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SPACE SHUTTLE
ORBIT MANEUVERING ENGINE
REUSABLE THRUST CHAMBER PROGRAM
NAS9-12802

TASK XII DATA DUMP (PHASE II)
OME INTEGRATED THRUST CHAMBER
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INTRODUCTION

The Orbit Maneuvering Engine of the Space Shuttle will use a regeneratively cooled thrust chamber. Present plans call for using MMH as the fuel and coolant for the engine with NTO as the oxidizer. Under Tasks I and II of Contract NAS9-12802, Rocketdyne investigated, analytically, several thrust chamber cooling concepts and fuel coolants. Using the criteria of performance, reliability, safety, maintainability, cost, and development risk, Rocketdyne concluded that the regeneratively cooled chamber using amine fuel was a superior combination.

Under Task IV of the contract, Rocketdyne fabricated a regeneratively cooled, electroformed thrust chamber. The chamber simulated flight type hardware in all areas except the inlet and outlet manifold configuration, which were designed for test flexibility and low cost. The thrust chamber was tested with two like-doublet element injectors in Tasks V and VIII, and the results reported in Data Dump ASR73-349. The thrust chamber assembly demonstrated safe, stable operation over a wide range of operating conditions at a moderately high performance level.

Under Task X of the contract, an integrated thrust chamber was fabricated which simulated the injector-end configuration of a flight type thrust chamber assembly. A test program was conducted under Task XII to characterize the steady-state stability, thermal, and performance characteristics of the integrated thrust chamber assembly, as well as limited tests to investigate transient characteristics. The results of these tests were published as Data Dump ASR74-117.

Task XII was continued to experimentally investigate: 1) the start, shutdown, and restart characteristics of the integrated thrust chamber; and 2) performance and thermal conditions for blowdown operation and for operation without supplementary boundary layer cooling. The results of this test program are described in this report.

SUMMARY

A total of 116 tests and 744 seconds were accumulated during Phase II of the Integrated Thrust Chamber Test Program. All of the tests were conducted with the electroformed regeneratively cooled thrust chamber and the like-doublet No. 1 injector. The injector diameter is 8 inches and the injector-to-throat distance is 14.7 inches. Most of the tests were conducted with the heat sink/radiation cooled nozzle having an area ratio of 72 to 1. Tests at low chamber pressure and tests with zero boundary layer coolant were conducted with a radiation cooled nozzle having an area ratio of 9 to 1. Including previous tests, the integrated thrust chamber has been fired 156 times for a total duration of 1190 seconds and the No. 1 like-doublet injector has been fired 284 times for a total of duration of 1695 seconds.

A series of tests were conducted with various posttest purge and flush sequences to determine how the engine might be returned to ambient temperature between multiple tests. It was decided that no flush or purge would be used between tests in order to avoid possibility of contaminating the engine. A brief series of tests were conducted wherein the fuel valve signal delay time (relative to the oxidizer valve signal) was varied from 100 milliseconds to 0 milliseconds. No significant change in pressure or thrust overshoots or 'g' level at start resulted from these variations.

Hot engine restart tests were conducted by firing the engine until it reached thermal equilibrium and then shutting down for various coast periods ranging from 1 to 180 seconds. These tests were conducted with ambient temperature propellants and with cold (approximately 45 F) propellants. This series of conditions resulted in starting the engine with no propellants in the manifold, residual fuel only in the engine, and both residual oxidizer and fuel in the

engine. One 1500 g spike was recorded at oxidizer prime with no engine damage. A 530 g start was also recorded but could not be repeated. All other starts had acceleration spikes of less than 130 g. Accelerations of 15-40 g's were recorded with normally operating valves at ignition. Thrust overshoots as high as 160% were recorded. No damage was done to the thrust chamber.

A series of tests was conducted with coast times ranging from 0.3 to 180 seconds wherein the engine was fired 1 second each time between coast periods. This was termed a warm-engine start and represents the minimum firing duration required of the OME. Maximum 'g' levels at start and thrust overshoots were only 20 g's and 120 percent, respectively. These tests were conducted with ambient temperature propellants.

A final series of restart tests was conducted with the engine being fired for a duration of only 0.2 seconds between coast periods. The coast periods ranged from 2.5 seconds to 14-1/4 minutes. Maximum 'g' levels were about 20 g's at ignition for all coast times. However, acceleration spikes as high as 180 g's occurred at oxidizer prime (before ignition) for long coast times. The maximum thrust overshoot of 150 percent occurred at a coast time of 2.5 seconds but there was considerable scatter in the data. Ambient temperature propellants were used.

No hardware damage was incurred as a result of any of these tests which indicated that the OME can be safely restarted without any limit on the coast time.

A series of tests of 5-second durations were conducted with unsaturated propellant at lower than nominal chamber pressure to investigate engine operating characteristics under propellant tank blowdown conditions. Tests at 80 and 75 psia chamber pressure resulted in chugging at start which damped out during the tests. At 65 psia chamber pressure, the chug persisted throughout the test. The chugging occurred at frequencies of 115 to 310 Hz and did not appear to be detrimental to the engine. The tests results indicate that under conditions of smoothly decaying tank pressures and unsaturated propellants the engine could probably blowdown to approximately 65 to 75 psia chamber pressure without chugging.

A fuel depletion test was conducted for a duration of 4.5 seconds. The test was started with very little fuel in the fuel tank and ended with an indicated mixture ratio of 4.4 although assessment of the mixture ratio is difficult because the test data indicate that slugs of helium were also entering the thrust chamber. After the test, the thrust chamber was observed to have a number of blue streaks in the combustion zone particularly in the converging section. A dye penetrant test on the thrust chamber did not indicate any cracks or leaks and testing was continued.

Supplementary boundary layer coolant is supplied to the thrust chamber by orifices in the periphery of the injector. These orifices were plugged for one sequence of tests which were conducted over a range of chamber pressures and mixture ratios. Comparison of these test results with results of the Phase 1 tests indicate that at nominal conditions a performance gain of approximately 1.5 seconds I_s results from the elimination of the BLC. Concurrently, the heat load to the regeneratively cooled chamber increased by approximately 26 percent which would result in a safety factor of 1.2 at off-design conditions (P_c = 120 psia, O/F = 1.73, T_f = 100F).

TEST HARDWARE

The hardware used for the test program consisted of a regeneratively cooled thrust chamber, full size and truncated radiation cooled nozzles, and a like-doublet injector. The injector and chamber were designed to closely simulate the thermal and dynamic characteristics of flight type hardware. All components were bolted together and sealed with either metallic or elastomeric O-rings, as appropriate.

A drawing of the thrust chamber assembly is shown in Fig. 1. Table 1 provides a summary of the regenerative cooled chamber design characteristics. The combustion chamber has a length of 14.7 inches and a contraction ratio of 2:1 with a throat diameter of 5.820. The expansion area ratio of the regeneratively cooled nozzle is 7:1. The inner wall and the lands of the chamber are 321 CRES, and the channels are closed out with electroformed nickel. The thrust chamber was designed for the heat flux profile shown in Fig. 2. Channel sizes are such that the minimum safety factor is approximately 1.5 at a fuel inlet temperature of 100 F, chamber pressure of 120 psia, and propellant mixture ratio of 1.85. The coolant jacket itself is flightweight with nickel closeout thicknesses as thin as 0.025 inches at the throat. The fuel inlet manifold is a heavyweight configuration to reduce cost, but simulates flight manifold volume. The coolant outlet manifold is more critical thermally and represents a typical flight design.

The completed regeneratively cooled thrust chamber is shown in Fig. 3. The thrust chamber was extensively instrumented to measure outside wall temperatures as described in Table II and shown in Fig. 1. Additional engine instrumentation for Phase II tests is described in Table III and shown in Figs. 4, 5, and 6.

Accelerometers were initially mounted as described in Table III but were relocated after Test IHT 1-1-4 onto a diameter line oriented in the 30^{o}-210^{o}

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TABLE 1. Demonstrator Thrust Chamber Design Characteristics

COMBUSTOR	
Contraction Ratio	2:1
Length, in	14.7
Contour	Tapered from 7 in. upstream of throat
NOZZLE	
Regen Section Expansion Ratio	to 7:1
Nozzle Extension Expansion Ratio	7:1 to 72:1
Contour	Flight parabolic
COOLANT	
Circuit	Counterflow
Number of Regen Coolant Channels	120
Coolant Pressure Drop, psid	15
Coolant Bulk Temperature,Rise, F	178
Auxiliary Film Coolant	2.7% Total Propellant
Channel Dimensions at throat, inches	
Width, inches 0.114	
Height, inches 0.068	
Channel Dimensions near injector, inches	
Width, inches 0.114	
Length, inches 0.042	
MATERIALS	
Hot Wall (0.030 in.) and Lands	CRES 321
Cold Wall (0.030 in.)	Electroformed Nickel
Nozzle Extension	CRES

INTEGRATED THRUST CHAMBER HEAT FLUX PROFILE

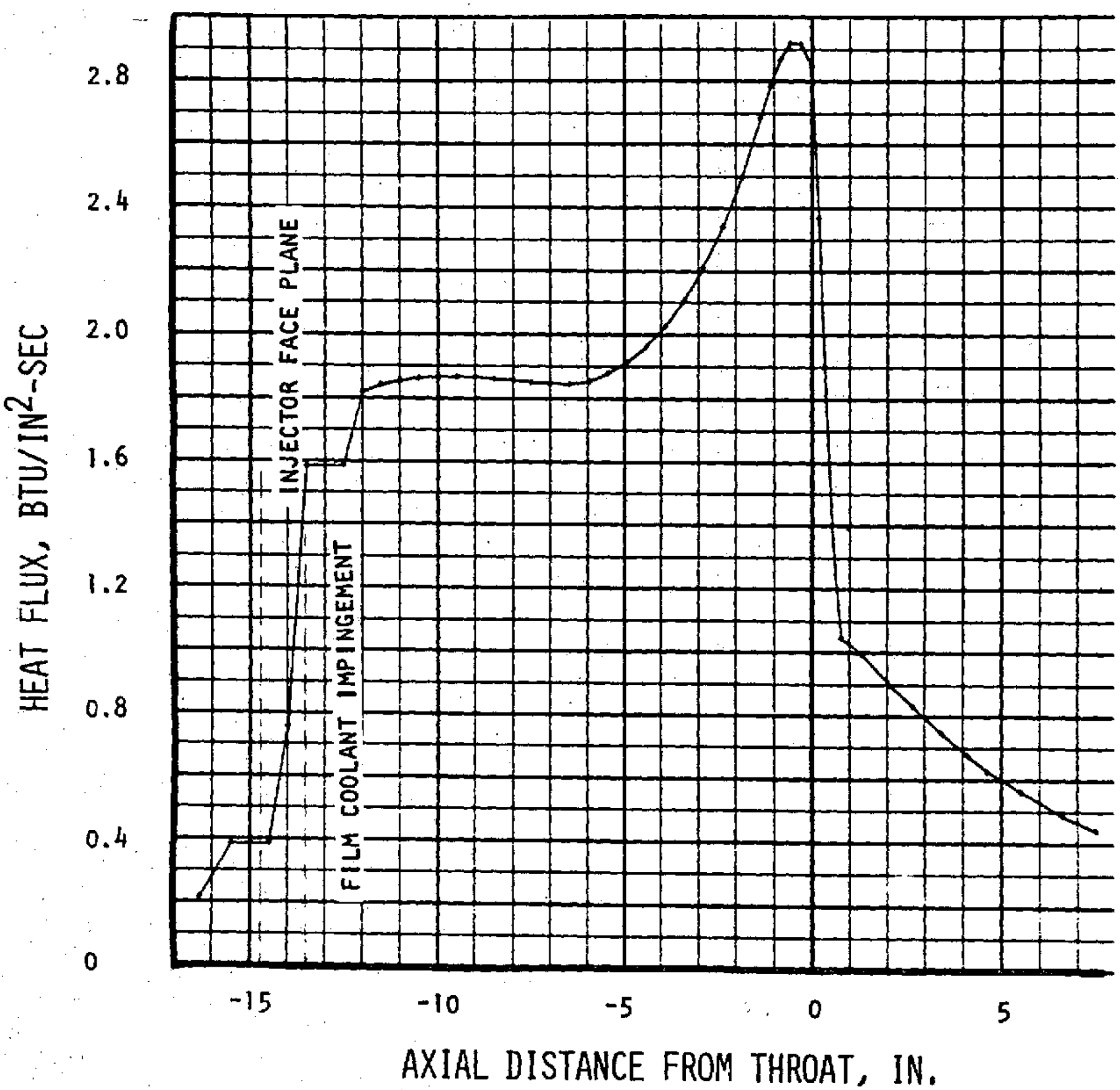

Figure 2

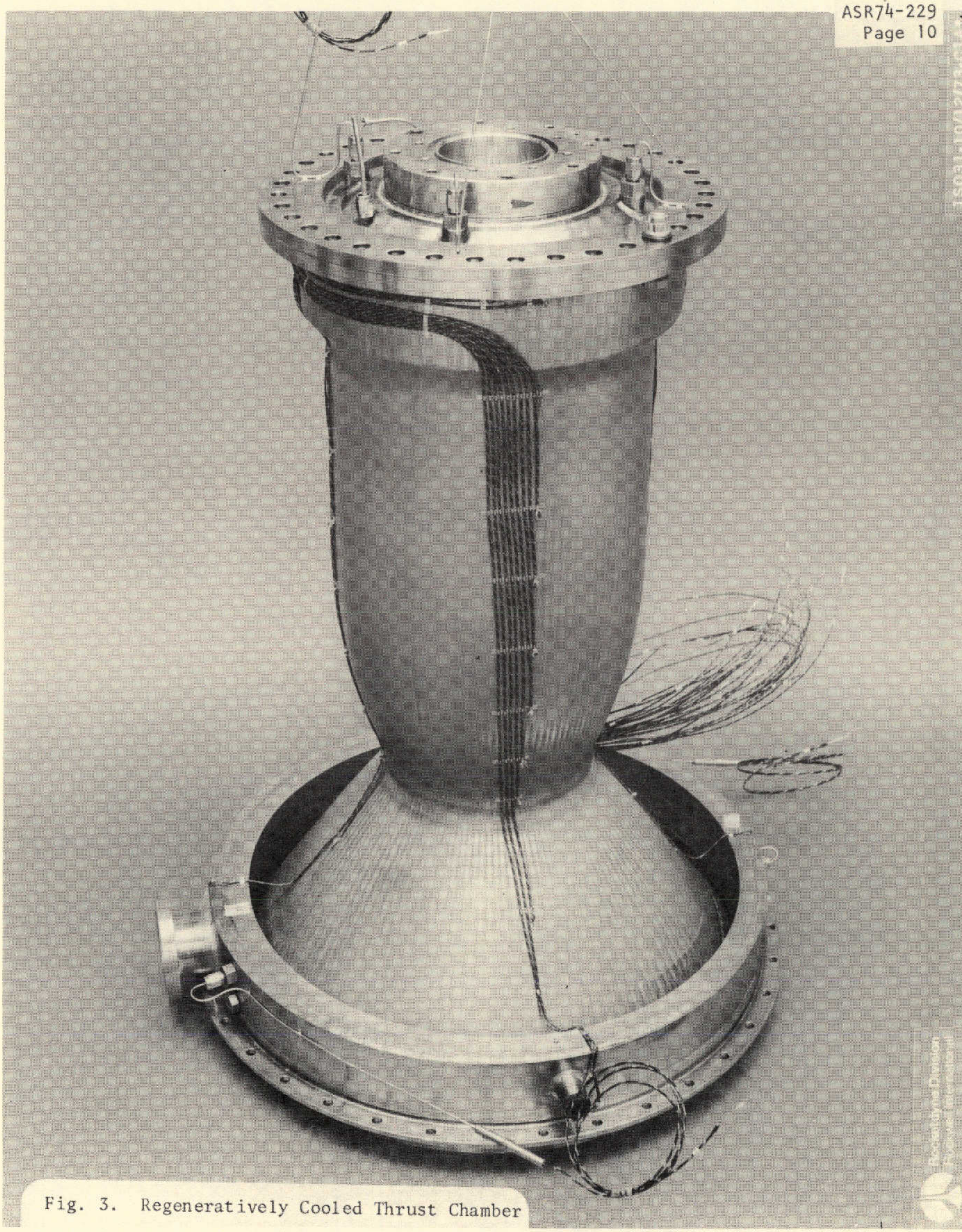

Fig. 3. Regeneratively Cooled Thrust Chamber

TABLE II

ENGINE TEMPERATURE INSTRUMENTATION LIST

	Temperature	Location, Degrees
TFB-1	Fuel Temp - T/C Outlet Manifold	300
TFB-2	Fuel Temp - T/C Outlet Manifold	30
TFB-3	Fuel Temp - T/C Outlet Manifold	120
TFB-4	Fuel Temp - T/C Inlet Manifold	0
TFB-5	Fuel Temp - T/C Inlet Manifold	255
TFB-6	Fuel Temp - T/C Inlet Manifold	90
TFB-7	Fuel Temp - T/C Inlet Manifold (Top)	260
TFB-8	Fuel Temp - T/C Inlet Manifold (Bottom)	260
TINJ	Injector Body	45, 75, 155
T34	Ni Back Wall @STA+3.0	90
T35	Ni Back Wall @STA+3.0	270
T36	Ni Back Wall @STA-0.3	90
T37	Ni Back Wall @STA-0.3	270
T38	Ni Back Wall @STA-2.0	0
T39	Ni Back Wall @STA-2.0	90
T40	Ni Back Wall @STA-2.0	180
T8	Ni Back Wall @STA-10.0	0
T9	Ni Back Wall @STA-10.0	90
T10	Ni Back Wall @STA-10.0	180
T11	Ni Back Wall @STA-10.0	270
T12	Ni Back Wall @STA-6.0	0
T13	Ni Back Wall @STA-6.0	180
T14	Ni Back Wall @STA-.30	0
T13	Ni Back Wall @STA-.30	180
T16	Ni Back Wall @STA +3.0	0
T17	Ni Back Wall @STA +3.0	180
T18	Skin Temp - T/C Inlet Manifold	0
T19	Skin Temp - T/C Inlet Manifold	180
T20	Nozzle Flange - T/C Side	0
T30	Nozzle Flange - T/C Side	180
T41	Ni Back Wall @STA-2.0	270
T42	Ni Back Wall @STA-4.0	0
T43	Ni Back Wall @STA-4.0	90
T44	Ni Back Wall @STA-4.0	180
T45	Ni Back Wall @STA-4.0	270
T46	Ni Back Wall @STA-6.0	90
T47	Ni Back Wall @STA-6.0	270
T48	Ni Back Wall @STA-8.0	0
T49	Ni Back Wall @STA-8.0	90
T50	Ni Back Wall @STA-8.0	180
T51	Ni Back Wall @STA-8.0	270
T52	Ni Back Wall @STA-13.0	0
T53	Ni Back Wall @STA-13.0	90
T54	Ni Back Wall @STA-13.0	180

TABLE II
(Continued)

	Temperature	Location, Degrees
T55	Ni Back Wall @STA-13.0	270
T56	Ni Back Wall @STA-16.0	0
T57	Ni Back Wall @STA-16.0	15
T58	Ni Back Wall @STA-16.0	75
T59	Ni Back Wall @STA-16.0	135
T60	Ni Back Wall @STA-16.0	180
T61	Ni BAck Wall @STA-16.0	195
T62	Ni Back Wall @STA-16.0	255
T63	Ni Back Wall @STA-16.0	315
	Nozzle Back Wall @STA-7.2	0
	7.2	90
	7.8	0
	7.8	90
	9.9	0
	9.9	90
	11.7	0
	11.7	90
	16.2	0
	16.2	90
	28.4	0
	28.4	90
	40.4	0
	40.4	90
	57.5	0
	57.5	90

NOTE: 0 degrees reference plane located 90 degrees clockwise from inlet manifold looking aft. Locations noted are clockwise from 0 degrees reference plane. STA location (±) from throat with aft (+).

TABLE III

LOCATIONS OF MODIFIED INSTRUMENTATION FOR ROCKETDYNE INTEGRATED T/C RESTART TESTS

Acceleration	
GA-0, GA-1, GA-2	On thrust mount as close to engine mounting bolt circle as possible.
GA-3	On injector oxidizer dome. Tapped hole furnished.
Temperatures	
TFV (TOV)	Tack weld to engine fuel (oxidizer) valve outlet adapter approximately 1-inch from valve flange. -1 and -2 refer to top and bottom sides respectively of adapters.
TFD (TOD)	Tack weld to fuel (oxidizer) duct approximately 1-inch from engine connector. -1 and -2 refer to top and bottom sides of the ducts.
TINJ	On injector at radial location shown in Fig. 5 (45, 75, and 155°).
TFB-7	In boss shown in Fig. 6.
TFB-8	In boss shown in Fig. 6. Bottom out thermocouple then retract 0.1-inch.
Pressures	
PF1L*	In drain port in coolant inlet manifold 90° CCW from inlet flange (looking aft)
PF2L*	Use tee in TFB-2 port to measure both temperature and pressure.
PO1L*	PO1 port and 1/8 tubing.
PO1 (high pressure, high response)	In port shown in Fig. 7 using drilled out fitting furnished.
PF2 (high pressure, High response)	Onto special fitting welded onto PF2 boss on dome shown in Fig. 5.

*These parameters require isolation valves to prevent transducer damage during mainstage operation. Sequence the valves to open 5 seconds after the cutoff signal.

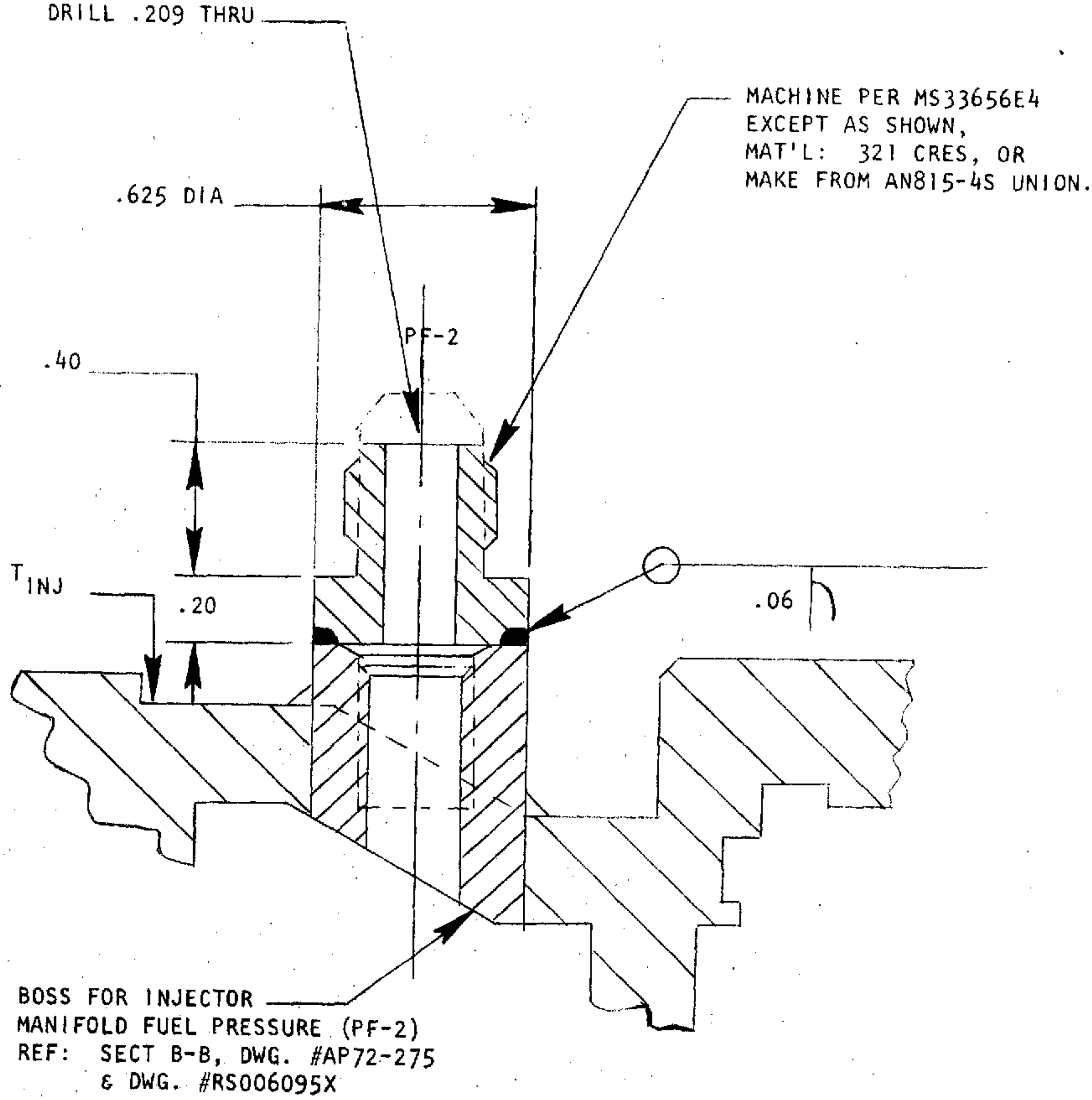

FIGURE 4. BOSS MODIFICATION - OME THRUST CHAMBER,
EWR #R214638 SCALE: 2/1 MCW 1-8-74

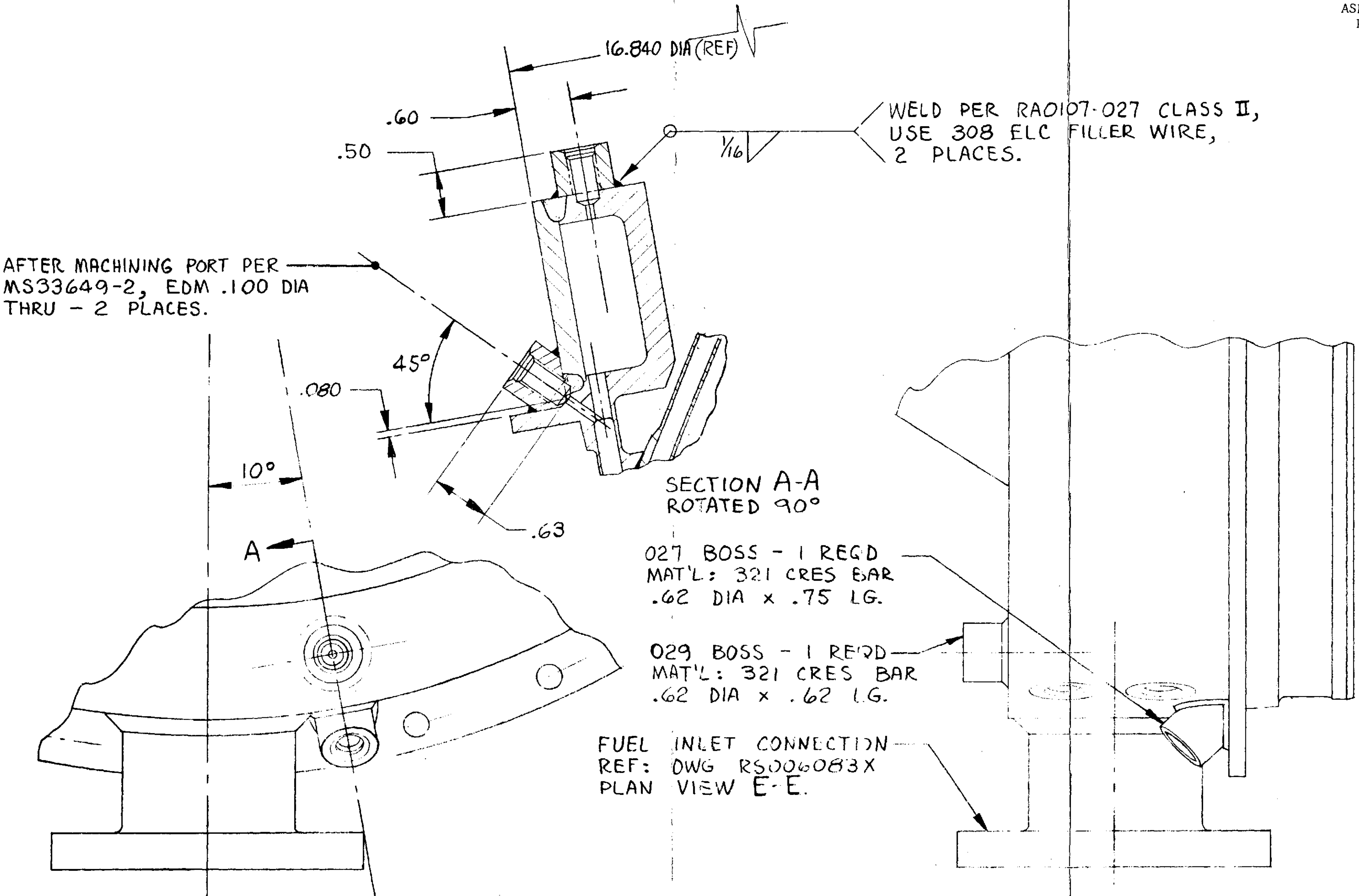

FIGURE 5. ADDITION OF BOSSES - EWR SKETCH 1

SCALE: FULL ICW 1-4-74

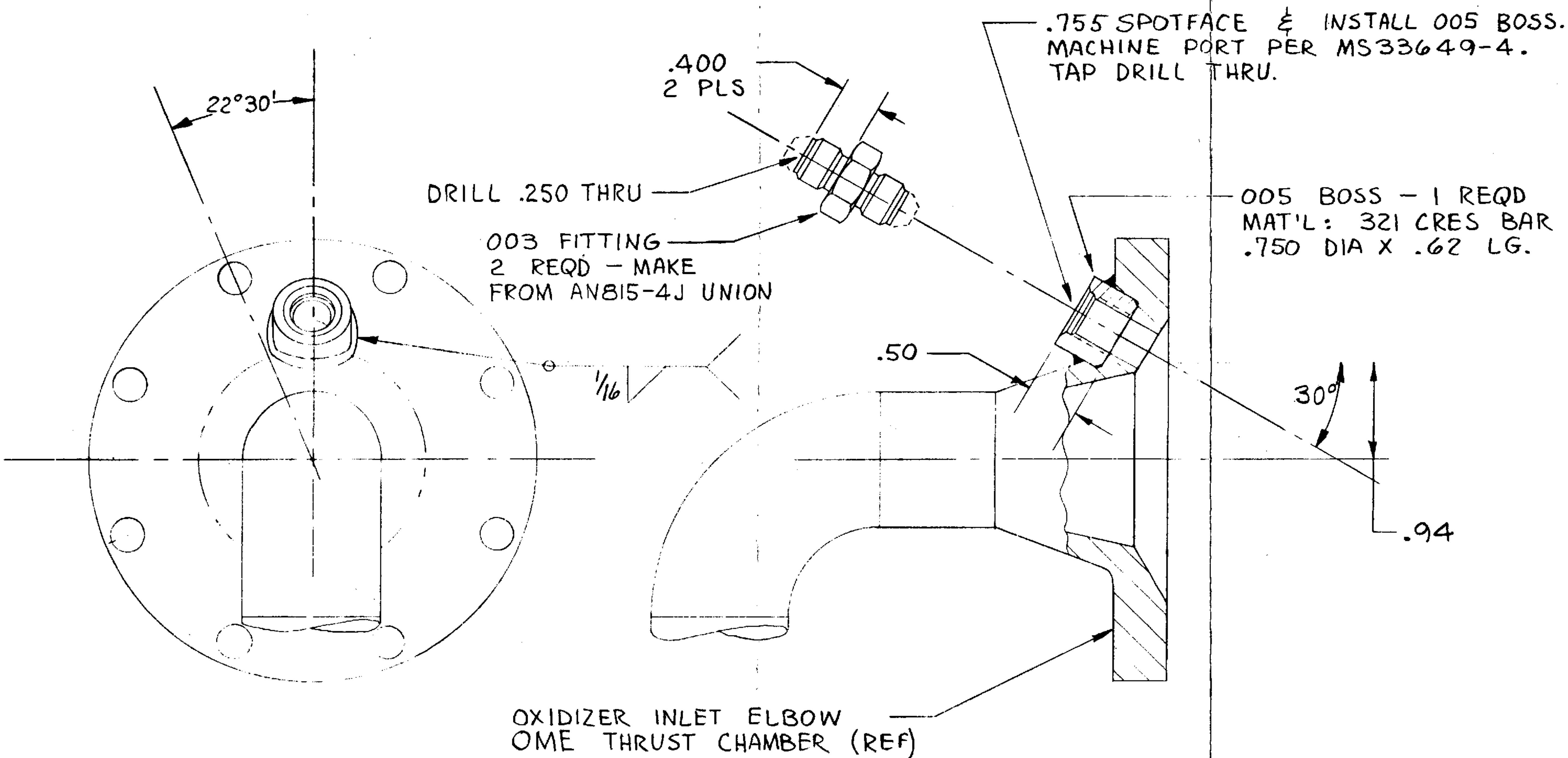

FIGURE 6. ADDITION OF BOSS - OXID. INLET ELBOW

EWR # R083453 SCALE: FULL MCW 1-7-74

FOLDOUT FRAME 1

FOLDOUT FRAME 2

direction (coolant inlet duct at 270°) as follows:

Accelerometer	Location	Range 'g'	Output
4006	Thrust Ring	±2,000	Analog
4007	Ox. Dome	±200	Analog, Oscillograph
4008	Thrust Ring	±200	Analog, Brush
4097	Ox. Dome	±1,000	Analog, Oscilloscope, CSM

After test IHT 1-3-6 accelerometers 4006 and 4008 were relocated to the injector/chamber flange and accelerometers 4006, 4007, and 4097 outputs were recorded directly on oscillograph as well as the other formats shown above.

The TFD-2 thermocouple was actually welded to the bottom of the fuel duct at the low point in the system about 5 inches upstream of the inlet. The TFB-7 and -8 thermocouple bosses were added at the same circumferential location as TFB-5 to record fuel boilout during posttest vacuum soaks. Low-level pressure (15 psid) transducers were added to provide vapor pressure/saturation temperature correlations with the fuel temperatures and to indicate propellant depletion. Close coupled high-pressure transducers were used to record the transients in fuel and oxidizer injection pressures and fuel coolant jacket inlet pressure. Chamber pressure instrumentation was not configured to provide high response transient data.

The injector used was a like-doublet (L/D No. 1), which had 186 elements arranged in nine rows. Oxidizer orifice diameters ranged from 0.032 to 0.038 inches, while fuel orifice diameters ranged from 0.028 to 0.033 inches. The injector included 68 orifices (0.020-inch diameter) to provide boundary layer coolant amounting to 2.7 percent of the total propellant flow at nominal mixture ratio. Injector characteristics are summarized in Table IV.

A flight contoured, radiation cooled CRES nozzle with $\epsilon = 72$ was used to provide realistic thrust overshoot and sideload data for the restart tests.

TABLE IV Injector L/D No. 1 Characteristics

Diameter, in.	8.200
Number of Elements	186
Number of Rows	9
Type of Elements	Like Doublet
Oxidizer Element Diameter, in. (minimum/maximum)	0.032/ 0.038
Fuel Element Diameter, in. (minimum/maximum)	0.028/ 0.033
Pressure Drop @ Nominal Flows	
Oxidizer, psi	56
Fuel, psi	62
Number of Acoustic Cavities*	8/4
Mode Suppression	1st & 3rd Tangential, 1st Radial

*Cavities formed by chamber and injector

A radiation cooled Columbium nozzle with $\epsilon = 9$ used for the tests at low chamber pressure and no film cooling to eliminate the chance of chamber damage from high side loads.

TEST FACILITY

The thrust chamber assembly was tested at the White Sands Test Facility at Las Cruces, New Mexico. Figure 7 is a photograph of the installation which is shown schematically in Figure 7a. Fuel (MMH) and oxidizer (NTO) was stored and conditioned in 2000-gallon propellant tanks external to the vacuum cell. The propellant was pumped from the external tanks to the two 60-gallon tanks inside the vacuum cell simulating the OMS tankage exits. Line sizes and lengths from the propellant tanks to the OME interface were configured so as to simulate OMS ducting. A flow meter was located in each propellant feedline between the tanks and the engine interface. A common pressure source was used to pressurize both the internal and external fuel tanks.

The fuel sides of two LM descent engine valves were used as the engine propellant control valves. Fuel valves were used for both fuel and oxidizer sides because these valves contained the actuators and the position indicators. Each valve was series and parallel redundant including upstream isolation valves and downstream shutoff valves. Positions were measured on one of the isolation valves and one of the shuttle valves for each propellant. The valves were located so as to provide a slight positive drain into the engine inlets in an attempt to simulate the depletion which would occur after shutdown under zero 'g' conditions. The ducting between the valves and the engines was configured to simulate typical line volumes and sizes for the flight OME as shown in Fig. 8.

Provisions for GN_2 purges were made downstream of the valves. Provision for an isopropyl alcohol flush was also made downstream of the fuel valve. A water spray ring was provided at the radiation side of the regen/radiation nozzle interface. Finally, a high volume air cooling purge of the radiation nozzle was provided to cool the nozzle after testing. The steam ejector was

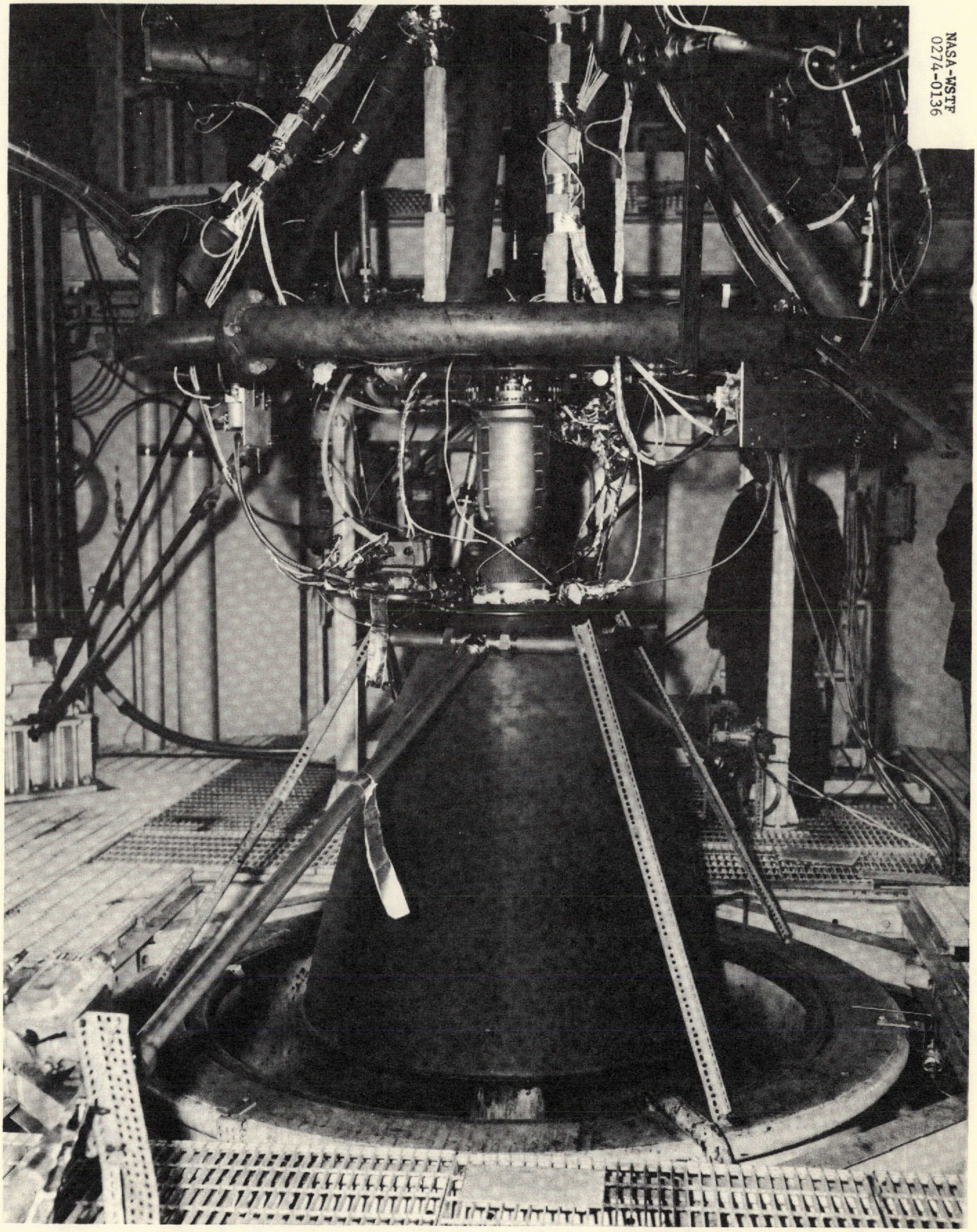

Figure 7. Engine Installation at WSTF

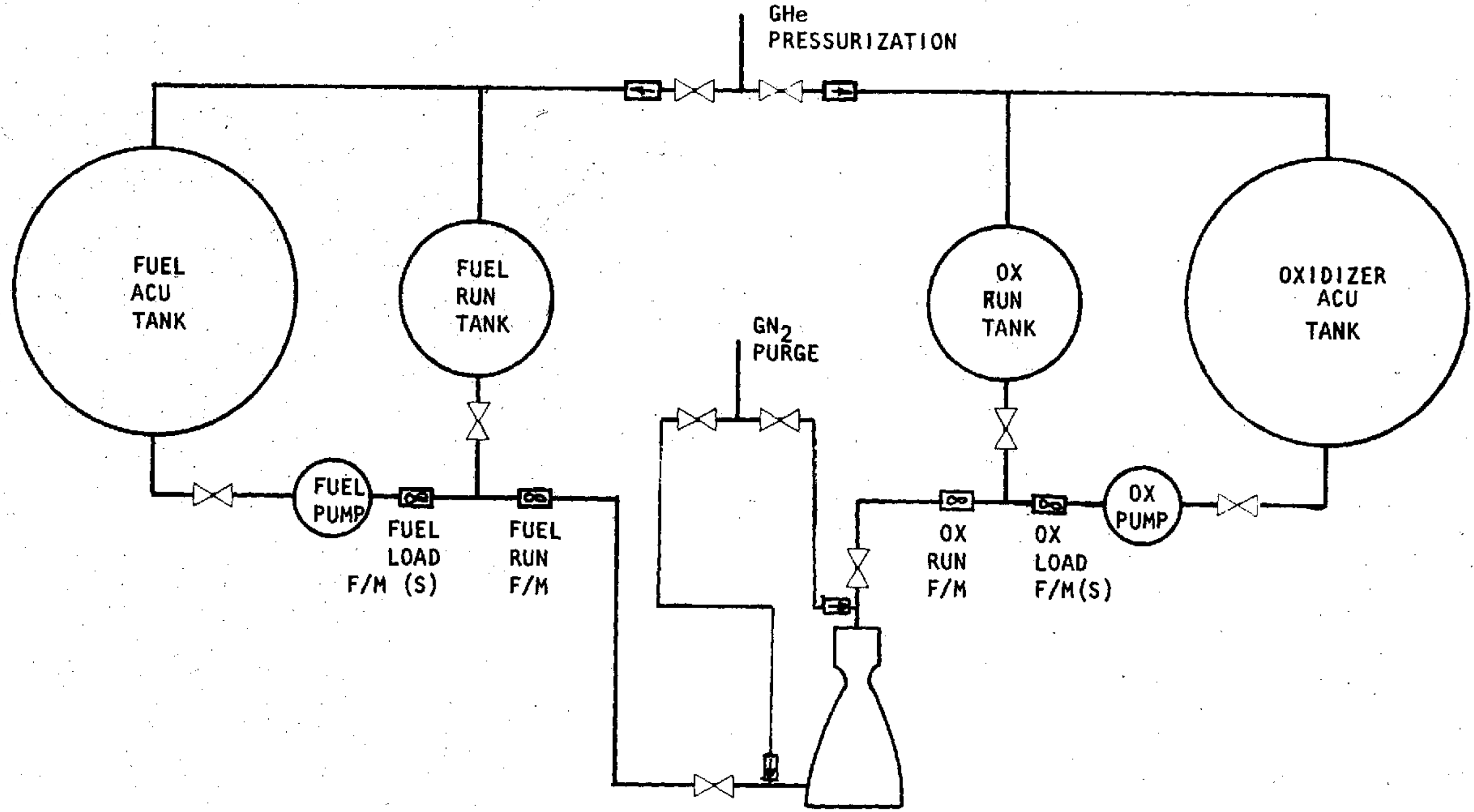

Figure 7a. Simplified NASA/WSTF Propellant Feed System Schematic

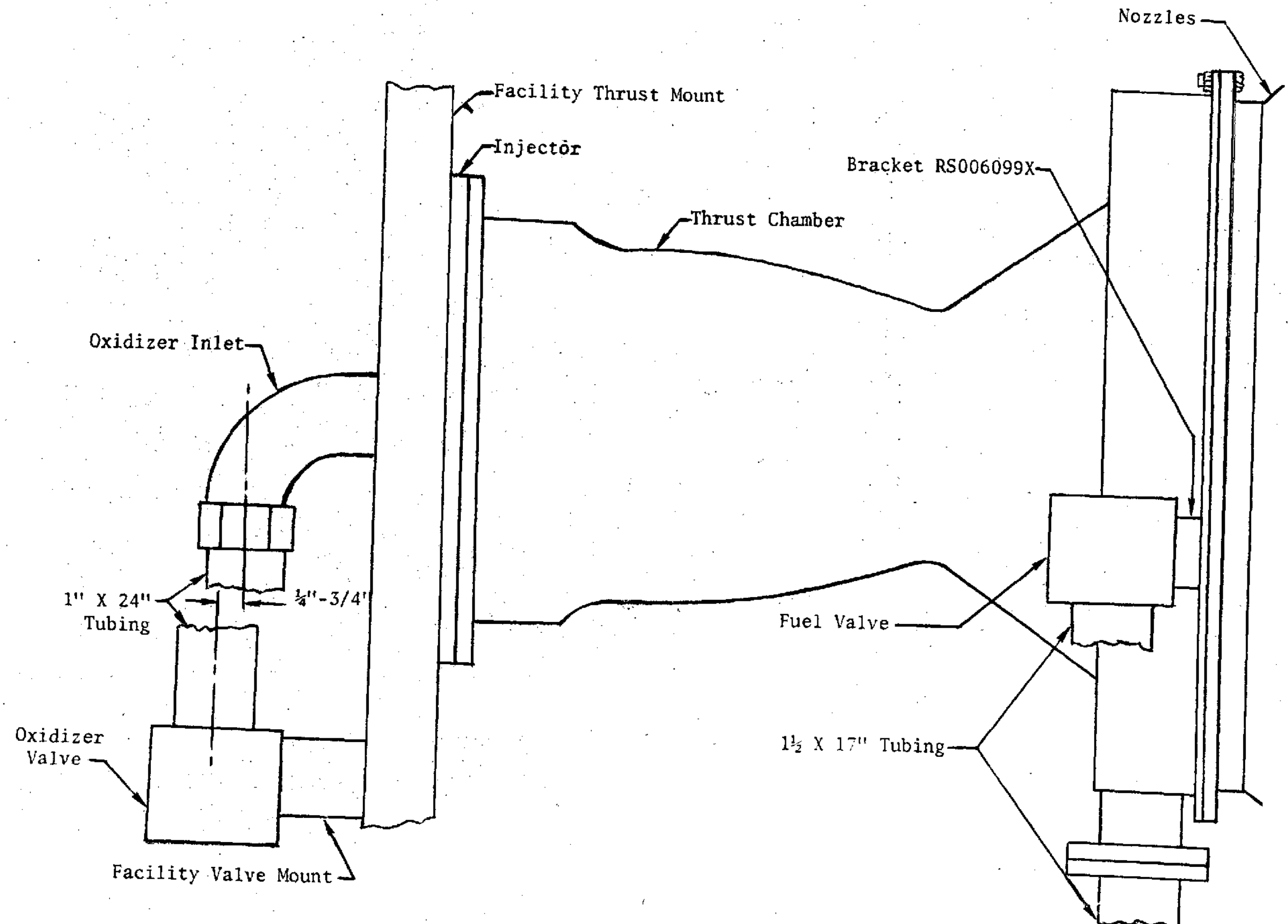

Figure 8. Propellant Inlet Ducting and Valves

able to pump the capsule down to a pressure of approximately 0.06 psia equivalent to an altitude in excess of 100,000 feet. A complete list of facility instrumentation is given in Table V.

The test operation at WSTF was initiated with a vacuum pump evacuation of test stand 401. This operation was performed about 2-3 hours prior to the actual test operation. The engine test stand was then readied for operation by pressurizing the propellant tanks to the required run pressures and assuring that the engine stand and the engine instrumentation were in readiness for the test. With this assurance that the engine was ready for testing, the hyperflow gas generator system was started and brought up to full operation. At this time, the altitude capsule isolation valve was opened to permit the hyperflow action to pump down the altitude cell to the final run pressure. The cell pressure was continuously monitored, and when it reached 0.1 psia, engine test activity commenced. The first event, at sequence time equals zero, was activation of the "fire switch." At this time, the electrical signal was simultaneously applied to both fuel and oxidizer main propellant valves. For tests in the first part of Phase II, the signal to the fuel valve was delayed by as much as 100 msec to assure a definite oxidizer lead.

TABLE V

TEST INSTRUMENTATION

Parameter	Range	Recorder			
		TMP	OSC	Brush	Digit
Thrust 1A	0-5000 Lbs	X			X
Thrust 1B	0-5000 Lbs				X
Thrust 2A	0-5000 Lbs	X			X
Thrust 2B	0-5000 Lbs				X
Thrust 3A	0-5000 Lbs	X			X
Thrust 3B	0-5000 Lbs				X
Total Vertical Thrust	0-15000 Lbs	X	X	X	X
Horizontal Force 1A	±1000 Lbs			X	X
Horizontal Force 1B	±1000 Lbs				X
Horizontal Force 2A	±1000 Lbs			X	X
Horizontal Force 2B	±1000 Lbs				X
Horizontal Force 3A	+1000 Lbs			X	X
Horizontal Force 3B	±1000 Lbs				X
Axial Acceleration GA-1	0-3000G		X	X	
Axial Acceleration GA-2	0-200G (CSM)		X	X	
Axial Acceleration GA-3	0-200G		X		
Fuel Valve Position	0-100%		X	X	
Fuel Valve Position	Open/Closed		X		
Oxid. Valve Position	0-100%		X	X	
Oxid. Valve Position	Open/Closed		X		
Fuel Flow 1	0-100 GPM	X		X	X
Fuel Flow 2	0-100 GPM				X
Oxidizer Flow 1	0-100 GPM	X		X	X
Oxidizer Flow 2	0-100 GPM				X
Fire Switch Signal	On/Off	X	X	X	X
Fuel Tank Press.	0-300 PSIA	X			X
Oxid. Tank Press.	0-300 PSIA	X			X
Fuel Valve Inlet Press.	0-300 PSIA			X	X
Oxid. Valve Inlet Press.	0-300 PSIA			X	X
Cell Press, HIgh	0-15 PSIA	X			X
Cell Press, Low	0-1/2 PSIA	X			X

TABLE V
(Continued)

Parameter	Range	Recorder			
		TMP	OSC	Brush	Digit
Fuel Inlet Manifold Press PF1	0-300 PSIA	X	X		X
Fuel Inlet Manifold Press PF1L	0-15 PSIA				X
Fuel Injection Press PF2	0-300 PSIA	X	X		X
Fuel Injection Press PF2L	0-15 PSIA				X
Oxid Injection Press P01	0-300 PSIA	X	X		X
Oxid Injection Press P01L	0-15 PSIA				X
Chamber Press 1	0-200 PSIA				X
Chamber Press 2	0-200 PSIA	X	X	X	X
Fuel Temp, Tank	32-150 F	X			X
Oxid Temp, Tank	32-150 F	X			X
Fuel Temp, F/M	32-150 F				X
Oxid Temp, F/M	32-150 F	X			X
Ox Temp, Valve Inlet	-50-150 F	X			X
Fuel Valve Outlet Temp TFV-1	-50-300 F				X
Fuel Valve Outlet Temp TFV-2	-50-300 F	X			X
Ox. Valve Outlet Temp. TOV-1	-50-300 F				X
Ox. Valve Outlet Temp. TOV-2	-50-300 F	X			X
T/C Fuel Inlet Duct Temp TFD-1	-50-300 F				X
T/C Fuel Inlet Duct Temp TFD-2	-50-300 F	X			X
T/C Ox. Inlet Duct Temp. TOD-1	-50-300 F				X
T/C Ox. Inlet Duct Temp. TOD-2	-50-300 F	X			X
All Engine Propellant Temps	-50-300 F				
All Nickel Backwell Temps	-50-300 F				
All Nozzle Temps	32-2500 F				
Engine Temps on TMP:					
T9-Nickel Backwall @ STA-10 & 90^o		X			
T19-Inlet Manifold Skin @ 180^o		X			
Nozzle Backwall @ STA + 9.9 & 0^o		X			
Nozzle Backwall @ STA + 7.8 & 0^o		X			
TFB4- Jacket Coolant Inlet		X			
TFB1- Jacket Coolant Outlet		X			

TEST PROGRAM AND RESULTS

The primary objective of the test program was to investigate the OME start, shutdown, and restart characteristics to determine if restrictions of the mission-duty cycle exists for the current configuration of the OM_. Secondary objective was the investigation of OME thrust chamber operating characteristics at very low chamber pressures typical of propellant tank blowdown operation and without supplementary boundary layer coolant.

TEST SEQUENCES

To accomplish these objectives, the tests were broken down into groups of tests called test sequences each having specific detailed objectives or test conditions. The number of tests in each sequence and the objectives of the sequence are shown in Table VI. A summary of the most significant conditions for each test is presented in Table VII. As noted, all tests of sequence 1 through 6 (except 1-1 and 1-2) were conducted at approximately nominal chamber pressure and propellant mixture ratio.

Twelve tests were conducted in the first test sequence to check out the facility instrumentation and engine and to determine the effects of posttest purge and flushing operations. All tests for sequence 1 were conducted with a 100 millisecond oxidizer valve opening signal lead relative to the fuel valve signal. The first test was a 1-second duration firing followed by water spray, flush, and purging operations which brought the engine to temperatures approaching $0^{o}F$. After these procedures, the engine was restarted and fired for three seconds for Test 1-2. Data from this test was used to reset the tank pressures during the 5-minute posttest soak period. Following this vacuum soak, the engine was purged and restarted for another 1-second firing. After Test 1-3, a briefer sequence of purging and flushing was followed again cooling the engine down to low temperatures. The purpose of these procedures

TABLE VI

INTEGRATED CHAMBER TEST PROGRAM SUMMARY - PHASE II

SEQUENCE	TESTS	PURPOSE
1	12	CHECKOUT, POSTTEST PURGE AND FLUSH EFFECTS, PERFORMANCE
3	35	VALVE SEQUENCING, HOT ENGINE RESTART, SOAKOUT, FUEL DEPLETION
4	13	WARM ENGINE RESTART, SOAKOUT
5	15	HOT ENGINE RESTART WITH COLD PROPELLANTS, SOAKOUT
6	17	AMBIENT ENGINE RESTART, SOAKOUT
7	14	PERFORMANCE, THERMAL LOW Pc OPERATION
8	10	PERFORMANCE AND THERMAL WITHOUT BLC
TOTAL	116	745 SEC DURATION

TABLE VII

TEST CONDITIONS

Test Seq. No.	Ox. Valve Lead, msec	Duration sec.	Comments
1-1*	100	1.0	Targeted P_c and o/F 125 psia and 1.5 respectively for tests 1-1 and 1-2; 125 psia and 1.65 for subsequent tests. Posttest water spray (38 sec) alcohol flushing (42 sec) and GN_2 purge.
1-2	100	3.1	Restarted immediately after above procedures. Five-minute posttest soak.
1-3*	100	1.0	Restarted without purges after soak. Posttest water spray, alcohol flush, and GN_2 purge to cool engine.
1-4	100	0.14	Restarted after above procedures. Hard start and CSM shutdown.
1-5*	100	0.3	One minute of purge (cycling) posttest, then restart.
1-6	100	0.3	One minute posttest purges, then restart.
1-7	100	0.3	One minute of posttest purge, then restart.
1-8	100	0.3	One minute of posttest purge, then restart.
1-9	100	1.3	One minute of posttest purge, then restart.
1-10	100	0.3	One minute of posttest purge, then restart.
1-11	100	0.3	15 sec. posttest purge, 8 sec. alcohol flush, 100 sec GN_2 purge, then restart.
1-12	100	35.6	18 sec. posttest GN_2 purge, 30 sec. alcohol flush, 40 sec. purge, 5 min. soak.
3-1*	100	0.3	One-minute posttest purge.
3-2	100	0.3	One-minute posttest purge.
3-3	50	0.3	One-minute posttest purge.
3-4	0	29.3	Simultaneous propellant valve signals for this and subsequent tests. No posttest purge.

*First test of a vacuum period.

TABLE VII. TEST CONDITIONS (Continued)

Test Seq. No.	Duration Sec.	Pretest Coast Time, Sec.	Comments
3-5	14.3	180	No posttest purge.
3-6	4.3	120	2 min. posttest purge (including upper nozzle external purge).
3-7*	32.0		No posttest purge after this and following tests, except each day's testing or as noted.
3-8	14.7	60.1	
3-9	9.9	30.0	
3-10	9.8	35.5	
3-11	4.8	21.1	
3-11A	4.8	53.6	
3-12	4.8	9.9	Hard start.
3-13	4.8	10.0	
3-14	4.8	4.9	
3-15	4.8	2.0	
3-16	4.8	1.1	
3-17	4.8	1.2	30 min. vacuum soak.
3-18*	0.15		No tape data during posttest soak.
3-18A*	0.15		Pretest purge. Hard start at Ox. injector prime. 10 min. posttest soak.
3-18B*			Injector rotated. 6 Ox. valve on-off cycles.
3-18C	0.94		30 min. posttest soak.
3-19*	31.7		Ox. valve changed.
3-20	9.8	25.2	
3-21	9.8	24.4	
3-22	4.8	18.1	
3-23	4.8	12.5	Fuel depletion and helium injestion.
3-24*	31.8		
3-25	4.8	16.0	
3-26	4.8	16.3	
3-27	4.8	11.3	
3-28	4.8	11.3	
3-29	4.8	29.2	

*First test of a vacuum period.

TABLE VII. TEST CONDITIONS (Continued)

Test Seq. No.	Duration Sec.	Pretest Coast Time, Sec.	Comments
3-30	4.8	5.4	
3-31	4.8	5.0	
3-32	4.8	2.0	
3-33	4.1	2.0	3 minutes posttest soak
4-1*	1.0		
4-2	1.0	179.8	
4-3	1.0	120.8	
4-4	1.0	61.2	
4-5	1.0	31.2	
4-6	1.0	16.1	
4-7	1.0	9.0	
4-8	2.9	4.6	
4-9	1.1	0.3	
4-10	1.1	0.7	
4-11	1.0	13.8	
4-12	1.0	30.1	
4-13	0.4	44.8	30 min. posttest soak.
5-1*	31.8		Cold propellants for sequence 5.
5-2	17.7	181.0	
5-3	14.7	121.2	
5-4	11.8	61.3	
5-5	8.7	31.3	
5-6	4.8	15.5	
5-7	4.8	9.9	
5-8	4.8	4.4	
5-9	4.8	2.0	
5-10	4.8	1.6	
5-11	4.8	20.3	
5-12	10.8	46.3	
5-13	13.8	91.2	
5-14	4.8	31.1	
5-15*	0.15		Posttest soak.
6-1*	0.16		Ambient propellants for sequence 6.
6-2	0.18	180.7	

*First test of a vacuum period.

TABLE VII TEST CONDITIONS (Continued)

Test Seq. No.	Duration Sec.	Pretest Coast Time, Sec.	Comments		
6-3	0.20	119.7			
6-3A	0.18	55.9			
6-4A	0.20	15.7			
6-5	0.20	60.8			
6-6	0.20	31.1			
6-7	0.25	6.3			
6-7A	0.26	5.1			
6-8	0.27	2.5			
6-9	0.16	(14 min.16 sec.)			
6-10	0.23	5.2			
6-11	0.20	45.4			
6-12	0.16	2.7			
6-12A	0.17	3.1			
6-12B	0.16	7.6			
6-13	0.04	45.9	10 minute posttest soak.		
			P_c, psia	O/F	Comments
7-1*	9.7		125	1.45	Cold fuel, ambient ox., 9:1 nozzle for seq. 7 & 8.
7-2*	9.7		125	1.65	
7-3	9.7		100	1.65	
7-4	9.7		100	1.45	
7-5	9.8		125	1.45	
7-6	9.8		125	1.85	Posttest purges on tests 6-13
7-7	34.7		125	1.65	
7-8	4.7		80	1.65	
7-9	4.7		70	1.65	
7-10	4.7		60	1.65	
7-10A	4.7		70	1.45	
7-12	4.7		60	1.45	
7-13	4.7		60	1.65	
7-14	9.7		125	1.65	30 min. posttest coast.
8-1*	33		125	1.8	Injector BLC orifices plugged for sequence 8.
8-2	10		140	1.75	
8-3	10		140	1.55	
8-4	10		125	1.55	
8-5	10		110	2.0	
8-6	10		109	1.6	
8-7	10		135	2.0	
8-8	10		109	1.5	
8-9	10		106	2.0	
8-10	10		126	1.8	30 min. posttest soak.

* First test of a vacuum period.

was to determine the response of various portions of the engine to flushing and purging in order that the proper procedures might be specified later in the test program to return the engine to near ambient temperatures during multiple tests in a given steam period. Test 1-4 experienced a premature CSM shutdown and testing was terminated for the day.

The flushing and purging procedures after Tests 1-1 and 1-3 had significantly cooled the engine down and significant ice formations were observed in the region of the fuel inlet manifold after these tests. At the start of Test 4 temperatures of 20 F on the regen chamber wall and 17 F near the coolant inlet were measured. Tests 1-2 and 1-4 exhibited relatively hard starts although posttest inspection indicated no damage to the engine. Tests 1-5 through 1-11 were brief (0.3 to 1.3 seconds of 90% or greater thrusts) tests followed by 1-minute purges to determine the effects of engine temperature on start transient characteristics. Alcohol flush and purge procedures were followed after Tests 1-11 and 1-12, the latter test being a 35-second duration test to obtain thrust chamber performance and thermal data. Propellant tank pressurization difficulties on this test resulted in varying mixture ratio throughout the test.

Test sequence 2, initially intended to be an extensive investigation of propellant valve sequencing was deleted and an abbreviated valve sequencing program was incorporated into sequence 3. Previous testing had indicated that the first test of a vacuum period had unusual starting characteristics so the second test of sequence 3 was a duplicate of the first to provide a baseline for subsequent valve sequencing tests. Both tests were conducted with the fuel valve electrical signal delayed 100 milliseconds after the oxidizer valve opening signal. On Tests 3-3 and 3-4 the delay time was reduced to 50 and 0 milliseconds, respectively. The engine was purged after each of the first three tests so that each test would simulate a first start on an engine. No posttest purging was conducted after Tests 3-4 and 3-5 since tests 3-5 and 3-6 were the first of the hot engine restart evaluation tests.

The engine was fired for 23 seconds on Test 3-4 to bring it to thermal equilibrium prior to the 180-second coast period which preceded Test 3-5. Test 3-5 was fired for 14 seconds to reheat the engine to equilibrium conditions prior to the 120-second coast period which preceded Test 3-6.

During the next test day, Tests 3-7 through 3-17 of Sequence 3 were conducted to evaluate the hot engine restarting characteristics. No purges were used between these tests and each test was fired long enough to heat the engine to equilibrium conditions. Coast durations ranged from 1 to 60 seconds.

To evaluate engine soakout characteristics after a very brief firing, Test 3-18 was conducted with a mainstage duration of 0.15 seconds. Approximately 7 minutes into the soak period it was observed that data was not being properly acquired. The engine was purged for approximately 1 minute and the 0.15-second duration firing repeated (3-18A) followed by a 10-minute soak. An unusually high 'g' level was experienced at oxidizer injector prime which occurs before ignition. Testing was terminated for the day and the engine inspected and found to be in good condition.

Six cycles of the oxidizer valve were programmed to chill down the oxidizer feed system and determine if the temperature was factor in the hard start. No hard starts were encountered and it was concluded that the hard start on Test 3-18A was the result of contamination, either from the facility or from the fuel side of the engine. Test 3-18C was conducted to determine vacuum soakout characteristics after a 1-second firing.

During checkouts before Test 3-19, the operation of the oxidizer valve was erratic and indicated closing without being signaled to do so. The valve was changed.

A fairly high 'g' level was encountered at start on Test 3-12 but was not repeated on Test 3-13 although the coast times were approximately equal (10 seconds). Tests 3-19 through 34 were therefore undertaken to explore hot engine restarts with coast times of approximately 10 seconds. Testing proceeded satisfactorily through Test 3-22 with coast times ranging between 18 and 25 seconds. After a coast of 12 seconds, Test 3-23 was initiated. However, the OMS simulating fuel tank was almost empty at the start of this test and was completely depleted during the 4.5 second test. Test data indicated slugs of helium were probably also being ingested into the fuel system. The indicated propellant mixture ratio was approximately 4.4 at the end of this test. However, the value is questionable because of presence of helium. Chamber pressure was down to 65 psia. Subsequent to shutdown external wall temperatures on the regeneratively cooled thrust chamber exceeded 500 F, the maximum recording capability of the instrumentation. Posttest inspection of the thrust chamber indicated a number of blue streaks in the converging section of the combustion chamber. A dye penetrant check of the combustion chamber indicated no leaks. The hot engine restart tests with ambient temperature propellants were concluded the next test day with Tests 3-24 through 33 exploring coast periods ranging from 2 to 29 seconds. The high 'g' level experienced at ignition on Test 3-12 was not repeated during any of these tests.

The minimum firing time required of the OME is currently 1 second. Test Sequence 4 was conducted to determine the restart capability of the engine after firing for this period and coasting for various times. Test Sequence 4 was conducted without any difficulties. Coast periods ranged from 0.3 to 180 seconds. No unusually high 'g' levels were encountered during this series. The final test in this series was for a 0.4-second duration and followed by a posttest vacuum soakout.

Cold propellant will remain in the engine for a longer period after shutdown than ambient temperature propellants. The effect of this variable on restart characteristics was investigated in Test Sequence 5 by chilling the propellants to approximately 45 F and conducting a series of hot engine restarts. Coast periods for this test sequence ranged from 1.6 to 180 seconds with no unusually high 'g' levels being encountered on any of the starts. A final test in this sequence was conducted later with engine at an ambient temperature. The engine was fired for 0.15 seconds and allowed to soakout in vacuum to determine the minimum temperatures which would result if the engine were signalled to shut down prematurely before heating up. This test provided the data upon which was based the scheduling of the tests in the next test sequence.

Sequence 6 was scheduled to investigate restart characteristics of the engine after a premature shutdown involving a very short firing. Firing durations for this sequence were approximately 0.2 seconds with coast times ranging from 2.5 seconds to 14 minutes, 16 seconds. No high 'g' levels were encountered at start during this test sequence. The last test of the sequence was conducted for the shortest duration of any of the tests in this program, 0.04 seconds, and was followed by a 10-minute posttest vacuum soak.

The purposes of Sequence 7 testing were two-fold: 1) to provide baseline performance and thermal data with the engine in its nominal configuration for comparison with subsequent tests in Sequence 8 which would be conducted without boundary layer coolant; and 2) to investigate OME operation at very low chamber pressures typical of propellant tank blowdown operation. In order to prevent excessive side loads which might be associated with very low pressure operation, the 72:1 nozzle was replaced with the 9:1 nozzle. To provide a higher safety factor, the fuel temperature was reduced to approximately 45 F. To provide more accurate flow data, two additional flow meters were installed in each propellant feedline under ideal ducting conditions between the outside propellant tanks and the tee which branches to the engine and to the OMS simulating tanks. The OMS tanks were valved closed for the first 7 tests of the sequence and propellant flowed from the external tanks to the engine. Tests were conducted in this configuration for propellant mixture ratios of 1.45, 1.65, and 1.85 at nominal chamber pressure and for the two lower propellant mixture ratios at 100 psia chamber pressure.

The boundary layer coolant (BLC) orifices in the injector were plugged with short wires prior to Sequence 8 to investigate the effects of BLC on performance and heat transfer. Ten tests were conducted at chamber pressures ranging from 106 to 140 psia andpropellant mixture ratios of 1.5 to 2.0. All tests were of 10 seconds duration except the first which was fired for 33 seconds to assure complete heating of the regeneratively cooled hardware. Cold fuel (~ 45 F) was used for this sequence to enhance the regenerative cooling safety factor because of the off-nominal conditions being tested. Sequences 7 and 8 were terminated with a 30-minute vacuum soak to compare the soakout characteristics of the columbium radiation cooled nozzle with those of the CRES nozzle.

Sequence 8 completed this phase of the test program. The injector and chamber were inspected and found to be usable if required for future testing. The integrated thrust chamber has accumulated 156 starts and 1189 seconds of operation. The L/D #1 injector has accumulated 284 starts and 1695 seconds.

START TRANSIENTS

Facility and engine ducting were configured to simulate, as far as possible, the volumes and lengths of the current Orbit Maneuvering System propellant feed system. A brief investigation of the effects of propellant valve sequencing on start transient characteristics was made during the first four tests of Sequence 3. These tests also provide a comparison of the first start transient of a vacuum period with subsequent starts. Previous experience had indicated, in general, slightly higher g-loads at start on the first tests. Therefore, the first and second tests were both conducted with the fuel valve opening signal delayed 100 msec relative to the oxidizer valve signal. The delay was reduced to 50 msec on the third test and to 0 msec (simultaneous signals) on the fourth test. Figures 9, 10, and 11 are reproductions of oscillographs derived from the analog tape for Tests 1, 2, and 4 respectively of Sequence 3. Comparison of the start transients for Tests 1 and 2 indicates a more gradual oxidizer injection pressure rise at oxidizer prime and a complete absence of pressure surges at ignition in the oxidizer injection pressure on the first test. The data indicates a hard liquid system for the second test and the presence of some gas in the system for the first test. (Test 3-18B consisted of a series of cyclings of the oxidizer valve only. The same difference between oxidizer injection pressure transients for the first test and subsequent tests was noted.)

The fuel injection pressure transients also indicate a more gas-free system on the second test by virtue of the more regular and higher frequency oscillation which occur during the priming transient. Gases in the fuel at ignition would lead to the smoother transient indicated in thrust for the first test. Note that the thrust transient on the first test indicates a more rapid rise to a low thrust value than on the second test. This rise is accompanied by accelerometer activity not present on the second test. The engine was purged completely before each of these tests so it is presumed that no propellants existed downstream of the propellant valves in either case. It therefore appears that small amounts of gas existed in the propellant feed system upstream of the valves on the first test and that the second test is therefore a more typical start.

