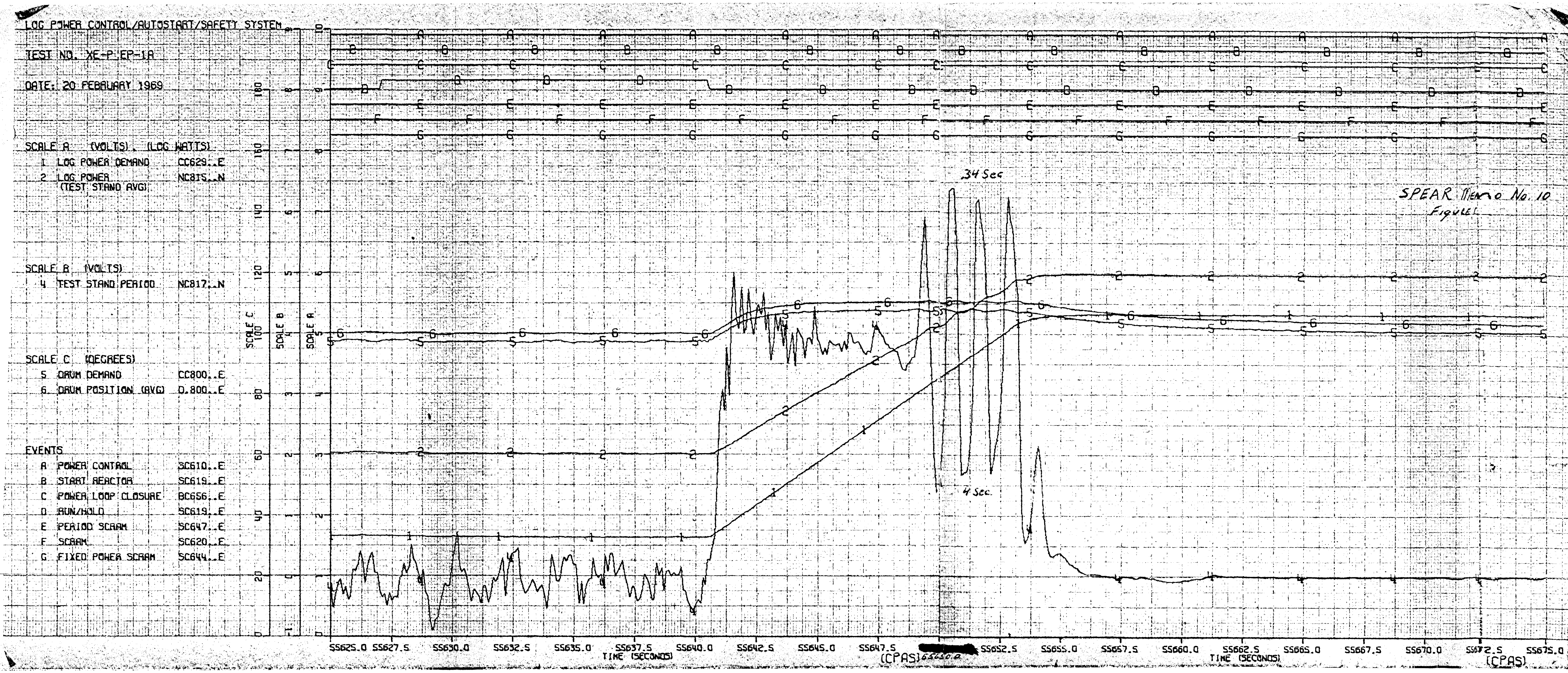
STATIC ACCURACY

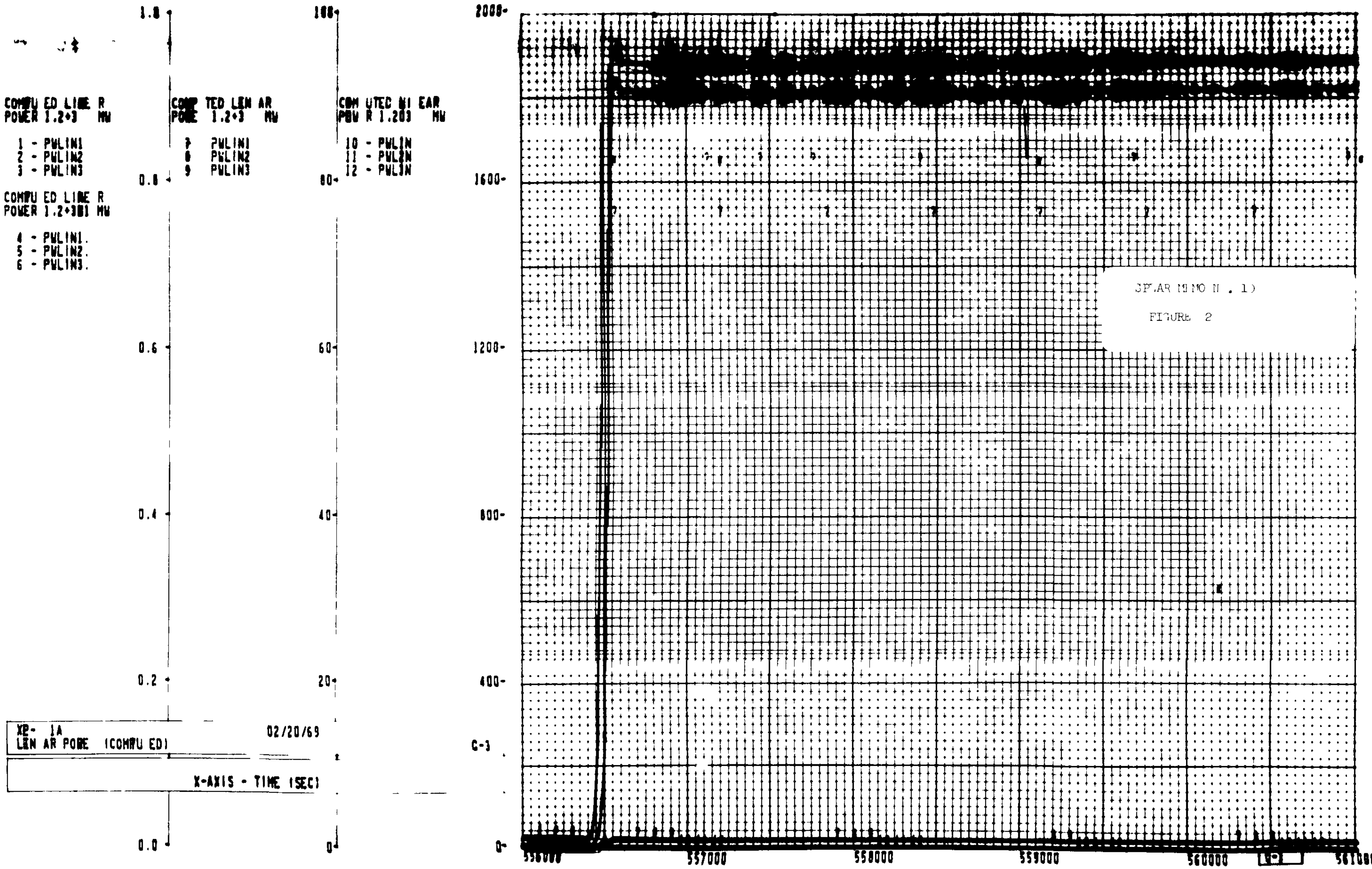
POWER LEVEL 1 MW

RANGE TIME	POWER DEMAND CC629 VOLTS	MEASURED POWER NC815 LOG WATTS	POWER DEMAND CONVERTED TO LOG WATTS	POWER CONTROLLER STATIC ACCURACY (%)
55681	5.32	5.971	5.996	.417%
55686	5.31	5.954	5.988	.568%
55691	5.31	5.972	5.988	.267%
55696	5.31	5.959	5.988	.501%
55701	5.32	5.971	5.996	.417%
55706	5.31	5.960	5.988	.468%
55713	5.32	5.973	5.996	.384%

POWER LEVEL 1.8 KW

47270	1.92	3.246	3.276	.916%
47275	1.93	3.238	3.284	1.4
47280	1.94	3.261	3.292	.942%
47285	1.93	3.249	3.284	1.066%
47290	1.93	3.253	3.284	.944%

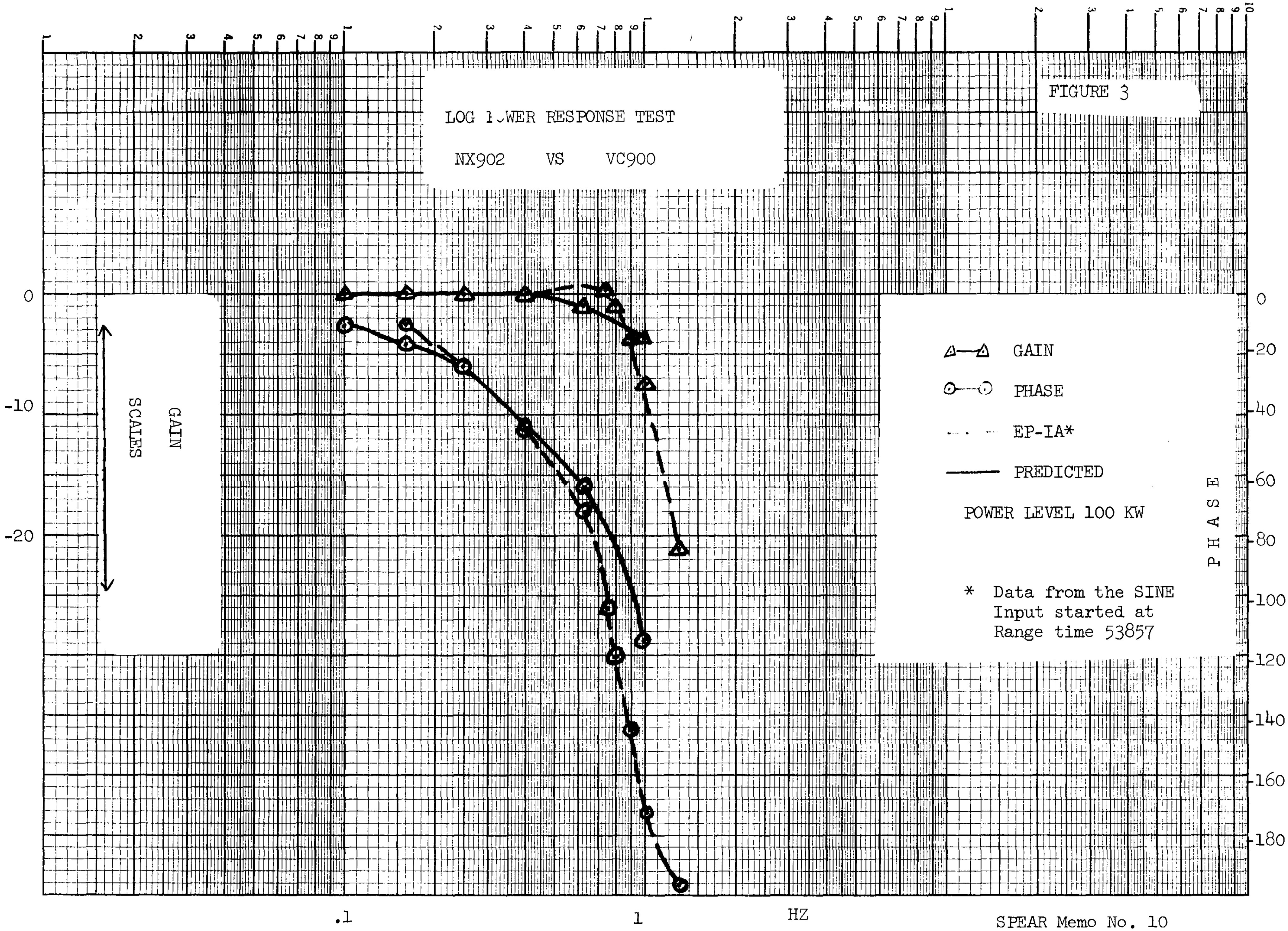

LOG POWER CONTROL/AUTOSTART/SAFETY SYSTEM
TEST NO. XE-P EP-1A
DATE: 20 FEBRUARY 1969
SCALE A (VOLTS), (LOG WATTS)
1 LOG POWER DEMAND CC629..E
2 LOG POWER (TEST STAND AVG) NC815..N
SCALE B (VOLTS)
4 TEST STAND PERIOD NC817..N
SCALE C (DEGREES)
5 DRUM DEMAND CC800..E
6 DRUM POSITION (AVG) D.800..E
EVENTS
A POWER CONTROL SC610..E
B START REACTOR SC619..E
C POWER LOOP CLOSURE BC656..E
D RUN/HOLD SC619..E
E PERIOD SCRAM SC647..E
F SCRAM SC620..E
G FIXED POWER SCRAM SC644..E
SCALE C
SCALE B
SCALE A
34 Sec
4 Sec.
SPEAR Memo No. 10
Figure 1
55625.0 55627.5 55630.0 55632.5 55635.0 55637.5 55640.0 55642.5 55645.0 55647.5 [redacted] 55652.5 55655.0 55657.5 55660.0 55662.5 55665.0 55667.5 55670.0 55672.5 55675.0
TIME (SECONDS)
(CPAS)



SPEAR MEMO N . 1)

FIGURE 2

[redacted] SEMI RITH 3
KEUFFEL & ESSER CO. MADE IN U.S.A.
4 CYCLES X 70 DIVISIONS



SPEAR Memo No. 11
J. Matsueda:rb

XE-PRIME

EP-IA

Subject: AVERAGERS

SUMMARY

The drum position averager performance was satisfactory with all the drum position anomalies that were noted in EP-I and EP-SL2 corrected.

