NERVA TEST OPERATIONS

Nuclear Rocket Development Station

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NTO-M-11652

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Attention: P. W. Rowe

Subject: Test Description for Facility Experimental Plan I

Enclosure: Test Description for Facility Experimental Plan I

Dear Mr. Rice:

Attached is the subject document as revised in accordance with the review comments by REON, SNPO-C and NTO.

Sincerely yours,

N. E. Erickson
N. E. Erickson, Manager
NERVA Test Operations

NEE:cjb

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TEST DESCRIPTION
FOR
FACILITY EXPERIMENTAL PLAN I
LN₂ COOLDOWN FLOW TESTS

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ETS-1 Test Planning

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August 25, 1966

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ETS-1 FACILITY EXPERIMENTAL PLAN I

LN₂ COOLDOWN FLOW TEST (V-3601)

I. INTRODUCTION

A. General

This experimental plan is the first subsystem checkout and will, in general, be used to prove the construction and operation of the liquid nitrogen cooldown system and its components.

B. LN₂ Cooldown System Description

1. Function

The function of the LN₂ Cooldown System is to provide liquid nitrogen to the engine at the required flow rates following engine test runs in order to accomplish the required cooldown of the test article.

2. Cooldown Bypass System

The Cooldown Bypass System is an arrangement of pipes and valves thru which the coolant fluids may be passed in such a manner that the engine impedance is simulated. The system tees off 4-IN-6" downstream of LF-7, is then routed above the top shield through the FE-X venturi where it turns vertically downward to the engine flow simulator device (EFSD). The EFSD consists of an analog control valve, PCV-750, which can be remotely regulated to control flow at the desired rate and back pressure. Instrumentation is available to measure and record temperatures and pressures on both the upstream and downstream sides of the system.

The coolant is exhausted out the temporary flow stack after passing through the cooldown bypass system.

3. LN₂ Cooldown System

The LN₂ Cooldown System is depicted in Figure 1. LN₂ is stored in V-3601 which has a capacity of 28,000 gallons. An ullage pressure of approximately 250 psig (GN) is maintained in V-3601 during test runs. Shutoff is provided by RSV-326 at the storage vessel and RSV-545 upstream of the engine interface; these valves are operated by command from the FER and TSE consoles, respectively. 150 micron absolute filtration is provided by LF-7. Cooldown flow is controlled by varying PCV-517 by command from the TSE Console in AUTO (flow feedback) or MANUAL (Position) control modes.

ETS-1 Facility Experimental Plan I
LN₂ Cooldown Flow Test (V-3601)

II. SPECIFIC TEST OBJECTIVES

- A. Verify LN₂ system and functional integrity under operating conditions.
- B. Determine chilldown and flow characteristics of the LN₂ cooldown system.
- C. Determine the length of time and the quantity of LN₂ required to establish and maintain a hard chill using the following modes of operations:
 - 1. Constant venting technique.
 - 2. Pulse venting technique.
- D. Determine transfer functions of the LN₂ cooldown system at various pressure and flow rates.
- E. Determine transfer function characteristics of the low pressure GN₂ system (FCV-50) and verify gas impedance setting for PCV-750.
- F. Develop optimum chilldown and operating procedures.
- G. Provide operator training.

III. TEST DESCRIPTION

Initial Checkout (GN₂)

The low pressure GN₂ system (30-GN-6") will be pressurized to 500 psig and frequency response tests will be conducted on FCV-50 in position control. FCV-50 will then be placed in flow control and frequency response tests conducted. Concurrent with above, PCV-750 will be positioned to simulate gaseous impedance conditions.

Chilldown and Inspection

V-3601 will be pressurized to approximately 50 psig. The LN₂ cooldown line to PCV-517 will be chilled down slowly to avoid overspeeding FE-52. The remainder of the line down to RSV-545 will be chilled by venting out RSV-717 or PCV-754. During the chilldown operations, while at 50 psig, a visual inspection will be made of the piping for leakage.

