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AEC - NASA SPACE NUCLEAR PROPULSION OFFICE

NES DESIGN DEMONSTRATION TEST PLAN
WITH TEMPORARY ENGINE COMPARTMENT

JUNE 1966

NERVA PROGRAM

CONTRACT SNP-1

MASTER

AEROJET-GENERAL CORPORATION

ROCKFORD, ILLINOIS

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ROCKET ENGINE OPERATIONS - NUCLEAR

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ABSTRACT

This report presents an alternate Design Demonstration Test Plan for the Nuclear Exhaust System (NES) using a Temporary Engine Compartment (TEC). This test program will be substituted for the test program detailed in REON Report RN-S-0137B if the Permanent Engine Compartment is not completed in time for use during the NES testing. This alternate test program does provide, however, for a minimum amount of testing using the Permanent Engine Compartment upon its completion, to demonstrate satisfactory operation of the NES Engine Compartment System. A Temporary Engine Compartment and test device (simulated engine and turbine exhaust nozzles) will be supplied to support the test program. The tests will be conducted at NRDS using the ETS-1 facility.

C. M. Rice
Program Manager
REON

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1. Introduction

The purpose of the Nuclear Exhaust System (NES) is to direct the hot exhaust gases and fission products away from the test stand during a NERVA engine firing, and also to provide a steam safety purge. Because of these requirements, it is necessary that a high confidence level in NES performance be attained prior to utilizing it in a full scale NERVA engine firing. To meet these requirements, the prototype NES will be installed and cold-flow tested for performance at both NERVA design and off-design conditions. This will simulate near operational conditions prior to testing under actual environment.

The Steam Generator System (SGS) is operated during this test program as part of the NES. Any additional testing that is required as specific Design Demonstration tests for the SGS will be conducted concurrently. The specifics of the additional SGS tests will be published at a later date.

2. Technical Discussion

2.1 Program Description and Schedule

Because of facility limitations (i.e., the Engine Test Compartment, ETC, is not available at the scheduled initiation of the program), the Design Demonstration Test Program will be conducted in two phases. Phase I testing will use a Temporary Engine Compartment (TEC) and GN_2 primary tests will be conducted while the permanent engine compartment is being completed. Upon completion of the permanent engine compartment checkout, the TEC will be removed and the testing described as Phase II, involving GH_2 , will be conducted.

All GN_2 primary tests will be conducted using the TEC. The GH_2 primary tests will not be conducted until the permanent engine compartment is complete including satisfactory operation of the ETC purge and gas sampling tests. This will preserve program continuity by avoiding unnecessary changeovers and hold the test program duration to a minimum.

The Design Demonstration Test program provides for cold flow testing of the NES at both NERVA and off-design conditions. Testing at two levels of primary chamber pressure provides assurance that the duct will perform safely over the entire operating range. Testing at off-design conditions will verify that the duct performance is not marginal. The GH_2 primary flow tests are to substantiate the GN_2 primary test results, provide data on the exhaust plume thermal radiation, and demonstrate test stand safety with respect to engine malfunction and hydrogen disposal. The tests conducted in the permanent engine compartment are required to demonstrate safe and satisfactory operation of the NES engine compartment system prior to using the NES during actual engine testing.

The design demonstration test program includes the following tests:

2.1.1 Phase I GN_2 Primary Flow (Using TEC)

- a. Final system check
- b. Steam generator system checkout test with excessive leakage
- c. NES checkout test at $200 P_{pc}$. No leakage and no turbine exhaust.
- d. NES checkout test at maximum P_{pc} . No leakage and design turbine exhaust.
- e. NES off-design test at $200 P_{pc}$. Excessive leakage and excessive turbine exhaust.
- f. NES off-design test at maximum P_{pc} . Excessive leakage and design turbine exhaust.
- g. NES off-design test at maximum P_{pc} . Maximum expected leakage and excessive turbine exhaust.

2.1.2 Phase II GH_2 Primary Flow (Using ETC)

- a. NES design test at 200 psia P_{pc} . Maximum expected leakage and design turbine exhaust.
- b. NES off-design test at maximum P_{pc} . Maximum expected leakage and excessive turbine exhaust.

The test program presented herein is considered to be the minimum (no redundancy or duplication of tests) necessary to substantiate the prototype duct design. In conducting this austere program consideration must be given to the following concessions:

- a. Correction for equipment failure or human error on a given test cannot be accomplished.
- b. There will be no means of demonstrating reproducibility of operation.
- c. Questionable data cannot be verified.
- d. Any desirable changes in data acquisition to improve performance evaluation for a given test cannot be achieved.

Should any of these problems arise, additional tests will be needed resulting in some stretch-out in the minimal schedule.

The tests will require approximately nine weeks, plus two weeks for facility activities between test phases and three weeks for clean-up. Total program time will be approximately fourteen weeks. A detailed estimate of the test time is included in the test summary shown in Table I.