The Engine Log Power Averager Channel No. 1 (NC801.AE) was noisy/erratic during the early portions of the run.

The Engine and Test Stand Log Power Averagers automatically reject one input channel during engine startup due to the spread in individual readings in the subpower region.

The Test Stand and Engine Log Power Averagers performed adequately throughout the test except at subpower levels. Although precise evaluations of signal rejection and reset was not possible because adequate records were not kept.

The Reactor Temperature Averagers were evaluated even though a thorough evaluation could not be made since the reactor temperatures did not go high enough for this test. Several anomalies were observed and are being investigated, and will be reported on in a supplement to this memo.

TECHNICAL DISCUSSION

A. Introduction

This memo summarizes the performance evaluation for three of the averagers in the TSCS/ECS. The three averagers are (a) Drum Position Averager, (b) Engine Log Power Averager, and (c) Test Stand Log Power Averager. The data used was taken from the XE Prime, EP-IA Thinned 1/10 data.

A preliminary performance evaluation for T.600, T.622, T.621, T.710, T.680, T.623, T.300, T.306 and T.158 Temperature Averagers was conducted although a complete evaluation could not be made since the reactor and engine temperatures did not go high enough during this test. The averagers were operated over a range generally less than 10% of their full scale output.

B. Drum Position Averager

1. Technical Description: The drum position averager is an averager with twelve inputs and no automatic or manual reject capabilities. The

averager adds the twelve inputs and divides by twelve. A failure of an individual drum position input will effect the averaged position by 1/12th of the signal deviation. The EP-I and EP-SL2 SPEAR Report noted large errors between the calculated drum position average and the drum position averager. A different calibration procedure was used for EP-IA. Simulating a 90° drum position, the drum position averager balance pot and the data buffer amplifier balance pot were adjusted for zero error at 90°. However with the drums against the lock at 15 ± .25° the Data System read 16.8 - 17.5°. Additional investigation is being conducted. See SPEAR Memo No. 9 .

2. Drum Position Averager Performance Evaluation: The thinned 1/10 data for EP-IA for the entire test was reviewed and the error between the calculated drum position average and the drum position averager during steady state conditions was always less than 1° which is within the acceptable limit. Figure 1 shows the drum averager error during a time duration from a shutdown condition through startup to 100 watts steady state, and drum roll-in initiated by a planned Period Scram. The maximum error was 0.9% and that was when the drums were rolled in and locked (less than 15°).

C. Engine and Test Stand Log Power Averagers

1. Technical Description: The Engine Log Power Averager and the Test Stand Log Power Averagers are identical pieces of electronic equipment. The only difference is in the physical location of the Ion Chambers. Basically, the Log Power Averagers average three Ion Chamber input signals, establishes a rejection band around this average (this reject band is adjustable within the equipment) and rejects any one channel that is outside the band, it then provides an output signal equal to the average of the inputs not rejected. A second channel may be manually rejected by the operator at the LRE Console. Circuitry within the equipment prevents the rejection of all three channels. A rejected channel may be reset by the LRE operator providing its reading is within the allowable error band. The allowable error band for EP-IA was set at 0.250 volts which is equivalent to 0.200 log watts.

2. Performance Evaluation For Engine Log Power Averager: The performance evaluation of the Engine Log Power Averager at various power levels from 300 watts to 1 megawatt is presented in Table 1. The variations between channels 1, 2, and 3 and the averaged output ranged from 0.066 to 0.093. At these power levels, all averager inputs were within the acceptable error tolerance of 0.200 logwatts.

Table 3 shows the Log Power Averagers and their inputs at low power levels during reactor startup. At range times 46518.7 and 47144.5 the difference between the Engine Log Power Averager output and channel 1 is 0.338 logwatts and 0.372 logwatts respectively and the difference between the Test Stand Log Power Averager output and channel 2 is 0.474 and 0.253 logwatts respectively. In all four cases, these channels had a greater than 0.200 logwatt deviation from the average and should have been rejected. It was determined from talking with the LRE that on a startup, one of the log channels will automatically reject due to the spread in individual readings at the sub-power levels. The SPEAR Report for EP-I and EP-SL2 noted these discrepancies and recommended that a record be made when any of the Log Power Channels are rejected and/or reset to provide data for Log Power Averager evaluation. The LRE log book recorded a Test Stand channel no. 2 reject at 48711 and 53100 and reset at 48820 and 54100. Entries into the log book should be expanded to include all Log Power Averager channels during the entire test.

Table 2 shows two things of importance: Engine Log Power Channel No. 1 is noisy/erratic and Engine Log Power Channel No. 2 is consistantly higher than Engine Log Power Channel No. 3 although within the error band tolerance of 0.200 log watts.

At range time 54033.5 Channel No. 1 was 4.796 logwatts, Channel No. 2 was 4.899 logwatts, Channel No. 3 was 5.136 logwatts and the averager output was 5.189 logwatts. This was prior to stabilization of power to 1 KW and a power increase to 1 megawatt on a 2 second period. Channel 1 and 2 have more than a 0.20 logwatt deviation and one of them should have been rejected although no data is available to confirm this. The Preliminary Chronology directed the LRE to "Reset Logs which rejected" at range time 54102. (The LRE logbook shows Test Stand Channel No. 2 was rejected at range time 53100). The noise on Log Power Channel No. 1 did not appear after this.

The anomalies discussed in the above paragraph may be due to a failure of the averager at this time. However, without a record keeping of the rejected channels this can not be concluded. It is possible that Channel No. 1 was automatically rejected and Channel No. 2 was manually rejected. With these assumptions the averaged output signal is sufficiently close to the Channel No. 3 signal.

3. Performance Evaluation For Test Stand Log Power Averager: The performance evaluation of the Test Stand Log Power Averager at various power levels from 300 watts to 1 megawatt is presented in Table 1. The variations between Channels 1, 2, and 3 and the averaged output ranged from 0.057 to 0.072. At these power levels, all averager inputs were within the acceptable error tolerance of 0.200 log watts. The Thinned 1/10 data for EP-IA for the entire test was reviewed and the variations between Channels 1, 2, and 3 and the averaged output was always within 0.200 logwatts except at subpower levels during startup.

D. Reactor Temperature Averagers

1. Technical Description: There are seven 10-input Reactor Temperature Averagers. The chart below is a list of the averagers covered and tabulates the number of input signals to each averager, the high and low reject bands and the maximum number of automatic rejects allowed.

Channel No.	Description	No. of Input Signals to	Reject Band in Volts		Max. No. of Rejects
			High	Low	
T.300	Outer Reflector	4	2.0 ± .25	2.0 ± .25	2
T.600	Ave. Core Sta. Temp.	6	1.2 ± .25	1.2 ± .25	4
T.621	Ave. Core Sta. Temp.	4	1.33 ± .25	1.33 ± .25	2
T.622	Ave. Core. Sta. Temp.	10	1.11 ± .25	1.11 ± .25	6
T.623	Ave. Core Sta. Temp.	8	1.11 ± .25	1.11 ± .25	6
T.680	Cluster Exit Gas	6	1.2 ± .25	1.2 ± .25	4
T.710	Tie Rod Material	6	1.8 ± .25	1.8 ± .25	4

The Average of the input signals is compared with individual signals in the automatic reject circuitry and when any temperature input is outside a preset voltage band (adjustable from 0.5 V to 2 V), a reject signal is generated. The averagers also have the capability for manual rejection within the averager. When a signal is rejected, the averager provides an output equal to the average of the inputs not rejected. After the automatic reject limit is reached, variations of any of the remaining inputs will be averaged.

2. Reactor Temperature Averagers Evaluation: The Reactor Temperature Averagers were given a cursory performance evaluation. The temperature changes covered but a narrow band of the averager ranges and the temperatures seen during the test did not go high enough to provide a complete evaluation. Several anomalies were observed from the Thinned Data and an investigation was initiated. The investigation was not completed prior to publication of this memo and these anomalies will be reported on in a supplement to this memo.

E. RECOMMENDATIONS

Improve the record keeping of Log Power Channels which are automatically or manually rejected and/or reset.

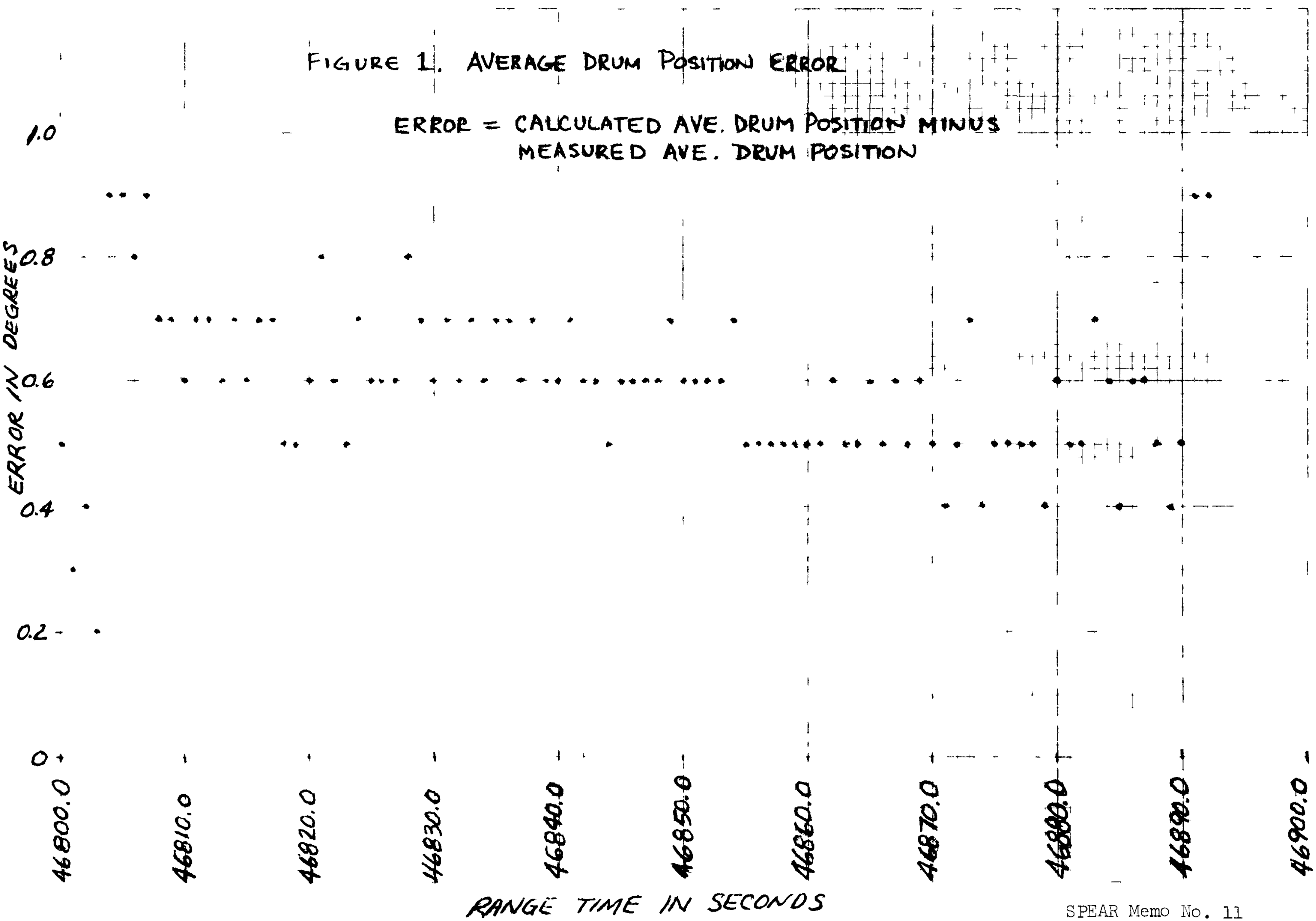


FIGURE 1. AVERAGE DRUM POSITION ERROR

TABLF 1

EP-IA LOG POWER AVERAGER EVALUATION

	ENGINE LOG CHANNELS			ENGINE AVERAGER		TEST STAND LOG CHANNELS			TEST STAND AVERAGER	
RANGE TIME	NC801.AE IN LOGWATTS	NC802.AE IN LOGWATTS	NC803.AE IN LOGWATTS	NC804..E IN LOGWATTS	CALCULATED AVERAGE IN LOGWATTS	NC812.AN IN LOGWATTS	NC813.AN IN LOGWATTS	NC814.AN IN LOGWATTS	NC815..N IN LOGWATTS	CALCULATED AVERAGE IN LOGWATTS
46704.2	3.094	3.139	2.952	3.045	3.062	2.939	3.008	3.058	2.990	3.002
47410.3	2.526	2.640	2.467	2.548	2.544	2.445	2.489	2.558	2.502	2.497
48021.4	4.704	4.799	4.626	4.718	4.711	4.608	4.668	4.726	4.668	4.667
55651.4	5.503	5.608	5.497	5.542	5.536	5.352	5.411	5.478	5.421	5.414
55691.4	6.062	6.163	6.030	6.087	6.085	5.900	5.957	6.025	5.972	5.961