A comparison of the start transients of Tests 2 and 4 (Figs. 10 and 11) indicates that simultaneous signalling of the propellant valves on Test 4 has moved the oxidizer injection prime point much closer to the fuel injector prime point but the effect on the ignition characteristics is not

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FIGURE 9. START TRANSIENT FOR TEST HT1-3-1

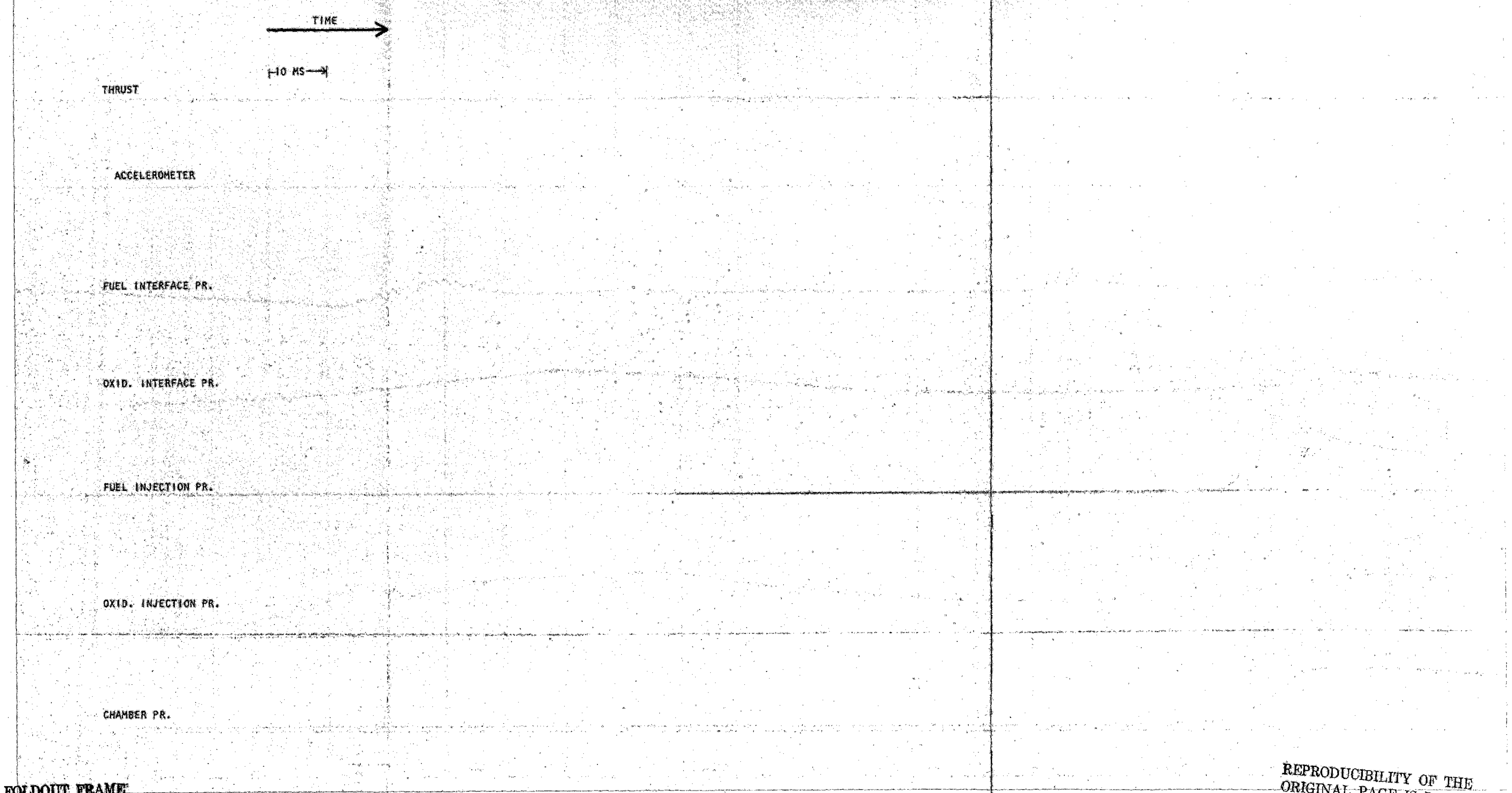

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FIGURE 10 START TRANSIENT FOR TEST IHT1-3-2

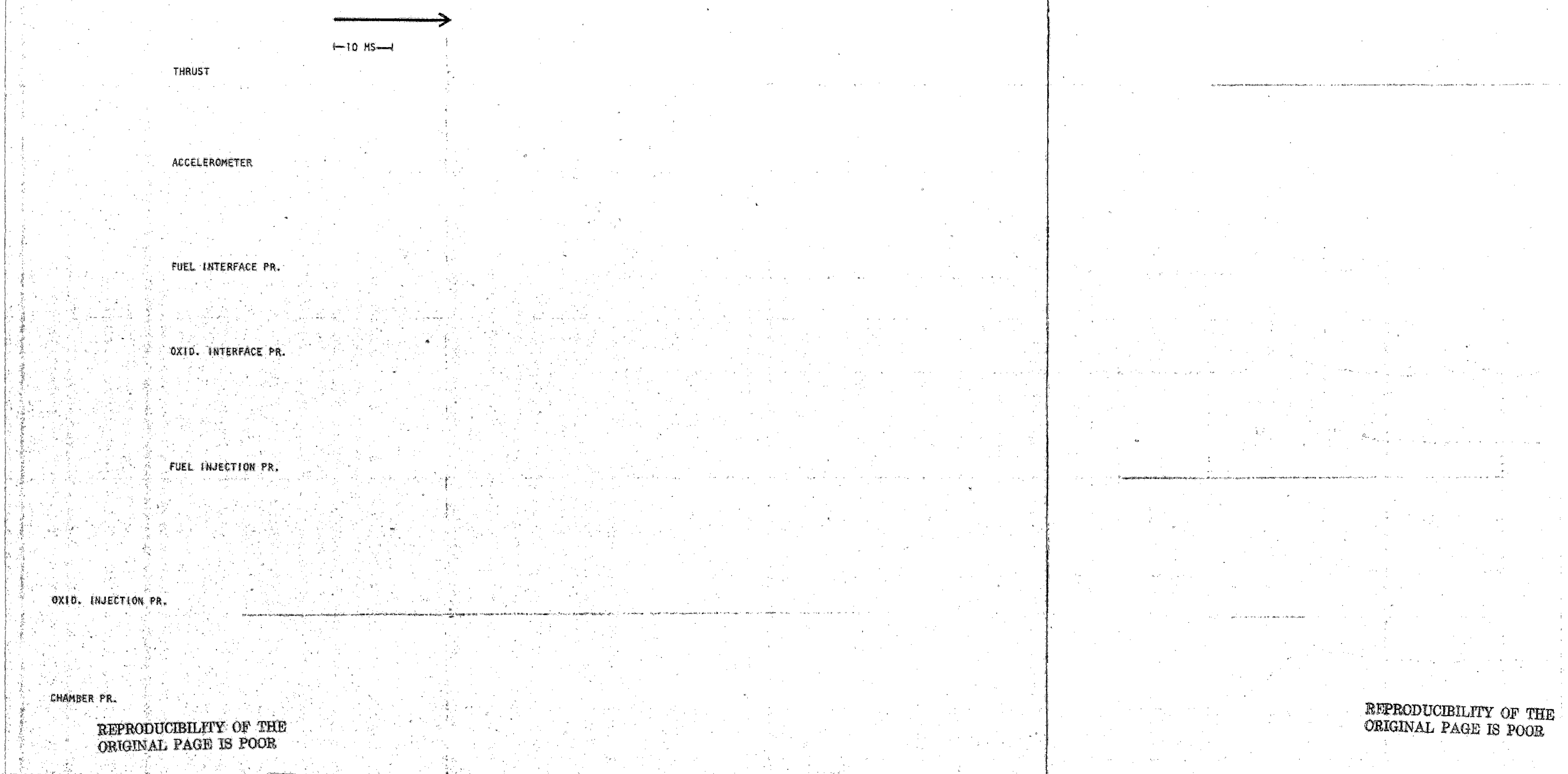

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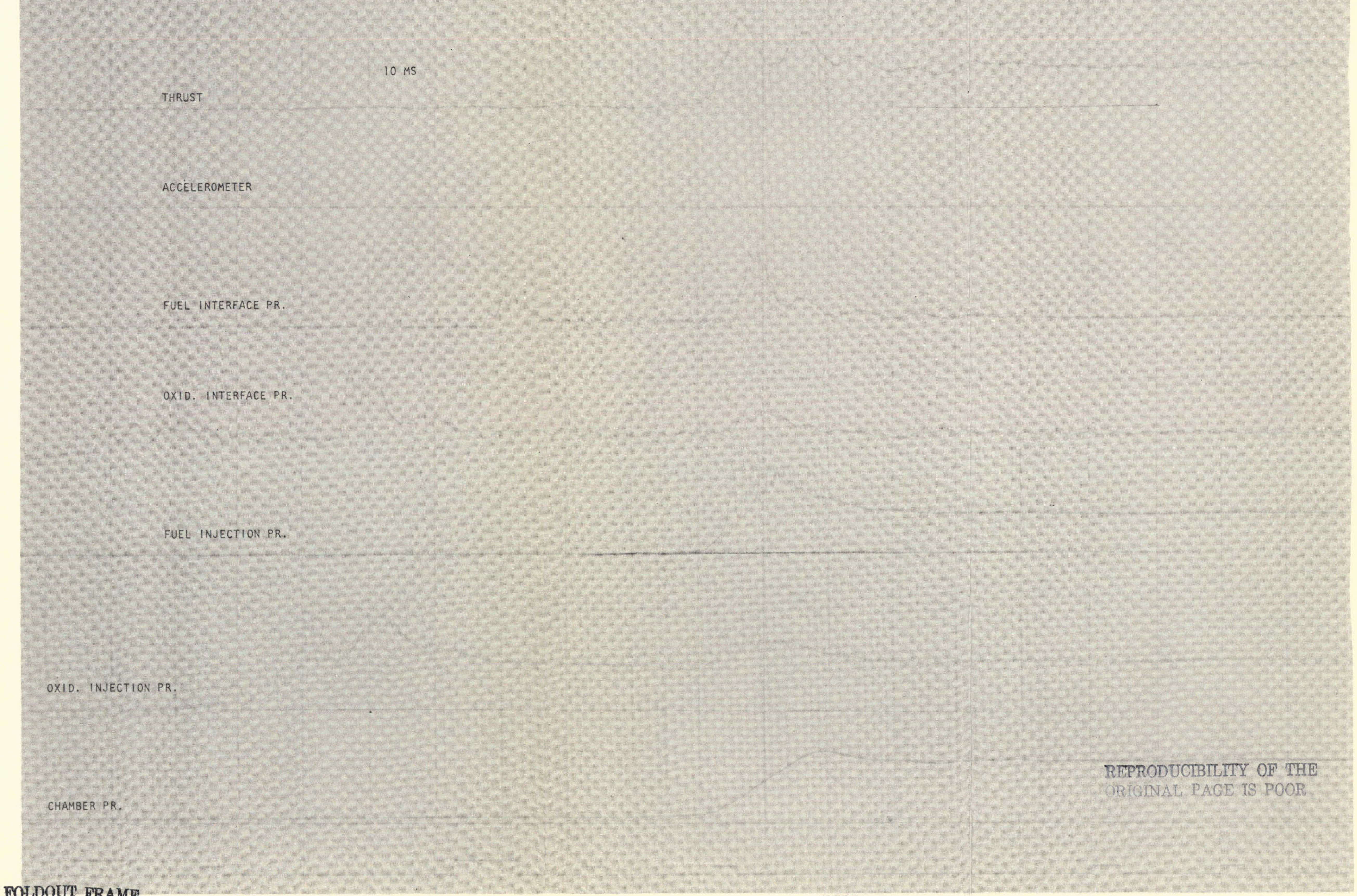
FIGURE 11. START TRANSIENT FOR TEST IHT 1-3-4 -



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significant for this range of oxidizer leads. The reason for this can be seen in Fig. 11. The oxidizer injection prime transient is completed by the time the fuel injection transient and ignition occurs even with simultaneous valve signals. In fact, the shape of the transient indicates that fuel injector prime could occur 20 to 30 milliseconds earlic without significantly affecting the ignition characteristics. However, restart characteristics could be affected because short coast times tend to reduce the oxidizer lead even further. Thrust overshoot and accelerometer data tabulated in Appendix A indicate that these characteristics did not vary much between Tests 3-2 through 3-4.

The start transient for Test 3-18A is shown in Fig. 12. The high acceleration spike on this test occurred not at ignition but at the time the oxidizer injector primed. The ±2000 g accelerometer (not recorded in Fig. 12) indicated 1500 g at that time. The high value of the spike in oxidizer injection pressure at prime implies a detonation in the oxidizer dome at this time. (The instrumentation is nearly saturated so that the actual value of the spike is even higher than indicated.) It is suspected that the dome was contaminated even though the injector was purged before the test.

An accelerometer spike of lesser magnitude occurred at ignition. The magnitude of this spike was more typical of values recorded at the start of a first test of a vacuum period. Note the wide variation in accelerations recorded by accelerometers at different locations on the chamber. As an indication of the physical significance of the magnitudes of these acceleration, it is noted that a light tap with a hammer on the injector dome resulted in accelerations of up to 500 g's.

ENGINE SHUTDOWN AND SOAKOUT CHARACTERISTICS

A typical shutdown transient after a long duration test without posttest purges is shown in Fig. 13. Approximately 0.6 seconds after the shutdown

FIGURE 12. TEST 1HT1-3-18A

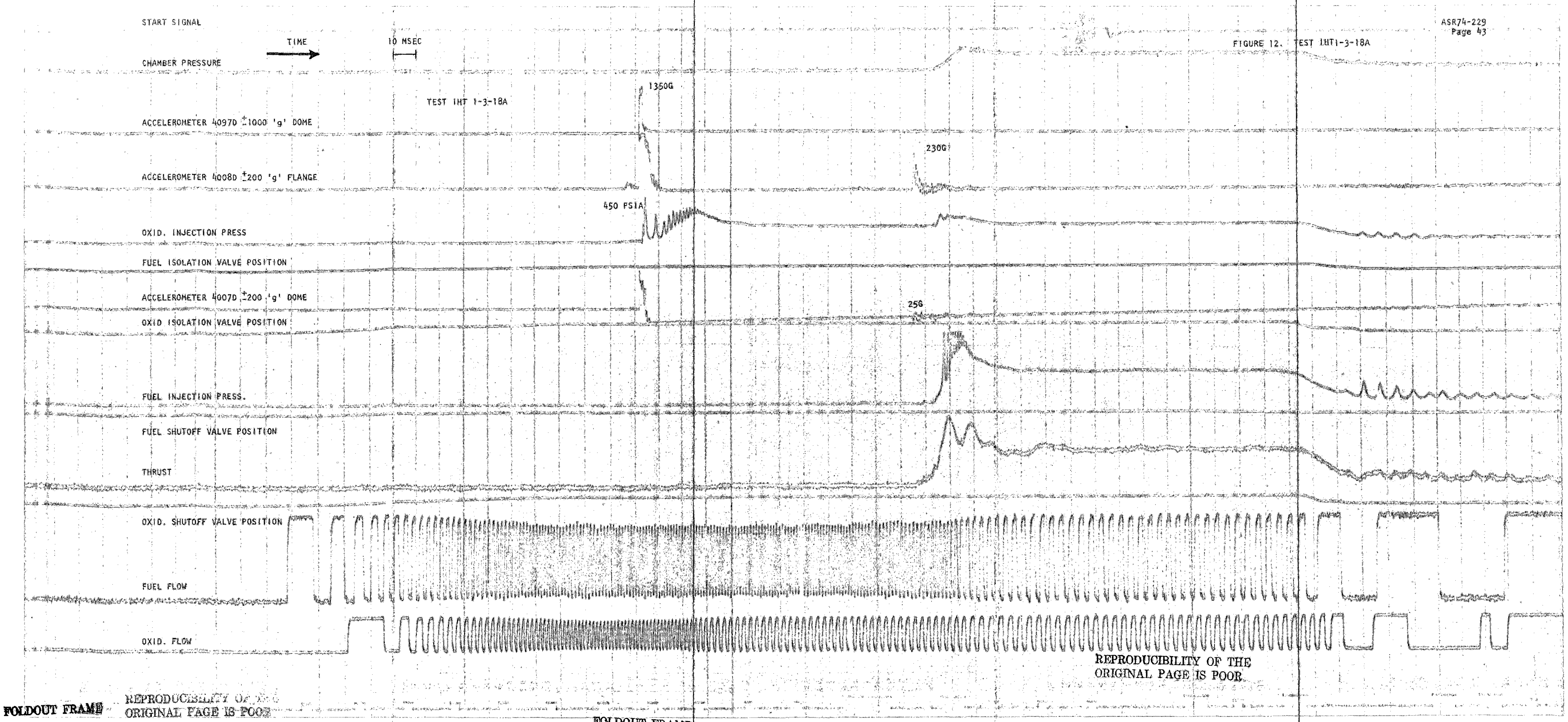

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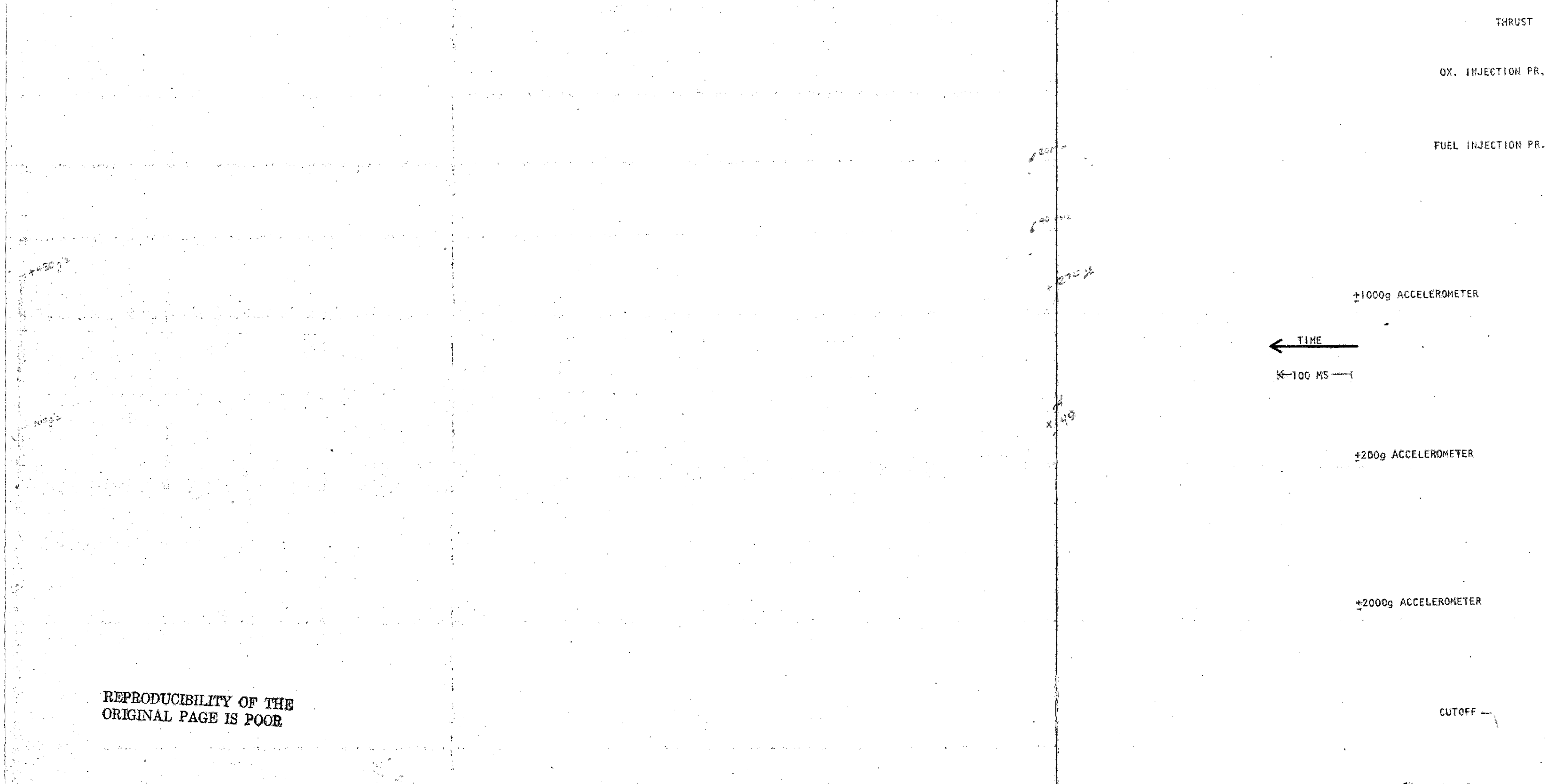
FIGURE 13. SHUTDOWN TRANSIENT FOR TEST 1HT1-3-4



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signal considerable accelerometer activity begins and lasts for up to several seconds. Because of this phenomenon, it was difficult to evaluate g-loads at restart for test with coast durations less than 5 seconds. Posttest accelerometer readings of several hundred g's were occasionally recorded. 'Football' type oscillation of 2400 Hz were frequently encountered on one of the accelerometers whereas the data from the other 3 accelerometers was fairly random.

Fuel and oxidizer injection pressures at the beginning of the accelerometer activity were in the order of 40 and 20 psia respectively, which corresponds to a saturation temperature of 240 F for MMH and 60 F for NTO. On short duration tests such as 3-18 and 3-18A which were of 0.15-second duration no posttest accelerometer activity occurred.

On Test 3-18C, which was 0.9-second duration, accelerometer activity did not occur until approximately 1.2 seconds after shutdown and was significantly less severe than that following long-duration tests. Sequence 4 was a series of 1-second duration tests with varying coast times. Accelerometer activity began 1.4 seconds after shutdown for the first tests and occurred at progressively shorter times, such that, at the latter tests the activity was commencing at 0.5 seconds after the shutdown signal.

Sequence 6 included a series of 16 tests of approximately 0.2-second duration. The only posttest accelerometer activity recorded during this test sequence was after Test 8 which was the longest duration (0.27 sec) test of the series. The activity was quite mild and occurred 1.7 seconds after the shutdown signal. The posttest value of the regenerative thrust chamber wall temperature was the highest on Test 8. At the time the accelerometer activity occurred, the highest temperature was 235 F measured at the -8 inch station on the chamber. Fuel injection pressure at this time was approximately 20 psia corresponding to a saturation temperature of 200 F. Coolant inlet manifold temperatures were quite cool averaging approximately 50 F.

Thus, it appears that the posttest accelerometer activity depends upon the engine temperature at shutdown which, in turn, is a function of the test duration.

The accelerometer activity may be due to violent boiling of MMH in the regenerative coolant jacket or NTO in the injector. However, a more probable source of the effect is suggested by the following data (all times referred to the shutdown signal).

Test IHT 1-	Time of Accelerometer Activity, Sec.	Time of Purge Initiation, Sec	
		Oxidizer	Fuel
3-4	0.6 to 4.6	None	None
3-5	0.7 to 4.6	None	None
3-6	0.7 to 3.6	2	7
1-12	0.7 to 2.7	2	7
7-6, 7-7	None	-1	-1

These tests were all of sufficiently long duration (>5 sec) to heat the engine. When the oxidizer purge only was initiated manually approximately 2 seconds after the shutdown signal, the duration of the accelerometer activity was significantly reduced. When the purges were initiated during the shutdown transient (by setting the purge pressures lower than steady-state injection pressures prior to the shutdown signal) the characteristic accelerometer activity did not occur. This suggests that for an unpurged hot engine shutdown, the oxidizer drains out of the duct while fuel boils out of the chamber jacket giving rise to sporadic low-level combustion and popping. The oxidizer purge blows the NTO out of the duct rapidly and eliminates the low-level combustion. With a cold chamber (firing times ≤ 0.2 sec) the fuel comes out of the jacket very slowly so that the oxidizer simply drains out of the injector and chamber without combusting. Although the accelerometer activity is quite pronounced after cutoff the effects are not manifested in either thrust or injector pressures (the chamber pressure measurement did not have rapid response characteristics) and are probably not harmful to the engine.

Figures 14 through 23 represent typical soakout transients for an engine which has been fired long enough to have reached thermal equilibrium. The test shown was a 5-second test after a hot engine restart. Regenerative chamber outer wall temperatures at the -16 inch location, behind accoustic cavities, are shown in Fig. 14. The wall at this point receives heat inputs from the accoustic cavity dams and the injector and is cooled by MMH being boiled in the jacket. The heat inputs at first predominate and the temperature rises for approximately 40 seconds, after which the cooling injector and cavity dams cannot keep up with the cooling capability of the MMH and the temperature again decays. When the MMH is depleted to the point that liquid can no longer percolate up the channel to cool this region, the temperature again rises in response to the injector heat input.reaches a maximum and decays as heat is transfered to the rest of the chamber and the environment. The maximum temperature at this location was less than 300 F, well below the decomposition temperature of MMH.

The back wall temperatures at the -13 inch location are plotted in Fig. 15. The upper two curves indicate that the cooling effect of the MMH is not being felt at these locations. The maximum temperature reached on this test at this location was 445 F, the highest on the regenerative chamber wall. That the chamber can be safely started with channel wall temperatures much higher than this value has been demonstrated in the heated tube test program of Task IX.

Back wall temperature profiles at -10 inches are shown in Fig. 16. These curves peak at a maximum value of 370 F. The temperature transients reached their first maximum sooner at the -13 inch location and locations

FIGURE 14. NICKEL WALL TEMPERATURE AT X = -16 INCHES

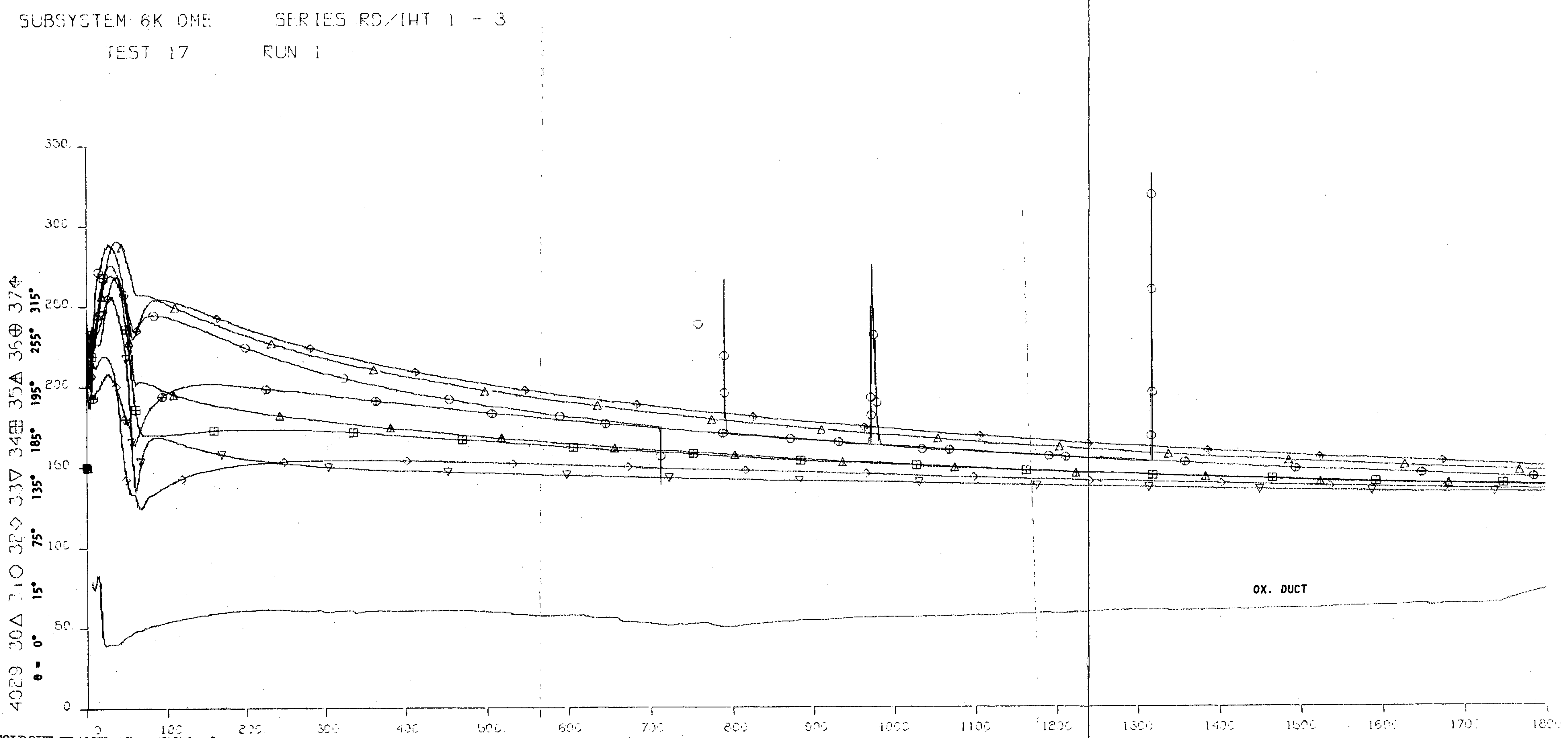

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FIGURE 15. NICKEL WALL TEMPERATURE AT X = -13 INCHES

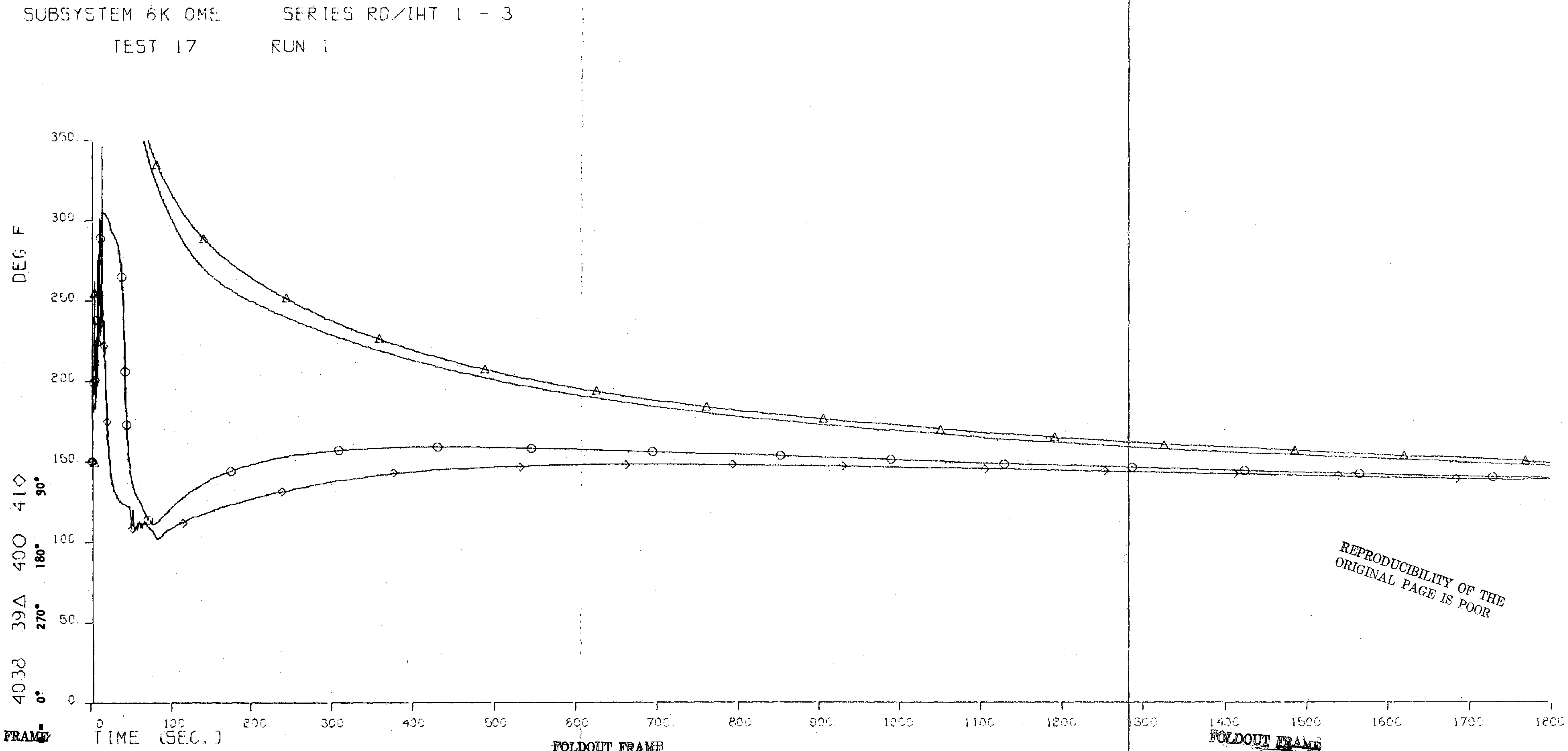

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FIGURE 16. NICKEL WALL TEMPERATURE AT X = -10 INCHES

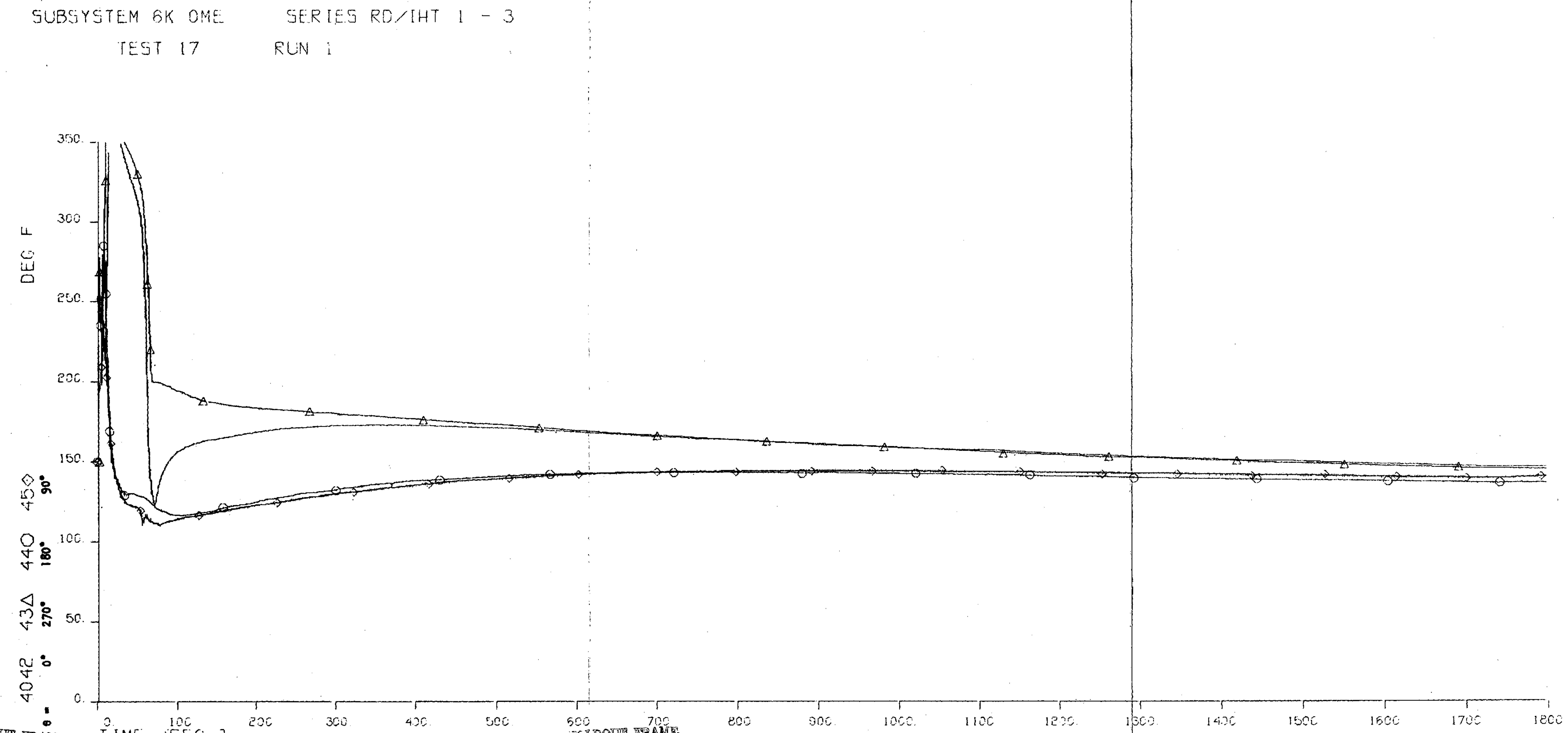

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FIGURE 17. NICKEL WALL TEMPERATURE AT X = -8 INCHES

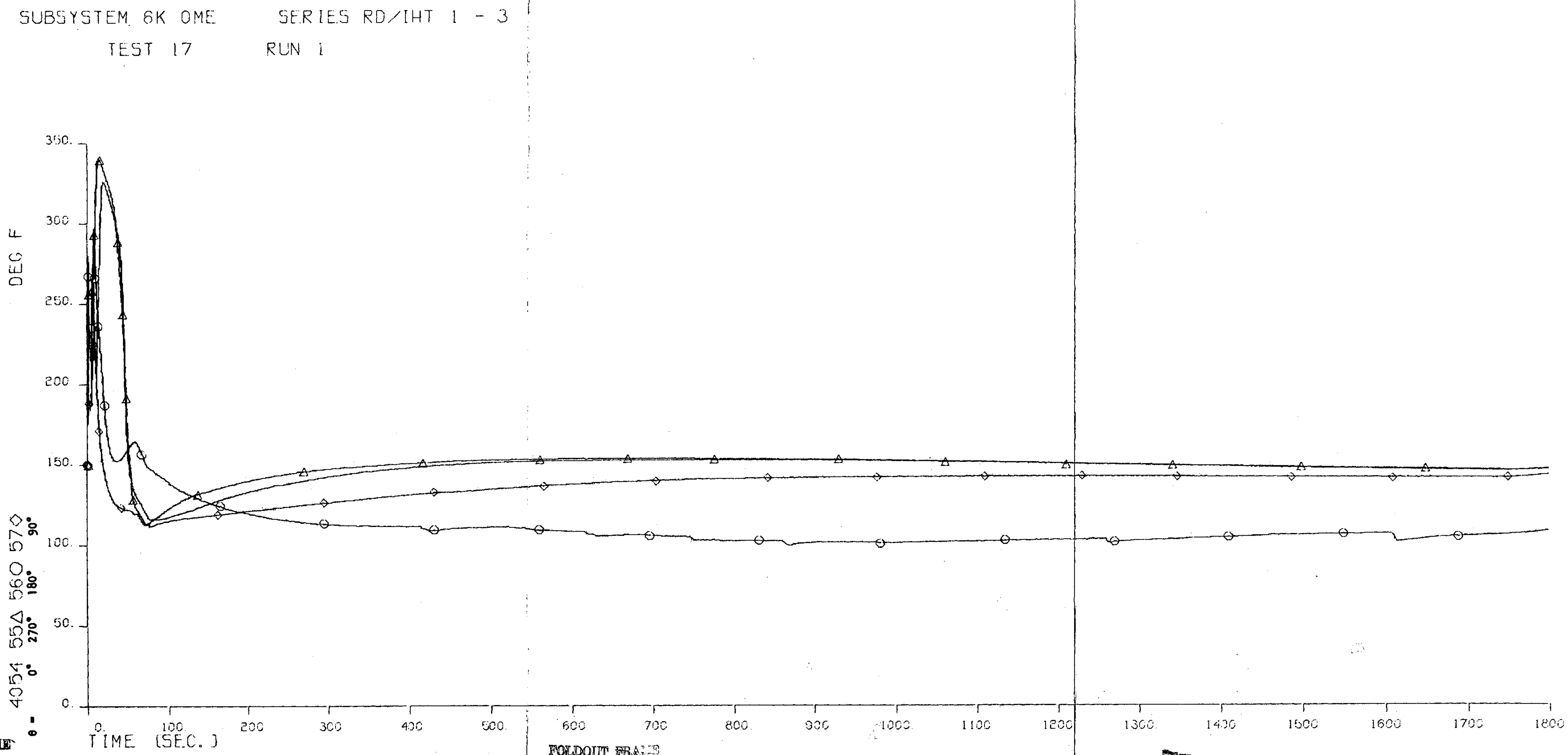

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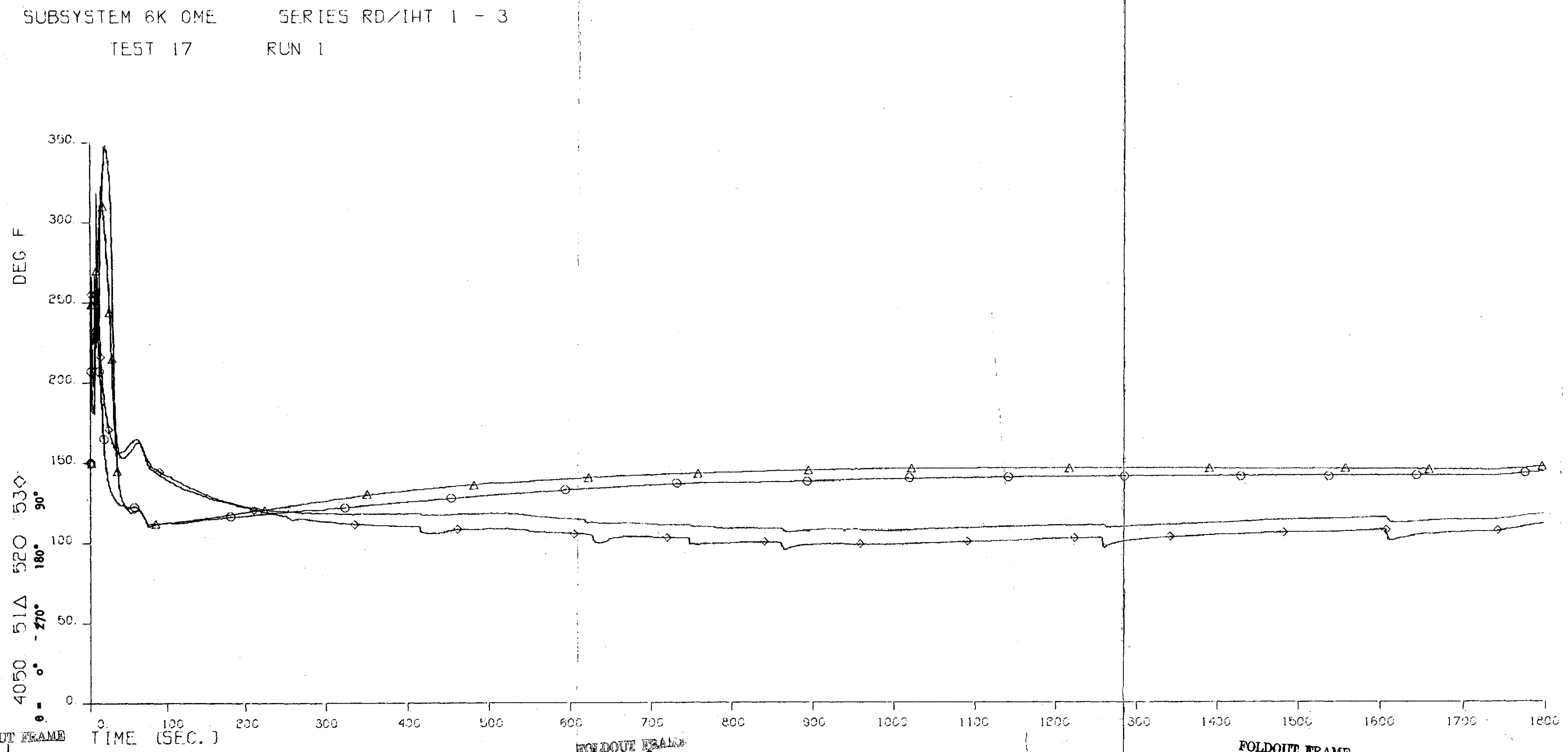
FIGURE 18. NICKEL WALL TEMPERATURE AT X = -6 INCHES



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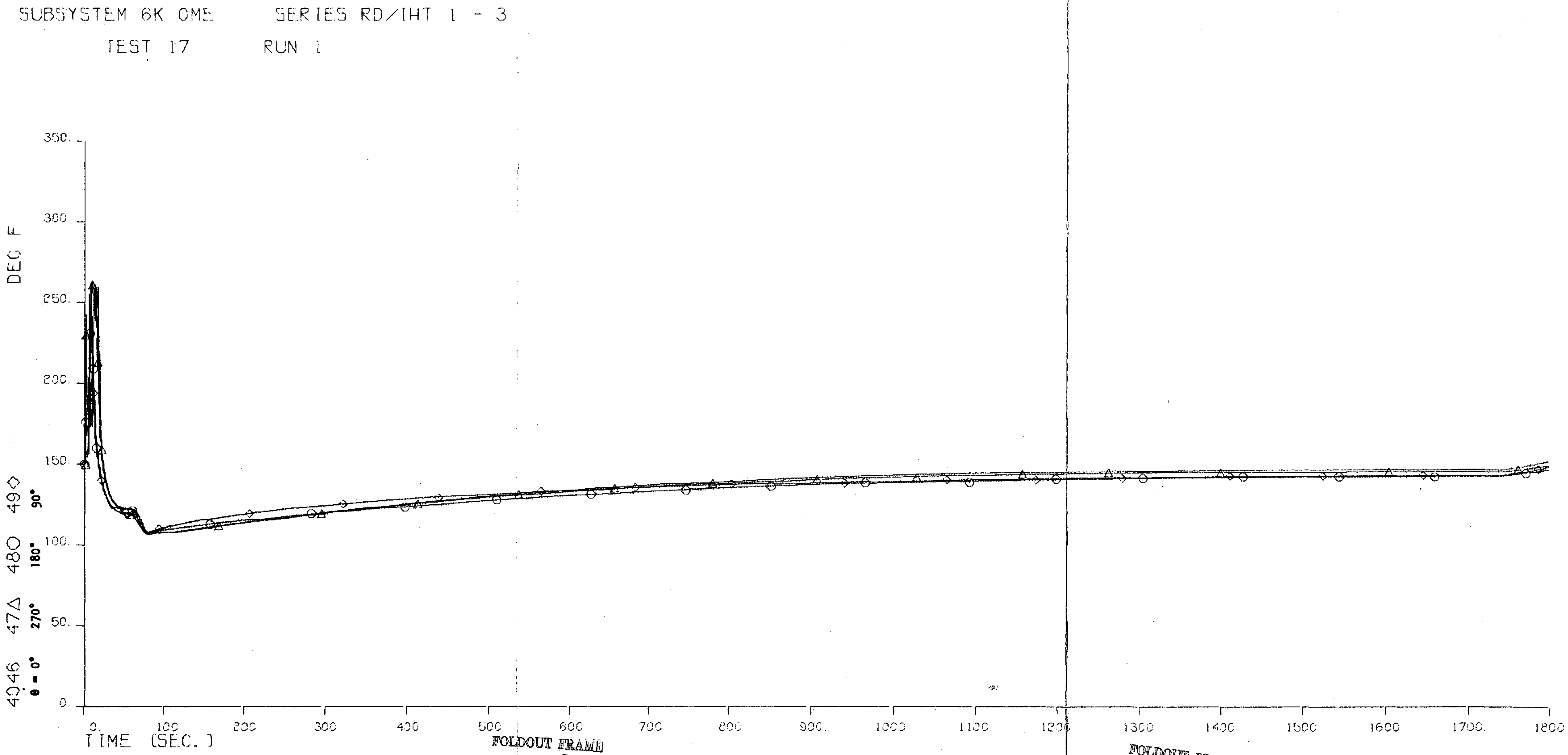
FOLDOUT FRAME 3

FIGURE 19 . NICKEL WALL TEMPERATURE AT X = -4 INCHES

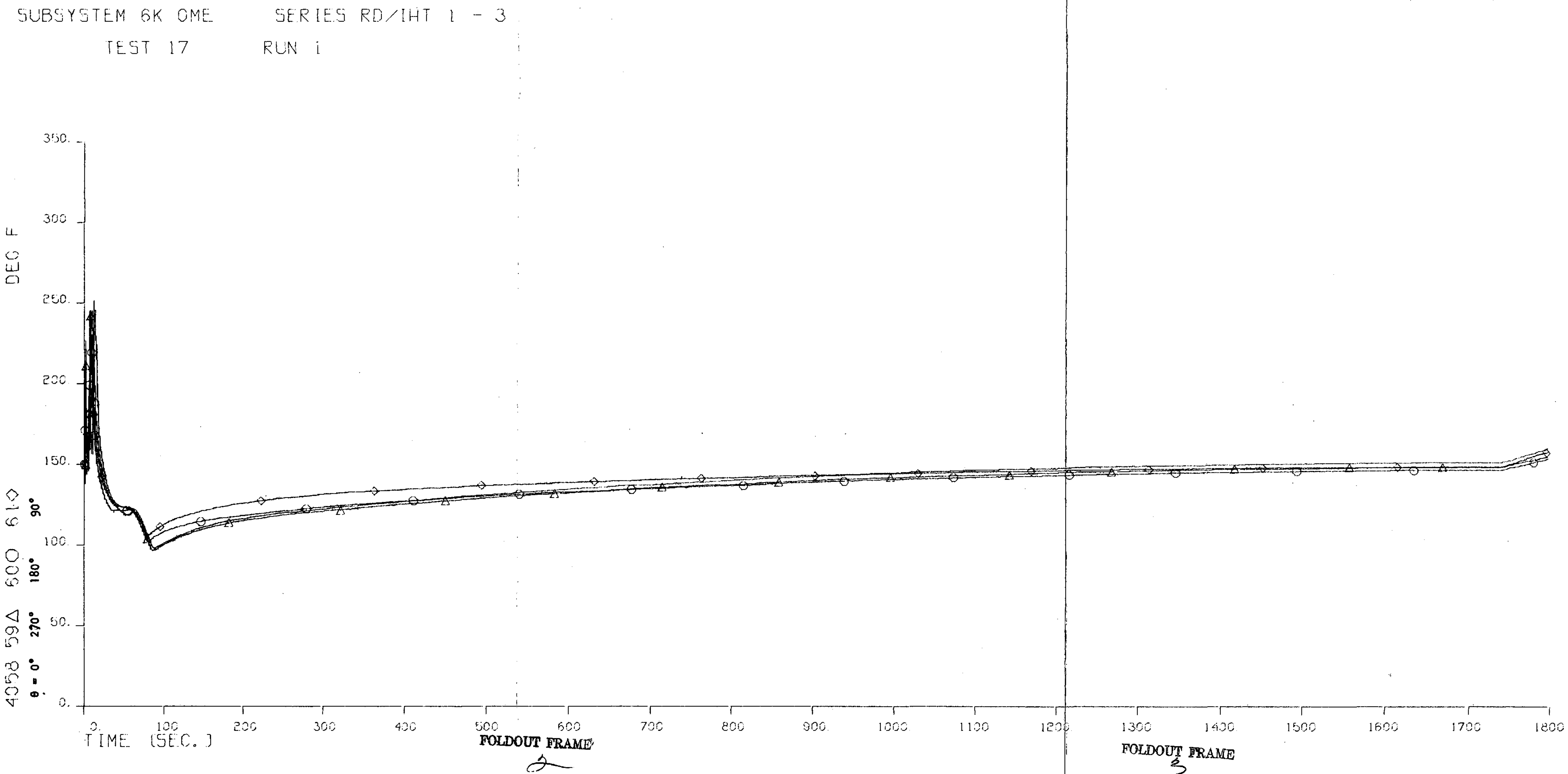


FOLDOUT FRAME 1

FOLDOUT FRAME 2

FOLDOUT FRAME 3

FIGURE 20 . NICKEL WALL TEMPERATURE AT X = -2 INCHES

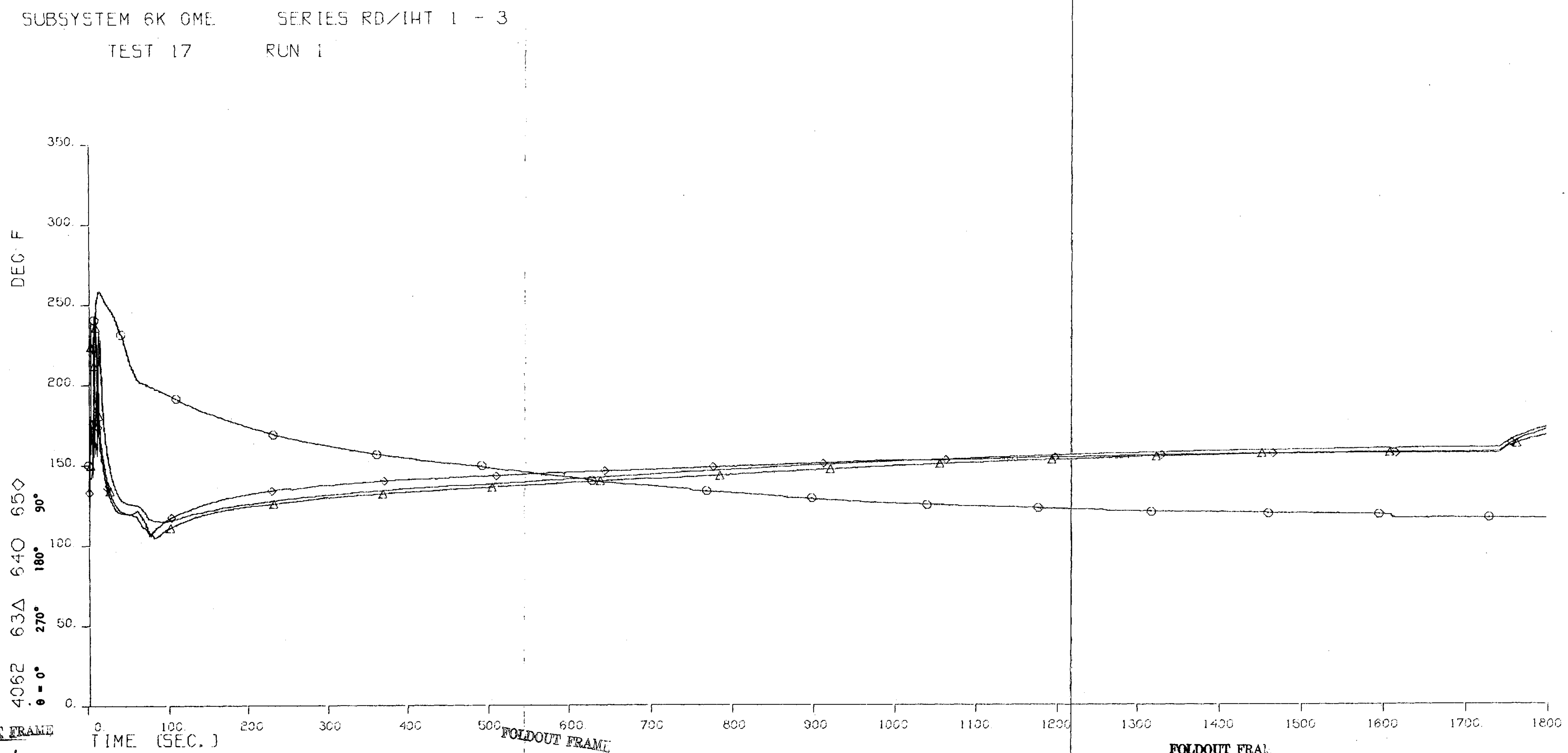


FOLDOUT FRAME 1

FOLDOUT FRAME 2

FOLDOUT FRAME 3

FIGURE 21 . NICKEL WALL TEMPERATURE AT THROAT

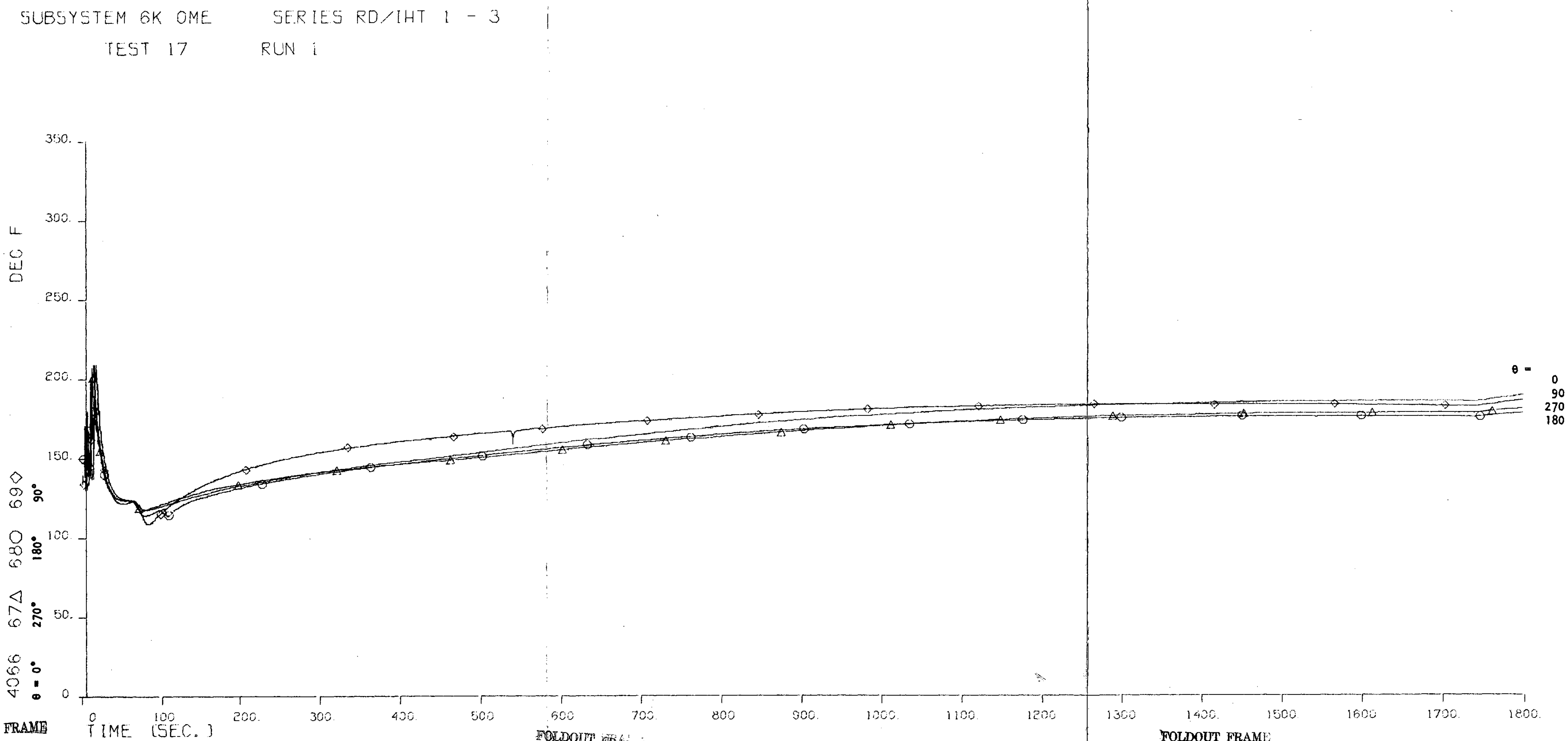


FOLDOUT FRAME 1

FOLDOUT FRAME 2 C-2

FOLDOUT FRAME 3

FIGURE 22 . NICKEL WALL TEMPERATURE AT X = +3 INCHES



FOLDOUT FRAME 1

FOLDOUT FRAME 2

FOLDOUT FRAME 3

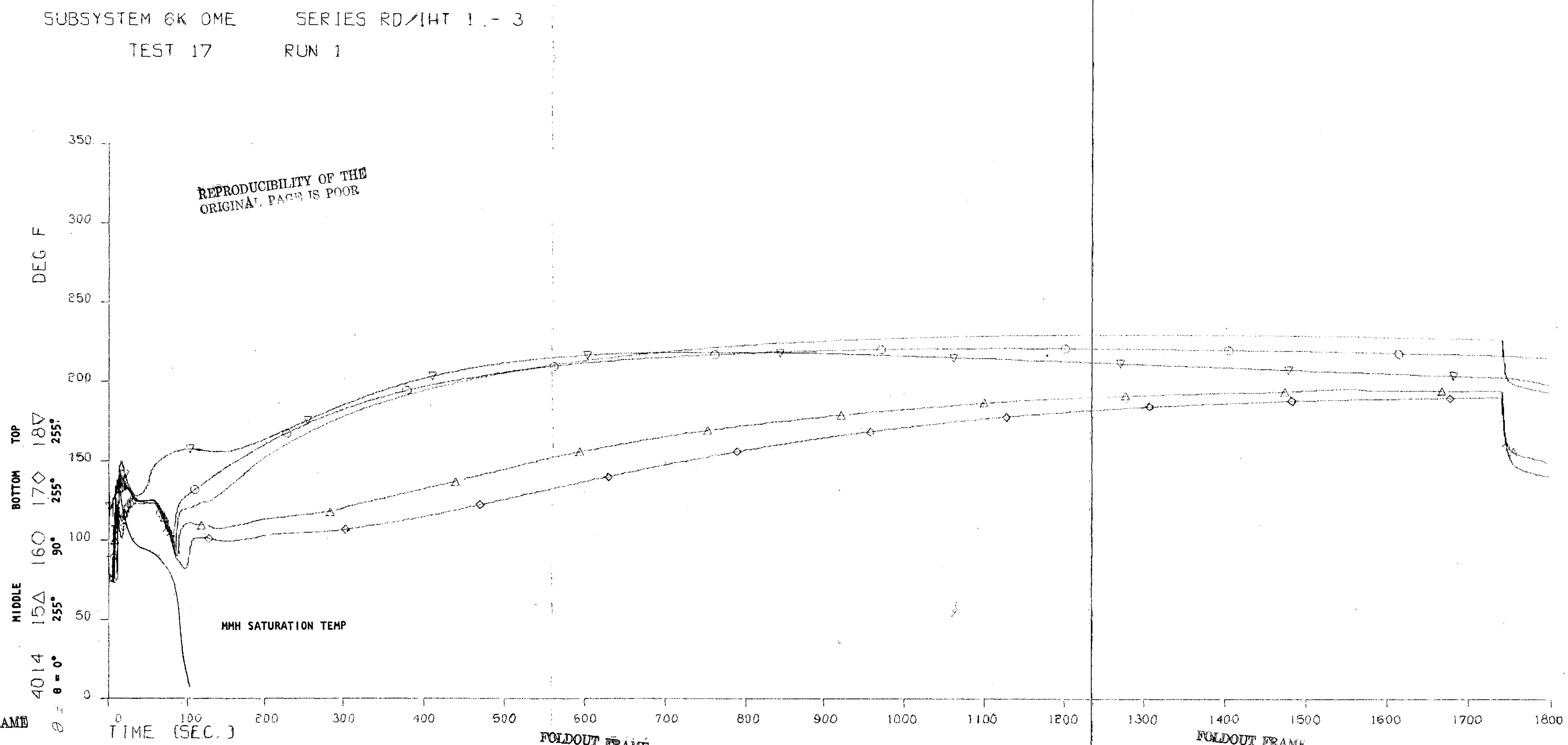


FIGURE 23. COOLANT TEMPERATURE AT INLET

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FOLDOUT FRAME 1

FOLDOUT FRAME 2

FOLDOUT FRAME 3

further aft compared to the -16 inch location because of the relatively thin walls of the chamber compared to the greater masses involved with the acoustic cavity dams. The second peak occurs later because of the time required for the heat to diffuse down from the injector. The time at which the minimum value occurs does not appear to be strongly affected by location, implying that the fuel does not boil down in the channels in an orderly fashion, but rather percolates through the channels cooling them until fuel is virtually exhausted in the inlet manifold.

Temperatures at the coolant inlet are plotted in Fig. 23. After shutdown the temperatures generally indicate a constant temperature value until approximately 60 seconds after which they decay at the same rate. As the coolant is exhausted at each thermocouple, the thermocouple is heated by the surrounding metal and indicates an increasing temperature. The minimum values therefore indicate the time of fuel depletion at each thermocouple location. The thermocouple measuring the temperature indicated by the curve coded with a triangle is near the top of the inlet manifold and is depleted very soon. The other thermocouples are further down in the manifold. One thermocouple, indicated by the data coded with a diamond, is fairly close to the lowest point in the inlet manifold and, thus, its turnaround point indicates nearly complete depletion of fuel in the manifold. This occurs at 95 seconds or approximately 90 seconds after cutoff.

A summary of propellant depletion times and conditions for typical vacuum soakout tests is given in Table VIII. The fuel and oxidizer interface temperatures are measured upstream of the valves and are given at the start of the firing as indications of propellant temperatures during the test. Test durations quoted are the durations during which the thrust exceeded approximately 90% of the steady-state value. The fuel inlet thermocouples measure the temperature of the fuel at the lowest elevation in the system. The fuel depletion times were determined as the time when inlet thermocouples indicated

TABLE VIII

PROPELLANT DEPLETION TIMES

Test	Test Duration Sec	Fuel Interface Temp., F	Conditions at Fuel Depletion				Ox. Interface Temp., F (@ t = 0 sec)	Ox. Depletion Time, Sec.	Min. Ox. Duct Temp. F	Meas. Ox Press. @ Depletion, psia
			Time, Sec.	Inlet Temp., F	P_{SAT}, PSIA	Measured Press. Psia				
3-17	4.8*	74	90	82	1.3	0.7	74	12	40	4.5
3-18C	1.0	70	180	60	0.6	0.3	68	11	29	3.9
7-14	10*	44	300	65	0.7	0.7				
3-18A	0.15	54	600**	47	0.4	0.2	66	12	24	0.9
5-15	0.15	44	3700**	38	0.3	0.3	45	12	13	4.0
6-13	0.04	73	-	64***	0.7	0.3	78	10	13	1.0
6-4A	0.20						78	12	11	3.1

*Engine hot from previous firings

**Very shallow minimums

***At end of 10-minute soak

a minimum in temperature. That minimum temperature and its corresponding saturation pressure are also tabulated. For comparison the actual measured pressure, determined by averaging the low-pressure-range fuel inlet and fuel injection pressures at that time, is also presented.

The lowest elevation in the oxidizer system is in the inlet duct near the engine inlet. The oxidizer inlet duct generally drains down from the valve into the engine with a very small puddling capability at the above mentioned location. Thermocouples are welded to the top and bottom of the duct at this location. The oxidizer depletion time is taken as the time at which the bottom thermocouple indicates a minimum value. The value of that minimum and the injection pressure measured at that time are also tabulated.

Tests 3-17 and 3-18C were conducted with nearly ambient-temperature propellants. Test 3-16 was the last of series of hot-engine restart tests so that the engine was at thermal equilibrium after this test. Test 3-18C was a single one-second duration test corresponding to the current minimum required burn time of the OME. The fuel inlet temperature transients are shown in Fig. 24 for Test 3-18C. A comparison of the fuel depletion times of these two tests indicates that there is a factor of two in depletion times between the currently specified conditions which lead to the engine at its hottest and coldest temperatures. When a hot-engine soakout was conducted with cold fuel (Test 7-14) 300 seconds were required to deplete the fuel as indicated by the temperature transients of Fig. 25. No vacuum soakout tests were conducted after the engine had been fired for one second with cold fuel. However, using the previously noted factor of two in fuel depletion times for hot-engine and one-second tests with ambient fuel, it is estimated that fuel depletion will occur within 10 minutes after a one-second firing with cold fuel.

Test 3-18A, 5-15 and 6-4A were typical of short-firing bursts which might be the result of a premature shutdown signal. The posttest fuel temperature transients associated with these tests were very gradual because of the cold

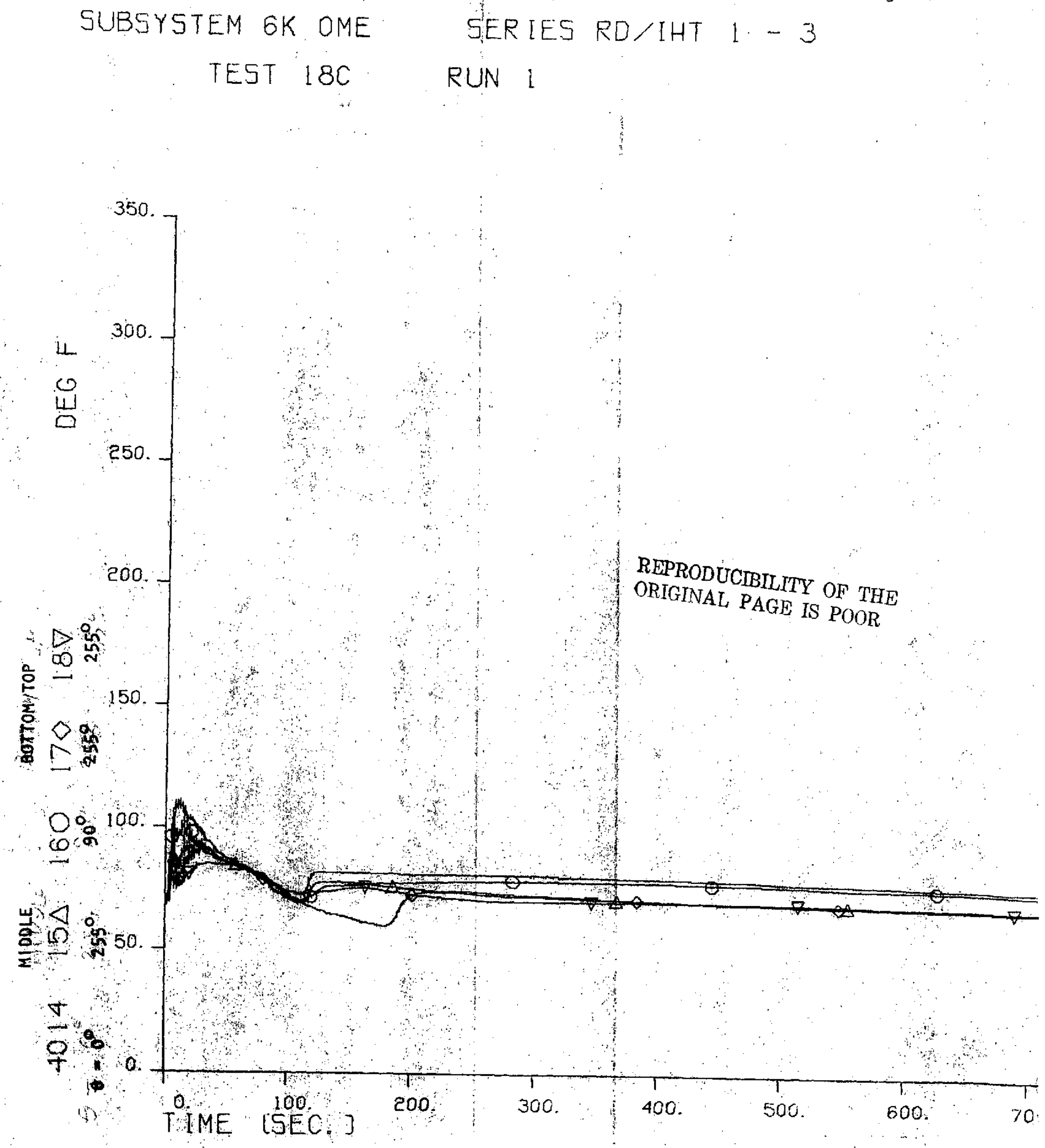

Figure 24. Propellant Inlet Temperature Transient After Test 3-18C

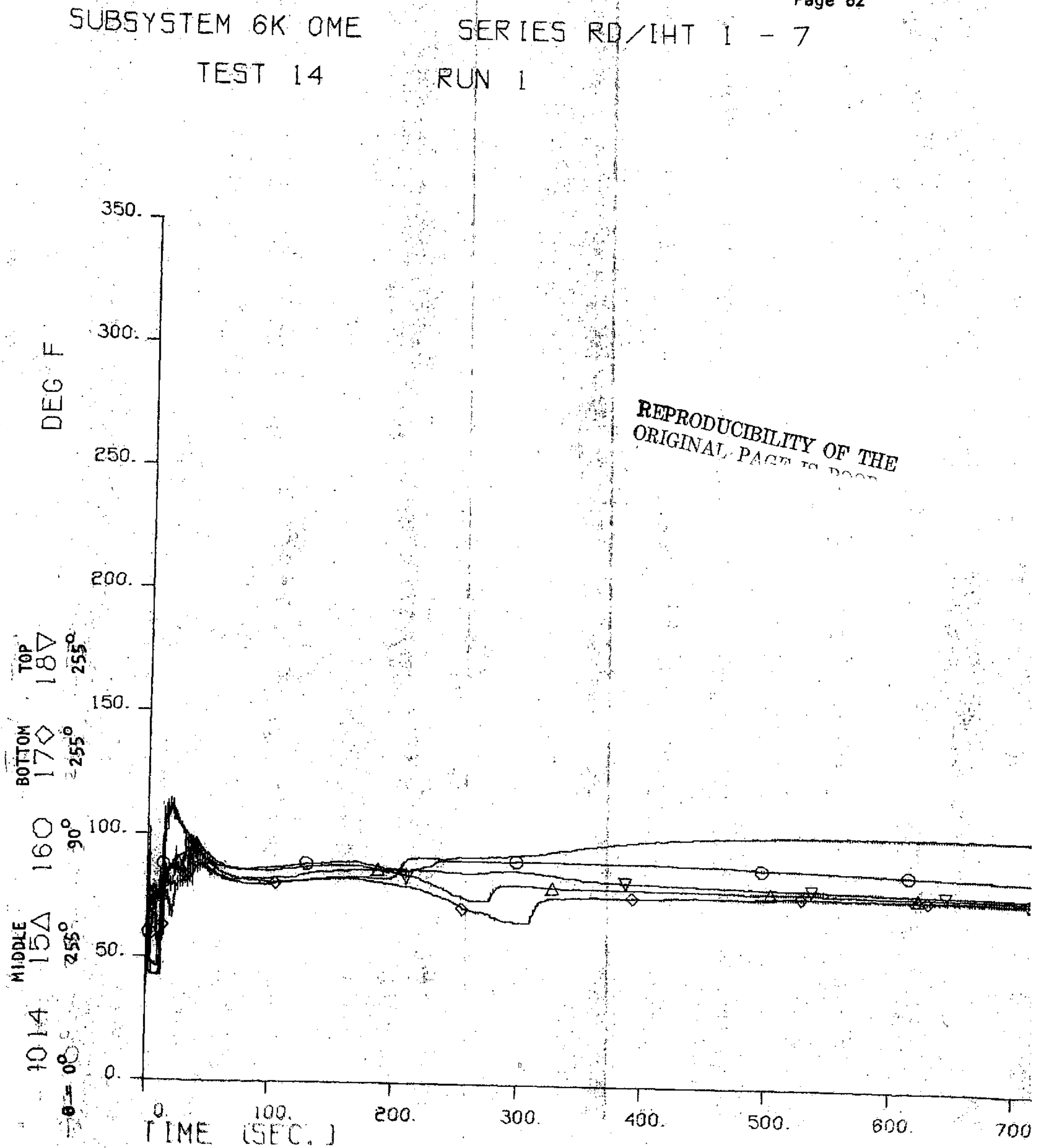

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Figure 25. Propellant Inlet Temperature Transient After Test 7-14

fuel and engine hardware making the actual depletion time difficult to determine. It appears that under these conditions, fuel can be retained in the engine for periods of 10 minutes to an hour after shutdown. The longer depletion time on Test 5-15 is probably the result of the colder fuel even though the engine hardware was somewhat colder on Test 5-18A.

