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REPORT TITLE

AUTHOR

NAA–SR–MEMO 10667

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TECHNICAL DATA RECORD

NAA-SR-
TDR NO. 10667

PAGE 1 OF 26

DATE 11-4-64

GO NO. 7561

S/A NO. 4521

TWR 002

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DEPT. & GROUP NO.
722-22
722-22

TITLE
SNAP 10A PbSnTe T/E Pump S/N-038 Acceptance Test

PROGRAM
SNAP 10A

SUBACCOUNT TITLE
T/E Pump and Emissivity Coating

SECURITY CLASSIFICATION

(CHECK ONE BOX ONLY)	AEC	DOD
UNCL.	☒	☒
CONF.	☐	☐
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SS-038
S. R. Rocklin

STATEMENT OF PROBLEM

Present the results of the Acceptance Test of the SNAP 10A PbSnTe T/E Pump S/N-038, in a NaK 78 Acceptance Test Loop, in accordance with Test Specification NA 0204-005, Revision "A".

ABSTRACT:

The SNAP 10A PbSnTe T/E Pump S/N-038 was Acceptance Tested in accordance with Test Specification NA 0204-005, Revision "A" and data as obtained, is submitted with a short summary of the results.

The maximum output obtained during the Orbital Full Flow Test was measured as 15.00 gpm of 1010°F NaK at a pressure of 1.060 psi.

The maximum output obtained during the Pre-Reactor Startup Test at a NaK temperature of 90°F was measured to be 0.29 gpm at a pressure of 0.00415 psi, with a startup current of 40 amperes DC.

Based on the results of the above tests, T/E Pump S/N-038 meets the requirements of the Test Specification NA 0204-005, Revision "A", with regards to the Orbital Full Test but does not meet the Pre-Reactor Startup requirements.

Acceptance Test Report of T/E Pump S/N-038

Summary of Data and Performance

The SNAP 10A PbSnTe T/E Pump S/N-038 was Acceptance tested in accordance with Test Specification NA0204-005, Revision "A", and data as obtained is submitted with a short summary of the results.

Full Flow Test - With the test loop valve in the "open" position, the maximum output obtained at 1010°F NaK temperature was measured to be 15.00 gpm at a pressure of 1.060 psi.

Pressure vs. Flow measurements were obtained at 800°F, 900°F and 1010°F NaK temperatures.

Pre-Reactor Startup Test - The maximum output obtained during this phase of the test was measured as 0.29 gpm at a pressure of 0.00415 psi, with a startup current of 40 amperes DC and a NaK temperature of 90°F.

The pump was instrumented to measure T/E element voltages and hot and cold junction temperatures. The pump magnet was magnetized to a maximum obtainable field strength of 2500 gauss as measured at the center axis of the pump throat, prior to delivery to the Environmental Test Unit. Upon its return from the Environmental Test Unit, the pump magnet field strength was measured to be 2460 gauss. The raw data obtained from the above tests is contained in AI Log Notebook B-266251.

Based on the results of the above tests, the T/E Pump S/N-038 meets the requirements of the Test Specification NA0204-005, Revision "A" with regards to the Full Flow Test but does not meet the Pre-Reactor Startup requirements.

Included in this report are the data and results of the Environmental Acceptance Test performed by the Environmental Test Unit.

NOTE: Pump pressures are presented above using measured values plus a tare pressure which was re-calculated by W. D. Leonard, taking into account the temperature effect on density and viscosity of NaK. Also included are the transition from turbulent flow to laminar flow in the low flow region. Previous tare values were based on the temperature effect on the density of NaK only. (Reference IL #1)

(1) IL: To K. A. Davis from W. D. Leonard
Dated: July 24, 1964
Subject: SNAP 10A T/E Pump Hydraulic Losses and Test Loop Tare Losses.

Schedule of Events

October 19, 1964 -	Received pump from Emissivity Coating Unit
October 19, 1964 -	Visual Inspection of the pump
October 19, 1964 -	Pressure test and Helium Leak Check of the pump
October 20, 1964 -	Pump Magnet Magnetization
October 20, 1964 -	Pump delivered to Environmental Test Unit for Environmental Acceptance Test
October 23, 1964 -	Received pump from Environmental Test Unit
October 23, 1964 -	Visual Inspection of the pump
October 23, 1964 -	Pump magnet field strength measurement
October 26, 1964 -	Pump installation into Acceptance Test Loop A-3
October 26, 1964 -	Helium leak check pump test loop
October 26, 1964 -	Installation and checkout of pump instrumentation
October 26-27, 1964 -	Vacuum Vessel and Pump Test Loop Evacuation
October 27, 1964 -	Test system NaK Loading
October 27, 1964 -	System heatup to 850°F
October 27, 1964 -	System cool down to 100°F
October 27-28, 1964 -	System heatup to 1010°F
October 28, 1964 -	Pressure vs. Flow at 1010°F
October 28, 1964 -	Pressure vs. Flow at 900°F
October 28, 1964 -	Pressure vs. Flow at 800°F
October 28-29, 1964 -	20 hours test at 1010°F
October 29, 1964 -	Pressure vs. Flow at 100°F NaK, (Pre-Reactor Startup)
October 30, 1964 -	Pressure vs. Flow at 90°F NaK, (Pre-Reactor Startup)
October 30, 1964 -	Test System Shut down

Component:	SNAP 10A PbSnTe T/E Pump S/N-038
Drawing Number:	10FS-81001
Data Source:	AI Log Notebook
Test Performed by:	Liquid Metals Test Unit, 722-22
Delivered to:	Special Testing

Test Results:

TO: DEPT. DATE

ENVIRONMENTAL EVALUATION COMPONENT TEST REPORT # 494

Component Identification SNAP 10A Thermoelectric NaK Pump #038.

Responsible Engineer and/or Unit supplying component K. A. Davis **date rec'd** 10-20-64

Applicable environmental specifications NA0204-005 "NaK Pump, Thermoelectric SNAP 10A Acceptance Test," 11-26-64.

Tests requested Vibration Acceptance

TEST PLAN OF ACTION

Test assigned to A. L. Jones **;ext** 6464 **date** 10-20-64 **scheduled test start** 10-22-64

Test equipment to be utilized 246 shaker system

Instrumentation required Table input; control accelerometer on pump top, X-Y plotter.

Measurements required Convertor element resistance and magnetic field measurement after each pass; X-Y plot of table input and pump top response.

Specimen support fixture Pump was installed in the acceptance test fixture #ETLA-1; struts were torqued per drawing #10FS-12001.

Test inputs: **VIBRATION** (constant octave sweep rate requiring 30 minutes)

Lateral and normal axes	5	14	½ "DA	Longitudinal	5	11	½ "DA
	14	50	5 g		11	30	3 g
	50	100	2.5 g		30	80	4 g
	100	250	1.0 g		80	2000	2.5 g
	250	2000	2.5 g				g

Vibration (other) The response on the pump top was limited to 5 g in the lateral and normal axes and to 4 g in the longitudinal tests per Specification. Test sequence was X, Y, and Z.

SHOCK

Lateral and Normal axes _____g, ½ sine____millisec pulse; _____shocks in each direction of each axis

LONGITUDINAL

_____g, ½sine, _____millisec pulse; _____shocks in each direction

ACCELERATION

Lateral and Normal axes _____g, for a total of_____minutes

LONGITUDINAL

_____g, aft direction, for a total of_____minutes.

_____g, forward direction, for a total of_____minutes.

TEST RESULTS

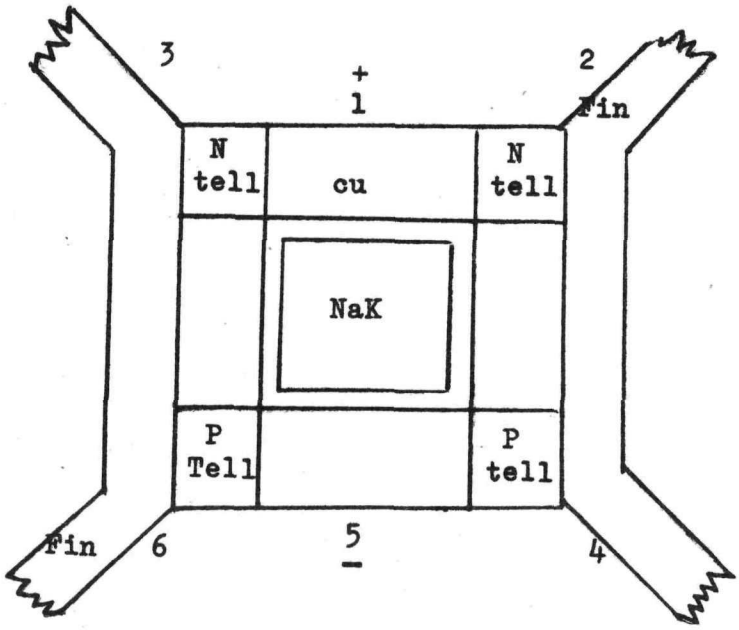
Test conducted by A. L. Jones **ext** 6464 **date** 10-23-64 **IN page No**
B-262792
B-262793
B-262794

Results A detailed visual inspection showed no apparent physical damage as a result of the test. Thermoelectric resistance readings of the telluride elements were recorded. To counteract the effect of emf generated in the telluride material, readings were taken in each direction through each element as noted in the table of results. It is extremely difficult to make accurate resistance measurements in the low micro-ohm range because the thermal emf from the telluride and the thermal emf present in the junctions between the test leads and the copper bars and/or radiators are of the same order magnitude as the IR drop of the telluride material. Since the trend of readings for each element from test to test did not vary significantly, it is assumed that within the resolution of the measuring device employed, no appreciable damage to the telluride material and/or interfaces occurred.