When the inspection is complete, hard chill conditions will be established by raising V-3601 pressure to 250 psig and flowing out RSV-717 or PCV-754 until T-510 has stabilized. An additional inspection will be made at 250 psig when cryogenic conditions have been achieved.

Run #1 - Chill Maintenance Test

Constant venting technique - RSV-717 will be closed, PCV-517 will be open and the flow thru PCV-754 will be reduced in steps until T-510 indicates a steady-state temperature of greater than T_{sat} corresponding to PT-580. Flow rates, temperatures and pressures will be recorded during the chill holding operation.

ETS-1 Facility Experimental Plan I
LN₂ Cooldown Flow Test (V-3601)

Pulse venting technique - With PCV-754 closed, RSV-717 will be closed until T-510 reaches a pre-determined value. At this time, RSV-717 will be opened and the line vented until T-510 is reduced to the previously established hard chill temperature. RSV-717 will then be closed and the cycle repeated until sufficient data is obtained to establish the optimum pulse venting technique. Flow rates, temperatures and pressures will be recorded during this operation.

Run #2 - Flow Test, Manual (Position) Control

A hard chill will be established on the 225-LN-6" line down to RSV-545 with V-3601 pressurized to 250 psig. PCV-750 will be set to simulate engine impedance at gas flow conditions. PCV-517 will be opened to 100%, RSV-717 closed and RSV-545 opened. As FE-52 approaches maximum flow rate, PCV-750 will be adjusted to simulate engine LN₂ impedance and prevent FE-52 from over-speeding. When LN₂ conditions exist at PCV-750, steady-state data will be obtained at the 80, 60, 40, 20 and 10% flow. At the 10% flow position of PCV-517, step and frequency response tests will be conducted.

Run #3 - Flow Test, Manual (Position) Control

Prior to initiation of this run, the line downstream of RSV-545 will be warmed up to ambient conditions by flowing GN₂ from 30-GN-6" through RSV-460 and out the temporary flow stack and V-3601 will be pressurized to 250 psig. The 225-LN-6" line will have a hard chill down to RSV-545 and PCV-750 will be set for liquid impedance conditions. PCV-517 will be opened 100%, RSV-717 closed and RSV-545 opened. The test will be terminated when LN₂ conditions are reached at PCV-750.

Run #4 - Flow Test, Auto (Flow) Control

A hard chill will be established down to RSV-545 with ambient conditions existing downstream. PCV-517 will be in Auto (flow rate) control and set for 80% of the maximum flow obtained during runs 2 and 3. V-3601 will be at 250 psig and PCV-750 will be set to simulate gas impedance conditions. RSV-545 will be opened and RSV-717 closed. LN₂ will flow until liquid conditions are reached at PCV-750 at which time PCV-517 will be reset to 40 #/sec and PCV-750 readjusted to achieve steady-state conditions. PCV-517 will then be reset to 10 #/sec and PCV-750 readjusted. PCV-517 will then be reset to 5 #/sec and PCV-750 readjusted. Step response data will be obtained at the 40 and 10 #/sec flow rates.

Run #5 - Flow Test, Auto (Flow) Control

A hard chill will be established down to RSV-545 with ambient conditions existing downstream. PCV-517 will be in Auto (flow rate) control and set for 80% of the maximum flow obtained during runs 2 and 3. V-3601 will be at 250 psig and PCV-750 will be set to simulate liquid impedance conditions. RSV-545 will be opened and RSV-717 closed. LN₂ will flow until liquid conditions are reached at PCV-750.

Fluid Sampling

Fluid samples will be extracted during the course of LN₂ flow tests. The sampling system, schematically depicted in Figure 1, consists of RSV-751 and a filter tapped off the flow simulation system upstream of FE-X. After

ETS-1 Facility Experimental Plan I
LN₂ Cooldown Flow Test (V-3601)

each LN₂ flow test, the filter will be removed and analyzed for contaminants, sizing and identification if practical. At the conclusion of FEP-I, LF-7 will be removed and similarly analyzed.

