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DEC 16 1970

Attention: Mr. R. G. Staker

Subject: Data Item F-004, Test Cell "C" Facility Requirements
Document, December 1970

Gentlemen:

The subject data item is submitted in compliance with Technical Directive W71-10, December 3, 1970.

This document has been prepared as requested by SNPO-C. There are two requirements contained in this document which WANL does not agree with. They have been included herein at the specific verbal direction of SNPO-C personnel. As discussed in some detail during the Long Range Planning meeting of November 13, 1970, held in Washington, WANL believes it is necessary to have a scrubber for the DR-1 and DR-2 power test series as well as PQR-1, QR-1 and QR-2. Also, as briefly discussed in the same meeting, WANL does not require the dual TPA assemblies to develop or qualify the NSS. However, WANL does believe the program would benefit considerably by utilizing the dual TPA's on as many reactor tests as possible.

Approval or comments on this document will be appreciated in order to assist WANL in planning the necessary Test Cell "C" facility modifications.

Respectfully,

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A. C. Sanderson, Manager
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Attachment - 6 Copies of Data Item F-004

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DATA ITEM F-004

TEST CELL "C"

FACILITY REQUIREMENTS DOCUMENT

NERVA PROGRAM

SUBCONTRACT NP-1

CODE IDENTIFICATION NO. 14683

DECEMBER 1970

INFORMATION CATEGORY

Unclassified

R. E. Thompson

Authorized Classifier

12/4/70

Date

TABLE OF CONTENTS

	<u>Page</u>
1.0 INTRODUCTION	1
1.1 Scope	1
1.2 Objective	1
1.3 Facility Program Plan	1
1.3.1 Facility Planning	1-2
1.3.2 Relationship to Other Facilities	2
1.4 Major Assumptions	2-3
2.0 TEST ARTICLE DESCRIPTION	4
2.1 Scope	4
2.2 NSS Description	4
2.2.1 DR-1 Test Assembly Configuration	4-5
2.2.2 DR-2, PQR-1, QR-1 and QR-2 Test Assembly Configuration	5-6
2.3 NSS Operating Characteristics	6
2.4 Facility/NSS Test Assembly Interface Requirements	6
2.4.1 NSS Fluid Interface	7-8
2.4.2 NSS Instrumentation Interface	8
2.4.3 NSS Controls Interface	9
2.4.4 NSS Electrical Power Interface	9
2.4.5 NSS Mechanical Interface	9-10
2.4.6 NSS Environmental Interface	10
3.0 TEST PROGRAM AND OPERATIONS	14
3.1 Scope	14
3.2 NSS Test Series Plan	14-15
3.3 NSS Test Operations Requirements	15

TABLE OF CONTENTS (Continued)

		<u>Page</u>
4.0	NUCLEAR RADIATION AND SHIELDING	17
4.1	Scope	17
4.2	Radiation Environmental Requirements	17
4.3	Access Requirements	17-18
4.4	Facility Hardware Protection	18
4.5	Source Term	18-19
5.0	RELIABILITY, MAINTAINABILITY, AND QUALITY ASSURANCE	21
5.1	Scope	21
5.2	Guidelines	21-22
5.3	Requirements	22-23
6.0	SAFETY	24
6.1	Scope	24
6.2	Standards	24
6.2.1	Philosophy	24
6.2.2	Documents	24
6.3	Requirements	25
6.3.1	General Requirements	25-26
6.3.2	Special Requirements	26-27
7.0	FACILITY SYSTEMS	28
7.1	Scope	28
7.2	Guidelines	28
7.3	NSS Test Support Systems	28
7.3.1	Scope	28
7.3.2	Requirements	29
7.3.3	Liquid Hydrogen System	29
7.3.4	Gaseous Hydrogen System	29-30

TABLE OF CONTENTS (Continued)