TABLE 2

DATA SHOWING NOISE ON ENGINE
LOG CHANNEL NO. 1 DURING EP-IA

RANGE TIME	NC801.AE IN LOGWATTS	NC802.AE IN LOGWATTS	NC803.AE IN LOGWATTS	NC804..E IN LOGWATTS
46605.7	2.825	2.851	2.695	2.776
46606.7	2.490	2.858	2.690	2.770
46607.7	2.916	2.850	2.697	2.770
46608.7	2.728	2.850	2.686	2.776
46609.7	2.714	2.858	2.684	2.773
46610.7	1.259	2.851	2.685	2.772
46611.7	1.892	2.862	2.697	2.783
46612.7	2.746	2.855	2.691	2.771
46613.7	2.029	2.860	2.699	2.771
46615.2	2.774	2.866	2.716	2.790
46616.2	2.850	2.858	2.695	2.776
46617.2	2.913	2.859	2.696	2.776
46618.2	-.090	2.870	2.700	2.783
46619.2	2.656	2.858	2.697	2.782
46620.2	2.661	2.872	2.697	2.775
46621.2	2.998	2.857	2.695	2.783
46622.2	2.701	2.852	2.697	2.778
Reading Spread	3.088	.022	.032	.020

TABLE 3
EP-IA LOG POWER AVERAGER EVALUATION

	ENGINE LOG CHANNELS			ENGINE LOG AVERAGE				TEST STAND LOG CHANNELS			TEST STAND LOG AVG.					
RANGE TIME	NC801.AE IN LOGWATTS	NC802.AE IN LOGWATTS	NC803.AE IN LOGWATTS	NC804..E IN LOGWATTS	CALCULATED AVERAGE IN LOGWATTS			NC812.AN IN LOGWATTS	NC813.AN IN LOGWATTS	NC814.AN IN LOGWATTS	NC815.AN IN LOGWATTS	CALCULATED AVERAGE IN LOGWATTS				
46518.7	.010	.265	.418	.348	.231			.344	-.205	.189	.269	.109				
47144.5	.089	.415	.514	.461	.339			.437	.145	.358	.398	.300				

SBEAR Memo. No. 12
F. Guyer/L. Mackey/D.Glover

XE-PRIME

Subject: SAFETY SYSTEMS EVALUATION

SUMMARY

There were three SCRAM trips evaluated for this report (2 Period and 1 Fixed Power). One period and the Fixed Power SCRAM's were intentionally generated in MANUAL drum control. The second period SCRAM trip was the result of a drum bounce after the fixed power SCRAM.

The result of this analysis indicate that the Fixed Power and Period SCRAM's will limit the reactor to acceptable power excursions without causing excessive numbers of unwarranted SCRAM's.

The actual delay time of the SCRAM circuits cannot be determined from the data as SCRAM events are not in high speed recording.

Two drum overrides occurred. The one in manual drum position control was intentional. However, it could not be evaluated due to failure of drum override event BC662..E to indicate. One occurred unintentionally in power control but could not be evaluated because the data system was on low.

TECHNICAL DISCUSSION

(1) Period Scram: During EP-IA, the period scram circuit was checked out. The following is a description of the XE-P period scram (Sampled Data Period Limiter) operation and an analysis of the test data obtained.

Sampled Data Period Limiter (SDPL) Description: The SDPL is designed to initiate a SCRAM to the Engine Safety System if the average test stand log power registers a power increase greather than a preselected increase limit in a time less than a preselected time. The allowed power increase and time are selected at the LRE console. The LRE selects period by selecting one of four push buttons labeled .1, .25, .5 and 1. The LRE also selects the allowed power increase from one of the four push buttons labeled 25%, 50%, 100% and 200%. Table one shows the times for various combinations of selected period and selected allowable power increase.

TABLE I
POWER INC. (PI)

Period	25%	50%	100%	200%
1.0	.223	.405	.694	1.0
.5	.1114	.2025	.347	.55
.25	.0556	.10125	.1735	.275
.1	.0223	.0405	.0694	.11
	Time in Seconds			

The times in Table I are obtained as follows. Power increasing on a fixed period in described by:

$$S_c = So\ e^{\frac{t}{T}} \qquad 1)$$

Where:

S_t = Power at time t

S_o = Power at time o

t = time

T = Period of power change

Dividing by the power at time 0 and taking the nature log is

$$Ln \left(\frac{St}{So}\right) = \frac{t}{T} \qquad 2)$$

Since the LRE is selecting power increase in percent PI the value of S_t in equation 2 is given by

$$S_t = So + \frac{PI}{100} So. \qquad 3)$$

Substituting this for St in equation 2 results in

$$t = T\ Ln \left(1 + \frac{PI}{100}\right)$$

Solving this equation for various period settings T and power intervals PI results in the times given in table 2.

The allowable power increase is determined as follows with values shown in Table. 2.

The voltage input to the SDPL is

$$V = 1.25 (Log\ S - Log\ 55) \qquad 4)$$

Where:

V = Volts

S = Power in Watts

Therefore,

$$Vo = 1.25\ (\text{Log } So - \text{Log } 55) \qquad 5)$$

and

$$Vt = 1.25\ (\text{Log } S_t - \text{Log } 55) \qquad 6)$$

to obtain the change in voltage from time = 0 to time = t
subtract 5 from 6

$$\Delta V = 1.25\ ;(\text{Log } S_t - \text{Log } So) \qquad 7)$$

$$\Delta V = 1.25\ \text{Log } (\frac{St}{So}) \qquad 8)$$

However, since the LRE is selecting % power increse $St = So + \frac{P_I}{100} So$

$$\Delta V = 1.25\ \text{Log } (1 + \frac{P_I}{100}) \qquad 9)$$

The data printout is in $\log_{10}$ (Watts)

Therefore:

$$\Delta X = \text{Log } S$$

$$\Delta X = \text{Log } (1 + \frac{P_I}{100})$$

TABLE 2
POWER INC. (P_I)

Period	25%	50%	100%	200%
ΔV (Control Voltage)	.122	.22	.362	.596
ΔX (Log Watts change)	.097	.176	.301	.477

Data Analysis: During the checkout of the period scram circuit, a 1 second period and a 25% power interval was selected by the LRE.

The curve of Figure 1 is a plot of Log watts vs. time during the period scram. As described above this is the signal that drives the SDPL. The curve of Figure 2 is a plot of linear power and log power converted to watts. The average period obtained as calculated from log watts (NC815) of Figure 1 is approximately 0.19 seconds and the average calculated from the linear power (NC821) of Figure 2 is approximately 0.3 seconds. This confirms that a scram should have been obtained since the power level did increase in excess of the level required to activate the SDPL.

Shown on the plot of Figure 2 are the power levels for which the scram will occur for the first sample interval and the power level for which a scram will occur in the second interval of the SDPL. The level indicated for the second interval is the worst case condition. It assumes that the scram was just missed in the first interval.

It is not possible from test data to determine accurately when the scram did occur (event channels are sampled once every 0.1 seconds). In order to reconstruct the probable time, the curve of Figure 3 is included. Figure 3 is a plt of the average control drum position during the period scram. Just prior to the scram the CTE was ramping the control drums out at approximately 25 degrees per second. Under these conditions, it is estimated that there is a 6 m second delay between the time the torque motor current changes and the time the drum starts rolling in. The estimated time of torque motor current change is indicated on the curve of Figure 3 as range time 46890.135. This time is also plotted on the curve of Figure 2. The total delay time from obtaining a trip to de-energizing the scram relays in the drum amplifiers is approximately 15 m seconds. The probable time of the scram is then obtained by subtracting 15 m seconds from the range time of torque motor current change or 46890.120. This time indicated on the plot of Figure 2.

From Figure 2, it is seen that the scram occurred at a power level slightly below the power level indicated for the second interval. This simply means that the worst case conditions for the period circuit were not obtained during this scram check. The scram circuit rather than updating the scram power level at the time indicated on the plot, probably updated at range times 46890.052.

(2) Fixed Power SCRAM: The XE-P Fixed Power SCRAM is adjustable from 55 Watts to 5.5×10^9 watts at the LRE console. During EP-IA a Fixed Power SCRAM was caused in MANUAL drum control by setting the Fixed Power SCRAM at 160 pot divisions and increasing the drum angle to get on a very slow period.

Table I shows that the SCRAM occurred very close to the desired level.

TABLE I
XE PRIME EP-IA

Range TIME IN SECONDS	D.800.. WD 591E DEGREES	.NC815., WD 75IN LOG WATT	NC817.. WD 761 N VOLTS	
46705.1	101.6	3.017	.352	
	101.6	3.017	.343	
	101.6	3.015	.358	
	101.6	3.021	.343	
	101.6	3.016	.316	
	101.5	3.017	.315	
	101.5	3.020	.365	
	101.6	3.025	.414	
	101.6	3.017	.434	
	101.5	3.025	.480	- Probable SCRAM detection
46705.2	101.5	3.017	.472	
	101.5	3.011	.328	- Start of Drum Roll in
	101.4	3.007	.063	
	100.2	3.004	- .293	
	97.1	2.968	-1.447	
	92.6	2.892	-7.615	
	87.3	2.778	-10.279	
	81.3	2.653	-10.279	
	75.2	2.512	-10.279	
	68.9	2.385	-10.279	
46705.3	62.6	2.257	-10.279	

The delay time from SCRAM detection to drop out of the SCRAM relay in the drum amplifier has been estimated to be 15 ms. The delay time from change of torque motor current to start of drum movement is between 0 and 5 ms for the steady state drum position.

It can be seen from Table I that drum roll in started between 46705.21 and 46705.22 range time. Subtracting the maximum delay of 20 ms the probable point of SCRAM detection was between 46705.19 and 46705.20 range time. Indicating that the Fixed Power SCRAM occurred at 3.025 log watts (1.06 KW). Using SPEAR Memo No.2 from XE-P, EP-I (NTO-R-0164) the 160 pot division is a setting for 1.03 KW SCRAM. This results in a 2.9% error from the pot calibration curve.

A point of interest observed from the data is that a period scram occurred between 46705.4 and 46705.5. This is attributed to a bounce of the drums after being driven in on the Fixed Power SCRAM. Table 2 shows the bounce of the drums and the resulting power and period data.

TABLE 2
XE PRIME EP-1A

TIME IN SECONDS	Range D.800.. WD 591E DEGREES	NC815.. WD 751N LOG WATT	NC817.. WD 761N VOLTS	
46705.3	62.6	2.257	-10.279	
	56.2	2.163	-10.279	
	49.8	2.090	-10.279	
	43.4	2.041	-10.279	
	36.8	1.993	-10.279	
	30.4	1.966	-10.279	
	24.0	1.953	-10.279	
	17.5	1.957	-10.279	
	11.9	1.959	-10.279	
	9.6	1.979	-10.279	- Drum Min.
46705.4	11.1	1.967	-10.279	
	13.6	2.016	-7.547	
	14.3	2.041	-4.299	- Drum Max. After Bounce
	13.7	2.074	-1.713	
	12.1	2.122	.937	
	10.4	2.129	4.544	
	10.2	2.149	7.557	
	10.6	2.160	7.737	- Period Min.
	10.8	2.181	7.559	
	10.6	2.194	7.536	
46705.5	10.4	2.195	7.439	- Power Max.
	10.0	2.185	7.322	
	9.8	2.180	7.193	
	9.5	2.182	6.833	
	9.5	2.171	5,670	
46705.55	9.2	2.156	4.053	

The power excursion and minimum period reached are sufficient to cause a period SCRAM with the Sampled Data Period Limiter set for 1 sec/25% as indicated in the chronology for XE-P, EP-1A.

(3) **Drum Override:** The drum override tracks the drum demand at a rate which increases with the error between demand and override tracker up to a maximum of 1.25 deg/sec at a 2.5 degree error. When the demand exceeds the tracked value by more than 8.5 degrees, the tracked value replaces the demand as the required drum position.

The operation is complemented by sending the manual position demand potentiometer output to the drums when an override has occurred. Since this potentiometer follows the override tracker when in power or temperature control, the override becomes effective to reduce the drum demand if an override has occurred.

In position control the manual demand potentiometer is hand-set and does not follow the override tracker. The potentiometer output in this mode goes to the drums by either the normal or the override path depending on the state of the override relay. A drum override therefore can occur in position control without affecting the drums.

The drum override circuit was exercised during this test at an approximate range time of 46826. The override was initiated in the manual position control mode by having the CTE operator manually rotate the drum outward from a 60° drum position until the override occurs. The CTE received an indication that the override occurred, however, the binary channel BC662..E, drum override, did not indicate any override during this test and was apparently inoperative.Failure to receive this binary event precluded an evaluation of the drum override circuit.Binary channel BC662..E was also reported as inoperative in SPEAR Memo 15 during EP-I and EP-SL2.

The drum override circuit ideally should be evaluated in the power or temperature control mode, since it was designed to provide protection from drum roll-out when operating in these modes. An override in the power control mode was reported by the operators at range time of approximately 50000. This occurred during the drum worth test when a number of individual drums were being reset from individual control to power control. This override probably could have been evaluated even without the binary event channel had the data system been on high. With the data system on high it should have indicated a sudden change in drum demand signal CC800..E when the override occurred. The reason for occurrance of this override while resetting the drums should be investigated further.

CONCLUSIONS

Analysis of the data available from the XE-P, EP-1A test indicates that both the Period and Fixed Power SCRAM performed within their system requirements. The uncertainties involved in the analysis could be removed by putting SCRAM events on high speed digital. In addition to using the high speed data to evaluate scram delay times it is also required to determine the first-to-trip for multiple closely spaced SCRAMS.