Specimen disposal Pump returned to Pumps and Emissivity Unit

Report prepared by A. L. Jones **date** 10-23-64 **approved** _____ **date** _____

NaK Pump #038
Vibration Test Results



Read Out Location	Resistance Readings In Micro Ohms Readings X Axis		Y Axis	Z Axis
1 to 2	16 (5)	15 (12)	18 (7)	12 (12)
1 to 3	18 (6)	14 (10)	15 (8)	12 (12)
1 to 5	28 (18)	21 (16)	21 (18)	22 (18)
4 to 5	28 (16)	26 (17)	25 (18)	23 (20)
5 to 6	27 (14)	24 (16)	25 (18)	24 (19)
Gauss *	2480	2480	2480	2480

*Magnetic flux at internal Center of pump throat

( ) Leads reversed

Figure 1

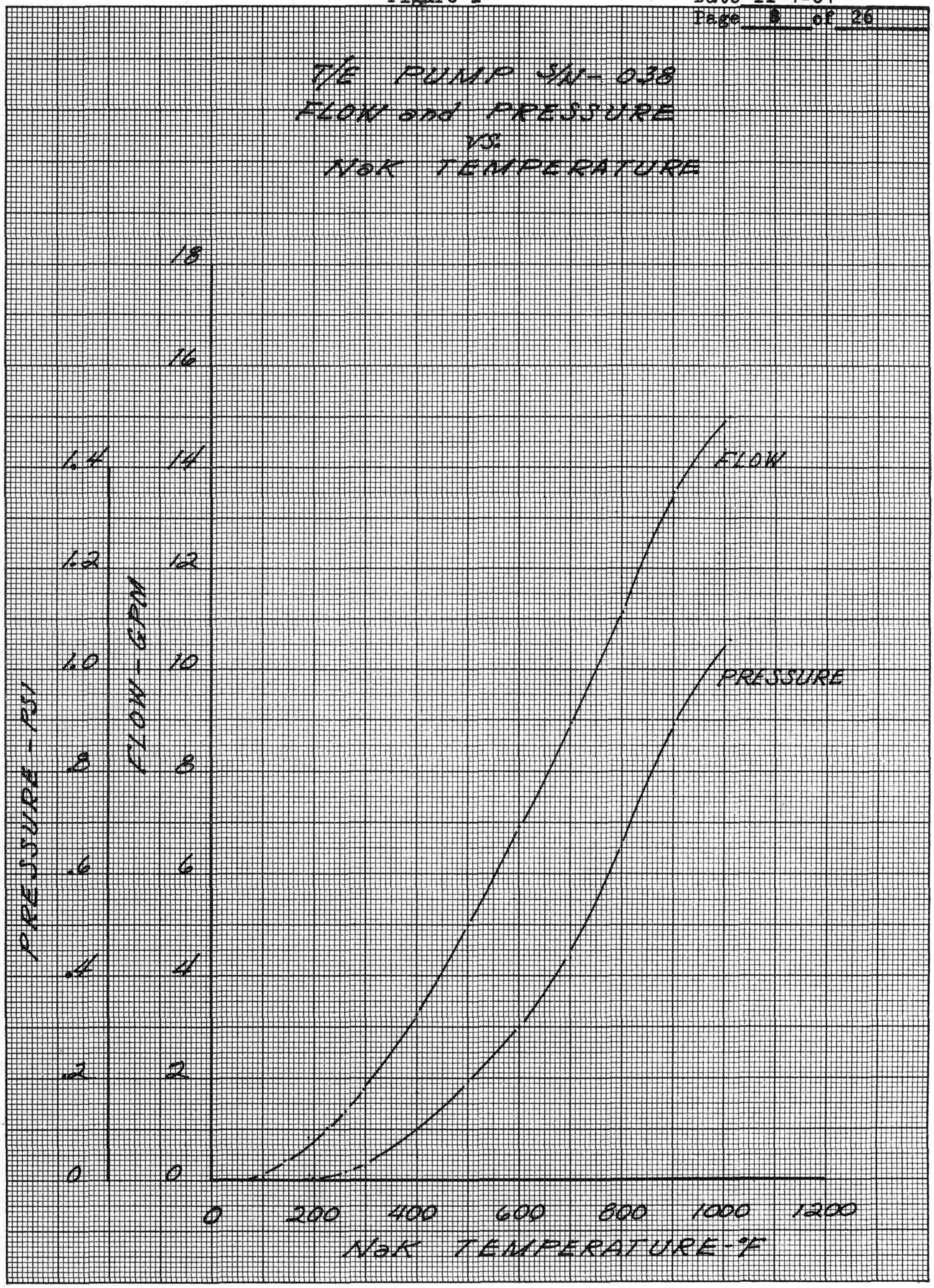
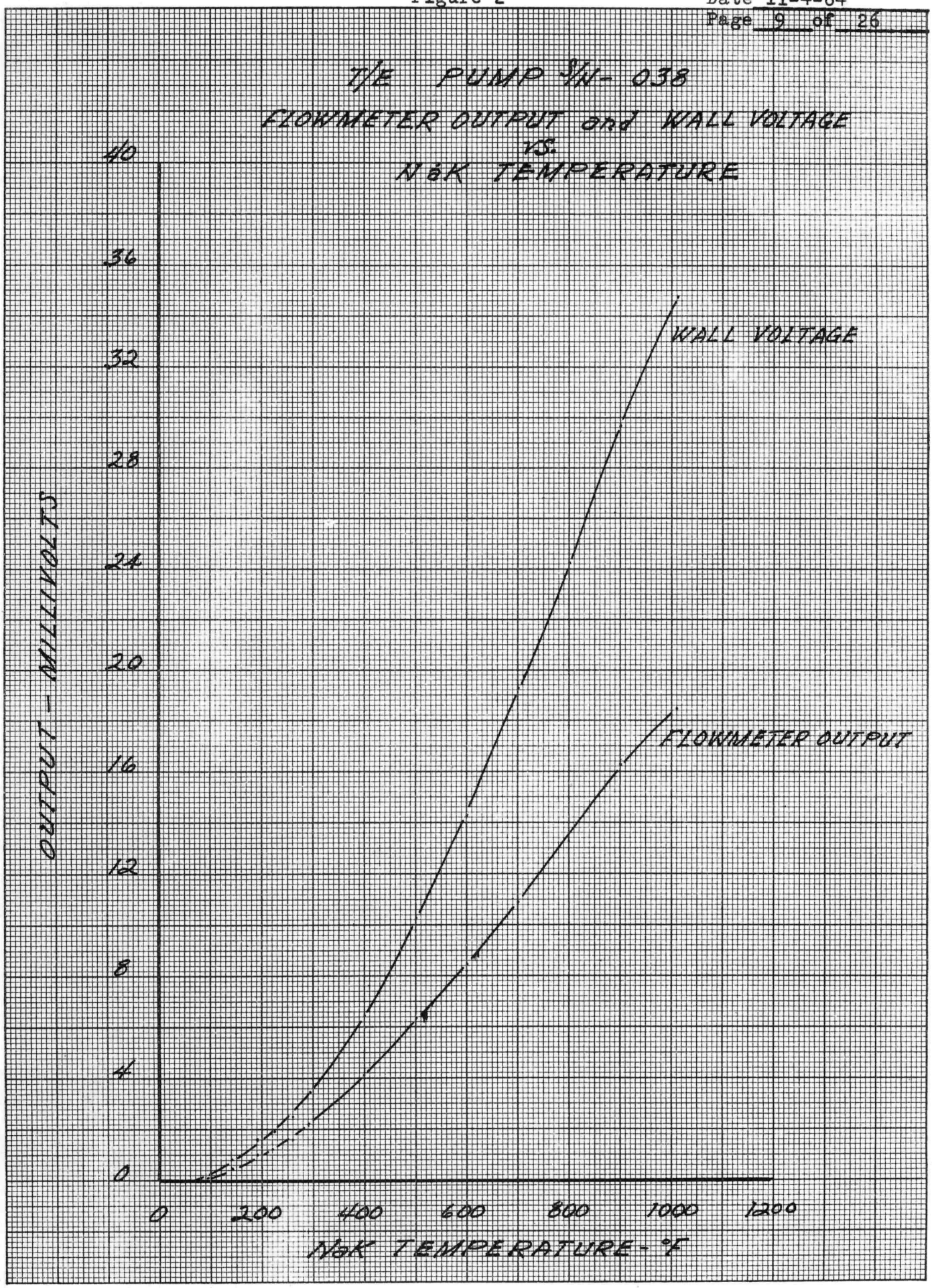

T/E PUMP S/N- 038
FLOW and PRESSURE
VS.
NaK TEMPERATURE
PRESSURE - PSI
FLOW - GPM
1.4
1.2
1.0
.8
.6
.4
.2
0
18
16
14
12
10
8
6
4
2
0
FLOW
PRESSURE
0
200
400
600
800
1000
1200
NaK TEMPERATURE-°F

Figure 2


T/E PUMP S/N- 038
FLOWMETER OUTPUT and WALL VOLTAGE
VS.
NaK TEMPERATURE
40
36
32
28
24
20
16
12
8
4
0
OUTPUT - MILLIVOLTS
WALL VOLTAGE
FLOWMETER OUTPUT
0
200
400
600
800
1000
1200
NaK TEMPERATURE - °F