	<u>Page</u>
7.3.5 Liquid Nitrogen System	30
7.3.6 Gaseous Nitrogen System	30
7.3.7 Gaseous Helium System	31
7.3.8 Water Systems	31
7.3.9 Ancillary Systems	32
7.4 Reactor Effluent Handling Systems	32
7.4.1 Reactor Exhaust Duct System (REDS)	32-33
7.4.2 Reactor Effluent Purification System	33
7.4.3 Filter Reactor Outlet Gas (FROG)	34
7.5 Instrumentation and Controls for NSS Tests	34
7.5.1 Scope	34
7.5.2 Guidelines	35-36
7.5.3 Requirements	36-38
7.6 Structures for NSS Tests	38
7.6.1 Guidelines	38-39
7.6.2 Requirements	39-41
7.7 Buildings for NSS Tests	41
7.7.1 Guidelines	41
7.7.2 Requirements	41-43
7.7.3 Operational Buildings	43-44
7.8 Utilities for NSS Tests	44
7.8.1 Guidelines	44
7.8.2 Requirements	45-46
7.9 Site Work for NSS Tests	46
7.9.1 Guidelines	46
7.9.2 Requirements	46-47
8.0 AUTOMATIC DATA PROCESSING	50
8.1 Scope	50
8.2 Guidelines	50-51

TABLE OF CONTENTS (Continued)

		<u>Page</u>
	8.3.1 Real-Time Engineering Analysis	51
	8.3.2 Post Test Analysis Support	52
	8.3.3 Data Recordin g	52
	8.3.4 Displays	52
	8.3.5 Channel Engineering	53
	8.3.6 Data System Calibration and Performance Analysis	53
	8.3.7 Maintenance Record Storage	53
9.0	SPECIAL TEST EQUIPMENT	54
	9.1 Scope	54
	9.2 Test Equipment	54
10.0	TEST CELL "C" FACILITY QUALIFICATION REQUIREMENTS	55
	10.1 Scope	55
	10.2 General Qualification Requirements	55
	10.3 Phase I Qualification Requirements	55-56
	10.4 Phase II Qualification Requirements	56

LIST OF TABLES

		<u>Page</u>
Table 4-1	Test Cell "C" Required Access for 2 - 3 Day Turnaround	20
Table 7-1	Test Cell "C" Environments	48

LIST OF FIGURES

Figure 2-1	NSS Test Assembly Envelope	11
Figure 2-2	DR-1 Flow Schematic	12
Figure 2-3	DR-2, PQR-1, QR-1 and QR-2 Flow Schematic	13
Figure 3-1	Preliminary NSS Test Program and Modification Schedule at Test Cell "C"	16
Figure 7-1	Existing Test Cell "C" Layout	49

1.0 INTRODUCTION

1.1 SCOPE

This data item specifies the integrated facility requirements for Test Cell "C" (TCC), NRDS, for the development and qualification testing of the Nuclear Subsystem (NSS). The facility requirements for non-nuclear NERVA engine hardware that will be tested at Test Cell "C" will be added to this document as these requirements become available. Changes to this document shall be made in accordance with NERVA Configuration Management Plan.

1.2 OBJECTIVE

The information presented herein is to be used in the preliminary estimates of TCC facility modifications, the approximate cost of these modifications and scheduling of construction and testing. Sufficient information is supplied to develop the Test Cell "C" facility design criteria so as to provide a facility capable of testing an NSS of the basic configuration described in Section 2.0 of this document.

1.3 FACILITY PROGRAM PLAN

The evolution of the Nuclear Subsystem will progress through two stages of maturity, i.e., development hardware and pre-qualification and qualification hardware. This will in turn allow TCC to be modified from its present state to its ultimate required capabilities in two phases.

1.3.1 Facility Planning

The improvement of the Test Cell "C" capabilities shall be completed in two phases, A and B, and shall be coupled with specific NERVA test articles.

1.3.1.1 Phase A Requirements

Phase A of the Test Cell "C" modifications shall be completed and activated to support the DR-1 and DR-2 Nuclear Subsystem tests.