												REVISIONS	
												DESCRIPTION	DATE APPROVED
ESTIMATED FLUID REQ. (LBS)	TYPE OF TEST	OBJECTIVE	NO. OF TESTS	TIME (WEEKS)			TEST DURATION (SECONDS) PRIMARY FLOW	DESCRIPTION	NOTES	REQUIRED HARDWARE		REMARKS	
				TOTAL	DATA RED	GH ₂ , GN ₂ & WATER TANK REFILL				RES	FACILITY		
	I ACCEPTANCE (AT NRDS)												
	A. PHASE I (VENDOR)												
	1. ASSEMBLY & INSTALLATION	DUCT INSTALLATION	NOT APPLICABLE	3			NOT APPLICABLE	INSTALL SEALS & INTERFACE, DUCT SECTIONS, CHECK INTERFACE, ALIGN DUCT TO VAULT, WELD TRUNNIONS & WATER HEADERS.		DUCT & SEALS	CRANE & GENERAL SUPPORT EQUIPMENT		
145,000 H ₂ O	2. PROOF & LEAK	VERIFY STRUCTURAL & SEAL INTEGRITY		1	1/3			PROOF TEST DUCT AT 360 ± 15 PSIG & LEAK TEST AT 240 PSIG, VISUAL INSPECTION	SEE PROCESS SPECIFICATION 6884	DUCT & INSTRUMENTATION	I & C PROCESS WATER & GN ₂		
	B. PHASE II (NTO)												
	1. INSTALL & CHECKOUT PERMANENT I & C	I & C INSTALLATION		9				INSTALL INSTRUMENTATION HARNESS & TRANSDUCERS		DUCT HARNESS & TRANSDUCERS	PORTABLE STANDS WELDING EQUIP, GN ₂		
	2. INSTALL & CHECKOUT TEC, NES TEST DEVICE & TEMPORARY I & C	PREPARE SYSTEM FOR TESTING						INSTALL NES TEST DEVICE, TEC, & TEMPORARY I & C		TEMPORARY I & C		THIS ACTIVITY WILL BE ACCOMPLISHED CONCURRENTLY WITH PERMANENT I & C INSTALLATION	
8,000,000 H ₂ O	a. CALIBRATE	CALIBRATE DUCT	NOT APPLICABLE	4	4	(FILL WATER TANK)	NOT APPLICABLE	FLOW & BALANCE DUCT TO PROVIDE DESIGN FLOW RATES THRU EACH DUCT SECTION	SEE ACCEPTANCE TEST PLAN RN-5-0127				
	II. DESIGN DEMONSTRATION	ACCEPTANCE PROGRAM TOTAL		17	4 1/3								
	A. PHASE I GN ₂ PRIMARY FLOW TESTS - TEMPORARY ENGINE COMPARTMENT												
	1. FINAL SYSTEM CHECKOUT	VERIFY THAT ALL SYSTEMS ARE READY FOR USE, PERFORM SIMULATED COUNTDOWN	1	2/3			NOT APPLICABLE	VERIFY SEAL INTEGRITY, FUNCTIONAL CHECK ON GAS SUPPLY VALVES & NES INSTRU & CHECK FLARE SYSTEM.		DUCT & INSTRUMENTATION DUCT FLARE SYSTEM STEAM GENERATOR & PROPELLANT FEED SYSTEM 10/1 NOZZLE	WATER SYSTEM GN ₂ SYSTEM GN ₂ SYSTEM FOR TURBINE EXHAUST ONLY (4 TRAILERS) GN ₂ SYSTEM FOR PURGE & SIMULATED LEAKAGE, O ₂ -H ₂ ANALYZER SYSTEM		
5,000 N ₂ 65,000 H ₂ O	2. STEAM GEN. SYSTEM CHECKOUT	DEMONSTRATE SATISFACTORY SGS OPERATION & ESTABLISH EFFECTS OF LEAKAGE ON CELL PRESSURE	1	3/5	2/5		100	TEST FIRE SGS ONLY, INTRODUCE LEAKAGE TO DETERMINE THE EFFECT ON CELL PRESSURE RECORD OXYGEN CONCENTRATION IN TEC					
	3. NES CHECKOUT (GN ₂ PRIMARY)	NOTED BELOW											
16,000 N ₂ 95,000 H ₂ O	a. Ppc AT 200 PSIA	ESTABLISH NES PULL-IN & OPERATION, VERIFY STRUCTURAL INTEGRITY & ADEQUACY OF THE PRE-FIRE PURGE SYSTEM, DEMONSTRATE SAFE SHUTDOWN WITHOUT S.G.S.	1	1	2/3	4/3 (GN ₂)	45 (10 SEC. STEADY STATE)	S.G.S. PURGE SYSTEM, PRIMARY GN ₂ FLOW ONLY, DESIGN START-UP TO 275 PSIA & SHUT-DOWN, PRE-FIRE PURGE SYSTEM ADEQUACY WILL BE VERIFIED W/THIS TEST	S.G.S. TO BE SHUTDOWN PRIOR TO SHUTDOWN OF PRIMARY FLOW				
40,000 N ₂ 175 H ₂ 1,900,000 H ₂ O	b. MAXIMUM Ppc	CONFIRM PREVIOUS TEST RESULTS AND DEMONSTRATE SATISFACTORY DUCT OPERATION AT FULL-FLOW CONDITIONS.	1	1	4/3	4/3 (GN ₂)	75 (10 SEC. STEADY STATE)	S.G.S. PURGE SYSTEM, DESIGN TURBINE EXHAUST PRIMARY GN ₂ & DESIGN H ₂ O FLOW DESIGN START-UP (TO MAX Ppc) & SHUT-DOWN.					
	4. NES DUCT OFF-DESIGN TESTS (GN ₂ PRIMARY)	NOTED BELOW						DESIGN START-UP & SHUT-DOWN NOT REQUIRED FOR THESE, HOWEVER THE SHUT-DOWN ON TEST (C) SHALL SIMULATE A NERVA ENGINE MALFUNCTION					
15,000 N ₂ 140 H ₂ 88,000 H ₂ O	a. Ppc AT 200 PSIA & EXCESSIVE SEAL LEAKAGE & EXCESSIVE TURBINE EXHAUST	DETERMINE AMOUNT OF LEAKAGE OR TURBINE EXHAUST AT 200 Ppc TO CAUSE FLOW SEPARATION	1	1	1/3	4/3 (GN ₂)	40 (30 SEC. STEADY STATE)	S.G.S. PURGE SYSTEM, DESIGN TURBINE EXHAUST, GN ₂ PRIMARY & EXCESSIVE SIMULATED SEAL LEAKAGE, REDUCE SEAL LEAKAGE TO EXPECTED VALUE AND INCREASE TURBINE EXHAUST.					
22,000 N ₂ 180 H ₂ 88,000 H ₂ O	b. Ppc AT MAX & EXCESSIVE SEAL LEAKAGE	DETERMINE AMOUNT OF LEAKAGE TO CAUSE FLOW SEPARATION AT MAX. Ppc	1	1	3/3	4/3 (GN ₂)	35 (10 SEC. STEADY STATE)	S.G.S. PURGE SYSTEM, DESIGN TURBINE EXHAUST, GN ₂ PRIMARY, EXCESSIVE SEAL LEAKAGE, MAX Ppc.					
22,000 N ₂ 88,000 H ₂ O	c. Ppc AT MAX & EXCESSIVE TURBINE EXHAUST	DEMONSTRATE NES DUCT WILL MAINTAIN FULL FLOW WITH EXCESSIVE TURBINE EXHAUST DEMONSTRATE NES PERFORMANCE UNDER XE ENGINE MALFUNCTION CONDITIONS	1	1	3/3	4/3 (GN ₂)	35 (10 SEC. STEADY STATE)	S.G.S. PURGE SYSTEM, EXPECTED SEAL LEAKAGE, ABOVE DESIGN TURBINE EXHAUST & GN ₂ PRIMARY, SIMULATED XE ENGINE MALFUNCTION SHUT-DOWN.					
	COMPLETE DATA REDUCTION & REMOVE THE TEC & FACILITY ACTIVATION OF PROTOTYPE ENGINE COMPARTMENT & REINSTALL NES TEST DEVICE			7	6								
	B. PHASE II GN ₂ PRIMARY FLOW TESTS PERMANENT ENGINE COMPARTMENT	PHASE I TOTAL		7	8								
5,000 N ₂ 3,600 H ₂ 100,000 H ₂ O	1. NES TEST AT DESIGN CONDITIONS (GN ₂ PRIMARY)	VERIFY SATISFACTORY NES OPERATION AT DESIGN CONDITIONS & CHECK THERMAL RADIATION.	1	2	4/3	1 1/3 (GN ₂)	50 (10 SEC. STEADY STATE)	S.G.S. PURGE SYSTEM, DESIGN TURBINE EXHAUST, PRIMARY GN ₂ FLOW DESIGN START-UP (200 PSIA) & SHUT-DOWN, RECORD % GO ₂ & GN ₂ IN E.T.C.		RADIOMETER & CALORIMETER			
5,000 N ₂ 2,100 H ₂ 82,000 H ₂ O	2. NES OFF DESIGN TEST (GN ₂ PRIMARY)	DEMONSTRATE NES DUCT WILL MAINTAIN FULL FLOW WITH ABOVE DESIGN TURBINE EXHAUST DEMONSTRATE NES PERFORMANCE UNDER XE ENGINE MALFUNCTION CONDITIONS.	1	1	4/3		25 (10 SEC. STEADY STATE)	S.G.S. PURGE SYSTEM, EXPECTED SEAL LEAKAGE, ABOVE DESIGN TURBINE EXHAUST, GN ₂ PRIMARY & SIMULATED XE ENGINE MALFUNCTION SHUT-DOWN.					
	PHASE II SUB-TOTAL			2	3								
	REMOVAL OF NES TEST DEVICE AND CLEANUP												
	DESIGN DEMONSTRATION TEST PROGRAM TOTAL			9	14								
130,000 N ₂ 6,195 H ₂ 10,651,000 H ₂ O	TOTALS	⚠ S.G.S. OPERATION REQUIRES 600 LB / SEC MINIMUM THRU DUCT											
	USE FACTOR	⚠ FLOW DESIGN PROCESS WATER THRU DUCT											
260,000 N ₂ 18,585 H ₂ 19,651,000 H ₂ O	GRAND TOTAL												