IV. OPERATING LIMITS

- A. LN₂ storage dewar (V-3601) pressure shall not exceed 250 psig.
- B. Do not flow FE-52 at a rate which will exceed 100 #/sec indication.

V. TEST SCHEDULE

FEP-I will commence with R-day on 27 September 1966 and will require second shift operation for approximately one week.

VI. A. STATUS BOARD

A Status Board will be established for this FEP and will assume control of the facility 0800 on R-day. Inputs for the status board must be submitted to Test Planning by R-7 day.

B. PRODUCT ASSURANCE

Installation and calibration of system components will be accomplished in conformity with established PA procedures. PA personnel will follow the conduct of the FEP, and keep a discrepancy log of all systems which are exercised in this FEP.

VII. DATA REQUIREMENTS

- A. Data requirements are listed in Appendix A, NTO ETS-1 Measurements and Control Requirements. Only those instruments and controls which require recording are listed in Appendix A.
- B. Data Recording
 - 1. Specific operation of the oscillograph charts and strip recorders will be in accordance with the Lead Instrumentation Engineer's checklist.
 - 2. Tape data system operation will be in accordance with the LIE's checklist.
- C. Television coverage will be required for test observation and surveillance of the facility for safety considerations; the following television cameras will be used, although all cameras will be operational and capable of being substituted:

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LN₂ Cooldown Flow Test (V-3601)

<u>Monitor 1</u>	<u>Camera Position No.</u>	<u>Location</u>	<u>Primary Observation</u>
1	16	Valve House	HP GN ₂ Piping
2	20	LO ₂ Tank	LN ₂ Supply Piping
3	3	West Side of Ditch	ETC Area
4	9	LN ₂ Tank	South End of LN ₂ Tank
5	13 ext.	Cold Side Shield Wall at 3848 Level	LN ₂ Piping
6	4 ext.	Hot Side Shield Wall at 3848 Level	LN ₂ Piping at Top of Shield
7	1	North Side of Ditch	ETC Pad Level
8	5	North Corner of Pad	ETC Pad Level

Auxiliary instrumentation, as required, will be provided by search lights.
No still or motion picture photography is required for FEP-I.

Kinescope capability will be available during all phses of the test operation.

VIII. OPERATIONAL REQUIREMENTS

A. Control Point

The following consoles and their associated equipment will be operational
for the conduct of FEP-I.

Test Director
Deputy Test Director
NES Temporary Console
Test Stand Engineer
Assistant Stand Engineer
Facility Engineer Right
Gas Fill and Service
Facility Electrical Power Console
Lead Safety Engineer
Lead Instrument Engineer
Digital Data Operator
Remote Recorder Operator
TV Operator

B. Facility and Test Stand

The following systems and their associated equipment will be operational
for the conduct of FEP-I:

ETS-1 Facility Experimental Plan I
LN₂ Cooldown Flow Test (V-3601)

Gas Fill and Storage System
Gas Distribution System
Liquid Nitrogen Nitrogen System
Liquid Nitrogen Cooldown System
Cooldown Bypass System Installed
Gaseous Nitrogen Cooldown System

C. Coolants

The LN₂ dewar will be filled to 10% ullage by R-2 day. Gas storage bottles V-3201, V-3202, and V-3203 will be pressurized to approximately 2500 psig with GN₂.

D. Safety System

Safety system operational requirements will be limited to the use of Area Warning and Surveillance Systems.

Personnel access to the ETS-1 area during test operations will be controlled by means of approved access lists and entry will be permitted under green or yellow light conditions only. Movement at the facility will be permitted under red light conditions at specific Test Director direction only. Re-entry teams operating under the direction of the Test Director will be permitted access only when gas systems are pressurized to less than 50 psi.

IX. REPORT REQUIREMENTS

A technical memorandum will be issued within one week following completion of FEP-I establishing preliminary conclusions and recommendations. A final report will be prepared and issued following the conclusion of the Facility test series.