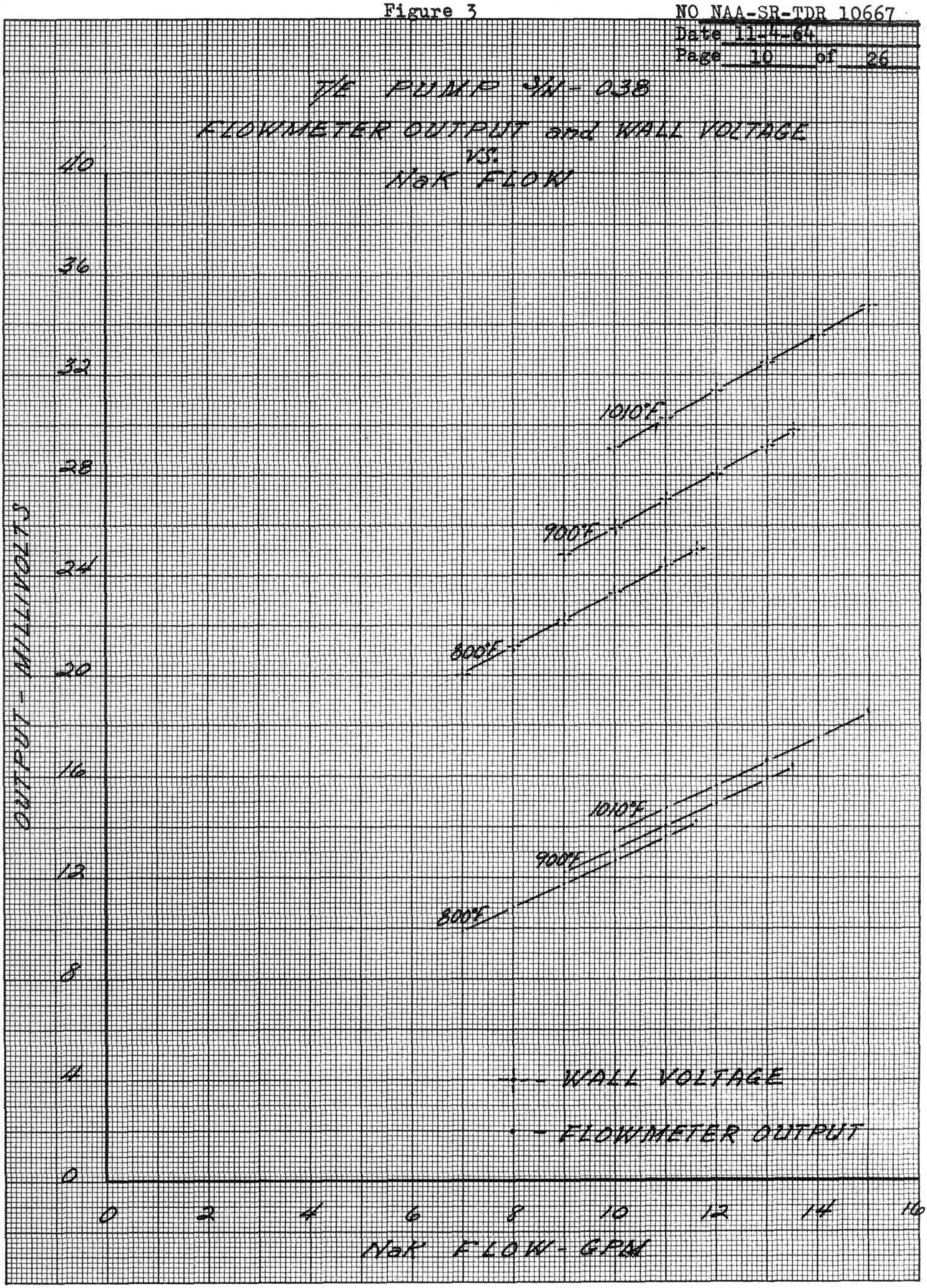
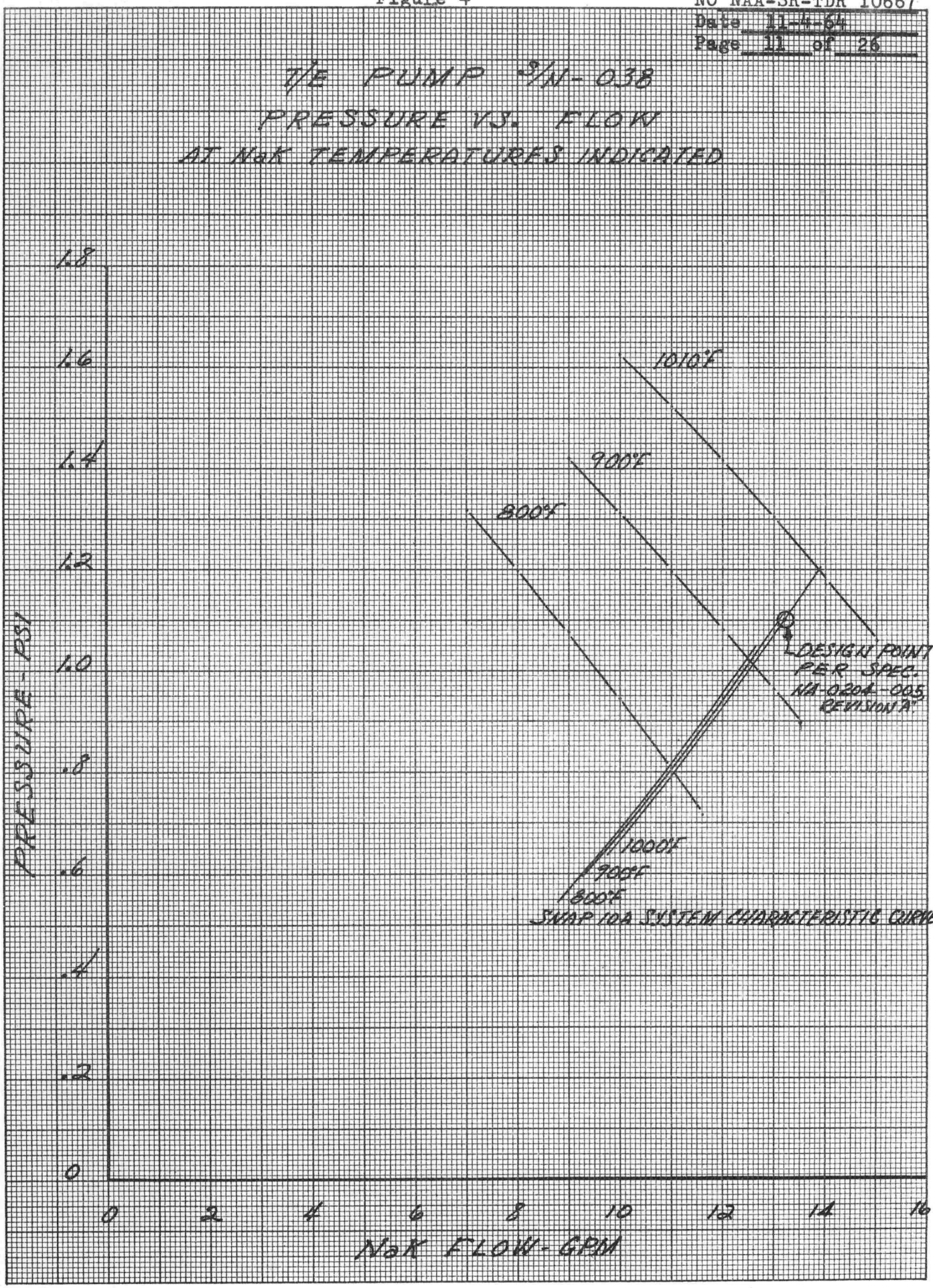

TE PUMP S/N - 038
FLOWMETER OUTPUT and WALL VOLTAGE
VS.
NaK FLOW
OUTPUT - MILLIVOLTS
40
36
32
28
24
20
16
12
8
4
0
1010°F.
900°F
800°F
1010°F
900°F
800°F
- - WALL VOLTAGE
· - FLOWMETER OUTPUT
0
2
4
6
8
10
12
14
16
NaK FLOW - GPM

Figure 4


T/E PUMP S/N-038
PRESSURE VS. FLOW
AT NaK TEMPERATURES INDICATED
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
0
PRESSURE - PSI
1010°F
900°F
800°F
DESIGN POINT PER SPEC. NA-0204-005, REVISION A
1000°F
900°F
800°F
SNAP 10A SYSTEM CHARACTERISTIC CURVES
0
2
4
6
8
10
12
14
16
NaK FLOW - GPM