TABLE I

QTY REQD	SYM	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPECIFICATION	UNIT WT.	ZONE	ITEM NO.
<div> <div> UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON DECIMALS .001 ± .010 DO NOT SCALE DRAWING </div> <div> DRAWING NO. 70143 CHECKED BY DESIGNED BY STRENGTH BY MATERIALS BY PRODUCTION BY DESIGN ACTIVITY APPD </div> </div>									
<div> <div> ON THRU PREP NEXT FINAL NEXT ASSY USED ON EFFECTIVE SERIAL NO. DRAWING DATA NO. PER ASSY DRAWING LEVEL APPLICATION </div> <div> SIMILAR TO ACT W/ CALC W/ CUSTOMER </div> </div>									
<div> <div> AEROJET-GENERAL CORPORATION AZUSA, CALIFORNIA </div> <div> TITLE DESIGN DEMONSTRATION TEST PROGRAM SUMMARY CHART </div> </div>									
<div> <div> DWG NO. 70143 SCALE RELEASE DATE </div> <div> SHEET 1 OF 1 </div> </div>									

Table I

2.2 Design Demonstration Test Plan for Prototype Nuclear Exhaust System, For ETS-1 at NRDS

2.2.1 Scope

This document provides instructions for performing design demonstration tests on the Nuclear Exhaust System (NES). The test program will be conducted at NRDS using the facility permanent instrumentation and control equipment, process water, gas supply system, and ETS-1.

2.2.2 Applicable Documents

ETS-1 NES Duct Permanent and Temporary Measurement Requirements Lists
Specification for Electro-Hydraulic Control Valve - NIO 6506
Specifications for Test Stand Process Systems - Invitation to Bid
No. 292-62-14
Specification for ETS-1 Exhaust Duct - No. 6884
NES Use and Operational Analysis, REON Report RN-S-0174
NES Acceptance Test Plan, REON Report RN-S-0127
Specifications for ETS-1 Engine Compartment Radiation Shields -
No. 6914, Appendix D
NES Duct Instrumentation Checkout Procedure, REON Report RN-S-0226
NES Duct Instrumentation Installation Procedure, REON Report RN-S-0225
NES Steam Generator System Design Demonstration Test Plan (To be
published)
Test Specifications (To be published four weeks prior to testing)
Design Specification Engine Test Compartment Gas Sampling and
Analyzing System (To be published)

3. Description of Test Specimen

3.1 The NES duct prototype design conforms to the following design drawings:

<u>Drawing No.</u>	<u>SNPO-C Drawing No.</u>	<u>Title</u>
F-19204	3300-13	Index Drawing
F-19205	3301-C22	General Layout
F-19206	3305-M36	Process Flow Diagram
F-19207	3305-M37	P & I Flow Diagram
F-19208	3350-S201	Duct-Truss Assembly
F-19209	3350-S202	Primary Duct Section
F-19210	3350-S203	Inlet Water Shield and Details
F-19211	3350-S204	Bellows and Upper Seal
F-19212	3350-S205	Primary Duct Details
F-19213	3350-S206	Primary Duct Lower Support
F-19214	3350-S207	Primary Duct Upper Support
F-19215	3350-S208	Severance Plane Seal
F-19216	3350-S209	Cooling Water Coupling
F-19217	3350-S210	Elbow Duct Section
F-19218	3350-S211	Elbow Duct Sections and Details
F-19219	3350-S212	Water Jacket
F-19220	3350-S213	Water Jacket Sections
F-19221	3350-S214	Water Jacket Sections and Details
F-19222	3350-S215	Steam Ejector
F-19223	3350-S216	Steam Ejector Sections
F-19224	3350-S217	Steam Ejector Details No. 1
F-19225	3350-S218	Steam Ejector Details No. 2
F-19226	3350-S219	Secondary Duct Section
F-19227	3350-S220	Secondary Duct Exit Elbow
F-19228	3350-S221	Secondary Duct Exit Elbow Details
F-19229	3350-S222	Secondary Duct Supports

<u>Drawing No.</u>	SNPO-C <u>Drawing No.</u>	<u>Title</u>
F-19230	3350-S223	Upper Truss Plans and Elevation No. 1
F-19231	3350-S224	Upper Truss Plans and Elevation No. 2
F-19232	3350-S225	Lower Truss Plan and Elevations
F-19233	3350-S226	Lower Truss Elevation and Sections No. 1
F-19234	3350-S227	Lower Truss Elevation and Sections No. 2
F-19235	3350-S228	Truss Platform Details No. 1
F-19236	3350-S229	Truss Platform Details No. 2
F-19237	3350-S230	Truss Details No. 1
F-19238	3350-S231	Truss Details No. 2
F-19252	3350-S232	Truss Details No. 3

All the duct permanent instrumentation is identified on AGC drawing No. 114669, Instrumentation Installation, NES Duct Permanent.

3.2 The design and orientation plan of the temporary engine compartment (TEC), work platform, and NES test device (simulated chamber and nozzle, simulated turbine exhaust nozzles, simulated intermediate shield, and purge header) are per the following drawings:

<u>AETRON</u> <u>Drawing No.</u>	<u>Title</u>
F-19314	Vessel Details
F-19315	Test Arrangement Plans and Details
F-19318	Simulated Intermediate Shield
F-19361	Orientation Plan and Sections
F-19362	Work Platform

<u>Aerojet-General</u> <u>Drawing No.</u>	<u>Title</u>
096411	Simulated Nozzles Installation Dwg.

AETRON Drawing No. F-19315 (Test Arrangement Plans and Details) and Aerojet-General Drawing No. 096411 (Simulated Nozzles Installation Drawing) are included in this test plan, Figures 1 and 2 respectively, for reference. The alternate test arrangement shown in Figure 2 will be used only if it is necessary to change the clearance between the nozzles and the duct.