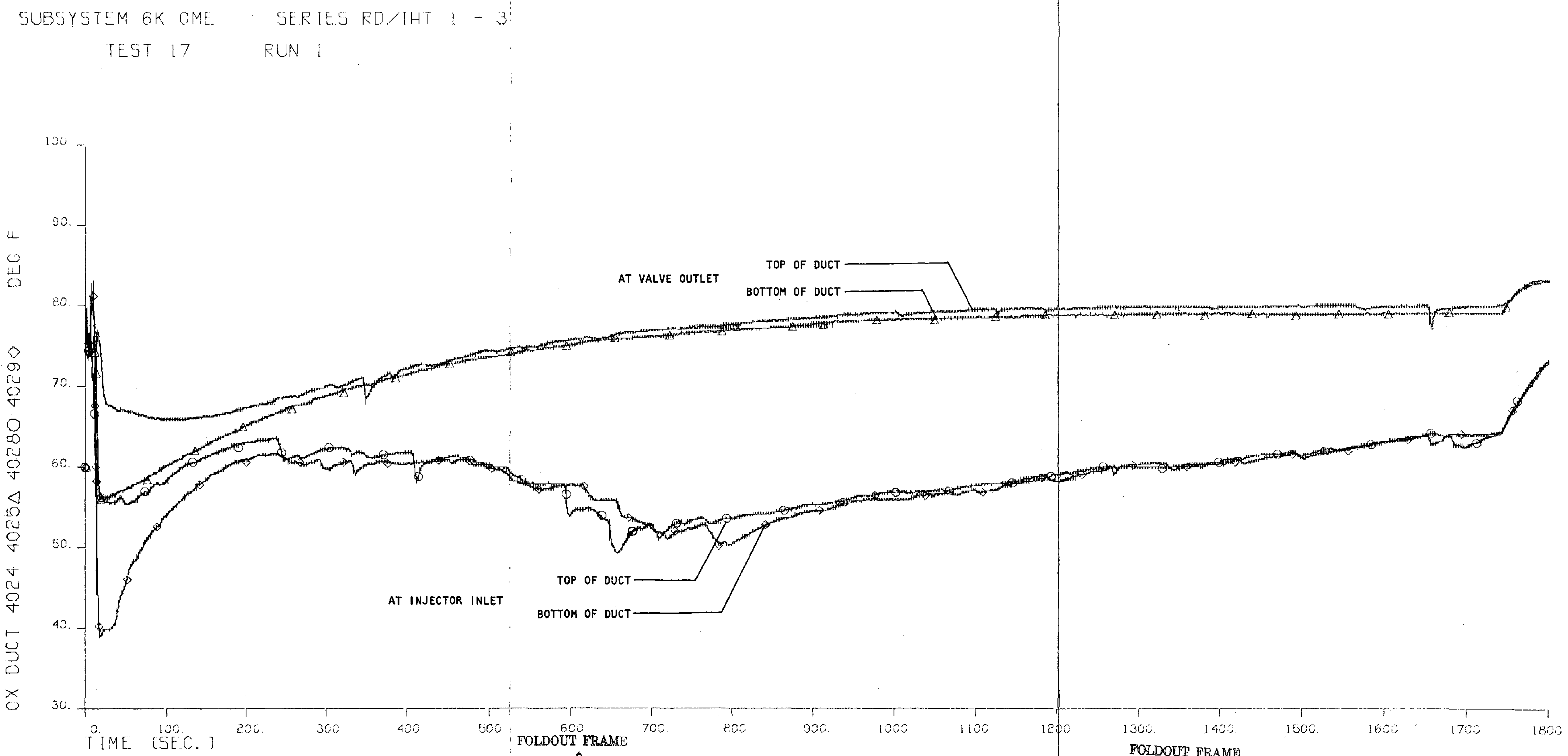
One test (6-13) was conducted for an extremely short-firing time of 0.04 seconds in order to determine whether freezing of the propellants would occur with a firing duration so short as to input practically no heat into the chamber. The 10 minute vacuum soak period was not sufficiently long to determine minimum fuel temperatures. However, the temperatures were sufficiently high (70 F) and falling at so slow a rate as to indicate that freezing of the fuel was not a likelihood.

In all cases, the measured pressures at the fuel inlet and injector were lower than saturation pressure at the time of depletion. This provided additional evidence of the absence of fuel in the system at that time.

Very little oxidizer accumulates in the system as is evidenced by the 10- to 12-second oxidizer depletion times for all of these tests. The relative depletion times of the fuel and oxidizer indicate that engine restarts between approximately 10 and 100 seconds after shutdown would result in a start with residual fuel only in the engine. A series of oxidizer valve only cycling tests were conducted during the program with 70 F oxidizer. The duct temperatures always remained above 17 F during the post flow soakout periods. Oxidizer duct temperature transients after Test 3-17 are shown in Fig. 26.

Test Sequence 5 was conducted with cold (approximately 40 F) NTO. On all tests except 5-14 the minimum oxidizer duct temperature was 17 F or greater, which is above the freezing point of NTO (12 F). After Test 5-14, the duct temperature dropped to a minimum of 7 F. This was the last test of a vacuum period.

FIGURE 26. OXIDIZER DUCT TEMPERATURE



FOLDOUT FRAME 1

FOLDOUT FRAME 2

FOLDOUT FRAME 3

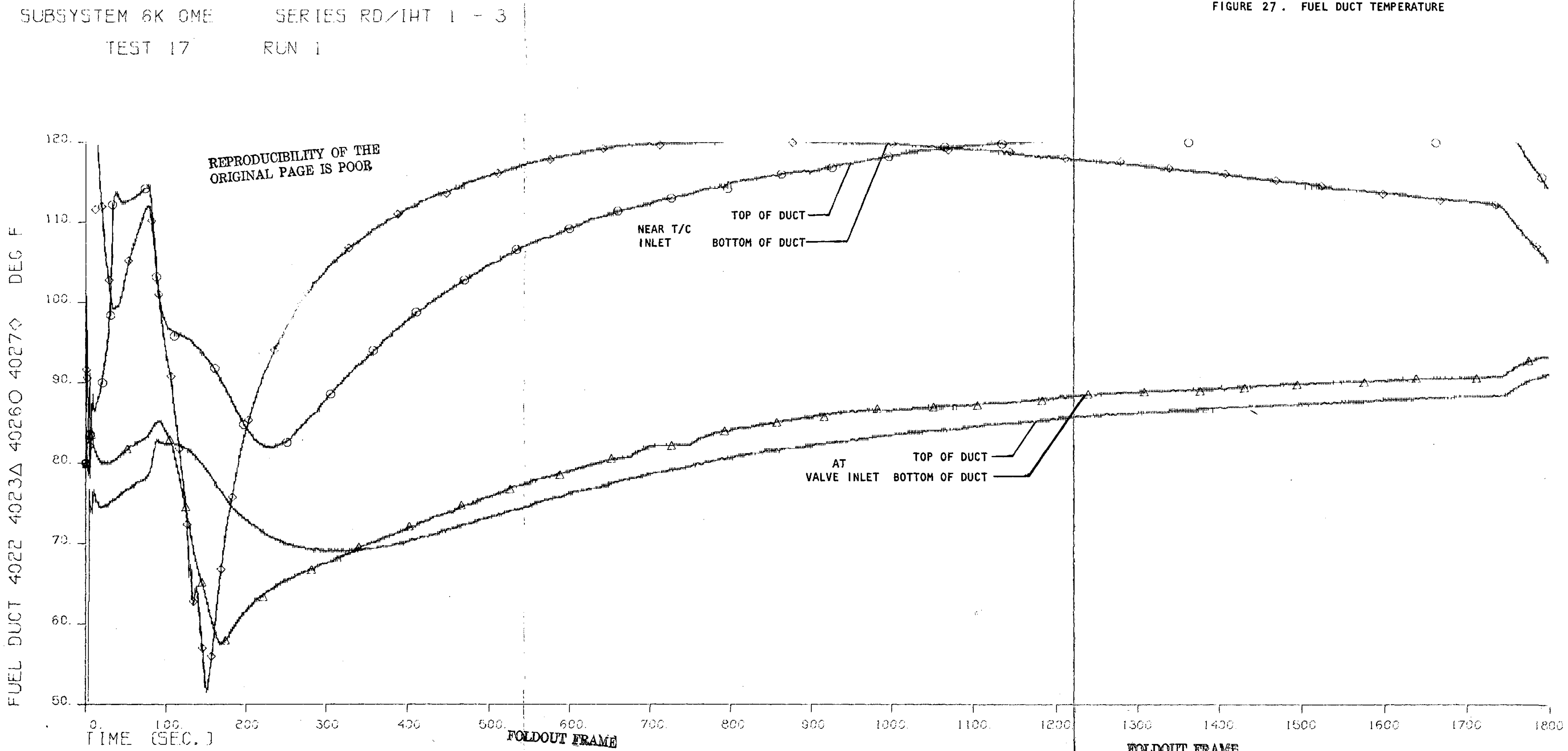
Test Sequence 6 was conducted with ambient propellants but consisted of very short (approximately 0.2 seconds) engine firings. Some of the coast periods were less than 10 seconds duration. Where long posttest duration data was available, the minimum oxidizer duct temperatures occurred at approximately 10 seconds after shutdown.

Fuel duct temperature transients after Test 3-17 are shown in Fig. 27. The transients are somewhat difficult to evaluate because of the thermal input from the radiation cooled nozzle. The well-defined minimums and the temperatures of the bottoms of the fuel duct near the valve and near the chamber inlet imply the presence of fuel in the duct for as long as 170 seconds after the firing.

The regenerative coolant inlet manifold is cooled during the soakout by vaporizing MMH and is heated primarily by the radiation cooled nozzle through the connecting flange. Comparison of Figs. 28 and 29 indicates that these locations reach thermal equilibrium after approximately 30 minutes of vacuum soak after a hot-engine shutdown. The equilibrium temperatures at the zero and 90^o circumferential locations is approximately 225 F. The equilibrium temperature at the 180^o location is approximately 190 F. The minimum in the temperature transient of the fuel inlet manifold is related to fuel depletion but cannot be used to define the exact time of fuel depletion because of the massive nature of the inlet manifold.

Test Sequences 1 through 6 were run with the full length, $\epsilon = 72$, nozzle in order that the thrust overshoot might be correctly simulated. This nozzle is more massive than the flight type nozzle. The columbium nozzle, although only an $\epsilon = 9$ nozzle, was designed by thickness control to simulate the early soakout transients of a flight type nozzle. Test Sequences 7 and 8 were conducted with this columbium nozzle.

FIGURE 27. FUEL DUCT TEMPERATURE



FOLDOUT FRAME 1

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FOLDOUT FRAME 3

FIGURE 28. REGEN NOZZLE FLANGE TEMPERATURE

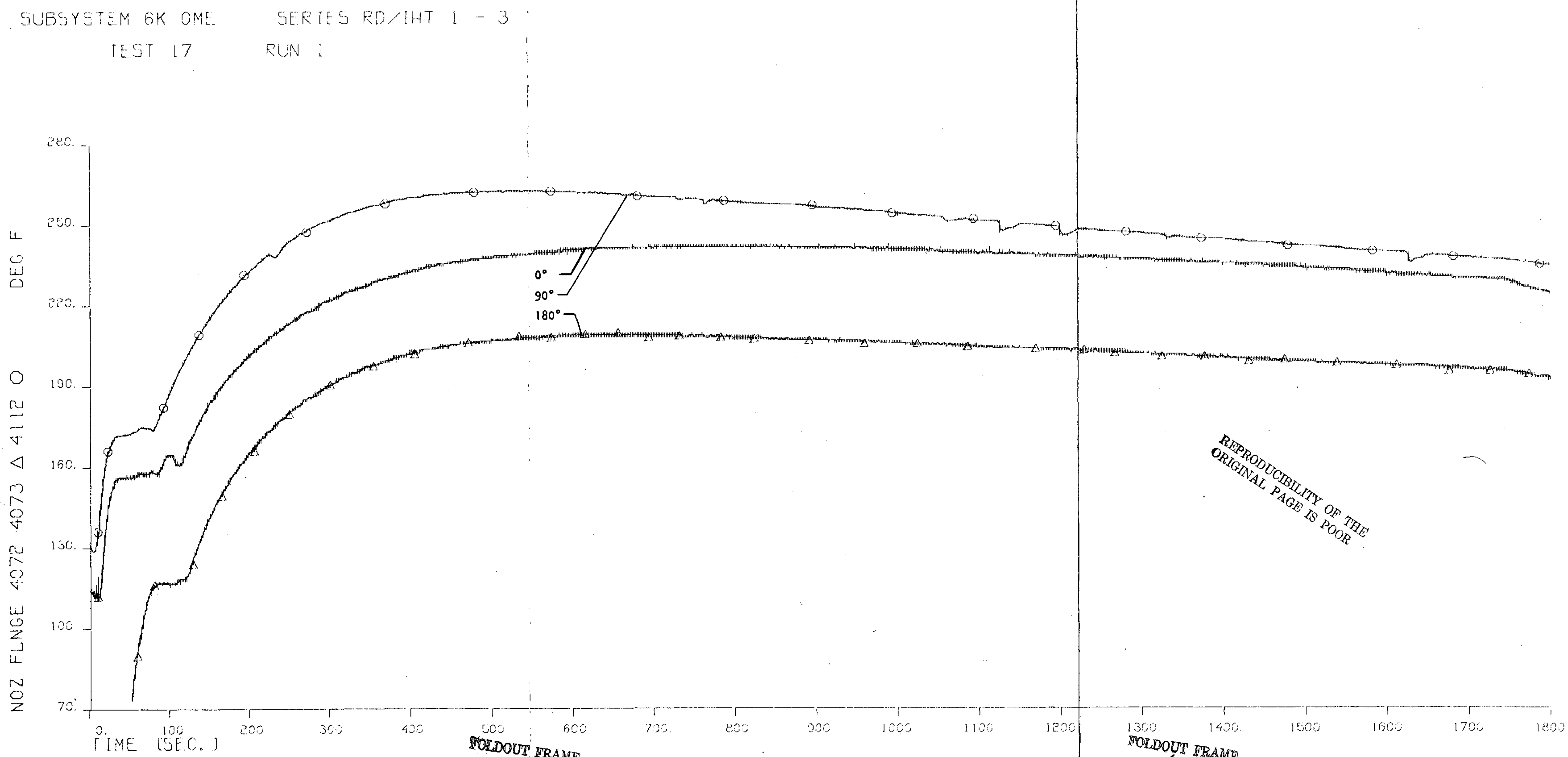

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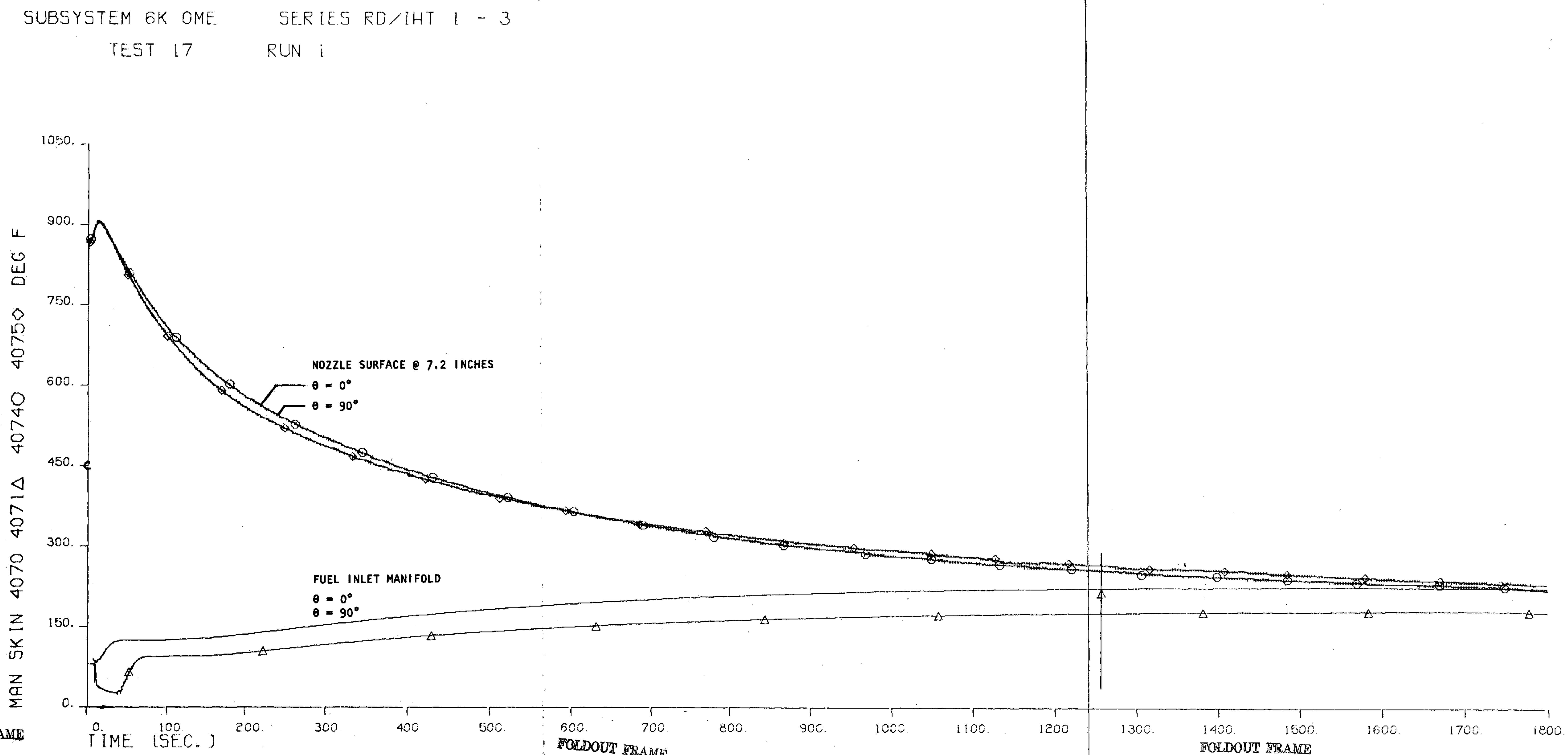
FIGURE 29. NOZZLE AND FUEL INLET MANIFOLD TEMPERATURES



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FOLDOUT FRAME 3

The nozzle surface and fuel inlet manifold skin temperature soakout transients are shown in Fig. 30 for Test 7-14. In comparison with Fig. 29, for the steel nozzle, the nozzle temperature decay is much more rapid. However, the affect on the fuel inlet manifold skin temperature for the first 100 to 200 seconds is quite similar. For the steel nozzle, he average inlet manifold temperature at 150 seconds is approximately 25 F higher than the pretest value. For the columbium nozzle, the posttest value is approximately 15 F higher than the pretest value. Thus, the thermal inputs from the steel nozzle to the fuel inlet manifold are similar to thermal inputs which may be expected from a flight type nozzle during the early soakout transient.

The steel nozzle and fuel inlet manifold skin temperature soakout transients after a 1-second firing are shown in Fig. 31. The nozzle does not heat up significantly and causes very little temperature rise in the inlet manifold during the soakout transient.

Injector dome temperatures are shown in Fig. 32. The temperatures during the early part of the transient reflect the propellant temperatures at shutdown. All the injector temperatures reach equilibrium within 30 minutes after shutdown at a value approximately halfway between the fuel and oxidizer temperatures.

RESTARTS

The objective of this phase of the testing was primarily to evaluate the restart capabilities of the OME and determine whether any limitations of the presently specified duty cycle exist.

Potential Problems

Conditions which were determined to be potential problem areas before the test program were high and low propellant and hardware temperatures, and an inversion of the nominal oxidizer lead start sequence.

SUBSYSTEM 6K OME SERIES RD/IHT 1 - 7

TEST 14 RUN 1

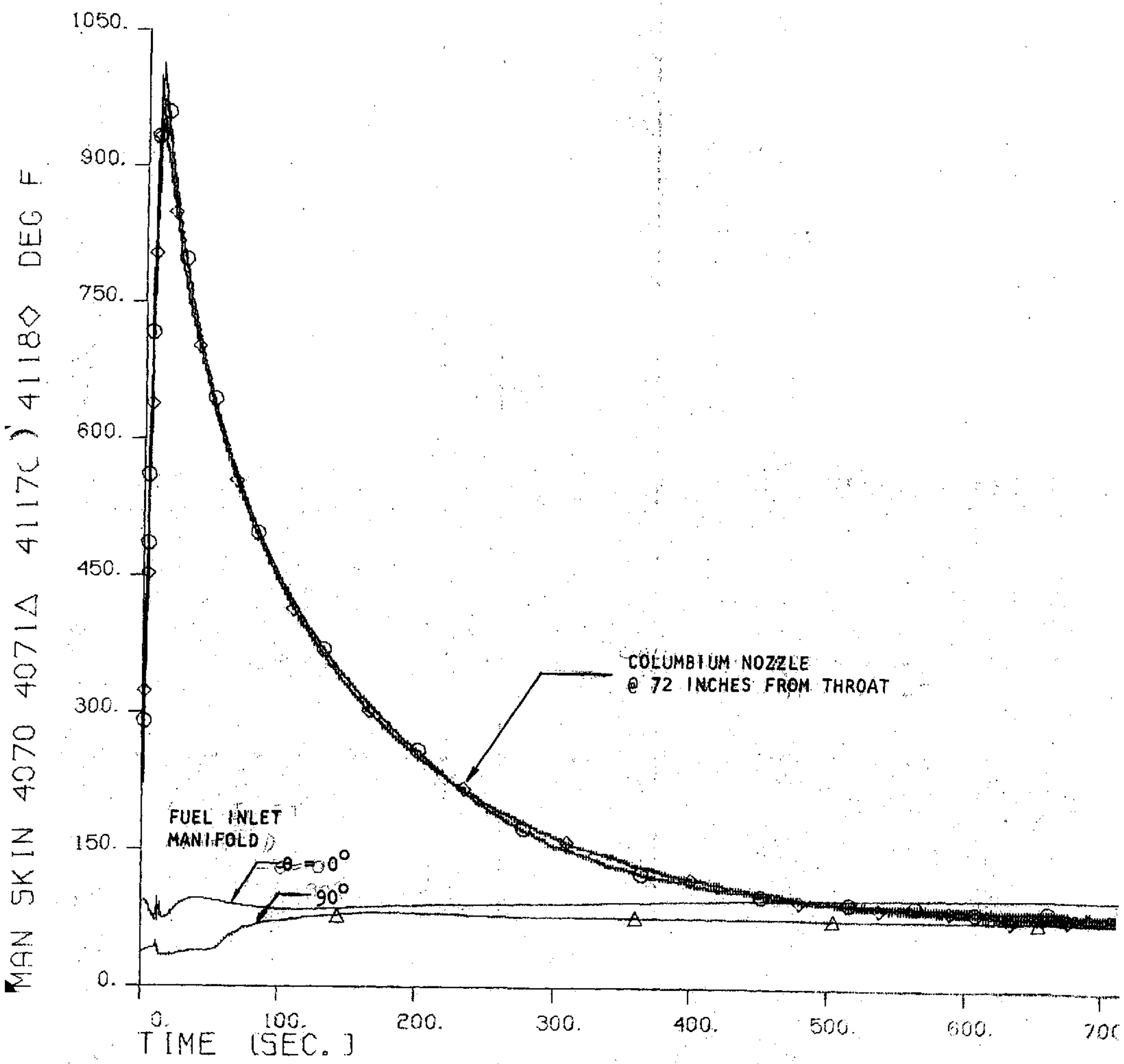


Figure 30. Columbium Nozzle And Fuel Inlet Manifold Temperatures

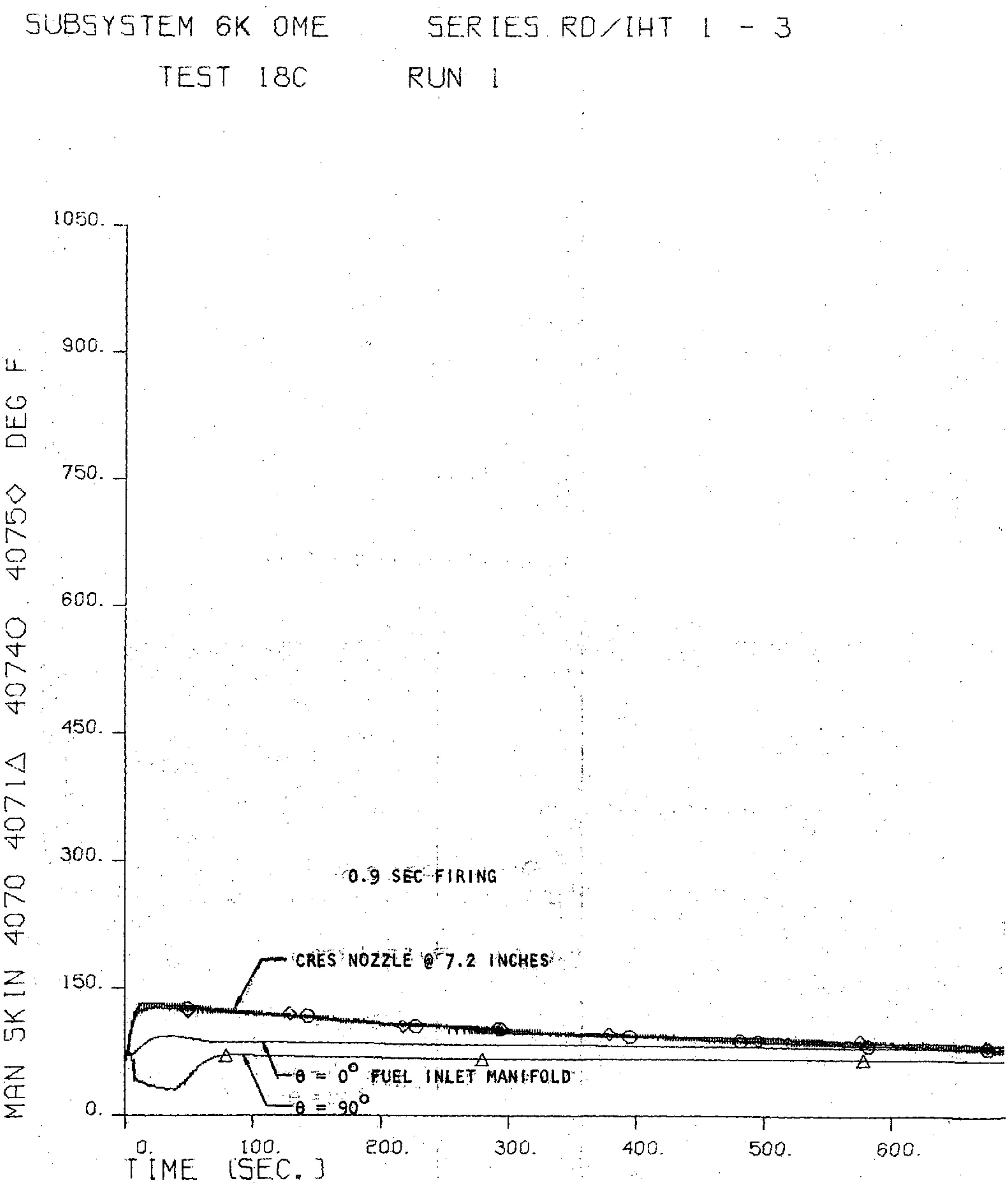
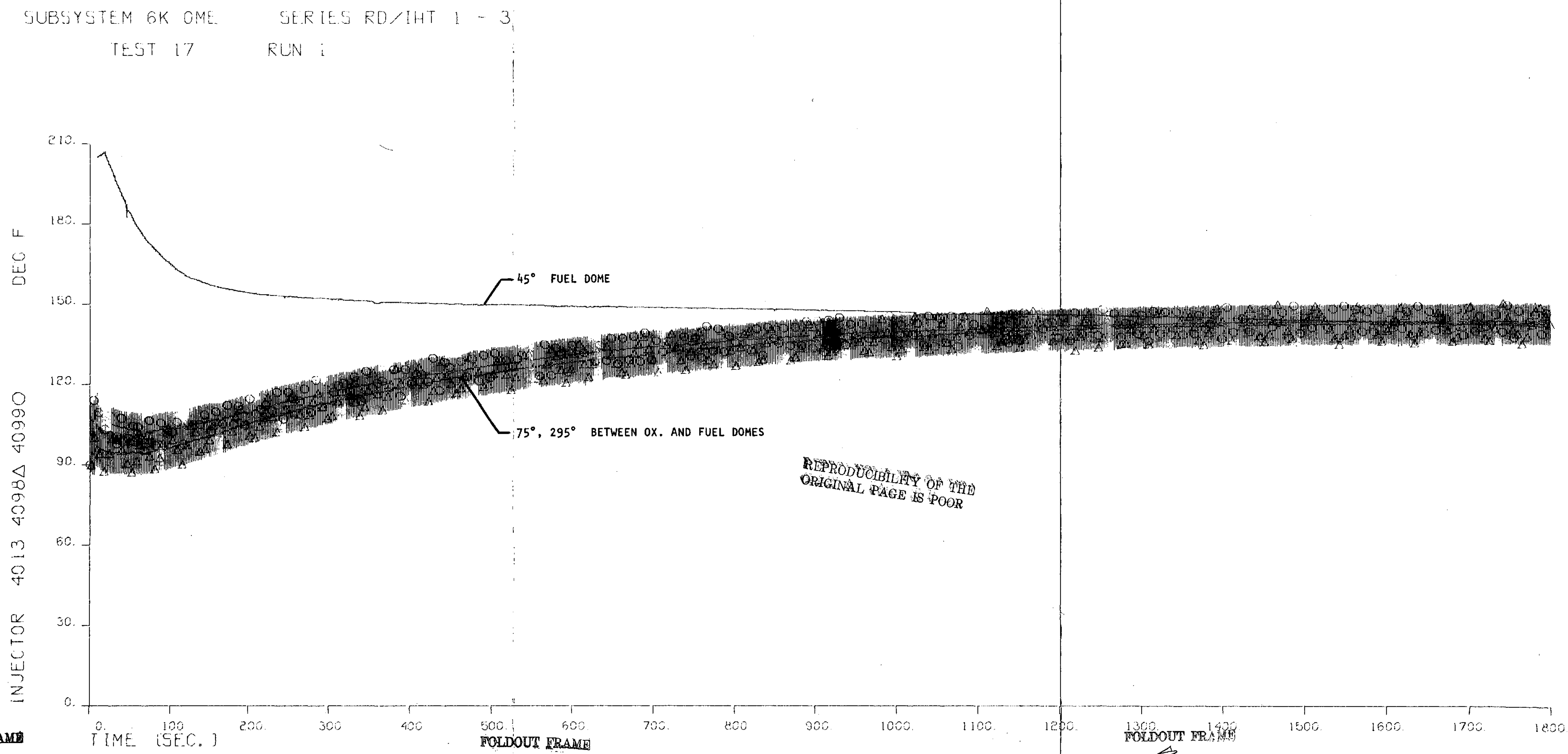


Figure 31. Nozzle and Manifold Temperatures After Short Firing

FIGURE 32. INJECTOR TEMPERATURE



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FOLDOUT FRAME 3

Stagnant fuel in the regenerative chamber after shutdown could have been heated to the decomposition point by the hot hardware. It is also possible that the hot regenerative chamber could have heated the incoming fuel for a restart to the decomposition point. However, this latter condition was deemed to be quite unlikely because of the results of the heated tube test program of Task IX wherein MMH was flowed through nickel and CRES tubes heated to 1600 F at nominal starting flow rates. No instance of rapid decomposition was noted in that phase of the heated tube test program. Potential low temperature problems could arise as the propellants evaporated in the engine after a firing, thereby, locally cooling to their freezing points. This would be a much more significant problem with the NTO because of its higher freezing point (12 F) compared to that of MMH (-62 F).

With simultaneous signals to the propellant valves, the oxidizer nominally enters the chamber approximately .15 to .20 seconds before the fuel because of the additional time required for the fuel to pass through the regenerative coolant jacket. This same resistance would result in the oxidizer draining out of the engine after a firing more rapidly than the fuel. The result is that a restart after a particular coast period could result in a fuel lead (or, at least, a shorter oxidizer lead) because of the residual MMH in the coolant jacket. The relationship between the propellant lead and the coast period would be strongly dependent upon the regenerative coolant jacket temperature, i.e., upon the previous firing duration. The effect of the propellant lead on thrust and pressure overshoots and acceleration spikes had not been determined for the OME.

The test program was therefore accomplished with engine and propellant temperatures and coast times selected to generate those conditions which would be most conducive to the aforementioned potential problems.

Potential Freezing and Overheating Conditions

The oxidizer cooling effects were alluded to in the discussion of the posttest shutdown transients. The most severe conditions tested to aggravate this potential problem were the tests conducted in Sequence 6. These tests were approximately of 0.2 seconds duration so that very little heat was added to the engine and the hardware was cooled by evaporation. The test conditions and effects on the oxidizer system and chamber pressure are tabulated for Sequence 6 tests in Table IX. As previously noted, the minimum oxidizer duct temperature occurs at approximately 10 seconds after shutdown. Therefore, those tests which have shorter coast durations than 10 seconds do not reach the minimum duct temperature. The data indicates that the duct temperature reaches the freezing point of NTO between some of the tests. However, no significant effect on oxidizer injection pressure or chamber pressure for the subsequent test was noted indicating that very little freezing of the NTO occurs during the coast period. Figure 33 is a plot of the oxidizer duct temperature transient after a 16-second coast period. The short period of oxidizer flow (approximately 0.2 seconds) is sufficient to warm the duct to 50 F.

From these data it appears that repetitive tests of even 0.2 seconds duration (the currently required minimum firing duration is 1.0 seconds) would not result in significant icing of the oxidizer system with ambient temperature propellants and >1 second between tests. The only tests of greater severity which could have been imposed would be to have conducted the cycling test with 40 F oxidizer at higher simulated altitudes. However, the data in Table VIII indicates that oxidizer temperature had little effect on oxidizer depletion time or minimum duct temperature as can be seen by comparing the values tabulated for Tests 5-15 and 6-4A. It therefore appears that repeated cycling even with 40 F oxidizer would not cause significant freezing of the NTO.

Freezing of MMH between firings does not appear to be a problem at all. The data in Table VIII indicate that for engine firings ranging from 1 second to maximum burn durations the MMH soakout temperature will be approximately ambient. The MMH soakout temperatures even after very short duration firings are very far removed from the freezing point.

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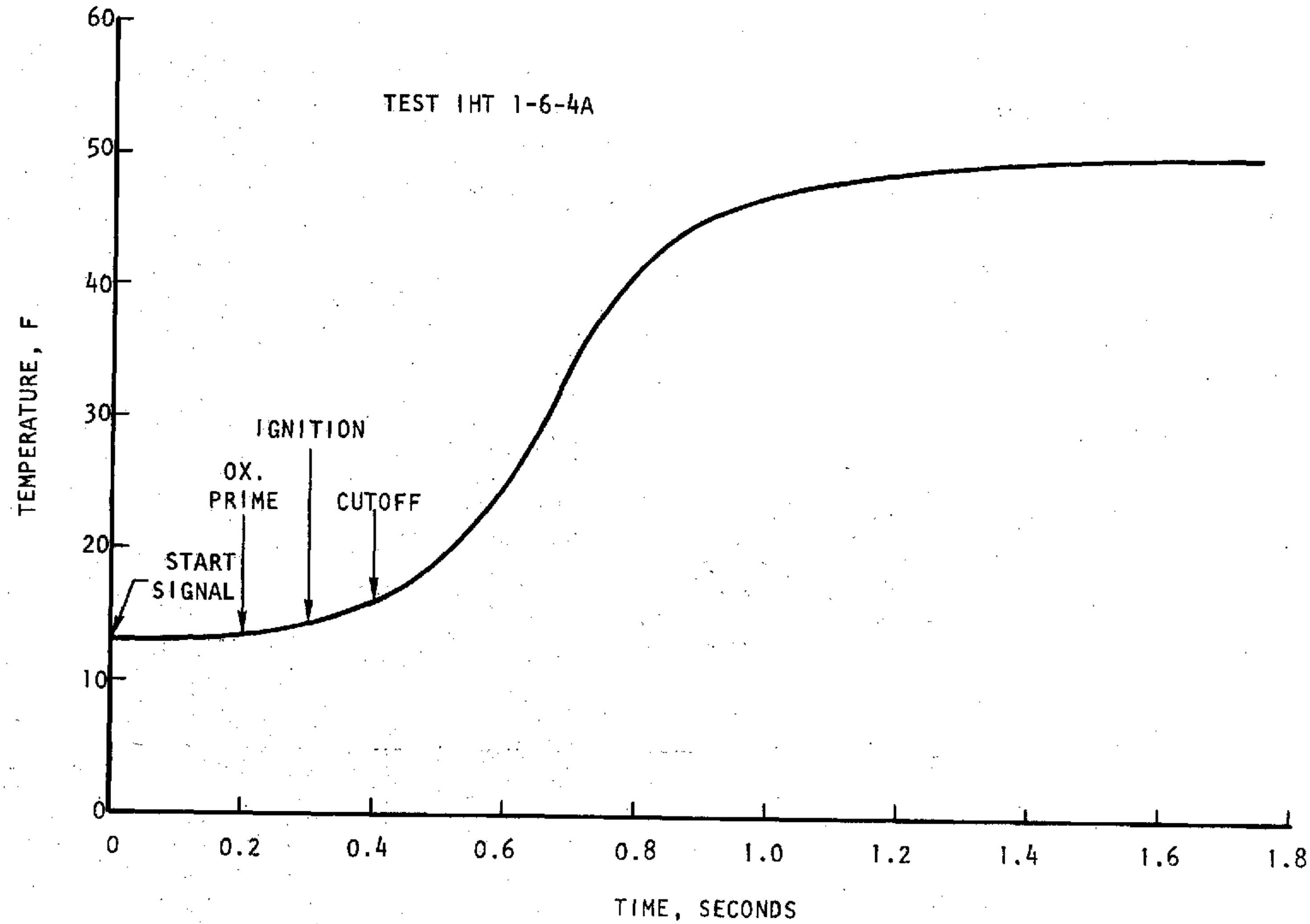

Figure 33. Oxidizer Duct Temperature Transient

It was demonstrated that the thrust chamber could start with a hot regeneratively cooled jacket on Sequence 3. Reference to Table X indicates that the engine was started with chamber wall temperatures approaching 400 F several times. This substantiates the results of the heated tube tests conducted under Task IX of this contract. Test 3-23 was fuel depletion test on which wall temperatures soaked out to values exceeding 500 F (the instrumentation limit) with no indication of explosive decomposition or fouling of the channels.

Restart Transients

Pretest values of engine and propellant temperatures and pressures are summarized in Table X for the restart test sequences. The consistent values of the propellant interface pressures indicate that the facility was always setup to deliver the same engine inlet conditions. The most significant deviations in the interface pressures occur during the very short coast times when the system was still experiencing some pressure transients from the previous shutdown. Tank pressures were more nearly constant even for these conditions. The restart tests may be grouped into hot engine restarts, where the engine is at equilibrium temperature at shutdown; warm engine restarts, where the engine has been fired to 1 second prior to shutdown; and near-ambient engine restarts where the engine has been fired only a few tenths of a second prior to shutdown.

Ideally, the test program would be conducted by bringing the engine and all components to a uniform temperature, firing the engine, coasting the prescribed time period, restarting the engine, and returning the complete engine to the required temperature prior to the next test. Returning the engine to a specified temperature involves considerable time. The purging and flushing operations conducted in Sequence 1 indicated that the purges were not very effective in bringing the hardware rapidly to a uniform temperature and

TABLE X PRETEST CONDITIONS

1 TEST NUMBER	2 PRETEST COAST TIME SEC	3 FUEL PRESS. INTER-FACE PSIA	4 OXID. PRESS. INTER-FACE PSIA	5 FUEL TEMP. INTER-FACE F	6 OXID. TEMP. INTER-FACE F	7 FUEL VALVE TEMP. F	8 OXID. VALVE TEMP. F	9 FUEL DUCT TEMP. F	10 OXID DUCT TEMP. F	11 INLET MANIFOLD SKIN TEMP F	12 REGEN. NOZZLE FLANGE TEMP. F	13 CHAMBER WALL TEMPERATURE, F X= -16"	14 X= -13"	15 X= -10"	16 X= -8"	17 X= -6"	18 X= -4"	19 X= -2"	20 X= -0.3"	21 X= 3"	22 INJECTOR TEMP F	23 FUEL INJ. PRESS. PSIA	24 OXID. INJ. PRESS. PSIA
SEQUENCE 3: HOT ENGINE WITH AMBIENT PROPELLANTS																							
1	*	222	218	60	62	57	55	55	46	53	53	52	52	52	52	51	53	53	52	53	52	0.8	-4
2	**	221	218	68	73	49	39	45	36	53	52	50	37	45	47	48	45	45	47	49	54	0.4	-4
3	**	221	218	70	76	48	32	46	32	51	53	54	42	47	49	51	47	47	49	54	55	0	-4
4	**	221	218	72	79	48	31	48	40	50	55	58	44	50	54	57	48	49	52	51	56	0.4	-4
5	180	220	218	76	82	59	62	63	52	102	139	167	176	122	97	82	94	93	103	107	105	0.4	-5
6	120	221	217	77	82			NO	DATA							NO	DATA					0.4	-5
7	*	220	215	68	67	55	60	53	60	57	61	61	61	61	61	61	61	61	60	61	57	0.8	-4
8	60	221	215	74	75	74	58	87	45	85	91	199	299	263	235	157	104	104	114	105	105	3	-5
9	30	220	212	75	74	76	57	90	45	85	90	229	325	249	246	194	123	122	135	122	116	4	-4
10	36	221	211	76	75	76	56	104	43	82	94	191	282	220	130	122	118	119	133	125	117	4	-4
11	21	220	214	76	76	77	55	91	44	80	99	222	319	265	269	220	141	137	152	137	122	5	-4
11A	54	220	214	79	80	78	53	96	46	116	145	152	131	114	110	110	100	107	121	110	113	1.5	-4
12	10	220	213	75	82	78	60	100	48	111	139	212	324	285	265	205	173	170	175	168	121	8	-3
13	10	219	212	76	76	78	61	106	42	112	140	240	339	296	257	202	175	172	181	172	126	9	-3
14	4.9	215	217	75	86		NO	DATA			131	225	331	299	NO	DATA	231		NO	DATA		16	4
15	2.0	223	214	74	75	80	74	105	77	97	127	228	273	271	266	271	243	233	218	191	137	35	1
16	1.1	226	214	74	74	80	76	103	76	90	119	224	243	261	260	267	229	214	214	172	130	38	2
17	1.2	221	217	74	74	80	78	102	78	85	113	221	239	257	259	269	225	209	217	171	132	36	2
18	*	221	215	53	63	58	60	62	58	60	60	60	60	60	60	60	60	60	60	60	60	0.1	-4
18A	*	221	215	54	66	41	57	50	51	53	48	39	33	30	30	30	30	30	30	32	45	0.1	-4
19	*	220	215	72	70	59	67	57	65	70	68	69	71	64	72	73	73	72	72	72	69	1	-5
20	25	221	218	74	77	74	59	84	47	76	82	266	353	214	197	128	126	125	123	117	114	4	-5
21	24	220	216	74	77	74	57	89	44	80	86	250	374	297	261	180	128	126	125	120	120	4	-5
22	18	220	214	74	76	75	56	93	44	79	86	227	326	334	318	322	248	141	136	131	126	5	-5
23	13	220	214	75	77	76	54	91	41	82	92	239	367	314	290	213	148	141	138	134	127	6	-5
24	*	220	216	56	63	59	61	62	47	55	59	116	61	53	62	62	62	61	61	61	61	0.8	-5
25	16	220	214	71	73	74	57	89	43	72	80	244	385	296	265	237	159	140	138	133	111	6	-5
26	16	220	213	71	74	74	51	91	39	77	82	252	385	301	263	221	143	140	136	132	115	6	-5
27	11	219	212	72	73	74	57	97	83	74	81	234	397	317	305	306	238	158	150	146	119	9	-3
28	11	220	211	72	78	75	58	97	49	76	83	248	381	294	266	206	167	162	159	153	123	9	-3
29	29	220	214	75	76	75	49	94	41	117	140	195	198	140	150	140	136	132	139	143	120	5	-5

*FIRST TEST OF VACUUM PERIOD
**VALVE SEQUENCING SERIES

FOLDOUT FRAME 1 FOLDOUT FRAME 2 FOLDOUT FRAME 3

TABLE X PRETEST CONDITIONS (Continued)

	1 TEST NUMBER	2 PRETEST COAST TIME SEC	3 FUEL PRESS. INTER-FACE PSIA	4 OXID. PRESS. INTER-FACE PSIA	5 FUEL TEMP. INTER-FACE F	6 OXID. TEMP. INTER-FACE F	7 FUEL VALVE TEMP. F	8 OXID. VALVE TEMP. F	9 FUEL DUCT TEMP. F	10 OXID DUCT TEMP. F	11 INLET MANIFOLD SKIN TEMP F	12 REGEN. NOZZLE FLANGE TEMP. F	13 CHAMBER WALL TEMPERATURE, F X= -16″	14 X= -13″	15 X= -10″	16 X= -8″	17 X= -6″	18 X= -4″	19 X= -2″	20 X= -0.3″	21 X= 3″	22 INJECTOR TEMP F	23 FUEL INJ. PRESS. PSIA	24 OXID. INJ. PRESS. PSIA
1	30	5.4	219	212	74	74	78	67	107	70	101	125	231	322	253	261	251	240	226	213	205	125	22	4
2	31	5.0	220	211	74	74	79	74	112	75	98	122	238	328	268	274	256	246	234	220	208	130	24	6
3	32	2.0	227	216	74	74	81	78	112	78	98	123	243	285	279	299	277	266	256	246	195	134	43	13
4	33	2.0	223	210	74	74	81	81	112	78	96	118	244	287	281	301	277	266	256	243	221	137	41	12
5	SEQUENCE 4:	WARM ENGINE WITH AMBIENT PROPELLANTS																						
6	1	*	221	215	75	73	75	71	65	66	72	70	80	79	67	77	77	76	75	73	72	82	1	-5
7	2	180	220	214	75	75	69	58	67	50	80	71	85	62	54	62	63	61	58	59	60	87	1	-5
8	3	121	220	214	75	76	71	51	76	45	86	76	87	70	60	68	72	72	72	72	72	91	2	-5
9	4	61	220	215	77	76	74	46	79	42	87	72	122	92	77	77	85	83	81	86	90	95	2	-5
10	5	31	220	214	77	77	76	43	81	57	74	75	186	181	101	97	109	112	108	107	103	101	3	-5
11	6	16	220	214	76	77	77	41	84	43	79	80	216	262	183	134	135	137	135	131	127	107	5	-5
12	7	9.0	220	213	76	78	77	48	87	52	82	84	225	256	182	162	178	174	169	165	161	113	11	-2
13	8	4.6	219	212	75	77	78	55	91	68	90	85	225	267	233	227	244	231	218	206	187	116	23	3
14	9	0.3	222	216	75	79	78	61	82	74	91	86	221	216	214	194	194	179	156	159	135	118	65	28
15	10	0.7	222	213	75	77	79	67	91	74	90	83	227	233	237	219	221	209	175	181	141	120	54	21
16	11	14	218	212	78	78	78	51	91	44	83	85	261	366	289	216	166	135	133	130	126	123	5	-5
17	12	30	220	213	79	78	78	45	86	41	83	84	259	293	134	165	102	117	115	114	112	119	4	-5
18	13	45	220	213	80	79	80	43	90	39	97	87	216	151	102	96	111	113	111	110	111	113	2	-5
19	SEQUENCE 5:	HOT ENGINE WITH COLD PROPELLANTS																						
20	1	*	221	215	46	46	49	47	51	50	48	51	54	53	52	53	53	52	52	52	52	55	0.8	-5
21	2	181	221	215	44	46	45	32	63	31	67	107	215	241	125	67	77	74	73	74	79	96	0.4	-5
22	3	121	221	216	45	52	45	31	76	31	74	111	229	207	152	79	94	93	93	94	94	99	2	-5
23	4	61	221	216	44	46	43	32	64	40	66	78	249	314	253	162	96	91	89	89	89	101	1.5	-5
24	5	31	220	214	43	45	42	32	56	33	64	81	261	332	266	203	194	115	93	98	94	105	2	-5
25	6	16	220	214	41	45	42	34	64	30	66	81	251	342	279	227	216	161	128	125	122	109	4	-3
26	7	10	219	213	39	44	42	38	64	38	68	80	235	320	268	192	191	180	170	164	158	111	9.9	-1.8
27	8	4.4	220	212	38	42	43	42	69	48	63	87	217	260	247	237	232	218	204	194	170	112	21	5
28	9	2.0	218	211	38	41	45	46	66	40	61	88	213	227	238	243	232	213	198	198	155	110	31	18
29	10	1.6	219	212	38	43	44	45	58	42	53	82	199	198	217	212	194	174	150	160	125	114	43	16
30	11	20	219	212	44	45	42	36	67	31	77	84	285	352	257	167	134	126	125	124	121	113	2	-5
31	12	46	221	215	49	49	44	31	85	32	79	90	268	315	229	180	115	98	97	98	95	104	2	-5
32	13	91	220	215	53	50	47	31	93	31	93	119	241	248	193	97	102	101	101	101	102	101	2	-5
33	14	31	219	214	47	47	42	33	60	33	77	90	260	354	290	245	186	105	101	101	98	106	2	-5
34	15	*	220	214	44	45	42	48		54	53	53	60	59	53	57	58	57	56	56	55	62	1	-5
35		*First Test of VACUUM PERIOD																						

FOLDOUT FRAME 1

FOLDOUT FRAME 2

FOLDOUT FRAME 3

TABLE X PRETEST CONDITIONS (Continued)

1 TEST NUMBER	2 PRETEST COAST TIME SEC	3 FUEL PRESS. INTER-FACE PSIA	4 OXID. PRESS. INTER-FACE PSIA	5 FUEL TEMP. INTER-FACE F	6 OXID. TEMP. INTER-FACE F	7 FUEL VALVE TEMP. F	8 OXID. VALVE TEMP. F	9 FUEL DUCT TEMP. F	10 OXID DUCT TEMP. F	11 INLET MANIFOLD SKIN TEMP F	12 REGEN. NOZZLE FLANGE TEMP F	13 CHAMBER WALL TEMPERATURE, F X= -16"	14 X= -13"	15 X= -10"	16 X= -8"	17 X= -6"	18 X= -4"	19 X= -2"	20 X= -0.3"	21 X= 3"	22 INJECTOR TEMP F	23 FUEL INJ. PRESS. PSIA	24 OXID. INJ. PRESS. PSIA
SEQUENCE 6: AMBIENT ENGINE WITH AMBIENT PROPELLANTS																							
1	*	222	215	57	58	53	52	52	48	48	48	48	48	49	50	49	50	49	49	48	47	1	-5
2	181	221	215	64	65	53	41	53	32	53	50	30	26	31	35	32	32	26	24	38	46	1	-5
3	120	221	214	66		55	37	56	29	55	46	32	31	31	34	30	30	27	28	39	47	1	-5
3A	56	220	215	67		57	33	57	24	56	54	38	29	29	37	33	28	19	21	43	47	0.4	-5
4A	16	221	213	69		61	31	68	23	46	45	65	48	54	59	55	53	52	60	70	51	1.5	-5
5	61	221	215	69		63	28	66	24	59	50	45	38	34	41	37	35	33	42	60	50	0.4	-5
6	31	221	215	69		64	27	67	23	51	49	52	39	30	36	33	32	26	24	47	52	1	-5
7	6.3	220	214	70		66	34	75	41	52	46	93	99	95	109	106	101	99	93	93	53	2	-2
7A	5.1	219	213	70		68	39	78	46	48	46	123	134	130	148	155	141	133	127	102	56	6	-1
8	2.5	219	213	70		69	41	83	59	49	49	143	164	160	189	194	177	172	164	120	60	1	3
9	*	221	215	71		41	48	24	40	71	71	66	64	61	61	60	59	58	57	57	66	0.8	-5
10	5.2	220	214	70		47	51	64	49	72	71	103	117	113	121	122	116	111	101	84	66	3	-1
11	45	221	215	71		55	41	68	30	67	54	59	36	41	46	50	51	49	51	66	70	0.8	-5
12	2.7	225	216	71		57	46	76	54	69	56	94	126	134	144	145	145	134	132	89	70	4	2
12A	3.1	228	215	71		61	50	80	58	68	57	134	153	147	172	178	164	159	152	120	72	8	1
12B	7.6	219	212	71		64	49	80	46	69	59	143	151	151	152	147	138	129	125	128	79	5	-3
13	46	221	215	73		66	37	75	32	74	60	74	61	64	64	54	47	52	55	67	78	0.4	-5

*FIRST TEST OF VACUUM PERIOD

FOLDOUT FRAME 1
FOLDOUT FRAME 2
FOLDOUT FRAME 3

that the flushes could be a source of contamination. It was decided, therefore, not to condition the engine between tests.

The propellant interface and valve temperatures may be expected to be reasonably independent of coast period and therefore would be nominally expected to be the same for each test. The hot engine restarts were conducted during Test Sequences 3 and 5, the former being with ambient temperature propellants and the latter being with cold propellants. For Sequence 3, these temperatures were always within the nominal spec limit and were, generally, within the range of 50 to 80 F. For Sequence 5, the temperature range was narrower, generally between 30 and 50 F. The remaining temperatures reflect, for the most part, the true effects of thermal soakout with some lesser effect of cumulative testing.

Relatively high values of propellant injection pressures indicate the presence of propellants in the engine prior to test. The values presented are measured by the high range injection pressure instrumentation and are subject to some zero shift. Therefore, the values should be compared within a given vacuum period. For example, Tests 3-7 through 3-17 were conducted in the same vacuum period. The oxidizer injection pressure indicates a bias of approximately minus 4 psi which is indicated for all tests with coast periods in excess of 10 seconds. For coast periods of 5 seconds or less, the pretest oxidizer injector pressure becomes positive indicating the presence of oxidizer in the system. This is in agreement with the previously noted oxidizer depletion time of approximately 10 seconds. On the fuel side for long soak periods, the pretest fuel injection pressure indicates a bias of 1 psi. As the coast period decreased below 60 seconds, the pretest value of the fuel injection pressure increases up to a value of almost 40 psia for the one-second coast.

Thrust overshoot data and the data from the four accelerometers are shown in Appendix A. Accelerometer 4006D was a ±2000 g accelerometer and was used only for Test 3-18A where an acceleration of approximately 1500 g's was indicated. Accelerometer 4097D, a ±1000 g accelerometer located on the dome, was used only for comparison with the data from accelerometer 4007D, a ±200 g accelerometer also located on the dome, when the latter indicated g-loads in excess of 50 g's. Accelerometer 4008D was a ±200 g accelerometer located on the injector flange. This accelerometer gave very erratic data and was not used for the correlations.

An attempt to correlate the thrust overshoots and accelerations at start with the pretest coast time was not successful for Sequence 3. The reason for this is evident in Fig. 34 where the injector prime times are plotted against pretest coast time. The fuel side correlates quite well but considerable scatter exists on the oxidizer side. The oxidizer priming data falls into two sets corresponding to the original oxidizer valve which became erratic and was replaced and the data corresponding to the replacement valve. Each propellant valve is quad redundant, i.e., there are two parallel flow paths each of which contains two valves in series. The positions of only the two valves in one parallel path were recorded for each propellant. Thus, the recorded valve actuation times define only the latest time at which flow could start. These values are tabulated in Appendix A.

An approach to deduce the correlation of starting characteristics with coast time was as follows. The acceleration and thrust overshoot were plotted against the injector prime oxidizer lead in Fig. 35. Very good correlation of acceleration and a fair correlation of thrust overshoot resulted. The difference between the priming times for the oxidizer side for the new valve and for the fuel side were determined from the data of Fig. 34 for coast times from 0 to 40 seconds, the range over which data was taken with the second oxidizer valve. This oxidizer lead time versus coast time relationship together with the acceleration and overshoot verus oxidizer lead time relationships were used to relate the acceleration and thrust overshoot to coast time for coast times ranging from 0 to 40 seconds. For the test preceded by a 180-second coast time, the oxidizer injection pressure transient was completed before the fuel prime even with

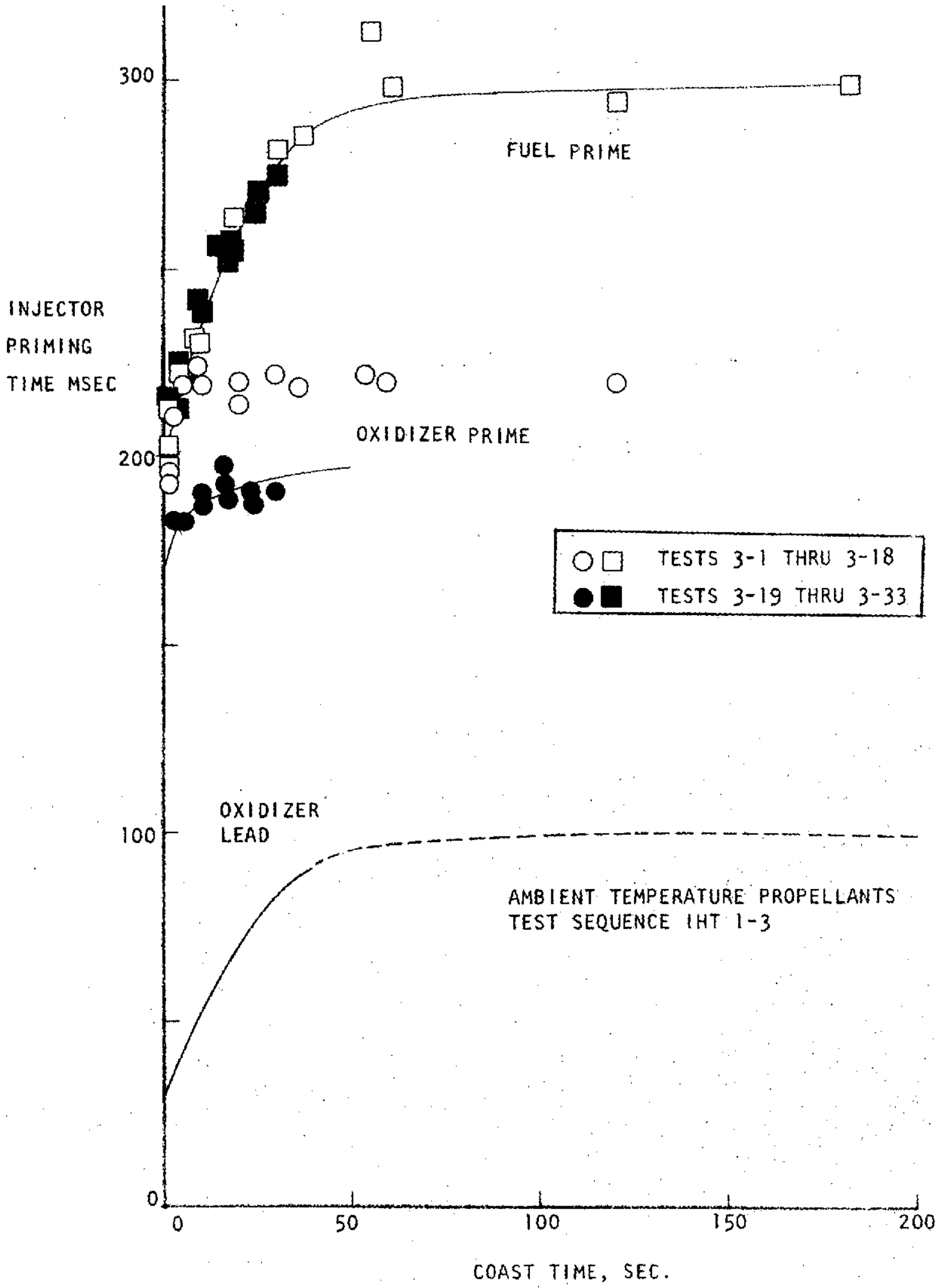

FIGURE 34. INJECTOR PRIMING TIMES FOR HOT ENGINE RESTARTS

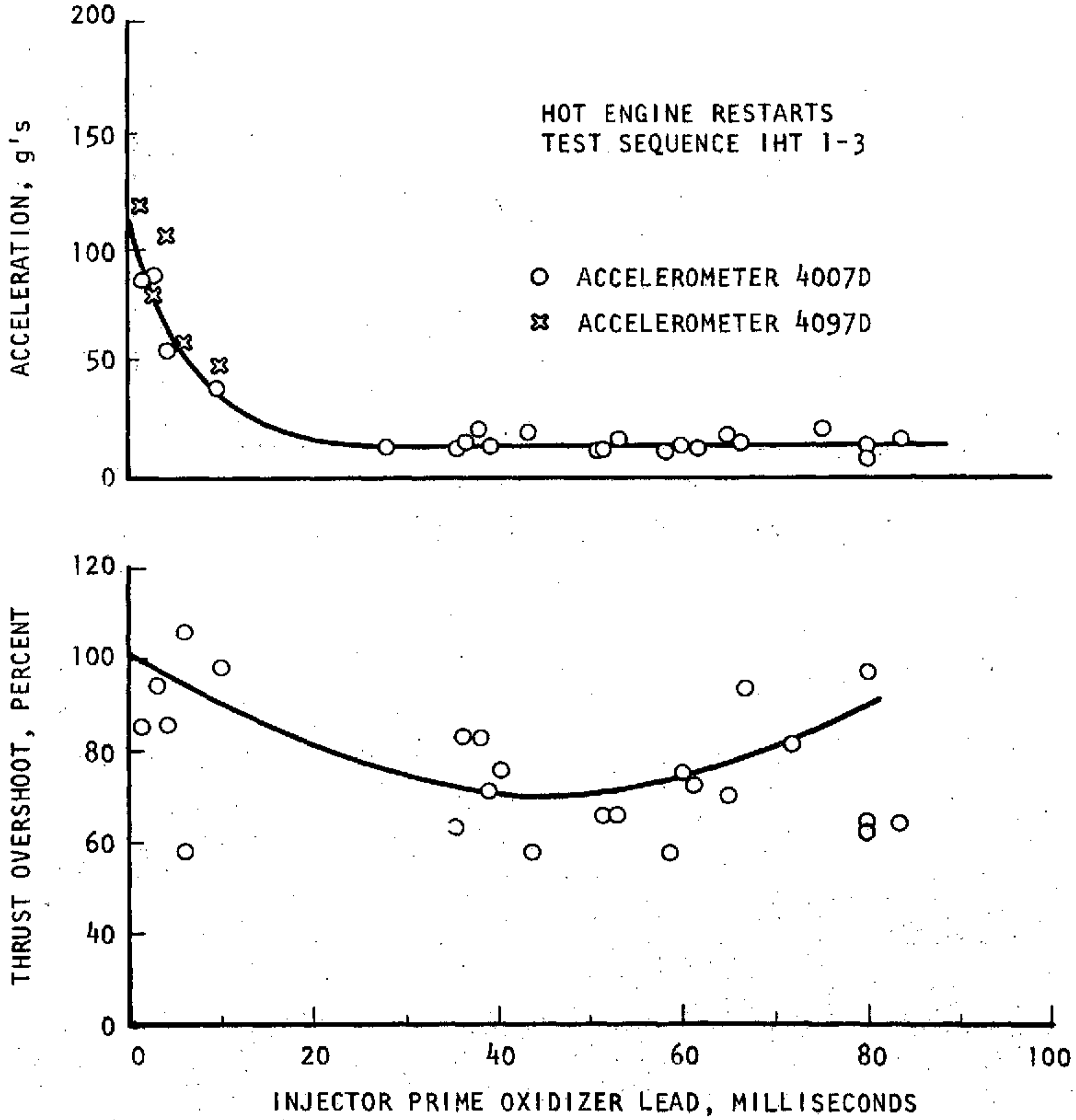

Figure 35. Accelerations and Thrust Overshoots Vs Oxidizer Lead

the slow acting oxidizer valve. This data point is therefore felt to be valid and was used with the derived correlations to produce the acceleration and thrust overshoot versus coast time curves shown in Fig. 36.

It should be noted that the derived injector oxidizer lead time versus coast time curve indicates that no matter what the coast time, the oxidizer lead would be 25 milliseconds or greater. This is the result of the rapid priming of the oxidizer system relative to the priming of the fuel system. Even for the case of a 10-second coast period where the propellant depletion data indicated that no oxidizer remained in the system while significant amounts of fuel did exist, the oxidizer system refilled completely in a shorter time than that required to fill the fuel side. Thus, the higher accelerations related to the short oxidizer leads experienced during Test Sequence 3 would not exist in a system wherein the valves operated simultaneously. Accelerations in the order of 15 g's would result for a all-coast times.

Thrust overshoots shown in Fig. 36 vary from 70 percent for short-coast time to 130 percent for long-coast times. These values can be reduced possibly by reducing the valve opening rates. On the previous (Phase I) test program with the same thrust chamber assembly, using facility valves, thrust overshoots were in the order of 70 percent for a 200 msec oxidizer injection pressure lead.

The injector priming characteristics for hot engine test with cold propellants are shown in Fig. 37. Oxidizer priming characteristics are similar to the characteristics with ambient temperature propellants. Fuel injector priming characteristics are also similar except that for long coast times the system primes more rapidly with cold fuel as is to be expected because of the greater quantity of residual fuel with cold propellants. Since the injector priming times correlated well with coast times, the accelerations and thrust overshoots were correlated directly with the coast times and presented in Fig. 38. Accelerations were similar to those experienced with ambient propellants except for slightly higher accelerations for very short coast times.