The drum override could not be evaluated because of lack of data.

RECOMMENDATIONS

Investigate why a drum override occurred in power control mode, while resetting an individual drum from manual to power control.

Correct problem with binary event channel BC662..E.

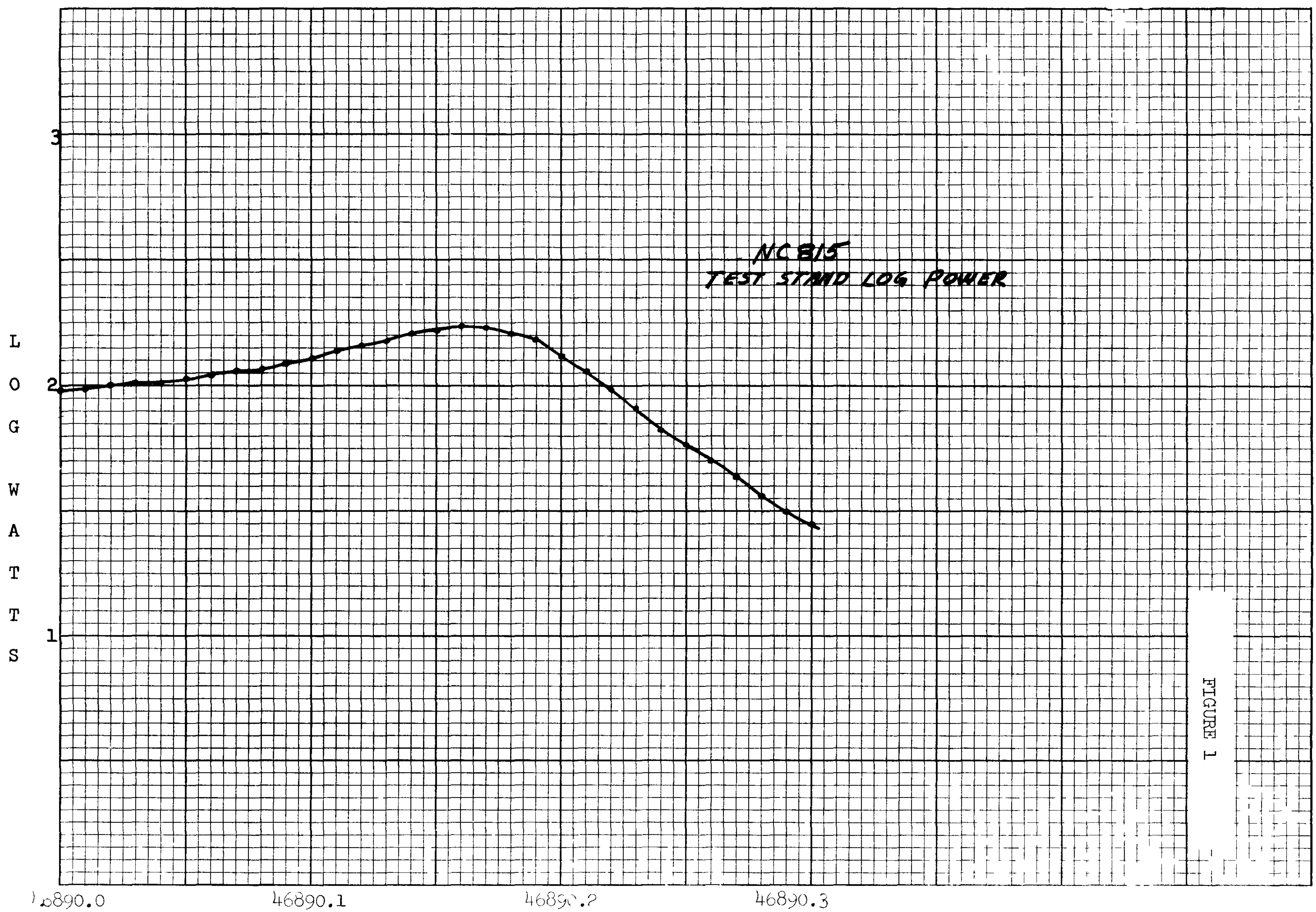


FIGURE 1

SPEAR Memo No. 12

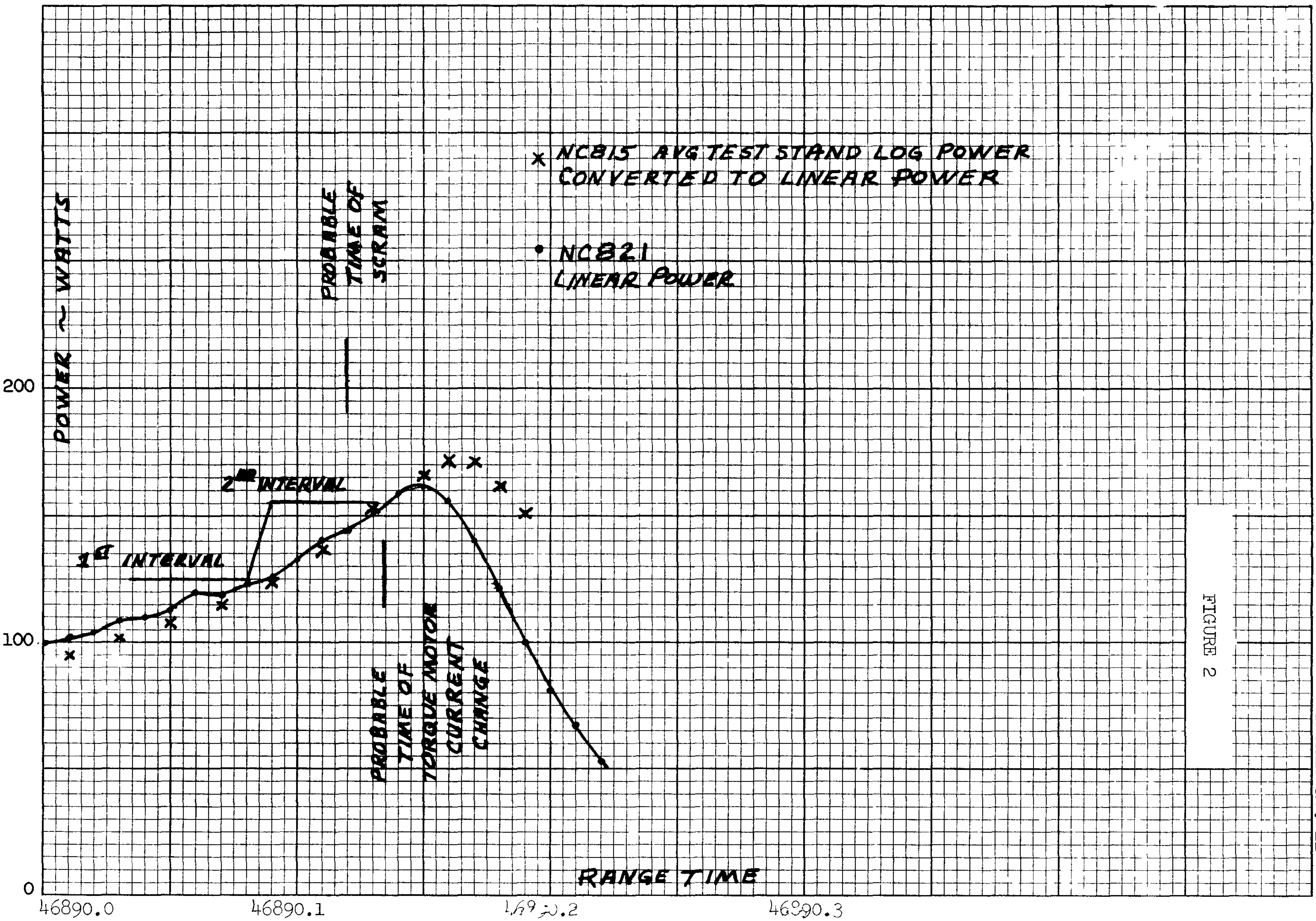


FIGURE 2

SPEAR Memo No. 12

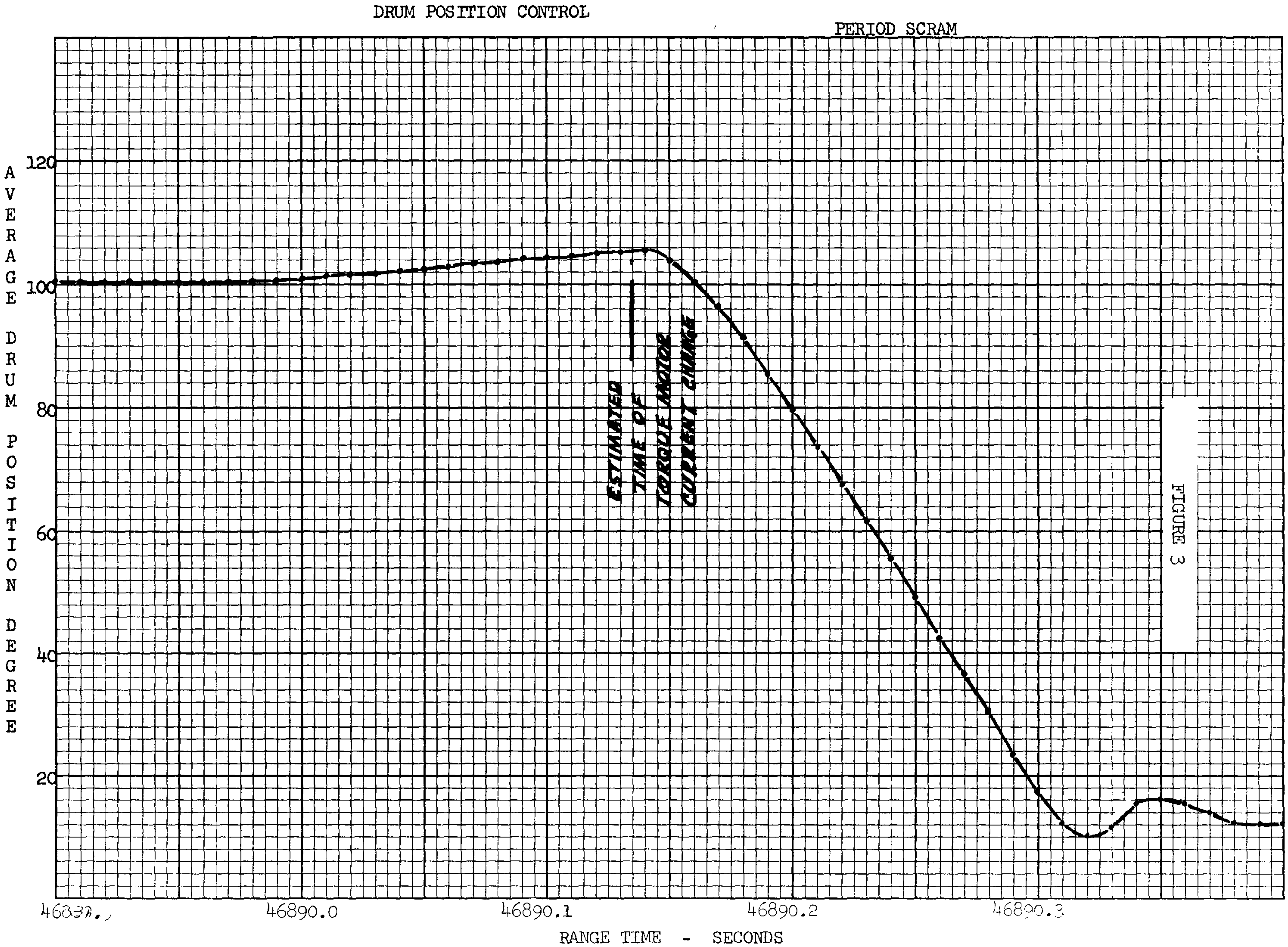


FIGURE 3

SPEAR Memo No. 12

SPEAR Memo No. 13
L.C. Mackey/R.D. Pfremmer:rb

XE-PRIME

EP-IA

Subject: NUCLEAR AUTOSTART EVALUATION

SUMMARY

A nuclear autostart was performed in EP-IA and is evaluated in this memo. The nuclear autostart consisted of:

1. Exponential programming of the control drums to 104°.

2. A power loop closure at 300 watts.

Upon closure of the power loop the power demand generator had been pre-set to increase power to 100 KW on a 5 second period. The nuclear autostart performance is satisfactory and adequate to support future EP's.

DISCUSSION

The nuclear autostart programs the drums out on a profile which is approximately an exponential plus a linear ramp. The final position of the exponential program and the rate of the linear ramp are determined by settings which are made on the Lead Reactor Engineer's console. By use of the exponential plus linear ramp programming the drums are rotated out past the critical angle which causes power to increase. When power has increased to a level which corresponds to an initial condition point set in the power demand generator by a potentiometer on the Chief Test Engineer's console, the power loop closure relay switches from the exponential plus linear ramp programming to closed power loop control operation. Once this power loop closure is achieved, the autostart is complete.

After power loop closure, the system is in power control and the power demand is changed on a period to a power level which is determined by the power demand potentiometer on the Chief Test Engineer's console. The period of this power increase is determined by a push button selection on the Chief Test Engineer's console.

The nuclear autostart was conducted at range time 53558 to 53616. For this autostart, the exponential part of drum programming was set to produce 104 degrees of drum angle as indicated on the ATE meter and the linear ramp rate was set to zero degrees per second. The initial condition set into the power demand generator for the autostart was 300 watts. Figure 1 shows the time history of drums and power demand and average from the time of selection of the reactor start mode at range time 53558.2. From this figure the performance of test objectives can be evaluated.