4. Test Program

4.1 Test Setup

4.1.1 Install NES duct test device and TEC as outlined in Appendix A.

4.1.2 Install temporary instrumentation shown in Table II. The temporary instrumentation is identified on Aerojet Drawing No. 1114686 Instrumentation Installation, Temporary - Design Demonstration Test, and Figure 3, and the temporary measurement requirements list.

4.1.3 The engine test compartment gas analysis system shall be installed and be operational.

4.1.4 Connect facility gas supply lines. These lines shall provide the following capability:

4.1.4.1 Primary Flow Requirements

Gaseous nitrogen and hydrogen in sufficient quantity and at sufficient pressure to accomplish the following (Reference Figure 1):

	Pressure at Interface (psia)	Flow Rate (lb/sec)		Equivalent Duration at Noted Flow (sec)	Storage Temp
		N ₂	H ₂		
Minimum Allowable	190	285	76	30	amb
Desired Maximum	512	780	208*	45	amb

*The facility gas supply system may not be able to provide the desired maximum flow rates. Therefore, to evaluate NES operating characteristics at two levels of chamber pressure, both above duct pull-in, tests will be conducted at the minimum allowable flow rate and at the maximum flow rate attainable.

Figure 1

Test Arrangement Plans and Details

Figure 2

Figure 3

Temporary Instrumentation

The primary gas flow control system must control primary gas flow to simulate, within $\pm 20\%$, the XE-Engine startup and shutdown transient as shown in Figures 4 and 5. The transients may be anywhere within the limits shown. However, the gas flow must be continuous without step changes in either pressure or time. In addition, the system shall permit a rapid increase in pressure, to conserve the gas supply, for those tests where transients are not significant. The system must provide a rapid shutdown to simulate an XE-Engine malfunction. A malfunction will consist of decreasing chamber pressure from maximum to zero within 0.6 seconds. The control system requirements are presented below:

<u>Condition</u>	<u>Startup</u>	<u>Shutdown</u>
1	Figure 4, to 200 psia P_{pc}	Figure 5, from 200 psia P_{pc}
2	Figure 4, to 550 psia P_{pc}	Figure 5, from 550 psia P_{pc}
3	From zero to 550 psia P_{pc} in 6 ± 1 sec	From 550 psia to zero P_{pc} in 6 ± 1 sec
4		From 550 psia to zero P_{pc} in 0.6 sec maximum

The transients indicated may be interchanged; that is, condition one startup may be run with condition four shutdown, etc.

A block diagram of the control system is shown in Figure 6.

4.1.4.2 GN_2 Purge and Leakage Requirements

Gaseous nitrogen at ambient temperature and 30 lb/sec for a duration of 100 sec plus an additional 20 sec for simulated leakage. Flow shall be controllable from 0 to 30 lb/sec.

4.1.4.3 Simulated Turbine Exhaust Requirements

Gaseous hydrogen at ambient temperature and 15 lb/sec flow rate at an interface pressure of 100 psia for a duration of 12 seconds.

Figure 4
Startup Transient for NES Design Demonstration Tests

Figure 5
Startup Transient for NES Design Demonstration Tests

NOTES:

1. THE 12 PCV PER SPEC NTD 6506 SERVO AMPLIFIER AND ACCUMULATOR ARE INCLUDED.
2. θ_m = SERVO VALVE POSITION MEASURED.
 θ_d = SERVO VALVE POSITION DEMAND.
 P = CHAMBER PRESSURE MEASURED.
 P_d = CHAMBER PRESSURE DEMAND.
3. THIS EQUIPMENT IS PART OF THE ENGINE TEST SYSTEM.
4. THIS EQUIPMENT WILL BE ADAPTED FROM THE ENGINE TEST SYSTEM IF AVAILABLE.
5. THIS EQUIPMENT FABRICATED FROM FACILITY HARDWARE.

Figure 6

4.1.5 Functionally check the duct exhaust igniter system (Reference AETRON Drawing F-19184).

4.1.6 Calibrate all instrumentation.

4.1.7 Visually inspect all connections, electrical and mechanical.

4.2 Test Operations

NOTE: On all tests conducted using GH_2 (primary flow or turbine exhaust), the respective supply line downstream of the control valve shall be purged with GN_2 during the pre- and post-fire purge of the engine compartment.

4.2.1 Phase I (Testing with Temporary Engine Compartment - 7 Tests, Reference Table I)

4.2.1.1 Final System Checkout

Check all seals for leakage, functional check gas supply valves, check electrical continuity of the NES instrumentation, and functional check the duct exhaust flare system.

4.2.1.1.1 Objectives

- a. To verify that all systems are ready for use.
- b. To perform simulated countdown.

4.2.1.1.2 Test Required

Perform one system checkout test.

4.2.1.2 Steam Generator System Checkout

Test fire Steam Generator System (SGS) only at design conditions for approximately 100 sec duration. During this test, after steady-state operation is achieved, introduce simulated GN_2 leakage into the engine compartment and record compartment pressure vs leakage. The leakage shall be increased from 0 to 30 lb/sec in approximately 10 sec, then decreased to 0 and again increased to 30 lb/sec in approximately 10 sec, then held for 30 sec. Flow 600 to 700 lb/sec of process water through the duct when the SGS is operating. Record oxygen concentration in the engine compartment.

4.2.1.2.1 Objectives

- a. To demonstrate satisfactory operation of the SGS.
- b. To establish the effects of leakage on the cell pressure.

4.2.1.2.2 Test Required

Perform one test with a run duration of 100 sec.

4.2.1.3 NES Checkout Tests

Two checkout tests, using GN_2 as the primary gas, shall be conducted to establish satisfactory NES operation prior to conducting tests at off-design conditions. The SGS shall be operated 50 sec preceding, all during, and 50 sec following primary duct flow unless SGS concurrent testing requires extended durations, or if SGS is not required during shutdown. T.E.C. GN_2 purge shall be operated for 50 seconds preceding and 50 seconds following primary duct flow. The purge flow rate shall be 25 lb/sec to 30 lb/sec. Flow 600 to 700 lb/sec coolant water through the duct when SGS is operating.

4.2.1.3.1 Checkout Test at 200 psia P_{pc} (No Turbine Exhaust)

Perform one test at 200 psia P_{pc} with SGS and prefire purge only. The startup and shutdown shall be per the startup (to 200 P_{pc}) and shutdown shown in Figures 4 and 5, respectively. Oxygen concentration in the TEC shall be recorded. SGS shall be shutdown prior to primary flow shutdown for this test.

4.2.1.3.1.1 Objectives

- a. To establish NES pull-in and operation with the temporary compartment.
- b. To verify structural integrity.
- c. To verify the TEC prefire purge system.
- d. Demonstrate safe shutdown without SGS operating.

4.2.1.3.1.2 Test Required

Perform one test with a run duration of 10 sec, steady-state, primary flow.