The basic facility capabilities shall be as follows:

- (a) Provide the capability to test the NSS for up to 60 minutes at full power.
- (b) Provide the capability to utilize a flight type turbopump assembly on the second reactor test (DR-2) with the facility TPA as a backup.
- (c) Provide for a seven day turnaround between NSS tests in so far as constrained by data handling and test fluid replenishment.
- (d) Provide digital controls for NSS tests.

1.3.1.2 Phase B Requirement

Phase B of the Test Cell "C" modification shall be completed and activated to support the PQR-1 through QR-2 NSS tests. The requirements listed in this document shall constitute Test Cell "C" capabilities following Phase B modifications. The basic facility capabilities shall be extended to:

- (a) Reduce the turnaround time between tests to a 2-3 day period.
- (b) Provide an effluent scrubber with a connecting duct.

1.3.2 Relationship to Other Facilities

The Test Cell "C" Automatic Data Processing requirements stated in Section 8 shall be utilized as input to size and design the total ADP facility. The ADP facility must be available to support the Test Cell "C" operations as shown.

1.4 MAJOR ASSUMPTIONS

Much of the information presented herein is based upon assumptions which resulted from technology program experience, hot bleed cycle engine data and preliminary 10 hour reactor design. F-004 will mature as trade studies are identified and the results are used to verify or invalidate these assumptions. The following are

The major assumptions used for this document; any modification to this may have a major impact on the facility requirements.

- (a) The DR-1 and DR-2 reactors will be fired vertically up, without a scrubber, similar to NRX techniques.
- (b) The PQR-1, QR-1 and QR-2 reactors will be fired vertically and will use a scrubber.
- (c) All reactor test assemblies will use a 24:1 area ratio nozzle and will not require altitude simulation.
- (d) The DR-2 through QR-2 reactors will utilize a flight candidate propellant feed system (PFS).
- (e) The reactor test assembly controls will be digital type.
- (f) The location and configuration of the propellant feed system, cooldown supply system and structural support coolant system are as described in Section 2.0.
- (g) Replenishment fluids are available as necessary.

2.0 TEST ARTICLE DESCRIPTION

2.1 SCOPE

This section describes the test assembly configuration and presents major operating and interface characteristics.

2.2 NSS DESCRIPTION

The reactor test article will utilize as much NERVA engine hardware as practical in support of the Nuclear Subsystem qualification testing. Hardware not used because of the limitations of the facility, NSS testing priorities, hardware development status, or safety aspects shall be simulated as closely as possible so as not to compromise the qualification program.

The Nuclear Subsystem performance, design, test and qualification requirements are presented in the NSS Specification, CP677555. The Nuclear Subsystem will be tested at Test Cell "C" in a similar manner as the NRX type reactors. The NSS, pressure vessel and nozzle will be mounted on a test car, and a turbopump mounted in the facility will be used to supply hydrogen such that the NSS/Engine interface conditions are duplicated. The exact test article configuration for DR-1 through QR-2 has not been fully defined, however, the following information is the latest available and will be updated as the design develops. This updating will be made via the Test Cell "C" Test Facility Performance Document, T-134, which describes the detailed test assembly interface conditions that the facility is required to meet.

2.2.1 DR-1 Test Assembly Configuration

The DR-1 Test Assembly will include the following major components: (1) Nuclear Subsystem, (2) Pressure Vessel and Closure, (3) 24:1 area ratio nozzle, (4) Turbine Simulator Assembly and (5) test car model T-21. The overall dimensions are shown in Figure 2-1 and the schematic flow path is shown in Figure 2-2.

The Nuclear Subsystem will be made up of flight hardware except for possible substitutes for the Structural Support Coolant Assembly (SSCA). The SSCA will use facility type valves mounted on the test car outside the 360° facility radiation shield. The CDDA will use hardware identical to the flight type and will be mounted in an accessible location under the test car privy roof with guide tubes passing through the roof and connecting the control drums in the NSS. The turbine simulator assembly, which will simulate the pressure drop in the turbine portion of the flight turbopump assembly, will consist of an orifice with a bypass control valve. The valve will be located outside the facility shield on the test car.