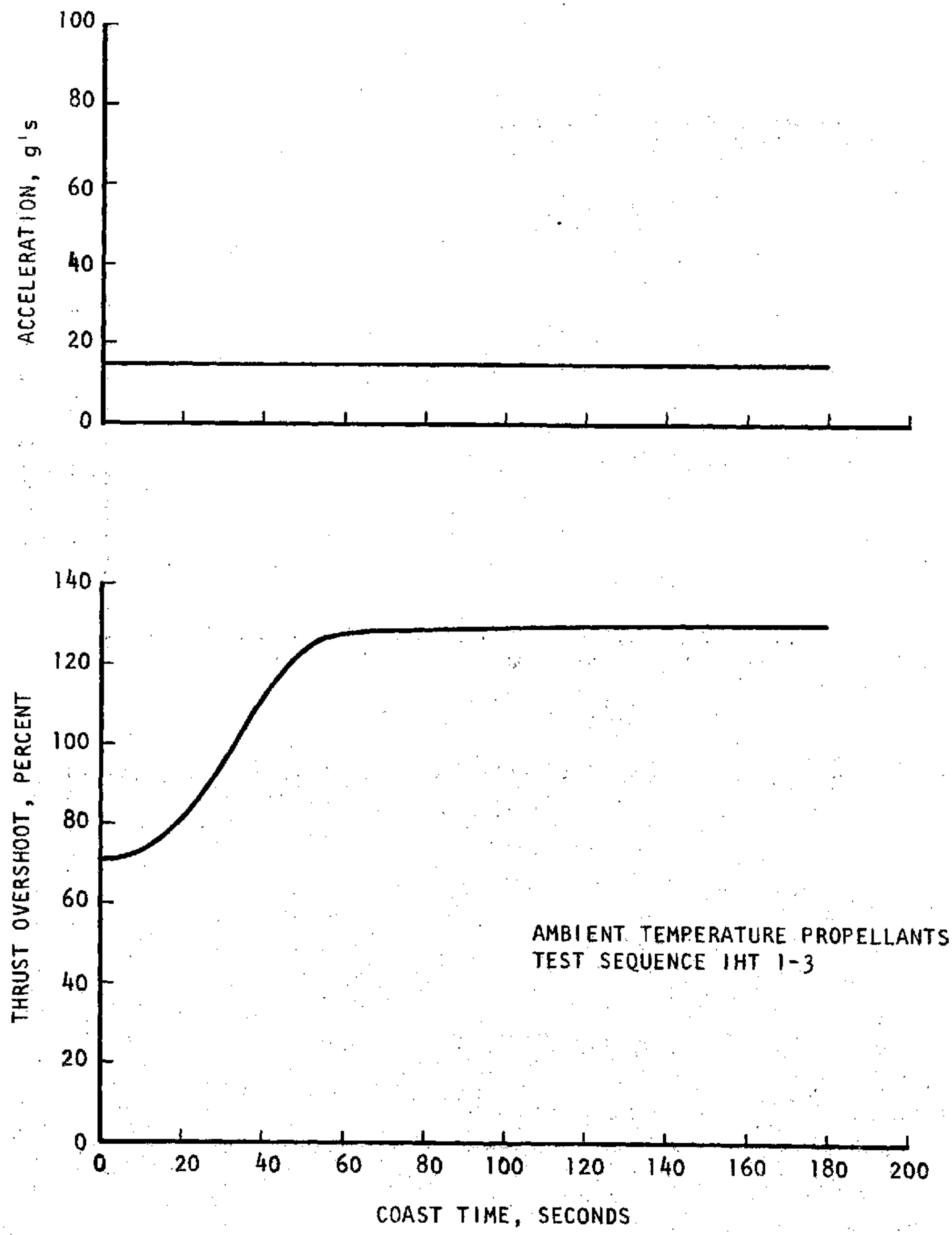

Figure 36. Accelerations and Thrust Overshoots For Hot Engine Restarts

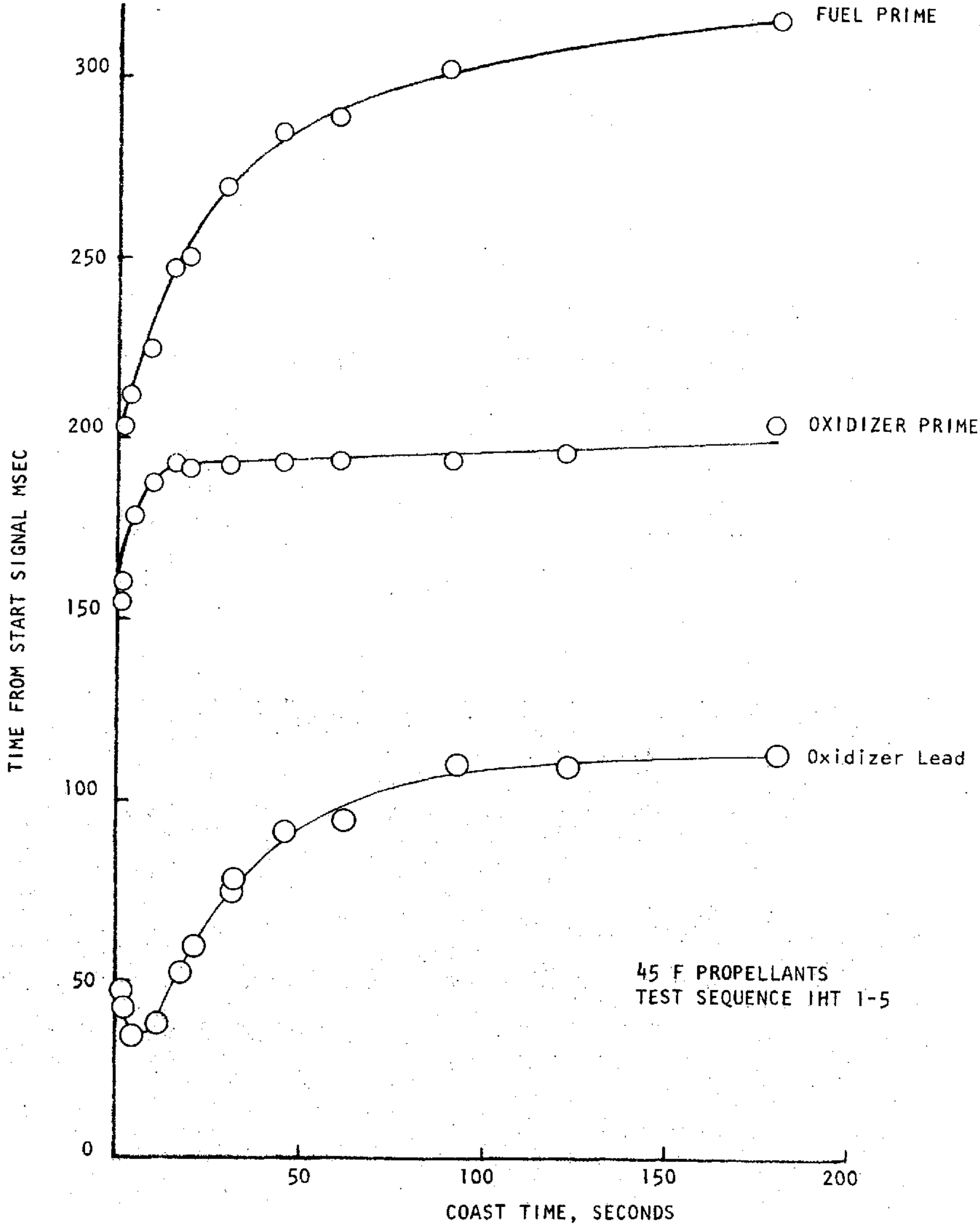

FIGURE 37. Injector Priming Times - Hot Engine With Cold Propellants

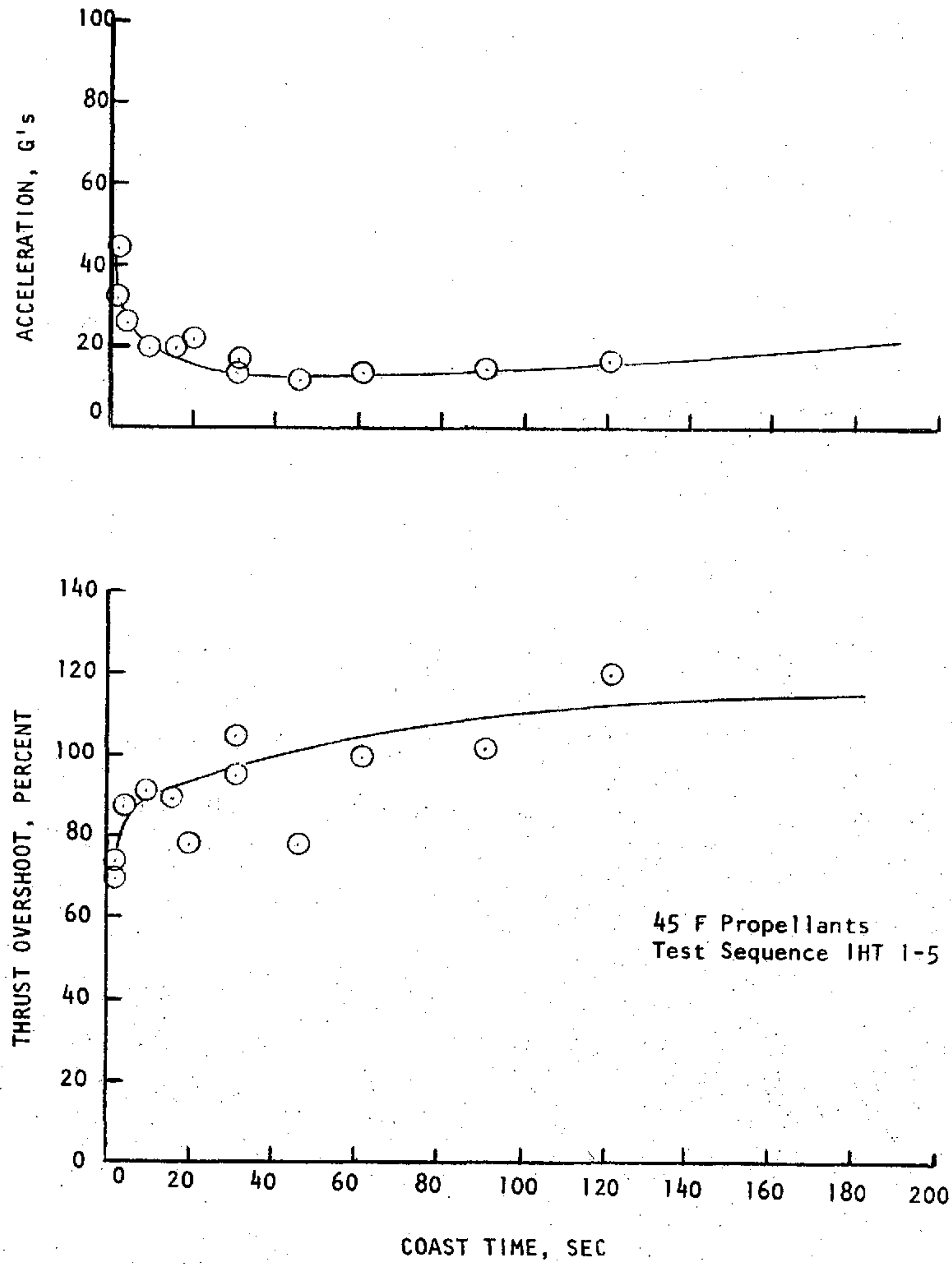

Figure 38. Acceleration And Thrust Overshoot For Hot-Engine Restarts

Data for the test preceded by a 180-second coast period was not valid because of an unusually low oxidizer flow rate and injection pressure at the time of fuel prime because of a momentary decay of oxidizer tank pressure. The thrust overshoot versus coast time curves for the cold propellants is within 20 percent of the curve for ambient temperature propellants for all coast times. Considering the data scatter and the assumptions involved generating the curve for the ambient propellants, it may be said that thrust overshoot is not significantly affected by propellant temperature.

Warm Engine Restarts

Injector priming times and the resultant oxidizer lead are plotted against coast time in Fig. 39 for engine firing times of one second. The curves are fairly similar to those of the data for the hot engine fired with cold propellants (Fig. 37). Oxidizer leads were always greater than 30 msec.

Accelerations and thrust overshoots at start are plotted in Fig. 40. The curves are similar to the curves obtained with the hot engine except that the accelerations become even lower for very short coast times.

Ambient Engine Restarts

Injector priming times are plotted versus coast times in Fig. 41 for the tests in which the engine was fired for approximately 0.2 seconds duration. The fuel priming times are slightly lower than on any other sequence as would be expected because of the greater fuel retention by the colder hardware. Oxidizer priming times are about the same as those for the warm engine restarts at the longer coast periods but are peculiar in this case in that the priming times do not fall off very rapidly for the very short coast times. Oxidizer leads again exceeded 30 msec for all conditions tested.

The accelerations and thrust overshoots are shown in Fig. 42 for the ambient engine restarts. There is considerable scatter in the overshoot data for

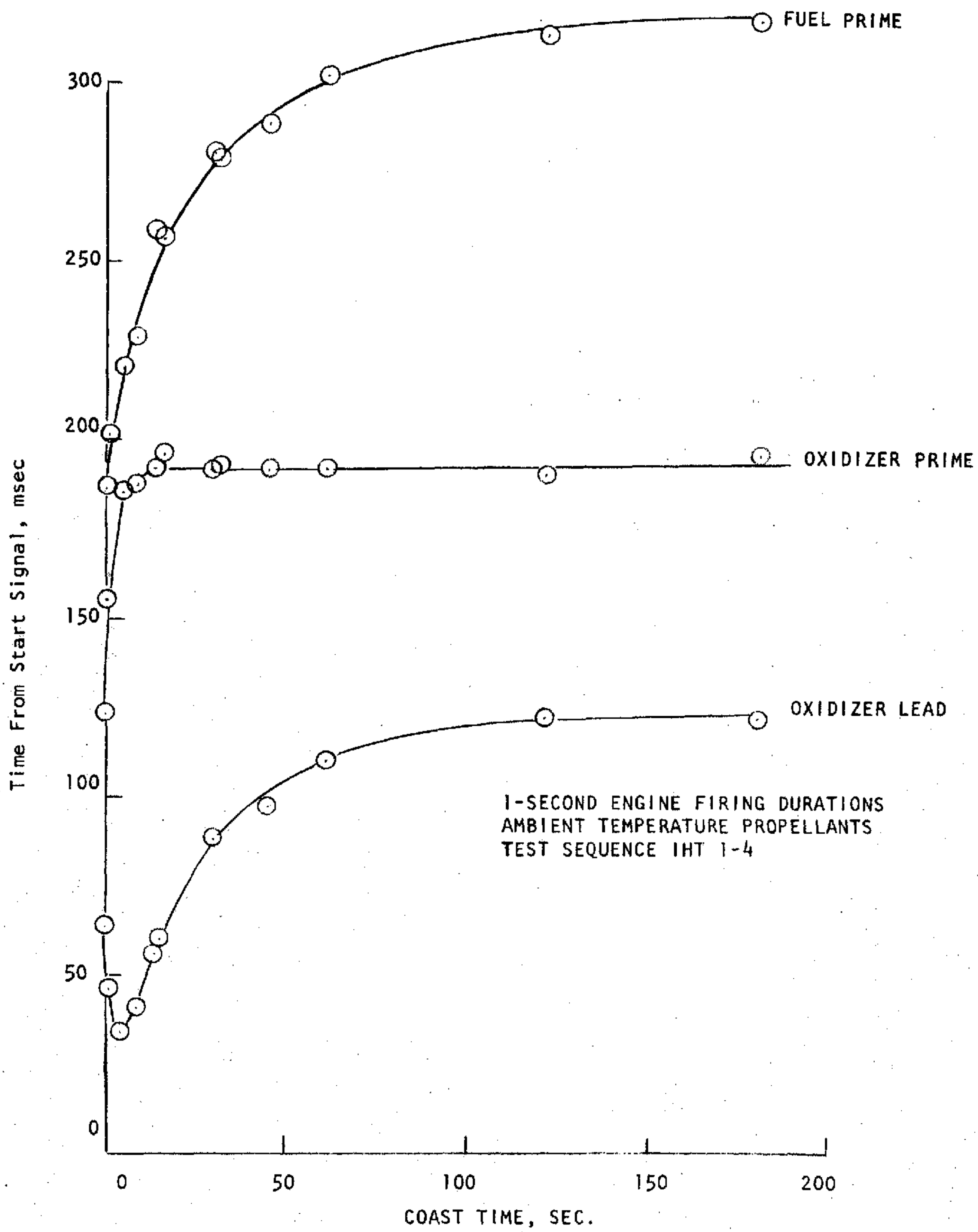

Figure 39. Injector Priming Times For Warm Engine Restarts

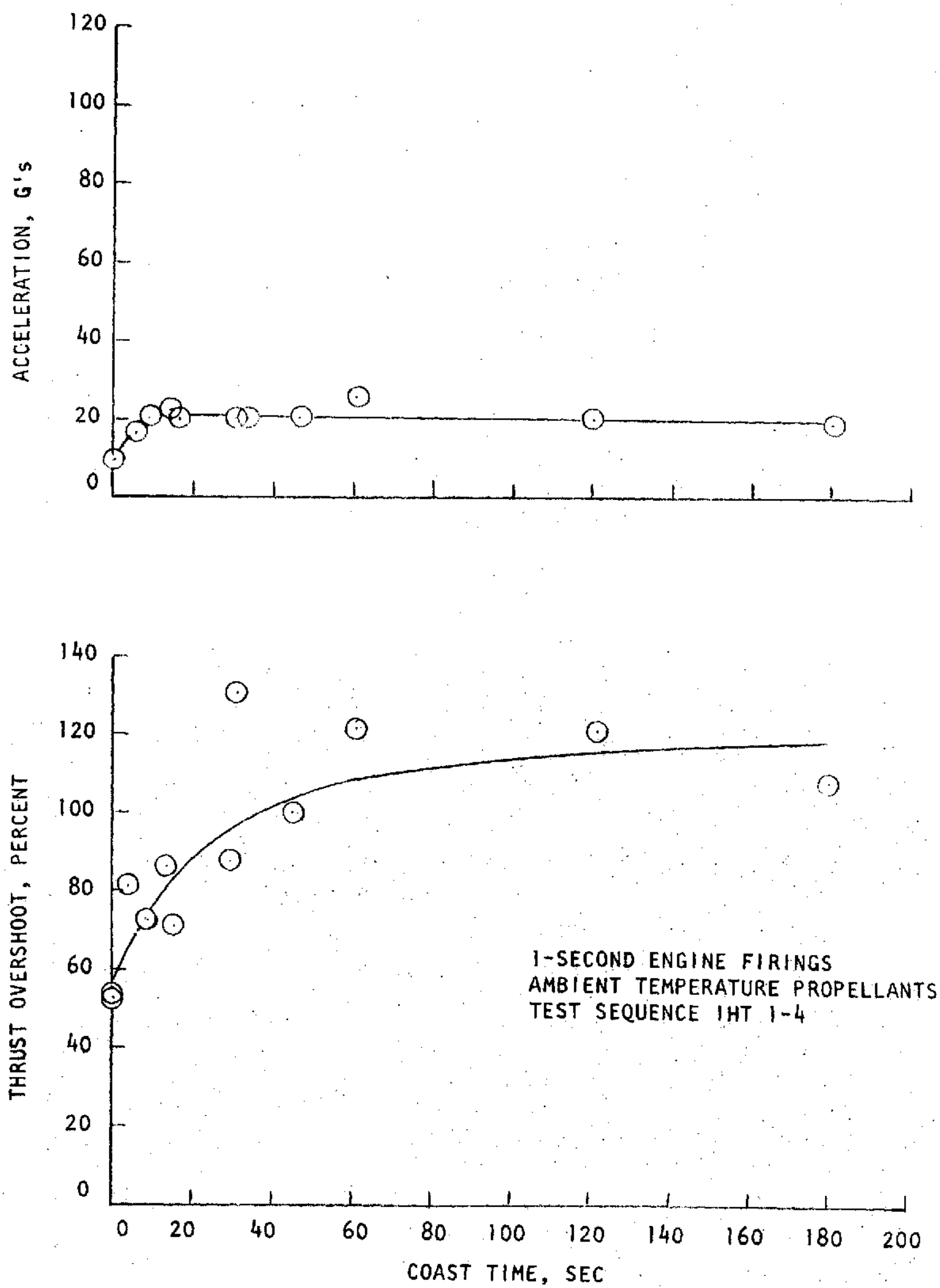

Figure 40. Acceleration and Thrust Overshoot Data for Warm Engine Restarts

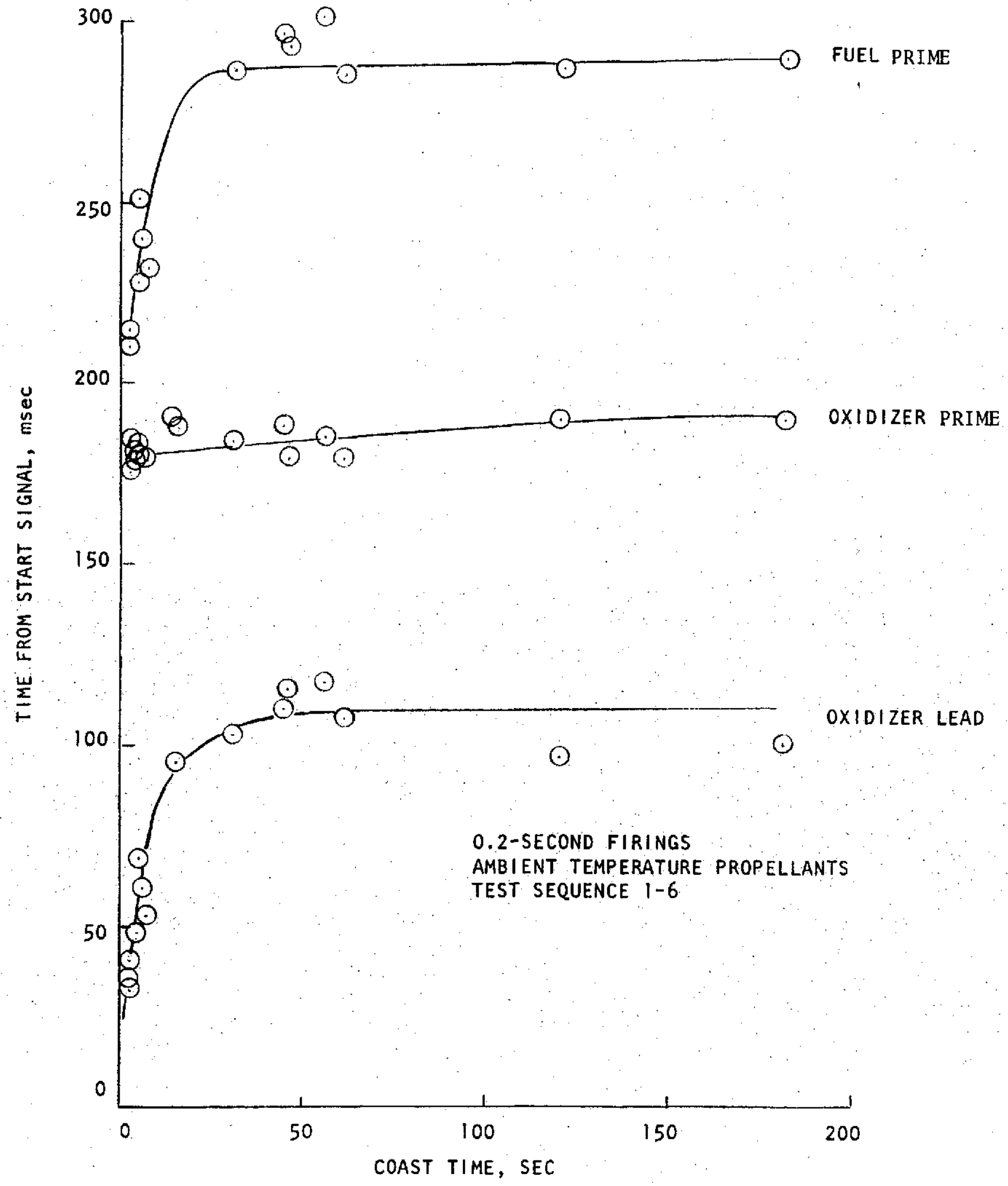

Figure 41. Injector Priming Times For Ambient Engine Restarts

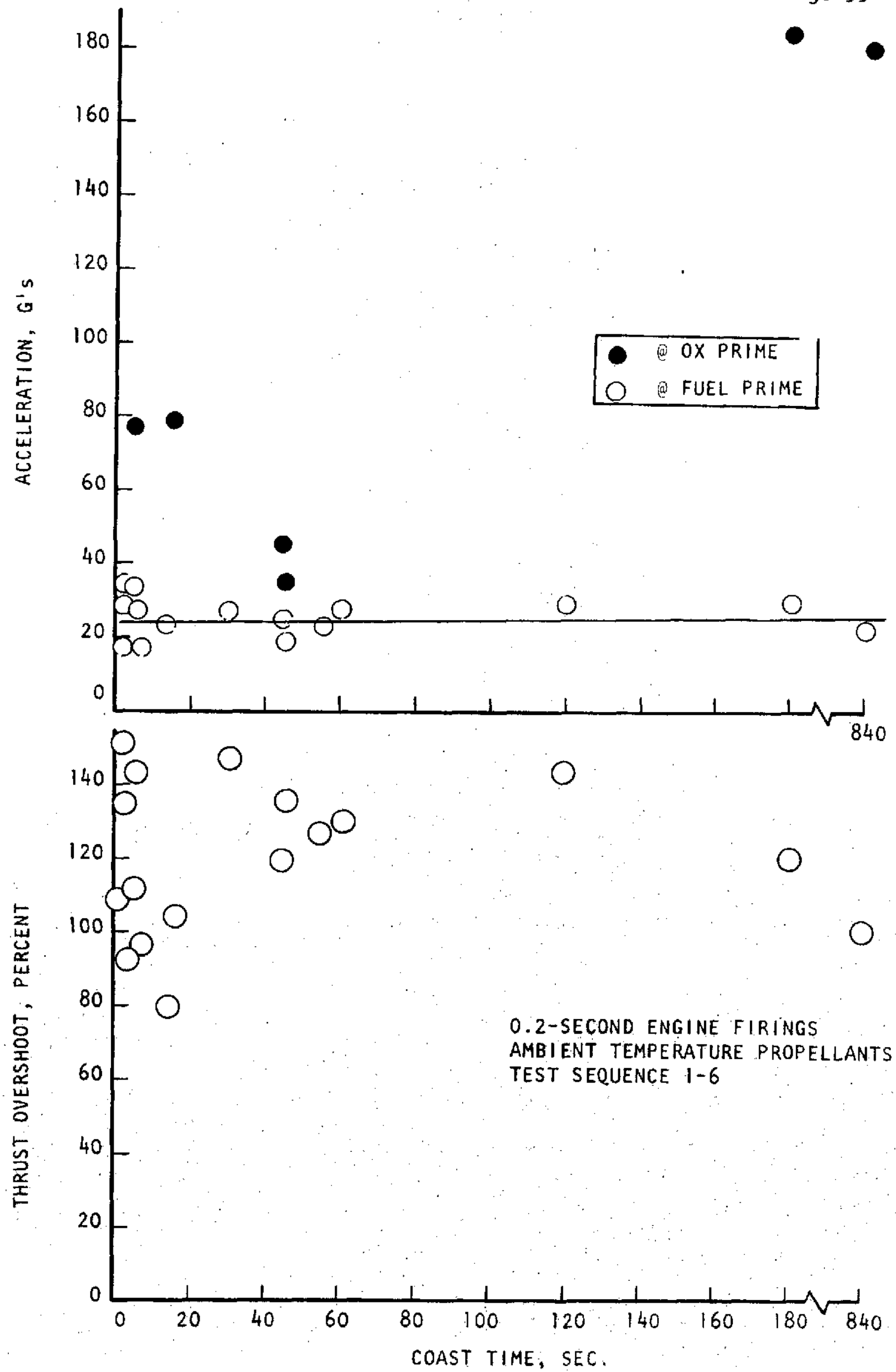

Figure 42. Accelerations And Thrust Overshoots For Ambient Engine Restarts

the short coast times. This may be because of the small quantities of propellant used during the firings (approximately one quart of each propellant is consumed during the firing). The maximum thrust overshoots for the ambient engine restarts do not greatly exceed the maximum values recorded for the hot engine restarts. The accelerations at ignition were slightly greater than those measured on the hot engine restart tests. Significantly higher accelerations (which were also harmless to the engine) were recorded at oxidizer prime on some tests. These accelerations may be the result of residual fuel in the cool engine hardware.

THROTTLING TESTS

Test Sequence 7 included a series of tests the purpose of which was to determine the level to which chamber pressure could be reduced before chugging would occur and the effect of mixture ratio on this minimum pressure level. Discrete 5-second tests were conducted (as opposed to continuous blowdown tests) to minimize facility hyperflow time. Cold fuel (40 F) was used to enhance the regenerative coolant safety factor at low chamber pressures. Propellants were not saturated with helium for Sequences 7 and 8.

These tests (7-7 through 7-14) were conducted with unsaturated propellant using the facility feed-system configuration which simulates the OMS. Tests 7-2 and 7-4 were moderately low-pressure tests conducted with the external facility propellant tanks. Based on the stiffness factor, $\sqrt{\Delta P/\dot{w}}$ (where ΔP is the difference between propellant tank and chamber pressures, and $\dot{w}$ is the propellant flowrate) the feed system using external oxidizer tanks is 3% stiffer than the OMS simulated system and the feed system using external fuel tanks is 8% stiffer than the corresponding OMS system.

The range of chamber pressures, propellant flow rates, and mixture ratios tested is shown in Table XI. Measured and predicted injector pressure drops are tabulated. The measured pressure drops are the values recorded when no

TABLE XI

INTEGRATED CHAMBER LOW-PRESSURE TESTS

	7-3	7-4	7-7	7-8	7-9	7-10	7-10A	7-11	7-12	7-14
CHAMBER PR., PSIA	99	100	126	84	76	68	73	66	68	126
MIXTURE RATIO, O/F	1.67	1.46	1.68	1.7	1.8	1.8	1.5	1.6	1.9	1.66
FLOWRATE, LB/SEC										
OX	9.79	9.32	12.4	8.29	7.41	6.34	6.78	6.02	6.57	12.2
FUEL	5.86	6.41	7.39	4.72	4.10	3.48	4.53	3.79	3.40	7.39
MEASURED INJ. ΔP,*										
PSI OX	31	26	56	19	11	-	-	-	-	51
FUEL	41	48	57	18	10	-	-	-	-	52
PREDICTED INJ. ΔP,										
PSI OX	36	32	56**	24	20	15	17	13	16	54
FUEL	38	45	57**	23	17	12	21	15	12	57
PREDICTED ΔP/Pc OX	.36	.32	.44	.29	.26	.22	.23	.20	.24	.42
FUEL	.38	.45	.45	.28	.22	.19	.29	.23	.18	.43
CHUG DURATION, SEC	0	0	0	0.6	2.1	4.7	1.6***	4.7	4.7	0
FREQUENCY, HZ	-	-	-	310	270	115/230	280	230/280	240/270	-
PK/PK AMPLITUDE,										
PSI OX	-	-	-	290	370	200	250	180	160	-
PSI FUEL	-	-	-	80	60	100	80	70	100	-
LB THRUST	-	-	-	1400	1700	3300	1300	3500	3500	-

*DURING STABLE PART OF TEST **REFERENCE ***SPORADIC THROUGHOUT TEST significant oscillations were occurring during the test. Predicted values are all referred to the measured values of Test 7-7 and ratioed according to the square of the flow rates. The difference between the measured and predicted pressure drops particularly at lower pressures may be the result of subtracting two high pressure measurements (injection and chamber pressures) to obtain a ΔP although the discrepancy is greater than would be expected from instrumentation inaccuracies. Values of injecto. ΔP divided by Pc are also tabulated based on the predicted pressure drops. Tests were conducted with values as low as approximately 0.2 on each side of the injector.

Chugging was not evident as the chamber pressure was reduced from test-to-test until Test 7-8 where a chamber pressure of 84 psia was obtained for steady state. On this test, chugging occurred for approximately 0.6 seconds after ignition at a frequency of about 300 Hz as shown in Fig. 43. As the chamber pressure was reduced on the successive tests, the duration of the chugging increased until at a chamber pressure of 68 psia chugging continued throughout the test. When the chamber pressure was increased on the next test to 73 psia and the mixture ratio was decreased to 1.5, continuous chugging occurred for 1.6 seconds but continued sporadically throughout the remaining duration of the test. Variation of the mixture ratio to 1.6 and 1.9 at $\sim$67 psia chamber pressure on the next two tests resulted in small changes in the chug amplitude.

Based on the results of these tests, it may be concluded that the chamber can be started to a chamber pressure of approximately 90 psi without chugging. However, in the blowdown mode of operation (where chamber pressure decays gradually) if no external disturbances occur, the engine may be throttled to perhaps 65-75 psia without chugging. The chugging did not appear to be detrimental to the engine over the several 5-second duration tests conducted in this program.

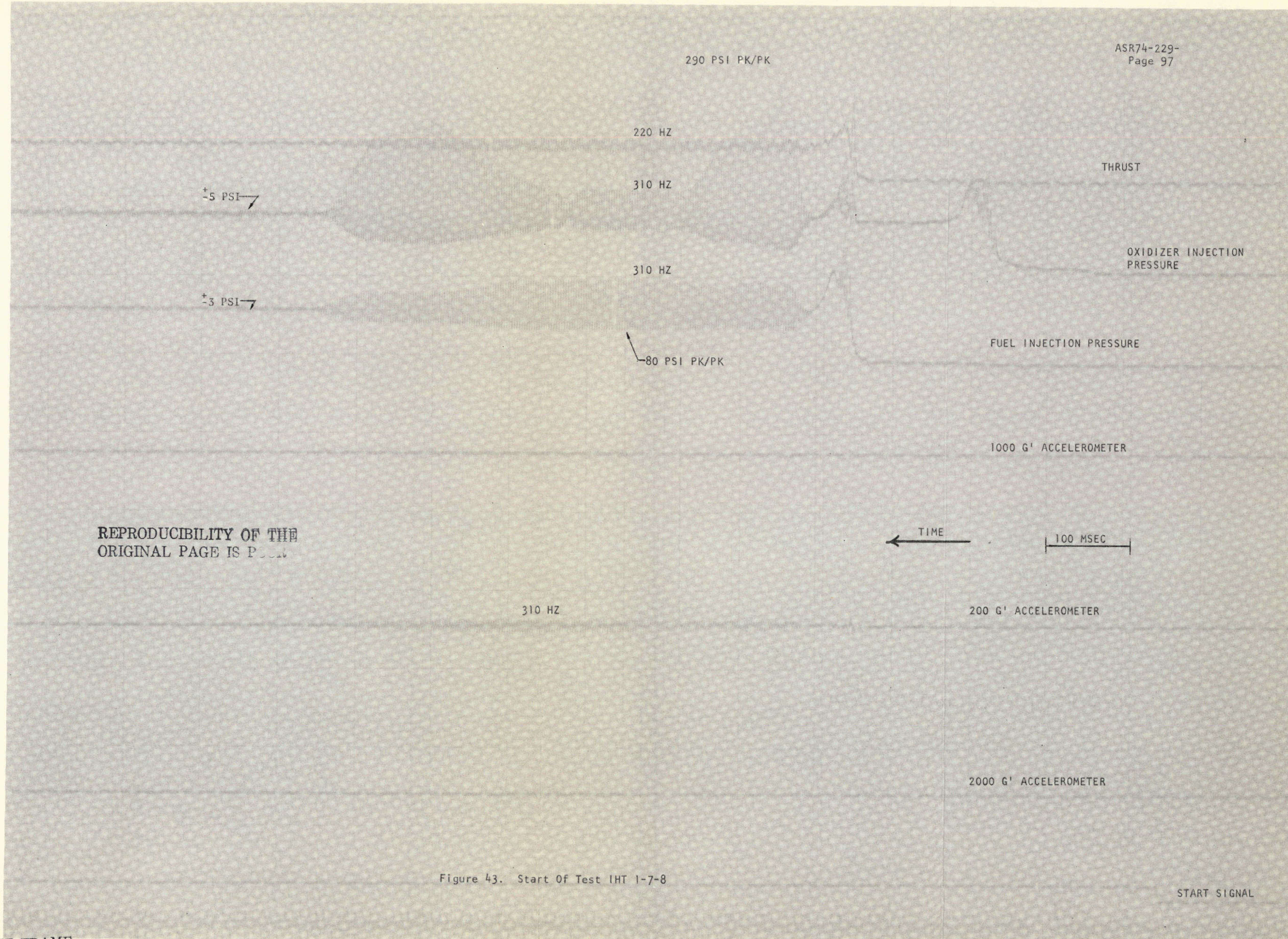

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Figure 43. Start Of Test IHT 1-7-8

FOLDOUT FRAME 1

FOLDOUT FRAME 2

Chug frequencies of 200-300 Hz were noted. Oscillations at two frequencies were indicated during the early portions of some of the tests as shown in Fig. 44. The lower frequency persisted for less than a second after start.

Additional chugging tests conducted in the blowdown mode and starting at about 100 psia chamber pressure should be conducted to further define the chugging limit in this mode. The tests should also be conducted at various mixture ratios.

Heat load data for the throttling tests are shown in Fig. 45. The data taken on the 10-second duration tests at nominal pressure agree quite well with the data from the previous Phase I test effort. The data from the 10-second tests indicated that the value of the heat load measured at 10 seconds was approximately 60 BTU per second higher than the value measured at 5 seconds. The throttling tests were of 5-second duration. The values recorded at this time are plotted in Fig. 45. Raising the plotted values by 60 BTU per second results in very good agreement with the Phase I data. Therefore it appears that no adverse thermal effects occur during chugging operation. The chug frequencies are high enough so that cyclic effects almost completely damp out across the chamber wall. Cycle life is probably degraded to a small extent by the chugging.

BOUNDARY LAYER COOLANT EFFECTS

Tests were conducted to determine the effects of elimination of boundary layer coolant, BLC, on performance and heat transfer. The first seven tests of Sequence 7 and all the tests of Sequence 8 were conducted with the feed system configured to provide precise flow data. Less precision of flow measurement was required for the other tests conducted to determine restart and throttling characteristics wherein it was more important to simulate the OMS ducting. Sequence 7 was also conducted to evaluate throttling characteristics. Therefore, the high area ratio radiation cooled nozzle was replaced by the

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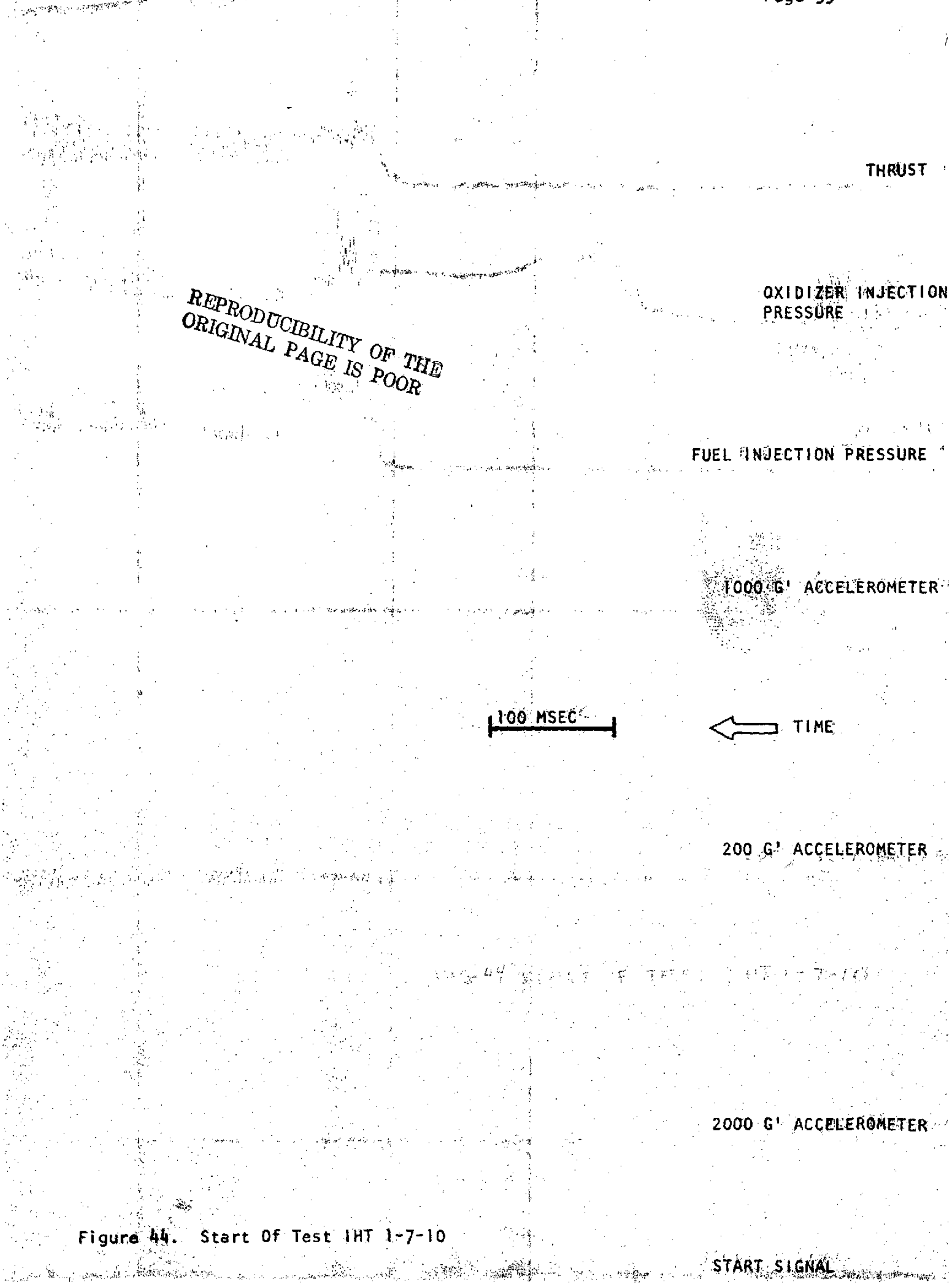


Figure 44. Start Of Test IHT 1-7-10

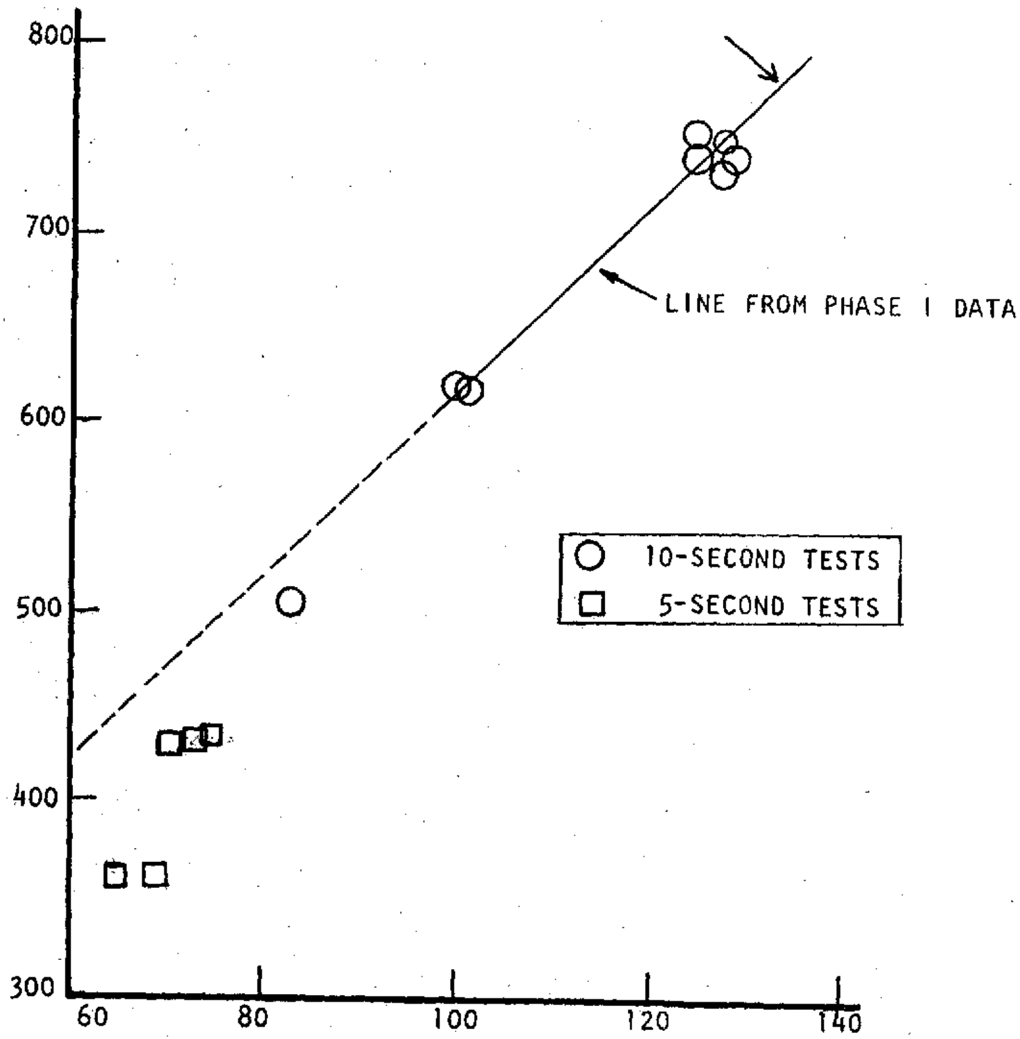


Figure 45. Heat Load During Throttling

shorter, $\epsilon = 9$, nozzle to prevent chamber damage resulting from vibrations during deep throttling. The same nozzle configuration was retained for Sequence 8.

The fuel temperature was reduced to 40 F for Sequences 7 and 8 to enhance the cooling safety factor during the throttling tests and the tests without BLC. Prior to Sequence 8, the injector was modified by inserting pins into the 68 BLC orifices around the periphery of the injector. Ten of these pins were found to be missing after the Sequence 8 tests. Eight of these were in the sector of the chamber defined by $\theta = 70$ to 110° (the fuel inlet is at $\theta = 270^{\circ}$). Theta is measured clockwise viewing from the injector end of the chamber.

Performance

Performance data for applicable tests in Sequences 7 and 8 is tabulated in Appendix B. The injector used in this program, L/D #1, had been previously tested at Rocketdyne in the demonstrator regeneratively cooled thrust chamber with a nozzle having a 9:1 expansion area ratio, at WSTF with the same hardware configuration, and at WSTF with the integrated thrust chamber with a 72:1 nozzle. All of these test programs indicated a vacuum specific impulse with a 72:1 nozzle of 309-310 seconds. The baseline performance tests on Sequence 7 indicated a 2-3 second lower performance, the reason for which could not be determined. However, the objective of determining the effect of eliminating BLC on performance was obtained by comparing the performance data Sequences 7 and 8. Performance data for these two test series is presented graphically in Fig. 46.

The performance penalty for operating with 40 F fuel (instead of 70 F) was calculated to be 0.3 seconds. The data indicates a performance gain of approximately 1.5 seconds at nominal chamber pressure and mixture ratio by eliminating BLC.

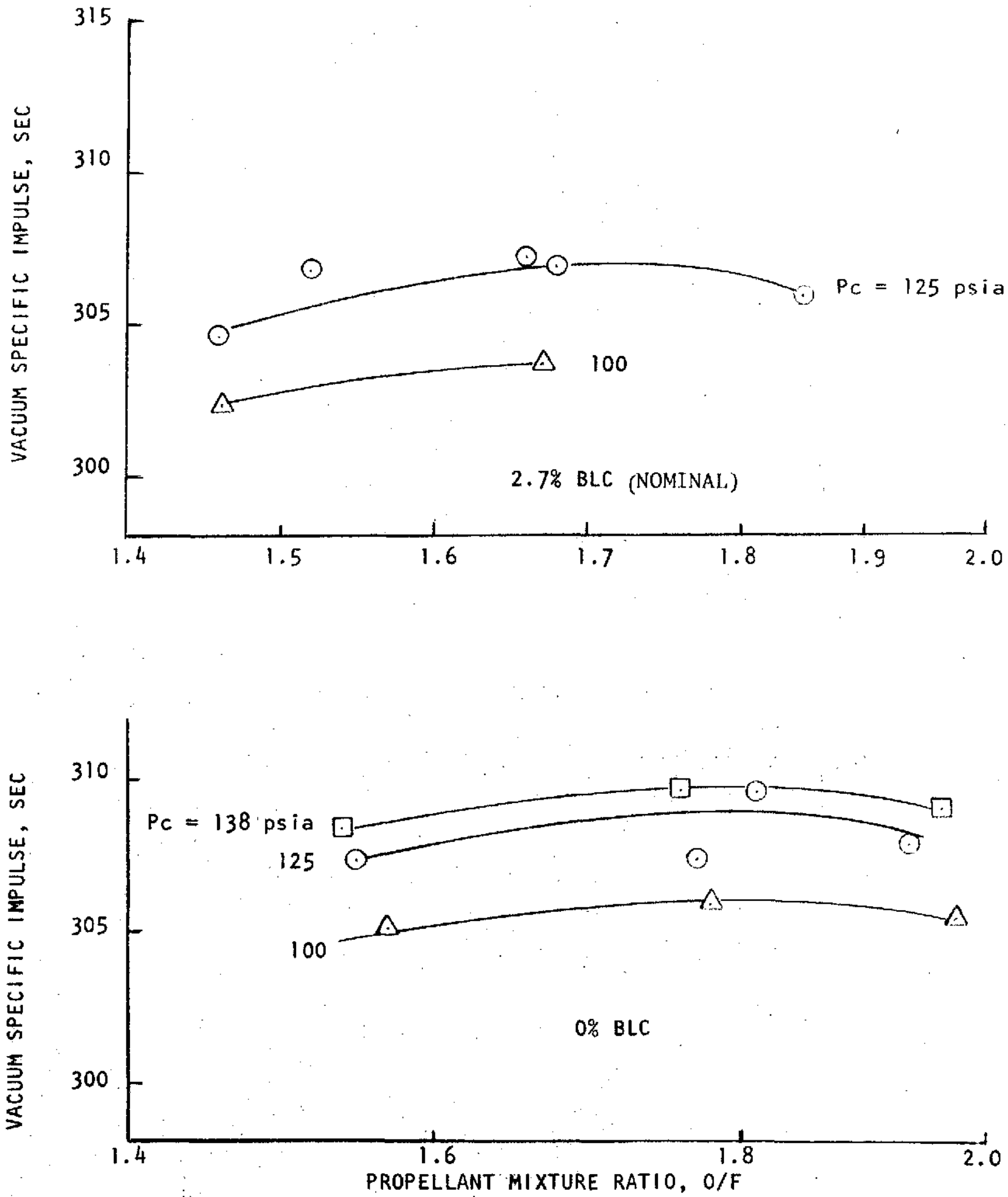


Figure 46. Performance With and Without Boundary Layer Coolant

Based on previous test data, the projected effects of lengthenging the chamber (injector-to-throat distance) and eliminating BLC are shown in Fig. 47. The thermal safety factors determined by two-dimensional and by one-dimensional analyses and the coolant bulk temperature rise values are tabulated on the figure for nominal mixture ratio at each condition. A specific impulse of 313 seconds at nominal conditions results from lengthening the chamber and eliminating BLC.

Thermal Data

Thermal data taken during the Phase II test series at WSTF consisted of fuel bulk temperature rise, regenerative chamber back wall temperature, and steel heat sink nozzle temperature transients or columbium radiation cooled nozzle temperature response and equilibrium values. These data, together with the data generated during the heated tube tests under this contract, were used to provide an indication of the safety margin at which the OME Integrated Thrust Chamber (ITC) was operating both with and without supplemental boundary layer cooling (BLC). Radiation equilibrium temperatures for a full size (ϵ = 72:1) columbium nozzle with and without BLC were predicted based on the results of tests with the short demonstrator columbium nozzle ($7 \leq \epsilon \leq 9$) in conjunction with the full size steel heat sink nozzle temperature transients.

Bulk Temperature Rise and Heat Load. Coolant inlet and outlet temperatures, ΔT's, and the heat load are tabulated in Table XII for each of the 36 tests, which were of sufficient duration to obtain thermal data. The operating conditions are also noted in this table. Five inlet temperature measurements were made in the coolant inlet manifold. Coolant jacket outlet temperatures were measured in three circumferential locations in the injector fuel distribution passages (see Fig. 1, ITC Installation Assembly).

Three bulk temperature rises were calculated based on the three outlet temperature thermocouples. The inlet temperature thermocouple TFB-6 was used as the

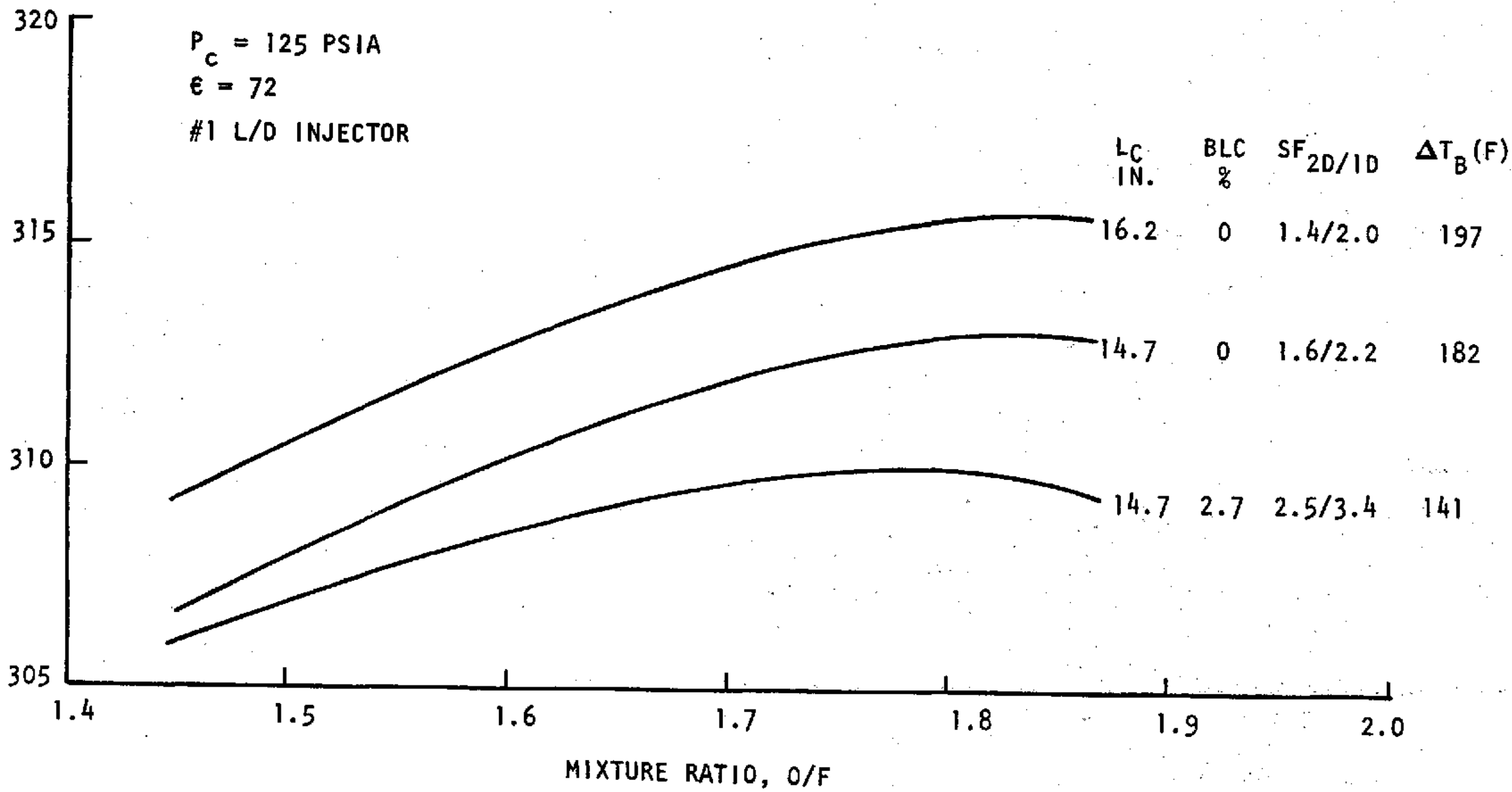


Figure 47. OME Performance With #1 L/D Injector

TABLE XII - PHASE II STEADY-STATE THERMAL DATA

	TEST	TEST DURATION, SEC	MIXTURE RATIO, O/F	$P_{C_{NS}}$ PSIA	$\dot{W}_{FUEL}$ (LB/SEC)	COOLANT OUTLET TEMPERATURE, F TFB-1	TFB-2	TFB-3	INLET TEMP, F TFB-6	COOLANT ΔT F	COOLANT ΔQ BTU/SEC	CHAMBER OUTER SURFACE TEMPERATURES (F), X = -16", θ, DEG/0	15	75	135	180	195	255	315	AVERAGE	X = 13", θ = 0°	90°	180°	270°	AVERAGE	X = 10", 0°	90°	180°	270°	AVERAGE
1	1-12	35.6	1.59	124	7.45	188	201	217	72	130	691	206	213	181	202	202	205	203	208	203	224	176	191	213	201	216	192	185	236	207
2	3-4	29.3	1.67	125	7.32	196	209	222	75	134	699	204	218	187	211	213	215	216	209	209	228	183	196	204	203	219	200	189	224	208
3	3-5	14.3	1.62	125	7.53	187	205	217	76	127	685	203	218	184	198	202	210	217	207	205	226	178	185	202	198	216	193	163	222	199
4	3-7	32.0	1.76	124	7.131	202	214	226	74	140	715	210	227	189	217	218	220	220	215	215	232	187	201	207	207	221	203	198	229	213
5	3-8	14.7	1.62	124	7.47	191	207	226	75	134	713	208	218	188	204	211	214	215	208	208	223	180	201	203	202	214	197	226	231	217
6	3-9	9.9	1.67	126	7.39	191	209	222	75	133	702	217	223	188	201	219	209	218	213	211	227	179	214	203	206	215	191	207	233	212
7	3-10	9.8	1.64	126	7.43	185	209	218	75	128	681	213	213	175	194	218	209	216	210	206	225	178	211	199	203	213	193	189	227	206
8	3-19	31.7	1.59	123	7.82	214	216	222	74	121	679	182	229	205	214	229	216	227	209	214	218	196	227	221	216	190	213	205	240	212
9	3-20	9.8	1.70	126	7.33	216	218	223	74	145	760	224	229	212	215	229	218	216	213	220	220	198	235	218	218	189	212	208	241	213
10	3-21	9.8	1.82	126	7.29	216	218	223	73	145	755	223	228	211	215	226	217	223	219	220	221	199	235	224	220	193	213	243	247	224
11	3-24	31.8	1.76	126	7.21	216	219	226	73	148	762	185	230	212	219	231	506	226	220	218	221	196	229	224	218	194	213	201	239	212
12	5-1	31.8	1.66	125	7.43	181	182	189	38	145	771	188	196	177	180	193	182	188	183	185	189	158	192	188	182	196	180	184	214	194
13	5-2	17.7	1.68	127	7.39	180	181	188	39	143	757	189	198	178	180	171	179	190	183	184	189	158	165	192	176	196	180	149	217	186
14	5-3	14.7	1.66	127	7.48	180	182	187	39	143	764	190	196	178	180	171	179	191	185	184	189	149	160	184	171	195	163	147	211	179
15	5-4	11.8	1.65	128	7.45	179	182	190	38	144	767	196	194	183	180	171	181	194	188	186	193	149	167	194	176	199	155	184	223	190
16	5-5	8.7	1.68	128	7.38	179	182	190	38	144	760	198	199	184	180	172	181	194	189	187	193	151	167	187	175	196	159	172	220	187
17	5-12	10.8	1.69	127	7.37	180	183	191	37	146	770	188	212	184	181	172	181	192	190	188	179	148	166	192	171	182	154	172	221	182
18	5-13	13.8	1.67	127	7.35	168	183	190	37	142	746	198	197	181	167	198	184	193	188	188	210	162	200	192	191	199	184	177	219	195
19	7-1	9.7	1.52	131	8.15	171	173	177	46	127	742	167	187	170	176	173	173	175	171	174	187	158	183	217	186	190	178	171	224	191
20	7-2	9.7	1.66	127	7.43	185	186	192	48	138	735	180	203	183	189	189	189	194	183	189	200	171	199	197	192	203	190	179	219	198
21	7-3	9.7	1.67	99	5.86	194	196	206	50	149	623	202	213	197	197	208	202	203	202	203	208	174	222	214	205	210	193	244	244	223
22	7-4	9.7	1.46	100	6.41	181	182	192	47	138	633	194	197	184	180	196	185	188	189	189	193	166	208	197	191	198	186	233	231	212
23	7-5	9.8	1.46	125	7.89	176	175	188	48	133	751	189	191	179	177	170	176	188	188	182	188	146	171	190	174	189	149	220	227	196
24	7-6	9.8	1.84	124	6.81	197	197	210	48	155	756	210	216	201	198	197	199	212	208	205	210	168	195	213	197	210	181	234	245	218
25	7-7	34.7	1.68	126	7.39	188	188	196	44	147	777	197	204	191	187	200	190	199	193	195	198	168	204	193	191	200	187	229	226	211
26	7-14	9.7	1.65	127	7.39	176	181	201	48	141	744	182	196	185	179	164	180	196	199	185	193	165	161	191	178	197	185	180	220	196
27	8-1	33.0	1.81	124	6.91	231	237	256	44	198	978	241	248	233	234	258	237	251	239	243	266	231	281	282	265	232	213	270	298	253
28	8-2	9.7	1.76	139	7.66	227	229	256	45	193	1060	228	242	233	227	240	223	257	249	237	243	229	266	266	251	211	209	289	277	247
29	8-3	9.7	1.54	138	8.32	215	214	236	45	178	1061	206	222	221	213	223	208	235	235	220	219	216	247	262	236	192	197	266	254	227
30	8-4	9.7	1.55	123	7.45	217	217	238	44	180	960	210	218	226	216	225	213	242	246	225	224	221	250	265	240	198	202	254	255	227
31	8-5	9.7	1.95	123	6.45	242	243	265	45	206	949	219	238	247	244	258	242	260	257	246	217	244	285	282	257	215	223	266	284	247
32	8-6	9.7	1.57	109	6.56	221	221	243	44	184	865	201	218	233	220	229	221	248	254	228	196	225	254	273	237	197	206	272	265	235
33	8-7	9.7	1.97	138	7.15	240	240	254	46	200	1022	219	239	251	241	254	238	267	258	246	218	241	284	277	255	212	220	294	285	253
34	8-8	9.7	1.78	109	6.07	232	234	247	46	193	839	211	233	247	235	242	236	258	258	240	210	238	268	274	248	209	217	282	279	247
35	8-9	9.7	1.98	109	5.67	247	248	261	45	208	843	220	246	253	249	262	252	266	252	250	216	252	286	286	260	218	231	267	290	252
	8-10	9.7	1.77	126	7.01	233	230	233	47	188	942	201	242	245	232	239	227	257	247	[illegible]	[illegible]	236	267	269	242	190	214	277	276	239

FORM R 79

FOLDOUT FRAME 1 FOLDOUT FRAME 2 FOLDOUT FRAME 3

TABLE XII - PHASE II STEADY-STATE THERMAL DATA (Continued)

	TEST	CHAMBER OUTER SURFACE TEMPERATURES (F)																													
		X = -8"					X = -6"					X = -4"					X = -2"					X = -0.3"					X = +3"				
		θ = 0°	90°	180°	270°	Average	0°	90°	180°	270°	Average	0°	90°	180°	270°	Average	0°	90°	180°	270°	Average	0°	90°	180°	270°	Average	0°	90°	180°	270°	Average
1	1-12	198	184	154	223	190	147	129	182	199	164	166	154	164	176	165	148	141	149	151	147	144	141	126	161	143	130	129	134	136	132
2	3-4	202	189	153	214	190	145	128	187	194	164	171	159	169	174	168	154	146	154	152	152	148	146	125	163	146	135	133	139	139	137
3	3-5	196	186	148	214	186	144	126	183	193	162	169	157	166	171	166	151	144	152	150	149	145	147	134	163	147	135	132	138	138	136
4	3-7	204	193	149	217	191	196	179	191	197	191	173	162	173	176	171	155	148	157	154	154	149	148	123	165	146	136	135	141	141	138
5	3-8	200	187	163	214	191	184	174	185	193	184	167	157	166	171	165	150	144	152	150	149	145	144	138	160	147	132	131	137	137	134
6	3-9	204	186	192	215	199	175	174	188	194	183	168	157	169	172	167	151	145	153	151	150	146	145	157	162	153	133	132	138	138	135
7	3-10	194	185	206	211	199	190	173	186	191	185	165	157	167	169	165	149	144	152	149	149	145	144	167	159	154	131	131	137	136	134
8	3-19	202	196	153	229	195	194	180	193	207	194	171	160	173	183	172	153	147	156	160	154	149	147	158	168	156	135	135	140	143	138
9	3-20	201	195	147	226	192	193	179	190	204	192	171	160	170	181	171	153	147	152	158	153	148	147	149	167	153	134	135	119	142	133
10	3-21	207	196	149	230	196	195	180	190	208	193	171	160	169	184	171	153	147	150	160	153	149	147	149	168	153	135	135	122	143	134
11	3-24	205	196	148	230	195	197	180	195	209	195	173	162	175	184	174	155	147	157	161	155	150	148	159	170	157	137	135	141	143	139
12	5-1	180	165	183	203	183	171	151	166	182	168	145	131	145	156	144	125	117	126	131	125	127	125	135	147	133	109	109	112	118	112
13	5-2	176	166	126	206	169	170	151	162	184	167	145	131	143	157	144	125	117	126	132	125	126	125	134	149	134	109	108	110	118	111
14	5-3	176	163	125	199	166	169	150	162	178	165	144	131	142	152	142	124	118	124	129	124	126	125	134	145	133	108	109	111	116	111
15	5-4	186	161	118	208	170	172	149	161	185	167	146	130	134	157	142	127	117	122	133	125	127	125	128	149	132	111	109	105	118	111
16	5-5	189	163	114	203	167	171	150	160	181	166	145	131	136	155	142	125	117	120	129	123	126	125	128	145	131	109	109	102	115	109
17	5-12	173	159	165	207	176	160	149	160	184	163	136	129	137	156	140	118	116	119	132	121	121	124	127	147	130	103	109	103	118	108
18	5-13	181	169	165	206	180	170	155	169	183	169	145	134	146	157	146	125	119	125	133	126	126	126	134	147	133	108	111	111	118	112
19	7-1	185	165	186	217	188	169	152	163	197	170	144	133	145	172	149	126	120	127	144	129	127	126	133	152	135	108	112	115	126	115
20	7-2	194	175	184	211	195	180	161	175	190	177	154	142	155	166	154	135	128	137	143	136	134	133	142	152	140	118	121	123	126	122
21	7-3	203	182	215	224	206	185	167	180	200	183	158	147	152	173	158	138	132	136	149	139	139	138	139	158	144	121	123	113	130	122
22	7-4	189	171	234	210	201	172	156	168	188	171	149	136	145	166	149	128	122	126	139	129	130	127	128	148	133	112	113	104	121	113
23	7-5	188	154	228	205	198	166	146	156	182	163	143	129	135	159	142	124	117	119	135	124	126	122	123	143	129	106	110	99	118	108
24	7-6	205	178	278	224	221	184	165	177	200	182	159	146	153	178	159	138	129	210	150	157	140	137	137	158	143	121	125	109	131	122
25	7-7	199	171	298	208	219	176	159	172	186	173	151	138	153	167	152	132	124	230	143	157	137	131	140	151	140	115	121	121	125	121
26	7-14	192	170	229	206	199	174	213	163	184	184	149	137	148	164	150	131	123	129	139	131	134	129	137	149	137	112	118	116	124	118
27	8-1	227	195	220	294	234	203	178	199	269	212	172	156	180	221	180	151	142	208	175	169	153	145	160	154	153	130	127	137	140	134
28	8-2	210	190	202	251	213	186	173	182	217	190	159	152	151	190	163	140	138	220	158	164	141	141	141	143	142	119	128	115	130	123
29	8-3	192	179	189	224	196	168	162	171	197	175	143	142	141	177	151	126	129	221	151	157	128	132	131	153	136	106	118	109	127	115
30	8-4	197	184	191	228	200	173	167	173	201	179	148	146	141	178	153	128	131	225	150	159	131	136	133	157	139	110	120	111	127	117
31	8-5	212	203	217	263	224	190	186	196	230	201	164	164	162	200	173	142	147	237	168	174	145	151	151	153	150	124	134	119	138	129
32	8-6	197	188	196	236	204	174	171	178	208	183	150	149	150	184	158	131	134	184	155	151	133	141	140	161	144	112	122	113	131	120
33	8-7	215	201	219	260	224	187	183	197	226	198	160	162	169	198	172	140	146	148	161	149	143	149	155	151	150	122	133	125	135	129
34	8-8	211	200	208	255	219	185	182	190	221	195	158	159	170	195	171	138	143	142	161	146	142	149	153	147	148	121	130	123	134	127
35	8-9	208	212	217	266	226	191	193	197	232	203	164	169	158	203	174	143	151	145	170	152	147	156	152	154	152	126	135	122	140	131
	[illegible]	196	196	204	250	212	172	178	185	[illegible]	188	147	157	156	190	162	129	141	247	158	169	133	146	144	145	142	113	128	118	131	123

FOLDOUT FRAME 1 FOLDOUT FRAME 2 FOLDOUT FRAME 3

reference temperature for all three ΔT's because of its proximity to the inlet and general agreement with the fuel flowmeter temperature measurement. Temperature rises calculated in this manner generally agree within 8 percent to 10 percent.

The response of the coolant outlet bulk temperature with and with ut film cooling is compared in Fig. 48 for typical cold starts. Steady-state outlet temperatures without film cooling are achieved in about 15 to 20 seconds. Ninety percent of the final value is achieved in about nine seconds. The cold start test with film coolant appears to reach equilibrium in about 9 to 10 seconds although the test was not of sufficient duration to verify this.

The long duration to achieve final steady-state conditions is due primarily to the time required for the non-flightweight inlet manifold to reach equilibrium operating temperatures. Subsequent tests achieve steady-state conditions in less than 10 seconds as noted in Fig. 49 for typical hot-start conditions.

The majority of the tests were 10 seconds duration with the iniital test of most of the test series about 30 to 35 seconds to assure achievement of thermal equilibrium. The resulting average values of coolant bulk temperature rise were multiplied by the fuel coolant flowrate through the jacket and the specific heat of the fuel to determine the heat absorbed by the fuel. The resulting heat loads for the tests without BLC are presented in Fig. 50 as a function of chamber pressure with coded symbols to denote approximate mixture ratio. These data follow the predicted variation with Pc to the 0.8 power. The effect of mixture ratio on heat load appears negligible, which is consistent with heat transfer theory for the range of mixture ratios tested.

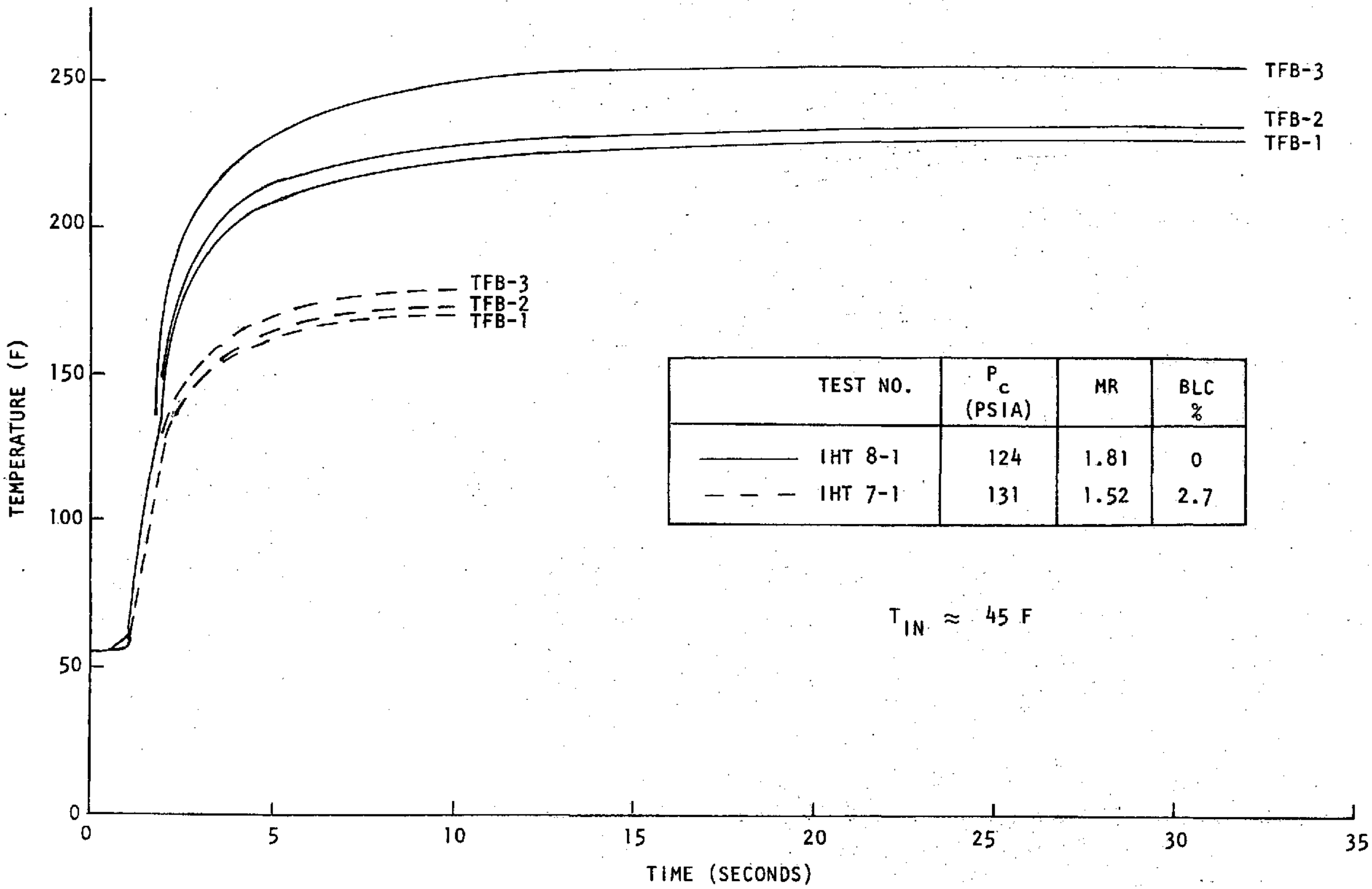


Figure 48 . Typical Outlet Bulk Temperature Response - Cold Start

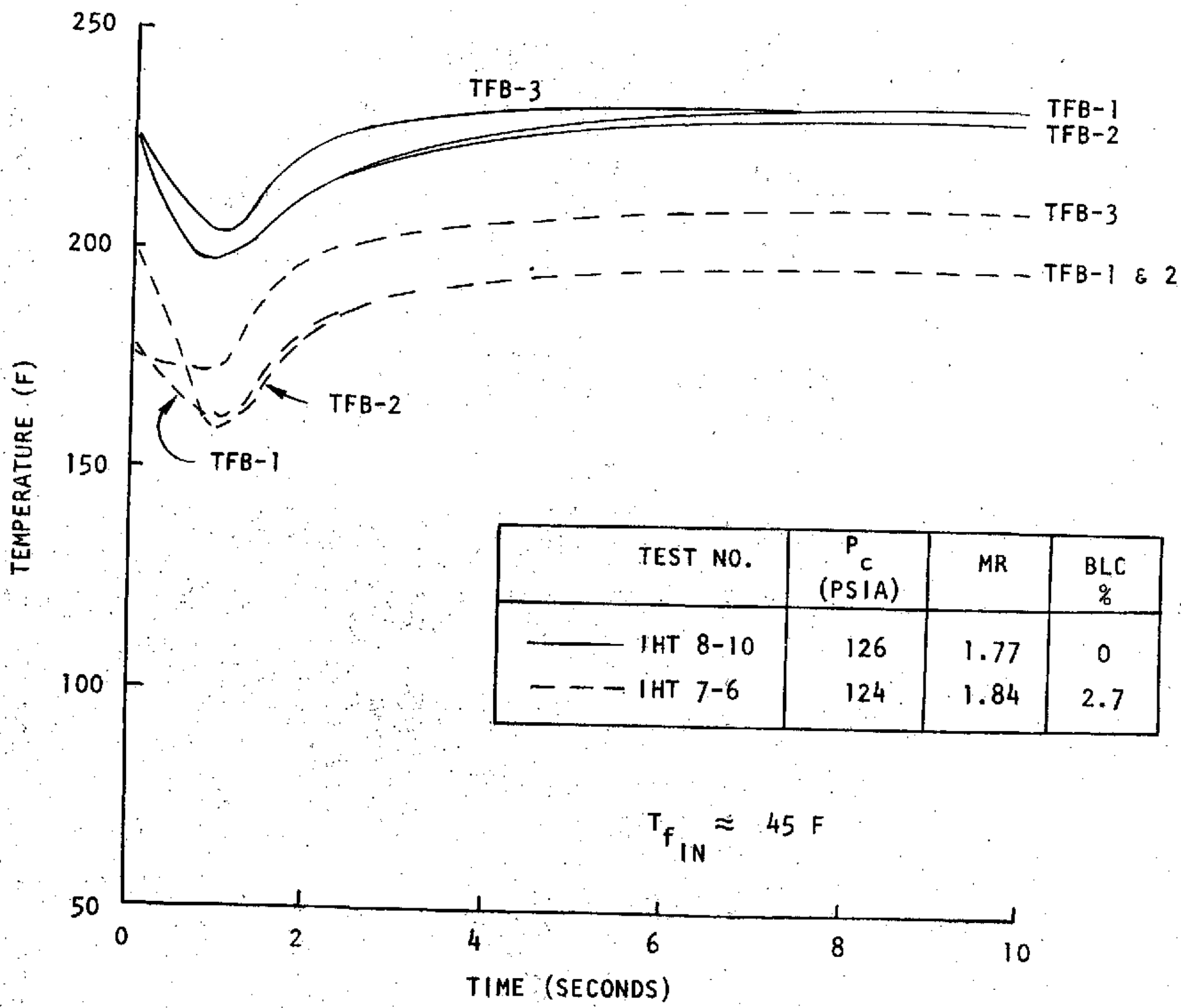


Figure 49. Typical Outlet Bulk Temperature Response - Hot Start

The best-fit line obtained from the earlier ITC tests with a nominal 2.7 percent flowrate is also presented in Fig. 50. The heat load for the ITC without BLC is about 26 percent higher than for the nominal film cooled design. The actual heat loads at nominal operating conditions (Pc = 125 psia, MR = 1.65) are about 750 BTU/sec and 950 BTU/sec with and without BLC, respectively. As will be shown later, most of the increased heat load occurs in the cylindrical section of the combustor near the injector end. These results agree favorably with the original theoretical predictions of a 23 percent higher heat load without BLC.