4.2.1.3.2 Checkout Test at Maximum Attainable P_{pc}

A test shall be conducted using GN_2 primary flow, GH_2 turbine exhaust, GN_2 prefire purge, SGS, and duct design process water flow. Primary chamber pressure shall be increased to maximum obtainable, refer to the startup shown in Figure 4. The turbine exhaust shall then be increased, in 8 to 10 seconds, to design value (for maximum attainable P_{pc}). During increase of the turbine exhaust, the cell pressure and nozzle exit pressure shall be closely observed for indication of flow separation and/or cell over-pressurization. Turbine exhaust shall be shut down prior to primary flow. The primary flow shall be shut down as shown in Figure 5. Duct design process water flow and simulated leakage shall be used

during this test. The sequence of operation of the process water flow shall be according to Figure 7, except that the SGS duration shall be per Paragraph 4.2.1.3 and no cooldown time is required. The simulated leakage shall be achieved by reducing the prefire purge flow rate to 1.5 lb/sec during primary flow, as shown in Figure 8. The excessive turbine exhaust shown in Figure 8 is not applicable to this test. Record oxygen and hydrogen concentration in the engine compartment to verify adequacy of the prefire purge system.

4.2.1.3.2.1 Objectives

- a. To confirm previous test results.
- b. To demonstrate satisfactory operation at full flow conditions (primary flow, turbine exhaust, and process water).

4.2.1.3.2.2 Test Required

Perform one test with a run duration of 10 sec, steady-state, primary flow.

4.2.1.4 NES Duct Off-Design Tests

A series of three tests shall be conducted to evaluate aerodynamic performance, structural integrity, and operational safety of the prototype duct at off-design conditions. All tests will use GN_2 as the primary gas, GN_2 to simulate leakage, and GH_2 turbine exhaust. The startup for the tests shall be accomplished as rapidly as possible, consistent with safety to the facility and NES (approximately six seconds). The shutdown shall be accomplished in approximately six seconds except where noted. SGS and TEC purge system shall be used for all tests as described in Paragraph 4.2.1.3. Record oxygen and hydrogen concentration in the TEC during these tests.

NOTE: REMOTELY OPERATED SUPPLY VALVES A₁, A₂, AND A₃ ARE UPSTREAM OF DUCT AND REMOTELY OPERATED FLOW CONTROL VALVES B₁, B₂, AND B₃ ARE DOWNSTREAM OF DUCT AS SHOWN ON FIG. 1, "PROCESS WATER FLOW DIAGRAM FOR NUCLEAR EXHAUST SYSTEM FOR ETS-1".

2-8-65

Figure 7

Sequence of Operation - Process Water System

NOTE: The pre-fire and post-fire purge flow rates and duration shall be in accordance with established procedures.

Figure 8
Sequence of Operation - Off-Design Conditions
(Excessive Turbine Exhaust)

4.2.1.4.1 Off-Design Test at 200 psia P_{pc} (Excessive Leakage and Excessive Turbine Exhaust)

Subsequent to GN_2 prefire purge, set P_{pc} at 200 psia and simulated leakage at 1.5 lb/sec. Then increase the GH_2 turbine exhaust, within 5 seconds maximum, until either flow separation occurs in the primary nozzle or until the turbine exhaust flow rate is 15 lb/sec maximum. Next, reduce the turbine exhaust flow rate to design flow rate for an engine chamber pressure of 200 psia and increase the simulated leakage within 5 to 10 seconds, until either flow separation occurs in the primary nozzle or the simulated leakage flow rate is 30 lb/sec maximum. See Figure 9 for sequence of operation.

4.2.1.4.1.1 Objectives

To determine amount of seal leakage or turbine exhaust to cause nozzle flow separation at 200 psia P_{pc} .

4.2.1.4.1.2 Tests Required

Perform one test with a run duration of 30 sec, steady-state, primary flow.

4.2.1.4.2 Off-Design Tests at Maximum P_{pc} (Excessive Leakage and Design Turbine Exhaust)

Perform a test with P_{pc} set at maximum valve attainable and with turbine exhaust flow set at the design valve for engine chamber pressure equal to P_{pc} maximum. Increase simulated leakage (within five seconds maximum) until flow separation occurs in the nozzle, or the flow rate is 30 lb/sec. See Figure 10 for sequence of operation.

4.2.1.4.2.1 Objectives

To determine amount of leakage to cause nozzle flow separation at maximum P_{pc} .

Figure 9

Sequence of Operation - Off-Design Conditions
(Excessive Seal Leakage and Excessive Turbine Exhaust)

NOTE: The pre-fire and post-fire purge flow rates and duration shall be in accordance with established procedures.

Figure 10
Sequence of Operation - Off-Design Conditions
(Excessive Seal Leakage)

4.2.1.4.2.2 Test Required

Perform one test with a run duration of 10 sec steady-state, primary flow.

4.2.1.4.3 Off-Design Tests at Maximum P_{pc} (Excessive Turbine Exhaust and Maximum Expected Leakage)^{pc}

Perform test with P_{pc} set a maximum value attainable with 1.5 lb/sec total leakage. Increase the GH_2 turbine exhaust (within 5 to 10 seconds) until flow separation occurs in the primary nozzle or the GH_2 flow rate is 15 lb/sec. The shutdown for this test shall simulate an XE-Engine malfunction (i.e., shutdown in 0.6 sec). The turbine exhaust flow shall be reduced to zero prior to initiating malfunction shutdown. See Figure 8 for sequence of operation.

4.2.1.4.3.1 Objectives

a. To demonstrate that the NES duct will maintain full flow with excessive turbine exhaust and maximum expected leakage with P_{pc} at maximum attainable.

b. To demonstrate NES performance under XE-Engine malfunction conditions.

4.2.1.4.3.2 Tests Required

Perform one test with a run duration of 10 sec, steady-state, primary flow.

4.2.2 Phase II (Testing with Permanent Engine Test Compartment (2 Tests)), (Reference Table I).

4.2.2.1 NES Duct Tests Using the Permanent Engine Test Compartment

Two tests, using GH_2 primary, shall be conducted to demonstrate satisfactory operation of the NES Engine Compartment system. The first test will be at design conditions and the second test will be off-design. Both tests shall use GH_2 as the turbine exhaust.

4.2.2.1.1 Test at Design Conditions

Perform a test with SGS, prefire purge, simulated leakage (1.5 lb/sec), and design GH_2 turbine exhaust (for 200 psia P_{pc}) and duct design process water flow. The startup of the primary flow shall be in accordance with the maximum startup rate (to 200 psia P_{pc}) shown in Figure 4. The shutdown shall be per Figure 5. See Figure 11 for sequence of operation. Oxygen and hydrogen concentration in the engine compartment shall be recorded.

4.2.2.1.1.1 Objectives

- a. To verify GN_2 primary test results.
- b. To evaluate exhaust plume thermal radiation.
- c. To demonstrate NES Engine Compartment operation.