The T-21 Test Car, which was used for Phoebus 2A testing, will be modified in accordance with DR-1 requirements. Similar to the test cars used in the NERVA Technology Program, the T-21 has a flat bed assembly, privy roof, piping assemblies, front connector plug and instrumentation plug.

Other systems that are required to simulate an engine configuration at TCC, such as the cooldown supply assembly and propellant feed system will be mounted in the facility using facility type hardware.

The controls for the test assembly will use concepts consistent with DR-1 test objectives and will be mounted in the facility. The instrumentation mounted on the test assembly will require facility signal conditioning for recording or control system input.

2.2.2 DR-2, PQR-1, QR-1 and QR-2 Test Assembly Configuration

The DR-2, PQR-1, QR-1 and QR-2 Test Assembly will include the following major components: (1) Nuclear Subsystem, (2) Pressure Vessel and Closure, (3) 24:1 area ratio nozzle and (4) test car. The schematic flow path is shown in Figure 2-3. The NSS will be made up of all flight hardware including the SSCA and CDDA. The SSCA will be mounted outside the facility shield and the CDDA will be mounted on the pressure vessel. The test car type will be defined at a later date.

The test assembly will utilize a flight propellant feed system (PFS) mounted in the facility to supply hydrogen to the test assembly. The PFS will consist of two T PA's and all associated valves. The facility propellant feed system will be used as a backup to the flight system and shall be capable of being switched between tests.

2.3 NSS OPERATING CHARACTERISTICS

The NSS is designed to supply the thermal energy to the turbine drive fluid and the thermal energy required to obtain a thrust chamber inlet temperature of 4250 degrees Rankine at 450 psia pressure for a flow rate of 91.2 pounds per second. The NSS test assembly requires facility supplied hydrogen, facility controls and electrical power.

The "R" series test assembly utilizing Test Cell "C" will be required to demonstrate the following major operating characteristics*:

- (a) Capable of prestart, start-up, steady state, shutdown, and cooldown operations in the normal mode and simulated malfunction and emergency modes.
- (b) Capable of endurance up to 300 minutes at rated conditions for DR-1. This duration will be accumulated in up to 30 cycles of varying duration up to 60 minutes. For DR-2 through QR-2, the endurance will be 600 minutes at rated conditions, accumulated in up to 60 cycles of varying duration, up to 60 minutes.

2.4 FACILITY/NSS TEST ASSEMBLY INTERFACE REQUIREMENTS

The facility/test assembly interface is defined as the common boundary between the facility and test assembly. This in actuality for the NSS test assembly is the front connector plug; instrumentation module, test car mechanical interface points and the nozzle exit plane. The interface requirements have been divided into fluid interface, instrumentation, controls interface, electrical power interface, mechanical interface and environmental.

* Refer to NSS Specification CP-677555 for complete characteristics.

2.4.1 NSS Fluid Interface

The fluid interface will be through the front connector plug of the test car and the nozzle exit plane. The fluids supplied to the test assembly shall be filtered to ensure that no particles larger than 600 microns exist in the fluid and that no more than 220 grams of material with the density of aluminum be allowed to enter the test assembly during its operating life. The fluids supplied to the test article shall conform to the following specifications:

- (a) Nitrogen: MFSC-Spec-234
- (b) Helium: MFSC-Spec-364
- (c) Hydrogen: MFSC-Spec-356

2.4.1.1 Main Propellant Line

The test assembly will require the following fluids through the main propellant line:

- (a) Liquid hydrogen at high pressure for simulated bootstrap, start-up, steady state, and shutdown in the normal mode and simulated malfunction and emergency modes.
- (b) Liquid hydrogen for emergency cooldown mode.
- (c) Gaseous hydrogen for warm-up of the test assembly prior to switchover to LN_2 or GN_2 .
- (d) Gaseous helium for warm-up, inerting, leak testing, purging, and limited cooldown.
- (e) Gaseous nitrogen for purging and for a pretest pressure transducer stimulus check.

