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ATOMICS INTERNATIONAL A Division of North American Aviation, Inc.		(SR-Memo)	APPROVALS
TECHNICAL DATA RECORD		TDR NO 9363	<i>JF Burgard</i>
AUTHOR <i>W.F. Marten</i> DEPT & GROUP NO. 722-251		PAGE 1 OF 37	
TITLE Simulated Orbital Startup Test of SNAP 10A FSM-1 Power System		DATE 1/7/64	
PROGRAM SUBACCOUNT TITLE		GO NO	S A NO 3160 TWR 51446
SNAP 10A FSM-1 S10A FSM-1 System Test		SECURITY CLASSIFICATION **	
DISTRIBUTION		(CHECK ONE BOX ONLY)	(CHECK ONE BOX ONLY)
		AEC DOD	RESTRICTED ☐
		UNCL. ☐	DATA ☐
		CONF. ☒	DEFENSE ☐
		SECRET ☐	INFO ☒ GROUP 3
		AUTHORIZED CLASSIFIER SIGNATURE	DATE
		<i>John F. Burgard</i>	1-6-64
STATEMENT OF PROBLEM			
* To present the method used and thermal and electrical transients the S10A FSM-1 Power Unit underwent during a programmed simulated orbital startup.			
ABSTRACT			
* The simulated orbital startup sequence which includes squib firing, control drum insertion and thermal heating to design operating temperature was conducted on the SNAP 10A FSM-1 Power Unit on October 10 and 11, 1963. The expected nuclear reactor thermal cycle was automatically programmed into the electrical core heater.			
* Testing was conducted in a 70°-80°F water cooled vacuum chamber at a pressure of 6 microns. Cryogenic heat sinks surrounding the instrument compartment and thermoelectric pump were provided for local space temperature simulation. An additional heat sink was located beneath the instrument compartment to simulate the Agena environment.			
* A detailed test procedure, with pertinent comments, is presented as are curves showing some of the transients the system underwent.			
Classification Cancelled Or Changed To UNCLASSIFIED By Authority Of <i>DOE</i> By <i>Jefferson</i> Date <i>3 Nov 71</i>			
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<i>John F. Burgard</i> 1/6/64			
Exempt from CCRP Re-review Requirement (per 7/22/82 Duff/Caudle memorandum) NA 9/28/84			
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DATE 1/7/64

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Introduction

The orbital startup transient for a SNAP 10A system will impose high thermal stresses on the power unit. This test was conducted on the S10A FSM-1 system to prove the ability of the unit to withstand the cycle. Any weaknesses or limitation of the system would best be found during the ground test of a prototype.

The specific questions to be answered by this test were:

1. Can the structure withstand the thermal stresses which will result from this transient?
2. Will all components in the thermoelectric converter circuit remain intact during the transient?
3. How well does the resultant thermal time constant agree with the predicted transient?
4. Will all the Power Unit's components operate as planned during the startup?

Method Used

The detailed test procedure listing the time each step was performed is included. All deviations to the procedure are listed in Table I.

The automatically programmed core heater power transient is listed as Table II. The power difference between saturable core reactor output and core heater input is due to electrical line losses.

Figure 1 illustrates the transients five of the system's sub-assemblies underwent. After 200 minutes NaK was transferred from the Power Unit tubing to an auxiliary surge tank located outside the vacuum chamber. This was required to prevent over-extension of the expansion compensator bellows at design temperature. The decrease in bellows deflection illustrates this mass transfer.

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SPECIFICATION FOR
ORBITAL STARTUP TEST PROCEDURE

1. SCOPE This specification establishes the requirements and procedures for the Orbital Startup Test to be performed on SNAP 10A FSM-1.

1.1 Objective The objectives of this test are as follows:

To conduct the prelaunch electrical checkout and to enable the busses which will be on the launch pad prior to lift off.

To verify the performance of the power and control system during the startup sequence including squib firing.

To determine the thermal operating characteristics of the FSM-1 under startup conditions.

To determine the effects of temperature transients on the system.

To operate telemetry equipment and tape recorder to determine system compatibility and record some transient information.

2. APPLICABLE DOCUMENTS The following documents are applicable to this specification to the extent specified. The latest issue in effect shall apply.