4.2.2.1.1.2 Tests Required

Perform one test with a run duration of 10 sec steady-state, primary flow.

4.2.2.2 Off-Design Test at Maximum P_{pc} (Excessive Turbine Exhaust)

Perform one test, using GH_2 primary, in accordance with Figure 8 sequence of operation. Flow duct design process water flow during this test. Set P_{pc} at maximum attainable with 1.5 lb/sec total leakage, and increase the GH_2 turbine exhaust within 5 to 10 seconds until either flow separation occurs in the

NOTE: The pre-fire and post-fire purge flow rates and duration shall be in accordance with established procedures.

Figure 11
Sequence of Operation - Design Conditions

primary nozzle or the GH_2 flow rate is 15 lb/sec. The shutdown for this test shall simulate an XE malfunction (i.e., shutdown in 0.6 seconds). The turbine exhaust flow shall be reduced to zero prior to initiating the malfunction shutdown.

4.2.2.2.1 Objective

a. Demonstrate that the NES duct will maintain full flow with GH_2 primary, above design turbine exhaust and maximum expected seal leakage with P_{pc} at maximum attainable.

b. Demonstrate NES performance under XE-Engine malfunction conditions.

c. Demonstrate NES Engine Compartment operation.

4.2.2.2.2 Test Required

Perform one test with a run duration of 10 sec, steady-state, primary flow.

5.0 Test Fluid

5.1 Test Gases

5.1.1 The test gases shall be filtered, dry, and oil-free nitrogen, dry hydrogen, and dry and oil-free air.

5.2 Test Liquid

5.2.1 The test liquid shall be inhibited-demineralized water per Volume I of Specifications for Test Stand Process Systems (Invitation No. 292-62-14), Paragraph 29.5.24.3 (inhibitor will be specified at a later date).

6. Instrumentation Requirements

6.1 The required instrumentation shall consist of the instrumentation supplied with the NES prototype duct and, in addition, the temporary instrumentation shown in Table II.

7. Test Data

7.1 The following data on each NES test is required as applicable. These data shall be listed on reproducible forms and approved by the cognizant Test Engineer.

7.2 Tabulated Data

All data noted in Paragraph 6.1 shall be presented in tabulated form at specified data points. The data points will be specified by the NES Project for each test.

7.3 Plotted Data (Required on Tests as Specified)

7.3.1 Plot engine compartment oxygen concentration vs time.

7.3.2 Plot nozzle exit and engine compartment pressures vs leakage at design turbine exhaust. (See Figure 12 for sample.)

7.3.3 Plot nozzle exit and engine compartment pressures vs turbine exhaust at 1.5 lb/sec leakage. (See Figure 13 for sample.)

7.3.4 Plot engine chamber pressure vs engine compartment pressure. (See Figure 14 for sample.)

SYMBOL	PARAMETER	PRIMARY ELEMENT LOCATION	RECORDER				CALC PARAM ETER	PRIMARY ELEMENT			REMARKS
			OSCILL	PEN TYPE	COMPUTER PRINT-OUT	ANALOG TAPE		RANGE	OPER TEMP	QTY	
P _{TC} -1	Turbine Exhaust Chamber Pressure	Turbine Exhaust Chamber	X	X	X			0-100 PSIA	AMB.	1	
P _{TE} -1	Turbine Exhaust Nozzle Exit Pressure	Turbine Exhaust Nozzle Exit			X			0-5 PSIA	AMB.	1	
P _{TE} -2	Turbine Exhaust Nozzle Exit Pressure	Turbine Exhaust Nozzle Exit			X			0-5 PSIA	AMB.	1	
P _S	Engine Gas Supply Line Pressure	Common Supply Line at Engine		X	X			0-3000 PSIG	AMB.	1	
O ₂ -1	Oxygen Content Inside Test Compartment	Environmental Cell		X				(Later) AMB.			Facility-supplied
O ₂ -2	Oxygen Content Inside Test Compartment	Environmental Cell		X				(Later) AMB.			Facility-supplied
O ₂ -3	Hydrogen Content Inside Test Compartment	Environmental Cell		X				(Later) AMB.			Facility-supplied
O ₂ -4	Hydrogen Content Inside Test Compartment	Environmental Cell		X				(Later) AMB.			Facility-supplied
FS	Fire Switch Trace		X		X					1	
T _{LP}	Simulated Leakage and Purge Gas Temp.	Simulated Leakage and Purge Supply Line			X			-420 to +2490°F	AMB.	1	
T _{TC}	Turbine Exhaust Gas Temperature	Turbine Exhaust Supply Line			X			-420 to +2490°F	AMB.	1	
Q _{PR}	Thermal Radiation of H ₂ Exhaust Plume	Ref. ETS-1 NES Duct Temporary Measurement Requirement List			X			0-15 BTU/FT ² SEC		1	Do not run radio meter cables through temp. ref. junction.
Q _{PE}	Thermal Emittance of H ₂ Exhaust Plume	Ref. ETS-1 NES Duct Temporary Measurement Requirement List						0-25 BTU/FT ² SEC		1	
P _{pc} -1	Primary Chamber Pressure	Primary Chamber	X	X	X			0-1000 PSIA	AMB.	1	
P _{pc} -2	Primary Chamber Pressure	Primary Chamber			X			0-300 PSIA	AMB.	1	
P _v -1	Engine Environmental Cell Pressure	Environmental Cell	X	X	X			0-5 PSIA	AMB.	1	
P _v -4	Engine Environmental Cell Pressure	Environmental Cell	X		X			0-30 PSIA	AMB.	1	
P _E -1	Engine Nozzle Exit Pressure	Approx. 1/4" Upstream from Nozzle Exit Plane	X		X			0-30 PSIA	AMB.	1	
P _E -2	Engine Nozzle Exit Pressure	Same Plane, but 90° from P _E -1	X	X	X			0-5 PSIA	AMB.	1	
P _E -3	Engine Nozzle Exit Pressure	Approx. 1" Upstream from Nozzle Exit Plane	X					0-30 PSIA	AMB.	1	
P _E -4	Engine Nozzle Exit Pressure	Same Plane, but 90° from P _E -3	X					0-5 PSIA	AMB.	1	
T _{PC}	Primary Chamber Temp.	Primary Chamber		X	X			-420 to +2490°F		1	
W _{N/H}	Primary Gas Flow Rate	--					X				
W _L	Simulated Leakage						X				
Δ P _{LP1}	Simulated Leakage and Purge Flow Tube Differential Pressure	Leakage Gas Supply Flow Tube	X	X	X			50 PSID	AMB.	1	
Δ P _{LP2}	Simulated Leakage and Purge Flow Tube Differential Pressure	Leakage Gas Supply Flow Tube	X	X				50 PSID	AMB.	1	
W _P	Pre-fire Purge Flow Rate						X				
W _T	Turbine Exhaust Flow Rate						X				
P _D -1	Duct Wall Pressure	Duct Severance Plane @ 0°	X		X			0-30 PSIA	AMB.	1	
P _D -2	Duct Wall Pressure	Duct Severance Plane @ 180°	X		X			0-30 PSIA	AMB.	1	
Δ P _W	Secondary Outlet Water Flow	Secondary Duct Flow Control Orifice	X		X			100 PSID	AMB.	1	