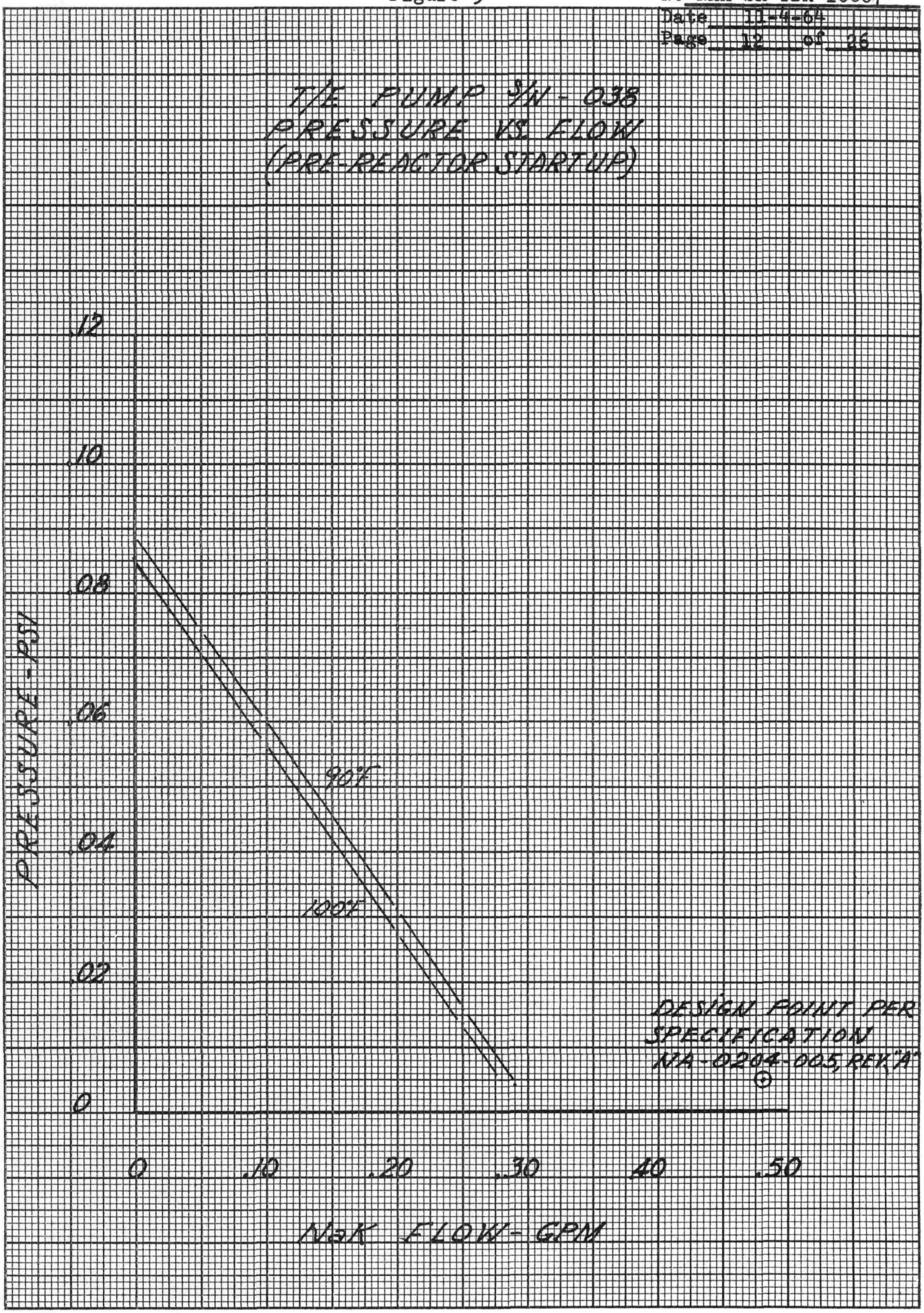
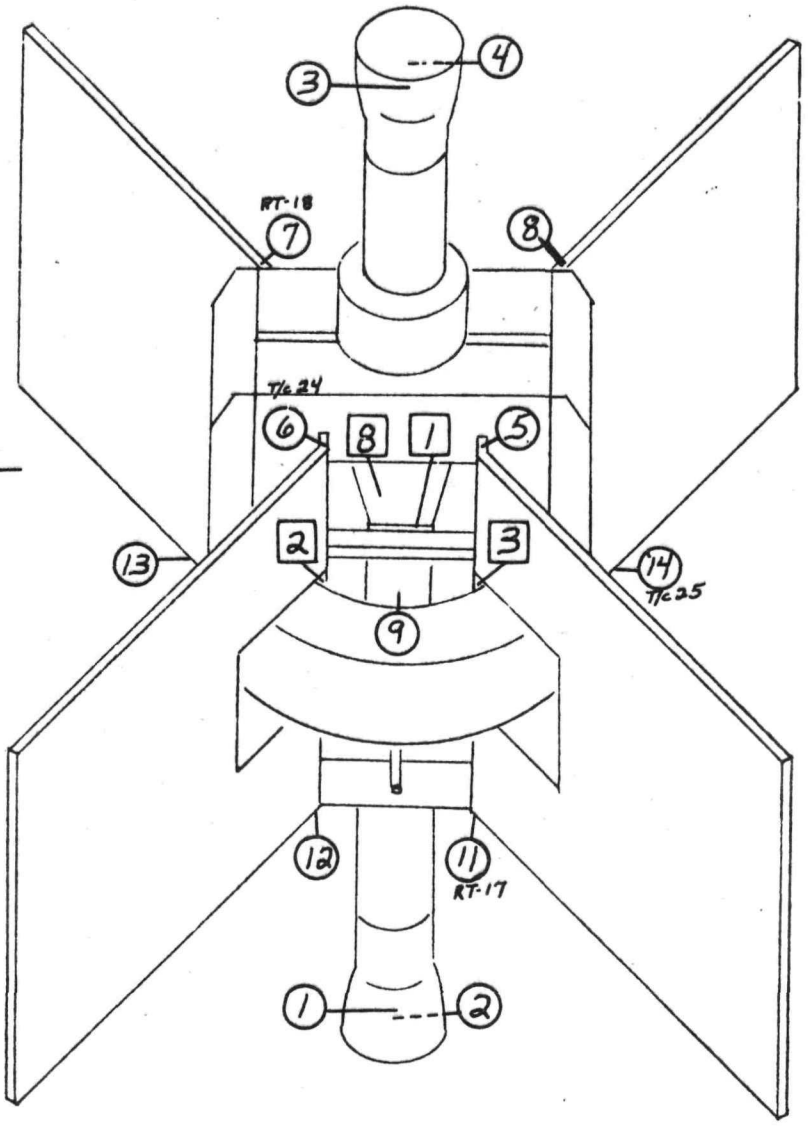

T/E PUMP S/N - 038
PRESSURE VS. FLOW
(PRE-REACTOR STARTUP)
PRESSURE - PSI
12
10
08
06
04
02
0
90°F
100°F
DESIGN POINT PER
SPECIFICATION
NAA-0204-005, REV "A"
0
.10
.20
.30
40
.50
NaK FLOW - GPM

Figure 6

S-10A T/E PUMP S/N 038

FRONT VIEW Positive Copper



Calibrated T/c's

#1 5361
2 5366
3 5359
4 5370

○ Thermocouples

#10 IN Neg copper opposite #9

□ Voltage Probes

#5 IN Neg copper opposite #1
#4 ON Neg side opposite #2
#6 ON Neg side opposite #3
#7 ON Neg side opposite #8

Instrument Calibration

Instrument	Calibration Date
Robertshaw Pressure Gage	September, 1964
Temperature Recorder	October 20, 1964
Flow Recorder	October 20, 1964
Temperature Controller	October 20, 1964
Rubicon Potentiometer	August 28, 1964
Level Probe Meter	September, 1964
Level Probe	September, 1964
D.C. Power Supply	August 19, 1964
Leak Detector	Prior to each test
Immersion Thermocouples	January 8, 1964

NOTE: All calibrations were made by the Instrumentation Unit, Department 744-42, Santa Susana, with the exception of the PM Flowmeter, the Immersion Thermocouples and the RFL Gaussmeter.

A. The test loop Flowmeter was calibrated over a flow range of 1-12 gpm against a calibrated Venturi Meter at Santa Susana by the Liquid Metals Test Unit, Department 722-22, Lab Notebook B-222251.

B. Immersion Thermocouples were fabricated by the Liquid Metals Test Unit, and calibrated by the AI Standards Lab at HQ, DeSoto.

C. The pump magnet was magnetized with the Sweinhart Electronic Magnetizer, Model LG 5. The magnet field strength was measured at the center axis of the pump throat with the RFL Gaussmeter, Model 1890. The Gaussmeter was calibrated prior to each magnet field strength measurement and accuracy of measurements were in the order of $\pm$ 0.75% as specified in the Manufacturer's Manual.