2.1 AI Documents

NS10FS1-16-001 SNAP 10A Startup and Control System Description (classified)

NAO222-012 Interface Heat Transfer Test

NS10FSM1-00-001 SNAP 10A FSM-1 System Test

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3. REQUIREMENTS

3.1 Configuration The complete FSM-1 Power System, minus the heat shield, shall be tested. Both the safety and control drums shall be in the out position and locked by squib actuated lockout pins. The expansion compensators shall be provided with special gravitational loading springs. The compensators shall not be locked by the squib ejected pins. The compensator squibs will have been fired prior to this test.

3.2 Test Equipment The following equipment shall be required to perform the orbital startup test:

1. LMSCsupplied equipment (telemetry gear, surge battery, voltage regulators, tape recorder)
2. Test Chamber
3. Heater Controller
4. Instrument Compartment Heat Sink
5. Pump Heat Sink
6. LMSC Calorimeter
7. Electrical Load Simulator
8. All diagnostic instrumentation and special instrumentation
- 9.. Marquardt Programmer
10. Eighteen Channel Recording Oscillograph including appropriate galvanometers and amplifiers
11. Test Console to simulate Agena supplied circuits
12. Any additional recording and indicating instrumentation as required

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3.3 Test Method This startup test is part of the total test program specified in NS10FSM1-00-001, and shall simulate all electrical and thermal operations of an orbital reactor startup within the limitations of the test facility. In addition, the necessary prelaunch electrical checkout and arming will be simulated.

3.3.1 Test Sequence The test sequence shall be as follows:

1. Conduct the prelaunch electrical checkout and set the power and control system in the launch condition.
2. Evacuate the test chamber.
3. Fire squibs and simulated squibs and energize the control system during specified startup sequence. (The elapsed times between commands may be fore-shortened to save time during the startup).
4. Program input power to the core heater with the Marquardt Programmer to simulate the expected reactor core thermal input power.
5. Allow temperature switches to actuate heat shield ejection squib firing circuit and associated circuits.
6. Allow temperature switches to stop controller operation.
7. Continue increase of NaK temperature with Marquardt Programmer until $990 \pm 10^{\circ}\text{F}$ is attained.
8. Switch core heater control onto the manual core heater controller and off of the Marquardt Programmer when system has stabilized.
9. Conduct Interface Heat Transfer Test per Specification No. NAO222-012.
10. Set Power Unit parameters for 90 Day Test.

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4.1 Precautions and Limitations (Continued)

2. NaK flow rate shall not drop below 0.5 gpm. (0.5 mv on D/L #251).
3. Temperature difference between core heater outlet and core heater inlet shall not exceed 300F.
4. Core heater outlet temperature shall not exceed 1030F.
5. Vacuum chamber pressure shall not exceed 100 microns during entire test. (If pressure reaches 100 microns, stop transient and maintain equilibrium until supervision is contacted).
6. Vacuum vessel wall temperature shall not exceed 200F.
7. The pump cryo panel temperature shall not exceed zero F (less than 5 mv on data logger channels 276 to 281 and 284 to 289). If LN₂ flow to panel fails, turn on freon coolant system.
8. Maximum allowable calorimeter temperature shall be 75F.
9. The instrument compartment temperature shall not exceed 150F (about 40 mv for RTD #13 to #16 - data logger channels 262-5. Turn off startup controller (IB112 or 125) if temperature exceeds 150F in instrument compartment.
10. Expansion compensator bellows shall not exceed 1.5 in. deflection ($\approx$ 45 mv on data logger channels #268 and #269) at any time during test. Drain excess NaK into auxiliary surge tank if this signal is exceeded.

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4.2 Initial Status The system shall have the following initial status:

1. Wiring of RTD's (except for RT 1, 2, 3, 4) TC's, Inl's, FT's, IT's, Fns's, TS's and all power circuits shall be checked out prior to the test. All power supplies shall be turned on and properly adjusted.
2. Telemetry equipment, including tape recorder, shall have been operated for a total of 10 minutes at ambient temperature, prior to this test, to verify satisfactory operation of the equipment. The data train shall be played out as the signal plugs are attached to the submultiplexers.
3. Signals shall be wired into the recording oscillograph as follows: (Instruments calibrated and in working order).