2.4.1.2 Cooldown Supply Line

The test assembly will require the following fluids through the cooldown supply line:

- (a) Liquid hydrogen for cooldown after 60 minutes at rated conditions.
- (b) Liquid hydrogen for temperature conditioning prior to start-up.
- (c) Gaseous hydrogen for warm-up of the test assembly prior to switch-over to LN_2 or GN_2 .
- (d) Gaseous helium for warm-up, inerting, leak testing, purging, and limited cooldown.

2.4.1.3 Reactor/Facility Shield Annulus Purge Supply Line

The test assembly will require gaseous nitrogen through the reactor/facility shield annulus purge line to purge the volume around the NSS.

2.4.1.4 Test Car Coolant System Supply and Return Lines

The test assembly will require borated water through the test car coolant system supply line and back through the return line for cooling the privy roof shield.

2.4.1.5 Actuator Hydraulic System Supply and Return Lines

The test assembly will require hydraulic oil through the actuator hydraulic system supply line and back through the return line for SSCA and TSV actuator working fluid for R-1 only.

2.4.1.6 Test Assembly Nozzle Exhaust

The test assembly will flow to the facility through the test assembly nozzle exhaust all fluids specified in paragraphs 2.4.1.1 and 2.4.1.2.

2.4.2 NSS Instrumentation Interface

The instrumentation interface will be through the test car instrumentation module. The test assembly will require power for the instrumentation and will send signals to the facility for signal conditioning, recording, controls and display. Approximately 500 channels of instrumentation will be installed on the test assembly.

2.4.3 NSS Controls Interface

The controls interface will be through the test car instrumentation module. The test assembly will require controls for the Control Drum Drive Assembly (CDDA) to position the control drums, the Structural Support Coolant Assembly (SSCA) to position the valves, and turbine simulation assembly to position the valves (DR-1 only). These controls will be integrated with the facility controls to achieve the desired chamber pressure and temperature profiles in the test assembly.

The primary control system for the NSS, facility or flight turbopump and cooldown system will be through a state variable feedback controller implemented on a digital computer system. The control system will mature during the NSS test program and aid in the development of the NSS flight control system.

An analog control system shall also be provided as a backup system to the primary control system for selected test operations during the NSS development tests. The analog system will not necessarily have the high speed performance of the digital system but will permit safe startups, steady state operation and shutdown.

The test assembly shall be provided with safety controls, independent of the operational controls, to satisfy the ground safety requirements for reactor tests.

Analog-digital simulation shall be provided to assist in the development and checkout of the digital controls hardware and software.

2.4.4 NSS Electrical Power Interface

The electrical power interface will be through the test car instrumentation module. The test assembly will require the following electrical power:

- a) Direct current for excitation of instrumentation.
- b) Direct current for SSCA actuators (DR-2 through QR-2) and CDDA actuators.
- c) Direct current for SSCA and TSCV actuator servo valves (DR-1 only).

2.4.5 NSS Mechanical Interface

The mechanical interface will be at the various points that the test car is in contact with the facility. The following interfaces will be required:

- a) The test assembly, which weighs approximately 225,000 lbs., and transmits an additional force of approximately 50,000 lbs. during firing, shall be supported by the facility.

- (b) The test assembly shall be constrained in the horizontal plane.
- (c) The test assembly will require positioning in its final position after being moved to within 18 inches of this position.
- (d) The test assembly will be required to be demated from the facility shortly after a hot firing, thus precluding direct pad access by personnel for this purpose.
- (e) The test assembly will require a mating half for the front connector plug and instrumentation plug.
- (f) The test assembly will require a mating surface for the facility radiation shields.
- (g) The test assembly will require a mechanical interface with the scrubber or reactor outlet gas filter (FROG). The FROG interface should be remotely operable.