Figure 7

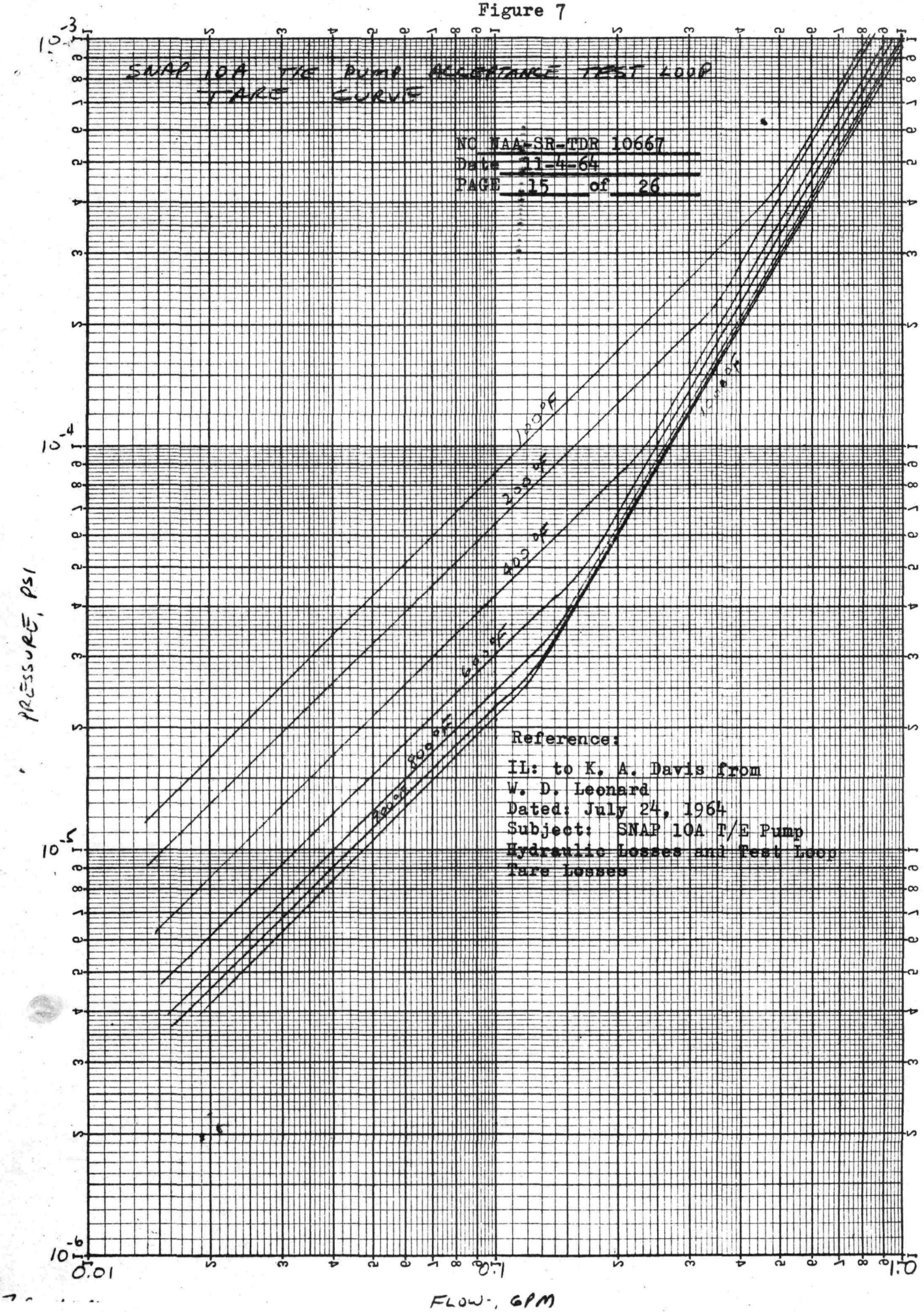
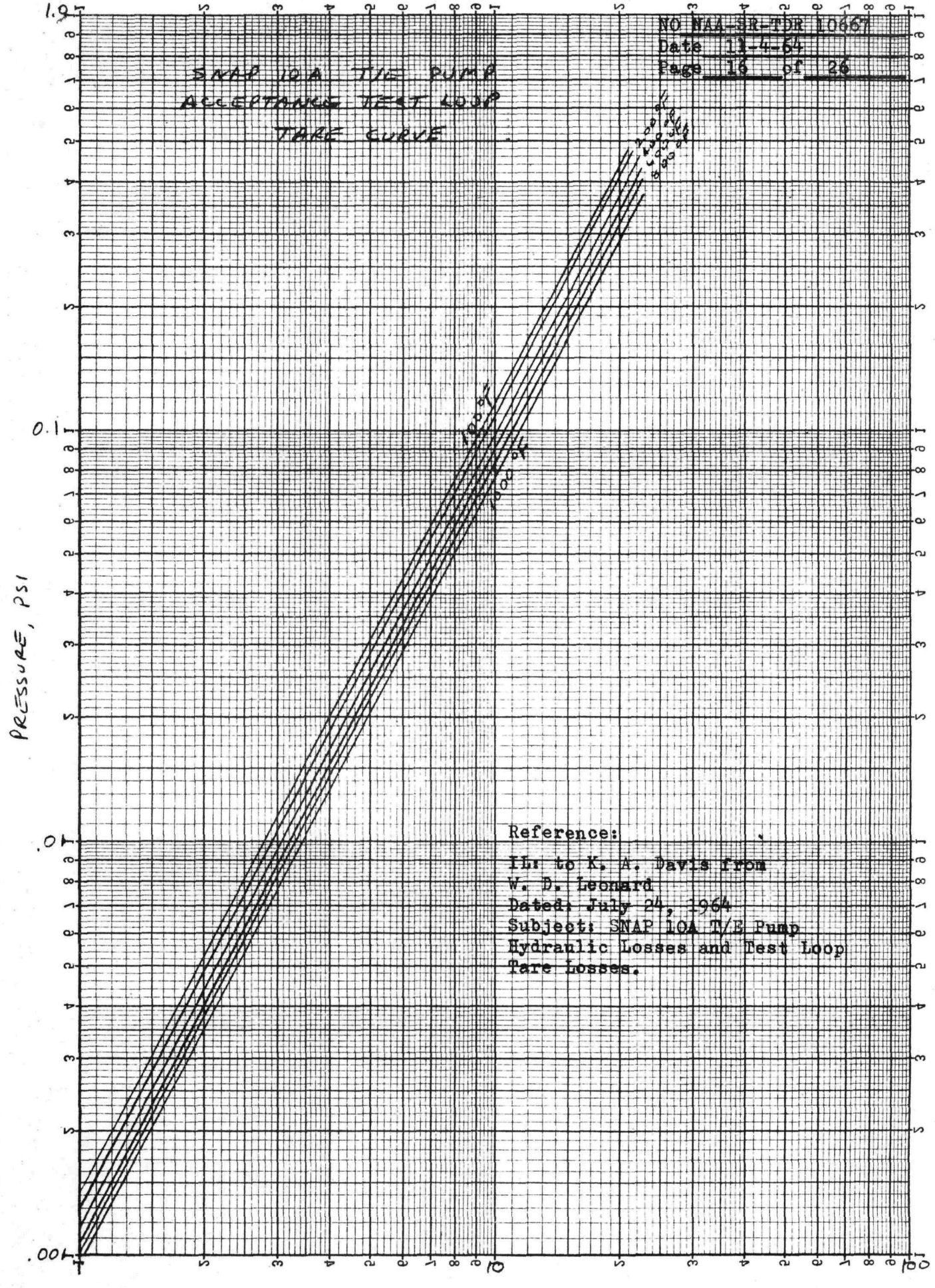

SNAP 10A T/E Pump Acceptance Test Loop
Tare Curve
NC NAA-SR-TDR 10667
Date 11-4-64
PAGE 15 of 26
100°F
238°F
402°F
600°F
800°F
1000°F
1200°F
Reference:
IL: to K. A. Davis from
W. D. Leonard
Dated: July 24, 1964
Subject: SNAP 10A T/E Pump
Hydraulic Losses and Test Loop
Tare Losses
PRESSURE, PSI
FLOW, GPM
10^-3
10^-4
10^-5
10^-6
0.01
0.1
1.0

Figure 8



7-9-64 MAL

Figure 9

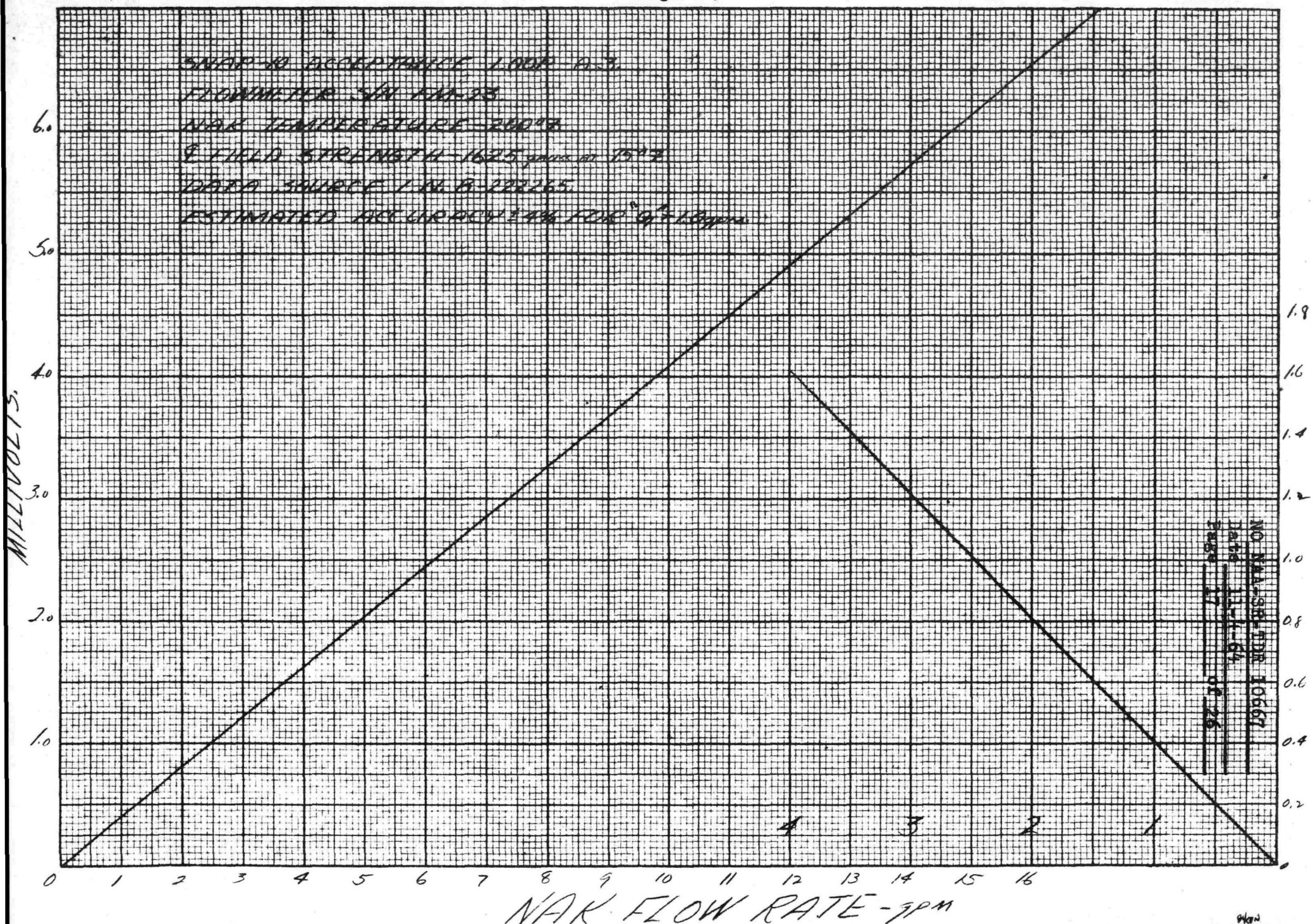

SNAP-8 ACCEPTANCE LOOP D-7
FLOWMETER SN NAK-28
NAK TEMPERATURE 210°F
FIELD STRENGTH-1625 gauss at 15"Z
DATA SOURCE LMEC-222265
ESTIMATED ACCURACY ±2% FOR 9 FLOWS
MILLIVOLTS.
NAK FLOW RATE-GPM
NO NAK-SIDE FOR 1966?
Date
Time
6.0
5.0
4.0
3.0
2.0
1.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
4 3 2 1