10/8 WFM

10/10 AO

10/10 JE

CHANNEL REQUIREMENTS FOR

RECORDING OSCILLOGRAPH

Channel	Sensor	Inst. No.	Description	Signal	Impedance
1	VT-1	70	Converter Voltage	0-5V	1,000 Ω
2	TC-8	8	Manifold Inlet at Tube #27		50
3	TC-3	3	Reactor Inlet #207		64
4	TC-4	4	Reactor Inlet #208		64
5	TC-12	14	Tube Man. #17 Inlet		57
6	TC-13	15	Tube #17 Fin #1		95
7	TC-15	16	Tube #17 Fin #22		50
8	TC-14	17	Tube #17 Outlet		28
9	TC-24	32	Pump Rad. # 1		150
10	TC-25	33	Pump Rad. # 2		150
11	PnI-1	89	Drum #1 Full Range	0-5V	10,000
12	PnI-2	90	Drum #2 Full Range	0-5V	10,000
13	PnI-4	152	X Comp. #1 Pos.	0-50 mv	5,000
14	PnI-5	153	X Comp. #2 Pos.	0-50 mv	5,000
15		2043	Heater Power	0-120 mv	1.2
16	FT-1	82	Hot Pump Wall Voltage	0-50 mv	0.5
17	FT-2	159	Pump Flow Rate	0-20 mv	0.5
18	IT-1	68	Converter Current	0-50 mv	.001

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4.2 Initial Status (Continued)

<u>Channel</u>	<u>Events Recorder (E_vR)</u>
1 <u>y</u>	When the squib bus (K6A or K6B) is energized, a signal occurs.
2 <u>q</u>	When the expansion compensator squib is fired (EVM-8), K2Q closes and a signal occurs.
3 <u>k</u>	When the startup controller is enabled (K1B (EVM-2) closes), a signal occurs.
4 <u>cc</u>	When the startup controller is enabled (K19 closes) loss of signal occurs.
5 <u>z</u>	When the startup controller is enabled (K21 closes), loss of signal occurs.
6 <u>t</u>	When the startup controller is activated (K6A closes), loss of signal occurs.
7 <u>aa</u>	When the startup controller is activated (K6B closes), loss of signal occurs.
8 <u>r</u>	When safety drum #1 squib is fired (K16 (EVM-9) closes), a signal occurs.
9 <u>dd</u>	When safety drum #1 is in (Pn2-1B closes), a signal occurs.

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4.2 Initial Status (Continued)

4. Channel

Events Recorder (E R
V

10	<u>ff</u>	When safety drum #2 is in (PnS-3 closes) a signal occurs.
11	<u>ii</u>	When control drum #1 starts in (PnS-6 closes), a signal occurs.
12	<u>kk</u>	When control drum #2 starts in (PnS-8 closes), a signal occurs.
13	<u>hh</u>	When control drum #1 is in (PnS-5 closes), a signal occurs.
14	<u>jj</u>	When control drum #2 is in (PnS-7 closes), a signal occurs.
15	<u>i</u>	When the heat shield squib is fired (EVM-1) K14A closes and a signal occurs (actuated by TS-5).
16	<u>l</u>	When the malfunction arm relay (K12) EVM-3 is energized, a signal occurs.
17	<u>tt</u>	When the expansion compensator is less than 50 percent expanded, a signal exists until K8 (PnS-9) opens.
18	<u>uu</u>	When the expansion compensator is less than 50 percent expanded, a signal exists until K9(Pn10) opens.
19	<u>ll</u>	When control bus low voltage occurs (23 ± 1 vdc) a signal occurs.
20	TP41	When TS-6 closes, K14B closes as a result of simulating firing of S12 squib.

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4.2 Initial Status (Continued)

5. Press the following switches to verify that the system is in prelaunch status:
 - a. SW113 to Disable (K6A and B off)
 - b. PB-129 (Startup Relays off)
 - c. PB-130 (Events Marker Relays off)
 - d. PB-123 (Squib and Startup Relays off)
 - e. PB-125 (KCA-KCE off)
6. Complete the following check sheets prior to starting test. Verify that all instrumentation and power supplies are in proper position and no shorting occurs.
 - a. Instrumentation Status Checklist
 - b. Instrument Isolation (-4A)
 - c. Converter Impedance Checksheet (individual modules and diagnostic voltage taps, 60 cycle method)
7. Install squibs at all control and safety drums if all squib circuits appear correct.
8. Assemble vacuum vessel and evacuate to less than 50 microns.
9. Determine leak rate of vacuum vessel before proceeding with this test. Leak rate shall not exceed 3 cc/sec, stp.