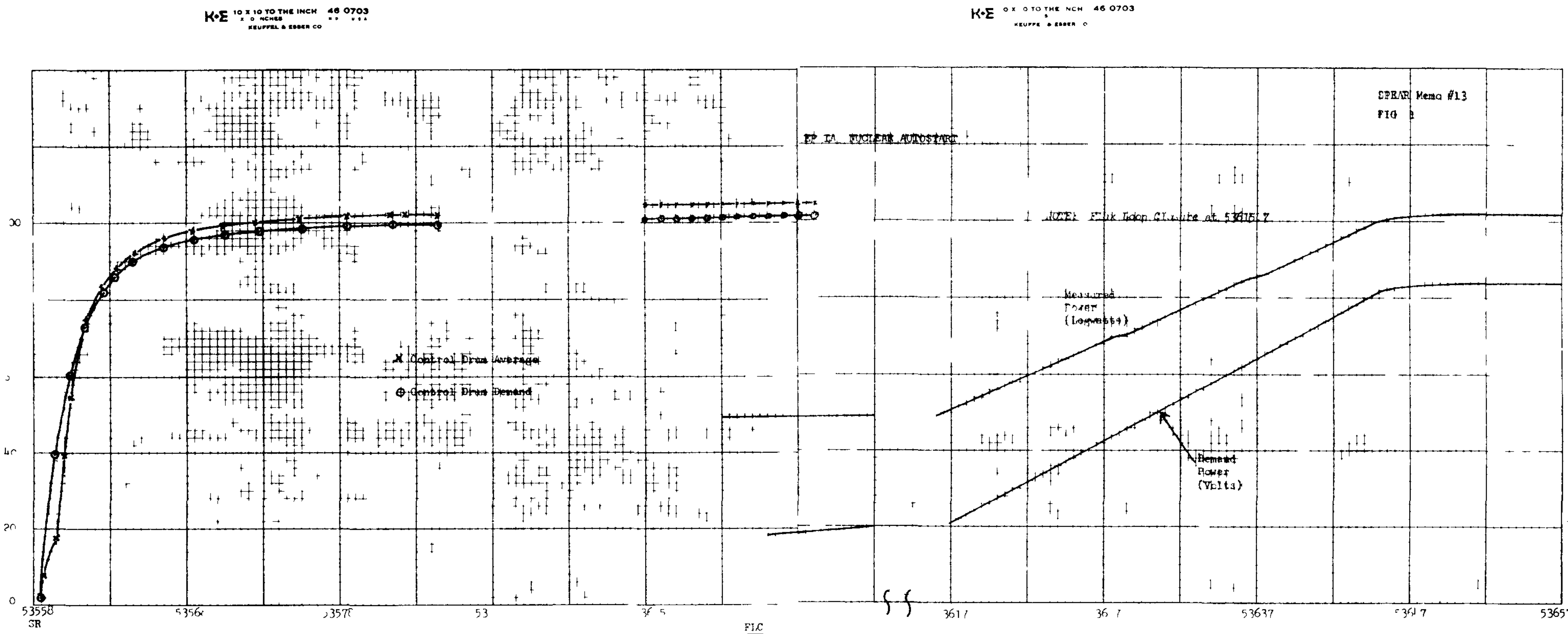
The exponential potentiometer setting was set to produce 104 degrees of drum motion. The reactor became critical about 97 degrees as indicated by movement of the log power channel. The power loop closure setting was to have been 300 watts but appears to have been between 288 and 294 watts. The measured power level at which power loop closure occurred was approximately 268 watts.

Power loop closure was accomplished smoothly. No noticeable perturbation in drum angle or log power occurs. The test stand period indicated a jump from 9 seconds to 6.4 seconds at the point of closure. A period change of this magnitude is consistant with a smooth transition upon transfer to power control.

A check of the data was made to determine the accuracy of the period setting. The period was 5 seconds as planned. The setting power level was 126 KW.

CONCLUSIONS

No anomalies were noted from the data during the nuclear autostart. No changes to the test setup are recommended.



SPEAR Memo #13
FIG
NUCLEAR AUTOSTART
Control Drum Average
Control Drum Demand
Measured
Demand
Power
(Volts)
53558
SR
53637
53657
FLC
0
20
40

SPEAR Memo No. 14

H. W. Brandt HB, BSN

XE-PRIME

EP-IA

Subject: GN_2 SUPPLY SYSTEM PERFORMANCE DURING THE THERMAL CALIBRATION TEST

INTRODUCTION

GN_2 was supplied to the engine for the thermal calibration test from the 2500 psig GN_2 supply system through PCV-251. This memo presents some of the pertinent GH_2 system steady-state data. The data used for this evaluation were: 1 sample per second digital data and analog recorder traces.

SUMMARY

The GH_2 system data was in good agreement with previous FEP data and no serious anomalies were evidenced. Low amplitude pressure oscillations were evidenced in the cooldown system from PCV-251 to the nozzle torus during the flow initiation period.

TECHNICAL DISCUSSION

The pertinent GN_2 supply system data is presented in Table 1. The steady-state pressure versus flow characteristics are presented in Figure 1. PCV-543 was open during this test; therefore, there was a 17 to 1 flow split between the engine and the accumulator. The system GN_2 flowrate is based on the FE015 orifice equation. The LF-7 inlet pressure (PT846) and average nozzle torus pressure (PATOR) are plotted versus engine flow and the CHV-1721 inlet pressure (PT814) and CHV-681 inlet pressure (PT475) are plotted versus total flow; i.e. PCV-543 and engine flow. The pressures have been normalized to $500^{o}R$. The nozzle torus pressure versus engine flow rate is in reasonable agreement with previous hydrogen flow pressure data. For GN_2 flow the relationship

$$W(pps) = 2.78 \frac{PATOR}{\sqrt{TATOR}}$$

can be used to describe the flow-pressure-temp relationship at the nozzle torus. The hydrogen flow-pressure temperature relationship will be

$$W = .745 \frac{P}{\sqrt{T}} .$$

The system pressure drop from the CHV-681 inlet to the nozzle torus versus GN_2 flow squared is plotted in Figure 2. The data evidences a 9 psid offset. The impedance functions (K/A^2) for this cooldown system segment is 0.0521 in^{-4} based on the upstream density and 0.039 in^{-4} based on the downstream pressure. This value 0.039 in^{-4} compares favorably with the comparable FEP-V[(1)] value of 0.037 in^{-4}.

The impedance value for LF-7 was computed to be 4.1 versus an FEP-V value of 4.3. This comparison is satisfactory.

The calculated RO-492 GN_2 flowrate versus cooldown line pressure (PT-846) was in good agreement with previous FEP-V data[(2)]; therefore, the calculated flows through PCV-543 are reasonably accurate.

The integral FE015 flow for the entire thermal calibration test was 10,730 lbs versus a decrease in V-3201, 02 and 03 inventory of 10,420 lbs. It was planned to have an additional 1700 cu.ft. storage inventory on line; however, the status of these added tube trailers (approximately 1700 cu.ft.) was uncertain.

Evaluations of the analog recorder data revealed that pressure oscillations occurred in the cooldown system from PCV-251 to the nozzle torus during the initiation of GN_2 flow. The oscillations lasted for approximately 3.3 seconds and ceased when the PCV-251 outlet pressure (PT-475) reached approximately 95 psig. It is to be noted that the pressure (PT-475) was reduced during this test to 89 psig and the oscillations did not occur. This characteristic was evidenced during previous FEP series tests. The frequency was approximately 14 cps and the amplitude at PT-475 was ±5 psi. Very low amplitude oscillations were evidenced at the nozzle torus (PT-124) and no oscillations were evidenced at the reflector plenum (PT-302A).

In general, the data related to the facility gas systems was satisfactory and reflected significant improvements over previous data.

RECOMMENDATIONS

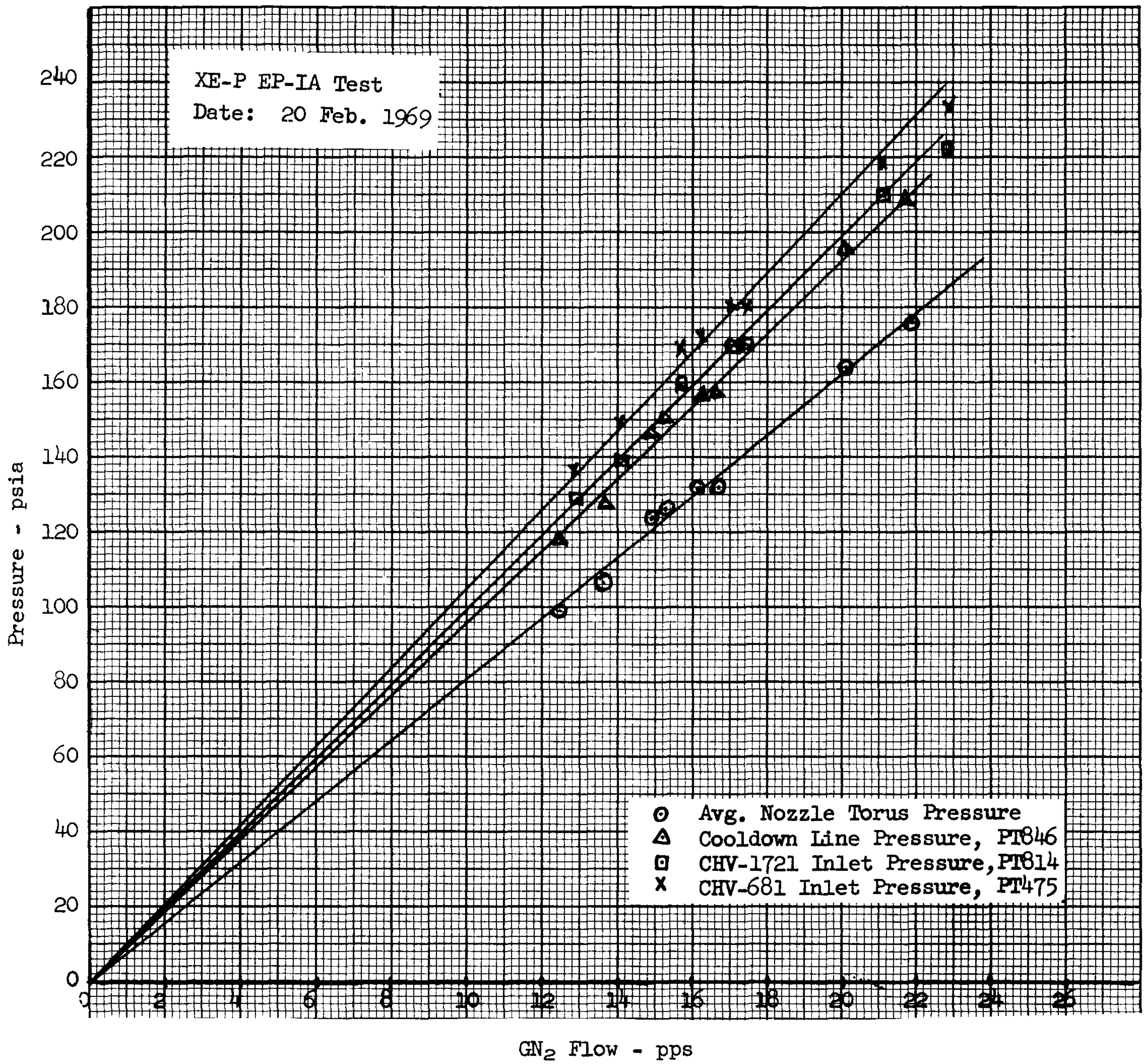
Install a pressure transducer, which will indicate the common pressure in the tube trailers connected to the GN_2 system.

ANOMALIES

There was no PCV-543 position data because this channel (DP543) did not calibrate.

(1) Reference FDET Memo No. 8, NTO-R-0157.

(2) Reference Figure 6.4.3, Page 218, RN-S-0492.