Figure 10

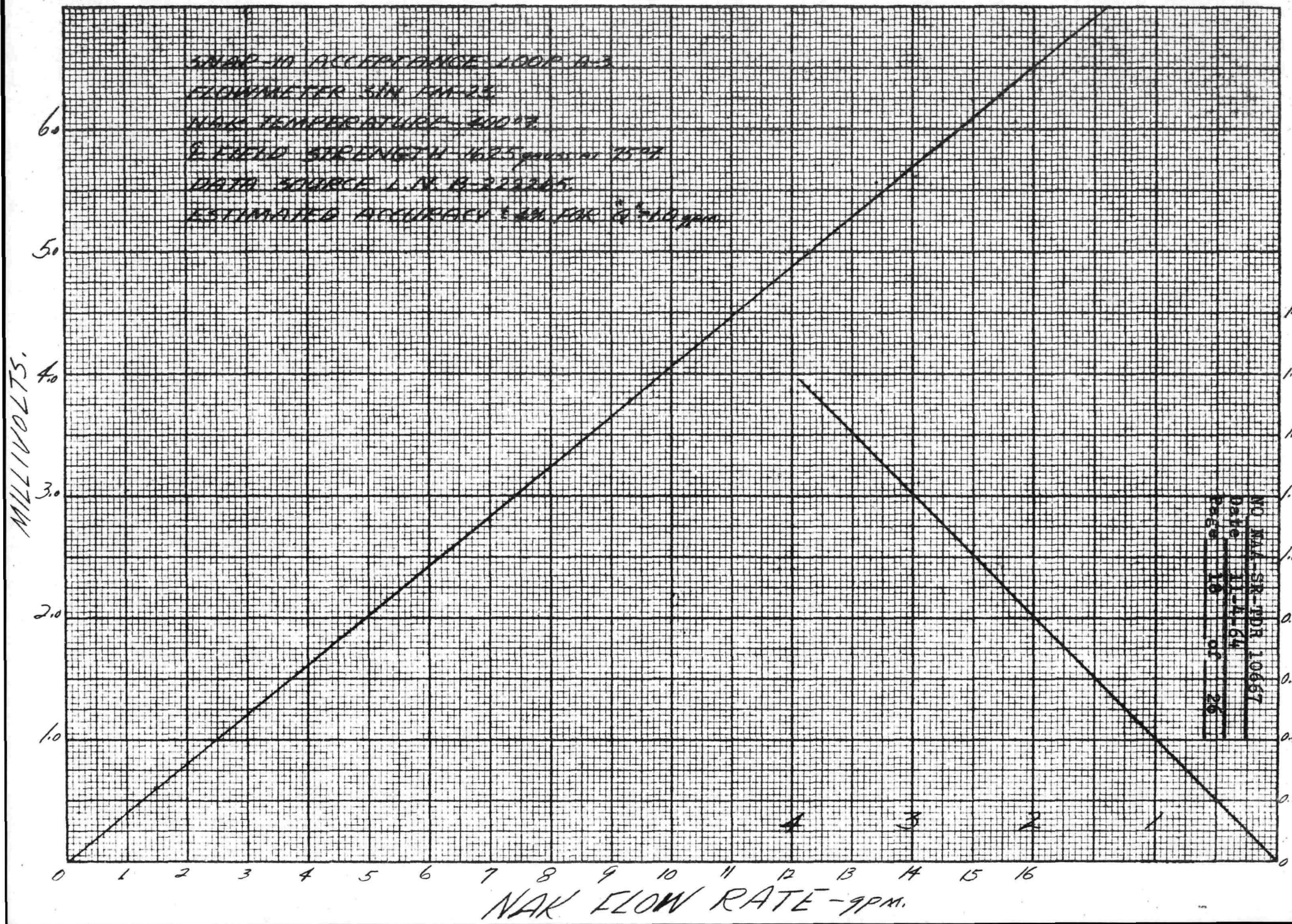

MILLIVOLTS.
NAK FLOW RATE - gpm.
0
1.0
2.0
3.0
4.0
5.0
6.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
1
2
3
4
NO NAA-SR-TDR 10667
Date 11-1-64
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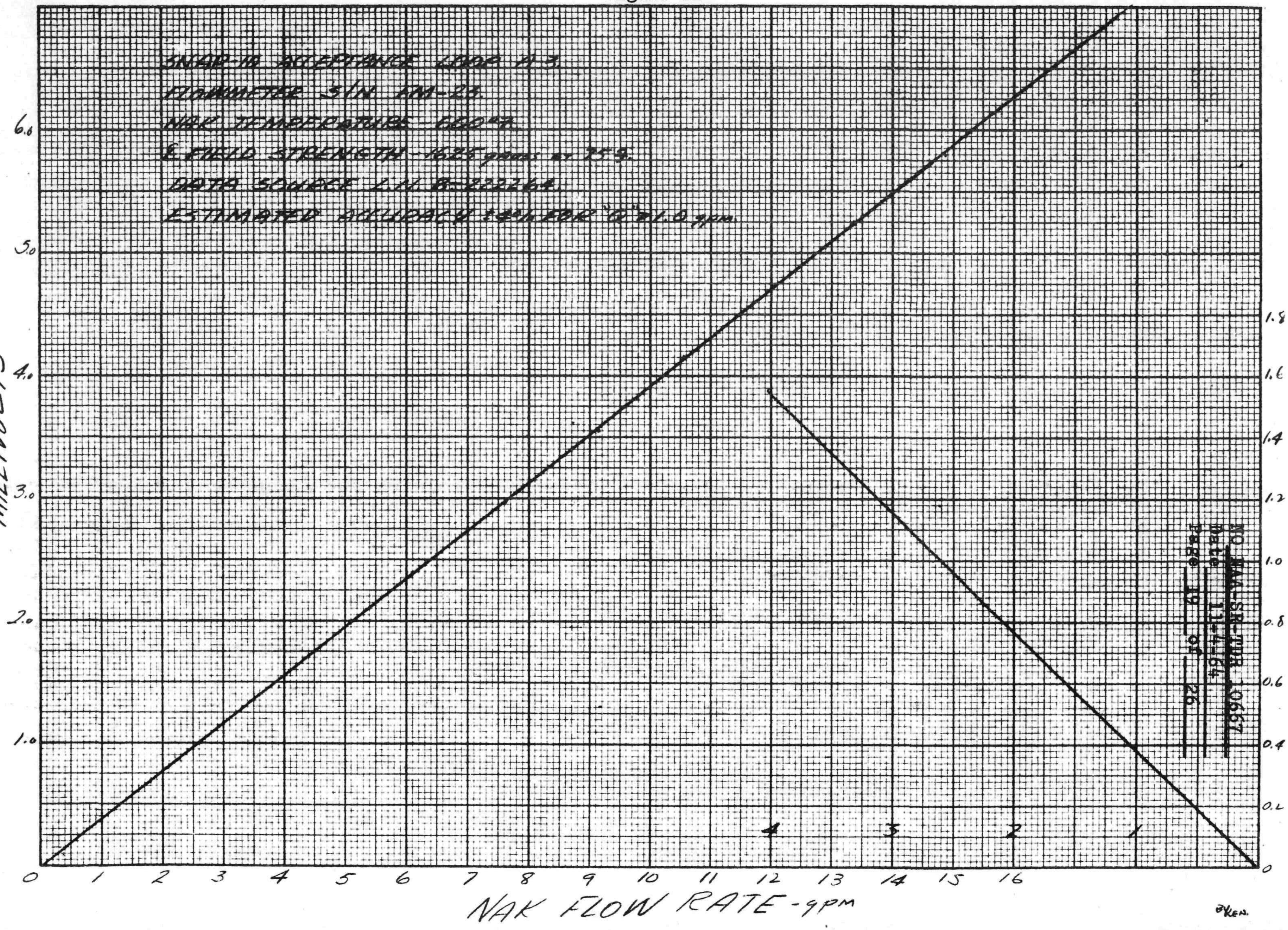
Figure 11



NO NAA-SR-TDR 10667
Date 11-4-64
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Figure 12