17/00	10/110	WFM
Y	Y	Y

10/8	WFM
10/7	WFM
10/10	

10/6	WFM
10/4	

1400	10/10	MTM
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1750	10/110	RA
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2115	14/110	RR
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4.3 Prelaunch

1. Data recording shall be as follows:

- a. Operate data logger at 10 minute intervals for duration of transient portion of test. The following telemetry plugs must be disconnected to operate logger:

H31-P4

H31-P5

H31-F6

H 32-F6

H63-F1

- b. Start events recorder and operate at maximum chart speed. (Continuously mark data logger time on chart) (Record chart speed), $7\frac{1}{2}$ div/m

- c. Operate recording oscillograph continually after Marquardt Programmer is started but only intermittently prior to this. Use high chart speeds during initial power spikes but use slower speeds later. (Record data logger time, Marquardt time, and chart speed on chart)

8. Start autograph connected to drum coil A
jacks (Continuously mark data logger time
on chart) (Record chart speed).

- e. Operate the following instruments continuously (Mark data logger time on chart).

- (1) Dual pen core outlet recorder - $1''/\text{min}$
(Fast speed during peak transient only)

- (2) Esterline Angus current recorders 12 lines/min

- (3) CAT controller.

- f. Constantly observe core heater control current.

- g. Patch Triplett meter into T1 7 and 8 and set on volts scale to observe when TG-1 and 2 close.

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4.3 Prelaunch (Continued)

- h. Start autograph recorder connected to Marquardt Programmer voltage output just prior to beginning core heater transient. (Continuously mark data logger time and Marquardt Programmer points on chart) (Record chart speed) $\frac{1}{4}$ " / sec.
 - i. Operate telemetry gear including tape recorder for 5 minute periods at 400F, 600F, and 800F temperature levels during the heating transient. Operate telemetry gear for two 5 minute periods after equilibrium is attained at design operating temperature.
 - j. Collect Observed Data each 30 minutes during a data logger cycle (Use logger cycle indicated time on data sheet).
 - k. Collect Facility Data prior to start, at finish of transient, and as often between as timer permits.
 - l. Collect Test Console Status Data prior to start, at finish of transient, and as often between as time permits.
 - m. Collect Events Recorder Schedule as events occur. Keep log events as they occur - use logger time.
 - n. Fill out Operation Load Sheet and Calorimeter Data Sheet - a minimum of each third cycle.
2. Set Coolant Flow to the following panels and walls:
- a. Calorimeter - mean temperature of 20F (GN₂)
 - b. Instrument Compartment - leave coolant off until NaK is ejected from compensators at 800F or instrument compartment reaches 130F. Use freon then. Record time freon was turned on.

2330 10/10 G D

10/11 A O V

10/10
410/11

10/10
10/11

10/11

10/11

10/11

2030 6/10 R V

0354 10/11 RM

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4.3 PreLaunch (Continued)

6. c. Energizes FL y

d. Check the following jacks:

- (1) TP 30 (hot) to TP-34 (neg) -0 to 28V when either K6A or B closes
- (2) TP 14 (hot) to TP-34 (neg) -28V to 0 when K6A closes.
- (3) TP 13 (hot) to TP 34 (neg) -28V to 0 when K6B closes

7. Initial events recorder and push button lights (PL) status shall be as follows:

a. Events recorder

- (1) Channels #1, 4, 5, 6, 7, 11 and 18, (17) are at 28V.
- (2) Channels #2, 3, 8, 9, 10, 12, 13, 14, 15, 16, 19 and 20 are at zero V.

b. PL's

- (1) Energized PL y, cc, z, t, aa, (tt) uu, ii, nn, ss, pp, qq, u, and n.
- (2) De-energized PL p, k, m, r, v, w, x, bb, dd, ff, kk, hh, rr, jj, ll, mm, oo, j, l, gg, ee, vv, ww, q, and o.

2026 10/10 MTM

2030 10/10 MTM

2030 10/10 MTM

2030 10/10 MTM

10/10 MTM ✓

10/10

✓

↓ ↓

4.4 Pre-Orbital Startup The following steps shall be accomplished:

NOTE: No nose cone ejection can be simulated.

1. Fire the simulated expansion compensator squib circuits. (Record data logger time on events recorder schedule).

a. Press PB 120.

2031 10/10 MTM

" " "

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4.4 Pre-Orbital Startup (Continued)

1. b. Events recorder channel #2 - changes from 0 to 28V (Signal when K20 closes (EVM-8)).

2031 10/10 MTM

- c. Energizes PL q (K20 is closed).

2. Turn pump power (PS-3) to maximum setting.

2032 10/10 MTM ✓
2035

3. Set ΔT between manifold inlet and pump radiator at $45 \pm 5F$ by raising NaK temperature with Marquardt programmer. (NaK temperature should be about 135F) (Maintain a graph of pump ΔT vs. inlet manifold temperature). (42-43° attained)

2330 10/10 WFM

4. Let system come to equilibrium before continuing test. (Equilibrium is less than 2F change in pump radiator or manifold inlet temperatures in 30 minutes).