GH_2 SYSTEM PRESSURE VS GN_2 FLOW

Note: All data normalized to $500^{\circ}R$

FIGURE 1

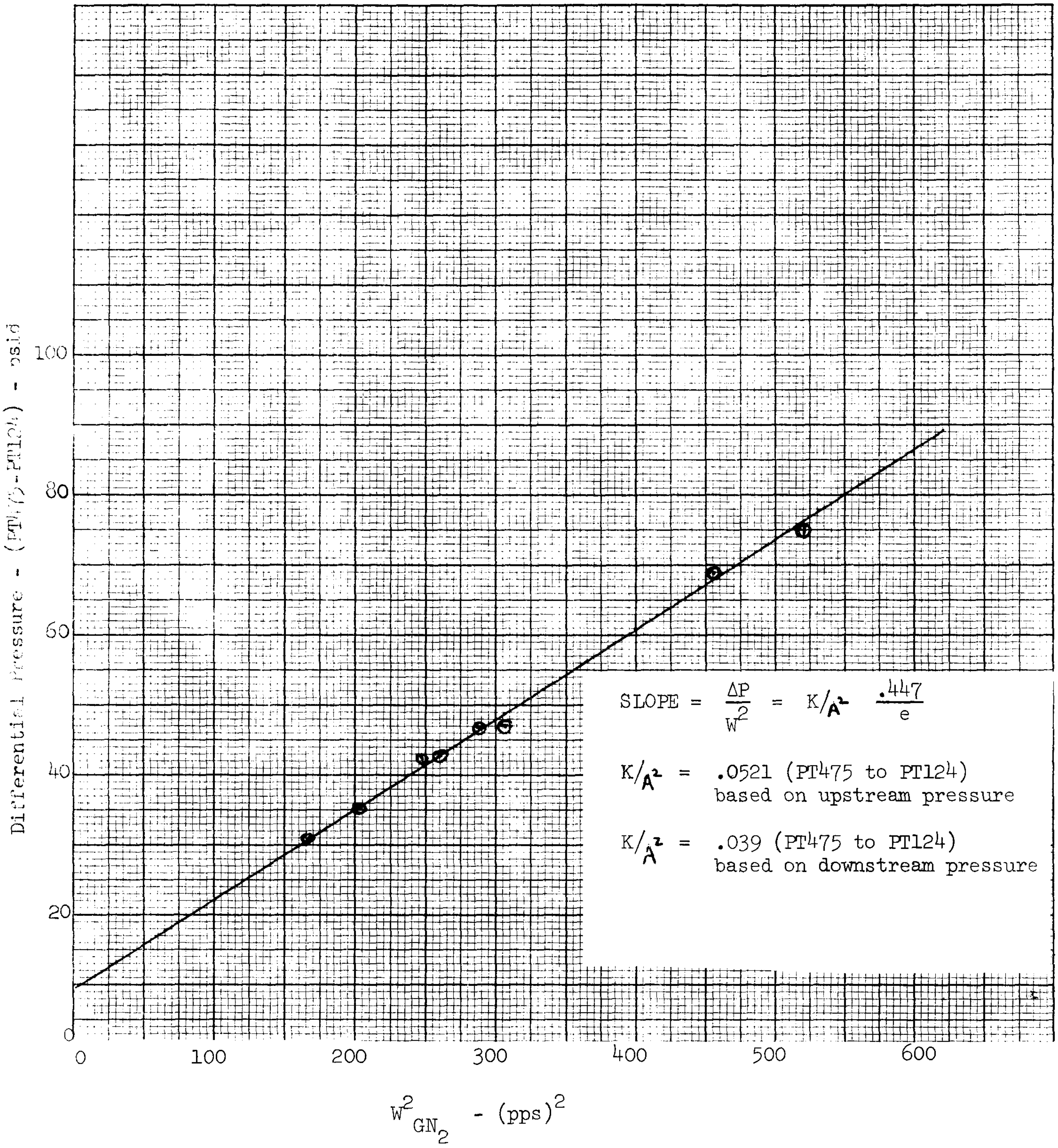

Differential Pressure - (PT475-PT124) - psid
0
20
40
60
80
100
0
100
200
300
400
500
600
$W^2_{GN_2}$ - $(pps)^2$
SLOPE = $\frac{\Delta P}{W^2}$ = K/A^2 $\frac{.447}{e}$
K/A^2 = .0521 (PT475 to PT124)
based on upstream pressure
K/A^2 = .039 (PT475 to PT124)
based on downstream pressure

FIGURE 2

TABLE 1

SUMMARY DATA TABLE - GN_2/GH_2 SYSTEM DATA

Range Time	Inlet Press. PT587 psia	Inlet Temp. TT527 °R	FE015 ΔP_1 PD589 psid	FE015 ΔP_1 PD589C psid	Corr. FE015 ΔP_2 PD778 psid	WRO-492 pps	WNFE015 pps	PCV251 Pos. DP251 %	Manual (Pos.) Demand CP.251M %	PCV251 Outlet Press. PT475 psia	PD845 psid	TT568 °R	PD847X psid	WH847X pps	PT851 psia	
55900.4	1934	509	14.9	-00	-1.0	0	0	0	0	12.8	0	494	.1	0	10	
55939.4	1918	509	42.6	27.9	26.1(25.1)	.45	12.94	10.4	12.6	135.9	-55.6	491	22.8	.12	57	
55944.4	1915	507.8	47.5	32.7	32.3(31.3)	.56	14.21	11.6	13.9	145	-49.6	488	28.5	.15	72	
55961.4	1900	507	54.5	40.4	39.6(38.6)	.78	15.21	14.1	15.9	164	-41.7	483	38.7	.21	98	
55971.9	1887	507	64.3	50.7	49.6(48.6)	.86	17.50	15.7	17.2	174	-44.7	485	41.3	.23	106	
55990.9	1863	507	100	66.8	86(85)	1.11	22.87	23.7	23.3	226	-59.1	480	54.2	.30	141	
56120.9	1727	508	93	80.1	80(79)	1.11	21.27	23.8	23.4	209	-48.0	476	53.0	.30	136	
56140.9	1717	508	65	52.3	52(51)	.90	17.05	17.9	18.9	172	-37.7	476	43.4	.24	110	
56250.9	1647	508	61	48.5	49(47.7)	.86	16.12	16.0	18.9	165	-36.8	474	40.8	.23	104	
57004.3	1476	510	11	00	-1.3		0	0	0	12.8	0	471	0	0	10	

Range Time	PCV471 Outlet Press. PT473 psia	CHV1721 Inlet Press. PT814 psia	CHV-1721 Inlet Temp. TT554 °R	Cooldown Line Press. PT646 psia	Cooldown Above CSV PT891 psia	Nozzle Torus Aver. Press. PATOR psia	LF-7 Δ P PD911 psia	Cooldown Line Temp. TT568 °R	Cooldown Line Temp. TT881 °R	V-3201 Press. PT001 psia	V-3202 Press. PT004 psia	V-3203 Press. PT007 psia	V-3201 Temp. TT491 °R	GN_2 Inventory lbs	Header Press. PT002 psia	Eng. Flow WENG pps
55900.4	14	13	494	13	13.2	12.9	0	497	499	1939	1942	1934	541	49750	1940	0
55939.4	47	126	477	116	106	97.3	3.2	476	491	1931	1935	1927	540	49583	1933	12.49
55944.4	65	135	477	125	113	105	3.5	477	488	1927	1931	1927	540	49534	1930	13.65
55961.4	98	155	474	143	130	121	3.9	475	488	1913	1918	1908	540	49226	1917	14.93
55971.9	108	165	473	153	138	129	4.1	473	481	1899	1907	1898	539	49000	1905	16.69
55990.9	180	216	471	203	185	171	5.0	469	481	1879	1885	1880	538	48619	1881	21.76
56120.9	190	200	470	188	169	158	5.0	468	470	1743	1746	1739	527	46110	1747	20.16
56140.9	190	162	469	150	138	127	4.2	468	470	1728	1732	1727	525	45880	1732	16.15
56250.9	190	155	470	145	131	122	3.9	471	472	1661	1661	1654	521	44457	1664	15.26
57004.3	182	13	470	13	12.8	12.9	0	466	474	1963	1486	1486	521	39330	1486	0

SPEAR Memo No. 15

B. L. Haertjens *BLH, BSM*

XE-PRIME

EP-IA

Subject: AUXILIARY SYSTEMS PERFORMANCE AND GROSS FLUIDS UTILIZATION

INTRODUCTION

This memo summarizes the pertinent information related to the LN_2 Cryotrap, the control drum actuation system and gross fluid usage.

SUMMARY

The operation and performance of the cryotrap assembly was satisfactory and in good agreement with previous test data. The control drum flowrates were in good agreement with previous data.

TECHNICAL DISCUSSION

LN_2 System and Cryotrap Performance

During EP-IA, the LN_2 system was operated to supply liquid nitrogen to the cryotrap for the purpose of filtering the control drum actuation gas (He). In general, the systems performed as expected. A comparison with the data obtained during the operation of the LN_2 cryotrap system during EP-SL2 disclosed no significant differences.

The LN_2 system was operated with 100 psig in V-3601. The initial pressurization and chilldown of the lines and cryotrap took approximately 18 minutes. Liquid was observed at FE-052 13 minutes after pressurization was started. It appears that pre-chilling of the LN_2 system and cryotrap on R-1 did reduce the LN_2 system and cryotrap system chilldown time. No information on LN_2 utilization during chilldown could be obtained since LT-026 was very erratic in the data. From EP-SL2, this was estimated to be 4000 lbs.

Following the initial cryotrap fill and chilldown, the chill of the LN_2 system to RSV-879 was maintained by setting PCV-754 to 13.5% with PCV-517 set at 100%. The temperature at TT-510 was maintained between 142^oR and 156^oR under these conditions. The decrease in temperature at TT-511 downstream of RSV-545 was less than 50^oR over the entire day, indicating no leakage past RSV-545. Using the integrated FE-052 flowrate data, the LN_2 flowrate through PCV-754 was determined to be 0.53 pps with an average upstream pressure (PT-580) of 24 psia. This would correspond to a Cv of 1.3 at the 13.5% setting. (Maximum Cv = 14)

Cryotrap fill cycles were initiated approximately every 35 minutes when the cryotrap level had decreased to 48%; the average level after fill was approximately 90%. The LN_2 boil-off during He flow was calculated to be 95 lb/hr and 135 lb/hr at He flowrates of 0.021 and 0.046 pps, respectively. The temperature of the actuation gas at the cryotrap discharge was maintained between $140^{\circ}R$ and $150^{\circ}R$ during the entire day.

The drum actuation gas flowrates measured at FE-430 were essentially the same as observed during EP-I and EP-SL2. With no drum command, the helium flowrate was 0.022 pps; with the reactor at delayed critical, the helium flowrate was 0.046 pps.

The LN_2 usage, based on the integrated FE-052 data following the initial chilldown, was 13,600 lbs. It is estimated that the initial chilldown to FE-052 requires an additional 2000 lbs for a total LN_2 usage of 15,600 lbs. The LT-026 data yields a total LN_2 usage of approximately 16,000 lbs.

Fluid Usage

GN_2

Approximately 15,400 lbs were used during EP-IA (34390 seconds to 58000 seconds). This usage was primarily for the thermal calibration test (10,700 lbs) and V-3601 pressurization (4700 lbs).

He

Approximately 1000 lbs of He were used during this test. The primary usages were: Control Drum actuation 0.022 pps (drums locked) and .046 pps during drum operation; and the Engine Purge 30 SCFM or .0051 pps.

SPEAR Memo No. 16
B. L. Haertjens BLH, BSM

TEST CHRONOLOGY
FOR
XE-PRIME
EXPERIMENTAL PLAN IA

February 12, 1969

I. PRE-OPERATIONAL PHASE

A. 32272 CHECKED THE CONTROL ROOM NET (Net #9)

B. 32400 CHECKED THE TDC AND TRB NET (Net #10)

C. 32490 ESTABLISHED AREA CONTROL

D. 32541 PERFORMED DATA SYSTEM CALIBRATION

32563 Switched all groups except #7 to ENABLE.

32574 Performed Manual Data System Calibration

33188 Data to HIGH

33222 Conducted a one point remote calibration of the log and linear neutronics system and report completion.

33428 Switched source drive control to EXPOSE.

33593 Data system to LOW.

33598 Returned all groups to INHIBIT.

33625 Sequentially selected startup channels 1, 2, and 3 for display.

33650 Shielded the source.

33670 Switched source drive to OFF.

E. UNLOCKED CONTROL DRUM PNEUMATIC DOUBLE BLOCK AND BLEED SYSTEM, SWITCHED CONTROL DRUM POWER AND SWITCHED ENGINE PURGE SYSTEM

33658 Verified Criticality Alarm System ACTIVE.

33679 Obtained Key #1, Key #5, SVB-11 Key and the Pneumatic System Keys.

33685 Verified that P-478 indicated ZERO psig.

33697 Unlocked RSV-444 and rotated the Manual Override hand wheel to the FULL OPEN (UP) position.

33725 Unlocked RSV-877 and rotated the Manual Override hand wheel to the FULL OPEN (UP) position.

33760 Unlocked SVB-11 and OPENED the Jamesbury Supply Valves for RSV-444 and RSV-877.

33930 Switched RSV-444 and RSV-877 to OPERATE.

Test Chronology for XE-Prime EP-IA

33999 Exercised RSV-444 CLOSED.

34010 Exercised RSV-877 CLOSED.

34022 LOCKED SVB-11.

34030 UNLOCKED 50-BV-2332 and manually CLOSED.

34075 Switched Engine Purge System from GN_2 to He in accordance with NTO-G-0056. Adjusted PRV-871 as necessary to obtain 30 SCFM.

34355 Proceeded to the TCB and reported in.

34656 Installed Key #1 and switched to CP control.

34665 Installed Key #5 and switched to Drum OPERATE.

35205 Returned to the Control Point and reported in.

34695 De-activated Criticality Alarm System.

F. PRESSURIZED V-3601, CHILLED DOWN 225-LN-6 AND SET UP CRYOTRAP CHILLER

34496 OPENED RSV-325.

34510 OPENED RSV-392.

34519 CLOSED PCV-517.

34535 OPENED RSV-326.

34546 Pressurized V-3601 to 100 psig using $\frac{1}{4}$RV-108.

34554 In Manual, slowly OPENED PCV-517 to 90%.

34574 OPENED RSV-879.

34585 Cycled RSV-879 as required to establish LN_2 in the Cryotrap.

34595 Used PCV-754 to chill until T-510 indicated LN_2.

34612 After LN_2 conditions were obtained at T-510, DDS to 1/10.

34621 When T-55 stabilized, CLOSED RSV-392.

34629 Used PCV-517 and PCV-754 to maintain LN_2 at T-510.

G. CONDUCTED MANUAL SCRAM AND INPUT SCRAM SETTING

34705 Verified the Master Key (#4) was in OPERATE.

34709 Reset Engine Safety System.

34711 Initiated Manual Scram.

34719 Set up the following scram inputs:

Fixed Power - 1 KW (160 div.) ACTIVE.