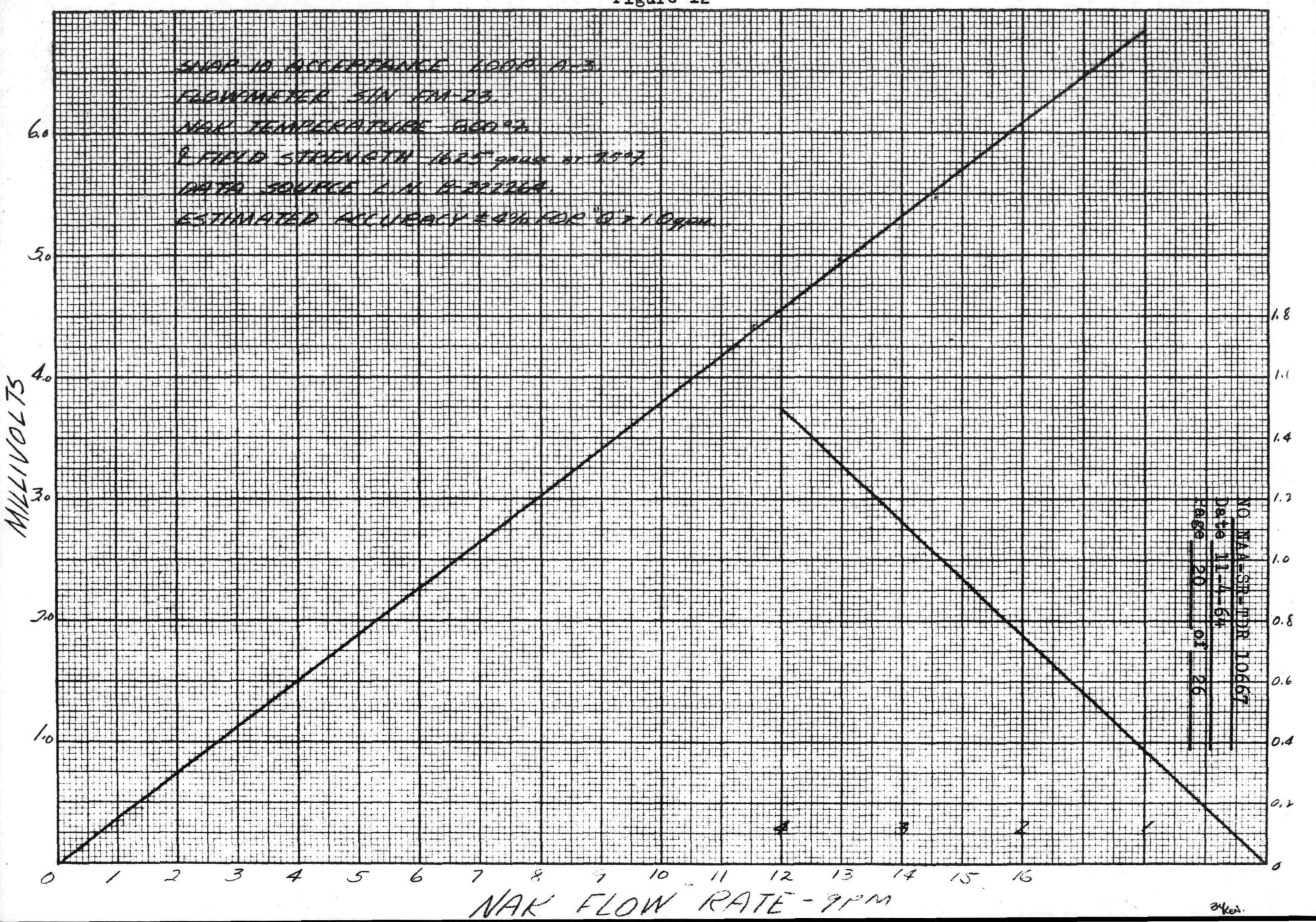

SNOR-10 ACCEPTANCE LOOP A-3
FLOWMETER SIN FM-23
NAK TEMPERATURE 600°F
B FIELD STRENGTH 1625 gauss or 7547
DATA SOURCE LAL B-222268
ESTIMATED ACCURACY ±4% FOR "0" TO 16 gpm
MILLIVOLTS
6.0
5.0
4.0
3.0
2.0
1.0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
NAK FLOW RATE - GPM
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
4 3 2 1
NO NAA-SR-MDR 10667
Date 11-4-64
Page 20 of 26
BAKER

Figure 13

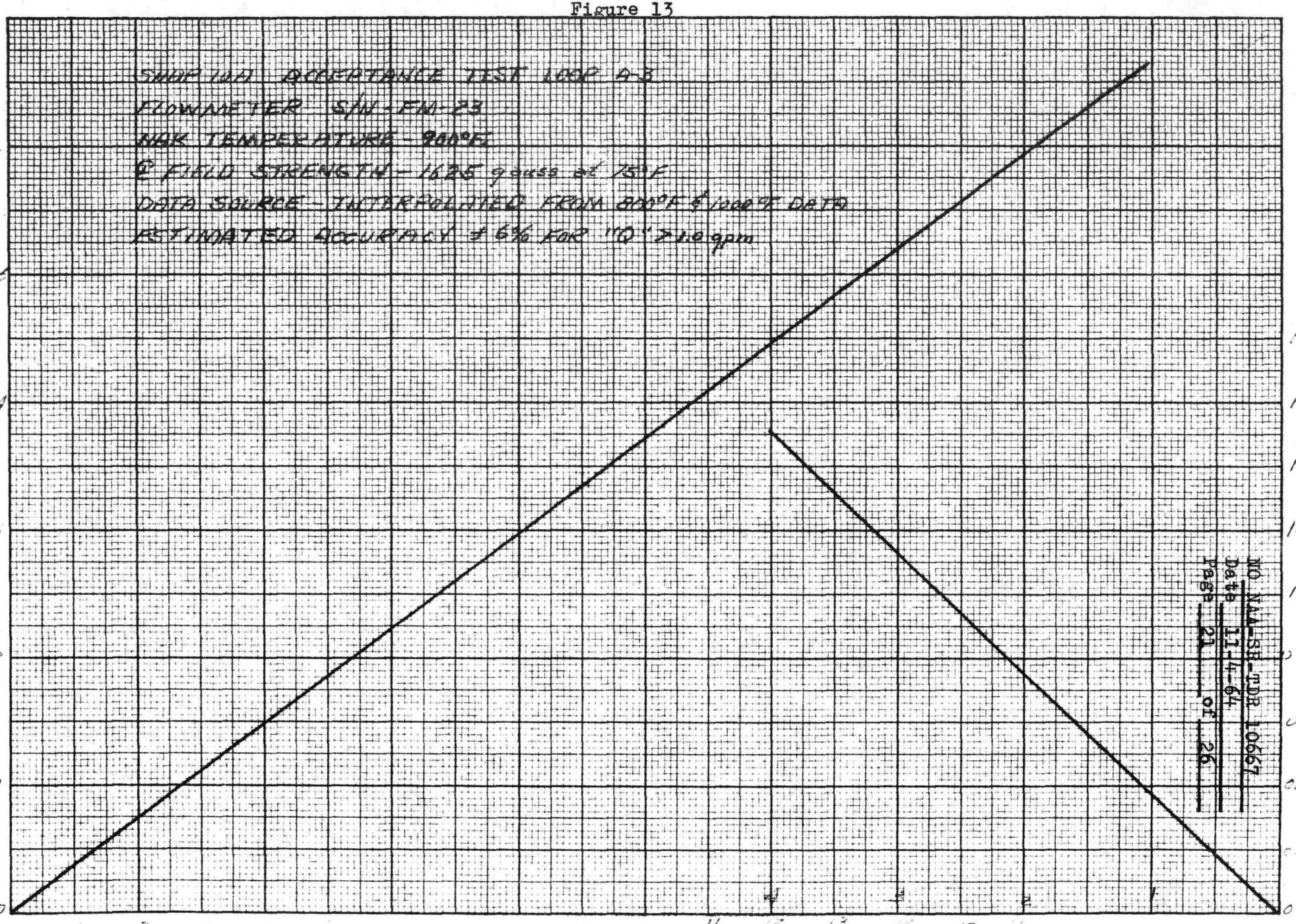
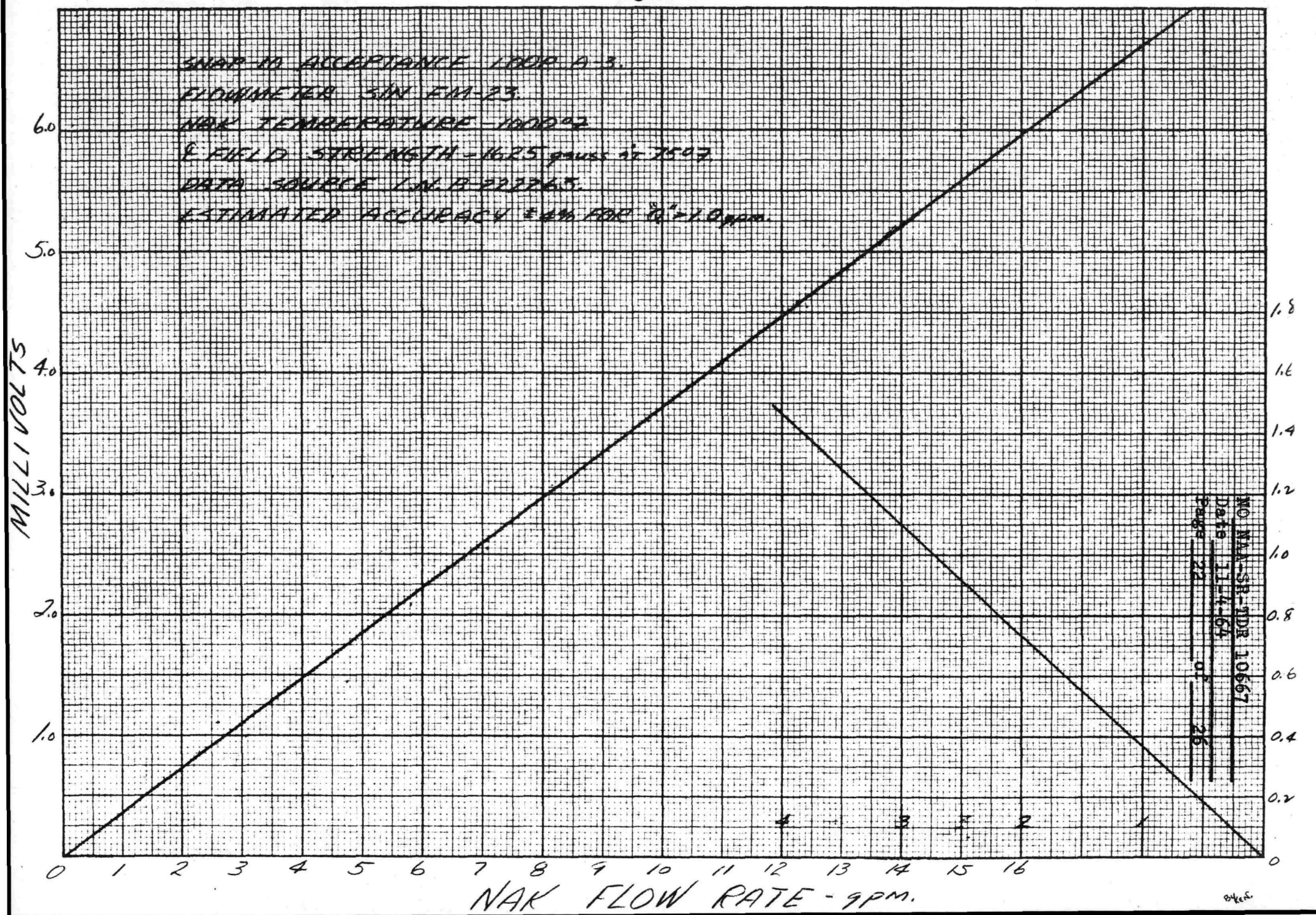