2330 10/10 WFM

5. Take complete set of data as indicated in 4.3 step 1.

2340 10/10 WFM

4.5 Orbital Startup

- 4.5.1 Startup Coils The startup coils (K1A and B, K2A, B, C and D, K3A and B, K18A and B, K1, K 21) shall be energized as follows:

1. Press PB 111 - Record following on Events Recorder Sheet at time this command is given.

2153 10/10 MTM

- a. Log the initial volts and amps, and then the peak current and the depressed voltage on PS-5 as squibs are fired by this action.

PS-5	Initial	Peak	Final
Amps	1.3	2.2	1.7
Volts	28.1	27.1	28.1
Power	36.5	59.7	47.7

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4.5.1 Startup Coils (Continued)

1. b. Record pressure on thermocouple gage before and after firing squibs to detect any pressure rise (Correct for leakup rate of vessel).

Gage	Initial	Final	Corrected Rise
McLeod	6.5	13.5	$\approx 7u$
NRC			$\approx 10u$

2. Verify that events recorder changes as follows:

- a. Channel #3, 0 to 28V (K1B is closed) (EVM-2)
- b. Channel #4, 28V to 0V (K19 is closed)
- c. Channel #5, 28V to 0V (K21 is closed)
- d. Channel #6, 28V to 0V (KCA is closed)
- e. Channel #7, 28V to 0V (KCB is closed)

2133	10/10	MTM
↓	↓	↓
↓	↓	↓
↓	↓	↓
↓	↓	↓

3. Verify that lights are de-energized as follows:

- a. Close FL cc (K19)
- b. Close FL z (K21)
- c. Close FL t (KCA (and, therefore, K1B))
- d. Close FL aa (KCB (and, therefore, K1A))

2135	10/10	MTM
↓	↓	↓
↓	↓	↓
↓	↓	↓
↓	↓	↓

4. Verify that FL k is energized (K1B is closed) (EVM-2)

5. Verify that the following jacks are affected:

- a. TP 23 (hot) to TP 34 (neg) - (0 to 28V when K19 is closed)
- b. TP 26 (hot) to TP 34 (neg) 0 to 28V when K21 is closed

2142	10/10	MTM
↓	↓	↓
↓	↓	↓
↓	↓	↓

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2133	10/10	M _{TM}
↓	↓	↓

2133	10/10	MT/19	✓
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4.5.3 Drum Released (Continued)

1. b. Channel #12, 0 to 28V (Control Drum #2 starts in) (FnS-3)
2. De-energizes the following:
 - a. PL nn - Safety drum #1 starts in (FnS-2)
 - b. PL ip - Safety drum #2 starts in (FnS-4)
 - c. PL oo - Control drum #1 off limit (FnS-6)
 - d. PL qq - Control drum #2 off limit (FnS-8)
3. Verify that the following are energized:
 - a. PL ee - Safety drum #1 off limit (FnS-2)
 - b. PL gg - Safety drum #2 off limit (FnS-4)
 - c. PL ii - Control drum #1 off limit (FnS-6)
 - d. PL kk - Control drum #2 off limit (FnS-8)

2153 10/10 MTM

2150 10/10 MTM

Y	Y	Y

2140 10/10 MTM

Y	Y	Y

4.5.4 Drums Full in The following steps shall occur and shall be monitored:

1. Verify that the events recorder changes are as follows:
 - a. Channel #9, 0 to 28V (Safety drum #1 in) (FnS-1B)
 - b. Channel #10, 0 to 28V (Safety drum #2 in) (FnS-3)
 - c. Channel #13, 0 to 28V (Control drum #1 in) (FnS-5) (This should never be energized)
 - d. Channel #14, 0 to 28V (Control drum #2 in) (FnS-7) (This should never be energized)

2140 10/10 MTM

Y	Y	Y

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4.5.4 Drums Full in (Continued)

2. Verify that the following are as indicated:

- a. PL dd - Safety drum #1 in (PnS-1B)
- b. PL ff - Safety drum #2 in (PnS-3)
- c. PL hh - Control drum #1 in (PnS-5)
(This should never be energized)
- d. PL jj - Control drum #2 in (PnS-7)
(This should never be energized)

2142	10/10	MTH							

4.5.5 Controller Operation

1. The following jacks are affected by control drum rotation; observe and record.

- a. Coil A - 1B (hot) to 1A (neut.),
5V pulses (Recorded on Autograf)
- b. Coil B - 2B (hot) to 2A (neut.),
5 V pulses
- c. Coil C - 3B (hot) to 3A (neut.),
5V pulses
- d. Coil D - 4B (hot) to 4A (neut.),
5V pulses

2140									

NOTE: 5V pulses start 50 seconds after controller is energized and are active during a 5 second period. Pulses occur at 150 second periods thereafter.