2.4.6 NSS Environmental Interface

The following are the environments at the test, assembly interface:

- (a) The test assembly will require environmental protection from the weather during non-run periods.
- (b) The radiation levels for the test assembly will be supplied at a later date.
- (c) The thermal radiation from the test assembly.

TEST CELL "C"

13'

$\epsilon = 24:1$

27' to 31'

11'

26'

NOTE: PRELIMINARY INFORMATION NOT FOR DESIGN USE

FIGURE 2.1 NSS TEST ASSEMBLY ENVELOPE

FIGURE 2-2, DR-1 FLOW SCHEMATIC

FIGURE 2-3, DR-2, PQR-1, QR-1 and QR-2 FLOW SCHEMATIC

3.0 TEST PROGRAM AND OPERATIONS

3.1 SCOPE

The purpose of this section is to describe the test sequence, test duration, and test operations required to support testing of the test assembly. Although the test schedule is subject to change, facility requirements developed from this schedule and related operational requirements will be adequate to support anything but requirements resulting from major program changes.

3.2 NSS TEST SERIES PLAN

The NSS qualification program will consist of five Nuclear Subsystem (NSS) tests. DR-1 and DR-2 are to be used as development reactors; PQR-1 is to be used for prequalification, while QR-1 and QR-2 are to be used for qualification. These reactors will have the general configuration as described in Section 2, Paragraph 2.3. All NSS development and qualification functional testing will be conducted at Test Cell "C".

Test operations at TCC will require approximately 17 to 21 weeks for each reactor. During this interval, the test assembly shall be mated with the test cell, checked out, power tested and de-mated from the test cell.

The reactor power test period will consist of individual test runs or experimental plans (EP). The first EP in each test series will consist of initial criticality, neutronics and control drum calibration, gas flow tests, shutdown and control system tests. Subsequent EPs

will consist of individual tests of endurance, control capabilities, operational concepts, operation sequencing and hardware performance and will be performed during startups, steady state operations and/or shutdown as necessary to obtain test information and to demonstrate and verify the requirements of Section 3 of the NSS Specification.

A preliminary schedule for the NSS Test Program at Test Cell "C" is shown in Figure 3-1. Included in the schedule are the major modifications identified for specific reactors. These modifications are to be completed in two phases, A and B. Phase A will include the basic modifications to conduct the "R" test series. Phase B major modifications will include adding an effluent scrubber and reducing the turnaround time between runs to a 2 - 3 day period, as defined in Section 3.3.

3.3 NSS TEST OPERATIONS REQUIREMENTS

For Development testing (DR-1 and DR-2), the Test Cell shall be capable of supporting six 10 minute full power cycles or one 60 minute cycle per EP per week, so far as constrained by data handling and fluid replenishment. The capability to utilize a flight type turbopump assembly, with the facility TPA as a back-up, shall be provided for the DR-2 and subsequent tests.

For pre-qualification and qualification testing, (PQR-1, QR-1 and QR-2) the Test Cell shall be capable of supporting six 10 minute full power cycles or one 60 minute full power cycle per EP per one half week on an intermittent basis to allow an average of one EP per week during the operational period. The facility shall be designed such that pre-programmed operations may be accomplished during the turnaround period. The facility design shall not take into account failures that may occur in the facility which would extend the turnaround period unless these credible failures would violate the safety philosophy described in Paragraph 6.2.1.

LEGEND:

ENGINEERING

PROCURE

INSTALL & CHECKOUT

FIGURE 3-1
PRELIMINARY NS² TEST PROGRAM AND MODIFICATION SCHEDULE AT TEST CELL "C"

YEARS

4.0 NUCLEAR RADIATION AND SHIELDING

4.1 SCOPE

This section defines the requirements for facility access requirements, facility hardware protection, and source term definition in support of the test program given in Section 3.0.