Table II
Temporary Instrumentation List

SYMBOL	PARAMETER	PRIMARY ELEMENT LOCATION	RECORDER			CALC PARAM	PRIMARY ELEMENT			REMARKS	
			PEN OSCILL TYPE	COMPUTER PRINT-OUT	ANALOG TAPE		RANGE	OPER TEMP	QTY		
V _{AX}	Vibration	Ref. ETS-1 NES Duct Temporary Measurement Requirement List	X		X		0-25g	AMB.	1		
V _{AY}			X		X						
V _{AZ}			X		X						
V _{BX}			X		X						
V _{BY}			X		X						
V _{BZ}			X		X						
V _{CX}			X		X						
V _{CY}			X		X						
V _{CZ}			X		X						
V _{DX}			X		X						
V _{DY}			X		X						
V _{DZ}			X		X						
V _{EX}			X		X		X		0-25g	AMB.	1
V _{EY}			X		X		X				
V _{EX}	Vibration	Ref. ETS-1 NES Duct Temporary Measurement Requirement List	X		X		0-25g	AMB.	1		
SG _A	Strain	Ref. ETS-1 NES Duct Temporary Measurement Requirement List		X			0-1000u"	AMB.	1		
SG _B			X						1		
SG _C			X						1		
SG _D			X						1		
SG _E			X						1		
SG _F			X						1		
SG _G			X						1		
SG _H			X						1		
SG _I			X						1		
SG _J			X						1		
SG _K			X						1		
SG _L			X						1		
SG _M			X						1		
SG _N	Strain	Ref. ETS-1 NES Duct Temporary Measurement Requirement List		X			0-1000u"	AMB.	1		
T _{TS-1}	Test Stand Temp	Ref. ETS-1 NES Duct Temporary Measurement Requirement List	X				AMB to 1500°F		1		
T _{TS-2}			X						1		
T _{TS-3}			X				AMB to 1500°F		1		
T _{TS-4}			X						1		
NOTE: Strain gauges and accelerometers are installed as part of permanent instrumentation.											
P _{DE}	Duct Exit Pressure	Duct Exit	X				0-50 PSIA		1		
P _{FE}	Drain Tunnel Exit Pressure	Drain Tunnel Exit	X				0-30 PSIA		1		

Table II, Continued
Temporary Instrumentation List

NOTES.

1. P_e = NOZZLE EXIT PRESSURE, P_v = ENGINE COMPARTMENT PRESSURE
2. TURBINE EXHAUST FLOW AT DESIGN VALUE
3. SAFETY PURGE AT DESIGN VALUE
4. $P_e = 12.8$ psia

Figure 12

Nozzle Exit and Engine Compartment Pressures vs Leakage

NOTES.

1. P_e = NOZZLE EXIT PRESSURE, P_v = ENGINE COMPARTMENT PRESSURE
2. N_2 SEAL LEAKAGE = 1.50 lb/sec.
3. SAFETY PURGE AT DESIGN VALUE
4. $P_a = 12.8$ psia

Figure 13

Nozzle Exit and Engine Compartment Pressures vs Turbine Exhaust

NOTES

1. TURBINE EXHAUST FLOW AT DESIGN VALUE
2. SAFETY PURGE - $P_{sc}=100-115$ psia, $T_{sc}=1600-1700^{\circ}R$, $\dot{W}_s=115-130$ lb/sec, $\dot{m}_s=18-21$
3. SEAL LEAKAGE FLOW = 0-2 lb/sec AMBIENT N_2
4. $P_a = 12.8$ psia

Figure 14

Engine Chamber Pressure vs Engine Compartment Pressure

7.4 Recorded Data

7.4.1 Photostats or equivalent shall be provided of the records, as required. Original records shall be kept on file by NTO for the duration of the contract and for a period of two years thereafter.

The records shall be identified prior to reproduction as follows:

- a. Calibration scale factors
- b. Functions
- c. NES serial number
- d. Test number and date

8.0 Photographic Requirements

8.1 Still Photographs

8.1.1 Each initial test setup shall be photographed and documented.

8.1.2 Photographs shall be taken of any significant component failure or damage during the test series and documented.

8.2 Motion Pictures

8.2.1 Twenty-four frames-per-second, color, documentary motion pictures shall be taken of the initial GH_2 primary flow test.

8.2.2 Twenty-four frames-per-second, color, motion pictures shall be taken as specified where major test hardware changes have been made.

9.0 Schematics

9.1 A schematic of the facility piping and wiring, as installed, to the NES test device shall be furnished to REON Department 7436 prior to test.

APPENDIX A

SEQUENCE AND INSTRUCTIONS FOR
INSTALLATION OF TEMPORARY ENGINE COMPARTMENT
ARRANGEMENT I (TEC)

Ref. AETRON Drawings F-19314, F-19315, F-19318, F-19361, F-19362

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1. Check Conditions Before Moving TEC Into Position

(a) The bottom shield, top shield, and annular bellows shall be in place and the bellows shall be connected to the top shield.

(b) The bottom trough, the complete rotating ring and the bottom shield seal shall be in place, and shall be connected to the bottom shield.

(c) The duct shall be in place.

(d) Temporary protection shall be provided (e.g., 1/2 inch plywood deck) over the entire bottom shield leaving exposed sufficient space around the center hole for setting the TEC flange (approximately 8 ft - 2 inches I.D.).

(e) Provide edge lips (e.g., 1-in. x 2-in. x 1/8-in. angle brackets or wooden cleats) on periphery of the bottom shield to prevent movement of the temporary protection. Temporary protection shall also be provided for the seal blades on the bottom shield.

(f) Provide wooden guides, screwed securely and rigidly to the protective deck to center the TEC as it is lowered. Seal leg on the bottom of TEC shall not contact shield I.D.

(g) Check to see that the TEC is completely assembled (with the 10:1 area ratio nozzle) as shown on the drawings, with internal spools, seal rings, and neoprene seal in place.

2. Install TEC

NOTE: During installation (and at other times when the TEC is not in place) the wood work platform (Drawing F-19362, Items 5a, 5b, 5c) shall be placed over the duct before installing the TEC.

(a) Place the 10 gage aluminum protective ring (Dwg. Item 1) and rubber gasket (Dwg. Item 2) on the bottom shield.

(b) Spray top of bottom shield, rubber gasket and aluminum protection sheet with a polysiloxane (silicone) mold-release agent. This agent may be used in the form of a silicone fluid, as an emulsion, or as a grease, provided a complete film is formed over those areas which will come in contact with the filler to be used under the TEC bottom plate. (A thin film of strippable plastic may be used in lieu of the silicone.)

(c) Set TEC (Dwg. Item 3) over the bottom shield with the center-line of the chamber perfectly aligned with the centerline of the shield. Use a 10-ton minimum crane with no less than a 25 foot telescoping boom with an experienced crane operator to place the TEC without touching shield I.D.