<u>Back Wall Temperature</u>. Back (outer surface) wall temperatures were measured in numerous locations on the ITC (See Fig. 1) to indicate steady-state operating values, as well as start and soakout temperature characteristics. The steady-state back wall temperatures are presented in Table XII for each test of sufficient duration (~10 seconds or longer).

Typical back wall temperature response from a cold start (i.e., first in a test series) is presented in Fig. 51 for a test without BLC. As would be expected, the response is more rapid in the higher heat flux throat and combustor regions as compared to the nozzle (X = +3 inches). Thermal equilibrium is achieved in about 15 seconds or less except at the injector end location (X = 13 inches) where about 20 seconds is required. The throat region temperature reaches 90 percent of its final value in about 3 seconds.

Typical hot-start back wall temperature transients are presented in Fig. 52 for a test without BLC. There is an initial cooling down of the backwall as the coolant flows through the channels before combustion gas heating

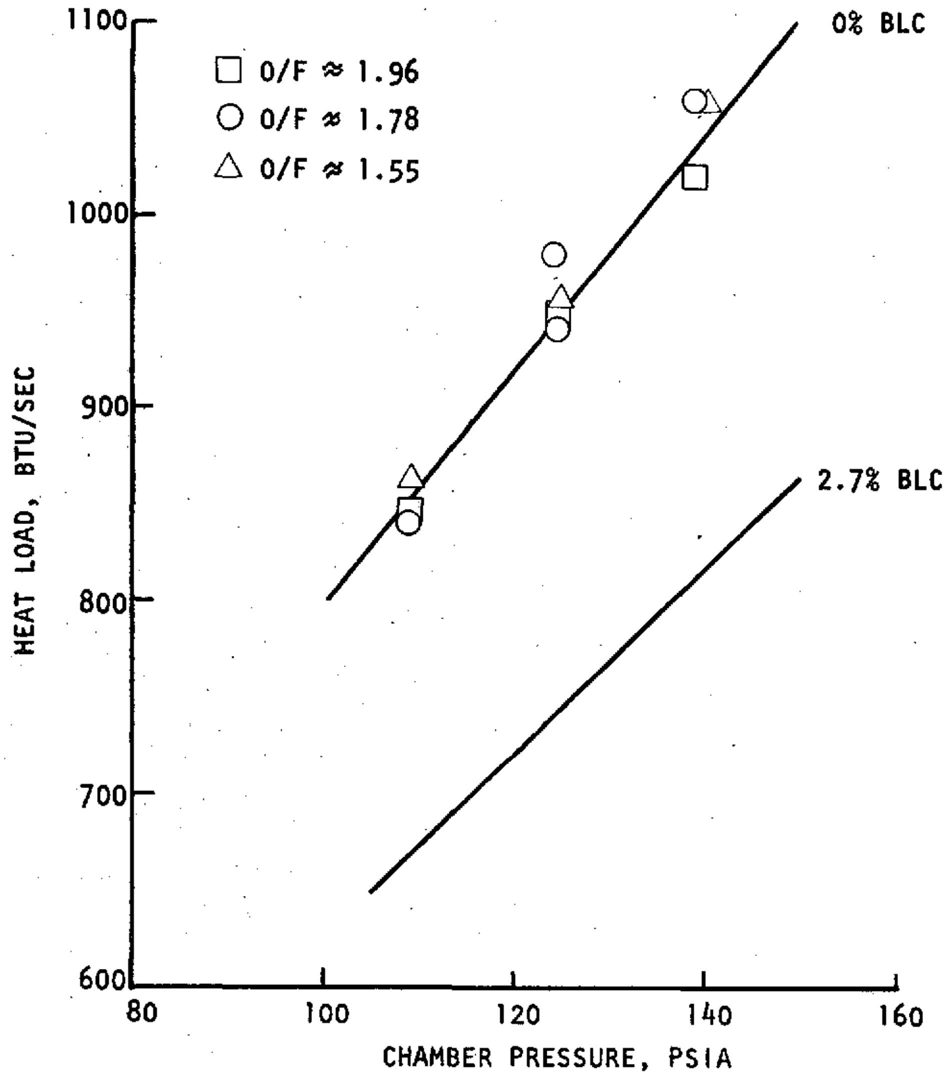


Figure 50. Effect of Boundary Layer Coolant on Regenerative Chamber Heat Load

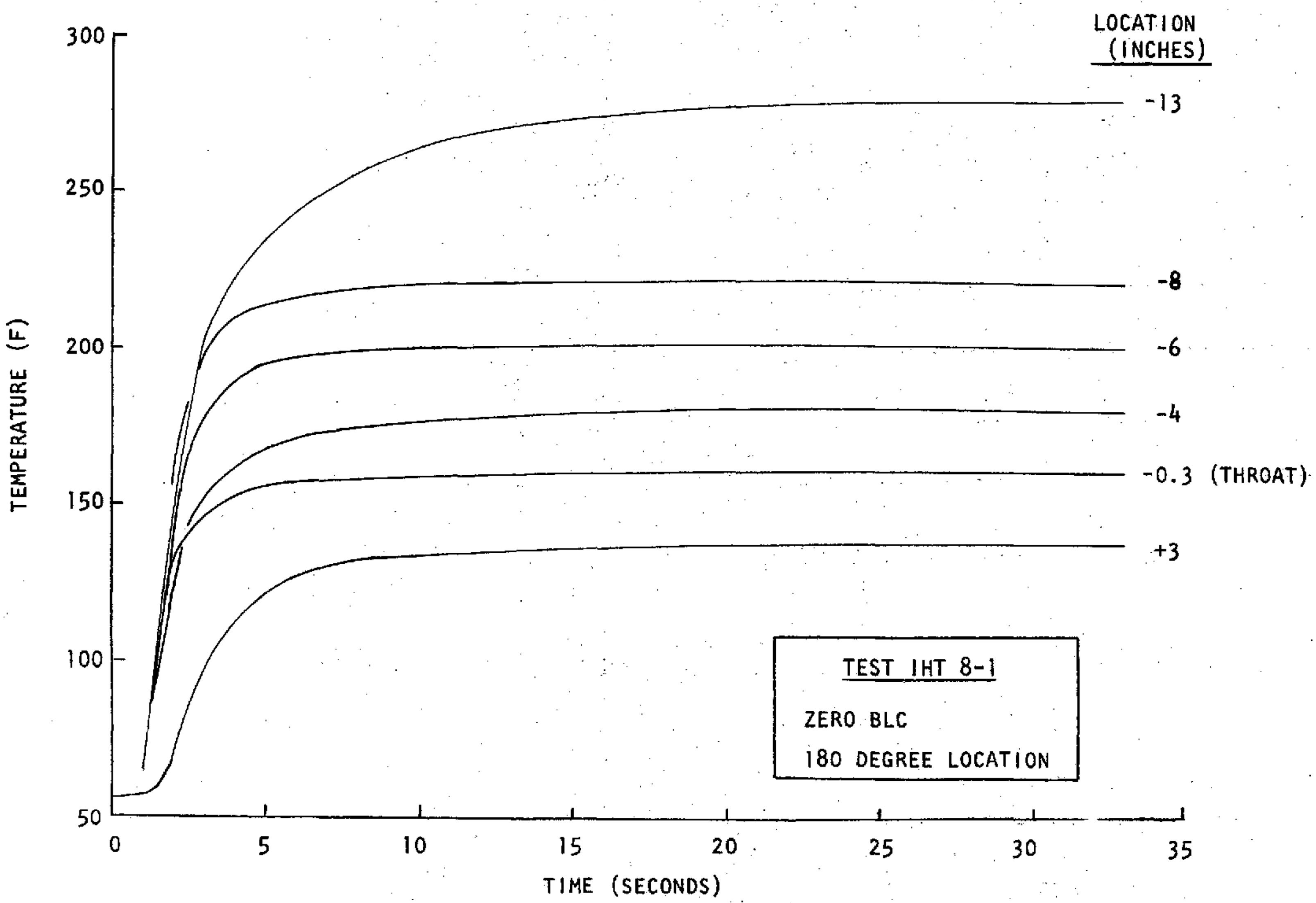


Figure 51. Typical Backwall Temperature Transients - Cold Start

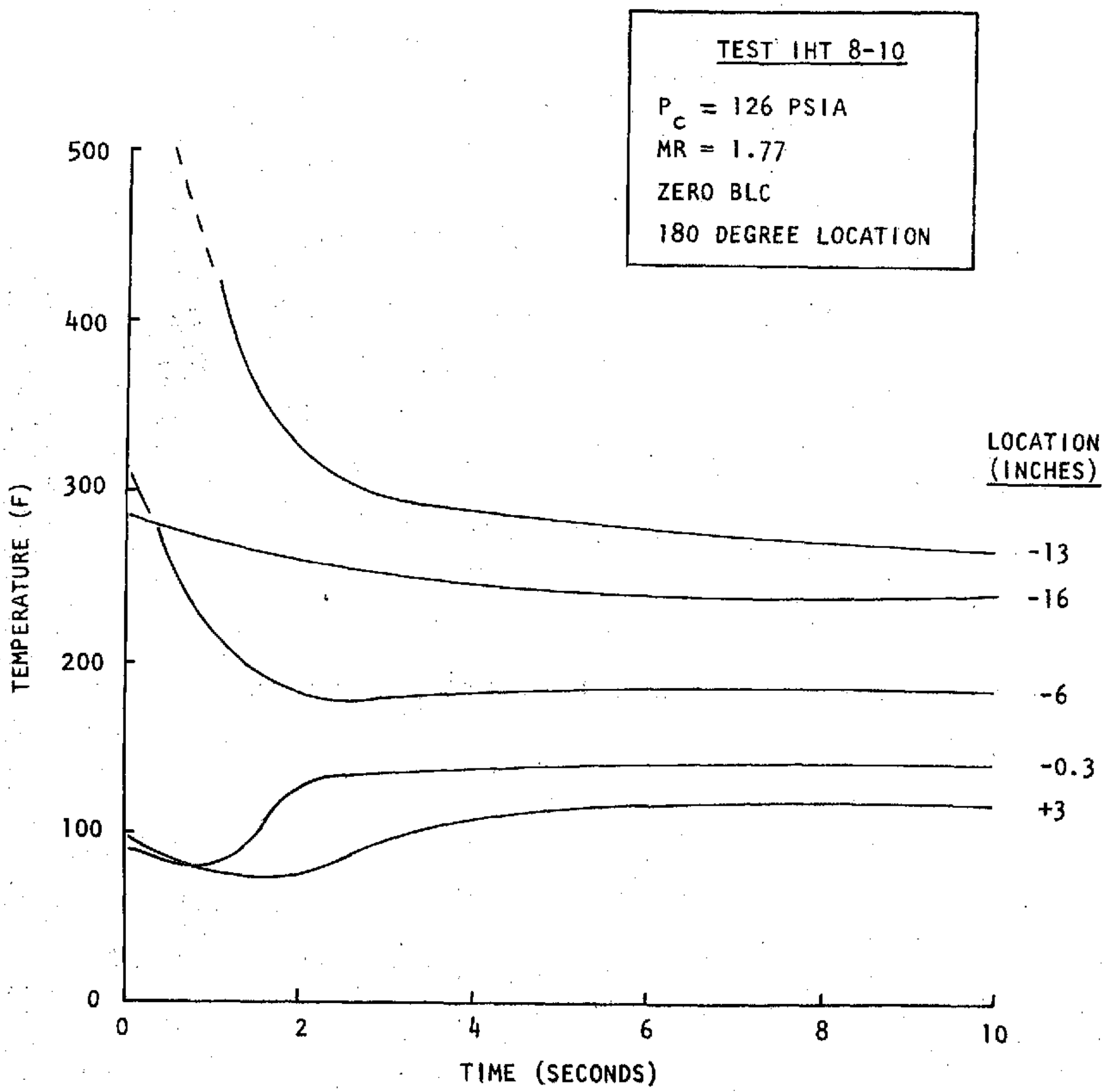


Figure 52 . Typical Backwall Temperature Transients - Hot Start

diffuses through the walls into the coolant and back wall region. Steady-state back wall temperatures are generally achieved in about 5 seconds except at the injector end (X = -13 inches) where about 10 seconds is required.

A notable difference between the tests with and without BLC is that the soakout temperatures prior to restart are in excess of 500 F at the x = -13 inch location without BLC. This compares to a value of about 300 F when supplemental BLC is utilized. The head end obviously operates hotter without BLC as would be expected due to higher operating back wall temperatures (due to higher bulk temperature) and hot-gas wall temperature (due to increased local heat flux). The acoustic cavity and dams probably also operate at higher temperatures and contribute to the higher soakout temperatures.

Steady-state back wall temperatures are utilized primarily as an indication of axial heat load distribution and circumferential heat load uniformity. These measurements are relatively insensitive to local heat flux variations and tend to reflect integrated heat load along a channel in that back wall temperatures are strongly influenced by the local bulk temperature.

A comparison of the average back wall temperature profile with and without BLC is presented in Fig. 53. The effect of BLC is seen to be small from the regenerative coolant inlet to a point about 8 inches upstream of the throat. The primary effect of BLC occurs in the region extending from the injector to about 10 inches upstream of the throat.

In the case of film cooling, the back wall temperatures are relatively flat or decreasing in going from X = 8 inches to the injector end. This would indicate a combination of reduced heat flux level and relatively constant bulk temperature resulting from the lower heat flux. Without BLC, however, the back wall temperatures continue to increase right up to injector end and decrease only in the acoustic cavity region. This would indicate a

SYMBOL	TEST NO.	P_c (PSIA)	MR	T_{IN} (F)	BLC %
○	IHT 8-1	124	1.81	44	ZERO
□	IHT 7-6	124	1.84	48	≈ 2.7

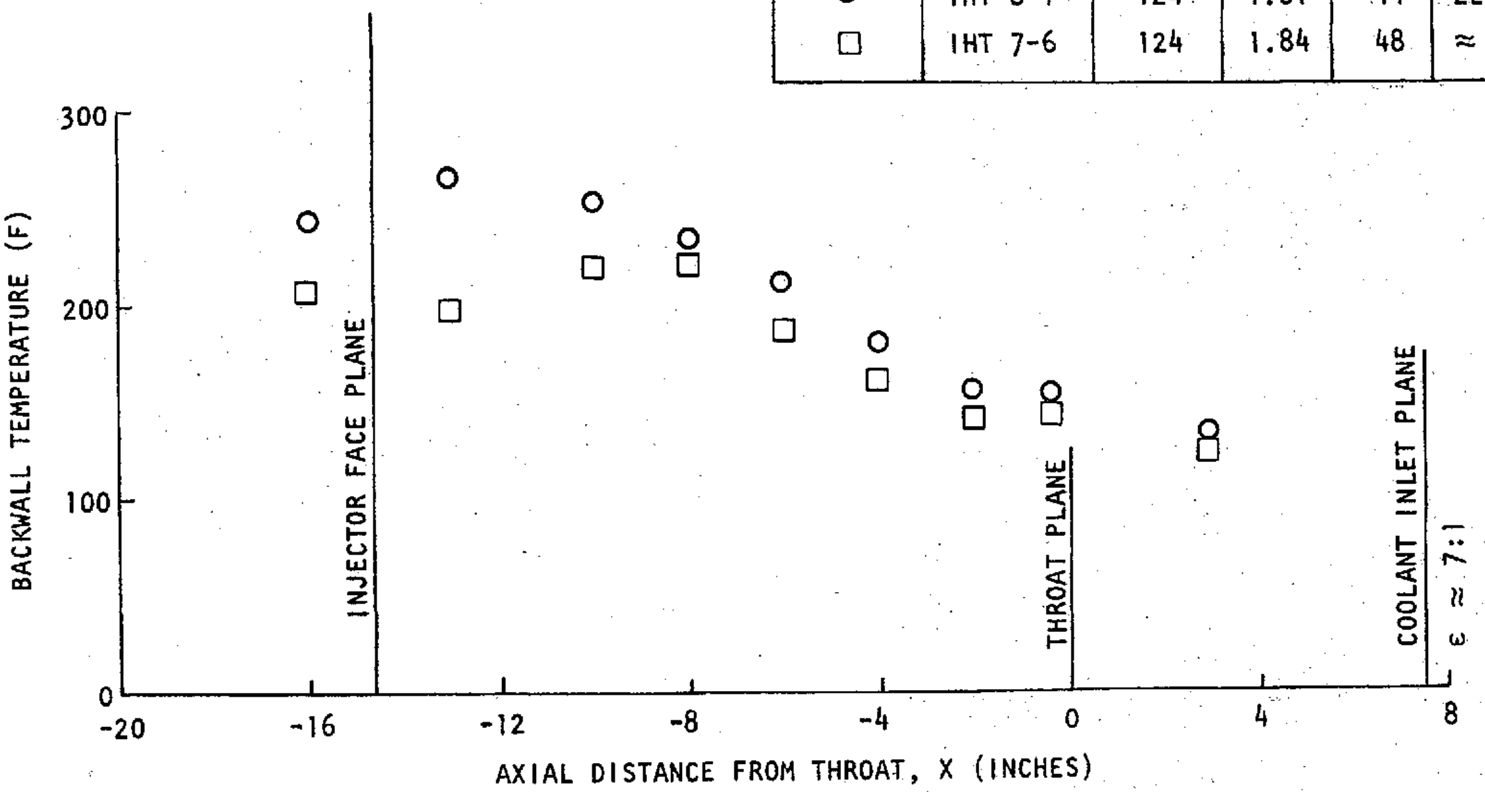


Figure 53. Effect of Supplemental Film Coolant on Backwall Temperature Profile

relatively constant heat flux and increasing regenerative coolant bulk temperature in the cylindrical region. Reduced heat flux level in the acoustic cavity accounts for the reduced back wall temperature in that region.

The effect of film coolant on throat and injector end is also hown in Fig. 54 as a function of chamber pressure for various maxture ratios as noted. It is apparent that BLC effectiveness is minimal in the throat region. A marked effect is noted at the injector end due primarily to the higher integrated heat load occurring without BLC. The difference in back wall temperatures at the injector end are greater than can be accounted for just with coolant temperature differences, however, indicating a higher local heat flux as well.

In general, circumferential variations in back wall temperatures were less than 10 F in the nozzle and throat region. The variation appears to increase significantly to about 30 to 40 F in the combustor/injector end region both with and without film cooling. This variation would amount to about ±10 percent difference in heat load to the regenerative coolant.

Comparison of the average acoustic cavity back wall temperatures (measured at 8 circumferential locations) with the average outlet bulk temperature give agreement within about 1 to 2 F in most cases. This would indicate that these acoustic cavity region measurements are essentially equivalent to local coolant bulk temperatures (due to very low heat flux levels) and can be utilized to indicate nonuniformity of circumferential heat load. Based on the results of the 10 nonfilm cooled tests, the average circumferential variation range in heat load was +10 percent and -12 percent.

A typical plot of back wall temperature distribution without BLC is presented in Fig. 55 for the test conditions as noted. (Thermocouples at the 270 degree location 4 inches to 13 inches upstream of the throat were inadvertently installed over mid-land rather than mid-channel and are not

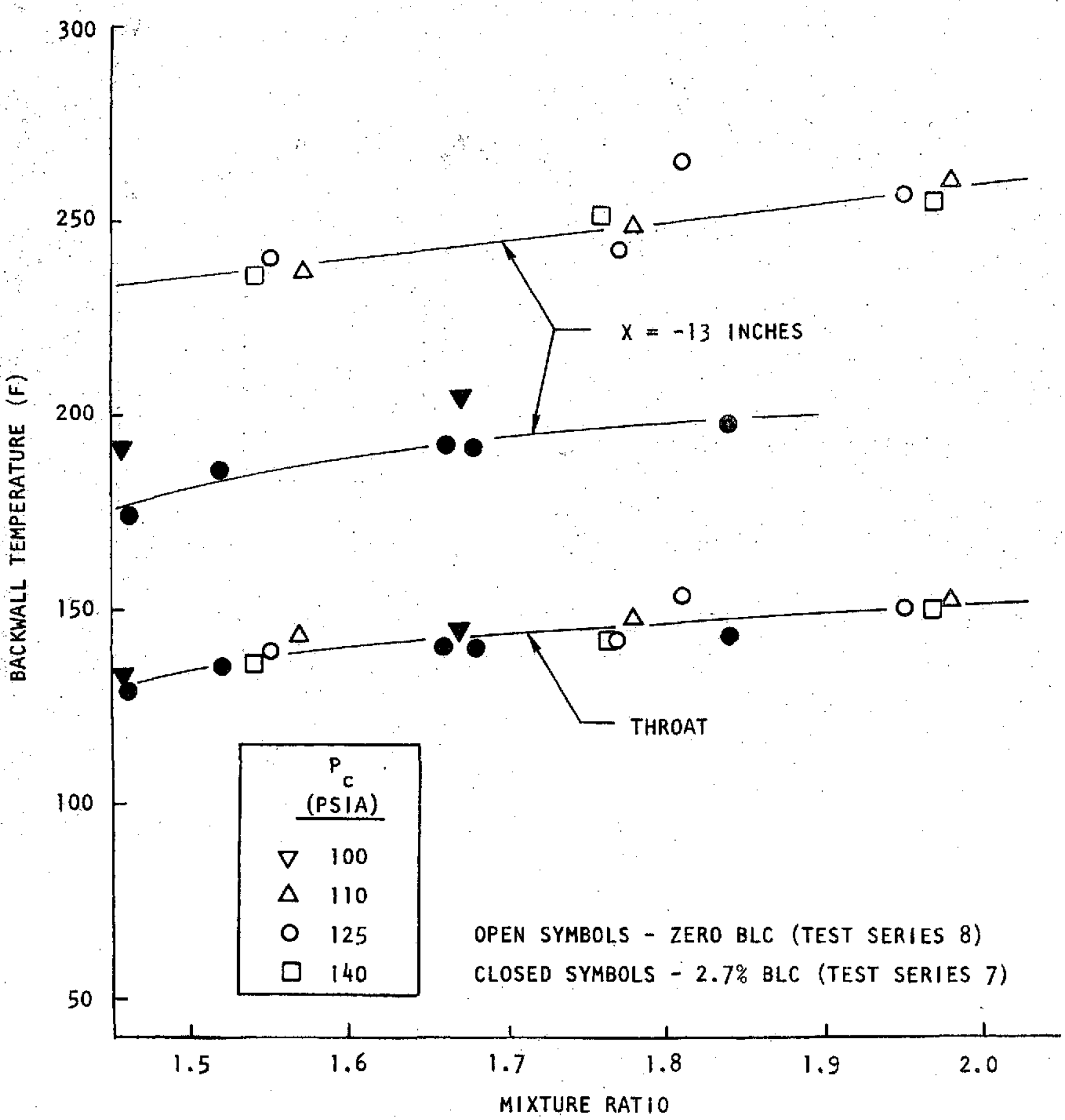


Figure 54. Effect of Various Parameters on Backwall Temperature

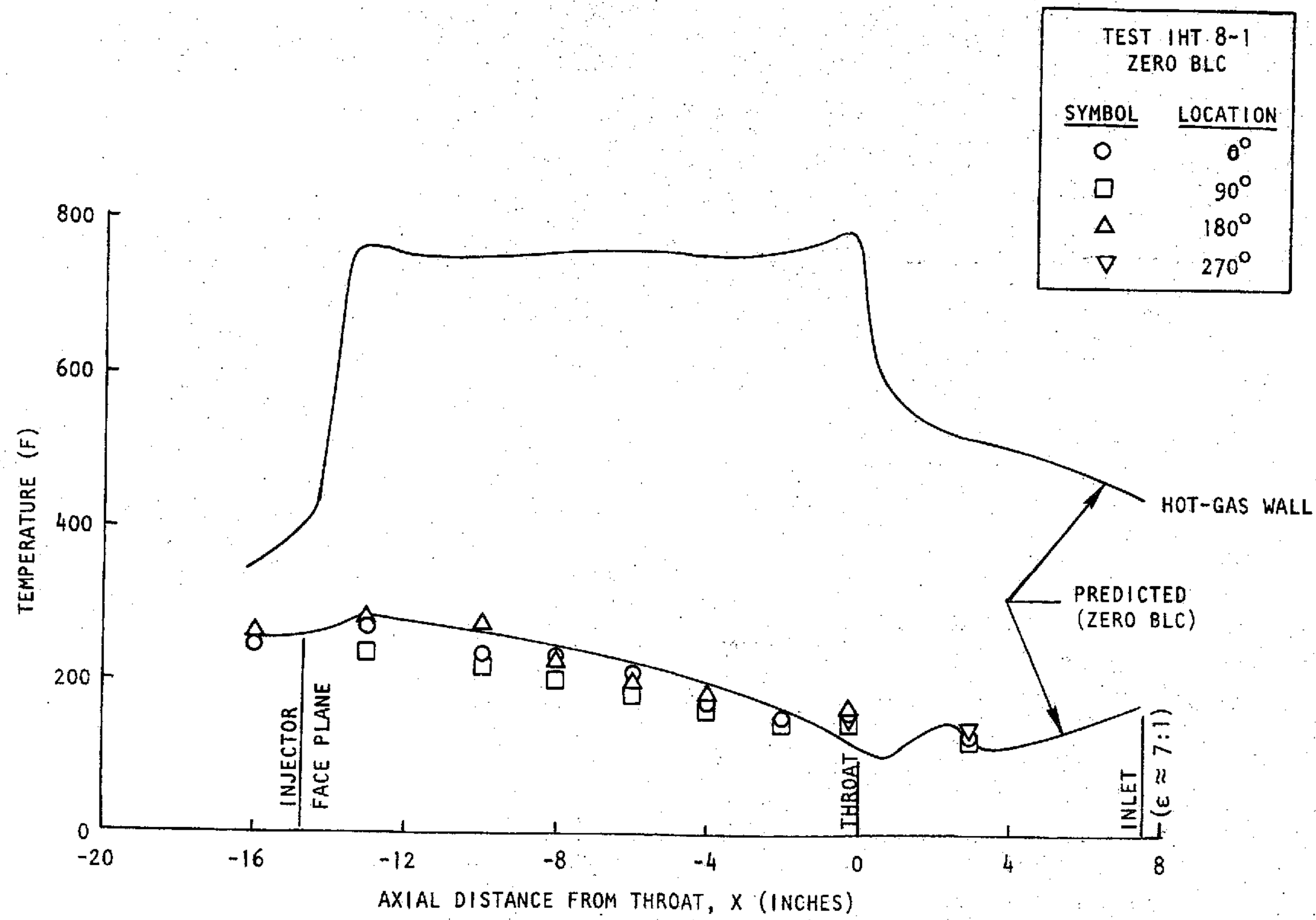


Figure 55 . Wall Temperature Profiles Without Supplemental Film Coolant

included due to the resulting higher recorded temperatures.) The predicted back wall and hot gas wall temperature profiles are also presented for comparison. The predicted values are based on a boundary layer analysis (without film cooling) with a slight adjustment ($\sim$4 percent reduction) in order to match the total integrated heat load. The experiment ' and predicted back wall temperature profiles appear to be in relatively good agreement. The predicted maximum hot gas wall temperature is about 780 F without BLC compared to about 740 F with BLC.

Radiation Cooled Nozzle. Test Sequences 7 and 8 were conducted using the columbium radiation cooled nozzle. The nozzle attaches to the ITC at an area ratio of 7:1 and extends to an area ratio = 9:1. The latter dimension was selected based on compatibility with the diffuser utilized during earlier tests at Rocketdyne's facility. The 0.050-inch wall thickness was selected to simulate soakback conditions after shutdown. The wall thickness has a negligible effect on radiation equilibrium temperature. Typical temperature response data for tests with and without BLC are presented in Fig. 56. It is apparent that there is a definite increase in equilibrium wall temperature for the test with no supplemental film coolant. This essentially proves that there is film coolant carry-over downstream of the throat.

The maximum temperature difference (with and without BLC) is about 240 F based on thermocouple #28. The predicted temperature difference is about 260 F based on the thermal model discussed in the Phase 1 data dump (ASR74-117). The maximum measured temperature is about 1710 F without BLC for the short columbium nozzle. This compares to a maximum measured temperature of about 1540 F when supplemental film cooling was utilized.

The use of full-size columbium nozzle ($\epsilon \approx 72:1$) would result in a wall temperature increase of about 90 F in each case due to a reduced view factor out of the nozzle exit plane. The resulting maximum equilibrium temperature

RADIATION NOZZLE TEMPERATURES

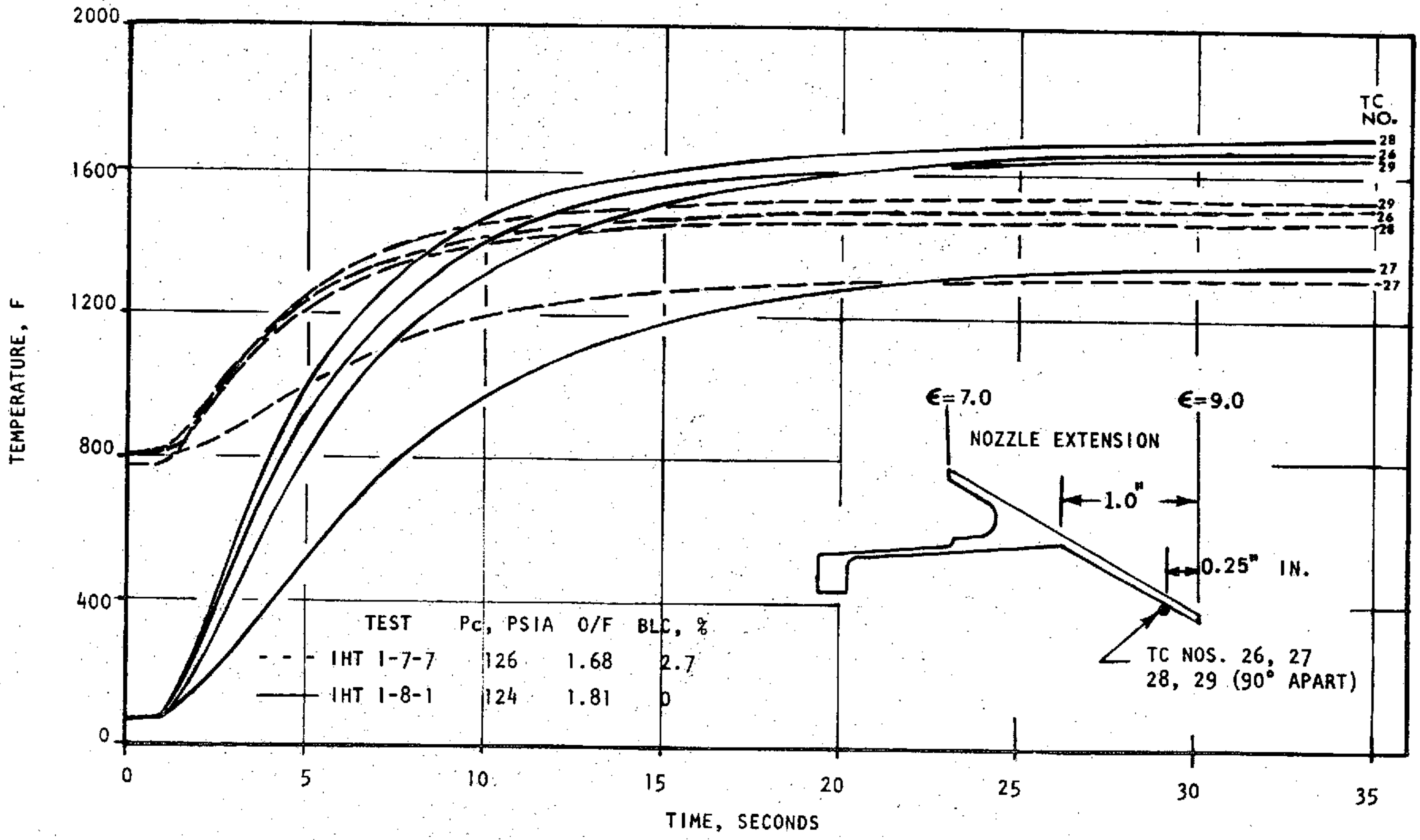


FIGURE 56. RADIATION COOLED NOZZLE TEMPERATURE TRANSIENTS

for a full-size columbium nozzle are, therefore, 1800 F and 1630 F without and with BLC, respectively. The latter value compares favorably with the 1700 F predicted based on theoretical extrapolation of the CRES heat sink nozzle test results as discussed in the Phase 1 data dump. The slightly lower temperature achieved by the columbium nozzle is due to the high emittance ($\approx$0.9) coating utilized for oxidation protection.

The most significant conclusion to be drawn from the columbium radiation cooled nozzle tests, in conjunction with the previous CRES heat sink nozzle tests, is that the use of a refractory material is unnecessary at the current attach point with or without supplemental BLC. The use of an L-605 type nozzle extension appears quite feasible which should result in considerable cost saving. Alternatievely, the columbium nozzle could be attached at a lower area ratio ($\approx$3:1) with an attendant reduction in engine weight and regenerative coolant bulk temperature rise ($\approx$20 F).

Safety Factor and Fatigue Life

A primary purpose of the OME Reusable Thrust Chamber Test program (both chamber and heated tube tests) was to obtain data which would improve estimation of the OME regenerative coolant safety factor profile and, indirectly, fatigue life capability. This was accomplished t modifying the analytical models to fit the thermal data and then utilizing these models to predict heat flux and wall temperature profiles.

The resulting predicted heat flux profiles at nominal operating conditions are presented in Fig. 57 with and without BLC. The film cooling model indicates a liquid film persists about 3 inches downstream of the point of impingement on the wall. The heat flux in this region is negligible since the film and regenerative coolant temperatures are nearly the same. The case without BLC indicates a nominal heat flux of 2 BTU/in-sec throughout the cylindrical combustor region.

The resulting safety factor profiles based on 2-D conduction effects is presented in Fig. 58 for current off-design conditions (Pc = 120 psia, MR = 1.73 and T_{in} = 100 F). The coolant safety factors are similar in the throat and nozzle region. There is a marked difference in safety factor in the combustor region, particularly near the injector end. The case without BLC results in a minimum safety factor of about 1.2 due to a combination of high coolant bulk temperature (reduced subcooling) and comparatively high heat flux level. The use of film coolant markedly increases the safety factor at the injector end due to greatly reduced heat flux level in the region of minimum subcooling. In addition, the maximum coolant bulk temperature is decreased which further enhances the safety margin.

It should be pointed out that the ITC was not originally designed to operate without BLC. The minimum safety factor could be raised to a value of about 1.5 simply by increasing the coolant velocity in about the last

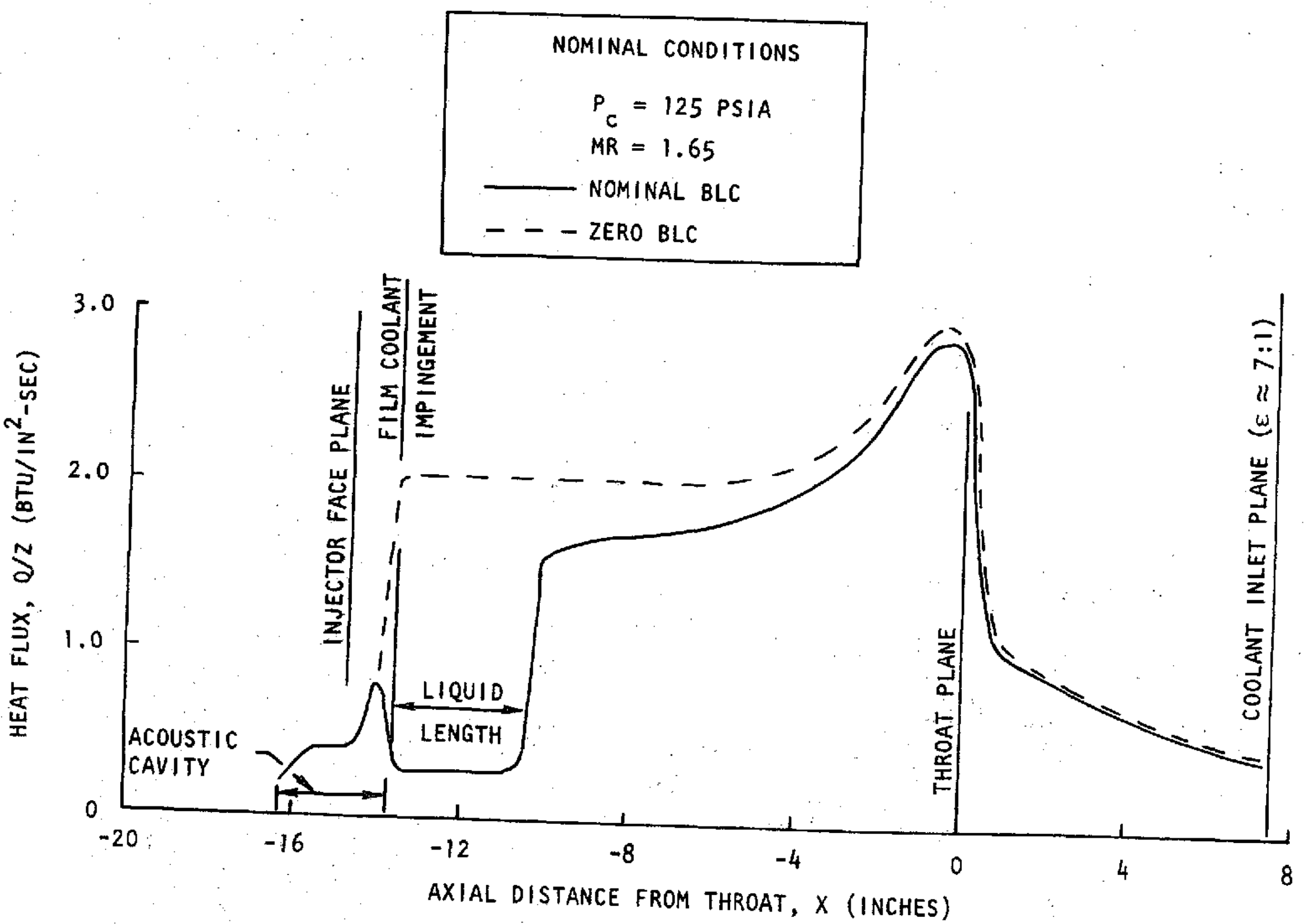


Figure 57. Integrated Thrust Chamber Heat Flux Profiles

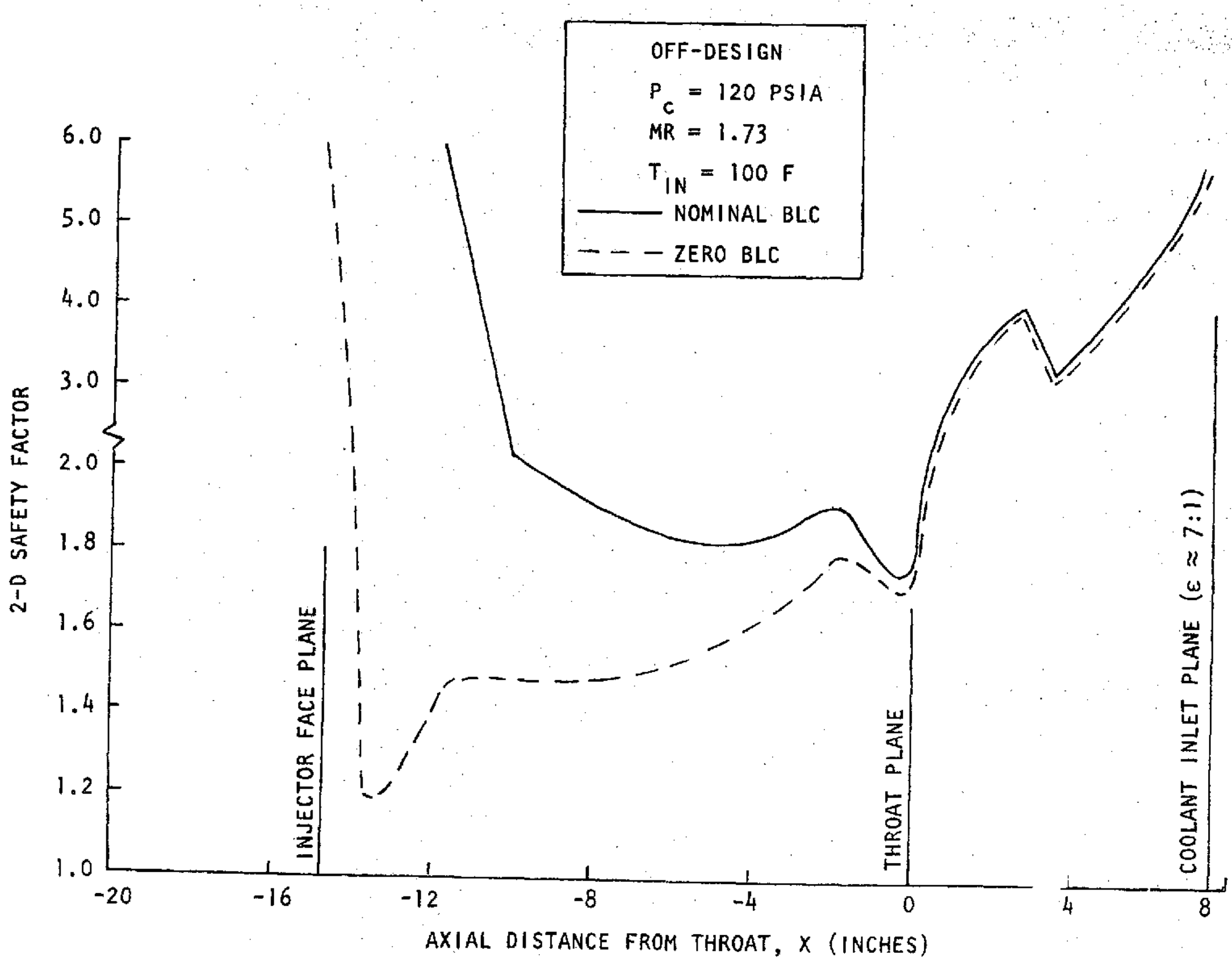


Figure 58 . Regenerative Coolant Safety Factor Profile

2 inches of the cylindrical section. This would result in an increased pressure drop of about 2 psi. Another consideration of interest is that limited electrically heated channel tests using a similar channel geometry indicated better agreement with 1-D burnout analysis. A 1-D an lysis indicates a local minimum safety factor of about 1.6.

The cyclic fatigue life profiles were calculated at minimal operating conditions using the predicted wall temperatures. The results, with and without BLC, are presented in Fig. 59. The minimum predicted life occurs in the region slightly upstream of the throat and is about 4800 and 4400 cycles for operation with and without BLC, respectively. Application of a life safety factor of 4 would indicate a life capability in excess of the required 1000 cycles for either operating condition.

The life cycle capability of the two operating conditions differs the most in the combustor region due primarily to the difference in hot wall temperatures.

It should be mentioned that a major restriction to the ITC fatigue life is due to the extremely high strength nickel ($\approx$66,000 psi yield) as electro-deposited at Rocketdyne. By simply annealing the nickel, the chamber fatigue life can be increased since the thermal load would be divided more equally between the CRES liner and nickel closeout. Life can also be increased by reducing the thickness of the nickel closeout and/or CRES liner.

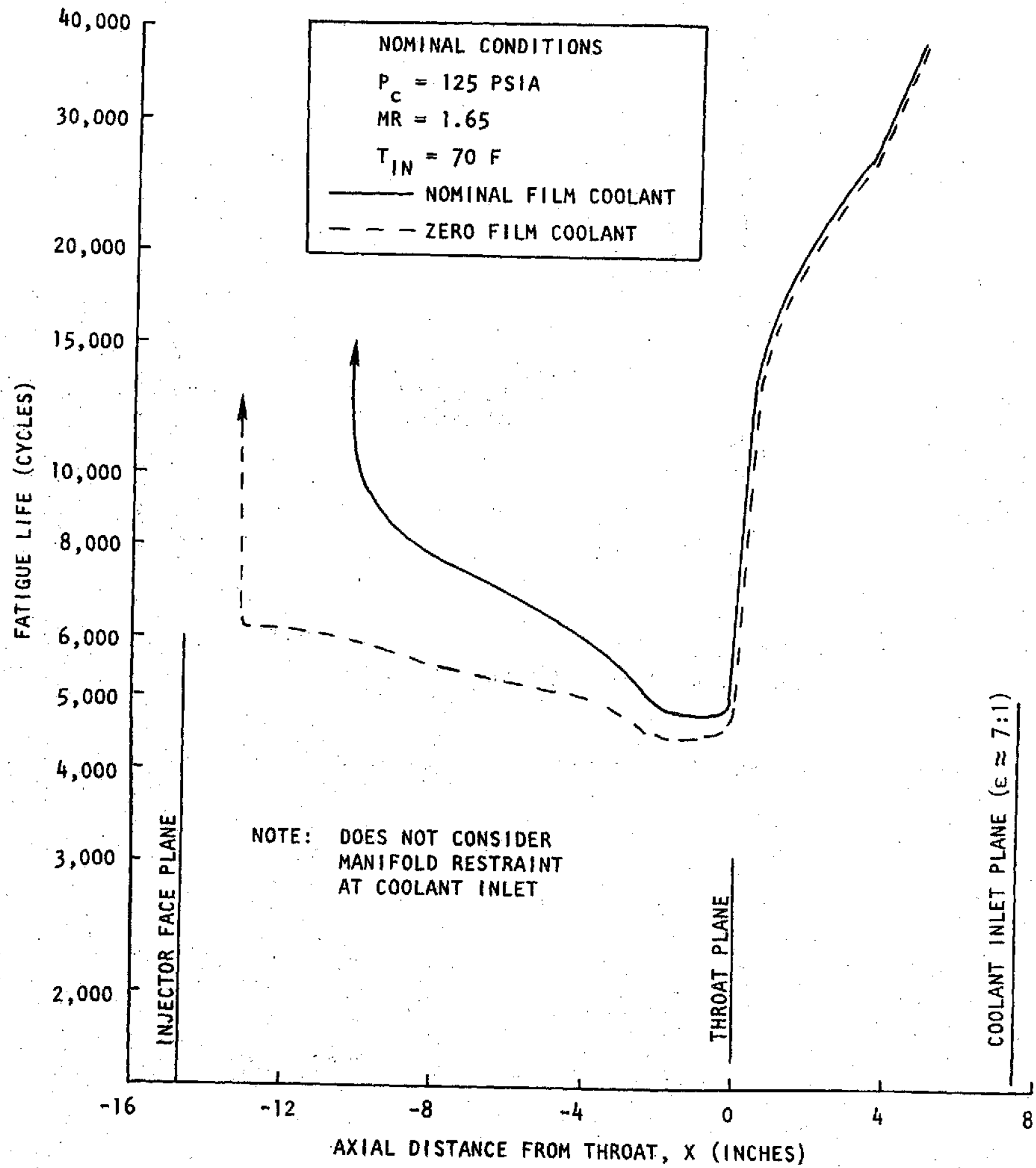


Figure 59 Predicted Fatigue Life Capability Profile

C-3

LIMITATIONS OF SIMULATION

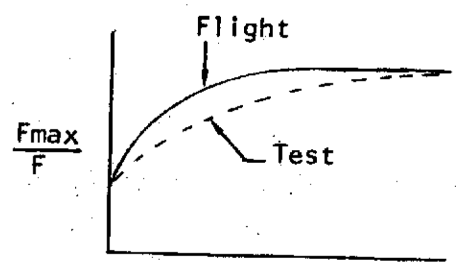
The test configurations and conditions were made to simulate, as closely as feasible, the Space Shuttle Orbit Maneuvering System and its environment. The results of the test program give valuable insights as to wl.. t might be expected in actual OMS operation. However, the simulations were limited in ways which might cause the test results to vary from flight results. Some of the limitations could be removed by additional tests, some by major facility modifications, and others only by conducting actual flight tests.

The purpose of this section is to point out these limitations and qualitatively estimate their impact on the agreement between test and flight results.

GRAVITY

The testing was, of necessity, conducted in a 1-g gravity field whereas the flight engine will experience 0-g coast periods. The oxidizer duct was arranged to provide a slight positive drain from the valve to the injector which was felt to be closest to 0-g simulation although no orientation can completely simulate 0-g with fluid coating the walls and draining by gas evolution and boiling. Little difference between test and flight results is expected although the oxidizer may be retained slightly longer and get colder in flight.

The engine fired vertically down during the test program so that fuel was retained by gravity in the coolant jacket, inlet manifold and inlet duct, after the test. Under 0-g flight conditions, complete depletion of the fuel could be considerably more rapid than after the test firings. This is particularly true for the low-heat input cases where the firing duration was 1 second or less. The effect would be to compress the acceleration and thrust overshoot vs coast time curves along the coast time axis as illustrated here schematically for a typical thrust overshoot curve. The end-points of the curves would probably not be significantly affected.



Accelerometer activity recorded after shutdown would be affected by the different propellant expulsion rates. The specific effect is not clear. However, since the posttest activity does not appear at all in thrust or injection pressures, it is likely that no problem would be encountered in this respect with the flight configuration.

AMBIENT PRESSURE

Ambient pressure was approximately 0.1 psia during the posttest vacuum soakouts and coast periods as opposed to the hard vacuum of space for the flight condition. This should have a small effect on propellant boiloff rates since the saturation pressures of the fuel and oxidizer at depletion were in excess of 0.3 and 3 psia respectively. Longer retention of the oxidizer due to gravity effects could increase the sensitivity to ambient pressure.

PROPELLANT SATURATION

Propellants will probably be saturated with helium during most of the OMS mission. The restart tests were conducted with helium saturated propellants. The throttling tests, however, were conducted with unsaturated propellants to provide baseline data. Saturating the propellants would probably limit the throttling capability although the extent of the effect is unknown.

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions are made based on the results of the Phase II tests.

1. Delaying the oxidizer valve opening signal from 0 to 100 msec after the fuel valve opening signal does not appreciably affect the start characteristics. The fuel valve signal could be delayed at least 20 msec without significant effects.

2. Unusual accelerations noted on the starts of first tests in a vacuum period are probably the result of small quantities of gas in the feed lines.

3. Oxidizer depletion occurs within 10 seconds after engine shutdown for all anticipated operating conditions. Fuel depletion times depend strongly on hardware and propellant temperatures. Over the nominal ranges of operating conditions, fuel depletion may occur from approximately 1 minute after shutdown of a long-duration test with hot fuel to 10 minutes after shutdown of a 1-second test with cold fuel. Even longer depletion times result from shorter firing durations.

4. Posttest accelerations with spikes in the order of 200-300 g's can result from low-level combustion as oxidizer dribbles out of the duct and fuel boils out of the engine. These accelerations are not harmful to the engine but can be avoided by a brief oxidizer purge at shutdown.

5. The engine does not impose any limitations on restart times. Accelerometer spikes are low for all conditions tested with simultaneously operating propellant valves . Thrust overshoots become less severe

5. (Continued)

for shorter coast periods. The overshoots exceed 100 percent of nominal thrust for restarts after long coast periods, and can probably be reduced by lengthening the propellant valve opening times.

6. The engine can probably be throttled in the blowdown mode to 65-75 psia chamber pressure with unsaturated propellants before experiencing feed system coupled instabilities. These instabilities did not enhance the heat transfer to the coolant and appear to be harmless to the engine for short-term operation.

7. Operation without boundary layer coolant, BLC, results in a 1.5 second increase in vacuum specific impulse and reduction of the regenerative cooling safety factor from 2.8 to 1.6 at nominal conditions. The engine can be operated over the entire anticipated P_c-O/F range without BLC with a minimum safety factor of 1.2 (@ P_c = 120, O/F = 1.74, T_F = 100 F). Based on previous test results, simultaneously lengthening the chamber to 16 inches and eliminating BLC would result in a vacuum I_s (ϵ = 72) of 313 sec and a safety factor of 1.4 at nominal conditions.

The test program results lead to the following recommendations.

1. Conduct further tests controling the valves (with all valves instrumented) to determine the effects of valve operating times and fuel valve signal delay on acceleration and thrust overshoot and start.

2. Verify that lower accelerations on the start of first tests can be achieved by thoroughly bleeding gases from the feed system.

3. Verify the projected 10-minute fuel depletion time for a one-second firing with 40 F fuel.

4. Determine experimentally the oxidizer purge requirements to suppress the posttest accelerations. Determine also the effects of varying the volume of the oxidizer duct between the valve and injector.

5. Verify projected blowdown throttling capabilities while minimizing facility operating time by starting tests at 100 psia chamber pressure. Determine the effects of helium saturation.

6. Analytically optimize the BLC flowrate, chamber length and coolant passage geometries based on the results of this and previous test programs with the L/D #1 injector.

APPENDIX A

TRANSIENT DATA

This appendix contains the pretest and start transient data recorded at WSTF. In general, the titles are self-explanatory. The following specific titles are further described.

Start Conditions

Test duration is the time between the start and the shutdown signals. The injector surface temperature is measured at three places on the outside of the propellant manifolds. The chamber top temperature is the value on the outside wall near the injector flange. The nozzle flange top refers to the regeneratively cooled chamber side of the regen/radiation interface flanges. The pretest temperature values may differ slightly from values presented as part of Table X in the text because of time differences when the data were taken.

Start Transient

The fire switch is the primary start signal. All times are referred to this signal, which is sometimes called out as FS1 in the table. To obtain maximum values, the analog data was sampled at the rate of 10,000 samples/sec which is certainly adequate for the pressure and thrust data but could result in maximum accelerations which are 20 percent below the actual peak value. This accuracy is adequate to indicate the trends resulting from various operating conditions.

ROCKETDYNE INTEGRATED OMS ENGINE
START TRANSIENT CHARACTERISTICS

DATE 02/22/74 SERIES RD/IHI-1 SEQUENCE 1
TEST DESCRIPTION

FIRST COMBINED ENGINE/FACILITY TEST SEQUENCE USING SIMULATED OMS FEEDLINES, RD INTEGRATED ENGINE WITH LIKE DOUBLET INJECTOR S/N 1, 72 TO 1 NOZZLE, MMH/NTO HELIUM-SATURATED AT 200 PSIA.

START CONDITIONS (T0-3 SEC)

TEST NO.	1	2	3	4
TEST DURATION	2.014	4.016	1.917	1.110
PREVIOUS COAST PERIOD, SEC	0	126.484	2799.602	84.441
FUEL INLET PRESSURE, PSIA	239.263	239.263	219.320	219.745
OXID INLET PRESSURE, PSIA	207.817	209.086	209.539	207.508
FUEL INLET TEMPERATURE, F	60.752	69.821	52.032	66.684
OXID INLET TEMPERATURE, F	60.668	68.216	54.656	69.658
INJECTOR SURFACE TEMP, F	40.410	49.668	62.535	64.907
CHAMBER TOP TEMP, F	39.559	34.694	54.546	51.174
COOLANT MANIFOLD TEMP, F	47.863	49.007	45.076	53.397
NOZZLE FLANGE TOP TEMP, F	40.952	34.805	36.854	38.391
TEST CELL PRESSURE, PSIA	.064	.065	.065	.065

START TRANSIENT

	1	2	3	4
FIRE SWITCH TIME	14 29 25.486	14 31 33.984	15 18 17.602	15 19 43.960
FUEL VALVE COMMAND, SEC	.724	.722	.720	.719
OXID VALVE COMMAND, SEC	.594	.598	.590	.595
FUEL ISOLATION START OPEN	.813	.783	.789	.793
FUEL ISOLATION FULL OPEN	.909	.903	.901	.897
FUEL ISOLATION TRAVEL TIME	.096	.120	.112	.114
FUEL SHUTOFF START OPEN	.791	.781	.789	.783
FUEL SHUTOFF FULL OPEN	.879	.875	.873	.873
FUEL SHUTOFF TRAVEL TIME	.088	.094	.084	.090
OXID ISOLATION START OPEN	.687	.663	.661	.663
OXID ISOLATION FULL OPEN	.747	.781	.755	.779
OXID ISOLATION TRAVEL TIME	.060	.118	.094	.116
OXID SHUTOFF START OPEN	.655	.661	.655	.657
OXID SHUTOFF FULL OPEN	.741	.769	.747	.763
OXID SHUTOFF TRAVEL TIME	.086	.108	.092	.106
FSI TO 10% PC, SEC	1.053	1.029	1.043	1.029
FSI TO 90% PC, SEC	1.067	1.029	1.053	1.031
MAXIMUM PC, PSIA	153.805	245.403	180.306	245.463
TIME OF MAXIMUM PC, SEC	1.071	1.029	1.057	1.031
PEAK ACCELERATION, 4006D, G	75.872	2061.925	64.714	660.530
TIME OF 4006D MAX G	1.049	1.031	.807	1.047
PEAK ACCELERATION, 4007D, G	41.343	196.737	15.572	196.737
TIME OF 4007D MAX G	1.047	1.031	1.045	1.039
PEAK ACCELERATION, 4008D, G	190.192	198.192	20.674	198.192
TIME OF 4008D MAX G	1.051	1.031	1.051	1.031
PEAK ACCELERATION, 4097D, G	173.005	180.656	27.104	163.656
TIME OF 4097D MAX G	1.049	1.031	1.045	1.031
MAXIMUM AXIAL THRUST, LBF	9192.095	19612.688	12329.918	19554.739
TIME OF MAX THRUST, SEC	1.059	1.031	1.047	1.033
THRUST OVERSHOOT, PCNT	53.202	226.878	105.499	225.912
MAXIMUM SIDELOAD -Y, LBF	174.144	240.409	160.476	232.867
MAXIMUM SIDELOAD -Z, LBF	166.145	372.182	260.775	436.785

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ROCKETDYNE INTEGRATED OMS ENGINE
START TRANSIENT CHARACTERISTICS

DATE 02/26/74 SERIES RD/IMT-1 SEQUENCE 1

TEST DESCRIPTION

COLD-ENGINE RESTART EVALUATION WITH POST-FIRE PURGING. COOLED ENGINE WITH ISOPROPYL ALCOHOL IN REGEN JACKET AFTER TEST 11, PURGED OUT PRIOR TO PERFORMANCE VERIFICATION TEST 12.

START CONDITIONS (T0-3 SEC)

	TEST NO. 5	6	7	8	9
TEST DURATION	1.006	1.013	1.013	1.010	2.015
PREVIOUS COAST PERIOD, SEC	0	64.480	65.086	63.730	63.894
FUEL INLET PRESSURE, PSIA	221.442	221.442	221.666	221.666	221.442
OXID INLET PRESSURE, PSIA	209.245	209.668	209.245	210.090	210.090
FUEL INLET TEMPERATURE, F	58.550	64.988	67.023	68.379	69.482
OXID INLET TEMPERATURE, F	61.721	67.576	70.038	70.208	71.565
INJECTOR SURFACE TEMP, F	46.261	48.867	49.966	50.964	51.661
CHAMBER TOP TEMP, F	43.940	42.484	46.847	50.715	51.681
COOLANT MANIFOLD TEMP, F	46.496	48.084	49.325	50.073	51.670
NOZZLE FLANGE TOP TEMP, F	46.067	47.091	50.164	46.575	48.112
TEST CELL PRESSURE, PSIA	.066	.066	.065	.065	.065

START TRANSIENT

	5	6	7	8	9
FIRE SWITCH TIME	15 43 42.958	15 44 48.442	15 45 54.541	15 46 59.204	15 48 4.188
FUEL VALVE COMMAND, SEC	.482	.474	.475	.478	.476
OXID VALVE COMMAND, SEC	.388	.398	.393	.390	.400
FUEL ISOLATION START OPEN	.585	.539	.543	.547	.543
FUEL ISOLATION FULL OPEN	.659	.655	.655	.657	.657
FUEL ISOLATION TRAVEL TIME	.074	.116	.112	.110	.114
FUEL SHUTOFF START OPEN	.535	.533	.539	.541	.531
FUEL SHUTOFF FULL OPEN	.629	.629	.631	.631	.629
FUEL SHUTOFF TRAVEL TIME	.094	.096	.092	.090	.098
OXID ISOLATION START OPEN	.483	.461	.465	.451	.455
OXID ISOLATION FULL OPEN	.553	.577	.573	.569	.533
OXID ISOLATION TRAVEL TIME	.070	.116	.108	.118	.078
OXID SHUTOFF START OPEN	.445	.455	.449	.457	.475
OXID SHUTOFF FULL OPEN	.519	.563	.561	.565	.579
OXID SHUTOFF TRAVEL TIME	.074	.108	.112	.108	.104
FSI TO 10% PC, SEC	.613	.791	.795	.795	.795
FSI TO 90% PC, SEC	.873	.799	.801	.801	.801
MAXIMUM PC, PSIA	154.778	183.466	183.466	185.168	185.898
TIME OF MAXIMUM PC, SEC	.845	.803	.805	.807	.807
PEAK ACCELERATION, 4006D, G	61.891	139.828	33.238	28.653	41.261
TIME OF 4006D MAX G	.805	.315	.797	.523	.657
PEAK ACCELERATION, 4007D, G	87.688	18.496	18.942	14.936	15.922
TIME OF 4007D MAX G	.807	.797	.797	.801	.797
PEAK ACCELERATION, 4008D, G	203.678	24.098	18.421	[illegible].726	18.421
TIME OF 4008D MAX G	.807	.801	.801	.801	.801
PEAK ACCELERATION, 4097D, G	78.541	37.588	35.344	31.417	33.100
TIME OF 4097D MAX G	.807	.767	.461	1.067	.795
MAXIMUM AXIAL THRUST, LBF	8492.982	12392.658	13597.844	13262.176	12958.325
TIME OF MAX THRUST, SEC	.819	.797	.799	.799	.799
THRUST OVERSHOOT, PCNT	41.550	106.544	126.631	121.036	115.972
MAXIMUM SIDELOAD -Y, LBF	146.484	190.328	233.412	236.960	238.227
MAXIMUM SIDELOAD -Z, LBF	190.325	327.300	431.529	328.702	487.623

ROCKETDYNE INTEGRATED OMS ENGINE
START TRANSIENT CHARACTERISTICS

DATE 02/26/74 SERIES RD/IHT-1 SEQUENCE 1

TEST DESCRIPTION

COLD-ENGINE RESTART EVALUATION WITH POST-FIRE PURGING. COOLED ENGINE WITH ISOPROPYL ALCOHOL IN REGEN JACKET AFTER TEST 11. PURGED OUT PRIOR TO PERFORMANCE VERIFICATION TEST 12.

START CONDITIONS (T0-3 SEC)

	TEST NO. 10	11	12
TEST DURATION	1.011	1.016	35.010
PREVIOUS COAST PERIOD, SEC	63.019	66.135	136.829
FUEL INLET PRESSURE, PSIA	221.019	220.593	221.442
OXID INLET PRESSURE, PSIA	209.668	209.668	209.245
FUEL INLET TEMPERATURE, F	70.924	71.433	71.963
OXID INLET TEMPERATURE, F	73.352	73.692	71.822
INJECTOR SURFACE TEMP, F	60.067	59.714	54.175
CHAMBER TOP TEMP, F	97.496	73.752	41.027
COOLANT MANIFOLD TEMP, F	65.137	65.178	65.290
NOZZLE FLANGE TOP TEMP, F	63.479	63.991	69.115
TEST CELL PRESSURE, PSIA	.065	.064	.064

START TRANSIENT

	10	11	12
FIRE SWITCH TIME	15 49 9.222	15 50 16.368	15 52 34.213
FUEL VALVE COMMAND, SEC	.475	.480	.480
OXID VALVE COMMAND, SEC	.394	.398	.398
FUEL ISOLATION START OPEN	.543	.547	.541
FUEL ISOLATION FULL OPEN	.653	.657	.657
FUEL ISOLATION TRAVEL TIME	.110	.110	.116
FUEL SHUTOFF START OPEN	.533	.533	.533
FUEL SHUTOFF FULL OPEN	.627	.629	.627
FUEL SHUTOFF TRAVEL TIME	.094	.096	.094
OXID ISOLATION START OPEN	.449	.455	.457
OXID ISOLATION FULL OPEN	.557	.571	.569
OXID ISOLATION TRAVEL TIME	.108	.116	.112
OXID SHUTOFF START OPEN	.469	.455	.453
OXID SHUTOFF FULL OPEN	.569	.565	.567
OXID SHUTOFF TRAVEL TIME	.100	.110	.114
FSI TO 10% PC, SEC	.795	.797	.791
FSI TO 90% PC, SEC	.803	.807	.803
MAXIMUM PC, PSIA	183.709	175.929	170.824
TIME OF MAXIMUM PC, SEC	.807	.811	.807
PEAK ACCELERATION, 4006D, G	35.538	30.946	152.436
TIME OF 4006D MAX G	.199	.071	.793
PEAK ACCELERATION, 4007D, G	17.716	16.156	55.153
TIME OF 4007D MAX G	.799	.799	.793
PEAK ACCELERATION, 4008D, G	14.830	15.641	[illegible]
TIME OF 4008D MAX G	.797	.803	.791
PEAK ACCELERATION, 4097D, G	38.710	35.905	100.982
TIME OF 4097D MAX G	.091	.079	.793
MAXIMUM AXIAL THRUST, LBF	12352.747	12261.974	10369.078
TIME OF MAX THRUST, SEC	.799	.801	.799
THRUST OVERSHOOT, PCNT	105.879	104.366	72.818
MAXIMUM SIDELOAD -Y, LBF	192.862	220.994	237.467
MAXIMUM SIDELOAD -Z, LBF	323.295	377.125	330.514

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START TRANSIENT CHARACTERISTICS

DATE 02/27/76
TEST DESCRIPTION SERIES RD/IHI-3 SEQUENCE 3

START EVALUATION WITH VARIABLE OX VALVE LEADS. SIMULTANEOUS VALVE SIGNALS TEST 4 AND SUBSEQUENT. HOT-ENGINE UNPURGED RESTARTS WITH 3 AND 2 - MINUTE COAST PERIODS.

START CONDITIONS (T0-3 SEC)

TEST NO.	1	2	3	4	5
TEST DURATION	1.015	1.015	1.015	30.003	15.014
PREVIOUS COAST PERIOD, SEC	0	63.435	63.099	62.917	185.053
FUEL INLET PRESSURE, PSIA	221.866	221.442	221.442	221.018	220.169
OXID INLET PRESSURE, PSIA	217.964	217.964	217.541	217.541	218.387
FUEL INLET TEMPERATURE, F	60.329	68.210	70.076	71.603	75.679
OXID INLET TEMPERATURE, F	61.732	73.165	76.643	75.511	81.911
INJECTOR SURFACE TEMP, F	52.388	54.586	55.181	56.977	104.900
CHAMBER TOP TEMP, F	51.174	46.828	52.138	56.392	170.457
COOLANT MANIFOLD TEMP, F	53.029	53.198	52.521	53.779	123.447
NOZZLE FLANGE TOP TEMP, F	52.724	52.724	52.723	54.772	138.831
TEST CELL PRESSURE, PSIA	.067	.066	.066	.065	.063

START TRANSIENT

TEST NO.	1	2	3	4	5
FIRE SWITCH TIME	14 51 1.893	14 52 6.343	14 53 16.457	14 54 14.389	14 57 52.445
FUEL VALVE COMMAND, SEC	.480	.476	.478	.476	.476
OXID VALVE COMMAND, SEC	.398	.394	.450	.490	.502
FUEL ISOLATION START OPEN	.569	.531	.539	.537	.531
FUEL ISOLATION FULL OPEN	.651	.651	.653	.649	.649
FUEL ISOLATION TRAVEL TIME	.082	.129	.114	.112	.114
FUEL SHUTOFF START OPEN	.537	.543	.539	.539	.541
FUEL SHUTOFF FULL OPEN	.627	.679	.629	.675	.623
FUEL SHUTOFF TRAVEL TIME	.090	.086	.090	.086	.080
OXID ISOLATION START OPEN	.469	.455	.517	.559	.555
OXID ISOLATION FULL OPEN	.551	.573	.627	.667	.669
OXID ISOLATION TRAVEL TIME	.082	.118	.110	.108	.114
OXID SHUTOFF START OPEN	.455	.451	.503	.547	.553
OXID SHUTOFF FULL OPEN	.559	.571	.621	.659	.667
OXID SHUTOFF TRAVEL TIME	.104	.120	.118	.112	.114
FSI TO 10% PC, SEC	.797	.791	.791	.791	.791
FSI TO 90% PC, SEC	.811	.801	.803	.803	.801
MAXIMUM PC, PSIA	154.535	177.388	169.851	156.966	157.695
TIME OF MAXIMUM PC, SEC	.625	.805	.809	.809	.809
PEAK ACCELERATION, 4006D, G	82.403	72.103	43.491	36.924	37.768
TIME OF 4006D MAX G	.791	.375	.673	.313	.441
PEAK ACCELERATION, 4007D, G	57.413	19.138	15.355	23.700	17.503
TIME OF 4007D MAX G	.791	.795	.795	[illegible]	.795
PEAK ACCELERATION, 4008D, G	203.731	21.981	22.213	31.915	22.444
TIME OF 4008D MAX G	.791	.675	.797	.791	.669
PEAK ACCELERATION, 4097D, G	208.549	46.531	34.198	33.076	33.976
TIME OF 4097D MAX G	.791	.119	.799	.791	.549
MAXIMUM AXIAL THRUST, LBF	7584.788	12829.738	12527.529	12304.953	13823.193
TIME OF MAX THRUST, SEC	.813	.795	.799	.795	.795
THRUST OVERSHOOT, PCNT	26.413	113.829	105.792	105.083	130.305
MAXIMUM SIDELOAD -Y, LBF	200.972	238.430	239.241	240.001	179.937
MAXIMUM SIDELOAD -Z, LBF	195.175	440.660	343.093	324.652	341.209

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

ROCKETDYNE INTEGRATED OMS ENGINE
START TRANSIENT CHARACTERISTICS

DATE 02/27/74 SERIES RD/IHI-3 SEQUENCE 3

TEST DESCRIPTION

START EVALUATION WITH VARIABLE OX VALVE LEADS. SIMULTANEOUS VALVE SIGNALS TEST 4 AND SUBSEQUENT. HOT-ENGINE UNPURGED RESTARTS WITH 3 AND 2 - MINUTE COAST PERIODS.

START CONDITIONS (T0-3 SEC) TEST NO.