APPENDIX A

NTO TEST OPERATIONS

FEP-I Measurement and Control Requirements

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**NERVA TEST OPERATIONS
ETS-1 MEASUREMENT & CONTROL REQUIREMENTS**

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INITIATOR - EP PARAMETERS	TAG NO.	PARAMETER TITLE	MEAS RANGE	RECORDING/CONTROL/DISPLAY																ETS-1 CHANNEL LIST CODING SYS & ABBRV LIST APPLIES						
				01	02	03	RA	RB	RC	RD	RE	RF	RFC	RCS	DL	DM	DH	E	F	S	SW	LGT	MIR	CON- SOLE		
	36-RSV-326	V-3601 LI ₂ DEWR TSFR SOV SR326..RLN BR326.ORLN BR326.CRIN	HA HA HA																					FR FR FR		
	36-RSV-327	V-3601 LI ₂ DEWR VV SR327..FLD BR327.OFLD BR327.CFLD	HA HA HA																					FR FR FR		
	36-VT-009	V-3601 LI ₂ DEWR JET PRESS VT009..FLD <u>LIQUID NITROGEN COOLDOWN SYSTEM</u>	10 U												X									TS		
	50-FT-52	LI ₂ CD SYS FLO FT052..RLN	100 PPS	29			4	4					TS		X								X	TS DTD		
	50-PCV-517	LI ₂ CD SYS FLO CP517..RLN DP517.MRLN DP517.NRLN	0-100% 0-100% 0-100 PPS	31 32 33			1 2	1 2					R5		X X X								X	TS TS TS		
	50-PT-580	LI ₂ PRESS AT IN SOV PT580..RLN	300 PSIG				3	3					R7		X								X	TS		

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**NERVA TEST OPERATIONS
ETS-1 MEASUREMENT & CONTROL REQUIREMENTS**

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	TAG NO.	PARAMETER TITLE	MEAS RANGE	RECORDING/CONTROL/DISPLAY																ETS-1 CHANNEL LIST CODING SYS & ABBRV LIST APPLIES							
				01	02	03	RA	RB	RC	RD	RE	RF	RFC	RCS	DL	DM	DH	E	F	S	SW	LGT	MIR	CON- SOLE			
INITIATOR - EP PARAMETERS	32-RSV-001	V-3201 THERM IN BLK VLV SR001..FGF LR001.OFGF BR001.CFGF	IA NA IA																	X			GF GF GF				
	32-RSV-006	V-3202 THERM IN BLK VLV SR006..FGF BR006.OFGF LR006.CFGF	IA NA IA																X		X	GF GF GF					
	32-RSV-011	V-3203 THERM IN BLK VLV SR011..FGF BR011.OFGF LR011.CFGF	IA NA IA																X		X	GF GF GF					
	32-TT-489	V-3201 THERM TEMP TT489..FGF	360-610°R	2										X								X	GF				
	32-TT-490	V-3202 THERM TEMP TT490..FGF	360-610°R	4										X								X	GF				
	32-TT-491	V-3203 THERM TEMP TT491..FGF	360-610°R	7										X								X	GF				
	<u>GAS DISTRIBUTION SYSTEM</u>																										
	32-PT-002	GAS DISTRIBUTOR (1-GT) PRESS PT002..FGS	3000 PSIG								1			X								X	GF				
	32-RSV-245	GAS DISTRIBUTOR (1-GT) SOV SR245..FGS BR245.OFGS LR245.CFGS	IA IA IA																	X		X	GF GF GF				