4.2 RADIATION ENVIRONMENTAL REQUIREMENTS

The reactor test compartment (360 degree shield) shall be constructed so as not to perturb the reactivity of the reactor by more than \$0.50.

4.3 ACCESS REQUIREMENTS

Personnel access to various test cell areas shall be required with and without the test assembly mated to Test Cell "C". The operation to be performed shall include maintenance, repair, modification, set-up, secure, test assembly installation, checkout, and removal, and fluid replenishment.

The test assembly will be designed to minimize personnel access required for all test assembly related activities including mate-up/de-mate with the test cell, checkout and maintenance after reactor operations. Provisions shall be provided to protect personnel against excessive exposure for any personnel access required to support the "R" series test program given in Section 3.

Provisions shall be made to protect personnel against excessive exposure for the access requirements shown in Table 4-1 for the 2 - 3 day turnaround requirements and for the following:

1.) Limited access to specific test facility locations (i. e., LCR, LH₂ fill station, gas fill station, and LN₂ fill station) for minimum facility securing and fluid replenishment will be required 12 hours after reactor shutdown. The source term for this access shall be based on the next to last shutdown of the fifth reactor discussed in Section 4.5.

2.) Limited access to specific test facility locations, i. e., Flow Control Room (FCR), High Pressure Room (HPR) and Propellant Pump Room (PPR) for facility securing operations will be required one day after reactor shutdown. The source term for this access shall be based on the last shutdown of the fifth reactor discussed in Section 4.5

3.) Limited access to the test cell pad area will be required two weeks after reactor shutdown with the test assembly removed from the test cell.

4.4 FACILITY HARDWARE PROTECTION

The facility hardware shall be either protected from the damage due to radiation effects or the hardware shall be designed to be maintainable. Maximum effort shall be made to select materials for the facility which have high enough threshold damage properties to withstand the source term defined in Paragraph 4.5. If the materials cannot withstand the environment, local shielding shall be provided or as a last recourse, the equipment shall be designed to be maintainable.

4.5 SOURCE TERM

The source term is defined as the radiation levels external to the pressure vessel. The source term should include direct and indirect radiation from the test assembly and the test cell material activation as well as net particulate fission product release from the test article with and without a scrubber where applicable.

The source term should be based on (1) "R" series operation at 1500 mw in one hour increments, two tests per week for a total of ten hours for the reactor schedule presented in Section 3.0, (2) Pewee test operation at Test Cell "C".

TABLE 4-1, TEST CELL "C" REQUIRED ACCESS FOR 2-3 DAY TURNAROUND

Station	Time After Shutdown ⁽¹⁾ When Entry Required	Type and Time Required in Area
1) LH ₂ Fill Station		
a) Dewars 1 and 2	12 hours	Continuous (29 hrs)
b) Dewars 4 and 5	No entry required	(2)
2) Local Control Room (Inside)	12 hours	Continuous (42 hrs)
3) LN ₂ Vaporizer	12 hours	Continuous (20 hrs)
4) Gas Fill Station		
a) GH ₂	N/A	N/A
b) GHe	12 hours	Intermittent (30 min)
5) Hot Water Tank	No entry required	(3)
6) LH ₂ Vaporizer	12 hours	Continuous (12 hrs)
7) Propane Storage	24 hours	Intermittent (15 min)
8) LN ₂ Fill Station	24 hours	Intermittent (15 min)
9) Test Cell Building	No entry required	

- NOTES:
- (1) Shutdown is defined as that portion of the run profile during which the LH₂ pump is shutdown and the control drums are run in.
 - (2) Can be filled from Dewars 1 and 2.
 - (3) Can be filled from inside Local Control Room.

5.0 RELIABILITY, MAINTAINABILITY, AND QUALITY ASSURANCE

5.1 SCOPE

This section identifies the reliability, maintainability, and quality assurance requirements to be applied in the design, fabrication, installation, qualification, and testing of a maintainable and reliable facility.