- e. Frequency Divider - 8B (hot) to 8A (neut.),
5 pulse

2230	Y	Y							
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NOTE: 5V pulses start 125 seconds after controller is energized and sustained for 75 seconds. This cycle is repeated at 150 second periods thereafter.

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4.5.5 Controller Operation (Continued)

2. Verify that the following jacks are affected by controller operation:

a. Low temperature - 7B (hot) to 7A (neut.); steady 0.2V bias signal until temperature turns off drum stepping function.

2240 10/10 MTH

b. High temperature - 6B (hot) to 6A (neut.), 0V until sensor is above set point of controller, then 5V signal.

2250 10/10 MTH

3. Continue rapping in drums for at least two hours before starting Marquardt Programmer.

2400 10/10 MTH

4.5.6 Graphs Required - The following curves shall be plotted continuously during the startup transient.

1. Manifold inlet vs time
2. Instrument compartment temperature vs time (RTD millivolts)
3. Pump flow vs time
4. Heater power vs time
5. Expansion compensator position vs time

4.5.7 Marquardt Programmer Start The following steps shall be accomplished:

1. Verify that the two Autographs are operating.
2. Press the programmer run control. Record exact logger time on chart paper.
3. While the program is running, observe the indicating instruments to determine satisfactory system operation.

2350 10/10 6D

0000 10/11 6D

0000 10/11 6D

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4.5.7 Marquardt Programmer Start (Continued)

4. If a malfunction occurs, stop the program by pressing the programmer stop control. (Stopping the programmer results in holding the power at the level at which the stop command was given. The operator can then adjust the power level manually as circumstances demand by simply repositioning one tab at which the programmer was stopped.)

No Malfunction

5. For normal operation of the system, press the programmer stop control when the reactor outlet temperature attains the desired value.

0330 10/11 60

6. If for some reason, the operator fails to stop the programmer at the desired reactor outlet temperature, the programmer will automatically stop at the tab position no. 34. The automatic stop will prevent excessive core heater power and temperature due to operator error.

7. Manually maintain the reactor outlet temperature at the desired value by one of the following ways:

- a. Gradually position the tab at which the programmer was stopped; move up or down until the desired temperature is again attained. Moving the tab up corresponds to increasing power and temperature.

- b. Manually run the programmer forward or backward using the indicator wheel. Moving the programmer forward will increase power and temperature and the reverse is true for moving the programmer backward. This is possible because at the end of the program power increases linearly with time.

CAUTION: If a 100F differential develops between the tube outlet temperatures, stop the transient and maintain equilibrium until supervision is contacted.

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4.6.1 Heat Shield Circuit (Continued)

1. c. 3) TP 17 - 0 to 28V as TS-5 closes

4) TP 3 - 0 to 28V as K14B closes

2. Shield Ejection (no shield installed)

0010	10/11	M _{TM}	
0010	10/11	I	
0010	10/11	V	

4.6.2 Startup Coils De-energized The off coils of startup rays will be reset by K14B completing circuit. The following coils are affected: K3A and B, K18A and B, K19, K21, K23A and B.

1. Events recorder channels are energized as follows:

a. Channel #4, 0 to 28V (K19 is turned off)

b. Channel #5, 0 to 28V (K21 is turned off)

2. Energizes the following:

a. FL cc (K19 is off)

b. FL z (K21 is off)

0030	10/11	EJ _B	

4.6.3 Operations Required During Heatup

1. If the expansion compensator extends to 1.5 inches (about 40 mv for -Z axis, D/L #269), drain some of the NaK (about 35 cu. in.) into the auxiliary surge tank. Theoretically, this volume transfer will be required at 800F if the drain line valve does not leak.

0330	To	10/11	JEB
0415			RM

2. If the instrument compartment temperature rises about 130F, turn on freon coolant to instrument compartment cryo panel.

0354	10/11	W _F	M
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3. Take an open circuit data logger run each 1/2 hour.