INITIATOR - EP PARAMETERS	TAG NO.	PARAMETER TITLE	MEAS RANGE	RECORDING/CONTROL/DISPLAY																ETS-1 CHANNEL LIST CODING SYS & ABBRV LIST APPLIES						
				01	02	03	RA	RB	RC	RD	RE	RF	RFC	RCS	DL	DM	DH	E	F	S	SW	LGT	MIR	CON-SOLE		
		<u>CABLE CONTROL COORDIN SYSTEM</u>																								
	50-PV-50	G ₂ CD STD PCV CF050..RGN DF050..RGN WY ..RGN	0-100 PC 0-100 PC 30 PPS	9 10						6		X X X							P P		X	TS TS TS				
	50-PT-50	G ₂ CD SYS FLO FT050..RGN	30 PPS	12						3		X					X				X	TS TH				
	50-RV-107	G ₂ CD PRESS RXG SV107I..RGN SV107V..RGN	IA IA																X X			TS TS				
	50-PT-191	G ₂ CD PRE-LIX PRESS PT191..RGN	500 PSTG							4		X								X		TS				
	50-PT-050	50-PT-50 DLEMA PRESS(PT 191 x KAP) PT534..RGN	20 PSID	13						6		X					X									
	50-RSV-134	G ₂ CD LINE SOV SR134..RGN BR134..ORGN BR134..CRGN	IA IA IA													X X X			X		X X	TS TS TS				
	50-PT-053	G ₂ CD SPLY TEMP TT053..RGN	360-610°R	14								X									X	TS				
	50-PT-54	G ₂ CD PRE-LIX TEMP TT054..RGN	360-610°R							5		X									X	TS				

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 ETS-1 MEASUREMENT & CONTROL REQUIREMENTS

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INITIATOR - EP PARAMETERS	TAG NO.	PARAMETER TITLE	MEAS RANGE	RECORDING/CONTROL/DISPLAY																ETS-1 CHANNEL LIST CODING SYS & ABBRV LIST APPLIES				
				01	02	03	RA	RB	RC	RD	RE	RF	RFC	RCS	DL	DM	DH	E	F	S	SW	LGT	MIR	CON-SOLE
		<u>COLDW PLASS SIGNAL</u>																						
	107-750	FLOW STEADY CONTROL VLV																						
		CP750..A..	0-100 PC												X				X		1		X	TH
		DI750..A..	0-100 PC										L6		X				X				X	TH
	107-750	FLOW STEADY PRESS																						
		PI770..A..	0-1500 PSID										L2		X				X				X	TH
	107-751	FLOW STEADY PRESS (100)																						
		PI771..A..	0-600 PSID										L3		X				X				X	TH
	107-752	FLOW STEADY PRESS (150)																						
		PI772..A..	0-50 PSID										L4		X				X				X	TH
	107-753	FLOW STEADY PRESS																						
		PI773..A..	0-1000 PSID										L7		X								X	TH
	107-754	FLOW STEADY PRESS																						
		PI774..A..	0-100 PSID												X				X				X	TH
	107-RSV-100	FLOW STEADY PRESS																						
		SR751..A..	1A																		X			TH
		BR751..CA..	1A																			X		TH
		BR751..CA..	1A																			X		TH
	107-755	FLOW STEADY PRESS (100)																						
		PI760..A..	30-610°R												X				X				X	TH

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INITIATOR - EP PARAMETERS	TAG NO.	PARAMETER TITLE	MEAS RANGE	RECORDING/CONTROL/DISPLAY																ETS-1 CHANNEL LIST CODING SYS & ABBRY LIST APPLIES							
				01	02	03	RA	RB	RC	RD	RE	RF	RFC	RCS	DL	DM	DH	E	F	S	SW	LGT	MIR	CON- SOLE			
	50-TT-761	PCV-750 INLET TEMP (NR) TT761..A..	35-60°R									L1	X				X				X	TN					
	50-TT-762	PCV-750 INLET TEMP (WR) TT762..A..	35-610°R									L5	X				X				X	TN DTD					
	50-TT-763	PCV-750 INLET TEMP (NR) TT763..A..	35-60°R									L6	X				X				X	TN					
	50-TT-764	PCV-750 OTLT TEMP (WR) TT764..A..	35-610°R										X				X				X	TN					
	50-PT-192	GN COOLDOWN SUPPLY PRESS PT192..RGN	0-500 PSIG	15									X								X	TS DTD					
	50-PCV-754	LN ₂ ANALOG VENT VALVE CP754..RLN DP754..MRLN	0-100% 0-100%																P		X	TS TS					
	NOTES:	*: New Component **: To be determined TN: Temporary NES Test Console																									

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NTO-M-11652

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* = Without enclosure