Programmed Power - BYPASSED.

Floating Power BYPASSED.

Period 1.0 sec/25% - ACTIVE.

Test Chronology for XE-Prime EP-IA

34772 Set up the following scram inputs:

± 24 VDC - ACTIVE
115 VAC - ACTIVE
RPM - BYPASSED
dp/dt - BYPASSED
TPCV Actuator Pressure - BYPASSED

34818 Set up the following scram inputs:
Max. Drum Position 40° (220 div.) - ACTIVE
Drum Roll-in Detector - BYPASSED

34841 Verified the following conditions:
Drum Override - ACTIVE
TPCV Override - BYPASSED
Pressure Mode Inhibit - BYPASSED

H. SET UP ENGINE COOLDOWN SYSTEM

34885 OPENED RSV-7 and stabilized pressure.
34915 CLOSED RSV-2, 7, and 12; OPENED RSV-1, 6, and 11.
34918 ARMED PCV-471 and exercised CLOSED.
34950 ARMED PCV-251 and exercised CLOSED. DDS to 1/1.
34991 Switched PCV-251 to SAFE.
35013 Exercised RSV-539 CLOSED.
35025 Exercised PCV-543 OPEN.
35068 OPENED RSV-324 and reported P-587.
35110 OPENED RSV-273 and reported when P-2 stabilized.
35550 OPENED RSV-245 and CLOSED RSV-273.
36635 Quick data calibration performed.
39200 HOLD COMPLETE. 24 VDC Scram Input Problem.

I. SET UP CONTROL DRUM PNEUMATIC SYSTEM.

39455 OPENED RSV-867.
39469 Used PRV-402 to establish 50 psig at P-618.
39496 OPENED RSV-881.
39509 When T-571 indicated less than 165°R, CLOSED RSV-881.
39678 Cycled RSV-879 as required to maintain T-571 less than 165°R.

39692 Used PRV-402 to establish 800 psig at P-618.

39730 OPENED RSV-877.

39739 OPENED RSV-444.

39746 Using PRV-200 slowly increased P-832 to 205 psig.

II. OPERATIONAL PHASE

A. CONDUCTED INDIVIDUAL DRUM ROTATION AND MAX. DRUM SCRAM CHECKOUT

39788 Verified Individual Drum Select Switch OFF and all individual pots at ZERO.

39796 Verified gang position demand pot at ZERO and that each drum switch was locked.

39951 Obtained ganged drum key (#3) from TD and switched to ENABLE.

39958 Verified drums LOCKED, and Drum Lock switches NOT ACTIVE.

DDS to 1/1.

One at a time rotated individual drums to 165° and SCRAM:

39970	Drum #1	40135	Drum #5	40260	Drum #9
40016	Drum #2	40170	Drum #6	40294	Drum #10
40048	Drum #3	40200	Drum #7	40325	Drum #11
40097	Drum #4	40230	Drum #8	40350	Drum #12

40425 Rechecked Drum #1 to 60° to check for noise problem in TDC.

40489 Rechecked Drum #7 to 50.5° to check for noise.

40638 Reset Engine Safety System

40725 In POSITION Control, set drums against locking pins.

40740 Printout drum position.

40786 Set exponential pot to ZERO Div. (60°).

40794 Set linear ramp pot to ZERO Div. (0°/sec).

40798 Set 1 KW demand on Power Control pot.

40806 Selected Power Control mode.

40813 Selected 20 second period.

40818 Set Power Loop Closure pot to ZERO Div. (250 W).

40825 Unlocked Drum No. 1.

40830 Narrow band data to HIGH.

40835 Started Reactor: Drum No. 1 stabilized at 59.0 degrees.

Data to 1/1.

Test Chronology for XE-Prime EP-IA

40998 Increased exponential pot setting until Drum No. 1 position indicated 95° (600 div.).

41172 Increased exponential pot setting until Drum No. 1 position indicated 105° (920 div.). Overshoot.

41250 Manual Scram to reset Auto Start.

41286 Set exponential pot setting for 102° (800 div.).

41295 Started Reactor - Auto Start. Exponential to 105° - maximum Position Drum No. 1 105.5 degrees.

41435 Set exponential pot for 115° (960 div.). Maximum Drum No. 1 Position 115.5 degrees.

41554 Slowly lowered Max. Drum Position Scram Set until scram occurred at 41587.

41624 Data System to LOW.

41624 Set Position Demand to ZERO and selected position control.

41627 Set Exponential pot to ZERO

41631 Locked Drum No. 1.

41660 Re-entry to TCB to check gamma system poser supply.

B. SECURED DRUMS PNEUMATIC SYSTEM

41747 CLOSED RSV-867.

41891 OPENED RSV-443

41897 CLOSED RSV-444 and RSV-877.

41901 Vented PRV-200 and PRV-402

41913 OPENED RSV-881.

41950 CLOSED RSV-881.

LUNCH BREAK

C. RE-ESTABLISHED DRUMS PNEUMATIC SYSTEM

43288 CLOSED RSV-443

43299 OPENED RSV-867.

43304 Used PRV-402 to establish 40 psig.

43325 OPENED RSV-881

43394 CLOSED RSV-881, when T-571 indicated 165°R

43410 Used PRV-402 to establish 800 psig at PT-618.

43441 OPENED RSV-877.

OPENED RSV-444.

43522 Used PRV-200 to establish 200 psig.

D. ESTABLISHED REACTOR CRITICALITY AND CONDUCTED FIXED POWER SCRAM CHECK

43513 Patched the transfer function generator to the position control loop.

43528 Set Fixed Power Scram at 160 divisions (1 KW) and ACTIVATED.

43562 Set period trip at 1.0 sec/25% and ACTIVATED.

43571 Set Max. Drum Position Scram to 415 divisions (75°) and ACTIVATED.

43584 Reset Engine Safety System.

43600 Reported total base counts.

Scaler #1	412 Co Counts/Min
Scaler #2	252 Co Counts/Min

43628 Verified Position Control selected.

43638 UNLOCKED all Control Drums.

43645 In Position Control initiated start reactor and withdrew drums to 47.2°.

43688 When count rate stabilized, took 5 minute count.

Scaler #1	2300 Total Counts	460 Counts/Min.
Scaler #2	1684 Total Counts	357 Counts/Min.

43695 Printout Drum Positions.

44073 ENABLED Transfer Function Input.

44079 DDS and wide band data to HIGH.

44085 Proceeded with Transfer Function Measurements.

44533 Wide band data OFF, DDS to LOW.

44533 INHIBITED Transfer Function Input.

44544 Withdrew drums to 70.8°.

44575 When count rate stabilized, took a 5-minute count:

Scaler #1	2901 Total Counts	580 Counts/Min.
Scaler #2	2612 Total Counts	522 Counts/Min.

44925 Printed out Drum Position.

45205 Withdrew drums to 83.9°.

45197 Maintained Max. Drum Position a maximum of 10° above actual drum position.

45278 When count rate stabilized, took a 3-minute count:

Scaler #1	2402 Total Counts	801 Counts/Min.
Scaler #2	2879 Total Counts	950 Counts/Min.

45710 Printout Drum Positions.

Test Chronology for XE-Prime EP-IA

45872 Withdrew drums to 91.9°.

45864 Maintained Max. Drum Scram a maximum of 10° above actual drum position.

45971 When count rate stabilized, took a 5-minute count:

Scaler #1	7737 Total Counts	1547 Counts/Min.
Scaler #2;	11731 Total Counts	2346 Counts/Min.

46310 Printout Drum Positions.

Printout neutronics.

46412 Maintained Max. Drum Scram a maximum of 10° above actual drum position.

46420 in POSITION CONTROL established 500 W.

46530 BF-3 Power OFF.

46670 Printout drum positions. Drum position pot 528 divisions.

46615 Printout neutronics.

46698 In POSITION CONTROL, initiated a Fixed Power Scram at 1 KW at 46706.

46712 Disabled gang key and verified all drums are LOCKED.

46715 Data System to LOW.

46730 BF-3 Power ON.

E. CONDUCTED DRUM OVERRIDE AND PERIOD SCRAM CHECK

46742 Set Fixed Power Scram to 160 div. (1 KW) and ACTIVATED.

46751 Set Period Scram at 1.0 sec/25% and ACTIVATED.

46756 Set Auto Start Exponential pot to ZERO div.

46763 Set Max. Drum Scram at 500 div. (90°) and ACTIVATED.

46773 Reset the Engine Safety System and ENABLED Gang Key.

46777 Data Systems to HIGH.

46800 In POSITION CONTROL initiated start reactor and withdrew drums to 60°.

46826 Rotated drums to produce a drum override.

46832 Reset the drum override.

46838 Set the Max. Drum Scram to 600 div. (108°).

46847 In POSITION CONTROL established power at 100 W.

46860 BF-3 power OFF.

46886 Bypassed max. drum SCRAM.

46890 Initiated a Period Scram.

46896 DISABLED Gang Key and verified all drums LOCKED.

46900 Data System to LOW.

Test Chronology for XE-Prime EP-IA

46905 BF-3 Power ON.

F. CONDUCTED DRUM INTEGRAL AND SIDE SHIELD WORTH TEST

46970 Set Fixed Power Scram at 410 divisions (100 KW) and ACTIVATED.

46987 Set Period SCRAM at 1.0 sec/25% and ACTIVATED.

46996 Set Max. Drum Scram at 600 divisions (108°) and ACTIVATED.

47003 Set Power Loop Closure Pot to ZERO divisions (250 W).

47010 Reset Engine Safety System and ENABLED Gang Key.

47018 In POSITION CONTROL initiated start reactor and set all drums at 15°.

47045 Switched Drum #1 to INDIVIDUAL Control.

47050 Reported and recorded E-folding times during positive period.

47060 Narrow Band Data System to HIGH.

47065 Rotated Drum #1 to 165°.

47092 In POSITION CONTROL, establish power level at 1.8 KW, switched to POWER CONTROL. Stable at 47259.

47129 BF-3 Power OFF.

47200 BYPASSED Max. Drum Position Scram above 100 W.

47296 Switched to POSITION CONTROL.

47333 Rotated Drum #1 to 15°.

47380 In POSITION CONTROL, established power level at 300 W. Switched to Power Control at 47410.

47490 Switched to POSITION CONTROL.

47512 Started to rotate Drum No. 1 to 165°. Problem encountered.

47540 Rotated Drum No. 1 back to 15°.

47576 Established 300 W.

47585 Switched to POWER CONTROL.

47638 Switched to POSITION CONTROL.

47688 Rotated Drum No. 1 to 165°.

47692 At a power level of 50 KW, re-established 1.8 KW.

47755 Switched to POWER CONTROL.

47805 Switched to POSITION CONTROL.

47846 Rotated Drum No. 1 to 15°.

47888 In POSITION CONTROL, established power level at 300 W, switched to POWER CONTROL.

47972 Switched to POSITION CONTROL.

Test Chronology for XE-Prime EP-IA

48005 Rotated Drum #1 to 165°. At a power level of 50 KW, re-established 1 KW and switched to Power Control.

48095 Switched Drum #1 to Gang Control.

48103 Set Fixed Power Scram at 196 div. ; (2KW)

48196 Printout drum positions.

48231 Switched Drums 2-12 tc individual control.

48311 Data Systems to LOW.

48318 Moved S-1 to water fill position.

48700 Completed.

48366 Printout Neutronics.

48502 OPENED RSV-296.

48517 OPENED RSV-666.

48867 CLOSED RSV-296 when duct bled in.

48739 Printout drum positions.

48800 Selected Position Control on Drums.

48810 Reset Test Stand Log.

48815 Selected Power Control.

48876 OPENED RSV-304.

49963 S-1 full.

49969 CLOSED RSV-304.

49988 CLOSED RSV-666.

49988 Printout drum positions.

50000 Switched Drums 2-12 to Gang Control.

50184 Set Fixed Power Scram at 410 div. (100 KW).

50217 Established 1.8 KW and switched to Power Control.

50238 Switched Drum #1 to Individual Control.

50257 Rotated Drum #1 to 165°.

50299 Reported and recorded E-folding times during positive period.

503300 Switched to POSITION Control.

50343 Rotated Drum #1 to 15°.

50380 In POSITION CONTROL, established power level at 300 W and switched to Power Control.

50460 Switched to POSITION CONTROL.

50485 Rotated Drum #1 to 165°. At a power level of 50 KW, re-established 1.8 KW and switched to POWER CONTROL.

Test Chronology for XE-Prime EP-IA

50630 Switched to POSITION Control.

50645 Rotated Drum #1 to 15°.

50690 In POSITION CONTROL, established power level at 300 W and switched to POWER CONTROL.

50772 Switched to POSITION Control.

50791 Rotated Drum #1 to 165°. At a power level of 50 KW, established 1.8 KW and switched to POWER Control.

50903 Switched to POSITION Control.

50917 Rotated Drum #1 to 15°.

50960 In POSITION CONTROL, established power level at 300 W and switched to POWER Control.

51048 Switched to POSITION Control.

51132 Rotated Drum #1 to 165°. At a power level of 50 KW, re-established 1.8 KW and switched to POWER Control.

51215 Switched Drum #1 to Gang Control.

51230 Switched Drum #7 to Individual Control.

51250 Rotated Drum #7 to 165°.

51288 Switched to POSITION Control.

51351 Rotated Drum #7 to 15°.

51393 In POSITION CONTROL, established power level at 300 W and switched to POWER Control.

51430 Switched to POSITION Control.

51580 Rotated Drum #7 to 165°. At a power level of 50 KW, re-established 1.8 KW and switched to POWER Control.

51687 Switched to POSITION Control

51785 Rotated Drum #7 to 15°.

51825 In POSITION CONTROL, established power level at 300 W and switched to POWER Control.

51875 Switched to POSITION Control.

52000 Rotated Drum #7 to 165°. At a power level of 50 KW, re-established 1.8 KW and switched to POWER Control.

52091 Switched to POSITION Control.

52218 Rotated Drum #7 to 15°.

52256 In POSITION CONTROL, established power level at 300 W and switched to POWER Control.

52275 Switched to POSITION Control.

52425 Rotated Drum #7 to 165°. At power levelof 50 KW, switched to POWER Control.

52466 Switched Drum #7 back to Gang Control.

52497 Neutronics Printout.

52530 Switched to POSITION Control to stabilize power.

52609 SCRAM.

52618 Disabled Gang Key and verified all Drums LOCKED.

Data Systems to LOW.