	6
TEST DURATION	5.015
PREVIOUS COAST PERIOD, SEC	123.157
FUEL INLET PRESSURE, PSIA	220.593
OXID INLET PRESSURE, PSIA	217.118
FUEL INLET TEMPERATURE, F	77.124
OXID INLET TEMPERATURE, F	81.826
INJECTOR SURFACE TEMP, F	113.495
CHAMBER TOP TEMP, F	159.730
COOLANT MANIFOLD TEMP, F	130.171
NOZZLE FLANGE TOP TEMP, F	139.853
TEST CELL PRESSURE, PSIA	.063

START TRANSIENT

FIRE SWITCH TIME	15 0 10.616
FUEL VALVE COMMAND, SEC	.477
OXID VALVE COMMAND, SEC	.499
FUEL ISOLATION START OPEN	.529
FUEL ISOLATION FULL OPEN	.649
FUEL ISOLATION TRAVEL TIME	.120
FUEL SHUTOFF START OPEN	.553
FUEL SHUTOFF FULL OPEN	.625
FUEL SHUTOFF TRAVEL TIME	.072
OXID ISOLATION START OPEN	.557
OXID ISOLATION FULL OPEN	.671
OXID ISOLATION TRAVEL TIME	.114
OXID SHUTOFF START OPEN	.553
OXID SHUTOFF FULL OPEN	.667
OXID SHUTOFF TRAVEL TIME	.114
FSI TO 10% PC, SEC	.791
FSI TO 90% PC, SEC	.799
MAXIMUM PC, PSIA	171.310
TIME OF MAXIMUM PC, SEC	.803
PEAK ACCELERATION, 4006D, G	44.635
TIME OF 4006D MAX G	.497
PEAK ACCELERATION, 4007D, G	17.135
TIME OF 4007D MAX G	.795
PEAK ACCELERATION, 4008D, G	21.171
TIME OF 4008D MAX G	.795
PEAK ACCELERATION, 4097D, G	32.516
TIME OF 4097D MAX G	.445
MAXIMUM AXIAL THRUST, LBF	11876.724
TIME OF MAX THRUST, SEC	.795
THRUST OVERSHOOT, PCNT	97.945
MAXIMUM SIDELOAD -Y, LBF	195.397
MAXIMUM SIDELOAD -Z, LBF	144.810

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

ROCKETDYNE INTEGRATED OMS ENGINE
START TRANSIENT CHARACTERISTICS

DATE 28 FEB 4 SERIES 6K ONE RD/INT 1 SEQUENCE - 3

TEST DESCRIPTION

HOT-ENGINE UNPURGED RESTART TESTS WITH COAST PERIODS RANGING FROM 1 MINUTE TO 1 SECOND. 70 DEG F. MMH/NTO. SATURATED AT 200 PSIA.

START CONDITIONS (T0-3 SEC) — TEST NO.

	7	8	9	10	11
TEST DURATION	32.004	15.016	10.762	10.008	5.015
PREVIOUS COAST PERIOD, SEC	0	60.062	30.933	35.516	20.091
FUEL INLET PRESSURE, PSIA	220.169	221.018	219.745	220.593	220.169
OXID INLET PRESSURE, PSIA	215.005	214.582	212.458	210.777	213.736
FUEL INLET TEMPERATURE, F	67.745	73.778	74.883	75.989	75.987
OXID INLET TEMPERATURE, F	66.556	74.606	74.267	75.115	75.709
INJECTOR SURFACE TEMP, F	61.457	104.626	116.218	117.312	122.894
CHAMBER TOP TEMP, F	60.313	204.046	239.604	259.374	251.341
COOLANT MANIFOLD TEMP, F	62.511	100.245	100.171	107.454	105.620
NOZZLE FLANGE TOP TEMP, F	60.939	91.196	89.669	92.240	95.314
TEST CELL PRESSURE, PSIA	.078	.078	.079	.076	.098

START TRANSIENT

	7	8	9	10	11
FIRE SWITCH TIME	15 3 47.042	15 5 19.108	15 6 5.057	15 6 51.335	15 7 21.434
FUEL VALVE COMMAND, SEC	.004	.004	.002	0	.009
OXID VALVE COMMAND, SEC	.006	.006	.004	.002	0
FUEL ISOLATION START OPEN	.091	.057	.059	.057	.055
FUEL ISOLATION FULL OPEN	.179	.179	.179	.177	.179
FUEL ISOLATION TRAVEL TIME	.088	.122	.120	.120	.124
FUEL SHUTOFF START OPEN	.061	.073	.055	.059	.055
FUEL SHUTOFF FULL OPEN	.153	.153	.151	.147	.151
FUEL SHUTOFF TRAVEL TIME	.092	.080	.096	.088	.096
OXID ISOLATION START OPEN	.091	.059	.059	.057	.059
OXID ISOLATION FULL OPEN	.177	.175	.179	.173	.175
OXID ISOLATION TRAVEL TIME	.086	.116	.120	.116	.116
OXID SHUTOFF START OPEN	.055	.057	.057	.055	.057
OXID SHUTOFF FULL OPEN	.169	.171	.171	.165	.175
OXID SHUTOFF TRAVEL TIME	.114	.114	.114	.110	.118
FSI TO 10% PC, SEC	.337	.293	.273	.281	.253
FSI TO 90% PC, SEC	.341	.305	.283	.3	.265
MAXIMUM PC, PSIA	143.108	172.526	187.113	184.725	173.255
TIME OF MAXIMUM PC, SEC	.357	.309	.289	.295	.273
PEAK ACCELERATION, 4006D, G	53.830	52.604	56.123	91.625	60.702
TIME OF 4006D MAX G	1.039	.301	.113	.349	.103
PEAK ACCELERATION, 4007D, G	33.872	13.036	12.033	15.710	20.167
TIME OF 4007D MAX G	.329	.297	.279	.287	.263
PEAK ACCELERATION, 4008D, G	201.014	63.242	89.618	4.776	70.042
TIME OF 4008D MAX G	.329	.197	.285	[illegible]	.269
PEAK ACCELERATION, 4097D, G	64.225	29.915	27.042	27.342	30.423
TIME OF 4097D MAX G	.329	.099	.997	.149	1.051
MAXIMUM AXIAL THRUST, LBF	7623.651	9700.466	9409.344	11593.466	9553.057
TIME OF MAX THRUST, SEC	.343	.303	.291	.287	.265
THRUST OVERSHOOT, PCNT	27.061	61.674	56.822	93.230	59.231
MAXIMUM SIDELOAD -Y, LBF	184.499	190.328	223.528	184.246	237.723
MAXIMUM SIDELOAD -Z, LBF	191.399	232.246	237.338	300.553	186.917

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

ROCKETDYNE INTEGRATED OMS ENGINE
START TRANSIENT CHARACTERISTICS

DATE 28 FEB 4 SERIES 6K OME RD/IHT 1 SEQUENCE = 3

TEST DESCRIPTION

HOT-ENGINE UNPURGED RESTART TESTS WITH COAST PERIODS RANGING FROM 1 MINUTE TO 1 SECOND. 70 DEG F. MMH/NTO. SATURATED AT 200 PSIA.

START CONDITIONS (T0-3 SEC)

TEST NO.	12	13	14	15	16
TEST DURATION	5.017	5.017	5.019	5.000	4.839
PREVIOUS COAST PERIOD, SEC	67.590	10.039	4.913	1.975	1.151
FUEL INLET PRESSURE, PSIA	220.169	219.320	218.047	218.047	218.047
OXID INLET PRESSURE, PSIA	212.468	210.777	213.736	213.736	213.736
FUEL INLET TEMPERATURE, F	74.713	74.803	74.288	74.288	74.288
OXID INLET TEMPERATURE, F	75.964	75.625	73.673	73.673	73.673
INJECTOR SURFACE TEMP, F	121.203	127.628	128.974	128.974	128.974
CHAMBER TOP TEMP, F	217.596	238.666	224.145	224.145	224.145
COOLANT MANIFOLD TEMP, F	121.503	121.839	117.954	117.954	117.954
NOZZLE FLANGE TOP TEMP, F	133.259	134.285	131.720	131.720	131.720
TEST CELL PRESSURE, PSIA	.104	.114	.146	.146	.146

START TRANSIENT

TEST NO.	12	13	14	15	16
FIRE SWITCH TIME	15 8 34.039	15 8 49.095	15 8 59.025	15 9 6.019	15 9 12.170
FUEL VALVE COMMAND, SEC	.006	.002	.002	.006	.002
OXID VALVE COMMAND, SEC	.002	.004	.004	.002	.004
FUEL ISOLATION START OPEN	.055	.051	.053	.053	.053
FUEL ISOLATION FULL OPEN	.181	.175	.177	.179	.177
FUEL ISOLATION TRAVEL TIME	.126	.124	.124	.126	.124
FUEL SHUTOFF START OPEN	.055	.053	.053	.051	.051
FUEL SHUTOFF FULL OPEN	.157	.151	.155	.159	.159
FUEL SHUTOFF TRAVEL TIME	.102	.098	.102	.108	.108
OXID ISOLATION START OPEN	.059	.057	.061	.065	.065
OXID ISOLATION FULL OPEN	.179	.173	.179	.181	.179
OXID ISOLATION TRAVEL TIME	.120	.116	.118	.116	.114
OXID SHUTOFF START OPEN	.057	.055	.059	.061	.061
OXID SHUTOFF FULL OPEN	.181	.173	.179	.183	.179
OXID SHUTOFF TRAVEL TIME	.124	.116	.120	.122	.118
FSI TO 10% PC, SEC	.227	.221	.215	.205	.179
FSI TO 90% PC, SEC	.239	.233	.229	.221	.209
MAXIMUM PC, PSIA	216.531	217.018	207.779	206.320	208.022
TIME OF MAXIMUM PC, SEC	.245	.239	.237	.229	.217
PEAK ACCELERATION, 40060, G	392.842	82.462	122.548	473.014	74.945
TIME OF 40060 MAX G	.065	.219	.227	.223	.177
PEAK ACCELERATION, 40070, G	159.554	39.331	89.248	87.354	56.267
TIME OF 40070 MAX G	.215	.219	.225	.219	.199
PEAK ACCELERATION, 40080, G	201.814	201.814	201.814	201.814	201.814
TIME OF 40080 MAX G	.215	.205	.211	.199	.195
PEAK ACCELERATION, 40970, G	532.958	49.577	80.000	121.127	105.915
TIME OF 40970 MAX G	.215	.221	.227	.219	.183
MAXIMUM AXIAL THRUST, LBF	12355.399	11860.887	11566.108	11081.747	11084.876
TIME OF MAX THRUST, SEC	.247	.241	.237	.229	.219
THRUST OVERSHOOT, PCNT	105.923	97.815	92.768	84.576	84.740
MAXIMUM SIDELOAD -Y, LBF	239.241	239.494	241.268	241.268	241.269
MAXIMUM SIDELOAD -Z, LBF	226.678	203.137	272.975	284.041	326.241

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REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

ROCKETDYNE INTEGRATED OMS ENGINE
START TRANSIENT CHARACTERISTICS

DATE 28 FEB 4 SERIES 6K ONE RO/IHT 1 SEQUENCE = 3

TEST DESCRIPTION

HOT-ENGINE UNPURGED RESTART TESTS WITH COAST PERIODS RANGING FROM 1 MINUTE TO 1 SECOND. 70 DEG F. MMH/NTO. SATURATED AT 200 PSIA.

START CONDITIONS (T0-3 SEC)

	TEST NO. 17
TEST DURATION	4.985
PREVIOUS COAST PERIOD, SEC	1.171
FUEL INLET PRESSURE, PSIA	218.047
OXID INLET PRESSURE, PSIA	213.736
FUEL INLET TEMPERATURE, F	74.288
OXID INLET TEMPERATURE, F	73.673
INJECTOR SURFACE TEMP, F	128.974
CHAMBER TOP TEMP, F	224.145
COOLANT MANIFOLD TEMP, F	117.954
NOZZLE FLANGE TOP TEMP, F	131.720
TEST CELL PRESSURE, PSIA	.146

START TRANSIENT

FIRE SWITCH TIME	15 9 18.180
FUEL VALVE COMMAND, SEC	.002
OXID VALVE COMMAND, SEC	.004
FUEL ISOLATION START OPEN	.049
FUEL ISOLATION FULL OPEN	.175
FUEL ISOLATION TRAVEL TIME	.126
FUEL SHUTOFF START OPEN	.049
FUEL SHUTOFF FULL OPEN	.155
FUEL SHUTOFF TRAVEL TIME	.106
OXID ISOLATION START OPEN	.063
OXID ISOLATION FULL OPEN	.175
OXID ISOLATION TRAVEL TIME	.112
OXID SHUTOFF START OPEN	.057
OXID SHUTOFF FULL OPEN	.177
OXID SHUTOFF TRAVEL TIME	.120
FSI TO 10% PC, SEC	.179
FSI TO 90% PC, SEC	.207
MAXIMUM PC, PSIA	207.049
TIME OF MAXIMUM PC, SEC	.213
PEAK ACCELERATION, 4006D, G	76.736
TIME OF 4006D MAX G	.197
PEAK ACCELERATION, 4007D, G	51.142
TIME OF 4007D MAX G	.197
PEAK ACCELERATION, 4008D, G	201.814
TIME OF 4008D MAX G	.179
PEAK ACCELERATION, 4097D, G	56.901
TIME OF 4097D MAX G	.175
MAXIMUM AXIAL THRUST, LBF	10945.664
TIME OF MAX THRUST, SEC	.217
THRUST OVERSHOOT, PCNT	82.428
MAXIMUM SIDELOAD -Y, LBF	234.172
MAXIMUM SIDELOAD -Z, LBF	256.617

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

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ROCKETDYNE INTEGRATED OMS ENGINE
START TRANSIENT CHARACTERISTICS

DATE 03/01/74 SERIES RD/IHT-1 SEQUENCE 3

TEST DESCRIPTION

MINIMUM DURATION FIRING FOR POST-TEST ENGINE THERMAL EVALUATION. DATA TAPE MALFUNCTIONED, PURGED ENGINE, REPEATED AS - 18A AFTER 10 MIN. COAST.

START CONDITIONS (T0-3 SEC)	TEST NO. 18	18A
TEST DURATION	.417	.406
PREVIOUS COAST PERIOD, SEC	0	1121.518
FUEL INLET PRESSURE, PSIA	220.444	220.869
OXID INLET PRESSURE, PSIA	214.582	214.582
FUEL INLET TEMPERATURE, F	52.878	53.894
OXID INLET TEMPERATURE, F	63.039	65.751
INJECTOR SURFACE TEMP, F	59.967	44.649
CHAMBER TOP TEMP, F	58.392	39.073
COOLANT MANIFOLD TEMP, F	60.751	51.898
NOZZLE FLANGE TOP TEMP, F	56.889	49.151
TEST CELL PRESSURE, PSIA	.067	.067

START TRANSIENT

	18	18A
FIRE SWITCH TIME	13 35 8.768	13 53 50.703
FUEL VALVE COMMAND, SEC	.002	.002
OXID VALVE COMMAND, SEC	.004	.004
FUEL ISOLATION START OPEN	.119	.059
FUEL ISOLATION FULL OPEN	.187	.195
FUEL ISOLATION TRAVEL TIME	.068	.136
FUEL SHUTOFF START OPEN	.063	.079
FUEL SHUTOFF FULL OPEN	.153	.163
FUEL SHUTOFF TRAVEL TIME	.090	.084
OXID ISOLATION START OPEN	.085	.059
OXID ISOLATION FULL OPEN	.175	.175
OXID ISOLATION TRAVEL TIME	.090	.116
OXID SHUTOFF START OPEN	.055	.061
OXID SHUTOFF FULL OPEN	.173	.177
OXID SHUTOFF TRAVEL TIME	.118	.116
FSI TO 10% PC, SEC	.341	.335
FSI TO 90% PC, SEC	.3[illegible]1	.3[illegible]3
MAXIMUM PC, PSIA	150.401	171.553
TIME OF MAXIMUM PC, SEC	.355	.347
PEAK ACCELERATION, 4006D, G	65.876	1453.733
TIME OF 4006D MAX G	.215	.215
PEAK ACCELERATION, 4007D, G	19.430	186.377
TIME OF 4007D MAX G	.341	.213
PEAK ACCELERATION, 4008D, G	193.536	198.165
TIME OF 4008D MAX G	.249	.213
PEAK ACCELERATION, 4097D, G	27.416	1040.713
TIME OF 4097D MAX G	.039	.215
MAXIMUM AXIAL THRUST, LBF	9041.539	11076.904
TIME OF MAX THRUST, SEC	.343	.339
THRUST OVERSHOOT, PCNT	50.692	84.615
MAXIMUM SIDELOAD -Y, LBF	218.966	247.351
MAXIMUM SIDELOAD -Z, LBF	261.927	333.273

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REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

ROCKETDYNE INTEGRATED OMS ENGINE
START TRANSIENT CHARACTERISTICS

DATE 87 MAR 4 SERIES 6K OME RV/INT 1 SEQUENCE = 3

TEST DESCRIPTION

OXIDIZER INJECTOR COLD FLOW INVESTIGATION OF HARD OX PRIMING SEEN ON TEST 19A. NO FUEL VALVE OPERATION. NO FIRING INTENDED.

START CONDITIONS (T0-3 SEC)	TEST NO. 188 -1	188 -2	188 -3	188 -4	188 -5
TEST DURATION	.514	.516	.508	.517	.539
PREVIOUS COAST PERIOD, SEC	0	62.379	115.641	139.727	115.492
FUEL INLET PRESSURE, PSIA	221.294	221.294	221.294	221.294	221.294
OXID INLET PRESSURE, PSIA	214.735	214.312	214.312	213.[illegible]	213.[illegible]
FUEL INLET TEMPERATURE, F	69.462	69.227	69.143	68.973	68.[illegible]
OXID INLET TEMPERATURE, F	65.921	69.971	80.915	72.791	75.764
INJECTOR SURFACE TEMP, F	63.657	61.271	56.693	53.[illegible]	49.247
CHAMBER TOP TEMP, F	61.751	57.432	45.761	42.955	34.101
COOLANT MANIFOLD TEMP, F	65.214	64.878	64.205	63.532	63.531
NOZZLE FLANGE TOP TEMP, F	64.527	64.015	62.989	62.477	61.764
TEST CELL PRESSURE, PSIA	.676	.566	.064	.064	.064

START TRANSIENT	188 -1	188 -2	188 -3	188 -4	188 -5
FIRE SWITCH TIME	15 12 16.395	15 13 13.2[illegible]6	15 15 9.445	15 16 59.6[illegible]8	15 18 55.6[illegible]9
FUEL VALVE COMMAND, SEC	0	0	0	0	0
OXID VALVE COMMAND, SEC	0	0	.004	0	.002
FUEL ISOLATION START OPEN	0	0	0	0	0
FUEL ISOLATION FULL OPEN	0	0	0	0	0
FUEL ISOLATION TRAVEL TIME	0	0	0	0	0
FUEL SHUTOFF START OPEN	0	0	0	0	0
FUEL SHUTOFF FULL OPEN	0	0	0	0	0
FUEL SHUTOFF TRAVEL TIME	0	0	0	0	0
OXID ISOLATION START OPEN	.095	.061	.067	.065	.063
OXID ISOLATION FULL OPEN	.179	.177	.179	.179	.179
OXID ISOLATION TRAVEL TIME	.084	.116	.112	.114	.116
OXID SHUTOFF START OPEN	.057	.059	.059	.057	.059
OXID SHUTOFF FULL OPEN	.171	.173	.175	.175	.17[illegible]
OXID SHUTOFF TRAVEL TIME	.114	.114	.116	.118	.120
FSI TO 10% PC, SEC	-N/A-	-N/A-	-N/A-	-N/A-	-N/A-
FSI TO 90% PC, SEC	-N/A-	-N/A-	-N/A-	-N/A-	-N/A-
MAXIMUM PC, PSIA	4.038	4.038	4.402	4.766	4.038
TIME OF MAXIMUM PC, SEC	.283	.257	.427	.297	.475
PEAK ACCELERATION, 40060, G	81.394	41.254	91.429	50.174	65.784
TIME OF 40060 MAX G	1.007	.197	1.035	.679	.137
PEAK ACCELERATION, 40070, G	4.671	5.431	5.974	4.779	6.409
TIME OF 40070 MAX G	.[illegible]69	.157	.969	1.073	1.385
PEAK ACCELERATION, 40080, G	10.021	11.035	10.922	22.407	18.578
TIME OF 40080 MAX G	1.007	.235	.261	.24[illegible]	.241
PEAK ACCELERATION, 40090, G	30.790	32.990	30.488	34.039	32.442
TIME OF 40090 MAX G	.737	.279	.969	.129	.471
MAXIMUM AXIAL THRUST, LBF	498.672	524.055	486.362	473.654	441.139
TIME OF MAX THRUST, SEC	.291	.261	.267	.263	.263
THRUST OVERSHOOT, PCNT	-91.689	-91.266	-91.694	-92.106	-92.649
MAXIMUM SIDELOAD -Y, LBF	197.684	148.832	142.504	152.376	171.866
MAXIMUM SIDELOAD -Z, LBF	202.650	124.560	164.518	136.825	153.353

ROCKETDYNE INTEGRATED OMS ENGINE
START TRANSIENT CHARACTERISTICS

DATE 07 MAR 4 SERIES 6K ONE RD/IHT 1 SEQUENCE - 3

TEST DESCRIPTION

OXIDIZER INJECTOR COLD FLOW INVESTIGATION OF HARD OX PRIMING SEEN ON TEST 1AA. NO FUEL VALVE OPERATION.
NO FIRING INTENDED.

START CONDITIONS (T0-3 SEC) TEST NO.

	180 -6
TEST DURATION	.515
PREVIOUS COAST PERIOD, SEC	129.586
FUEL INLET PRESSURE, PSIA	221.794
OXID INLET PRESSURE, PSIA	213.590
FUEL INLET TEMPERATURE, F	63.719
OXID INLET TEMPERATURE, F	99.046
INJECTOR SURFACE TEMP, F	45.669
CHAMBER TOP TEMP, F	33.231
COOLANT MANIFOLD TEMP, F	62.523
NOZZLE FLANGE TOP TEMP, F	61.452
TEST CELL PRESSURE, PSIA	.064

START TRANSIENT

FIRE SWITCH TIME	15 21 5.784
FUEL VALVE COMMAND, SEC	0
OXID VALVE COMMAND, SEC	.604
FUEL ISOLATION START OPEN	0
FUEL ISOLATION FULL OPEN	0
FUEL ISOLATION TRAVEL TIME	0
FUEL SHUTOFF START OPEN	0
FUEL SHUTOFF FULL OPEN	0
FUEL SHUTOFF TRAVEL TIME	0
OXID ISOLATION START OPEN	.067
OXID ISOLATION FULL OPEN	.181
OXID ISOLATION TRAVEL TIME	.114
OXID SHUTOFF START OPEN	.055
OXID SHUTOFF FULL OPEN	.175
OXID SHUTOFF TRAVEL TIME	.120
FS1 TO 10% PC, SEC	-N/A-
FS1 TO 90% PC, SEC	-N/A-
MAXIMUM PC, PSIA	4.402
TIME OF MAXIMUM PC, SEC	.275
PEAK ACCELERATION, 4066D, G	82.279
TIME OF 4066D MAX G	.081
PEAK ACCELERATION, 4067D, G	4.319
TIME OF 4067D MAX G	.949
PEAK ACCELERATION, 4068D, G	12.273
TIME OF 4068D MAX G	.743
PEAK ACCELERATION, 4070D, G	25.947
TIME OF 4070D MAX G	.893
MAXIMUM AXIAL THRUST, LBF	441.246
TIME OF MAX THRUST, SEC	.659
THRUST OVERSHOOT, PCNT	-92.646
MAXIMUM SIDELOAD -Y, LBF	165.285
MAXIMUM SIDELOAD -Z, LBF	156.659

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ROCKETDYNE INTEGRATED OMS ENGINE
START TRANSIENT CHARACTERISTICS

DATE 77 MAR 4 SERIES 6K OME R2/INT 1 SEQUENCE = 3

TEST DESCRIPTION

SHORT DURATION FIRING ON WARM ENGINE FOLLOWED BY 30-MINUTE SOAK. PROTOTYPE FOR COLD-ENGINE RESTARTS OF SEQUENCE 4.

START CONDITIONS (T0-3 SEC) TEST NO.

	13C
TEST DURATION	1.217
PREVIOUS COAST PERIOD, SEC	0
FUEL INLET PRESSURE, PSIA	221.294
OXID INLET PRESSURE, PSIA	214.312
FUEL INLET TEMPERATURE, F	69.991
OXID INLET TEMPERATURE, F	68.125
INJECTOR SURFACE TEMP, F	53.598
CHAMBER TOP TEMP, F	54.065
COOLANT MANIFOLD TEMP, F	69.452
NOZZLE FLANGE TOP TEMP, F	69.654
TEST CELL PRESSURE, PSIA	.067

START TRANSIENT

FIRE SWITCH TIME	15 59 31.383
FUEL VALVE COMMAND, SEC	.004
OXID VALVE COMMAND, SEC	.006
FUEL ISOLATION START OPEN	.091
FUEL ISOLATION FULL OPEN	.189
FUEL ISOLATION TRAVEL TIME	.098
FUEL SHUTOFF START OPEN	.063
FUEL SHUTOFF FULL OPEN	.155
FUEL SHUTOFF TRAVEL TIME	.092
OXID ISOLATION START OPEN	.063
OXID ISOLATION FULL OPEN	.181
OXID ISOLATION TRAVEL TIME	.118
OXID SHUTOFF START OPEN	.061
OXID SHUTOFF FULL OPEN	.179
OXID SHUTOFF TRAVEL TIME	.118
FS1 TO 10% PC, SEC	.341
FS1 TO 90% PC, SEC	.3[illegible]3
MAXIMUM PC, PSIA	160.913
TIME OF MAXIMUM PC, SEC	.359
PEAK ACCELERATION, 4006D, G	78.549
TIME OF 4006D MAX G	.333
PEAK ACCELERATION, 4007D, G	35.497
TIME OF 4007D MAX G	.335
PEAK ACCELERATION, 4008D, G	195.946
TIME OF 4008D MAX G	.333
PEAK ACCELERATION, 4097D, G	56.632
TIME OF 4097D MAX G	.333
MAXIMUM AXIAL THRUST, LBF	9960.202
TIME OF MAX THRUST, SEC	.347
THRUST OVERSHOOT, PCNT	66.003
MAXIMUM SIDELOAD =Y, LBF	119.724
MAXIMUM SIDELOAD =Z, LBF	267.605

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

ROCKETDYNE INTEGRATED OMS ENGINE
START TRANSIENT CHARACTERISTICS

DATE 08 MAR 4 SERIES 6K OME RO/INT 1 SEQUENCE - 3

TEST DESCRIPTION

EVALUATION OF HOT-ENGINE RESTART CHARACTERISTICS WITH COAST PERIODS OF 15 AND 20 SECONDS. RO INTEGRATED HARDWARE, SIMULATED OMS FEEDLINES. 70 + OR - 10 DEG F MMH/NTO SATURATED AT 200 PSIA.

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

START CONDITIONS (T0-3 SEC)

	TEST NO. 19	20	21	22	23
TEST DURATION	32.010	10.605	10.013	5.013	5.013
PREVIOUS COAST PERIOD, SEC	0	24.960	24.252	17.962	18.486
FUEL INLET PRESSURE, PSIA	220.444	221.294	220.444	219.594	219.594
OXID INLET PRESSURE, PSIA	215.157	218.113	216.001	214.312	213.468
FUEL INLET TEMPERATURE, F	71.603	73.725	74.405	74.465	75.169
OXID INLET TEMPERATURE, F	69.944	77.237	77.152	76.049	76.898
INJECTOR SURFACE TEMP, F	68.993	114.673	120.644	120.262	127.340
CHAMBER TOP TEMP, F	67.973	297.117	256.512	233.510	255.152
COOLANT MANIFOLD TEMP, F	71.274	90.121	96.965	94.041	98.155
NOZZLE FLANGE TOP TEMP, F	68.116	79.408	85.565	84.030	89.672
TEST CELL PRESSURE, PSIA	.071	.091	.089	.104	.100
START TRANSIENT					
FIME SWITCH TIME	15 31 41.614	15 32 38.584	15 33 12.841	15 33 40.756	15 34 3.855
FUEL VALVE COMMAND, SEC	.004	.002	.004	0	.004
OXID VALVE COMMAND, SEC	0	.004	.006	.004	.006
FUEL ISOLATION START OPEN	.097	.061	.059	.055	.057
FUEL ISOLATION FULL OPEN	.183	.183	.189	.179	.185
FUEL ISOLATION TRAVEL TIME	.086	.122	.126	.124	.128
FUEL SHUTOFF START OPEN	.057	.069	.071	.067	.065
FUEL SHUTOFF FULL OPEN	.153	.155	.159	.155	.155
FUEL SHUTOFF TRAVEL TIME	.096	.086	.088	.088	.090
OXID ISOLATION START OPEN	.059	.051	.051	.051	.051
OXID ISOLATION FULL OPEN	.163	.167	.169	.163	.163
OXID ISOLATION TRAVEL TIME	.104	.116	.118	.112	.112
OXID SHUTOFF START OPEN	.049	.061	.075	.075	.079
OXID SHUTOFF FULL OPEN	.141	.163	.165	.161	.163
OXID SHUTOFF TRAVEL TIME	.092	.102	.090	.086	.084
FSI TO 10% PC, SEC	.341	.263	.261	.241	.247
FSI TO 90% PC, SEC	.363	.281	.279	.259	.267
MAXIMUM PC, PSIA	157.491	154.203	154.203	163.337	164.798
TIME OF MAXIMUM PC, SEC	.363	.287	.265	.261	.271
PEAK ACCELERATION, 40060, G	60.702	38.941	36.650	42.377	33.941
TIME OF 40060 MAX G	.335	.225	.267	.991	1.059
PEAK ACCELERATION, 40070, G	29.172	7.905	20.621	12.502	16.706
TIME OF 40070 MAX G	.333	.269	.267	.255	.259
PEAK ACCELERATION, 40080, G	202.421	39.308	78.386	56.945	21.326
TIME OF 40080 MAX G	.333	.259	.265	.261	.259
PEAK ACCELERATION, 40970, G	34.831	30.337	30.337	32.022	35.393
TIME OF 40970 MAX G	.333	.469	.027	.497	.191
MAXIMUM AXIAL THRUST, LBF	8637.249	9727.608	10946.690	10315.199	10211.091
TIME OF MAX THRUST, SEC	.355	.271	.269	.253	.261
THRUST OVERSHOOT, PCNT	43.954	62.127	82.478	71.920	70.185
MAXIMUM SIDELOAD -Y, LBF	118.711	169.335	202.746	174.144	248.307
MAXIMUM SIDELOAD -Z, LBF	220.533	226.428	239.292	268.327	242.512

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REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

ROCKETDYNE INTEGRATED OMS ENGINE
START TRANSIENT CHARACTERISTICS

DATE 15 MAR 4 SERIES 6K ONE RD/IMT 1 SEQUENCE = 3

TEST DESCRIPTION

CONTINUATION OF HOT-ENGINE AMBIENT-PROPELLANT RESTART SEQUENCE TO EVALUATE RESTART CAPABILITIES WITH COAST PERIODS FROM 2 TO 30 SECONDS.

START CONDITIONS (T0-3 SEC) TEST NO.

	24	25	26	27	28
TEST DURATION	32.001	5.013	5.015	5.013	5.009
PREVIOUS COAST PERIOD, SEC	0	15.863	15.989	11.198	11.078
FUEL INLET PRESSURE, PSIA	220.444	219.594	219.594	219.170	219.170
OXID INLET PRESSURE, PSIA	215.546	214.275	213.427	212.156	211.309
FUEL INLET TEMPERATURE, F	55.760	71.070	71.241	71.241	71.496
OXID INLET TEMPERATURE, F	63.124	73.386	72.537	72.622	73.210
INJECTOR SURFACE TEMP, F	60.961	111.231	115.567	119.572	123.551
CHAMBER TOP TEMP, F	60.313	262.160	266.870	249.931	253.572
COOLANT MANIFOLD TEMP, F	60.505	79.061	86.619	86.687	90.615
NOZZLE FLANGE TOP TEMP, F	59.401	76.324	79.920	78.381	79.921
TEST CELL PRESSURE, PSIA	.068	.119	.107	.113	.115

START TRANSIENT

	24	25	26	27	28
FIRE SWITCH TIME	13 52 34.890	13 53 22.754	13 53 43.756	13 53 59.969	13 54 16.060
FUEL VALVE COMMAND, SEC	0	.002	.006	.002	.009
OXID VALVE COMMAND, SEC	.002	.004	.002	.004	.002
FUEL ISOLATION START OPEN	.075	.055	.057	.053	.055
FUEL ISOLATION FULL OPEN	.187	.187	.187	.185	.187
FUEL ISOLATION TRAVEL TIME	.112	.132	.130	.132	.132
FUEL SHUTOFF START OPEN	.069	.067	.067	.065	.067
FUEL SHUTOFF FULL OPEN	.157	.161	.161	.157	.157
FUEL SHUTOFF TRAVEL TIME	.088	.094	.094	.092	.090
OXID ISOLATION START OPEN	.079	.053	.053	.051	.051
OXID ISOLATION FULL OPEN	.165	.165	.165	.163	.165
OXID ISOLATION TRAVEL TIME	.086	.112	.112	.112	.114
OXID SHUTOFF START OPEN	.049	.075	.089	.077	.075
OXID SHUTOFF FULL OPEN	.151	.167	.167	.163	.163
OXID SHUTOFF TRAVEL TIME	.102	.092	.078	.086	.088
FSI TO 10% PC, SEC	.341	.241	.245	.227	.227
FSI TO 90% PC, SEC	.363	.269	.267	.245	.243
MAXIMUM PC, PSIA	160.352	165.078	154.899	168.713	170.165
TIME OF MAXIMUM PC, SEC	.367	.265	.273	.247	.245
PEAK ACCELERATION, 4006D, G	66.052	66.852	47.911	54.576	44.569
TIME OF 4006D MAX G	.333	.061	.631	.255	.595
PEAK ACCELERATION, 4007D, G	68.277	15.414	13.569	11.289	13.894
TIME OF 4007D MAX G	.333	.253	.255	.245	.239
PEAK ACCELERATION, 4008D, G	197.918	35.556	131.533	18.115	80.225
TIME OF 4008D MAX G	.333	.251	.255	.227	.239
PEAK ACCELERATION, 4097D, G	49.795	34.473	31.190	35.[illegible]	35.115
TIME OF 4097D MAX G	.333	.697	.749	.083	1.043
MAXIMUM AXIAL THRUST, LBF	8457.691	9984.344	10531.206	9891.287	10634.775
TIME OF MAX THRUST, SEC	.155	.257	.259	.245	.243
THRUST OVERSHOOT, PCNT	40.962	66.406	75.520	64.855	77.240
MAXIMUM SIDELOAD -Y, LBF	181.231	229.576	231.348	183.256	254.129
MAXIMUM SIDELOAD -Z, LBF	209.980	218.747	206.099	147.309	159.250

ROCKETDYNE INTEGRATED OMS ENGINE
START TRANSIENT CHARACTERISTICS

DATE 15 MAR 4 SERIES AK ONE H0/IMT 1 SEQUENCE = 3

TEST DESCRIPTION

CONTINUATION OF HOT-ENGINE AMBIENT-PROPELLANT RESTART SEQUENCE TO EVALUATE RESTART CAPABILITIES WITH COAST PERIODS FROM 2 TO 30 SECONDS.

START CONDITIONS (T0-3 SEC)

TEST NO.	29	30	31	32	33
TEST DURATION	5.017	5.017	5.015	5.021	[illegible]
PREVIOUS COAST PERIOD, SEC	28.924	5.257	4.837	1.813	[illegible]
FUEL INLET PRESSURE, PSIA	219.170	219.170	219.170	219.170	219.170
OXID INLET PRESSURE, PSIA	213.851	213.851	213.851	213.851	213.851
FUEL INLET TEMPERATURE, F	75.076	75.076	75.076	75.076	75.075
OXID INLET TEMPERATURE, F	76.019	76.019	76.019	76.019	76.017
INJECTOR SURFACE TEMP, F	120.134	120.134	120.134	120.134	120.134
CHAMBER TOP TEMP, F	243.827	243.827	243.827	243.827	243.827
COOLANT MANIFOLD TEMP, F	126.718	126.718	126.718	126.718	126.718
NOZZLE FLANGE TOP TEMP, F	137.878	137.878	137.078	137.678	137.878
TEST CELL PRESSURE, PSIA	.083	.083	.083	.083	.083

START TRANSIENT

	29	30	31	32	33
FIRE SWITCH TIME	13 54 49.993	13 55 .207	13 55 10.121	13 55 16.949	13 55 23.869
FUEL VALVE COMMAND, SEC	.002	.006	.004	.004	.004
OXID VALVE COMMAND, SEC	.004	.002	0	0	0
FUEL ISOLATION START OPEN	.055	.055	.053	.049	.049
FUEL ISOLATION FULL OPEN	.185	.187	.189	.181	.179
FUEL ISOLATION TRAVEL TIME	.130	.132	.136	.132	.130
FUEL SHUTOFF START OPEN	.071	.057	.061	.049	.049
FUEL SHUTOFF FULL OPEN	.151	.157	.159	.153	.153
FUEL SHUTOFF TRAVEL TIME	.080	.100	.098	.104	.104
OXID ISOLATION START OPEN	.051	.051	.051	.045	.045
OXID ISOLATION FULL OPEN	.161	.163	.163	.159	.157
OXID ISOLATION TRAVEL TIME	.110	.112	.112	.114	.112
OXID SHUTOFF START OPEN	.083	.069	.055	.051	.047
OXID SHUTOFF FULL OPEN	.163	.163	.163	.153	.153
OXID SHUTOFF TRAVEL TIME	.080	.094	.108	.102	.109
FSI TO 10% PC, SEC	.273	.211	.211	.181	.181
FSI TO 90% PC, SEC	.289	.229	.231	.213	.211
MAXIMUM PC, PSIA	152.354	305.762	172.712	173.439	175.257
TIME OF MAXIMUM PC, SEC	.295	.229	.237	.219	.215
PEAK ACCELERATION, 4006D, G	43.454	45.682	50.139	69.081	52.359
TIME OF 4006D MAX G	.629	.833	.133	.203	.159
PEAK ACCELERATION, 4007D, G	16.391	15.739	20.733	51.995	44.288
TIME OF 4007D MAX G	.275	.231	.231	.137	.137
PEAK ACCELERATION, 4008D, G	33.418	136.821	137.046	99.[illegible]	78.762
TIME OF 4008D MAX G	.277	.227	.227	.137	.029
PEAK ACCELERATION, 4097D, G	32.032	53.625	59.003	90.287	83.721
TIME OF 4097D MAX G	.363	.911	.135	.139	.135
MAXIMUM AXIAL THRUST, LBF	9894.389	10881.906	10878.681	9805.682	10283.059
TIME OF MAX THRUST, SEC	.287	.229	.229	.215	.213
THRUST OVERSHOOT, PCNT	64.906	61.305	81.311	63.428	71.394
MAXIMUM SIDELOAD -Y, LBF	225.780	234.132	230.589	221.477	185.534
MAXIMUM SIDELOAD -Z, LBF	244.315	180.822	217.885	190.997	181.690

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

ROCKETDYNE INTEGRATED OMS ENGINE
START TRANSIENT CHARACTERISTICS

DATE 20 MAR 4 SERIES 6K OME RD/INT 1 SEQUENCE = 5

TEST DESCRIPTION

HOT-ENGINE RESTART EVALUATION WITH 40 F SATURATED MMH/NTO. ROCKETDYNE REGEN CHAMBER, L/D INJECTOR S/N 1, 72 TO 1 NOZZLE. COAST PERIODS FROM 3 MINUTES TO 1 SECOND, NO POST-FIRE PURGES.

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

START CONDITIONS (T0-3 SEC)

TEST NO.	1	2	3	4	[illegible]
TEST DURATION	32.008	18.012	15.010	12.013	[illegible]
PREVIOUS COAST PERIOD, SEC	0	180.763	120.874	61.030	[illegible]
FUEL INLET PRESSURE, PSIA	220.869	220.869	221.294	220.869	[illegible]
OXID INLET PRESSURE, PSIA	215.123	215.123	215.546	215.970	[illegible]
FUEL INLET TEMPERATURE, F	45.546	43.509	44.527	44.273	[illegible]
OXID INLET TEMPERATURE, F	46.088	46.004	52.345	45.665	45.412
INJECTOR SURFACE TEMP, F	54.697	95.504	99.489	100.646	104.762
CHAMBER TOP TEMP, F	52.620	213.856	223.677	248.992	254.031
COOLANT MANIFOLD TEMP, F	50.508	76.719	85.627	74.713	72.570
NOZZLE FLANGE TOP TEMP, F	51.188	106.528	111.140	78.331	81.406
TEST CELL PRESSURE, PSIA	.070	.064	.064	.066	.070

START TRANSIENT

	1	2	3	4	
FIRE SWITCH TIME	11 13 53.597	11 17 26.368	11 19 45.254	11 21 1.294	11 21 44.366
FUEL VALVE COMMAND, SEC	0	.002	.004	.002	.004
OXID VALVE COMMAND, SEC	.002	.004	.006	.004	0
FUEL ISOLATION START OPEN	.065	.057	.057	.057	.051
FUEL ISOLATION FULL OPEN	.183	.185	.183	.183	.177
FUEL ISOLATION TRAVEL TIME	.118	.128	.126	.126	.126
FUEL SHUTOFF START OPEN	.081	.081	.087	.085	.077
FUEL SHUTOFF FULL OPEN	.169	.163	.167	.167	.165
FUEL SHUTOFF TRAVEL TIME	.088	.082	.080	.082	.088
OXID ISOLATION START OPEN	.051	.049	.049	.047	.047
OXID ISOLATION FULL OPEN	.135	.163	.167	.165	.157
OXID ISOLATION TRAVEL TIME	.084	.114	.118	.118	.110
OXID SHUTOFF START OPEN	.061	.071	.073	.077	.077
OXID SHUTOFF FULL OPEN	.143	.167	.169	.169	.169
OXID SHUTOFF TRAVEL TIME	.082	.096	.096	.092	.092
FSI TO 10% PC, SEC	.323	.315	.303	.285	.259
FSI TO 90% PC, SEC	.337	.365	.311	.293	.269
MAXIMUM PC, PSIA	158.898	138.177	182.891	198.886	193.796
TIME OF MAXIMUM PC, SEC	.343	.699	.313	.293	.269
PEAK ACCELERATION, 4006D, G	90.350	50.322	45.747	46.891	50.322
TIME OF 4006D MAX G	.315	.907	.119	.629	1.021
PEAK ACCELERATION, 4007D, G	70.393	30.689	17.120	13.842	13.933
TIME OF 4007D MAX G	.315	.313	.305	.295	.269
PEAK ACCELERATION, 4008D, G	200.518	107.165	170.014	99.223	171.858
TIME OF 4008D MAX G	.315	.195	.301	[illegible]	.269
PEAK ACCELERATION, 4097D, G	91.089	32.815	29.420	28.854	29.980
TIME OF 4097D MAX G	.315	.299	.307	.917	.269
MAXIMUM AXIAL THRUST, LBF	9012.968	9275.974	13194.882	11981.383	11681.063
TIME OF MAX THRUST, SEC	.329	.317	.307	.289	.267
THRUST OVERSHOOT, PCNT	50.216	54.600	119.915	99.690	94.684
MAXIMUM SIDELOAD -Y, LBF	143.517	155.413	239.448	265.519	251.344
MAXIMUM SIDELOAD -Z, LBF	185.015	202.443	290.410	421.646	268.533

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

ROCKETDYNE INTEGRATED OMS ENGINE
START TRANSIENT CHARACTERISTICS

DATE 20 MAR 4 SERIES 6K ONE RD/INT 1 SEQUENCE = 5

TEST DESCRIPTION

HOT-ENGINE RESTART EVALUATION WITH 40 F SATURATED MMH/NTO. ROCKETDYNE REGEN CHAMBER, L/D INJECTOR S/N 1, 72 TO 1 NOZZLE. COAST PERIODS FROM 3 MINUTES TO 1 SECOND, NO POST-FIRE PURGES.

START CONDITIONS (T0-3 SEC)

	TEST NO. 6	7	8	9	10
TEST DURATION	5.012	5.017	5.018	5.018	5.020
PREVIOUS COAST PERIOD, SEC	16.233	10.840	4.315	1.910	1.477
FUEL INLET PRESSURE, PSIA	219.594	219.170	219.170	219.170	219.170
OXID INLET PRESSURE, PSIA	213.051	213.427	213.427	213.427	213.427
FUEL INLET TEMPERATURE, F	40.791	39.347	39.347	39.347	39.347
OXID INLET TEMPERATURE, F	44.650	44.143	44.143	44.143	44.143
INJECTOR SURFACE TEMP, F	108.791	111.001	111.001	111.001	111.001
CHAMBER TOP TEMP, F	243.358	221.805	221.805	221.805	221.805
COOLANT MANIFOLD TEMP, F	74.125	76.430	76.430	76.430	76.430
NOZZLE FLANGE TOP TEMP, F	80.892	80.380	80.380	80.380	80.380
TEST CELL PRESSURE, PSIA	.104	.110	.110	.110	.110

START TRANSIENT

	6	7	8	9	10
FIRE SWITCH TIME	11 22 9.603	11 22 25.455	11 22 34.787	11 22 41.715	11 22 44.210
FUEL VALVE COMMAND, SEC	.006	.004	.002	0	.006
OXID VALVE COMMAND, SEC	.002	0	.004	-0.004	.004
FUEL ISOLATION START OPEN	.053	.053	.051	.045	.045
FUEL ISOLATION FULL OPEN	.181	.179	.175	.167	.169
FUEL ISOLATION TRAVEL TIME	.128	.126	.124	.122	.124
FUEL SHUTOFF START OPEN	.071	.069	.069	.061	.045
FUEL SHUTOFF FULL OPEN	.171	.169	.169	.165	.165
FUEL SHUTOFF TRAVEL TIME	.100	.100	.100	.104	.120
OXID ISOLATION START OPEN	.049	.049	.047	.041	.041
OXID ISOLATION FULL OPEN	.161	.165	.161	.155	.157
OXID ISOLATION TRAVEL TIME	.112	.116	.114	.114	.116
OXID SHUTOFF START OPEN	.085	.067	.055	.045	.047
OXID SHUTOFF FULL OPEN	.169	.161	.157	.151	.151
OXID SHUTOFF TRAVEL TIME	.084	.094	.102	.106	.104
FSI TO 10% PC, SEC	.237	.217	.199	.169	.163
FSI TO 90% PC, SEC	.249	.227	.217	.203	.201
MAXIMUM PC, PSIA	197.432	194.160	175.984	175.620	175.620
TIME OF MAXIMUM PC, SEC	.251	.229	.221	.207	.205
PEAK ACCELERATION, 4006D, G	46.034	45.747	46.091	69.704	82.345
TIME OF 4006D MAX G	.739	.079	.461	.081	.021
PEAK ACCELERATION, 4007D, G	19.306	19.852	25.589	31.670	44.257
TIME OF 4007D MAX G	.247	.225	.217	.053	.021
PEAK ACCELERATION, 4008D, G	154.360	115.799	61.007	146.374	102.446
TIME OF 4008D MAX G	.251	.225	.211	.049	.195
PEAK ACCELERATION, 4097D, G	32.815	42.999	53.740	83.168	65.064
TIME OF 4097D MAX G	.231	.369	.099	.055	.111
MAXIMUM AXIAL THRUST, LBF	11325.011	11462.960	11267.241	10450.383	10143.511
TIME OF MAX THRUST, SEC	.249	.227	.217	.201	.201
THRUST OVERSHOOT, PCNT	88.750	91.049	87.787	74.173	69.059
MAXIMUM SIDELOAD -Y, LBF	181.991	264.760	264.760	157.438	223.302
MAXIMUM SIDELOAD -Z, LBF	274.240	260.049	221.099	210.375	212.745

ROCKETDYNE INTEGRATED OMS ENGINE
START TRANSIENT CHARACTERISTICS

DATE 20 MAR 4   SERIES 6K OME RD/INT 1   SEQUENCE = 5

TEST DESCRIPTION

HOT-ENGINE RESTART EVALUATION WITH 40 F SATURATED MMH/NTO. ROCKETDYNE REGEN CHAMBER, L/D INJECTOR S/N 1. 72 TO 1 NOZZLE. COAST PERIODS FROM 3 MINUTES TO 1 SECOND, NO POST-FIRE PURGES.

START CONDITIONS (T0-3 SEC)

	TEST NO. 11	12	13	14
TEST DURATION	5.015	11.012	14.006	5.007
PREVIOUS COAST PERIOD, SEC	20.190	45.936	91.013	30.947
FUEL INLET PRESSURE, PSIA	218.745	221.294	220.444	219.170
OXID INLET PRESSURE, PSIA	212.156	215.123	215.123	213.051
FUEL INLET TEMPERATURE, F	43.509	48.941	53.269	46.904
OXID INLET TEMPERATURE, F	46.412	48.540	50.062	46.595
INJECTOR SURFACE TEMP, F	112.737	104.201	101.085	105.718
CHAMBER TOP TEMP, F	303.758	262.630	247.583	265.456
COOLANT MANIFOLD TEMP, F	89.609	92.826	111.625	89.318
NOZZLE FLANGE TOP TEMP, F	84.480	89.606	110.824	89.605
TEST CELL PRESSURE, PSIA	.102	.071	.065	.078

START TRANSIENT

	11	12	13	14
FIRE SWITCH TIME	11 23 13.420	11 24 4.371	11 25 46.396	11 26 31.349
FUEL VALVE COMMAND, SEC	.006	.002	.004	.002
OXID VALVE COMMAND, SEC	.002	.004	0	.004
FUEL ISOLATION START OPEN	.053	.053	.051	.051
FUEL ISOLATION FULL OPEN	.175	.179	.177	.181
FUEL ISOLATION TRAVEL TIME	.122	.126	.126	.130
FUEL SHUTOFF START OPEN	.079	.079	.083	.071
FUEL SHUTOFF FULL OPEN	.167	.163	.161	.161
FUEL SHUTOFF TRAVEL TIME	.088	.084	.078	.090
OXID ISOLATION START OPEN	.049	.049	.047	.047
OXID ISOLATION FULL OPEN	.159	.161	.159	.159
OXID ISOLATION TRAVEL TIME	.110	.112	.112	.112
OXID SHUTOFF START OPEN	.079	.085	.085	.081
OXID SHUTOFF FULL OPEN	.163	.165	.165	.169
OXID SHUTOFF TRAVEL TIME	.084	.080	.080	.088
FSI TO 10% PC, SEC	.243	.279	.279	.263
FSI TO 90% PC, SEC	.253	.287	.305	.273
MAXIMUM PC, PSIA	178.528	205.429	186.889	200.703
TIME OF MAXIMUM PC, SEC	.257	.269	.307	.277
PEAK ACCELERATION, 4006D, G	51.465	70.908	59.471	43.460
TIME OF 4006D MAX G	1.069	.189	.219	.003
PEAK ACCELERATION, 4007D, G	21.491	11.656	14.297	16.756
TIME OF 4007D MAX G	.253	.285	.301	.271
PEAK ACCELERATION, 4008D, G	178.072	107.201	89.094	182.331
TIME OF 4008D MAX G	.257	.269	.305	.273
PEAK ACCELERATION, 4097D, G	34.512	33.380	33.946	32 [illegible]49
TIME OF 4097D MAX G	.253	.017	.845	.067
MAXIMUM AXIAL THRUST, LBF	10674.973	10677.446	12120.706	12275.976
TIME OF MAX THRUST, SEC	.261	.287	.305	.271
THRUST OVERSHOOT, PCNT	77.916	77.957	102.012	104.600
MAXIMUM SIDELOAD -Y, LBF	192.115	191.609	206.568	252.610
MAXIMUM SIDELOAD -Z, LBF	302.654	328.039	420.436	230.990

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

ROCKETDYNE INTEGRATED OMS ENGINE
START TRANSIENT CHARACTERISTICS

DATE 20 MAR 4
TEST DESCRIPTION

SERIES 6K OME RD/IMT 1

SEQUENCE - 5

HOT-ENGINE RESTART EVALUATION WITH 40 F SATURATED MMH/NTO. ROCKETDYNE ROEN CHAMBER, L/D INJECTOR S/N 1, 72 TO 1 NOZZLE. COAST PERIODS FROM 3 MINUTES TO 1 SECOND. NO POST-FIRE PURGES.

START CONDITIONS (T0-3 SEC)

TEST NO.

	15
TEST DURATION	.416
PREVIOUS COAST PERIOD, SEC	0
FUEL INLET PRESSURE, PSIA	219.745
OXID INLET PRESSURE, PSIA	213.851
FUEL INLET TEMPERATURE, F	44.358
OXID INLET TEMPERATURE, F	44.989
INJECTOR SURFACE TEMP, F	62.251
CHAMBER TOP TEMP, F	59.353
COOLANT MANIFOLD TEMP, F	52.197
NOZZLE FLANGE TOP TEMP, F	52.725
TEST CELL PRESSURE, PSIA	.078

START TRANSIENT

FIRE SWITCH TIME	14 58 51.903
FUEL VALVE COMMAND, SEC	.002
OXID VALVE COMMAND, SEC	.004
FUEL ISOLATION START OPEN	.053
FUEL ISOLATION FULL OPEN	.179
FUEL ISOLATION TRAVEL TIME	.126
FUEL SHUTOFF START OPEN	.091
FUEL SHUTOFF FULL OPEN	.159
FUEL SHUTOFF TRAVEL TIME	.068
OXID ISOLATION START OPEN	.049
OXID ISOLATION FULL OPEN	.131
OXID ISOLATION TRAVEL TIME	.082
OXID SHUTOFF START OPEN	.087
OXID SHUTOFF FULL OPEN	.145
OXID SHUTOFF TRAVEL TIME	.058
FSI TO 10% PC, SEC	.317
FSI TO 90% PC, SEC	.331
MAXIMUM PC, PSIA	165.441
TIME OF MAXIMUM PC, SEC	.339
PEAK ACCELERATION, 40060, G	67.967
TIME OF 40060 MAX G	.315
PEAK ACCELERATION, 40070, G	42.065
TIME OF 40070 MAX G	.313
PEAK ACCELERATION, 40080, G	197.217
TIME OF 40080 MAX G	.313
PEAK ACCELERATION, 40970, G	46.100
TIME OF 40970 MAX G	.465
MAXIMUM AXIAL THRUST, LBF	8902.904
TIME OF MAX THRUST, SEC	.335
THRUST OVERSHOOT, PCNT	48.383
MAXIMUM SIDELOAD -Y, LBF	271.087
MAXIMUM SIDELOAD -Z, LBF	243.207

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

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REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

ROCKETDYNE INTEGRATED OMS ENGINE
START TRANSIENT CHARACTERISTICS

DATE 21 MAR 4 SERIES 6K OME RD/IHT 1 SEQUENCE = 6
TEST DESCRIPTION

COLD ENGINE RESTART EVALUATION WITH 70 F SATURATED MMH/NTO, ROCKETDYNE REGEN CHAMBER; L/D INJECTOR S/N 1, 72 TO 1 NOZZLE. COAST PERIODS FROM 3 MINUTES TO 1 SECOND, NO POST-FIRE PURGES.

START CONDITIONS (T0-3 SEC)

	TEST NO. 1	2	3	3A	4A
TEST DURATION	.418	.416	.416	.409	.417
PREVIOUS COAST PERIOD, SEC	0	180.477	120.484	55.721	15.460
FUEL INLET PRESSURE, PSIA	221.719	220.869	220.869	220.444	220.019
OXID INLET PRESSURE, PSIA	214.699	214.699	214.275	214.699	213.003
FUEL INLET TEMPERATURE, F	56.780	63.751	66.303	67.069	68.601
OXID INLET TEMPERATURE, F	58.264	64.524	99.243	79.021	73.419
INJECTOR SURFACE TEMP, F	47.280	46.170	46.374	47.278	51.171
CHAMBER TOP TEMP, F	46.828	26.876	32.743	38.101	69.407
COOLANT MANIFOLD TEMP, F	48.237	51.830	54.211	56.418	49.964
NOZZLE FLANGE TOP TEMP, F	48.095	49.119	45.033	53.212	44.017
TEST CELL PRESSURE, PSIA	.070	.062	.062	.062	.064

START TRANSIENT

	1	2	3	3A	4A
FIRE SWITCH TIME	13 57 27.667	14 0 28.582	14 2 29.462	14 3 25.599	14 3 41.468
FUEL VALVE COMMAND, SEC	.006	.006	.004	.002	.006
OXID VALVE COMMAND, SEC	.002	.002	0	.004	.002
FUEL ISOLATION START OPEN	.057	.053	.057	.065	.055
FUEL ISOLATION FULL OPEN	.177	.177	.177	.177	.181
FUEL ISOLATION TRAVEL TIME	.120	.124	.120	.112	.126
FUEL SHUTOFF START OPEN	.063	.083	.073	.069	.069
FUEL SHUTOFF FULL OPEN	.153	.157	.155	.155	.159
FUEL SHUTOFF TRAVEL TIME	.090	.074	.082	.086	.090
OXID ISOLATION START OPEN	.053	.051	.049	.051	.049
OXID ISOLATION FULL OPEN	.163	.167	.165	.165	.165
OXID ISOLATION TRAVEL TIME	.110	.116	.116	.114	.116
OXID SHUTOFF START OPEN	.051	.063	.053	.053	.053
OXID SHUTOFF FULL OPEN	.163	.167	.165	.165	.171
OXID SHUTOFF TRAVEL TIME	.112	.104	.112	.112	.118
FSI TO 10% PC, SEC	.323	.293	.287	.299	.275
FSI TO 90% PC, SEC	.335	.303	.295	.303	.287
MAXIMUM PC, PSIA	153.081	163.624	169.440	170.531	171.985
TIME OF MAXIMUM PC, SEC	.345	.309	.301	.313	.295
PEAK ACCELERATION, 4006D, G	112.775	340.675	51.689	63.436	89.280
TIME OF 4006D MAX G	.317	.191	.291	.495	.181
PEAK ACCELERATION, 4007D, G	93.609	185.509	28.925	22.320	78.690
TIME OF 4007D MAX G	.317	.191	.291	.5	.179
PEAK ACCELERATION, 4008D, G	235.011	235.011	142.285	133.539	235.011
TIME OF 4008D MAX G	.315	.191	.205	.195	.179
PEAK ACCELERATION, 4097D, G	91.160	704.420	40.884	38.122	81.215
TIME OF 4097D MAX G	.317	.193	.285	.311	.181
MAXIMUM AXIAL THRUST, LBF	7874.491	13167.555	14612.769	13527.925	12860.229
TIME OF MAX THRUST, SEC	.331	.297	.291	.303	.285
THRUST OVERSHOOT, PCNT	31.242	119.459	143.546	125.465	114.337
MAXIMUM SIDELOAD -Y, LBF	211.352	232.614	260.457	258.938	237.170
MAXIMUM SIDELOAD -Z, LBF	196.706	276.189	278.152	368.105	233.985

ROCKETDYNE INTEGRATED OMS ENGINE
START TRANSIENT CHARACTERISTICS

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

DATE 21 MAR 4 SERIES 6K OME RD/IMT 1 SEQUENCE = 6

TEST DESCRIPTION

COLD ENGINE RESTART EVALUATION WITH 70 F SATURATED MMH/NTO. ROCKETDYNE REGEN CHAMBER, L/D INJECTOR S/N 1, 72 TO 1 NOZZLE. COAST PERIODS FROM 3 MINUTES TO 1 SECOND, NO POST-FIRE PURGES.

START CONDITIONS (TO-3 SEC)

TEST NO.	5	6	7	7A	8
TEST DURATION	.415	.414	.420	.418	.422
PREVIOUS COAST PERIOD, SEC	60.617	30.919	6.162	4.725	2.083
FUEL INLET PRESSURE, PSIA	220.869	220.869	219.170	218.745	218.745
OXID INLET PRESSURE, PSIA	214.699	214.699	213.851	212.580	212.580
FUEL INLET TEMPERATURE, F	69.112	69.452	69.878	70.219	70.219
OXID INLET TEMPERATURE, F	89.321	71.554	117.278	76.558	76.558
INJECTOR SURFACE TEMP, F	50.268	62.557	52.661	55.236	55.236
CHAMBER TOP TEMP, F	42.955	58.873	77.509	102.126	102.126
COOLANT MANIFOLD TEMP, F	59.438	54.188	57.320	53.630	53.630
NOZZLE FLANGE TOP TEMP, F	49.131	49.133	47.599	44.025	44.025
TEST CELL PRESSURE, PSIA	.062	.063	.076	.080	.080

START TRANSIENT

TEST NO.	5	6	7	7A	8
FIRE SWITCH TIME	14 4 42.502	14 5 13.838	14 5 20.412	14 5 25.557	14 5 28.058
FUEL VALVE COMMAND, SEC	.006	.004	0	0	.006
OXID VALVE COMMAND, SEC	.002	0	.002	.002	.002
FUEL ISOLATION START OPEN	.055	.055	.053	.051	.055
FUEL ISOLATION FULL OPEN	.175	.177	.181	.175	.179
FUEL ISOLATION TRAVEL TIME	.120	.122	.128	.124	.124
FUEL SHUTOFF START OPEN	.071	.071	.067	.063	.055
FUEL SHUTOFF FULL OPEN	.151	.155	.161	.155	.159
FUEL SHUTOFF TRAVEL TIME	.080	.084	.094	.092	.104
OXID ISOLATION START OPEN	.049	.049	.049	.047	.049
OXID ISOLATION FULL OPEN	.161	.165	.167	.161	.165
OXID ISOLATION TRAVEL TIME	.112	.116	.118	.114	.116
OXID SHUTOFF START OPEN	.051	.057	.053	.049	.051
OXID SHUTOFF FULL OPEN	.163	.167	.171	.165	.167
OXID SHUTOFF TRAVEL TIME	.112	.110	.118	.116	.116
FSI TO 10% PC, SEC	.285	.291	.241	.223	.201
FSI TO 90% PC, SEC	.289	.299	.245	.235	.217
MAXIMUM PC, PSIA	173.075	173.439	170.894	180.709	184.708
TIME OF MAXIMUM PC, SEC	.297	.303	.255	.241	.223
PEAK ACCELERATION, 4006D, G	61.087	61.087	49.339	79.883	54.038
TIME OF 4006D MAX G	.085	1.029	.165	.173	.801
PEAK ACCELERATION, 4007D, G	27.217	26.969	26.762	33.139	17.537
TIME OF 4007D MAX G	.291	.293	.247	.173	.215
PEAK ACCELERATION, 4008D, G	133.090	216.734	31.507	226. 7	50.119
TIME OF 4008D MAX G	.191	.187	.245	.171	.213
PEAK ACCELERATION, 4097D, G	38.122	41.436	37.017	29.834	39.779
TIME OF 4097D MAX G	.277	.261	.493	.093	.211
MAXIMUM AXIAL THRUST, LBF	13803.294	14839.266	14554.951	11572.283	12559.442
TIME OF MAX THRUST, SEC	.287	.293	.245	.231	.215
THRUST OVERSHOOT, PCNT	130.055	147.321	142.583	92.871	109.324
MAXIMUM SIDELOAD -Y, LBF	266.784	268.050	236.664	267.038	240.207
MAXIMUM SIDELOAD -Z, LBF	404.053	377.146	262.797	337.935	265.324

ROCKETOYNE INTEGRATED OMS ENGINE
START TRANSIENT CHARACTERISTICS

DATE 21 MAR 4 SERIES 6K OME RD/IHT 1 SEQUENCE • 6

TEST DESCRIPTION

COLD ENGINE RESTART EVALUATION WITH 70 F SATURATED MMH/NTO. ROCKETOYNE REGEN CHAMBER: L/D INJECTOR S/N 1? 72 TO 1 NOZZLE. COAST PERIODS FROM 3 MINUTES TO 1 SECOND, NO POST-FIRE PURGES.

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

START CONDITIONS (T0-3 SEC)

	TEST NO. 9	10	11	12	12A
TEST DURATION	.416	.420	.420	.317	.315
PREVIOUS COAST PERIOD, SEC	856.056	5.079	45.115	2.544	2.963
FUEL INLET PRESSURE, PSIA	221.294	219.170	219.170	219.170	219.170
OXID INLET PRESSURE, PSIA	215.123	213.851	213.851	213.851	213.851
FUEL INLET TEMPERATURE, F	71.241	69.623	69.623	69.623	69.623
OXID INLET TEMPERATURE, F	104.914	77.492	77.492	77.492	77.492
INJECTOR SURFACE TEMP, F	65.435	66.029	66.029	66.029	66.029
CHAMBER TOP TEMP, F	56.470	73.700	73.700	73.700	73.700
COOLANT MANIFOLD TEMP, F	67.485	68.165	68.165	68.165	68.165
NOZZLE FLANGE TOP TEMP, F	70.611	71.123	71.123	71.123	71.123
TEST CELL PRESSURE, PSIA	.068	.089	.089	.089	.089

START TRANSIENT

	9	10	11	12	12A
FIRE SWITCH TIME	14 19 44.536	14 19 50.031	14 20 35.566	14 20 38.530	14 20 41.810
FUEL VALVE COMMAND, SEC	.004	.002	0	.004	.004
OXID VALVE COMMAND, SEC	0	.004	.002	0	0
FUEL ISOLATION START OPEN	.053	.051	.051	.047	.049
FUEL ISOLATION FULL OPEN	.179	.183	.179	.181	.185
FUEL ISOLATION TRAVEL TIME	.126	.132	.128	.134	.136
FUEL SHUTOFF START OPEN	.071	.067	.067	.063	.065
FUEL SHUTOFF FULL OPEN	.155	.159	.153	.161	.161
FUEL SHUTOFF TRAVEL TIME	.084	.092	.086	.098	.096
OXID ISOLATION START OPEN	.049	.049	.047	.047	.049
OXID ISOLATION FULL OPEN	.163	.165	.159	.163	.165
OXID ISOLATION TRAVEL TIME	.114	.116	.112	.116	.116
OXID SHUTOFF START OPEN	.061	.051	.051	.049	.051
OXID SHUTOFF FULL OPEN	.163	.165	.161	.163	.167
OXID SHUTOFF TRAVEL TIME	.102	.114	.110	.114	.116
FSI TO 10% PC, SEC	.325	.249	.295	.213	.211
FSI TO 90% PC, SEC	.337	.259	.303	.223	.223
MAXIMUM PC, PSIA	159.625	178.165	171.258	187.616	185.072
TIME OF MAXIMUM PC, SEC	.341	.265	.309	.229	.229
PEAK ACCELERATION, 4006D, G	77.533	75.184	131.571	61.087	55.213
TIME OF 4006D MAX G	.253	.179	.187	.065	.469
PEAK ACCELERATION, 4007D, G	173.779	77.552	45.552	34.050	28.470
TIME OF 4007D MAX G	.193	.179	.187	.221	.221
PEAK ACCELERATION, 4008D, G	235.011	235.011	211.128	41.486	27.358
TIME OF 4008D MAX G	.193	.179	.187	.221	.219
PEAK ACCELERATION, 4097D, G	183.978	53.039	40.331	.254	32.597
TIME OF 4097D MAX G	.193	.179	.187	.217	.217
MAXIMUM AXIAL THRUST, LBF	10731.113	12642.611	13180.383	15091.373	14053.911
TIME OF MAX THRUST, SEC	.329	.255	.299	.219	.219
THRUST OVERSHOOT, PCNT	78.852	110.710	119.673	151.523	134.232
MAXIMUM SIDELOAD -Y, LBF	210.846	267.038	253.369	267.038	267.038
MAXIMUM SIDELOAD -Z, LBF	283.764	328.178	331.960	304.412	289.282

ROCKETDYNE INTEGRATED OMS ENGINE
START TRANSIENT CHARACTERISTICS

DATE 21 MAR 4 SERIES 6K OME RD/IMT 1 SEQUENCE - 6

TEST DESCRIPTION

COLD ENGINE RESTART EVALUATION WITH 70 F SATURATED MMH/NTO. ROCKETDYNE REGEN CHAMBER, L/D INJECTOR S/N 1, 72 TO 1 NOZZLE. COAST PERIODS FROM 3 MINUTES TO 1 SECOND, NO POST-FIRE PURGES.

START CONDITIONS (T0-3 SEC) TEST NO.

	128	13
TEST DURATION	.300	.300
PREVIOUS COAST PERIOD, SEC	7.375	45.800
FUEL INLET PRESSURE, PSIA	219.170	219.170
OXID INLET PRESSURE, PSIA	213.851	213.851
FUEL INLET TEMPERATURE, F	69.623	69.623
OXID INLET TEMPERATURE, F	77.492	77.492
INJECTOR SURFACE TEMP, F	66.029	66.029
CHAMBER TOP TEMP, F	73.700	73.700
COOLANT MANIFOLD TEMP, F	68.165	68.165
NOZZLE FLANGE TOP TEMP, F	71.123	71.123
TEST CELL PRESSURE, PSIA	.089	.089

START TRANSIENT

FIRE SWITCH TIME	14 20 49.500	14 21 35.600
FUEL VALVE COMMAND, SEC	.068	.004
OXID VALVE COMMAND, SEC	.064	.006
FUEL ISOLATION START OPEN	.113	.051
FUEL ISOLATION FULL OPEN	.243	.181
FUEL ISOLATION TRAVEL TIME	.130	.130
FUEL SHUTOFF START OPEN	.129	.073
FUEL SHUTOFF FULL OPEN	.221	.155
FUEL SHUTOFF TRAVEL TIME	.092	.082
OXID ISOLATION START OPEN	.111	.049
OXID ISOLATION FULL OPEN	.223	.163
OXID ISOLATION TRAVEL TIME	.112	.114
OXID SHUTOFF START OPEN	.113	.053
OXID SHUTOFF FULL OPEN	.227	.165
OXID SHUTOFF TRAVEL TIME	.114	.112
FSI TO 10% PC, SEC	.293	.293
FSI TO 90% PC, SEC	.297	.303
MAXIMUM PC, PSIA	170.531	170.531
TIME OF MAXIMUM PC, SEC	.303	.307
PEAK ACCELERATION, 4006D, G	51.689	96.329
TIME OF 4006D MAX G	.011	.189
PEAK ACCELERATION, 4007D, G	16.285	34.619
TIME OF 4007D MAX G	.299	.189
PEAK ACCELERATION, 4008D, G	154.394	156.861
TIME OF 4008D MAX G	.235	.187
PEAK ACCELERATION, 4097D, G	30.307	46.961
TIME OF 4097D MAX G	.281	.187
MAXIMUM AXIAL THRUST, LBF	11772.048	14107.943
TIME OF MAX THRUST, SEC	.299	.299
THRUST OVERSHOOT, PCNT	96.201	135.132
MAXIMUM SIDELOAD -Y, LBF	267.038	267.038
MAXIMUM SIDELOAD -Z, LBF	297.466	310.212

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

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REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

ROCKETDYNE INTEGRATED OMS ENGINE
START TRANSIENT CHARACTERISTICS

DATE 27 MAR 4   SERIES 6K OME NO/IHT 1   SEQUENCE = 7

TEST DESCRIPTION

ENGINE PERFORMANCE EVALUATION WITH BLC, 9 TO 1 NOZZLE, COLD UNSATURATED FUEL. INCLUDES LOW PRESSURE "CHUGGING" CHARACTERIZATION. ALL RESTARTS ON HOT ENGINE, NO PURGES AFTER TESTS 2 THRU 5.