	10/11	W _F	M
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4.6.3 Operations Required During Heatup (Continued)

4. At 400F manifold inlet temperature after the power spike, operate the T/M equipment and tape recorder for 5 minutes. Data logger off.

0045 10/11 A 0

5. At 600F manifold inlet temperature, make another 5 minute run with T/M equipment. Data logger off.

Deleted

☐ ☐ ☒

6. At 800F the following is required:

a. Make transfer from expansion compensators as in Step 2.

03:30 10/11 WFM

b. Reconnect RT # 1, #2, #3 and #4. (Junction box strips J and K). Remove jumper wires.

0240 10/11 WFM

c. Make another 5 minute run with the T/M equipment. Data logger off.

0252 10/11 A 0

4.6.4 Expansion Compensator Position Switches

1. Verify that the following event markers actuate as the system becomes hot:

a. Channel #17, 28 to OV when PnS-9 (K8) de-energizes at 50 percent total bellows expansion. Record position at actuation _____ mv

Malfunctioning

b. Channel #18, 28 to OV when PnS-10 (K9) de-energizes at 50 percent bellows expansion. Record position at actuation 25.8 mv

2. Verify that the following are de-energized:

a. IL tt when PnS-9 (K8) is de-energized

Malfunctioned

☐ ☐ ☒

b. IL du when PnS-10 (K9) is de-energized

1:12 10/11 E B

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4.6.5 Core Outlet Temperature Condition The following will occur if the indicated temperatures are attained:

1. De-energizes FL n when temperature rises above 795F (TS-3 opens) (K10) (NA-TS-3 not installed)
2. Energizes FL o when temperature exceeds 1085F (TS-4 closes) (K11) *Not energized - correct*
3. Record the exact logger time that TS-1 and TS-2 close (Indicate by Triplet VCM) (Should close about 920 to 940F) (Measure through TP7 and TP8) *905 ± 5° closure*

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0320 10/11 EJA

4.7 First Phase of Completion of Startup Sequence The following steps shall be accomplished:

1. Allow the system to heat to 1010 ⁺²⁰/₋₁₀ F but not greater than 1030F. Adjust Marquardt programmer to increase or decrease system temperature to attain 1010F.
2. Turn off oscillograph when design temperature is attained.
3. Turn off pump power. Record exact data logger time.
4. Take another 5 minute run with T/M equipment. Data logger off.
5. Reduce manifold inlet temperature to 900 - 10 F and establish equilibrium. (Take all data as indicated on 4.3 Step 1.
6. Turn off 4 day bus power (3W 103) 10 hours after startup command was given.

0458 10/11 EJA ✓

0400 10/11 EJA

0500 10/11 EJA

0405 10/11 A0

Deleted

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0733 10/11 WFA

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4.7 First Phase of Completion of Startup Sequence (Continued)

7. Restart controller for 2 minutes each 8 hours for the next 72 hours. Use the KOR controller override switch to operate controller.
8. Conduct instrumentation checklist at this high temperature steady state condition.
9. Take last 5 minute run with telemetry gear at system equilibrium. Data logger off.
10. Conduct converter impedance measurements as follows (initial characteristics):
 - a. Take open and closed circuit data logger runs.
 - b. Vary the rheostat setting over 20 percent increments from 10 to 70 percent and take data logger run at each condition.
11. Switch from Marquardt Programmer to CAT controller.

1330 10/11 R ✓
1615 10/11 R

1700 10/11 R

1630 10/11 AO

0422 10/11 EJB

0720 10/11 EJB

0458 10/11 M

4.8 Instrument Compartment and Heat Rejection to Agena Test This test shall be conducted as detailed by Specification NAO222-012 (Continue operation of 4.7 Step 7 when permissible during the test).

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4.9 Final Phase of Completion of Startup Sequence (Continued)

3. a. Jack TP 51 (hot) to TP 34 (neg) goes from 0 to 28V as K12 closes if converter output voltage is less than 22.5V.

4. Malfunction T/M activates (K7 closure)

5. If any of the following conditions exist, the indicated actions will occur:

a. Condition

(1) If both expansion compensators are less than 50 percent expanded (event recorder channels #17 and #18 at 28V and PL tt and uu energized), K7 will be energized.

(2) If the 1 minute short duration timer (ESD) starts, K17 closes and K7 will be energized.

(3) If the core outlet temperature is less than 795F (PL n energized) (TS 3), K10 closes and K7 will be energized.