(d) Lower TEC until flange is resting on bottom shield.

(e) Check centerline measurement, level, and elevation of top flange A_1 . Raise the TEC and adjust level in all directions, providing metal shims under bottom flange of TEC as required.

(f) Pump polysulfide (Thiokol) under the TEC flange until full. No voids shall be permitted. Polysulfide shall be mixed, pumped into place, and shall be allowed to set in accordance with manufacturer's recommendation to form to a Durometer hardness of A80 to A85.

(g) Check accuracy per Paragraph (e). If not correct, remove polysulfide, repeat installation procedure, and recheck for accuracy.

(h) Pressurize inflatable seal.

3. Install Supports

(a) Place the 4 pipe supports (Dwg. Items 4a, 4b, 4c, 4d) between the TEC and the thrust measurement ring, bolting each in place in turn. Nuts shall be hand-tight.

(b) Shim shall be provided as necessary to prevent movement of the TEC while tightening the bolts.

(c) Tighten all bolts using a torque wrench. Torque as specified in Table A.

(d) Recheck for accuracy per Paragraph 2(e).

4. Work Platform Installation

The work platform shall be installed whenever it is necessary to work inside the TEC. It shall be installed through the TEC 42" manway (with the engine in place) as follows:

(a) Tie safety ropes to the lifting lugs of each platform section. Anchor the safety ropes outside the TEC, allowing sufficient rope to maneuver work platform sections through the manway and into position. (Make sure centering clips, wing nuts and washers have been removed from platform sections before placing platform sections in manway.)

(b) With a man leaning inside the manway of the TEC, maneuver one side section (Item 5b) of the work platform through the manway and position it in front of the manway.

(c) Maneuver center section (Item 5A) of the work platform through the manway, rotate and slip under nozzle into position.

(d) Maneuver side section (Item 5c) through the manway and slide over previously installed center section into proper position.

TABLE A
TORQUE FOR BOLTS

<u>Nominal Size</u>	<u>Torque in ft-lbs</u>
1/4	1
3/8	3
1/2	8
5/8	16
3/4	25
7/8	40
1	62

(e) Center all platform sections over exhaust duct opening so that the rubber pads on the underside of the work platform are bearing on top of the exhaust duct inlet.

(f) Install and adjust 8 centering clips with washers and wing nuts to contact TEC base ring. Lock centering clips in place with wing nuts.

(g) Safety ropes shall remain tied to platform sections and to anchors as long as the work platform remains inside the TEC.

5. Work Platform Removal

The work platform shall be removed through the 42" manway (with the engine in place) as follows:

(a) Man inside the TEC shall retract and remove 8 centering clips which possibly could scratch or mar the exhaust duct inlet.

(b) Reverse installation procedure to remove the work platform through the manway using the safety ropes.

NOTE: Safety rope shall be kept taut at all times during these operations.

6. TEC Removal

(a) Match-mark bottom exterior of the TEC and exposed top surface of the aluminum protective plate in no less than 3 places to facilitate orientation during replacement. The aluminum plate (Dwg. Item 1), in turn, shall be permanently match-marked with the top of the bottom shield.

(b) TEC shall be removed in reverse order of installation except that the polysulfide filler shall be left in place undisturbed on the bottom of the TEC.

(c) The TEC shall be stored on wood blocks and provisions made to prevent damage to TEC and polysulfide filler.

INSTALLATION OF TEST ARRANGEMENT II STRUCTURE

7. Check Conditions Before Moving Arrangement II into Position in the manner described in Paragraph 1(a) through 1(g) except reference to "TEC" shall mean "Arrangement II Structure."

8. Place Work Platform and fasten in place as described for TEC.

9. Install Arrangement II (Dwg. Item 6)

(a) Place the 10 gage aluminum protective ring (Dwg. Item 1) on the bottom shield.

(b) Assemble Arrangement II (Drawing F-19315) without 4 in. pipe supports.

(c) Set the assembly from "b", above, over bottom shield with centerline of spool A₁ perfectly aligned with centerline of shield. Use a 10-ton minimum capacity crane with no less than a 25-foot telescoping boom with an experienced crane operator to place Arrangement II without touching ID of shield.

(d) Lower until the flange of Arrangement II is resting on the bottom shield. Do not permit Arrangement II to contact the duct at any time.

(e) Place the 4 pipe supports (Dwg. Items 7a, 7b, 7c, and 7d) between Arrangement II and the thrust measurement ring, bolting each in place in turn to the thrust measurement ring. Nuts shall be hand-tight.

(f) Raise Arrangement II and bolt to supports. Bolts to be hand tight.

(g) Check centerline alignment and plumb. Check level and elevation of top flange A₁. Adjust level in all directions, providing metal shims between flanges of the supports and the flanges of Arrangement II or the thrust measurement ring as required.

(h) Tighten all bolts to torque given in Table A.

(i) Recheck accuracy per Paragraph (f) above. If not correct, loosen bolts and increase or reduce the shims as required, tighten bolts and recheck for accuracy.

(j) Pressurize inflatable spacer used to transmit lateral loads to the bottom shield.

(k) Mount simulated intermediate shield (Item 8) in place and tighten bolts to torque specified in Table A.

(l) At all times use extreme caution to prevent foreign objects from entering the duct.

POLYSULFIDE SUPPLIERS IN CALIFORNIA

Coast Pro-Seal & Mfg Co.
2235 Beverly Blvd.
Los Angeles 57, California

Furvane Plastics, Inc.
4516 Brazil St.
Los Angeles 39, California

Parker Seal Co.
10567 Jefferson Blvd.
Culver City, California

Poly Resins
11655 Wicks St.
Sun Valley, California

Products Research Co.
2919 Empire Ave.
Burbank, California

Rezolin Inc.
1651 - 18th St.
Santa Monica, California

Stillman Rubber Div.
The Electrada Corp.
Culver City, California

APPENDIX B

NES DESIGN DEMONSTRATION TEST
HARDWARE REQUIREMENTS

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APPENDIX B

NES DESIGN DEMONSTRATION TEST HARDWARE REQUIREMENTS

<u>Drawing No.</u>	<u>Item</u>	<u>Fabricator</u>	<u>Completion Date</u>	<u>NRDS Due Date</u>
F-19314	Vessel Details	Southwest Welding Co.	3-1-65	6-1-66
F-19315	Test Arrangement Plans & Details	Southwest Welding Co.	3-1-65	6-1-66
F-19318	Simulated Intermediate Shield	Southwest Welding Co.	3-1-65	6-1-66
F-19361	Orientation Plan & Sections	N/A	3-1-65	6-1-66
F-19362	Work Platform	NTO		6-1-66
096104	Nozzle - Conical	Sacramento	9-15-65	6-1-66
096551	Assembly, Conical Nozzle	Sacramento	7-15-65	6-1-66
096411	Simulated Nozzles Installation Drawing	N/A		6-1-66