START CONDITIONS (T0-3 SEC)	TEST NO. 1	2	3	4	5
TEST DURATION	10.007	10.010	10.007	10.008	10.000
PREVIOUS COAST PERIOD, SEC	0	2190.747	51.051	22.921	62.764
FUEL INLET PRESSURE, PSIA	251.032	225.967	160.542	172.013	234.889
OXID INLET PRESSURE, PSIA	232.708	227.974	162.361	156.435	210.619
FUEL INLET TEMPERATURE, F	47.583	52.336	57.428	57.258	63.709
OXID INLET TEMPERATURE, F	65.455	80.295	77.152	117.799	83.612
INJECTOR SURFACE TEMP, F	57.181	90.228	111.516	124.179	118.904
CHAMBER TOP TEMP, F	56.470	83.211	254.043	265.456	284.858
COOLANT MANIFOLD TEMP, F	56.456	69.489	64.341	7[illegible].593	77.506
NOZZLE FLANGE TOP TEMP, F	57.302	70.095	60.407	70.123	66.541
TEST CELL PRESSURE, PSIA	.064	.069	.068	.089	.066

START TRANSIENT	1	2	3	4	5
FIRE SWITCH TIME	13 51 14.897	14 27 55.651	14 28 56.712	14 29 29.640	14 30 41.712
FUEL VALVE COMMAND, SEC	.002	.009	.006	.006	.002
OXID VALVE COMMAND, SEC	.084	0	.002	.002	.004
FUEL ISOLATION START OPEN	.067	.057	.055	.055	.051
FUEL ISOLATION FULL OPEN	.185	.177	.181	.183	.181
FUEL ISOLATION TRAVEL TIME	.118	.120	.126	.128	.130
FUEL SHUTOFF START OPEN	.083	.095	.085	.081	.085
FUEL SHUTOFF FULL OPEN	.165	.163	.171	.171	.161
FUEL SHUTOFF TRAVEL TIME	.082	.068	.086	.090	.076
OXID ISOLATION START OPEN	.053	.047	.051	.051	.049
OXID ISOLATION FULL OPEN	.139	.155	.157	.159	.153
OXID ISOLATION TRAVEL TIME	.086	.108	.106	.108	.104
OXID SHUTOFF START OPEN	.055	.049	.053	.053	.049
OXID SHUTOFF FULL OPEN	.137	.159	.165	.167	.163
OXID SHUTOFF TRAVEL TIME	.082	.110	.112	.114	.114
FSI TO 10% PC, SEC	.351	.351	.333	.[illegible]47	.299
FSI TO 90% PC, SEC	.361	.363	.355	.309	.357
MAXIMUM PC, PSIA	174.530	179.255	145.811	161.443	206.383
TIME OF MAXIMUM PC, SEC	.383	.375	.379	.335	.307
PEAK ACCELERATION, 4006D, G	428.153	61.554	56.864	61.324	51.289
TIME OF 4006D MAX G	.209	.419	.667	.883	1.057
PEAK ACCELERATION, 4007D, G	181.867	19.486	20.460	14.939	22.842
TIME OF 4007D MAX G	.209	.355	.343	.299	.303
PEAK ACCELERATION, 4008D, G	197.270	166.756	31.414	15.201	182.632
TIME OF 4008D MAX G	.209	.217	.343	.3	.305
PEAK ACCELERATION, 4097D, G	1054.272	39.918	37.731	39.918	41.612
TIME OF 4097D MAX G	.209	.359	.059	.973	.023
MAXIMUM AXIAL THRUST, LBF	7548.685	9635.852	6901.647	6430.464	9941.974
TIME OF MAX THRUST, SEC	.355	.353	.343	.335	.301
MAXIMUM SIDELOAD +Y, LBF	50.876	88.591	86.819	41.256	169.335
MAXIMUM SIDELOAD +Z, LBF	209.477	188.182	207.069	178.375	199.634

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

ROCKETDYNE INTEGRATED OMS ENGINE
START TRANSIENT CHARACTERISTICS

DATE 27 MAR 4
TEST DESCRIPTION SERIES 6K OME RD/IHT 1 SEQUENCE = 7

ENGINE PERFORMANCE EVALUATION WITH BLC, 9 TO 1 NOZZLE, COLD UNSATURATED FUEL. INCLUDES LOW PRESSURE *CHUGGING* CHARACTERIZATION. ALL RESTARTS ON HOT ENGINE. NO PURGES AFTER TESTS 2 THRU 5.

START CONDITIONS (T0-3 SEC)

TEST NO.	6	7	8	9	10
TEST DURATION	10.010	35.006	5.009	5.009	5.313
PREVIOUS COAST PERIOD, SEC	23.023	26.204	90.785	31.659	43.448
FUEL INLET PRESSURE, PSIA	207.699	225.117	121.882	103.189	84.921
OXID INLET PRESSURE, PSIA	224.165	226.705	123.417	104.791	86.166
FUEL INLET TEMPERATURE, F	56.749	56.664	71.107	67.225	68.980
OXID INLET TEMPERATURE, F	117.799	117.799	72.232	87.671	75.585
INJECTOR SURFACE TEMP, F	126.984	125.535	117.114	123.262	121.660
CHAMBER TOP TEMP, F	255.572	182.582	198.444	157.712	182.116
COOLANT MANIFOLD TEMP, F	75.509	64.773	68.519	63.915	62.515
NOZZLE FLANGE TOP TEMP, F	67.572	61.414	66.999	69.094	66.027
TEST CELL PRESSURE, PSIA	.090	.087	.064	.073	.070

START TRANSIENT

TEST NO.	6	7	8	9	10
FIRE SWITCH TIME	14 31 14.738	14 31 50.949	14 33 56.740	14 34 33.408	14 35 21.765
FUEL VALVE COMMAND, SEC	.002	.002	.002	.004	.004
OXID VALVE COMMAND, SEC	.004	.004	.004	.006	.006
FUEL ISOLATION START OPEN	.053	.055	.057	.057	.057
FUEL ISOLATION FULL OPEN	.183	.107	.197	.201	.207
FUEL ISOLATION TRAVEL TIME	.130	.132	.140	.144	.148
FUEL SHUTOFF START OPEN	.083	.069	.083	.059	.077
FUEL SHUTOFF FULL OPEN	.169	.167	.175	.181	.191
FUEL SHUTOFF TRAVEL TIME	.086	.098	.092	.122	.114
OXID ISOLATION START OPEN	.053	.053	.051	.049	.049
OXID ISOLATION FULL OPEN	.159	.161	.157	.155	.155
OXID ISOLATION TRAVEL TIME	.106	.108	.106	.106	.106
OXID SHUTOFF START OPEN	.051	.051	.055	.055	.055
OXID SHUTOFF FULL OPEN	.167	.107	.163	.165	.167
OXID SHUTOFF TRAVEL TIME	.116	.116	.108	.110	.112
FSI TO 10% PC, SEC	.277	.355	.395	.413	.447
FSI TO 90% PC, SEC	.289	.787	-N/A-	-N/A-	-N/A-
MAXIMUM PC, PSIA	193.796	182.891	113.094	98.553	84.719
TIME OF MAXIMUM PC, SEC	.297	.375	.417	.413	.437
PEAK ACCELERATION, 4006D, G	71.359	75.819	70.244	89.199	54.034
TIME OF 4006D MAX G	1.003	.777	.791	.557	.915
PEAK ACCELERATION, 4007D, G	19.269	24.465	16.130	18.728	17.429
TIME OF 4007D MAX G	.287	.357	.819	.937	1.[illegible]87
PEAK ACCELERATION, 4008D, G	152.118	95.707	64.743	32.2[illegible]3	100.774
TIME OF 4008D MAX G	.789	.359	.195	.[illegible]43	.[illegible]35
PEAK ACCELERATION, 4097D, G	36.090	36.637	36.637	41.558	34.459
TIME OF 4097D MAX G	.895	.335	.565	.[illegible]85	1.[illegible]33
MAXIMUM AXIAL THRUST, LBF	9158.905	10555.446	6067.876	5478.691	4272.433
TIME OF MAX THRUST, SEC	.285	.359	.397	.419	.743
MAXIMUM SIDELOAD -Y, LBF	146.048	196.671	127.064	79.985	58.976
MAXIMUM SIDELOAD -Z, LBF	302.640	243.011	145.152	136.081	117.018

ROCKETDYNE INTEGRATED OMS ENGINE
START TRANSIENT CHARACTERISTICS

DATE 27 MAR 4 SERIES 6K ONE RD/IMT 1 SEQUENCE = 7

TEST DESCRIPTION

ENGINE PERFORMANCE EVALUATION WITH BLC, 9 TO 1 NOZZLE, COLD UNSATURATED FUEL. INCLUDES LOW PRESSURE #CHUGGING# CHARACTERIZATION. ALL RESTARTS ON HOT ENGINE, NO PURGES AFTER TESTS 2 THRU 5.

START CONDITIONS (T0-3 SEC)	TEST NO. 10A	11	12	14
TEST DURATION	5.015	5.015	5.015	10.013
PREVIOUS COAST PERIOD, SEC	46.904	36.010	24.988	211.337
FUEL INLET PRESSURE, PSIA	108.287	87.895	64.496	219.594
OXID INLET PRESSURE, PSIA	100.135	84.473	84.896	214.429
FUEL INLET TEMPERATURE, F	70.171	71.192	69.746	78.174
OXID INLET TEMPERATURE, F	78.001	78.681	75.208	79.445
INJECTOR SURFACE TEMP, F	122.583	121.637	123.937	114.647
CHAMBER TOP TEMP, F	159.263	161.596	169.525	136.381
COOLANT MANIFOLD TEMP, F	67.213	64.550	64.284	78.818
NOZZLE FLANGE TOP TEMP, F	68.079	64.497	61.433	66.512
TEST CELL PRESSURE, PSIA	.067	.071	.080	.060

START TRANSIENT

	10A	11	12	14
FIRE SWITCH TIME	14 36 13.682	14 36 54.707	14 37 24.710	14 41 1.562
FUEL VALVE COMMAND, SEC	0	.004	.002	.006
OXID VALVE COMMAND, SEC	.002	0	.004	.002
FUEL ISOLATION START OPEN	.057	.059	.061	.065
FUEL ISOLATION FULL OPEN	.209	.215	.219	.237
FUEL ISOLATION TRAVEL TIME	.152	.156	.158	.172
FUEL SHUTOFF START OPEN	.071	.077	.079	.101
FUEL SHUTOFF FULL OPEN	.189	.195	.199	.195
FUEL SHUTOFF TRAVEL TIME	.118	.118	.120	.094
OXID ISOLATION START OPEN	.049	.049	.049	.049
OXID ISOLATION FULL OPEN	.151	.151	.155	.157
OXID ISOLATION TRAVEL TIME	.102	.102	.106	.108
OXID SHUTOFF START OPEN	.053	.063	.053	.055
OXID SHUTOFF FULL OPEN	.163	.165	.165	.163
OXID SHUTOFF TRAVEL TIME	.110	.102	.112	.108
FSI TO 10% PC, SEC	.417	.443	.445	.359
FSI TO 90% PC, SEC	-N/A-	-N/A-	-N/A-	.367
MAXIMUM PC, PSIA	104.005	86.920	88.010	171.621
TIME OF MAXIMUM PC, SEC	.437	.469	.475	.371
PEAK ACCELERATION, 4006D, G	97.003	69.129	159.443	52.404
TIME OF 4006D MAX G	.817	.433	1.007	.311
PEAK ACCELERATION, 4007D, G	14.073	25.115	16.078	16.688
TIME OF 4007D MAX G	.421	.433	.431	.351
PEAK ACCELERATION, 4008D, G	189.838	187.136	63.167	126.3
TIME OF 4008D MAX G	.243	.431	.429	.195
PEAK ACCELERATION, 4097D, G	36.090	38.278	40.465	32.262
TIME OF 4097D MAX G	.841	.443	.801	.481
MAXIMUM AXIAL THRUST, LBF	6130.866	4885.749	4545.736	10043.108
TIME OF MAX THRUST, SEC	.419	.459	.851	.361
MAXIMUM SIDELOAD -Y, LBF	114.662	55.432	63.532	194.099
MAXIMUM SIDELOAD -Z, LBF	159.600	129.926	110.424	249.120

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

ROCKETDYNE INTEGRATED OMS ENGINE
START TRANSIENT CHARACTERISTICS

DATE 01 APR 4 SERIES 6K OHE RD/IMT 1 SEQUENCE = 8

TEST DESCRIPTION

ENGINE PERFORMANCE AND HEAT TRANSFER EVALUATION WITH PLUGGED BLC ORIFICES, 9 TO 1 NOZZLE, COLD UNSATURATED FUEL, ALL RESTARTS ON HOT ENGINE, NO POST-FIRE PURGES.

START CONDITIONS (T0-3 SEC)

TEST NO.	1	2	3	4	5
TEST DURATION	35.004	10.010	10.014	10.006	10.015
PREVIOUS COAST PERIOD, SEC	0	27.981	21.752	32.944	23.665
FUEL INLET PRESSURE, PSIA	224.548	256.026	270.018	232.630	297.108
OXID INLET PRESSURE, PSIA	226.705	253.373	243.214	205.902	223.741
FUEL INLET TEMPERATURE, F	52.091	52.176	51.584	50.150	53.951
OXID INLET TEMPERATURE, F	58.095	73.334	75.455	77.492	78.171
INJECTOR SURFACE TEMP, F	54.887	116.611	125.675	125.547	131.339
CHAMBER TOP TEMP, F	54.546	302.334	280.554	270.192	291.906
COOLANT MANIFOLD TEMP, F	55.433	70.502	77.037	86.552	91.779
NOZZLE FLANGE TOP TEMP, F	55.271	70.128	71.665	78.835	77.300
TEST CELL PRESSURE, PSIA	.068	.086	.096	.076	.091

START TRANSIENT

	1	2	3	4	5
FIRE SWITCH TIME	14 46 8.031	14 47 11.016	14 47 42.778	14 48 25.736	14 48 58.807
FUEL VALVE COMMAND, SEC	.002	.006	.002	.004	.009
OXID VALVE COMMAND, SEC	.004	.002	.004	.006	0
FUEL ISOLATION START OPEN	.077	.061	.111	.089	.073
FUEL ISOLATION FULL OPEN	.217	.215	.219	.217	.217
FUEL ISOLATION TRAVEL TIME	.140	.154	.108	.128	.144
FUEL SHUTOFF START OPEN	.087	.087	.067	.069	.067
FUEL SHUTOFF FULL OPEN	.199	.195	.201	.201	.203
FUEL SHUTOFF TRAVEL TIME	.112	.108	.134	.132	.136
OXID ISOLATION START OPEN	.053	.053	.053	.053	.069
OXID ISOLATION FULL OPEN	.163	.159	.161	.159	.155
OXID ISOLATION TRAVEL TIME	.110	.106	.109	.106	.136
OXID SHUTOFF START OPEN	.053	.051	.051	.053	.083
OXID SHUTOFF FULL OPEN	.161	.161	.163	.165	.167
OXID SHUTOFF TRAVEL TIME	.108	.110	.112	.112	.082
FSI TO 10% PC, SEC	.383	.287	.275	.303	.293
FSI TO 90% PC, SEC	.395	.303	.287	.313	.307
MAXIMUM PC, PSIA	170.894	218.699	213.063	177.074	206.983
TIME OF MAXIMUM PC, SEC	.407	.303	.289	.317	.317
PEAK ACCELERATION, 4007D, G	22.610	18.174	24.773	24.016	15.256
TIME OF 4007D MAX G	.375	.299	.265	.313	.307
PEAK ACCELERATION, 4008D, G	198.025	198.025	198.025	196.025	190.025
TIME OF 4008D MAX G	.375	.295	.265	.315	.307
PEAK ACCELERATION, 4097D, G	35.189	34.089	28.591	31.[illegible]	30.790
TIME OF 4097D MAX G	.403	.755	.267	.[illegible]17	.577
MAXIMUM AXIAL THRUST, LBF	7636.400	9128.562	10600.587	8616.237	9147.100
TIME OF MAX THRUST, SEC	.387	.399	.287	.313	.305
MAXIMUM SIDELOAD -Y, LBF	42.070	91.236	113.285	136.347	70.201
MAXIMUM SIDELOAD -Z, LBF	172.317	174.960	205.214	197.431	166.942

ROCKETDYNE INTEGRATED OMS ENGINE
START TRANSIENT CHARACTERISTICS

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

DATE 01 APR 4 SERIES 6K OME HU/IHT 1 SEQUENCE = 8
TEST DESCRIPTION

ENGINE PERFORMANCE AND HEAT TRANSFER EVALUATION WITH PLUGGED BLC ORIFICES, 9 TO 1 NOZZLE, COLD UNSATURATED FUEL. ALL RESTARTS ON HOT ENGINE, NO POST-FIRE PURGES.

START CONDITIONS (T0-3 SEC)

TEST NO.	6	7	8	9	10
TEST DURATION	10.015	10.006	10.011	10.008	10.000
PREVIOUS COAST PERIOD, SEC	43.929	53.060	59.031	17.080	34.655
FUEL INLET PRESSURE, PSIA	196.049	241.989	183.288	175.206	223.698
OXID INLET PRESSURE, PSIA	178.024	265.649	184.374	189.453	225.435
FUEL INLET TEMPERATURE, F	62.032	65.709	71.130	55.812	76.[illegible]13
OXID INLET TEMPERATURE, F	80.210	81.996	82.931	79.955	83.187
INJECTOR SURFACE TEMP, F	130.962	130.211	133.674	145.689	143.[illegible]
CHAMBER TOP TEMP, F	283.390	277.248	263.101	301.385	285.281
COOLANT MANIFOLD TEMP, F	108.590	114.166	122.608	107.042	122.562
NOZZLE FLANGE TOP TEMP, F	77.815	81.395	94.194	84.465	84.473
TEST CELL PRESSURE, PSIA	.072	.069	.066	.102	.075

START TRANSIENT

TEST NO.	6	7	8	9	10
FIRE SWITCH TIME	14 49 52.751	14 50 55.826	14 52 4.863	14 52 31.954	14 53 16.817
FUEL VALVE COMMAND, SEC	.006	.004	.006	.002	.036
OXID VALVE COMMAND, SEC	.002	0	.002	.004	.002
FUEL ISOLATION START OPEN	.063	.061	.061	.063	.061
FUEL ISOLATION FULL OPEN	.213	.213	.211	.215	.221
FUEL ISOLATION TRAVEL TIME	.150	.152	.150	.152	.16[illegible]
FUEL SHUTOFF START OPEN	.079	.087	.087	.071	.087
FUEL SHUTOFF FULL OPEN	.201	.197	.203	.207	.20[illegible]
FUEL SHUTOFF TRAVEL TIME	.122	.110	.116	.136	.122
OXID ISOLATION START OPEN	.051	.049	.051	.049	.051
OXID ISOLATION FULL OPEN	.153	.153	.153	.155	.155
OXID ISOLATION TRAVEL TIME	.102	.104	.102	.106	.104
OXID SHUTOFF START OPEN	.071	.071	.053	.083	.085
OXID SHUTOFF FULL OPEN	.165	.161	.161	.165	.165
OXID SHUTOFF TRAVEL TIME	.094	.090	.108	.082	.080
FSI TO 10% PC, SEC	.315	.307	.327	.285	.303
FSI TO 90% PC, SEC	.341	.317	.347	.311	.341
MAXIMUM PC, PSIA	141.085	209.428	139.268	228.695	165.[illegible]
TIME OF MAXIMUM PC, SEC	.375	.319	.357	.313	.355
PEAK ACCELERATION, 4007D, G	12.224	16.660	14.821	18.391	23.800
TIME OF 4007D MAX G	.333	.319	.349	.305	.319
PEAK ACCELERATION, 4008D, G	198.025	198.025	190.025	198.025	198.025
TIME OF 4008D MAX G	.337	.319	.349	.309	.319
PEAK ACCELERATION, 4097D, G	35.109	33.540	30.241	32.[illegible]	33.540
TIME OF 4097D MAX G	.495	.325	.661	.305	.321
MAXIMUM AXIAL THRUST, LBF	8155.082	8596.704	7712.333	8066.014	9025.241
TIME OF MAX THRUST, SEC	.335	.319	.347	.307	.321
MAXIMUM SIDELOAD -Y, LBF	153.834	158.902	89.200	54.235	145.724
MAXIMUM SIDELOAD -Z, LBF	251.126	215.903	172.241	363.881	135.251

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

ROCKETDYNE INTEGRATED OMS ENGINE
START TRANSIENT CHARACTERISTICS

DATE 15 MAR 4 SERIES 6K OME RO/IMT 1 SEQUENCE = 4

TEST DESCRIPTION

COLD-ENGINE, WARM PROPELLANT RESTART EVALUATION WITH COAST PERIODS RANGING FROM 3 MINUTES TO 1 SECOND.

START CONDITIONS (TO-3 SEC)	TEST NO. 1	2	3	4	5
TEST DURATION	1.217	1.208	1.213	1.213	1.217
PREVIOUS COAST PERIOD, SEC	0	179.593	119.597	60.015	29.933
FUEL INLET PRESSURE, PSIA	220.869	220.444	220.019	220.019	220.444
OXID INLET PRESSURE, PSIA	214.699	214.275	214.275	214.699	213.851
FUEL INLET TEMPERATURE, F	74.394	75.417	76.270	76.696	76.702
OXID INLET TEMPERATURE, F	72.961	74.575	76.614	76.189	78.229
INJECTOR SURFACE TEMP, F	81.843	67.498	90.991	94.943	100.708
CHAMBER TOP TEMP, F	77.985	63.189	70.839	130.767	205.913
COOLANT MANIFOLD TEMP, F	71.174	78.564	86.264	90.185	84.889
NOZZLE FLANGE TOP TEMP, F	70.679	71.193	78.371	71.201	74.264
TEST CELL PRESSURE, PSIA	.101	.088	.066	.088	.077

START TRANSIENT	1	2	3	4	5
FIRE SWITCH TIME	15 9 4.884	15 12 5.694	15 14 6.499	15 15 7.727	15 15 38.873
FUEL VALVE COMMAND, SEC	.004	.004	.002	.005	.006
OXID VALVE COMMAND, SEC	0	.006	.004	.002	.052
FUEL ISOLATION START OPEN	.055	.061	.059	.057	.057
FUEL ISOLATION FULL OPEN	.185	.187	.187	.187	.189
FUEL ISOLATION TRAVEL TIME	.130	.126	.128	.130	.132
FUEL SHUTOFF START OPEN	.077	.079	.075	.071	.071
FUEL SHUTOFF FULL OPEN	.151	.101	.155	.157	.157
FUEL SHUTOFF TRAVEL TIME	.074	.082	.080	.086	.086
OXID ISOLATION START OPEN	.051	.051	.051	.051	.051
OXID ISOLATION FULL OPEN	.161	.103	.163	.161	.163
OXID ISOLATION TRAVEL TIME	.110	.112	.112	.110	.112
OXID SHUTOFF START OPEN	.085	.069	.055	.053	.053
OXID SHUTOFF FULL OPEN	.163	.163	.163	.165	.165
OXID SHUTOFF TRAVEL TIME	.078	.094	.108	.112	.112
FSI TO 10% PC, SEC	.321	.315	.311	.299	.277
FSI TO 90% PC, SEC	.329	.327	.321	.311	.291
MAXIMUM PC, PSIA	167.986	159.625	160.352	151.991	148.356
TIME OF MAXIMUM PC, SEC	.333	.333	.327	.317	.295
PEAK ACCELERATION, 4006D, G	67.967	53.482	57.939	56.625	59.053
TIME OF 4006D MAX G	.137	.663	.311	.601	.199
PEAK ACCELERATION, 4007D, G	92.917	94.220	92.049	85.102	94.003
TIME OF 4007D MAX G	.323	.317	.311	.299	.277
PEAK ACCELERATION, 4008D, G	197.919	197.918	165.401	116.231	94.627
TIME OF 4008D MAX G	.311	.307	.199	.93	.277
PEAK ACCELERATION, 4097D, G	41.040	33.926	41.040	39.398	38.304
TIME OF 4097D MAX G	.639	.091	.311	.645	.277
MAXIMUM AXIAL THRUST, LBF	9464.625	12491.389	13269.543	13297.654	13785.606
TIME OF MAX THRUST, SEC	.335	.319	.315	.301	.279
THRUST OVERSHOOT, PCNT	57.744	108.190	121.159	121.628	129.760
MAXIMUM SIDELOAD -Y, LBF	126.811	266.325	241.979	209.833	170.600
MAXIMUM SIDELOAD -Z, LBF	231.229	290.105	271.179	322.606	345.871

ROCKETDYNE INTEGRATED OMS ENGINE
START TRANSIENT CHARACTERISTICS

DATE 15 MAR 4 SERIES AK ONE HO/INT 1 SEQUENCE = 4

TEST DESCRIPTION

COLD-ENGINE, WARM PROPELLANT RESTART EVALUATION WITH COAST PERIODS RANGING FROM 3 MINUTES TO 1 SECOND.

START CONDITIONS (T0-3 SEC)	TEST NO. 6	7	8	9	10
TEST DURATION	1.219	1.222	1.200	1.249	1.222
PREVIOUS COAST PERIOD, SEC	14.928	8.907	4.495	2.690	.550
FUEL INLET PRESSURE, PSIA	219.594	218.745	218.745	218.745	218.745
OXID INLET PRESSURE, PSIA	213.851	213.427	212.156	212.156	212.156
FUEL INLET TEMPERATURE, F	76.014	75.332	75.161	75.161	75.161
OXID INLET TEMPERATURE, F	77.039	77.404	76.529	76.529	76.529
INJECTOR SURFACE TEMP, F	106.736	111.518	113.719	113.719	113.719
CHAMBER TOP TEMP, F	225.549	227.889	226.485	226.485	226.485
COOLANT MANIFOLD TEMP, F	87.448	87.180	95.350	95.350	95.350
NOZZLE FLANGE TOP TEMP, F	77.873	80.434	86.073	86.073	86.073
TEST CELL PRESSURE, PSIA	.085	.090	.100	.100	.100

START TRANSIENT	6	7	8	9	10
FIRE SWITCH TIME	15 15 55.018	15 16 5.144	15 16 10.861	15 16 14.151	15 16 15.450
FUEL VALVE COMMAND, SEC	.004	.000	.010	.004	.004
OXID VALVE COMMAND, SEC	0	.002	.006	.006	.004
FUEL ISOLATION START OPEN	.055	.055	.059	.071	.059
FUEL ISOLATION FULL OPEN	.189	.187	.191	.199	.193
FUEL ISOLATION TRAVEL TIME	.134	.132	.132	.128	.134
FUEL SHUTOFF START OPEN	.069	.065	.065	.059	.057
FUEL SHUTOFF FULL OPEN	.159	.159	.167	.177	.175
FUEL SHUTOFF TRAVEL TIME	.090	.094	.102	.118	.118
OXID ISOLATION START OPEN	.051	.051	.055	.057	.053
OXID ISOLATION FULL OPEN	.161	.163	.169	.171	.167
OXID ISOLATION TRAVEL TIME	.110	.112	.114	.114	.114
OXID SHUTOFF START OPEN	.055	.053	.057	.059	.055
OXID SHUTOFF FULL OPEN	.169	.165	.169	.177	.171
OXID SHUTOFF TRAVEL TIME	.114	.112	.112	.118	.116
FS1 TO 10% PC, SEC	.247	.223	.213	.001	.001
FS1 TO 90% PC, SEC	.261	.236	.231	.201	.269
MAXIMUM PC, PSIA	163.624	172.348	215.244	168.350	167.960
TIME OF MAXIMUM PC, SEC	.267	.241	.231	.207	.217
PEAK ACCELERATION, 40060, G	52.368	43.454	49.025	44.568	75.766
TIME OF 40060 MAX G	.953	.229	.797	.595	.087
PEAK ACCELERATION, 40070, G	85.662	93.706	76.836	78.606	110.719
TIME OF 40070 MAX G	.253	.229	.227	.955	.095
PEAK ACCELERATION, 40080, G	31.565	36.456	131.195	13.277	197.916
TIME OF 40080 MAX G	.249	.227	.225	.179	.007
PEAK ACCELERATION, 40970, G	39.398	48.153	37.756	63.735	65.110
TIME OF 40970 MAX G	.571	.269	.151	.953	.059
MAXIMUM AXIAL THRUST, LBF	10277.924	10338.698	10845.256	9297.444	9233.693
TIME OF MAX THRUST, SEC	.257	.233	.229	.201	.211
THRUST OVERSHOOT, PCNT	71.299	72.312	80.754	54.957	53.698
MAXIMUM SIDELOAD -Y, LBF	225.020	232.867	247.801	191.103	190.576
MAXIMUM SIDELOAD -Z, LBF	222.541	188.735	224.526	144.087	236.875

REPRODUCIBILITY OF

ROCKETDYNE INTEGRATED OMS ENGINE
START TRANSIENT CHARACTERISTICS

DATE 15 MAR 4 SERIES 6K OME RD/IHT 1 SEQUENCE = 4

TEST DESCRIPTION

COLD-ENGINE, WARM PROPELLANT RESTART EVALUATION WITH COAST PERIODS RANGING FROM 3 MINUTES TO 1 SECOND.

START CONDITIONS (T0-3 SEC)	TEST NO. 11	12	13
TEST DURATION	1.215	1.217	.614
PREVIOUS COAST PERIOD, SEC	18.649	29.912	44.535
FUEL INLET PRESSURE, PSIA	219.320	220.019	220.019
OXID INLET PRESSURE, PSIA	212.156	213.427	213.427
FUEL INLET TEMPERATURE, F	77.720	79.086	80.282
OXID INLET TEMPERATURE, F	77.549	78.314	76.824
INJECTOR SURFACE TEMP, F	123.684	118.901	113.167
CHAMBER TOP TEMP, F	285.754	284.335	208.716
COOLANT MANIFOLD TEMP, F	88.930	92.825	100.284
NOZZLE FLANGE TOP TEMP, F	81.463	83.009	87.106
TEST CELL PRESSURE, PSIA	.099	.090	.073
START TRANSIENT			
FIRE SWITCH TIME	15 16 35.821	15 17 6.848	15 17 52.600
FUEL VALVE COMMAND, SEC	.002	.002	.004
OXID VALVE COMMAND, SEC	.004	.004	0
FUEL ISOLATION START OPEN	.053	.053	.051
FUEL ISOLATION FULL OPEN	.183	.183	.183
FUEL ISOLATION TRAVEL TIME	.130	.130	.132
FUEL SHUTOFF START OPEN	.071	.075	.077
FUEL SHUTOFF FULL OPEN	.159	.159	.159
FUEL SHUTOFF TRAVEL TIME	.088	.084	.082
OXID ISOLATION START OPEN	.051	.051	.049
OXID ISOLATION FULL OPEN	.159	.161	.159
OXID ISOLATION TRAVEL TIME	.108	.110	.110
OXID SHUTOFF START OPEN	.055	.053	.053
OXID SHUTOFF FULL OPEN	.165	.165	.163
OXID SHUTOFF TRAVEL TIME	.110	.112	.110
FSI TO 10% PC, SEC	.251	.275	.287
FSI TO 90% PC, SEC	.267	.291	.299
MAXIMUM PC, PSIA	158.898	150.537	149.446
TIME OF MAXIMUM PC, SEC	.271	.295	.305
PEAK ACCELERATION, 4006D, G	53.482	42.340	42.340
TIME OF 4006D MAX G	.793	.211	.697
PEAK ACCELERATION, 4007D, G	92.700	81.520	82.931
TIME OF 4007D MAX G	.257	.289	.287
PEAK ACCELERATION, 4009D, G	136.146	76.399	52.433
TIME OF 4009D MAX G	.257	.281	.291
PEAK ACCELERATION, 4097D, G	40.492	39.398	37.756
TIME OF 4097D MAX G	.257	.177	.281
MAXIMUM AXIAL THRUST, LBF	11163.028	11258.761	11965.824
TIME OF MAX THRUST, SEC	.261	.281	.291
THRUST OVERSHOOT, PCNT	86.050	87.813	99.430
MAXIMUM SIDELOAD -Y, LBF	232.361	201.734	229.564
MAXIMUM SIDELOAD -Z, LBF	254.181	232.529	206.437

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

APPENDIX B

STEADY-STATE DATA

Summaries of test data compiled and printed at NASA/WSTF are presented in this appendix. Data are presented for the 9-10 second slice on each test and for multiple times on tests of ~35-second duration.

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 27 MAR 4
SERIES RD/IHT-1 SEQUENCE 7 TEST 1
TEST DESCRIPTION
PERFORMANCE SURVEY OF RD INTEGRATED HARDWARE PRIOR TO CHUG TESTS. BASELINE BEFORE BLC PLUGGING TESTS. 9 TO 1 NOZZLE. 40 DEG FUEL. 70 DEG OXIDIZER. TARGET PCNS = 125.. MR = 1.45.

ACTUAL TEST DURATION 10.007 SEC
DATA SLICE TIME 9.000 SEC TO 10.000 SEC

PARAMETER	UNITS	AVG. MEASURED VALUE
FUEL TANK PRESSURE	PSIA	250.451
OXIDIZER TANK PRESSURE	PSIA	230.719
FUEL INTERFACE PRESSURE	PSIA	236.588
OXIDIZER INTERFACE PRESSURE	PSIA	214.005
T/C COOLANT INLET MAN. PRESSURE	PSIA	227.199
FUEL INJECTOR PRESSURE	PSIA	206.431
OXIDIZER INJECTOR PRESSURE	PSIA	194.909
CHAMBER PRESSURE NO. 1	PSIA	137.813
CHAMBER PRESSURE NO. 2	PSIA	138.612
AXIAL THRUST. SYSTEM A	LBF	5325.785
AXIAL THRUST. SYSTEM B	LBF	5340.457
Y-AXIS THRUST	LBF	-28.597
Z-AXIS THRUST	LBF	22.771
AVERAGE CELL PRESSURE	PSIA	.075
CELL PRESSURE AGREEMENT	%	.773
FUEL FLOWRATE	GPM	65.869
OXIDIZER FLOWRATE	GPM	61.788
FUEL INTERFACE TEMPERATURE	DEG F	41.303
OXIDIZER INTERFACE TEMPERATURE	DEG F	74.628
T/C COOLANT IN TEMPERATURE	DEG F	45.980
T/C COOLANT OUT TEMPERATURE	DEG F	173.374
INJECTOR SURFACE TEMPERATURE	DEG F	74.273
T/C SURFACE TEMP -16 IN	DEG F	173.939
T/C SURFACE TEMP -13 IN	DEG F	186.485
T/C SURFACE TEMP -10 IN	DEG F	190.732
T/C SURFACE TEMP - 8 IN	DEG F	148.287
T/C SURFACE TEMP - 6 IN	DEG F	170.011
T/C SURFACE TEMP - 4 IN	DEG F	188.228
T/C SURFACE TEMP - 2 IN	DEG F	129.422
T/C SURFACE TEMP -0.3 IN	DEG F	134.586
T/C SURFACE TEMP + 3 IN	DEG F	115.076
COOLANT IN MANIFOLD SKIN	DEG F	55.086
NOZZLE FLANGE TOP TEMPERATURE	DEG F	53.720
NOZZLE SURFACE TEMP + 8.0 IN	DEG F	891.289
NOZZLE SURFACE TEMP + 9.0 IN	DEG F	1187.605

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 27 MAR 4
SERIES RD/IHT-1 SEQUENCE 7 TEST 1

PERFORMANCE DATA

PARAMETER	UNITS	CALCULATED VALUE
PC, INJECTOR END	PSIA	138.163
PC, NOZZLE STAGNATION	PSIA	131.255
AXIAL THRUST, SITE	LBF	5333.121
AXIAL THRUST, VACUUM	LBF	5351.062
NOZZLE EXIT PRESSURE	PSIA	.085
FUEL DENSITY (MMH)	LB/FT3	55.532
OXIDIZER DENSITY	LB/FT3	89.870
FUEL FLOWRATE	LB/SEC	8.150
OXIDIZER FLOWRATE	LB/SEC	12.372
TOTAL PROPELLANT FLOWRATE	LB/SEC	20.522
MIXTURE RATIO (OVERALL)	O/F	1.518
BLC FLOWRATE	LB/SEC	.610
BLC TOTAL PERCENT	%	2.974
CORE MIXTURE RATIO	O/F	1.641
FUEL INJECTOR DELTA-P	PSID	68.268
OXIDIZER INJECTOR DELTA-P	PSID	56.746
T/C COOLANT DELTA-P	PSID	20.768
T/C COOLANT DELTA-T	DEG F	127.394
THRUST CHAMBER HEAT FLUX	BTU/SEC	742.332
C-STAR, SITE	FT/SEC	5454.247
C-STAR, UMR	FT/SEC	5497.607
C-STAR EFFICIENCY	%	95.758
CF, SITE	-----	1.533
CF SITE VACUUM	-----	1.538
CF, VAC 72 EXPECT	-----	1.518
CF CORRELATION	-----	101.340
CF, VAC 72	-----	1.798
ISP, TEST	SEC	259.877
ISP, SITE VACUUM	SEC	260.751
ISP, VAC 72 PREDICTED	SEC	306.761
ISP, TDK, TEST CONDITIONS	SEC	273.975
ISP EFFICIENCY	%	78.121
ENERGY RELEASE EFFICIENCY	%	96.205
C-STAR, ODE	FT/SEC	5695.894
ISP, ODE, TEST	SEC	333.779

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6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 27 MAR 4
SERIES RD/IHT-1 SEQUENCE 7 TEST 2
TEST DESCRIPTION
PERFORMANCE SURVEY OF RD INTEGRATED HARDWARE PRIOR TO CHUG TESTS. BASELINE BEFORE BLC PLUGGING TESTS. 9 TO 1 NOZZLE. 40 DEG FUEL, 70 DEG OXIDIZER. TARGET PCNS = 125.. MR = 1.65.

ACTUAL TEST DURATION 10.010 SEC
DATA SLICE TIME 9.000 SEC TO 10.000 SEC

PARAMETER	UNITS	AVG. MEASURED VALUE
FUEL TANK PRESSURE	PSIA	226.199
OXIDIZER TANK PRESSURE	PSIA	225.029
FUEL INTERFACE PRESSURE	PSIA	214.921
OXIDIZER INTERFACE PRESSURE	PSIA	208.502
T/C COOLANT INLET MAN. PRESSURE	PSIA	207.263
FUEL INJECTOR PRESSURE	PSIA	189.324
OXIDIZER INJECTOR PRESSURE	PSIA	188.313
CHAMBER PRESSURE NO. 1	PSIA	132.724
CHAMBER PRESSURE NO. 2	PSIA	133.611
AXIAL THRUST, SYSTEM A	LBF	5135.581
AXIAL THRUST, SYSTEM B	LBF	5150.631
Y-AXIS THRUST	LBF	-27.578
Z-AXIS THRUST	LBF	21.382
AVERAGE CELL PRESSURE	PSIA	.077
CELL PRESSURE AGREEMENT	%	.671
FUEL FLOWRATE	GPM	60.066
OXIDIZER FLOWRATE	GPM	61.624
FUEL INTERFACE TEMPERATURE	DEG F	41.617
OXIDIZER INTERFACE TEMPERATURE	DEG F	74.543
T/C COOLANT IN TEMPERATURE	DEG F	49.088
T/C COOLANT OUT TEMPERATURE	DEG F	187.497
INJECTOR SURFACE TEMPERATURE	DEG F	184.340
T/C SURFACE TEMP -16 IN	DEG F	188.751
T/C SURFACE TEMP -13 IN	DEG F	191.499
T/C SURFACE TEMP -10 IN	DEG F	197.597
T/C SURFACE TEMP - 8 IN	DEG F	154.245
T/C SURFACE TEMP - 6 IN	DEG F	176.288
T/C SURFACE TEMP - 4 IN	DEG F	190.756
T/C SURFACE TEMP - 2 IN	DEG F	135.964
T/C SURFACE TEMP -0.3 IN	DEG F	140.103
T/C SURFACE TEMP + 3 IN	DEG F	121.785
COOLANT IN MANIFOLD SKIN	DEG F	63.859
NOZZLE FLANGE TOP TEMPERATURE	DEG F	61.395
NOZZLE SURFACE TEMP + 8.0 IN	DEG F	916.484
NOZZLE SURFACE TEMP + 9.0 IN	DEG F	1226.605

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 27 MAR 4
SERIES 4B/IHT-1 SEQUENCE 7 TEST [illegible]

PERFORMANCE DATA

PARAMETER	UNITS	CALCULATED VALUE
PC, INJECTOR END	PSIA	133.167
PC, NOZZLE STAGNATION	PSIA	126.509
AXIAL THRUST, SITE	LBF	5143.106
AXIAL THRUST, VACUUM	LBF	5161.588
NOZZLE EXIT PRESSURE	PSIA	.087
FUEL DENSITY (MMH)	LB/FT3	55.524
OXIDIZER DENSITY	LB/FT3	89.874
FUEL FLOWRATE	LB/SEC	7.431
OXIDIZER FLOWRATE	LB/SEC	12.340
TOTAL PROPELLANT FLOWRATE	LB/SEC	19.770
MIXTURE RATIO (OVERALL)	O/F	1.661
BLC FLOWRATE	LB/SEC	.557
BLC TOTAL PERCENT	%	2.815
CORE MIXTURE RATIO	O/F	1.795
FUEL INJECTOR DELTA-P	PSID	56.157
OXIDIZER INJECTOR DELTA-P	PSID	55.146
T/C COOLANT DELTA-P	PSID	17.939
T/C COOLANT DELTA-T	DEG F	138.410
THRUST CHAMBER HEAT FLUX	BTU/SEC	735.360
C*STAR, SITE	FT/SEC	5456.883
C*STAR, UMR	FT/SEC	5514.755
C*STAR EFFICIENCY	%	95.547
CF, SITE	-----	1.534
CF SITE VACUUM	-----	1.539
CF, VAC 72 EXPECT	-----	1.526
CF CORRELATION	-----	100.901
CF, VAC 72	-----	1.800
ISP, TEST	SEC	260.144
ISP, SITE VACUUM	SEC	261.079
ISP, VAC 72 PREDICTED	SEC	307.207
ISP, TDK, TEST CONDITIONS	SEC	276.299
ISP EFFICIENCY	%	77.197
ENERGY RELEASE EFFICIENCY	%	95.553
C*STAR, ODE	FT/SEC	5711.212
ISP, ODE, TEST	SEC	338.197

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 27 MAR 4
SERIES RD/INT-1 SEQUENCE 7 TEST 1
TEST DESCRIPTION
PERFORMANCE SURVEY OF RD INTEGRATED HARDWARE PRIOR TO CHUG TESTS. BASELINE BEFORE BLC PLUGGING TESTS. 9 TO 1 NOZZLE. 40 DEG FUEL. 70 DEG OXIDIZER. TARGET PCNS = 100., MR = 1.65.

ACTUAL TEST DURATION 10.007 SEC
DATA SLICE TIME 9.000 SEC TO 10.000 SEC

PARAMETER	UNITS	AVG. MEASURED VALUE
FUEL TANK PRESSURE	PSIA	161.679
OXIDIZER TANK PRESSURE	PSIA	161.024
FUEL INTERFACE PRESSURE	PSIA	154.169
OXIDIZER INTERFACE PRESSURE	PSIA	151.355
T/C COOLANT INLET MAN. PRESSURE	PSIA	151.289
FUEL INJECTOR PRESSURE	PSIA	145.606
OXIDIZER INJECTOR PRESSURE	PSIA	136.324
CHAMBER PRESSURE NO. 1	PSIA	104.005
CHAMBER PRESSURE NO. 2	PSIA	104.956
AXIAL THRUST, SYSTEM A	LBF	4019.686
AXIAL THRUST, SYSTEM B	LBF	4024.324
Y-AXIS THRUST	LBF	-26.066
Z-AXIS THRUST	LBF	14.287
AVERAGE CELL PRESSURE	PSIA	.064
CELL PRESSURE AGREEMENT	%	.584
FUEL FLOWRATE	GPM	47.350
OXIDIZER FLOWRATE	GPM	48.878
FUEL INTERFACE TEMPERATURE	DEG F	41.617
OXIDIZER INTERFACE TEMPERATURE	DEG F	74.288
T/C COOLANT IN TEMPERATURE	DEG F	49.531
T/C COOLANT OUT TEMPERATURE	DEG F	198.397
INJECTOR SURFACE TEMPERATURE	DEG F	117.443
T/C SURFACE TEMP -16 IN	DEG F	203.107
T/C SURFACE TEMP -13 IN	DEG F	204.467
T/C SURFACE TEMP -10 IN	DEG F	222.728
T/C SURFACE TEMP - 8 IN	DEG F	157.628
T/C SURFACE TEMP - 6 IN	DEG F	183.179
T/C SURFACE TEMP - 4 IN	DEG F	205.750
T/C SURFACE TEMP - 2 IN	DEG F	138.747
T/C SURFACE TEMP -0.3 IN	DEG F	143.675
T/C SURFACE TEMP + 3 IN	DEG F	121.830
COOLANT IN MANIFOLD SKIN	DEG F	60.766
NOZZLE FLANGE TOP TEMPERATURE	DEG F	53.230
NOZZLE SURFACE TEMP + 8.0 IN	DEG F	970.955
NOZZLE SURFACE TEMP + 9.0 IN	DEG F	1203.239

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 27 MAR 4
SERIES RD/IHT-1 SEQUENCE 7 TEST 3

PERFORMANCE DATA

PARAMETER	UNITS	CALCULATED VALUE
PC, INJECTOR END	PSIA	104.481
PC, NOZZLE STAGNATION	PSIA	99.257
AXIAL THRUST, SITE	LBF	4022.005
AXIAL THRUST, VACUUM	LBF	4037.424
NOZZLE EXIT PRESSURE	PSIA	.074
FUEL DENSITY (MMH)	LB/FT3	55.524
OXIDIZER DENSITY	LB/FT3	89.859
FUEL FLOWRATE	LB/SEC	5.858
OXIDIZER FLOWRATE	LB/SEC	9.785
TOTAL PROPELLANT FLOWRATE	LB/SEC	15.643
MIXTURE RATIO (OVERALL)	O/F	1.671
BLC FLOWRATE	LB/SEC	.439
BLC TOTAL PERCENT	%	2.805
CORE MIXTURE RATIO	O/F	1.806
FUEL INJECTOR DELTA-P	PSID	41.125
OXIDIZER INJECTOR DELTA-P	PSID	31.843
T/C COOLANT DELTA-P	PSID	5.683
T/C COOLANT DELTA-T	DEG F	148.866
THRUST CHAMBER HEAT FLUX	BTU/SEC	623.483
C-STAR, SITE	FT/SEC	5410.866
C-STAR, UMR	FT/SEC	5470.249
C-STAR EFFICIENCY	%	94.738
CF, SITE	-----	1.529
CF SITE VACUUM	-----	1.535
CF, VAC 72 EXPECT	-----	1.526
CF CORRELATION	-----	100.559
CF, VAC 72	-----	1.794
ISP, TEST	SEC	257.108
ISP, SITE VACUUM	SEC	258.093
ISP, VAC 72 PREDICTED	SEC	303.719
ISP, TDK, TEST CONDITIONS	SEC	275.694
ISP EFFICIENCY	%	76.252
ENERGY RELEASE EFFICIENCY	%	94.961
C-STAR, ODE	FT/SEC	5711.412
ISP, ODE, TEST	SEC	338.476

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 27 MAR 4
SERIES RD/IHT-1 SEQUENCE 7 TEST 4
TEST DESCRIPTION
PERFORMANCE SURVEY OF RD INTEGRATED HARDWARE PRIOR TO CHUG TESTS, BASELINE BEFORE BLC PLUGGING TESTS. 9 TO 1 NOZZLE, 40 DEG FUEL, 70 DEG OXIDIZER. TARGET PCNS = 100., MR = 1.45.

ACTUAL TEST DURATION 10.008 SEC
DATA SLICE TIME 9.000 SEC TO 10.000 SEC

PARAMETER	UNITS	AVG. MEASURED VALUE
FUEL TANK PRESSURE	PSIA	173.576
OXIDIZER TANK PRESSURE	PSIA	155.808
FUEL INTERFACE PRESSURE	PSIA	164.366
OXIDIZER INTERFACE PRESSURE	PSIA	146.276
T/C COOLANT INLET MAN. PRESSURE	PSIA	160.107
FUEL INJECTOR PRESSURE	PSIA	154.349
OXIDIZER INJECTOR PRESSURE	PSIA	132.832
CHAMBER PRESSURE NO. 1	PSIA	104.369
CHAMBER PRESSURE NO. 2	PSIA	105.710
AXIAL THRUST, SYSTEM A	LBF	4019.704
AXIAL THRUST, SYSTEM B	LBF	4036.981
Y-AXIS THRUST	LBF	-29.862
Z-AXIS THRUST	LBF	13.649
AVERAGE CELL PRESSURE	PSIA	.067
CELL PRESSURE AGREEMENT	%	.580
FUEL FLOWRATE	GPM	51.801
OXIDIZER FLOWRATE	GPM	46.561
FUEL INTERFACE TEMPERATURE	DEG F	41.617
OXIDIZER INTERFACE TEMPERATURE	DEG F	74.203
T/C COOLANT IN TEMPERATURE	DEG F	46.794
T/C COOLANT OUT TEMPERATURE	DEG F	184.882
INJECTOR SURFACE TEMPERATURE	DEG F	122.637
T/C SURFACE TEMP -16 IN	DEG F	189.220
T/C SURFACE TEMP -13 IN	DEG F	190.803
T/C SURFACE TEMP -10 IN	DEG F	211.858
T/C SURFACE TEMP - 8 IN	DEG F	148.757
T/C SURFACE TEMP - 6 IN	DEG F	171.093
T/C SURFACE TEMP - 4 IN	DEG F	200.817
T/C SURFACE TEMP - 2 IN	DEG F	128.580
T/C SURFACE TEMP -0.3 IN	DEG F	133.375
T/C SURFACE TEMP + 3 IN	DEG F	112.552
COOLANT IN MANIFOLD SKIN	DEG F	63.390
NOZZLE FLANGE TOP TEMPERATURE	DEG F	59.880
NOZZLE SURFACE TEMP + 8.0 IN	DEG F	1025.432
NOZZLE SURFACE TEMP + 9.0 IN	DEG F	1215.543

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 27 MAR 4
SERIES RD/IHT-1

SEQUENCE 7 TEST 4

PERFORMANCE DATA

PARAMETER	UNITS	CALCULATED VALUE
PC, INJECTOR END	PSIA	105.039
PC, NOZZLE STAGNATION	PSIA	99.788
AXIAL THRUST, SITE	LBF	4028.342
AXIAL THRUST, VACUUM	LBF	4044.482
NOZZLE EXIT PRESSURE	PSIA	.077
FUEL DENSITY (MMH)	LB/FT3	55.524
OXIDIZER DENSITY	LB/FT3	89.863
FUEL FLOWRATE	LB/SEC	6.408
OXIDIZER FLOWRATE	LB/SEC	9.322
TOTAL PROPELLANT FLOWRATE	LB/SEC	15.730
MIXTURE RATIO (OVERALL)	O/F	1.455
BLC FLOWRATE	LB/SEC	.480
BLC TOTAL PERCENT	%	3.051
CORE MIXTURE RATIO	O/F	1.573
FUEL INJECTOR DELTA-P	PSID	49.310
OXIDIZER INJECTOR DELTA-P	PSID	27.792
T/C COOLANT DELTA-P	PSID	5.757
T/C COOLANT DELTA-T	DEG F	138.088
THRUST CHAMBER HEAT FLUX	BTU/SEC	632.701
C-STAR, SITE	FT/SEC	5409.681
C-STAR, UMR	FT/SEC	5445.895
C-STAR EFFICIENCY	%	95.220
CF, SITE	-----	1.523
CF SITE VACUUM	-----	1.529
CF, VAC 72 EXPECT	-----	1.514
CF CORRELATION	-----	100.978
CF, VAC 72	-----	1.787
ISP, TEST	SEC	256.087
ISP, SITE VACUUM	SEC	257.113
ISP, VAC 72 PREDICTED	SEC	302.414
ISP, TDK, TEST CONDITIONS	SEC	272.375
ISP EFFICIENCY	%	77.544
ENERGY RELEASE EFFICIENCY	%	95.751
C-STAR, ODE	FT/SEC	5681.228
ISP, ODE, TEST	SEC	331.570

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 27 MAR 4
SERIES RD/IHT-1 SEQUENCE 7 TEST [illegible]
TEST DESCRIPTION
PERFORMANCE SURVEY OF RD INTEGRATED HARDWARE PRIOR TO CHUG TESTS, BASELINE BEFORE BLC PLUGGING TESTS. 9 TO 1 NOZZLE, 40 DEG FUEL, 70 DEG OXIDIZER. TARGET PCNS = 125., MR = 1.45.

ACTUAL TEST DURATION 10.000 SEC
DATA SLICE TIME 9.000 SEC TO 10.000 SEC

PARAMETER	UNITS	AVG. MEASURED VALUE
FUEL TANK PRESSURE	PSIA	233.978
OXIDIZER TANK PRESSURE	PSIA	210.332
FUEL INTERFACE PRESSURE	PSIA	220.869
OXIDIZER INTERFACE PRESSURE	PSIA	195.380
T/C COOLANT INLET MAN. PRESSURE	PSIA	212.247
FUEL INJECTOR PRESSURE	PSIA	194.266
OXIDIZER INJECTOR PRESSURE	PSIA	177.062
CHAMBER PRESSURE NO. 1	PSIA	131.633
CHAMBER PRESSURE NO. 2	PSIA	131.348
AXIAL THRUST, SYSTEM A	LBF	5002.425
AXIAL THRUST, SYSTEM B	LBF	5024.076
Y-AXIS THRUST	LBF	-30.368
Z-AXIS THRUST	LBF	29.363
AVERAGE CELL PRESSURE	PSIA	.072
CELL PRESSURE AGREEMENT	%	.675
FUEL FLOWRATE	GPM	63.753
OXIDIZER FLOWRATE	GPM	57.619
FUEL INTERFACE TEMPERATURE	DEG F	41.702
OXIDIZER INTERFACE TEMPERATURE	DEG F	74.543
T/C COOLANT IN TEMPERATURE	DEG F	46.497
T/C COOLANT OUT TEMPERATURE	DEG F	179.740
INJECTOR SURFACE TEMPERATURE	DEG F	123.226
T/C SURFACE TEMP -16 IN	DEG F	181.989
T/C SURFACE TEMP -13 IN	DEG F	173.528
T/C SURFACE TEMP -10 IN	DEG F	196.232
T/C SURFACE TEMP - 8 IN	DEG F	141.165
T/C SURFACE TEMP - 6 IN	DEG F	162.632
T/C SURFACE TEMP - 4 IN	DEG F	193.683
T/C SURFACE TEMP - 2 IN	DEG F	123.490
T/C SURFACE TEMP -0.3 IN	DEG F	128.279
T/C SURFACE TEMP + 3 IN	DEG F	108.102
COOLANT IN MANIFOLD SKIN	DEG F	66.110
NOZZLE FLANGE TOP TEMPERATURE	DEG F	58.853
NOZZLE SURFACE TEMP + 8.0 IN	DEG F	991.418
NOZZLE SURFACE TEMP + 9.0 IN	DEG F	1230.619

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 27 MAR 4
SERIES RD/IHT-1 SEQUENCE 7 TEST 5

PERFORMANCE DATA

PARAMETER	UNITS	CALCULATED VALUE
PC, INJECTOR END	PSIA	131.491
PC, NOZZLE STAGNATION	PSIA	124.916
AXIAL THRUST, SITE	LBF	5013.251
AXIAL THRUST, VACUUM	LBF	5030.531
NOZZLE EXIT PRESSURE	PSIA	.062
FUEL DENSITY (MMH)	LB/FT3	55.521
OXIDIZER DENSITY	LB/FT3	89.865
FUEL FLOWRATE	LB/SEC	7.886
OXIDIZER FLOWRATE	LB/SEC	11.536
TOTAL PROPELLANT FLOWRATE	LB/SEC	19.423
MIXTURE RATIO (OVERALL)	O/F	1.463
BLC FLOWRATE	LB/SEC	.591
BLC TOTAL PERCENT	%	3.041
CORE MIXTURE RATIO	O/F	1.581
FUEL INJECTOR DELTA-P	PSID	62.775
OXIDIZER INJECTOR DELTA-P	PSID	45.571
T/C COOLANT DELTA-P	PSID	17.901
T/C COOLANT DELTA-T	DEG F	133.243
THRUST CHAMBER HEAT FLUX	BTU/SEC	791.319
C-STAR, SITE	FT/SEC	5484.570
C-STAR, UMR	FT/SEC	5921.723
C-STAR EFFICIENCY	%	96.503
CF, SITE	-----	1.514
CF SITE VACUUM	-----	1.519
CF, VAC 72 EXPECT	-----	1.515
CF CORRELATION	-----	100.302
CF, VAC 72	-----	1.776
ISP, TEST	SEC	258.112
ISP, SITE VACUUM	SEC	259.002
ISP, VAC 72 PREDICTED	SEC	304.620
ISP, TDK, TEST CONDITIONS	SEC	272.923
ISP EFFICIENCY	%	78.045
ENERGY RELEASE EFFICIENCY	%	95.993
C-STAR, ODE	FT/SEC	5683.339
ISP, ODE, TEST	SEC	331.862

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6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 27 MAR 4
SERIES RO/IHT-1 SEQUENCE 7 TEST 6
TEST DESCRIPTION
PERFORMANCE SURVEY OF RD INTEGRATED HARDWARE PRIOR TO CHUG TESTS. BASELINE BEFORE BLC PLUGGING TESTS. 9 TO 1 NOZZLE. 40 DEG FUEL. 70 DEG OXIDIZER. TARGET PCNS = 125., MR = 1.85.

ACTUAL TEST DURATION 10.010 SEC
DATA SLICE TIME 9.000 SEC TO 10.000 SEC

PARAMETER	UNITS	AVG. MEASURED VALUE
FUEL TANK PRESSURE	PSIA	207.438
OXIDIZER TANK PRESSURE	PSIA	225.029
FUEL INTERFACE PRESSURE	PSIA	197.503
OXIDIZER INTERFACE PRESSURE	PSIA	205.962
T/C COOLANT INLET MAN. PRESSURE	PSIA	192.311
FUEL INJECTOR PRESSURE	PSIA	180.200
OXIDIZER INJECTOR PRESSURE	PSIA	185.985
CHAMBER PRESSURE NO. 1	PSIA	130.543
CHAMBER PRESSURE NO. 2	PSIA	130.971
AXIAL THRUST. SYSTEM A	LBF	5008.779
AXIAL THRUST. SYSTEM B	LBF	5024.075
Y-AXIS THRUST	LBF	-32.646
Z-AXIS THRUST	LBF	19.350
AVERAGE CELL PRESSURE	PSIA	.080
CELL PRESSURE AGREEMENT	%	.667
FUEL FLOWRATE	GPM	55.074
OXIDIZER FLOWRATE	GPM	62.721
FUEL INTERFACE TEMPERATURE	DEG F	41.517
OXIDIZER INTERFACE TEMPERATURE	DEG F	74.543
T/C COOLANT IN TEMPERATURE	DEG F	46.275
T/C COOLANT OUT TEMPERATURE	DEG F	201.558
INJECTOR SURFACE TEMPERATURE	DEG F	128.986
T/C SURFACE TEMP -16 IN	DEG F	205.036
T/C SURFACE TEMP -13 IN	DEG F	196.286
T/C SURFACE TEMP -10 IN	DEG F	217.707
T/C SURFACE TEMP - 8 IN	DEG F	158.793
T/C SURFACE TEMP - 6 IN	DEG F	181.488
T/C SURFACE TEMP - 4 IN	DEG F	220.969
T/C SURFACE TEMP - 2 IN	DEG F	156.578
T/C SURFACE TEMP -0.3 IN	DEG F	143.191
T/C SURFACE TEMP + 3 IN	DEG F	121.697
COOLANT IN MANIFOLD SKIN	DEG F	65.421
NOZZLE FLANGE TOP TEMPERATURE	DEG F	58.349
NOZZLE SURFACE TEMP + 8.0 IN	DEG F	1137.402
NOZZLE SURFACE TEMP + 9.0 IN	DEG F	1368.877

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 27 MAR 4
SERIES RO/IHT-1 SEQUENCE 7 TEST 5

PERFORMANCE DATA

PARAMETER	UNITS	CALCULATED VALUE
PC, INJECTOR END	PSIA	130.757
PC, NOZZLE STAGNATION	PSIA	124.219
AXIAL THRUST, SITE	LBF	5016.427
AXIAL THRUST, VACUUM	LBF	5035.750
NOZZLE EXIT PRESSURE	PSIA	.090
FUEL DENSITY (MMH)	LB/FT3	55.624
OXIDIZER DENSITY	LB/FT3	89.873
FUEL FLOWRATE	LB/SEC	6.813
OXIDIZER FLOWRATE	LB/SEC	12.559
TOTAL PROPELLANT FLOWRATE	LB/SEC	19.372
MIXTURE RATIO (OVERALL)	O/F	1.843
BLC FLOWRATE	LB/SEC	.510
BLC TOTAL PERCENT	%	2.634
CORE MIXTURE RATIO	O/F	1.993
FUEL INJECTOR DELTA-P	PSID	49.443
OXIDIZER INJECTOR DELTA-P	PSID	55.228
T/C COOLANT DELTA-P	PSID	12.111
T/C COOLANT DELTA-T	DEG F	155.283
THRUST CHAMBER HEAT FLUX	BTU/SEC	756.436
C-STAR, SITE	FT/SEC	5468.194
C-STAR, UMR	FT/SEC	5550.751
C-STAR EFFICIENCY	%	95.968
CF, SITE	-----	1.524
CF SITE VACUUM	-----	1.529
CF, VAC 72 EXPECT	-----	1.536
CF CORRELATION	-----	99.600
CF, VAC 72	-----	1.789
ISP, TEST	SEC	258.949
ISP, SITE VACUUM	SEC	259.947
ISP, VAC 72 PREDICTED	SEC	305.853
ISP, TDK, TEST CONDITIONS	SEC	277.526
ISP EFFICIENCY	%	75.904
ENERGY RELEASE EFFICIENCY	%	94.745
C-STAR, ODE	FT/SEC	5697.924
ISP, ODE, TEST	SEC	342.468

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 77 MAR 4
SERIES RD/IHT-1 SEQUENCE 7 TEST 7
TEST DESCRIPTION
PERFORMANCE SURVEY OF RD INTEGRATED HARDWARE PRIOR TO CHUG TESTS. BASELINE BEFORE BLC PLUGGING TESTS. 9 TO 1 NOZZLE. 40 DEG FUEL. 70 DEG OXIDIZER. TARGET PCNS = 125.. MR = 1.65.

ACTUAL TEST DURATION 35.006 SEC
DATA SLICE TIME 9.000 SEC TO 10.000 SEC

PARAMETER	UNITS	AVG. MEASURED VALUE
FUEL TANK PRESSURE	PSIA	225.741
OXIDIZER TANK PRESSURE	PSIA	225.977
FUEL INTERFACE PRESSURE	PSIA	214.072
OXIDIZER INTERFACE PRESSURE	PSIA	209.349
T/C COOLANT INLET MAN. PRESSURE	PSIA	206.880
FUEL INJECTOR PRESSURE	PSIA	187.423
OXIDIZER INJECTOR PRESSURE	PSIA	187.925
CHAMBER PRESSURE NO. 1	PSIA	133.815
CHAMBER PRESSURE NO. 2	PSIA	134.365
AXIAL THRUST, SYSTEM A	LBF	5141.931
AXIAL THRUST, SYSTEM B	LBF	5156.961
Y-AXIS THRUST	LBF	-34.417
Z-AXIS THRUST	LBF	18.073
AVERAGE CELL PRESSURE	PSIA	.080
CELL PRESSURE AGREEMENT	%	.668
FUEL FLOWRATE	GPM	59.741
OXIDIZER FLOWRATE	GPM	62.063
FUEL INTERFACE TEMPERATURE	DEG F	41.702
OXIDIZER INTERFACE TEMPERATURE	DEG F	74.543
T/C COOLANT IN TEMPERATURE	DEG F	45.978
T/C COOLANT OUT TEMPERATURE	DEG F	188.617
INJECTOR SURFACE TEMPERATURE	DEG F	129.725
T/C SURFACE TEMP -16 IN	DEG F	192.544
T/C SURFACE TEMP -13 IN	DEG F	187.766
T/C SURFACE TEMP -10 IN	DEG F	201.801
T/C SURFACE TEMP - 8 IN	DEG F	150.860
T/C SURFACE TEMP - 6 IN	DEG F	172.180
T/C SURFACE TEMP - 4 IN	DEG F	208.249
T/C SURFACE TEMP - 2 IN	DEG F	138.842
T/C SURFACE TEMP -0.3 IN	DEG F	136.649
T/C SURFACE TEMP + 3 IN	DEG F	118.069
COOLANT IN MANIFOLD SKIN	DEG F	60.458
NOZZLE FLANGE TOP TEMPERATURE	DEG F	58.338
NOZZLE SURFACE TEMP + 8.0 IN	DEG F	1136.704
NOZZLE SURFACE TEMP + 9.0 IN	DEG F	1358.516

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 27 MAR 4
SERIES RD/IHT-1 SEQUENCE 7 TEST 7

PERFORMANCE DATA

PARAMETER	UNITS	CALCULATED VALUE
PC, INJECTOR END	PSIA	134.090
PC, NOZZLE STAGNATION	PSIA	127.385
AXIAL THRUST, SITE	LBF	5149.446
AXIAL THRUST, VACUUM	LBF	5168.649
NOZZLE EXIT PRESSURE	PSIA	.090
FUEL DENSITY (MMH)	LB/FT3	55.521
OXIDIZER DENSITY	LB/FT3	89.874
FUEL FLOWRATE	LB/SEC	7.390
OXIDIZER FLOWRATE	LB/SEC	12.427
TOTAL PROPELLANT FLOWRATE	LB/SEC	19.818
MIXTURE RATIO (OVERALL)	O/F	1.682
BLC FLOWRATE	LB/SEC	.554
BLC TOTAL PERCENT	%	2.793
CORE MIXTURE RATIO	O/F	1.818
FUEL INJECTOR DELTA-P	PSID	53.333
OXIDIZER INJECTOR DELTA-P	PSID	53.836
T/C COOLANT DELTA-P	PSID	19.457
T/C COOLANT DELTA-T	DEG F	142.639
THRUST CHAMBER HEAT FLUX	BTU/SEC	753.687
C-STAR, SITE	FT/SEC	5481.556
C-STAR, UMR	FT/SEC	5542.606
C-STAR EFFICIENCY	%	95.972
CF, SITE	-----	1.525
CF SITE VACUUM	-----	1.531
CF, VAC 72 EXPECT	-----	1.527
CF CORRELATION	-----	100.268
CF, VAC 72	-----	1.790
ISP, TEST	SEC	259.843
ISP, SITE VACUUM	SEC	260.812
ISP, VAC 72 PREDICTED	SEC	306.904
ISP, TDK, TEST CONDITIONS	SEC	276.461
ISP EFFICIENCY	%	76.984
ENERGY RELEASE EFFICIENCY	%	95.398
C-STAR, ODE	FT/SEC	5711.633
ISP, ODE, TEST	SEC	338.786

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 27 MAR 4
SERIES RD/IHT-1 SEQUENCE 7 TEST 7
TEST DESCRIPTION
PERFORMANCE SURVEY OF RD INTEGRATED HARDWARE PRIOR TO CHUG TESTS. BASELINE BEFORE BLC PLUGGING TESTS. 9 TO 1 NOZZLE. 40 DEG FUEL. 70 DEG OXIDIZER. TARGET PCNS = 125.. MR = 1.65.

ACTUAL TEST DURATION 35.006 SEC
DATA SLICE TIME 14.000 SEC TO 15.000 SEC

PARAMETER	UNITS	AVG. MEASURED VALUE
FUEL TANK PRESSURE	PSIA	226.199
OXIDIZER TANK PRESSURE	PSIA	226.451
FUEL INTERFACE PRESSURE	PSIA	214.072
OXIDIZER INTERFACE PRESSURE	PSIA	209.349
T/C COOLANT INLET MAN. PRESSURE	PSIA	207.263
FUEL INJECTOR PRESSURE	PSIA	188.183
OXIDIZER INJECTOR PRESSURE	PSIA	188.313
CHAMBER PRESSURE NO. 1	PSIA	133.088
CHAMBER PRESSURE NO. 2	PSIA	133.611
AXIAL THRUST, SYSTEM A	LBF	5148.267
AXIAL THRUST, SYSTEM B	LBF	5163.287
Y-AXIS THRUST	LBF	-33.405
Z-AXIS THRUST	LBF	18.326
AVERAGE CELL PRESSURE	PSIA	.078
CELL PRESSURE AGREEMENT	%	.669
FUEL FLOWRATE	GPM	59.796
OXIDIZER FLOWRATE	GPM	62.118
FUEL INTERFACE TEMPERATURE	DEG F	41.788
OXIDIZER INTERFACE TEMPERATURE	DEG F	74.543
T/C COOLANT IN TEMPERATURE	DEG F	45.386
T/C COOLANT OUT TEMPERATURE	DEG F	189.643
INJECTOR SURFACE TEMPERATURE	DEG F	128.023
T/C SURFACE TEMP -16 IN	DEG F	194.236
T/C SURFACE TEMP -13 IN	DEG F	189.633
T/C SURFACE TEMP -10 IN	DEG F	205.419
T/C SURFACE TEMP - 8 IN	DEG F	151.677
T/C SURFACE TEMP - 6 IN	DEG F	172.783
T/C SURFACE TEMP - 4 IN	DEG F	211.281
T/C SURFACE TEMP - 2 IN	DEG F	144.625
T/C SURFACE TEMP -0.3 IN	DEG F	137.861
T/C SURFACE TEMP + 3 IN	DEG F	119.431
COOLANT IN MANIFOLD SKIN	DEG F	58.132
NOZZLE FLANGE TOP TEMPERATURE	DEG F	55.777
NOZZLE SURFACE TEMP + 8.0 IN	DEG F	1220.981
NOZZLE SURFACE TEMP + 9.0 IN	DEG F	1419.011

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 27 MAR 4
SERIES RD/IHT-1 SEQUENCE 7 TEST 7

PERFORMANCE DATA

PARAMETER	UNITS	CALCULATED VALUE
PC, INJECTOR END	PSIA	133.349
PC, NOZZLE STAGNATION	PSIA	126.682
AXIAL THRUST, SITE	LBF	5155.777
AXIAL THRUST, VACUUM	LBF	5174.620
NOZZLE EXIT PRESSURE	PSIA	.088
FUEL DENSITY (MMH)	LB/FT3	55.519
OXIDIZER DENSITY	LB/FT3	89.874
FUEL FLOWRATE	LB/SEC	7.397
OXIDIZER FLOWRATE	LB/SEC	12.438
TOTAL PROPELLANT FLOWRATE	LB/SEC	19.835
MIXTURE RATIO (OVERALL)	O/F	1.682
BLC FLOWRATE	LB/SEC	.554
BLC TOTAL PERCENT	%	2.793
CORE MIXTURE RATIO	O/F	1.818
FUEL INJECTOR DELTA-P	PSID	54.834
OXIDIZER INJECTOR DELTA-P	PSID	54.964
T/C COOLANT DELTA-P	PSID	19.080
T/C COOLANT DELTA-T	DEG F	144.257
THRUST CHAMBER HEAT FLUX	BTU/SEC	762.902
C-STAR, SITE	FT/SEC	5446.496
C-STAR, UMR	FT/SEC	5507.548
C-STAR EFFICIENCY	%	95.358
CF, SITE	-----	1.536
CF SITE VACUUM	-----	1.541
CF, VAC 72 EXPECT	-----	1.527
CF CORRELATION	-----	100.941
CF, VAC 72	-----	1.802
ISP, TEST	SEC	259.934
ISP, SITE VACUUM	SEC	260.884
ISP, VAC 72 PREDICTED	SEC	307.011
ISP, TDK, TEST CONDITIONS	SEC	276.450
ISP EFFICIENCY	%	77.005
ENERGY RELEASE EFFICIENCY	%	95.427
C-STAR, ODE	FT/SEC	5711.633
ISP, ODE, TEST	SEC	338.787

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 27 MAR 4
SERIES RD/IHT-1 SEQUENCE 7 TEST 7
TEST DESCRIPTION
PERFORMANCE SURVEY OF RD INTEGRATED HARDWARE PRIOR TO CHUG TESTS. BASELINE BEFORE BLC PLUGGING TESTS. 9 TO 1 NOZZLE. 40 DEG FUEL. 70 DEG OXIDIZER. TARGET PCNS = 125., MR = 1.65.