(4) If the core outlet temperature is greater than 1085F (PL o energized) (TS 4), K11 closes and K7 will be energized.

b. The following lights will be energized when K7 is closed.

(1) PL m

(2) IL v

No Activation Occurred

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PARAGRAPH

DEVIATION OR GENERAL COMMENT

4.2.6 (b)

Negative side of 4 day bus was shorted to ground. This did not affect operation of the 4 day bus.

4.2.7

Control drum #1 was rotated in about 5° in order to install the squib and squib block. This rotation set the control drum #1 position switch, PnS-6 in the wrong position.

4.3.1 (c)

The galvanometer for Channel #18 on the recording oscillograph burned out when the 400 cps converter impedance device was turned on. Channel #15 didn't record because of a loose connection at the device used for measuring the core heater power.

4.3.1 (i)

The T/M equipment was operated at a manifold inlet temperatures of 500°F, 800°F, 980°F and design conditions. The T/M equipment was operated for only about 3 minute periods because of its interference with the data logger operation. Several T/M plugs had to be removed to obtain data on logger.

4.3.2 (a)

Calorimeter temperature could not be maintained at 20°F after the Power Unit began heating. At design temperature the calorimeter stabilized at about 40°F.

4.3.2 (c)

The LN₂ was turned off at the pump cryo panel at 02:50 and freon turned on at 03:20 when the ΔT across the pump thermoelectric material exceeded 300°F.

4.3.7 (a & b)

Channel #17 and PL tt were not energized because of a malfunction in the circuit of FnS-9, expansion compensator #1 limit switch.

4.4.2

The test console breaker tripped when the pump power supply (PS-3) was turned on. An extension cord was used to power PS-3 from another receptacle.

4.5.3 (1a)

Channel #11 had been energized since installation of the control drum squibs.

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TABLE I (Continued)

PARAGRAPH	DEVIATION OR GENERAL COMMENT
4.6.3.5	This section was deleted.
4.6.4.2a	PL tt light came on whenever the T/M plugs were connected.
4.7.1	The core heater was held steady at 40 KW rather than controlling to a particular temperature.
4.7.5	This section was deleted.
4.7.7	The control drums were operated only seven times for a total of 13 pulses during the 72 hour period.

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TABLE II

SLOA FSM-1 ORBITAL STARTUP CORE HEATER PROGRAM

Tab No.	Elapsed Time Min.	Sat. Reactor Current ma	Sat. Reactor Output KW	Core Heater Input KW	Program Sweep Rate Sec/tab	Remarks
1	0	0	0.5	0.5	30	
2	0	0	0.5	0.5	↑	
3	1/2	0.2	0.9	0.9	↑	
4	1	0.5	3.8	3.6	↑	
5	1 1/2	10.0	68	64.8	↑	
6	2	10.0	68	64.8	↑	
7	2 1/2	8.0	66.5	63.4	↑	
8	3	0	0	0	↓	
9	3 1/2	2.8	25.9	24.6	↓	
10	4	1.7	15.3	14.5	30	
11	7 1/3	0.6	4.8	4.5	200	
12	10 2/3	0.2	0.9	0.9	↑	
13	14	0.4	2.8	2.7	↑	
14	17 1/3	1.2	10.5	10.0	↑	
15	20 2/3	1.7	15.3	14.5	↑	
16	24	0.9	7.6	7.3	↓	
17	27 1/3	0.9	7.6	7.3	↓	
18	30 2/3	1.2	10.5	10.0	200	
19	44	1.4	12.4	11.8	800	
20	57 1/3	1.6	14.4	13.6	↑	
21	70 2/3	1.8	16.3	15.5	↑	
22	84	2.0	18.2	17.3	↑	
23	97 1/3	2.2	20.1	19.1	↑	
24	110 2/3	2.4	22.0	20.9	↑	
25	124	2.7	24.9	23.7	↑	
26	137 1/3	2.9	26.8	25.5	↑	
27	150 2/3	3.1	28.8	27.3	↑	
28	164	3.5	32.5	31.0	↑	
29	177 1/3	4.0	37.2	35.5	↑	
30	190 2/3	4.4	41.0	39.2	↑	
31	204	4.8	45.0	42.8	↑	
32	217 1/3	5.2	49.0	46.5	↑	
33	230 2/3	5.2	49.0	46.5	↓	
34	244	5.2	49.0	46.5	800	

Stopped Transient at
4.85 ma at 220 min.

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FIGURE 1. SNAP 10A FSM-1 ORBITAL START-UP OPERATING HISTORY