BF-3 POWER ON.

52632 Verified all Individual Drum Position Demands were ZERO.

G. CONDUCTED AUTO START TO 100 KW AND POWER CONTROL TRANSFER FUNCTION TESTS

53240 Verified CSV OPEN; not cycled.

53252 ARMED PCV-251, established 100 psig at P-475, then CLOSED.

53290 Patched the Transfer Function Generator to the Power Control Loop.

53340 Set Fixed Power Scram pot at 445 div. (200 KW) and ACTIVATED.

53370 Set Period Scram at 0.25 sec/100% and ACTIVATED.

53408 Set Auto Start Exponential Pot to 780 div. (θ crit + 7) 104 degrees.

53444 Set the linear ramp pot to ZERO div. (0°/sec).

53452 Set Max. Drum Scram at 600 div. (108°) and ACTIVATED.

53475 Set Power Demand to 100 KW.

53502 Selected 5 second period.

53510 Set Power Loop Closure Pot at 10 Div. (300 watts).

53515 Selected Power Control Mode.

53522 Reset Engine Safety System and ENABLED Gang Key.

53610 BYPASSED Max. Drum Position Scram.

53575 BF-3 POWER OFF.

53552 Data System to HIGH.

53558 Started Reactor.

53681 Set Exponential Pot to 660 div. (θ critical) 97°.

53717 ENABLED Transfer Function input.

53720 Wide Band Data ON.

Proceeded with Transfer Function Measurements.

53738 - 10 KW Step

53758 - Pseudo Random Input

53857 - Sine Wave Input

54026 INHIBITED Transfer Function Input.

Patched the Transfer Function Generator to the Position Control Loop.

54034 Switched to POSITION Control.

54102 Reset rejected Log Power channels.

54174 ENABLED Transfer Function Input.

54181 Proceeded with Transfer Function Measurements.

54465 Wide Band Data OFF.

54462 INHIBITED Transfer Function Input.

54473 In POSITION Control, reduced power to 1 KW.

54596 Switched to POWER Control.

54564 Data to LOW.

54560 Set Fixed Power Scram Pot at 196 div. (2 KW).

H. CONDUCTED THERMAL CALIBRATION AND DOSIMETRY IRRADIATION TEST

54631 OPENED RSV-948. CLOSED at 55180.

54645 CLOSED PCV-543.

54900 OPENED RSV-296.

54912 OPENED RSV-666 and bled in the duct.

55209 OPENED RSV-948.

55619 CLOSED RSV-948.

55275 OPENED RSV-297.

55542 OPENED: RSV-738, RSV-739, RSV-858, RSV-859

55566 Used FCV-32 to establish 6000 GPM Duct Flow.
OPENED PCV-543

55578 Set Fixed Power Scram Pot at 570 div. (2 KW).

55612 Narrow Band Data to HIGH.

55630 Increased Power to 1 MW on a 2-second period.

55665 Started 840 second timer.

55670 Monitored T-611 and T-646 and reported temperatures.

55690 Printout Neutronics.

55929 Used PCV-251 to maintain reactor within test parameter limits. Established 15 pps GN_2 flow.

56484 SCRAM - Time of Day: 15:41.

56492 DISABLED Gang Key and verified all drums LOCKED.

56498 Removed Ganged Drum Key #3 and returned to TD.

56507 Placed LOCKED Command on all 12 drums.

56520 Reported when reactor temperatures were less than 600 R.

56735 CLOSED PCV-251.

Test Chronology for XE-Prime EP-IA

56749 Data Systems to LOW.

56781 CLOSED: FCV-32, RSV-738, RSV-739, RSV-858, RSV-859.

56845 CLOSED RSV-297.

56881 CLOSED RSV-666.

56802 Monitored core temperatures. Rate of rise of In-Core less than 50^{o}R/hr.

56892 Set Max. Drum Scram at 200 div. (40^{o}) and ACTIVATED.

56920 Set Fixed Power Scram at 160 div. (1 KW) and ACTIVATED.

BF-3 POWER ON.

III. POST-OPERATIONAL PHASE

A. SECURED CONTROL DRUM PNEUMATICS.

57007 CLOSED RSV-867.

57140 OPENED RSV-443.

57180 CLOSED RSV-444 and RSV-877.

57217 CLOSED PRV-200.

57222 CLOSED PRV-402.

57230 OPENED RSV-881.

B. SECURED LN_2 SYSTEM

57042 CLOSED RSV-326. No Action.

58163 Vented PRV-108.

58198 OPENED RSV-327 until P-181 indicated ZERO, then CLOSED.

OPENED PCV-517.

OPENED PCV-754.

58413 CLOSED RSV-325.

C. SECURED GN_2 HEADER

58244 CLOSED RSV-245.

58250 OPENED RSV-539 and vented P-587 to ZERO.

58269 CLOSED PCV-251 and switched to SAFE.

58290 CLOSED PCV-543.

58600 Used PCV-251 to vent P-2.

58652 CLOSED RSV-324.

58661 Secured the GN_2 bottle valves.

58690 CLOSED RSV-539.

D. CONDUCTED POST-TEST DATA CALIBRATION

57678 Switched consoles to ENABLE.

57700 Switched all groups except #7 to ENABLE.

57725 Conducted a one-point remote calibration of the log and linear neutronics systems.

57821 Performed a Manual Data System Calibration.

58131 Data System to OFF.

58134 Returned all Groups to INHIBIT.

58140 Returned consoles to INHIBIT.

E. SWITCHED CONTROL DRUM POWER CONTROL AND LOCKED CONTROL DRUM PNEUMATIC DOUBLE BLOCK AND BLEED

58500 Proceeded to the TCB.

58541 Switched Key #5 to GROUNDED and removed.

58551 Switched Key #1 to OFF and removed.

58776 Proceeded to the RSV-877 area.

58809 Verified that P-478 indicated ZERO psig.

58833 Rotated the Manual Override Hand Wheels on RSV-444 to the CLOSED (DOWN) position.

58878 Rotated the Manual Hand Wheel on RSV-877 to the CLOSED (DOWN) position.

58909 LOCKED the actuators on RSV-444 and RSV-877 and removed the keys

58920 Manually OPENED 50-BV-2332.

LOCKED the handle on 50-BV-2332 and removed the key.

58956 UNLOCKED SVB-11 and CLOSED the Jamesbury supply valves to RSV-444 and RSV-877.

59000 Switched RSV-444 and RSV-877 to SAFE.

59047 LOCKED SVB-11.

59055 Removed CLOSED COMMAND on RSV-877 and RSV-444.

59059 CLOSED RSV-443.

59101 CLOSED RSV-881.

59076 Switched Engine Purge from He to GN_2 in accordance with NTO-G-0056.

59300 Returned to the CP. On arrival, returned all keys to TD.

SPEAR Memo No. 17
PAA/NTO Health & Safety
cjd

XE-PRIME

EP-IA

Subject: RADIOLOGICAL REPORT

Radiological support for EP-IA included: area monitoring surveillance of NRDS during the run and post-run periods; and test cell radiation and contamination survey support for re-entry teams and post-run activities.

A. Area Monitoring Surveillance:

1. Remote Area Monitoring

Table I presents the significant ETS-1 RAMS Station results at sustained power levels and at indicated intervals after shutdown. RAM locations are indicated in the Table.

2. Air Sampling

Air sampling was performed during EP-IA at the following locations: R-MAD, E-MAD, Test Cell "C", NRDS Main Gate, and the Central Support Area. The sampling units were activated at 0900 hours and secured at 1700 hours. Analysis of filter median indicated no significant activity above background.

3. Particulate Deposition

Post-run surveys were conducted outside ETS-1 and indicated no contamination above background.

B. Test Cell Radiation and Contamination Surveys:

1. Radiation Surveys

Table III contains selected survey data obtained during re-entry team and post-run radiation surveys. These data include: approximate time after shutdown, survey locations, and radiation dose rates.

2. Contamination Surveys

Contamination surveys were performed within the facility following reactor shutdown and indicated no significant activity above background. Locations and items surveyed included the reactor pad, test stand, pipe chase, duct vault entrance, and recovered dosimetry packets.

C. Personnel Radiation Exposure:

1. Exposure

Radiation exposure information for re-entry teams is presented in Table II.

TABLE I

RAMS STATION RADIATION MEASUREMENTS

LOCATION	DISTANCE (Feet)	AZIMUTH (Deg.)	POWER LEVEL	1 MW	1 MW					
			TIME AFTER SHUTDOWN			2 MIN	14 MIN	28 MIN	39 MIN	54 MIN
Coolant Water Reservoir	1,583	198		38	40	2.5	B	B	B	B
LOX Storage Dewar	463	137		38	56	3	B	B	B	B
NW Corner of High Pressure Gas Building	388	122		49	44	2	B	B	B	B
Outside Tunnel Access #7	169	127		494	554	39	2	1	B	B
NW of Reactor	475	303		993	993	68	4	1.5	1	B

NOTE: RESULTS IN mR/hr UNLESS FOLLOWED BY R, THEN RESULTS ARE IN R/hr.

B REPRESENTS BACKGROUND

TABLE II

RE-ENTRY TEAM INFORMATION

Re-entry Team	Secure	Dosimetry Recovery/ Preparation	Drums Secure
No. Participants**	5	14	6
Total Team Dose, mR*	0	825	30
Max. Individual Dose, mR*	0	165	10
Estimated Job Time, Minutes	90	20	30
Max. Dose Rate, mR/hr	10	5,000	20
Re-entry Date	2/20	2/20	2/20

* Pocket Dosimeter Results

** Includes Monitor

TABLE III

SELECTED SURVEY DATA -- EP-IA
Date: February 20, 1969

Time After Shutdown (Hrs.)	Location	Dose Rate mR/hr
.65	Top of Shadow Shield Wall (unshielded)	20
.65	Top of Shadow Shield Wall (shielded)	1
.66	Bottom of Stairs at Lead Bricks	1
.67	S. W. End of Shadow Shield Wall (unshielded)	440
.67	S. W. End of Shadow Shield Wall (shielded)	6
1.0	Reactor Shields at Opening	3,400
1.0	Shadow Shield Wall Opposite Shield Opening	1,400
1.1	S. W. End of Shadow Shield (unshielded)	280
1.1	S. W. End of Shadow Shield (shielded)	4
1.52	100 Feet from Reactor, S. W.	20
1.57	N. E. End of Shadow Shield (unshielded)	26
	N. E. End of Shadow Shield (shielded)	2
	100 Feet from Reactor, N. E.	18
1.62	1 Meter from N. E. Shield	1,200
3.15	25 Feet N.E. of Reactor - S-1 Retracted	5,000
3.37	1 Meter N.E. from S-1 Shield	2,000
4.0	1 Meter from S-1 Shield, inside	10,000
4.4	Pipe Chase General Dose Rate	2
4.5	Entrance to Duct Vault	10
16.5	10 Feet from S-2 Shield	.5
	N.E. End of Shadow Shield (unshielded)	10
	50 Feet N.E. of Reactor	30
	25 Feet N.E. of Reactor	200
	3 Feet N.E. of Reactor	1,000
	Contact with Reactor Midplane	8,000
	160 Feet N.E. of Reactor	.5
	All Areas Behind Shadow Shield (South Side)	Bkgd.

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SPEAR TEAM REPORT

TO:	TEST REVIEW BOARD J. J. Stewart, D. Reilly, P. W. Davison	DATE:	27 February 1969 NTO-M-27011 FBD:cjd
FROM:	SPEAR Team		
SUBJECT:	SPEAR Report, XE PRIME - EP-IA		
ENCLOSURES:	(1) through (17) SPEAR Memoranda (See Table of Contents)		

Enclosed are the SPEAR Team memos for XE Prime EP-IA Drum and Shield Worth, Thermal Calibration, and Dosimetry Irradiation Test conducted on 20 February 1969.

The memos cover detailed analysis of the engine, facility, and data processing systems by the Facility, Instrumentation, Controls and Nuclear Component groups of the SPEAR Team. Individual members participating in this activity are identified in the Table of Contents.

Memos 7 and 8 which are classified CRD have been issued as a separate supplement to this report.

F. B. Damerval

F. B. Damerval, Chairman
SPEAR Team