ACTUAL TEST DURATION 35.006 SEC
DATA SLICE TIME 24.000 SEC TO 25.000 SEC

PARAMETER	UNITS	AVG. MEASURED VALUE
FUEL TANK PRESSURE	PSIA	225.741
OXIDIZER TANK PRESSURE	PSIA	225.503
FUEL INTERFACE PRESSURE	PSIA	214.072
OXIDIZER INTERFACE PRESSURE	PSIA	208.926
T/C COOLANT INLET MAN. PRESSURE	PSIA	207.263
FUEL INJECTOR PRESSURE	PSIA	188.564
OXIDIZER INJECTOR PRESSURE	PSIA	188.313
CHAMBER PRESSURE NO. 1	PSIA	132.361
CHAMBER PRESSURE NO. 2	PSIA	133.234
AXIAL THRUST, SYSTEM A	LBF	5129.245
AXIAL THRUST, SYSTEM B	LBF	5144.304
Y-AXIS THRUST	LBF	-32.393
Z-AXIS THRUST	LBF	18.453
AVERAGE CELL PRESSURE	PSIA	.076
CELL PRESSURE AGREEMENT	%	.671
FUEL FLOWRATE	GPM	59.796
OXIDIZER FLOWRATE	GPM	61.953
FUEL INTERFACE TEMPERATURE	DEG F	41.786
OXIDIZER INTERFACE TEMPERATURE	DEG F	74.943
T/C COOLANT IN TEMPERATURE	DEG F	44.054
T/C COOLANT OUT TEMPERATURE	DEG F	189.736
INJECTOR SURFACE TEMPERATURE	DEG F	131.572
T/C SURFACE TEMP -16 IN	DEG F	194.470
T/C SURFACE TEMP -13 IN	DEG F	199.867
T/C SURFACE TEMP -10 IN	DEG F	208.692
T/C SURFACE TEMP - 8 IN	DEG F	151.676
T/C SURFACE TEMP - 6 IN	DEG F	172.541
T/C SURFACE TEMP - 4 IN	DEG F	214.818
T/C SURFACE TEMP - 2 IN	DEG F	142.461
T/C SURFACE TEMP -0.3 IN	DEG F	138.588
T/C SURFACE TEMP + 3 IN	DEG F	120.056
COOLANT IN MANIFOLD SKIN	DEG F	55.469
NOZZLE FLANGE TOP TEMPERATURE	DEG F	55.264
NOZZLE SURFACE TEMP + 6.0 IN	DEG F	1298.102
NOZZLE SURFACE TEMP + 9.0 IN	DEG F	1449.737

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 27 MAR 4
SERIES HO/IHT-1 SEQUENCE 7 TEST 7

PERFORMANCE DATA

PARAMETER	UNITS	CALCULATED VALUE
PC, INJECTOR END	PSIA	132.797
PC, NOZZLE STAGNATION	PSIA	126.157
AXIAL THRUST, SITE	LBF	5136.775
AXIAL THRUST, VACUUM	LBF	5155.137
NOZZLE EXIT PRESSURE	PSIA	.087
FUEL DENSITY (MMH)	LB/FT3	55.519
OXIDIZER DENSITY	LB/FT3	89.874
FUEL FLOWRATE	LB/SEC	7.397
OXIDIZER FLOWRATE	LB/SEC	12.405
TOTAL PROPELLANT FLOWRATE	LB/SEC	19.802
MIXTURE RATIO (OVERALL)	O/F	1.677
BLC FLOWRATE	LB/SEC	.554
BLC TOTAL PERCENT	%	2.798
CORE MIXTURE RATIO	O/F	1.813
FUEL INJECTOR DELTA-P	PSID	55.766
OXIDIZER INJECTOR DELTA-P	PSID	55.516
T/C COOLANT DELTA-P	PSID	18.700
T/C COOLANT DELTA-T	DEG F	145.682
THRUST CHAMBER HEAT FLUX	BTU/SEC	770.442
C-STAR, SITE	FT/SEC	5432.980
C-STAR, UMR	FT/SEC	5493.362
C-STAR EFFICIENCY	%	95.123
CF, SITE	-----	1.536
CF SITE VACUUM	-----	1.542
CF, VAC 72 EXPECT	-----	1.527
CF CORRELATION	-----	100.995
CF, VAC 72	-----	1.803
ISP, TEST	SEC	259.407
ISP, SITE VACUUM	SEC	260.334
ISP, VAC 72 PREDICTED	SEC	306.363
ISP, TDK, TEST CONDITIONS	SEC	276.410
ISP EFFICIENCY	%	76.872
ENERGY RELEASE EFFICIENCY	%	95.244
C-STAR, ODE	FT/SEC	5711.544
ISP, ODE, TEST	SEC	338.662

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6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 27 MAR 4
SERIES RD/IHT-1 SEQUENCE 7 TEST 7
TEST DESCRIPTION
PERFORMANCE SURVEY OF RD INTEGRATED HARDWARE PRIOR TO CHUG TESTS. BASELINE BEFORE BLC PLUGGING TESTS. 9 TO 1 NOZZLE. 40 DEG FUEL. 70 DEG OXIDIZER. TARGET PCNS = 125.. MR = 1.65.

ACTUAL TEST DURATION 35.006 SEC
DATA SLICE TIME 34.000 SEC TO 35.000 SEC

PARAMETER	UNITS	AVG. MEASURED VALUE
FUEL TANK PRESSURE	PSIA	226.199
OXIDIZER TANK PRESSURE	PSIA	226.451
FUEL INTERFACE PRESSURE	PSIA	214.072
OXIDIZER INTERFACE PRESSURE	PSIA	208.926
T/C COOLANT INLET MAN. PRESSURE	PSIA	207.263
FUEL INJECTOR PRESSURE	PSIA	188.944
OXIDIZER INJECTOR PRESSURE	PSIA	189.089
CHAMBER PRESSURE NO. 1	PSIA	132.361
CHAMBER PRESSURE NO. 2	PSIA	133.234
AXIAL THRUST, SYSTEM A	LBF	5141.913
AXIAL THRUST, SYSTEM B	LBF	5156.956
Y-AXIS THRUST	LBF	-31.634
Z-AXIS THRUST	LBF	18.326
AVERAGE CELL PRESSURE	PSIA	.076
CELL PRESSURE AGREEMENT	%	.671
FUEL FLOWRATE	GPM	59.741
OXIDIZER FLOWRATE	GPM	62.063
FUEL INTERFACE TEMPERATURE	DEG F	41.786
OXIDIZER INTERFACE TEMPERATURE	DEG F	74.543
T/C COOLANT IN TEMPERATURE	DEG F	43.683
T/C COOLANT OUT TEMPERATURE	DEG F	190.668
INJECTOR SURFACE TEMPERATURE	DEG F	133.876
T/C SURFACE TEMP -16 IN	DEG F	195.053
T/C SURFACE TEMP -13 IN	DEG F	190.801
T/C SURFACE TEMP -10 IN	DEG F	210.448
T/C SURFACE TEMP - 8 IN	DEG F	152.376
T/C SURFACE TEMP - 6 IN	DEG F	173.266
T/C SURFACE TEMP - 4 IN	DEG F	218.985
T/C SURFACE TEMP - 2 IN	DEG F	157.172
T/C SURFACE TEMP -0.3 IN	DEG F	139.558
T/C SURFACE TEMP + 3 IN	DEG F	120.438
COOLANT IN MANIFOLD SKIN	DEG F	55.299
NOZZLE FLANGE TOP TEMPERATURE	DEG F	55.263
NOZZLE SURFACE TEMP + 8.0 IN	DEG F	1322.985
NOZZLE SURFACE TEMP + 9.0 IN	DEG F	1457.452

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 27 MAR 4
SERIES RD/IHT-1 SEQUENCE 7 TEST 7

PERFORMANCE DATA

PARAMETER	UNITS	CALCULATED VALUE
PC, INJECTOR END	PSIA	132.797
PC, NOZZLE STAGNATION	PSIA	126.157
AXIAL THRUST, SITE	LBF	5149.435
AXIAL THRUST, VACUUM	LBF	5167.676
NOZZLE EXIT PRESSURE	PSIA	.086
FUEL DENSITY (MMH)	LB/FT3	55.519
OXIDIZER DENSITY	LB/FT3	89.874
FUEL FLOWRATE	LB/SEC	7.390
OXIDIZER FLOWRATE	LB/SEC	12.428
TOTAL PROPELLANT FLOWRATE	LB/SEC	19.817
MIXTURE RATIO (OVERALL)	O/F	1.682
BLC FLOWRATE	LB/SEC	.553
BLC TOTAL PERCENT	%	2.793
CORE MIXTURE RATIO	O/F	1.818
FUEL INJECTOR DELTA-P	PSID	56.147
OXIDIZER INJECTOR DELTA-P	PSID	56.292
T/C COOLANT DELTA-P	PSID	18.319
T/C COOLANT DELTA-T	DEG F	146.985
THRUST CHAMBER HEAT FLUX	BTU/SEC	776.616
C-STAR, SITE	FT/SEC	5428.804
C-STAR, UMR	FT/SEC	5489.867
C-STAR EFFICIENCY	%	95.048
CF, SITE	-----	1.540
CF SITE VACUUM	-----	1.545
CF, VAC 72 EXPECT	-----	1.527
CF CORRELATION	-----	101.225
CF, VAC 72	-----	1.807
ISP, TEST	SEC	259.847
ISP, SITE VACUUM	SEC	260.767
ISP, VAC 72 PREDICTED	SEC	306.884
ISP, TDK, TEST CONDITIONS	SEC	276.441
ISP EFFICIENCY	%	76.970
ENERGY RELEASE EFFICIENCY	%	95.389
C-STAR, ODE	FT/SEC	5711.635
ISP, ODE, TEST	SEC	338.789

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 81 APR 4
SERIES RD/IHT-1 SEQUENCE 8 TEST 1
TEST DESCRIPTION
ENGINE PERFORMANCE AND HEAT TRANSFER EVALUATION WITHOUT BLC.
L/O INJECTOR S/N1 (BLC PLUGGED), 9 TO 1 NOZZLE, UNSATURATED
MMH/NTO (40 F FUEL). TARGET PCNS = 125., MR = 1.65.

ACTUAL TEST DURATION 35.004 SEC
DATA SLICE TIME 9.000 SEC TO 10.000 SEC

PARAMETER	UNITS	AVG. MEASURED VALUE
FUEL TANK PRESSURE	PSIA	224.892
OXIDIZER TANK PRESSURE	PSIA	225.705
FUEL INTERFACE PRESSURE	PSIA	214.765
OXIDIZER INTERFACE PRESSURE	PSIA	208.926
T/C COOLANT INLET MAN. PRESSURE	PSIA	208.797
FUEL INJECTOR PRESSURE	PSIA	194.266
OXIDIZER INJECTOR PRESSURE	PSIA	189.089
CHAMBER PRESSURE NO. 1	PSIA	131.633
CHAMBER PRESSURE NO. 2	PSIA	132.266
AXIAL THRUST, SYSTEM A	LBF	5084.855
AXIAL THRUST, SYSTEM B	LBF	5101.996
Y-AXIS THRUST	LBF	-23.297
Z-AXIS THRUST	LBF	36.046
AVERAGE CELL PRESSURE	PSIA	.078
CELL PRESSURE AGREEMENT	%	.649
FUEL FLOWRATE	GPM	55.715
OXIDIZER FLOWRATE	GPM	62.063
FUEL INTERFACE TEMPERATURE	DEG F	0
OXIDIZER INTERFACE TEMPERATURE	DEG F	0
T/C COOLANT IN TEMPERATURE	DEG F	45.087
T/C COOLANT OUT TEMPERATURE	DEG F	231.715
INJECTOR SURFACE TEMPERATURE	DEG F	77.488
T/C SURFACE TEMP -16 IN	DEG F	221.938
T/C SURFACE TEMP -13 IN	DEG F	257.538
T/C SURFACE TEMP -10 IN	DEG F	227.166
T/C SURFACE TEMP - 8 IN	DEG F	178.309
T/C SURFACE TEMP - 6 IN	DEG F	211.245
T/C SURFACE TEMP - 4 IN	DEG F	227.840
T/C SURFACE TEMP - 2 IN	DEG F	151.339
T/C SURFACE TEMP -0.3 IN	DEG F	153.397
T/C SURFACE TEMP + 3 IN	DEG F	132.450
COOLANT IN MANIFOLD SKIN	DEG F	54.395
NOZZLE FLANGE TOP TEMPERATURE	DEG F	52.711
NOZZLE SURFACE TEMP + 8.0 IN	DEG F	996.810
NOZZLE SURFACE TEMP + 9.0 IN	DEG F	1286.070

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 01 APR 4
SERIES RD/IHT-1 SEQUENCE 8 TEST 1

PERFORMANCE DATA

PARAMETER	UNITS	CALCULATED VALUE
PC, INJECTOR END	PSIA	131.950
PC, NOZZLE STAGNATION	PSIA	125.352
AXIAL THRUST, SITE	LBF	5093.426
AXIAL THRUST, VACUUM	LBF	5112.280
NOZZLE EXIT PRESSURE	PSIA	.090
FUEL DENSITY (MMH)	LB/FT3	55.524
OXIDIZER DENSITY	LB/FT3	90.367
FUEL FLOWRATE	LB/SEC	6.892
OXIDIZER FLOWRATE	LB/SEC	12.496
TOTAL PROPELLANT FLOWRATE	LB/SEC	19.388
MIXTURE RATIO (OVERALL)	O/F	1.813
BLC FLOWRATE	LB/SEC	0
BLC TOTAL PERCENT	%	0
CORE MIXTURE RATIO	O/F	1.813
FUEL INJECTOR DELTA-P	PSID	62.316
OXIDIZER INJECTOR DELTA-P	PSID	57.139
T/C COOLANT DELTA-P	PSID	14.531
T/C COOLANT DELTA-T	DEG F	186.628
THRUST CHAMBER HEAT FLUX	BTU/SEC	919.726
C-STAR, SITE	FT/SEC	5513.550
C-STAR, UMR	FT/SEC	5513.550
C-STAR EFFICIENCY	%	96.692
CF, SITE	-----	1.533
CF SITE VACUUM	-----	1.539
CF, VAC 72 EXPECT	-----	1.528
CF CORRELATION	-----	100.681
CF, VAC 72	-----	1.806
ISP, TEST	SEC	262.709
ISP, SITE VACUUM	SEC	263.681
ISP, VAC 72 PREDICTED	SEC	309.509
ISP, TDK, TEST CONDITIONS	SEC	277.347
ISP EFFICIENCY	%	77.132
ENERGY RELEASE EFFICIENCY	%	96.151
C-STAR, ODE	FT/SEC	5702.189
ISP, ODE, TEST	SEC	341.859

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 01 APR 4
SERIES RD/INT-1 SEQUENCE 8 TEST 1
TEST DESCRIPTION
ENGINE PERFORMANCE AND HEAT TRANSFER EVALUATION WITHOUT BLC.
L/D INJECTOR S/N1 (BLC PLUGGED), 9 TO 1 NOZZLE, UNSATURATED
MMH/NTO (40 F FUEL). TARGET PCNS = 125., MR = 1.65.

ACTUAL TEST DURATION 35.004 SEC
DATA SLICE TIME 14.000 SEC TO 15.000 SEC

PARAMETER	UNITS	AVG. MEASURED VALUE
FUEL TANK PRESSURE	PSIA	224.892
OXIDIZER TANK PRESSURE	PSIA	225.231
FUEL INTERFACE PRESSURE	PSIA	214.765
OXIDIZER INTERFACE PRESSURE	PSIA	208.502
T/C COOLANT INLET MAN. PRESSURE	PSIA	208.413
FUEL INJECTOR PRESSURE	PSIA	194.646
OXIDIZER INJECTOR PRESSURE	PSIA	188.701
CHAMBER PRESSURE NO. 1	PSIA	130.543
CHAMBER PRESSURE NO. 2	PSIA	131.511
AXIAL THRUST, SYSTEM A	LBF	5072.166
AXIAL THRUST, SYSTEM B	LBF	5095.670
Y-AXIS THRUST	LBF	-21.525
Z-AXIS THRUST	LBF	35.412
AVERAGE CELL PRESSURE	PSIA	.078
CELL PRESSURE AGREEMENT	%	.650
FUEL FLOWRATE	GPM	55.883
OXIDIZER FLOWRATE	GPM	62.008
FUEL INTERFACE TEMPERATURE	DEG F	0
OXIDIZER INTERFACE TEMPERATURE	DEG F	0
T/C COOLANT IN TEMPERATURE	DEG F	44.421
T/C COOLANT OUT TEMPERATURE	DEG F	236.415
INJECTOR SURFACE TEMPERATURE	DEG F	90.544
T/C SURFACE TEMP -16 IN	DEG F	234.108
T/C SURFACE TEMP -13 IN	DEG F	261.902
T/C SURFACE TEMP -10 IN	DEG F	241.134
T/C SURFACE TEMP - 8 IN	DEG F	182.362
T/C SURFACE TEMP - 6 IN	DEG F	211.982
T/C SURFACE TEMP - 4 IN	DEG F	232.844
T/C SURFACE TEMP - 2 IN	DEG F	156.290
T/C SURFACE TEMP -0.3 IN	DEG F	150.693
T/C SURFACE TEMP + 3 IN	DEG F	132.459
COOLANT IN MANIFOLD SKIN	DEG F	53.688
NOZZLE FLANGE TOP TEMPERATURE	DEG F	51.176
NOZZLE SURFACE TEMP + 8.0 IN	DEG F	1221.220
NOZZLE SURFACE TEMP + 9.0 IN	DEG F	1460.796

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 81 APR 4
SERIES RO/IHT-1 SEQUENCE 8 TEST 1

PERFORMANCE DATA

PARAMETER	UNITS	CALCULATED VALUE
PC, INJECTOR END	PSIA	131.027
PC, NOZZLE STAGNATION	PSIA	124.476
AXIAL THRUST, SITE	LBF	5083.918
AXIAL THRUST, VACUUM	LBF	5102.652
NOZZLE EXIT PRESSURE	PSIA	.090
FUEL DENSITY (MMH)	LB/FT3	55.489
OXIDIZER DENSITY	LB/FT3	90.265
FUEL FLOWRATE	LB/SEC	6.909
OXIDIZER FLOWRATE	LB/SEC	12.471
TOTAL PROPELLANT FLOWRATE	LB/SEC	19.379
MIXTURE RATIO (OVERALL)	O/F	1.805
BLC FLOWRATE	LB/SEC	0
BLC TOTAL PERCENT	%	0
CORE MIXTURE RATIO	O/F	1.805
FUEL INJECTOR DELTA-P	PSID	63.619
OXIDIZER INJECTOR DELTA-P	PSID	57.674
T/C COOLANT DELTA-P	PSID	13.767
T/C COOLANT DELTA-T	DEG F	191.995
THRUST CHAMBER HEAT FLUX	BTU/SEC	948.417
C-STAR, SITE	FT/SEC	5477.460
C-STAR, UHR	FT/SEC	5477.460
C-STAR EFFICIENCY	%	96.040
CF, SITE	-----	1.541
CF SITE VACUUM	-----	1.547
CF, VAC 72 EXPECT	-----	1.528
CF CORRELATION	-----	101.229
CF, VAC 72	-----	1.815
ISP, TEST	SEC	262.336
ISP, SITE VACUUM	SEC	263.303
ISP, VAC 72 PREDICTED	SEC	309.065
ISP, TDK, TEST CONDITIONS	SEC	277.268
ISP EFFICIENCY	%	77.057
ENERGY RELEASE EFFICIENCY	%	96.043
C-STAR, ODE	FT/SEC	5703.298
ISP, ODE, TEST	SEC	341.700

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 81 APR 4
SERIES RD/IHT-1 SEQUENCE 8 TEST 1
TEST DESCRIPTION
ENGINE PERFORMANCE AND HEAT TRANSFER EVALUATION WITHOUT BLC.
L/O INJECTOR S/N1 (BLC PLUGGED), 9 TO 1 NOZZLE, UNSATURATED
MMH/NTO (40 F FULL). TARGET PCNS = 125., MR = 1.65.

ACTUAL TEST DURATION 35.004 SEC
DATA SLICE TIME 24.000 SEC TO 25.000 SEC

PARAMETER	UNITS	AVG. MEASURED VALUE
FUEL TANK PRESSURE	PSIA	224.892
OXIDIZER TANK PRESSURE	PSIA	225.231
FUEL INTERFACE PRESSURE	PSIA	214.765
OXIDIZER INTERFACE PRESSURE	PSIA	208.079
T/C COOLANT INLET MAN. PRESSURE	PSIA	208.797
FUEL INJECTOR PRESSURE	PSIA	196.547
OXIDIZER INJECTOR PRESSURE	PSIA	188.313
CHAMBER PRESSURE NO. 1	PSIA	130.179
CHAMBER PRESSURE NO. 2	PSIA	131.134
AXIAL THRUST, SYSTEM A	LBF	5072.166
AXIAL THRUST, SYSTEM B	LBF	5102.001
Y-AXIS THRUST	LBF	-22.031
Z-AXIS THRUST	LBF	34.015
AVERAGE CELL PRESSURE	PSIA	.077
CELL PRESSURE AGREEMENT	%	.651
FUEL FLOWRATE	GPM	55.881
OXIDIZER FLOWRATE	GPM	62.009
FUEL INTERFACE TEMPERATURE	DEG F	0
OXIDIZER INTERFACE TEMPERATURE	DEG F	0
T/C COOLANT IN TEMPERATURE	DEG F	44.199
T/C COOLANT OUT TEMPERATURE	DEG F	240.656
INJECTOR SURFACE TEMPERATURE	DEG F	107.162
T/C SURFACE TEMP -16 IN	DEG F	241.608
T/C SURFACE TEMP -13 IN	DEG F	265.676
T/C SURFACE TEMP -10 IN	DEG F	252.071
T/C SURFACE TEMP - 8 IN	DEG F	183.294
T/C SURFACE TEMP - 6 IN	DEG F	214.176
T/C SURFACE TEMP - 4 IN	DEG F	235.641
T/C SURFACE TEMP - 2 IN	DEG F	163.897
T/C SURFACE TEMP -0.3 IN	DEG F	153.719
T/C SURFACE TEMP + 3 IN	DEG F	133.812
COOLANT IN MANIFOLD SKIN	DEG F	54.312
NOZZLE FLANGE TOP TEMPERATURE	DEG F	51.688
NOZZLE SURFACE TEMP + 8.0 IN	DEG F	1434.040
NOZZLE SURFACE TEMP + 9.0 IN	DEG F	1567.902

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 01 APR 4
SERIES RD/IHT-1 SEQUENCE 8 TEST 1

PERFORMANCE DATA

PARAMETER	UNITS	CALCULATED VALUE
PC, INJECTOR END	PSIA	130.657
PC, NOZZLE STAGNATION	PSIA	124.124
AXIAL THRUST, SITE	LBF	5087.084
AXIAL THRUST, VACUUM	LBF	5105.578
NOZZLE EXIT PRESSURE	PSIA	.088
FUEL DENSITY (MMH)	LB/FT3	55.554
OXIDIZER DENSITY	LB/FT3	90.183
FUEL FLOWRATE	LB/SEC	6.917
OXIDIZER FLOWRATE	LB/SEC	12.459
TOTAL PROPELLANT FLOWRATE	LB/SEC	19.376
MIXTURE RATIO (OVERALL)	O/F	1.801
BLC FLOWRATE	LB/SEC	0
BLC TOTAL PERCENT	%	0
CORE MIXTURE RATIO	O/F	1.801
FUEL INJECTOR DELTA-P	PSID	65.890
OXIDIZER INJECTOR DELTA-P	PSID	57.657
T/C COOLANT DELTA-P	PSID	12.250
T/C COOLANT DELTA-T	DEG F	196.457
THRUST CHAMBER HEAT FLUX	BTU/SEC	971.572
C-STAR, SITE	FT/SEC	5462.936
C-STAR, UMR	FT/SEC	5462.936
C-STAR EFFICIENCY	%	95.777
CF, SITE	-----	1.546
CF SITE VACUUM	-----	1.552
CF, VAC 72 EXPECT	-----	1.528
CF CORRELATION	-----	101.588
CF, VAC 72	-----	1.822
ISP, TEST	SEC	262.546
ISP, SITE VACUUM	SEC	263.501
ISP, VAC 72 PREDICTED	SEC	309.297
ISP, TDK, TEST CONDITIONS	SEC	277.230
ISP EFFICIENCY	%	77.131
ENERGY RELEASE EFFICIENCY	%	96.127
C-STAR, ODE	FT/SEC	5703.815
ISP, ODE, TEST	SEC	341.626

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 81 APR 4
SERIES RD/IHT-1 SEQUENCE 8 TEST 1
TEST DESCRIPTION
ENGINE PERFORMANCE AND HEAT TRANSFER EVALUATION WITHOUT BLC. L/D INJECTOR S/N1 (BLC PLUGGED), 9 TO 1 NOZZLE. UNSATURATED MMH/NTO (40 F FUEL). TARGET PCNS = 125., MR = 1.65.

ACTUAL TEST DURATION 35.004 SEC
DATA SLICE TIME 34.000 SEC TO 35.000 SEC

PARAMETER	UNITS	AVG. MEASURED VALUE
FUEL TANK PRESSURE	PSIA	224.892
OXIDIZER TANK PRESSURE	PSIA	225.705
FUEL INTERFACE PRESSURE	PSIA	213.914
OXIDIZER INTERFACE PRESSURE	PSIA	208.079
T/C COOLANT INLET MAN. PRESSURE	PSIA	208.797
FUEL INJECTOR PRESSURE	PSIA	196.547
OXIDIZER INJECTOR PRESSURE	PSIA	188.701
CHAMBER PRESSURE NO. 1	PSIA	130.179
CHAMBER PRESSURE NO. 2	PSIA	131.134
AXIAL THRUST, SYSTEM A	LBF	5072.166
AXIAL THRUST, SYSTEM B	LBF	5102.001
Y-AXIS THRUST	LBF	-19.499
Z-AXIS THRUST	LBF	33.254
AVERAGE CELL PRESSURE	PSIA	.076
CELL PRESSURE AGREEMENT	%	.652
FUEL FLOWRATE	GPM	55.772
OXIDIZER FLOWRATE	GPM	62.118
FUEL INTERFACE TEMPERATURE	DEG F	0
OXIDIZER INTERFACE TEMPERATURE	DEG F	0
T/C COOLANT IN TEMPERATURE	DEG F	43.458
T/C COOLANT OUT TEMPERATURE	DEG F	241.578
INJECTOR SURFACE TEMPERATURE	DEG F	115.976
T/C SURFACE TEMP -16 IN	DEG F	242.486
T/C SURFACE TEMP -13 IN	DEG F	264.497
T/C SURFACE TEMP -10 IN	DEG F	253.016
T/C SURFACE TEMP - 8 IN	DEG F	182.360
T/C SURFACE TEMP - 6 IN	DEG F	212.224
T/C SURFACE TEMP - 4 IN	DEG F	234.173
T/C SURFACE TEMP - 2 IN	DEG F	169.092
T/C SURFACE TEMP -0.3 IN	DEG F	153.114
T/C SURFACE TEMP + 3 IN	DEG F	133.319
COOLANT IN MANIFOLD SKIN	DEG F	55.921
NOZZLE FLANGE TOP TEMPERATURE	DEG F	53.735
NOZZLE SURFACE TEMP + 8.0 IN	DEG F	1502.160
NOZZLE SURFACE TEMP + 9.0 IN	DEG F	1593.548

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 01 APR 4
SERIES HD/IHT-1 SEQUENCE 8 TEST 1

PERFORMANCE DATA

PARAMETER	UNITS	CALCULATED VALUE
PC, INJECTOR END	PSIA	130.657
PC, NOZZLE STAGNATION	PSIA	124.124
AXIAL THRUST, SITE	LBF	5087.084
AXIAL THRUST, VACUUM	LBF	5105.457
NOZZLE EXIT PRESSURE	PSIA	.088
FUEL DENSITY (MMH)	LB/FT3	55.571
OXIDIZER DENSITY	LB/FT3	90.115
FUEL FLOWRATE	LB/SEC	6.905
OXIDIZER FLOWRATE	LB/SEC	12.472
TOTAL PROPELLANT FLOWRATE	LB/SEC	19.377
MIXTURE RATIO (OVERALL)	O/F	1.806
BLC FLOWRATE	LB/SEC	0
BLC TOTAL PERCENT	%	0
CORE MIXTURE RATIO	O/F	1.805
FUEL INJECTOR DELTA-P	PSID	65.890
OXIDIZER INJECTOR DELTA-P	PSID	58.045
T/C COOLANT DELTA-P	PSID	12.250
T/C COOLANT DELTA-T	DEG F	198.120
THRUST CHAMBER HEAT FLUX	BTU/SEC	978.175
C-STAR, SITE	FT/SEC	5462.601
C-STAR, UMR	FT/SEC	5462.601
C-STAR EFFICIENCY	%	95.782
CF, SITE	-----	1.546
CF SITE VACUUM	-----	1.552
CF, VAC 72 EXPECT	-----	1.528
CF CORRELATION	-----	101.568
CF, VAC 72	-----	1.822
ISP, TEST	SEC	262.530
ISP, SITE VACUUM	SEC	263.478
ISP, VAC 72 PREDICTED	SEC	309.271
ISP, TDK, TEST CONDITIONS	SEC	277.264
ISP EFFICIENCY	%	77.103
ENERGY RELEASE EFFICIENCY	%	96.108
C-STAR, ODE	FT/SEC	5703.141
ISP, ODE, TEST	SEC	341.723

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 01 APR 4
SERIES RO/IHT-1 SEQUENCE 8 TEST 2
TEST DESCRIPTION
ENGINE PERFORMANCE AND HEAT TRANSFER EVALUATION WITHOUT BLC.
L/D INJECTOR S/N1 (BLC PLUGGED), 9 TO 1 NOZZLE, UNSATURATED
MMH/NTO (40 F FUEL). TARGET PCNS = 140., MR = 1.65.

ACTUAL TEST DURATION 10.010 SEC
DATA SLICE TIME 9.000 SEC TO 10.000 SEC

PARAMETER	UNITS	AVG. MEASURED VALUE
FUEL TANK PRESSURE	PSIA	257.259
OXIDIZER TANK PRESSURE	PSIA	256.590
FUEL INTERFACE PRESSURE	PSIA	244.541
OXIDIZER INTERFACE PRESSURE	PSIA	233.477
T/C COOLANT INLET MAN. PRESSURE	PSIA	237.167
FUEL INJECTOR PRESSURE	PSIA	231.902
OXIDIZER INJECTOR PRESSURE	PSIA	211.204
CHAMBER PRESSURE NO. 1	PSIA	145.811
CHAMBER PRESSURE NO. 2	PSIA	145.857
AXIAL THRUST, SYSTEM A	LBF	5554.011
AXIAL THRUST, SYSTEM B	LBF	5564.101
Y-AXIS THRUST	LBF	-37.984
Z-AXIS THRUST	LBF	29.056
AVERAGE CELL PRESSURE	PSIA	.086
CELL PRESSURE AGREEMENT	%	.541
FUEL FLOWRATE	GPM	61.852
OXIDIZER FLOWRATE	GPM	67.168
FUEL INTERFACE TEMPERATURE	DEG F	0
OXIDIZER INTERFACE TEMPERATURE	DEG F	0
T/C COOLANT IN TEMPERATURE	DEG F	43.753
T/C COOLANT OUT TEMPERATURE	DEG F	237.242
INJECTOR SURFACE TEMPERATURE	DEG F	121.950
T/C SURFACE TEMP -16 IN	DEG F	237.334
T/C SURFACE TEMP -13 IN	DEG F	251.071
T/C SURFACE TEMP -10 IN	DEG F	244.936
T/C SURFACE TEMP - 8 IN	DEG F	163.109
T/C SURFACE TEMP - 6 IN	DEG F	189.521
T/C SURFACE TEMP - 4 IN	DEG F	213.142
T/C SURFACE TEMP - 2 IN	DEG F	163.896
T/C SURFACE TEMP -0.3 IN	DEG F	141.372
T/C SURFACE TEMP + 3 IN	DEG F	123.085
COOLANT IN MANIFOLD SKIN	DEG F	66.918
NOZZLE FLANGE TOP TEMPERATURE	DEG F	57.324
NOZZLE SURFACE TEMP + 8.0 IN	DEG F	1342.644
NOZZLE SURFACE TEMP + 9.0 IN	DEG F	1544.499

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 81 APR 4
SERIES RD/IHT-1 SEQUENCE 8 TEST 2

PERFORMANCE DATA

PARAMETER	UNITS	CALCULATED VALUE
PC, INJECTOR END	PSIA	145.834
PC, NOZZLE STAGNATION	PSIA	138.542
AXIAL THRUST, SITE	LBF	5559.056
AXIAL THRUST, VACUUM	LBF	5579.654
NOZZLE EXIT PRESSURE	PSIA	.097
FUEL DENSITY (MMH)	LB/FT3	55.573
OXIDIZER DENSITY	LB/FT3	90.117
FUEL FLOWRATE	LB/SEC	7.658
OXIDIZER FLOWRATE	LB/SEC	13.486
TOTAL PROPELLANT FLOWRATE	LB/SEC	21.145
MIXTURE RATIO (OVERALL)	O/F	1.761
BLC FLOWRATE	LB/SEC	0
BLC TOTAL PERCENT	%	0
CORE MIXTURE RATIO	O/F	1.761
FUEL INJECTOR DELTA-P	PSID	86.068
OXIDIZER INJECTOR DELTA-P	PSID	65.371
T/C COOLANT DELTA-P	PSID	5.266
T/C COOLANT DELTA-T	DEG F	193.489
THRUST CHAMBER HEAT FLUX	BTU/SEC	1059.490
C-STAR, SITE	FT/SEC	5587.496
C-STAR, UMR	FT/SEC	5587.496
C-STAR EFFICIENCY	%	97.891
CF, SITE	-----	1.514
CF SITE VACUUM	-----	1.519
CF, VAC 72 EXPECT	-----	1.525
CF CORRELATION	-----	99.617
CF, VAC 72	-----	1.784
ISP, TEST	SEC	262.907
ISP, SITE VACUUM	SEC	263.881
ISP, VAC 72 PREDICTED	SEC	309.744
ISP, TDK, TEST CONDITIONS	SEC	277.224
ISP EFFICIENCY	%	77.443
ENERGY RELEASE EFFICIENCY	%	96.177
C-STAR, ODE	FT/SEC	5707.901
ISP, ODE, TEST	SEC	340.742

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 81 APR 4
SERIES RD/IHT-1 SEQUENCE 8 TEST 3
TEST DESCRIPTION
ENGINE PERFORMANCE AND HEAT TRANSFER EVALUATION WITHOUT BLC.
L/D INJECTOR S/N1 (BLC PLUGGED), 9 TO 1 NOZZLE, UNSATURATED
MMH/NTO (40 F FULL). TARGET PCNS = 140., MR = 1.45.

ACTUAL TEST DURATION 10.014 SEC
DATA SLICE TIME 9.000 SEC TO 10.000 SEC

PARAMETER	UNITS	AVG. MEASURED VALUE
FUEL TANK PRESSURE	PSIA	276.406
OXIDIZER TANK PRESSURE	PSIA	244.172
FUEL INTERFACE PRESSURE	PSIA	261.130
OXIDIZER INTERFACE PRESSURE	PSIA	224.588
T/C COOLANT INLET MAN. PRESSURE	PSIA	251.352
FUEL INJECTOR PRESSURE	PSIA	239.125
OXIDIZER INJECTOR PRESSURE	PSIA	204.221
CHAMBER PRESSURE NO. 1	PSIA	145.084
CHAMBER PRESSURE NO. 2	PSIA	145.479
AXIAL THRUST, SYSTEM A	LBF	5534.985
AXIAL THRUST, SYSTEM B	LBF	5545.110
Y-AXIS THRUST	LBF	-42.036
Z-AXIS THRUST	LBF	29.308
AVERAGE CELL PRESSURE	PSIA	.086
CELL PRESSURE AGREEMENT	%	.541
FUEL FLOWRATE	GPM	67.230
OXIDIZER FLOWRATE	GPM	63.983
~~FUEL INTERFACE TEMPERATURE~~	DEG F	0
OXIDIZER INTERFACE TEMPERATURE	DEG F	0
T/C COOLANT IN TEMPERATURE	DEG F	43.605
T/C COOLANT OUT TEMPERATURE	DEG F	221.925
INJECTOR SURFACE TEMPERATURE	DEG F	126.170
T/C SURFACE TEMP -16 IN	DEG F	220.352
T/C SURFACE TEMP -13 IN	DEG F	235.939
T/C SURFACE TEMP -10 IN	DEG F	226.876
T/C SURFACE TEMP - 8 IN	DEG F	150.856
T/C SURFACE TEMP - 6 IN	DEG F	174.645
T/C SURFACE TEMP - 4 IN	DEG F	195.958
T/C SURFACE TEMP - 2 IN	DEG F	156.384
T/C SURFACE TEMP -0.3 IN	DEG F	136.041
T/C SURFACE TEMP + 3 IN	DEG F	114.935
COOLANT IN MANIFOLD SKIN	DEG F	73.610
NOZZLE FLANGE TOP TEMPERATURE	DEG F	62.443
NOZZLE SURFACE TEMP + 8.0 IN	DEG F	1306.427
NOZZLE SURFACE TEMP + 9.0 IN	DEG F	1478.443

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 01 APR 4
SERIES RO/IHT-1 SEQUENCE 8 TEST 3

PERFORMANCE DATA

PARAMETER	UNITS	CALCULATED VALUE
PC, INJECTOR END	PSIA	145.282
PC, NOZZLE STAGNATION	PSIA	138.017
AXIAL THRUST, SITE	LBF	5540.048
AXIAL THRUST, VACUUM	LBF	5560.766
NOZZLE EXIT PRESSURE	PSIA	.097
FUEL DENSITY (MMH)	LB/FT3	55.571
OXIDIZER DENSITY	LB/FT3	90.084
FUEL FLOWRATE	LB/SEC	8.324
OXIDIZER FLOWRATE	LB/SEC	12.842
TOTAL PROPELLANT FLOWRATE	LB/SEC	21.166
MIXTURE RATIO (OVERALL)	O/F	1.543
BLC FLOWRATE	LB/SEC	0
BLC TOTAL PERCENT	%	0
CORE MIXTURE RATIO	O/F	1.543
FUEL INJECTOR DELTA-P	PSID	93.843
OXIDIZER INJECTOR DELTA-P	PSID	58.939
T/C COOLANT DELTA-P	PSID	12.228
T/C COOLANT DELTA-T	DEG F	178.320
THRUST CHAMBER HEAT FLUX	BTU/SEC	1061.286
C-STAR, SITE	FT/SEC	5560.720
C-STAR, UMR	FT/SEC	5560.720
C-STAR EFFICIENCY	%	97.559
CF, SITE	-----	1.514
CF SITE VACUUM	-----	1.520
CF, VAC 72 EXPECT	-----	1.513
CF CORRELATION	-----	100.476
CF, VAC 72	-----	1.784
ISP, TEST	SEC	261.744
ISP, SITE VACUUM	SEC	262.722
ISP, VAC 72 PREDICTED	SEC	308.384
ISP, TDK, TEST CONDITIONS	SEC	274.504
ISP EFFICIENCY	%	78.826
ENERGY RELEASE EFFICIENCY	%	96.706
C-STAR, ODE	FT/SEC	5699.848
ISP, ODE, TEST	SEC	334.570

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6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 01 APR 4
SERIES RO/IHT-1 SEQUENCE 8 TEST 4
TEST DESCRIPTION
ENGINE PERFORMANCE AND HEAT TRANSFER EVALUATION WITHOUT BLC.
L/D INJECTOR S/N1 (BLC PLUGGED), 9 TO 1 NOZZLE, UNSATURATED
MMH/NTO (40 F FUEL). TARGET PCNS = 125., MR = 1.45.

ACTUAL TEST DURATION 10.006 SEC
DATA SLICE TIME 9.000 SEC TO 10.000 SEC

PARAMETER	UNITS	AVG. MEASURED VALUE
FUEL TANK PRESSURE	PSIA	234.465
OXIDIZER TANK PRESSURE	PSIA	209.605
FUEL INTERFACE PRESSURE	PSIA	222.622
OXIDIZER INTERFACE PRESSURE	PSIA	194.533
T/C COOLANT INLET MAN. PRESSURE	PSIA	214.931
FUEL INJECTOR PRESSURE	PSIA	203.770
OXIDIZER INJECTOR PRESSURE	PSIA	176.286
CHAMBER PRESSURE NO. 1	PSIA	129.816
CHAMBER PRESSURE NO. 2	PSIA	130.001
AXIAL THRUST, SYSTEM A	LBF	4958.029
AXIAL THRUST, SYSTEM B	LBF	4969.074
Y-AXIS THRUST	LBF	-36.971
Z-AXIS THRUST	LBF	27.290
AVERAGE CELL PRESSURE	PSIA	.076
CELL PRESSURE AGREEMENT	%	.753
FUEL FLOWRATE	GPM	60.171
OXIDIZER FLOWRATE	GPM	57.673
FUEL INTERFACE TEMPERATURE	DEG F	0
OXIDIZER INTERFACE TEMPERATURE	DEG F	0
T/C COOLANT IN TEMPERATURE	DEG F	43.901
T/C COOLANT OUT TEMPERATURE	DEG F	224.145
INJECTOR SURFACE TEMPERATURE	DEG F	128.622
T/C SURFACE TEMP -16 IN	DEG F	224.394
T/C SURFACE TEMP -13 IN	DEG F	239.689
T/C SURFACE TEMP -10 IN	DEG F	226.965
T/C SURFACE TEMP - 8 IN	DEG F	153.074
T/C SURFACE TEMP - 6 IN	DEG F	178.513
T/C SURFACE TEMP - 4 IN	DEG F	200.066
T/C SURFACE TEMP - 2 IN	DEG F	158.567
T/C SURFACE TEMP -0.3 IN	DEG F	139.191
T/C SURFACE TEMP + 3 IN	DEG F	117.156
COOLANT IN MANIFOLD SKIN	DEG F	80.129
NOZZLE FLANGE TOP TEMPERATURE	DEG F	58.351
NOZZLE SURFACE TEMP + 8.0 IN	DEG F	1222.992
NOZZLE SURFACE TEMP + 9.0 IN	DEG F	1420.574

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 01 APR 4
SERIES RD/IHT-1 SEQUENCE 8 TEST 4

PERFORMANCE DATA

PARAMETER	UNITS	CALCULATED VALUE
PC, INJECTOR END	PSIA	129.909
PC, NOZZLE STAGNATION	PSIA	123.413
AXIAL THRUST, SITE	LBF	4963.551
AXIAL THRUST, VACUUM	LBF	4981.744
NOZZLE EXIT PRESSURE	PSIA	.087
FUEL DENSITY (MMH)	LB/FT3	55.573
OXIDIZER DENSITY	LB/FT3	90.086
FUEL FLOWRATE	LB/SEC	7.450
OXIDIZER FLOWRATE	LB/SEC	11.576
TOTAL PROPELLANT FLOWRATE	LB/SEC	19.026
MIXTURE RATIO (OVERALL)	O/F	1.554
BLC FLOWRATE	LB/SEC	0
BLC TOTAL PERCENT	%	0
CORE MIXTURE RATIO	O/F	1.554
FUEL INJECTOR DELTA-P	PSID	73.861
OXIDIZER INJECTOR DELTA-P	PSID	46.377
T/C COOLANT DELTA-P	PSID	11.161
T/C COOLANT DELTA-T	DEG F	180.244
THRUST CHAMBER HEAT FLUX	BTU/SEC	960.145
C-STAR, SITE	FT/SEC	5531.567
C-STAR, UMR	FT/SEC	5531.567
C-STAR EFFICIENCY	%	97.020
CF, SITE	-----	1.517
CF SITE VACUUM	-----	1.523
CF, VAC 72 EXPECT	-----	1.514
CF CORRELATION	-----	100.625
CF, VAC 72	-----	1.788
ISP, TEST	SEC	260.883
ISP, SITE VACUUM	SEC	261.839
ISP, VAC 72 PREDICTED	SEC	307.346
ISP, TDK, TEST CONDITIONS	SEC	274.484
ISP EFFICIENCY	%	78.179
ENERGY RELEASE EFFICIENCY	%	96.504
C-STAR, ODE	FT/SEC	5701.450
ISP, ODE, TEST	SEC	334.920

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 01 APR 4
SERIES RD/IHT-1 SEQUENCE 8 TEST 5
TEST DESCRIPTION
ENGINE PERFORMANCE AND HEAT TRANSFER EVALUATION WITHOUT BLC.
L/O INJECTOR S/N1 (BLC PLUGGED), 9 TO 1 NOZZLE, UNSATURATED
MMH/NTO (40 F FULL). TARGET PCNS = 125., MR = 1.85.

ACTUAL TEST DURATION 10.015 SEC
DATA SLICE TIME 9.000 SEC TO 10.000 SEC

PARAMETER	UNITS	AVG. MEASURED VALUE
FUEL TANK PRESSURE	PSIA	208.481
OXIDIZER TANK PRESSURE	PSIA	224.284
FUEL INTERFACE PRESSURE	PSIA	199.452
OXIDIZER INTERFACE PRESSURE	PSIA	205.539
T/C COOLANT INLET MAN. PRESSURE	PSIA	194.995
FUEL INJECTOR PRESSURE	PSIA	185.902
OXIDIZER INJECTOR PRESSURE	PSIA	185.597
CHAMBER PRESSURE NO. 1	PSIA	129.452
CHAMBER PRESSURE NO. 2	PSIA	130.001
AXIAL THRUST, SYSTEM A	LBF	4964.382
AXIAL THRUST, SYSTEM B	LBF	4975.407
Y-AXIS THRUST	LBF	-32.667
Z-AXIS THRUST	LBF	26.913
AVERAGE CELL PRESSURE	PSIA	.081
CELL PRESSURE AGREEMENT	%	.647
FUEL FLOWRATE	GPM	52.118
OXIDIZER FLOWRATE	GPM	62.666
FUEL INTERFACE TEMPERATURE	DEG F	0
OXIDIZER INTERFACE TEMPERATURE	DEG F	0
T/C COOLANT IN TEMPERATURE	DEG F	44.271
T/C COOLANT OUT TEMPERATURE	DEG F	249.948
INJECTOR SURFACE TEMPERATURE	DEG F	135.267
T/C SURFACE TEMP -16 IN	DEG F	245.551
T/C SURFACE TEMP -13 IN	DEG F	256.764
T/C SURFACE TEMP -10 IN	DEG F	246.657
T/C SURFACE TEMP - 8 IN	DEG F	172.091
T/C SURFACE TEMP - 6 IN	DEG F	200.172
T/C SURFACE TEMP - 4 IN	DEG F	223.927
T/C SURFACE TEMP - 2 IN	DEG F	173.581
T/C SURFACE TEMP -0.3 IN	DEG F	150.088
T/C SURFACE TEMP + 3 IN	DEG F	128.872
COOLANT IN MANIFOLD SKIN	DEG F	87.366
NOZZLE FLANGE TOP TEMPERATURE	DEG F	60.400
NOZZLE SURFACE TEMP + 8.0 IN	DEG F	1294.597
NOZZLE SURFACE TEMP + 9.0 IN	DEG F	1509.160

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6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 81 APR 4
SERIES RD/IHT-1

SEQUENCE 8 TEST 5

PERFORMANCE DATA

PARAMETER	UNITS	CALCULATED VALUE
PC, INJECTOR END	PSIA	129.727
PC, NOZZLE STAGNATION	PSIA	123.240
AXIAL THRUST, SITE	LBF	4969.894
AXIAL THRUST, VACUUM	LBF	4989.350
NOZZLE EXIT PRESSURE	PSIA	.092
FUEL DENSITY (MMH)	LB/FT3	55.568
OXIDIZER DENSITY	LB/FT3	90.073
FUEL FLOWRATE	LB/SEC	6.483
OXIDIZER FLOWRATE	LB/SEC	12.576
TOTAL PROPELLANT FLOWRATE	LB/SEC	19.029
MIXTURE RATIO (OVERALL)	O/F	1.949
BLC FLOWRATE	LB/SEC	0
BLC TOTAL PERCENT	%	0
CORE MIXTURE RATIO	O/F	1.949
FUEL INJECTOR DELTA-P	PSID	56.176
OXIDIZER INJECTOR DELTA-P	PSID	55.871
T/C COOLANT DELTA-P	PSID	9.092
T/C COOLANT DELTA-T	DEG F	205.677
THRUST CHAMBER HEAT FLUX	BTU/SEC	948.909
C-STAR, SITE	FT/SEC	5523.054
C-STAR, UMR	FT/SEC	5523.054
C-STAR EFFICIENCY	%	97.302
CF, SITE	-----	1.521
CF SITE VACUUM	-----	1.527
CF, VAC 72 EXPECT	-----	1.536
CF CORRELATION	-----	99.439
CF, VAC 72	-----	1.793
ISP, TEST	SEC	261.179
ISP, SITE VACUUM	SEC	262.202
ISP, VAC 72 PREDICTED	SEC	307.772
ISP, TDK, TEST CONDITIONS	SEC	276.625
ISP EFFICIENCY	%	76.137
ENERGY RELEASE EFFICIENCY	%	95.888
C-STAR, ODE	FT/SEC	5676.219
ISP, ODE, TEST	SEC	344.302

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 81 APR 4
SERIES RD/IHT-1 SEQUENCE 8 TEST 6
TEST DESCRIPTION
ENGINE PERFORMANCE AND HEAT TRANSFER EVALUATION WITHOUT BLC.
L/D INJECTOR S/N1 (BLC PLUGGED). 9 TO 1 NOZZLE. UNSATURATED
MMH/NTO (40 F FUEL). TARGET PCNS = 110.. MR = 1.45.

ACTUAL TEST DURATION 10.015 SEC
DATA SLICE TIME 9.000 SEC TO 10.000 SEC

PARAMETER	UNITS	AVG. MEASURED VALUE
FUEL TANK PRESSURE	PSIA	195.260
OXIDIZER TANK PRESSURE	PSIA	176.932
FUEL INTERFACE PRESSURE	PSIA	185.840
OXIDIZER INTERFACE PRESSURE	PSIA	165.325
T/C COOLANT INLET MAN. PRESSURE	PSIA	180.810
FUEL INJECTOR PRESSURE	PSIA	171.837
OXIDIZER INJECTOR PRESSURE	PSIA	149.515
CHAMBER PRESSURE NO. 1	PSIA	113.821
CHAMBER PRESSURE NO. 2	PSIA	114.901
AXIAL THRUST, SYSTEM A	LBF	4368.400
AXIAL THRUST, SYSTEM B	LBF	4361.394
Y-AXIS THRUST	LBF	-29.628
Z-AXIS THRUST	LBF	21.856
AVERAGE CELL PRESSURE	PSIA	.069
CELL PRESSURE AGREEMENT	%	.562
FUEL FLOWRATE	GPM	52.993
OXIDIZER FLOWRATE	GPM	51.356
FUEL INTERFACE TEMPERATURE	DEG F	0
OXIDIZER INTERFACE TEMPERATURE	DEG F	0
T/C COOLANT IN TEMPERATURE	DEG F	43.753
T/C COOLANT OUT TEMPERATURE	DEG F	228.117
INJECTOR SURFACE TEMPERATURE	DEG F	134.126
T/C SURFACE TEMP -16 IN	DEG F	227.973
T/C SURFACE TEMP -13 IN	DEG F	236.796
T/C SURFACE TEMP -10 IN	DEG F	234.842
T/C SURFACE TEMP - 8 IN	DEG F	158.326
T/C SURFACE TEMP - 6 IN	DEG F	182.748
T/C SURFACE TEMP - 4 IN	DEG F	204.182
T/C SURFACE TEMP - 2 IN	DEG F	150.712
T/C SURFACE TEMP -0.3 IN	DEG F	143.673
T/C SURFACE TEMP + 3 IN	DEG F	119.372
COOLANT IN MANIFOLD SKIN	DEG F	95.499
NOZZLE FLANGE TOP TEMPERATURE	DEG F	70.123
NOZZLE SURFACE TEMP + 8.0 IN	DEG F	1118.184
NOZZLE SURFACE TEMP + 9.0 IN	DEG F	1318.620

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 01 APR 4
SERIES RD/IHT-1 SEQUENCE 8 TEST 6

PERFORMANCE DATA

PARAMETER	UNITS	CALCULATED VALUE
PC, INJECTOR END	PSIA	114.361
PC, NOZZLE STAGNATION	PSIA	108.643
AXIAL THRUST, SITE	LBF	4364.897
AXIAL THRUST, VACUUM	LBF	4381.407
NOZZLE EXIT PRESSURE	PSIA	.080
FUEL DENSITY (MMH)	LB/FT3	55.571
OXIDIZER DENSITY	LB/FT3	90.047
FUEL FLOWRATE	LB/SEC	6.561
OXIDIZER FLOWRATE	LB/SEC	10.303
TOTAL PROPELLANT FLOWRATE	LB/SEC	16.865
MIXTURE RATIO (OVERALL)	O/F	1.570
BLC FLOWRATE	LB/SEC	0
BLC TOTAL PERCENT	%	0
CORE MIXTURE RATIO	O/F	1.570
FUEL INJECTOR DELTA-P	PSID	57.476
OXIDIZER INJECTOR DELTA-P	PSID	35.154
T/C COOLANT DELTA-P	PSID	8.973
T/C COOLANT DELTA-T	DEG F	184.364
THRUST CHAMBER HEAT FLUX	BTU/SEC	864.897
C-STAR, SITE	FT/SEC	5493.655
C-STAR, UMR	FT/SEC	5493.655
C-STAR EFFICIENCY	%	96.322
CF, SITE	-----	1.516
CF SITE VACUUM	-----	1.522
CF, VAC 72 EXPECT	-----	1.514
CF CORRELATION	-----	100.468
CF, VAC 72	-----	1.786
ISP, TEST	SEC	258.821
ISP, SITE VACUUM	SEC	259.800
ISP, VAC 72 PREDICTED	SEC	304.954
ISP, TDK, TEST CONDITIONS	SEC	274.466
ISP EFFICIENCY	%	77.448
ENERGY RELEASE EFFICIENCY	%	95.910
C-STAR, ODE	FT/SEC	5703.441
ISP, ODE, TEST	SEC	335.451

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 81 APR 6
SERIES RO/IHT-1 SEQUENCE 8 TEST 7
TEST DESCRIPTION
ENGINE PERFORMANCE AND HEAT TRANSFER EVALUATION WITHOUT BLC.
L/D INJECTOR S/N1 (BLC PLUGGED), 9 TO 1 NOZZLE, UNSATURATED
MMH/NTO (40 F FUEL), TARGET PCNS = 140., MR = 1.85.

ACTUAL TEST DURATION 10.006 SEC
DATA SLICE TIME 9.000 SEC TO 10.000 SEC

PARAMETER	UNITS	AVG. MEASURED VALUE
FUEL TANK PRESSURE	PSIA	242.215
OXIDIZER TANK PRESSURE	PSIA	265.481
FUEL INTERFACE PRESSURE	PSIA	231.354
OXIDIZER INTERFACE PRESSURE	PSIA	243.214
T/C COOLANT INLET MAN. PRESSURE	PSIA	224.515
FUEL INJECTOR PRESSURE	PSIA	210.993
OXIDIZER INJECTOR PRESSURE	PSIA	217.412
CHAMBER PRESSURE NO. 1	PSIA	144.357
CHAMBER PRESSURE NO. 2	PSIA	145.479
AXIAL THRUST, SYSTEM A	LBF	5566.696
AXIAL THRUST, SYSTEM B	LBF	5595.749
Y-AXIS THRUST	LBF	-33.426
Z-AXIS THRUST	LBF	20.746
AVERAGE CELL PRESSURE	PSIA	.082
CELL PRESSURE AGREEMENT	%	.645
FUEL FLOWRATE	GPM	57.783
OXIDIZER FLOWRATE	GPM	70.358
FUEL INTERFACE TEMPERATURE	DEG F	0
OXIDIZER INTERFACE TEMPERATURE	DEG F	0
T/C COOLANT IN TEMPERATURE	DEG F	44.641
T/C COOLANT OUT TEMPERATURE	DEG F	244.437
INJECTOR SURFACE TEMPERATURE	DEG F	139.717
T/C SURFACE TEMP -14 IN	DEG F	245.849
T/C SURFACE TEMP -13 IN	DEG F	294.995
T/C SURFACE TEMP -10 IN	DEG F	252.699
T/C SURFACE TEMP - 8 IN	DEG F	172.207
T/C SURFACE TEMP - 6 IN	DEG F	198.357
T/C SURFACE TEMP - 4 IN	DEG F	223.589
T/C SURFACE TEMP - 2 IN	DEG F	148.920
T/C SURFACE TEMP -0.3 IN	DEG F	149.362
T/C SURFACE TEMP + 3 IN	DEG F	128.795
COOLANT IN MANIFOLD SKIN	DEG F	100.892
NOZZLE FLANGE TOP TEMPERATURE	DEG F	70.122
NOZZLE SURFACE TEMP + 8.0 IN	DEG F	1239.498
NOZZLE SURFACE TEMP + 9.0 IN	DEG F	1514.363

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 01 APR 4
SERIES RO/IHT-1 SEQUENCE 8 TEST 7

PERFORMANCE DATA

PARAMETER	UNITS	CALCULATED VALUE
PC, INJECTOR END	PSIA	144.918
PC, NOZZLE STAGNATION	PSIA	137.672
AXIAL THRUST, SITE	LBF	5581.223
AXIAL THRUST, VACUUM	LBF	5600.919
NOZZLE EXIT PRESSURE	PSIA	.093
FUEL DENSITY (MMH)	LB/FT3	55.565
OXIDIZER DENSITY	LB/FT3	90.103
FUEL FLOWRATE	LB/SEC	7.153
OXIDIZER FLOWRATE	LB/SEC	14.124
TOTAL PROPELLANT FLOWRATE	LB/SEC	21.278
MIXTURE RATIO (OVERALL)	O/F	1.974
BLC FLOWRATE	LB/SEC	0
BLC TOTAL PERCENT	%	0
CORE MIXTURE RATIO	O/F	1.974
FUEL INJECTOR DELTA-P	PSID	66.075
OXIDIZER INJECTOR DELTA-P	PSID	72.494
T/C COOLANT DELTA-P	PSID	13.523
T/C COOLANT DELTA-T	DEG F	199.796
THRUST CHAMBER HEAT FLUX	BTU/SEC	1021.905
C-STAR, SITE	FT/SEC	5517.630
C-STAR, UNR	FT/SEC	5517.630
C-STAR EFFICIENCY	%	97.319
CF, SITE	-----	1.530
CF SITE VACUUM	-----	1.535
CF, VAC 72 EXPECT	-----	1.537
CF CORRELATION	-----	99.832
CF, VAC 72	-----	1.802
ISP, TEST	SEC	262.302
ISP, SITE VACUUM	SEC	263.228
ISP, VAC 72 PREDICTED	SEC	308.977
ISP, TDK, TEST CONDITIONS	SEC	276.922
ISP EFFICIENCY	%	76.355
ENERGY RELEASE EFFICIENCY	%	96.039
C-STAR, ODE	FT/SEC	5669.636
ISP, ODE, TEST	SEC	344.743

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 01 APR 4
SERIES RD/IHT-1 SEQUENCE 8 TEST 8
TEST DESCRIPTION
ENGINE PERFORMANCE AND HEAT TRANSFER EVALUATION WITHOUT BLC. L/D INJECTOR S/N1 (BLC PLUGGED), 9 TO 1 NOZZLE, UNSATURATED MMH/NTO (40 F FUEL). TARGET PCNS = 110., MR = 1.65.

ACTUAL TEST DURATION 10.011 SEC
DATA SLICE TIME 9.000 SEC TO 10.000 SEC

PARAMETER	UNITS	AVG. MEASURED VALUE
FUEL TANK PRESSURE	PSIA	184.319
OXIDIZER TANK PRESSURE	PSIA	183.561
FUEL INTERFACE PRESSURE	PSIA	176.056
OXIDIZER INTERFACE PRESSURE	PSIA	170.828
T/C COOLANT INLET MAN. PRESSURE	PSIA	171.992
FUEL INJECTOR PRESSURE	PSIA	160.432
OXIDIZER INJECTOR PRESSURE	PSIA	153.783
CHAMBER PRESSURE NO. 1	PSIA	113.821
CHAMBER PRESSURE NO. 2	PSIA	115.656
AXIAL THRUST, SYSTEM A	LBF	4381.689
AXIAL THRUST, SYSTEM B	LBF	4393.042
Y-AXIS THRUST	LBF	-26.589
Z-AXIS THRUST	LBF	21.607
AVERAGE CELL PRESSURE	PSIA	.067
CELL PRESSURE AGREEMENT	%	.663
FUEL FLOWRATE	GPM	49.045
OXIDIZER FLOWRATE	GPM	53.940
FUEL INTERFACE TEMPERATURE	DEG F	0
OXIDIZER INTERFACE TEMPERATURE	DEG F	0
T/C COOLANT IN TEMPERATURE	DEG F	44.345
T/C COOLANT OUT TEMPERATURE	DEG F	237.716
INJECTOR SURFACE TEMPERATURE	DEG F	139.912
T/C SURFACE TEMP -16 IN	DEG F	239.923
T/C SURFACE TEMP -13 IN	DEG F	247.347
T/C SURFACE TEMP -10 IN	DEG F	246.805
T/C SURFACE TEMP - 8 IN	DEG F	170.457
T/C SURFACE TEMP - 6 IN	DEG F	194.602
T/C SURFACE TEMP - 4 IN	DEG F	218.467
T/C SURFACE TEMP - 2 IN	DEG F	145.895
T/C SURFACE TEMP -0.3 IN	DEG F	147.787
T/C SURFACE TEMP + 3 IN	DEG F	126.808
COOLANT IN MANIFOLD SKIN	DEG F	107.664
NOZZLE FLANGE TOP TEMPERATURE	DEG F	77.802
NOZZLE SURFACE TEMP + 8.0 IN	DEG F	1099.752
NOZZLE SURFACE TEMP + 9.0 IN	DEG F	1338.672

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 01 APR 4
SERIES RO/IHT-1

SEQUENCE 8 TEST [illegible]

PERFORMANCE DATA

PARAMETER	UNITS	CALCULATED VALUE
PC, INJECTOR END	PSIA	114.738
PC, NOZZLE STAGNATION	PSIA	109.001
AXIAL THRUST, SITE	LBF	4387.066
AXIAL THRUST, VACUUM	LBF	4403.275
NOZZLE EXIT PRESSURE	PSIA	.079
FUEL DENSITY (MMH)	LB/FT3	55.565
OXIDIZER DENSITY	LB/FT3	90.051
FUEL FLOWRATE	LB/SEC	6.072
OXIDIZER FLOWRATE	LB/SEC	10.822
TOTAL PROPELLANT FLOWRATE	LB/SEC	16.894
MIXTURE RATIO (OVERALL)	O/F	1.782
BLC FLOWRATE	LB/SEC	0
BLC TOTAL PERCENT	%	0
CORE MIXTURE RATIO	O/F	1.782
FUEL INJECTOR DELTA-P	PSID	45.694
OXIDIZER INJECTOR DELTA-P	PSID	39.065
T/C COOLANT DELTA-P	PSID	11.560
T/C COOLANT DELTA-T	DEG F	193.372
THRUST CHAMBER HEAT FLUX	BTU/SEC	839.480
C-STAR, SITE	FT/SEC	5502.209
C-STAR, UMR	FT/SEC	5502.209
C-STAR EFFICIENCY	%	96.433
CF, SITE	-----	1.518
CF SITE VACUUM	-----	1.524
CF, VAC 72 EXPECT	-----	1.527
CF CORRELATION	-----	99.840
CF, VAC 72	-----	1.789
ISP, TEST	SEC	259.684
ISP, SITE VACUUM	SEC	260.643
ISP, VAC 72 PREDICTED	SEC	305.943
ISP, TDK, TEST CONDITIONS	SEC	276.616
ISP EFFICIENCY	%	76.387
ENERGY RELEASE EFFICIENCY	%	95.467
C-STAR, ODE	FT/SEC	5705.761
ISP, ODE, TEST	SEC	341.213

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 81 APR 4
SERIES RD/IHT-1 SEQUENCE 8 TEST 9
TEST DESCRIPTION
ENGINE PERFORMANCE AND HEAT TRANSFER EVALUATION WITHOUT BLC.
L/D INJECTOR S/N1 (BLC PLUGGED), 9 TO 1 NOZZLE, UNSATURATED
MMH/NTO (40 F FUEL). TARGET PCNS = 110., MR = 1.65.

ACTUAL TEST DURATION 10.008 SEC
DATA SLICE TIME 9.000 SEC TO 10.000 SEC

PARAMETER	UNITS	AVG. MEASURED VALUE
FUEL TANK PRESSURE	PSIA	175.202
OXIDIZER TANK PRESSURE	PSIA	188.770
FUEL INTERFACE PRESSURE	PSIA	167.974
OXIDIZER INTERFACE PRESSURE	PSIA	173.791
T/C COOLANT INLET MAN. PRESSURE	PSIA	165.091
FUEL INJECTOR PRESSURE	PSIA	155.490
OXIDIZER INJECTOR PRESSURE	PSIA	156.499
CHAMBER PRESSURE NO. 1	PSIA	113.457
CHAMBER PRESSURE NO. 2	PSIA	115.278
AXIAL THRUST, SYSTEM A	LBF	4368.400
AXIAL THRUST, SYSTEM B	LBF	4380.384
Y-AXIS THRUST	LBF	-27.602
Z-AXIS THRUST	LBF	19.837
AVERAGE CELL PRESSURE	PSIA	.076
CELL PRESSURE AGREEMENT	%	.652
FUEL FLOWRATE	GPM	45.781
OXIDIZER FLOWRATE	GPM	55.917
FUEL INTERFACE TEMPERATURE	DEG F	0
OXIDIZER INTERFACE TEMPERATURE	DEG F	0
T/C COOLANT IN TEMPERATURE	DEG F	44.271
T/C COOLANT OUT TEMPERATURE	DEG F	252.251
INJECTOR SURFACE TEMPERATURE	DEG F	146.842
T/C SURFACE TEMP -16 IN	DEG F	250.014
T/C SURFACE TEMP -13 IN	DEG F	259.947
T/C SURFACE TEMP -10 IN	DEG F	251.586
T/C SURFACE TEMP - 8 IN	DEG F	173.257
T/C SURFACE TEMP - 6 IN	DEG F	203.076
T/C SURFACE TEMP - 4 IN	DEG F	225.627
T/C SURFACE TEMP - 2 IN	DEG F	152.305
T/C SURFACE TEMP -0.3 IN	DEG F	152.265
T/C SURFACE TEMP + 3 IN	DEG F	130.966
COOLANT IN MANIFOLD SKIN	DEG F	105.465
NOZZLE FLANGE TOP TEMPERATURE	DEG F	65.008
NOZZLE SURFACE TEMP + 8.0 IN	DEG F	1249.775
NOZZLE SURFACE TEMP + 9.0 IN	DEG F	1450.787

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6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 01 APR 4
SERIES RD/IHT-1 SEQUENCE 8 TEST 9

PERFORMANCE DATA

PARAMETER	UNITS	CALCULATED VALUE
PC, INJECTOR END	PSIA	114.368
PC, NOZZLE STAGNATION	PSIA	108.649
AXIAL THRUST, SITE	LBF	4374.392
AXIAL THRUST, VACUUM	LBF	4392.645
NOZZLE EXIT PRESSURE	PSIA	.087
FUEL DENSITY (MMH)	LB/FT3	55.557
OXIDIZER DENSITY	LB/FT3	90.033
FUEL FLOWRATE	LB/SEC	5.667
OXIDIZER FLOWRATE	LB/SEC	11.217
TOTAL PROPELLANT FLOWRATE	LB/SEC	16.883
MIXTURE RATIO (OVERALL)	O/F	1.979
BLC FLOWRATE	LB/SEC	0
BLC TOTAL PERCENT	%	0
CORE MIXTURE RATIO	O/F	1.979
FUEL INJECTOR DELTA-P	PSID	41.122
OXIDIZER INJECTOR DELTA-P	PSID	42.131
T/C COOLANT DELTA-P	PSID	9.601
T/C COOLANT DELTA-T	DEG F	207.980
THRUST CHAMBER HEAT FLUX	BTU/SEC	842.691
C-STAR, SITE	FT/SEC	5487.827
C-STAR, UMR	FT/SEC	5487.827
C-STAR EFFICIENCY	%	96.815
CF, SITE	-----	1.519
CF SITE VACUUM	-----	1.525
CF, VAC 72 EXPECT	-----	1.538
CF CORRELATION	-----	99.192
CF, VAC 72	-----	1.790
ISP, TEST	SEC	259.093
ISP, SITE VACUUM	SEC	260.175
ISP, VAC 72 PREDICTED	SEC	305.393
ISP, TDK, TEST CONDITIONS	SEC	275.593
ISP EFFICIENCY	%	75.454
ENERGY RELEASE EFFICIENCY	%	95.652
C-STAR, ODE	FT/SEC	5668.370
ISP, ODE, TEST	SEC	344.811

6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 01 APR 4
SERIES RO/IHT-1 SEQUENCE 8 TEST 10
TEST DESCRIPTION
ENGINE PERFORMANCE AND HEAT TRANSFER EVALUATION WITHOUT BLC.
L/D INJECTOR S/N1 (BLC PLUGGED), 9 TO 1 NOZZLE, UNSATURATED
MMH/NTO (40 F FULL). TARGET PCNS = 125., MR = 1.65.

ACTUAL TEST DURATION 10.006 SEC
DATA SLICE TIME 9.000 SEC TO 10.000 SEC

PARAMETER	UNITS	AVG. MEASURED VAL
FUEL TANK PRESSURE	PSIA	225.348
OXIDIZER TANK PRESSURE	PSIA	225.231
FUEL INTERFACE PRESSURE	PSIA	214.340
OXIDIZER INTERFACE PRESSURE	PSIA	206.809
T/C COOLANT INLET MAN. PRESSURE	PSIA	207.646
FUEL INJECTOR PRESSURE	PSIA	192.365
OXIDIZER INJECTOR PRESSURE	PSIA	186.373
CHAMBER PRESSURE NO. 1	PSIA	131.997
CHAMBER PRESSURE NO. 2	PSIA	133.399
AXIAL THRUST, SYSTEM A	LBF	5065.827
AXIAL THRUST, SYSTEM B	LBF	5083.019
Y-AXIS THRUST	LBF	-29.881
Z-AXIS THRUST	LBF	23.121
AVERAGE CELL PRESSURE	PSIA	.077
CELL PRESSURE AGREEMENT	%	.851
FUEL FLOWRATE	GPM	56.642
OXIDIZER FLOWRATE	GPM	62.008
FUEL INTERFACE TEMPERATURE	DEG F	0
OXIDIZER INTERFACE TEMPERATURE	DEG F	0
T/C COOLANT IN TEMPERATURE	DEG F	44.344
T/C COOLANT OUT TEMPERATURE	DEG F	232.187
INJECTOR SURFACE TEMPERATURE	DEG F	146.073
T/C SURFACE TEMP -16 IN	DEG F	236.406
T/C SURFACE TEMP -13 IN	DEG F	241.493
T/C SURFACE TEMP -10 IN	DEG F	239.324
T/C SURFACE TEMP - 8 IN	DEG F	162.292
T/C SURFACE TEMP - 6 IN	DEG F	187.954
T/C SURFACE TEMP - 4 IN	DEG F	211.452
T/C SURFACE TEMP - 2 IN	DEG F	168.749
T/C SURFACE TEMP -0.3 IN	DEG F	141.854
T/C SURFACE TEMP + 3 IN	DEG F	122.383
COOLANT IN MANIFOLD SKIN	DEG F	112.927
NOZZLE FLANGE TOP TEMPERATURE	DEG F	70.638
NOZZLE SURFACE TEMP + 8.0 IN	DEG F	1235.519
NOZZLE SURFACE TEMP + 9.0 IN	DEG F	1471.934

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6K OMS ENGINE TECHNOLOGY
SUPPORT PROGRAM
ROCKETDYNE INTEGRATED HARDWARE TESTS

DATE 01 APR 4
SERIES RD/IHT-1 SEQUENCE 8 TEST 10

PERFORMANCE DATA

PARAMETER	UNITS	CALCULATED VALUE
PC, INJECTOR END	PSIA	132.698
PC, NOZZLE STAGNATION	PSIA	126.063
AXIAL THRUST, SITE	LBF	5074.423
AXIAL THRUST, VACUUM	LBF	5092.916
NOZZLE EXIT PRESSURE	PSIA	.089
FUEL DENSITY (MMH)	LB/FT3	55.568
OXIDIZER DENSITY	LB/FT3	90.047
FUEL FLOWRATE	LB/SEC	7.013
OXIDIZER FLOWRATE	LB/SEC	12.440
TOTAL PROPELLANT FLOWRATE	LB/SEC	19.453
MIXTURE RATIO (OVERALL)	O/F	1.774
BLC FLOWRATE	LB/SEC	0
BLC TOTAL PERCENT	%	0
CORE MIXTURE RATIO	O/F	1.774
FUEL INJECTOR DELTA-P	PSID	59.667
OXIDIZER INJECTOR DELTA-P	PSID	53.676
T/C COOLANT DELTA-P	PSID	15.281
T/C COOLANT DELTA-T	DEG F	187.843
THRUST CHAMBER HEAT FLUX	BTU/SEC	941.855
C-STAR, SITE	FT/SEC	5526.318
C-STAR, UMR	FT/SEC	5526.318
C-STAR EFFICIENCY	%	96.841
CF, SITE	-----	1.519
CF SITE VACUUM	-----	1.524
CF, VAC 72 EXPECT	-----	1.526
CF CORRELATION	-----	99.879
CF, VAC 72	-----	1.789
ISP, TEST	SEC	260.856
ISP, SITE VACUUM	SEC	261.806
ISP, VAC 72 PREDICTED	SEC	307.308
ISP, TDK, TEST CONDITIONS	SEC	277.087
ISP EFFICIENCY	%	76.770
ENERGY RELEASE EFFICIENCY	%	95.561
C-STAR, ODE	FT/SEC	5706.602
ISP, ODE, TEST	SEC	341.027

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