SWRP LWA ACCEPTANCE TEST LOOP B-3
FLOWMETER S/N - FM-23
MAX TEMPERATURE - 900°F
@ FIELD STRENGTH - 1625 gauss at 75°F
DATA SOURCE - INTERPOLATED FROM 800°F & 1000°F DATA
ESTIMATED ACCURACY ± 6% FOR "0" > 1.0 gpm
NO. NAA-SR-TDR 10667
Date 11-4-64
Page 21 of 26

Figure 14


SNAP 10 ACCEPTANCE LOOP A-3.
FLOWMETER SN FM-23.
NAK TEMPERATURE - 1000°F
E FIELD STRENGTH - 16.25 gauss at 7500.
DATA SOURCE LMEC-222265.
ESTIMATED ACCURACY ±6% FOR ΔQ ≥ 1.0 gpm.
MILLIVOLTS
6.0
5.0
4.0
3.0
2.0
1.0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
NAK FLOW RATE - GPM.
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
4 3 2 1
NO NAA-SR-TDR 10697
Date 11-1-64
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SNAP-10 PUMP DATA SHEET

Pump No. S/N 038 Test Acceptance

Date	Running Time Hrs	ΔP			FLOWMETERS			T_{NaK}		FIN TEMPERATURE				T_{sink}
		"-NaK	T_{NaK} °F	ΔP psi	Loop MV/GPM	FT-1T MV	FT-2T MV	T_{in} °F	T_{out} °F	TC24 °F	TC25 °F	RT17 °F	RT18 °F	
10/27/64		.125	105	.0039	.003/.01	.020	.040	99	100	100	100	100	99	77
10/28		.312	110	.0097	.181/.40	.538	.841	142	140	110	108	110	106	80
		.562	120	.0175	.353/.85	1.043	1.635	189	186	131	130	133	129	80
		.562	150	.0175	.410/1.02	1.237	1.915	225	223	164	162	165	160	85
		.875	170	.0270	.540/1.34	1.60	2.48	260	256	189	185	189	185	90
		1.312	200	.0408	.720/1.79	2.20	3.41	295	294	209	204	209	205	82
		3.00	250	.0915	1.32/3.26	4.10	6.44	400	396	260	255	260	255	80
		5.625	270	.1711	2.02/5.0	6.36	10.30	500	496	304	297	305	296	85
		8.50	290	.256	2.70/6.92	8.48	14.31	600	596	350	348	350	344	83
		12.06	305	.364	3.48/8.90	10.90	19.27	704	699	388	382	390	380	87
		18.50	400	.550	4.21/11.12	13.29	24.24	801	796	431	425	434	425	90
		25.31	460	.746	5.00/13.50	16.26	29.68	900	895	474	473	482	473	83
		30.25	450	.892	5.58/15.0	18.50	34.79	1010	1004	521	517	524	517	97

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SNAP-10 PUMP DATA SHEET

Pump No. S/N 038 Test Acceptance

Date	Running Time Hrs	ΔP			FLOWMETERS			T_{NaK}		FIN TEMPERATURE				T_{sink}
		"--NaK	T_{NaK} °F	ΔP psi	Loop MV/GPM	FT-1T MV	FT-2T MV	T_{in} °F	T_{out} °F	TC24 °F	TC25 °F	RT17 °F	RT18 °F	
10/28			Pressure		Vs	Flow	data	at	1010	°F				
		30.25	450	.892	5.58/15.0	18.50	34.79	1010	1004	521	517	524	517	96
		34.94	450	1.031	5.20/14.0	17.52	33.60	1011	1003	521	521	526	517	98
		39.94	450	1.178	4.83/13.0	16.61	32.51	1013	1005	523	521	527	519	100
		44.25	450	1.306	4.46/12.0	15.67	31.40	1013	1005	523	520	527	519	100
		48.50	450	1.431	4.09/11.0	14.77	30.30	1010	1001	522	519	526	517	93
		52.63	450	1.553	3.72/10.0	13.86	29.16	1010	1000	522	520	526	517	100
			Pressure		Vs	Flow	data	at	900	°F				
		25.44	450	.75	5.02/13.50	16.40	29.82	900	895	480	477	483	476	77
		28.13	450	.83	4.82/13.0	15.86	29.18	901	894	481	477	483	476	77
		32.81	450	.968	4.45/12.0	14.91	28.06	900	892	480	476	482	476	78
		37.31	450	1.101	4.08/11.0	14.04	27.02	900	890	480	476	482	476	82
		41.75	450	1.232	3.72/10.0	13.11	25.90	898	889	480	476	481	475	83
		46.31	450	1.366	3.35/9.0	12.21	24.84	897	889	480	476	482	475	84

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Pump No. S/N 038 Test Acceptance

Date	Running Time Hrs	ΔP			FLOWMETERS			T_{NaK}		FIN TEMPERATURE				T_{sink}
		"--NaK	T_{NaK} °F	ΔP psi	Loop MV/GPM	FT-1T MV	FT-2T MV	T_{in} °F	T_{out} °F	TC24 °F	TC25 °F	RT17 °F	RT18 °F	
			Pressure Vs Flow data at 800°F											
10/28/64		20.56	450	.606	4.41/11.6	14.30	25.04	800	795	441	438	444	438	84
		24.00	450	.708	4.17/11.0	13.67	24.34	801	795	442	438	444	439	86
		29.13	450	.860	3.79/10.0	12.76	23.34	801	795	442	438	444	439	82
		34.13	450	1.007	3.40/9.0	11.80	22.22	803	795	443	439	445	440	82
		38.75	450	1.144	3.02/8.0	10.85	21.20	805	796	443	440	445	440	82
		43.25	450	1.276	2.64/7.0	9.90	20.05	805	797	444	440	445	440	82
			20 Hour Test data at 1010°F											
10/28	0 hr.	30.50	450	.90	5.61/15.05	18.69	35.00	1014	1006	521	519	525	517	82
	4 hrs.	30.38	450	.896	5.60/15.02	18.50	34.73	1008	1001	520	518	525	516	80
10/29	8 hrs	30.19	450	.890	5.60/15.02	18.55	34.70	1008	1000	525	519	525	517	87
	12 hrs	30.50	450	.90	5.60/15.02	18.58	34.77	1010	1002	521	520	525	518	93
	16 hrs	30.56	450	.901	5.60/15.02	18.60	34.86	1010	1005	522	521	526	520	85
	20 hrs	30.63	450	.903	5.60/15.02	18.61	34.86	1010	1005	522	521	526	519	80

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Date	Running Time Hrs	ΔP			FLOWMETERS			T_{NaK}		FIN TEMPERATURE				T_{sink}
		"-NaK	T_{NaK} °F	ΔP psi	Loop MV/GPM	FT-1T MV	FT-2T MV	T_{in} °F	T_{out} °F	TC24 °F	TC25 °F	RT17 °F	RT18 °F	
10/29		Pre Reactor Start-up Data at 100°F 40 Amps D.C.												
		.125	105	.0039	.118/.29	.330	.330	100	100	100	103	101	100	101
		.437	105	.0136	.100/.25	.291	.280	100	100	100	100	100	100	100
		.875	105	.0272	.08/.20	.240	.230	100	100	100	100	100	100	99
		1.813	105	.0565	.04/.10	.141	.140	99	100	100	100	100	100	99
		2.25	105	.0701	.02/.05	.092	.100	99	99	100	99	99	100	97
		Pre Reactor Start-up Data at 90°F 40 Amps D.C.												
		.125	90	.0039	.118/.29	.318	.320	89	89	90	89	90	90	87
		.50	90	.0156	.10/.25	.278	.290	89	89	90	90	90	90	87
		1.0	90	.0312	.08/.20	.227	.244	89	89	90	90	90	90	87
		1.937	90	.0605	.04/.10	.129	.154	89	89	90	89	90	90	87
		2.375	90	.0741	.02/.05	.079	.112	89	89	90	89	90	90	88