5.2 GUIDELINES

The following documents shall be utilized in the preparation of the reliability, maintainability, and quality assurance plans for Test Cell "C".

- a.) SNPO-C-4, Quality Assurance Requirements for Facility and Test Support Equipment
- b.) FEO Reliability, Maintainability, and Quality Plans for Test Cell "C"
- c.) SNPO _____. Maintainability Program Requirements for Facility and Test Support Equipment
- d.) NPC-250-1: Reliability Program Provisions for Space Systems
- e.) NPC-325-1: Design Criteria and Construction Standards
- f.) SNPO-C-1: Structural Design Requirements
- g.) MIL-STD-470 (Maintainability)

Reliability, Maintainability, and Quality Assurance Plans shall be prepared to be compatible with the safety requirements specified in Section 6.0.

All systems shall be designed to "fail safe" in the condition that will do the least damage to personnel, facility, and test article in descending order to importance.

NPC-325-1 shall be applied to all design and construction.

SNPO-C-4 shall be applied to the design, fabrication, construction, installation, qualification and testing of all functional elements. (Functional elements include the TSS, I&C, and Shielding Structures.)

All systems shall be highly reliable as determined through a design and analysis process of identifying and eliminating, where possible, and controlling critical components of which single failures would render the system inoperative. Also, the system shall have a low probability of failure during a test, and consistent with a suitable maintenance program, be reliable throughout their useful life.

5.3 REQUIREMENTS

The FEO will prepare a reliability and quality assurance plan which defines and describes the program to be implemented upon initiation of facility design.

Design contractor(s) shall be required to prepare implementation procedures to satisfy the reliability, maintainability, and quality assurance plan.

The FEO will prepare a maintainability plan which defines and describes the program to be implemented upon initiation of facility design. The plan shall be developed around but not limited to the following criteria:

- a.) Identify the maintainability requirements to be applied in the design, fabrication, installation, qualification, and testing of the TCC complex.
- b.) All systems shall be designed to accommodate the following:
 - 1.) Two-three day turnaround for testing.
 - 2.) Facility and equipment accessibility.
 - 3.) Reduction of complexity for maintenance.
 - 4.) Minimize downtime, number of personnel, and human error.
 - 5.) Minimize design - dictated maintenance support cost.
- c.) All systems shall be designed to provide:
 - 1.) Rapid replacement or repair of malfunctioning equipment.

- 2.) System and component self-check.
- 3.) Redundance on critical systems.
- 4.) Adequate work space in accessible work areas.
- 5.) Test points in accessible work areas.
- 6.) Standardize circuits, components, and equipment where possible.
- 7.) Space parts.

6.0 SAFETY

6.1 SCOPE

This section identifies the safety requirements and to some extent safety techniques to be applied in the design, fabrication, installation, qualification operations, and testing of facility equipment.

6.2 STANDARDS

6.2.1 Philosophy

The basic philosophy shall be that all facilities, appurtenances, support equipment, etc., are designed and operated so that no single failure or credible combination of errors, malfunctions or accidents can cause personnel injury, and/or serious facility damage or test article loss. This philosophy requires the use of a formal hazards analysis which results in a categorization of potential hazards and documents the analysis and proposed procedures to reduce any undue consequences to acceptable levels. The hazards analysis technique is further described in Section 6.3.2.

6.2.2 Documents

The following documents shall be used as stated to aid in achieving safety goals:

- a.) The following documents shall be complied with:
 - 1.) SNPO-C Safety Plan (TBD)
 - 2.) AEC Manual Chapters 0500 Series; Health and Safety
 - 3.) SNPO-N NRDS Safety Requirements
- b.) The following document shall be used as a guide:
 - 1.) NASA Safety Manual NHB-1700.1 (V 1)

6.3 REQUIREMENTS

Safety requirements are generated by various techniques. Certain basic requirements or standards come from the documents listed above. Other safety requirements come from safety analyses such as the hazard analysis technique listed below.

6.3.1 General Requirements

The following safety requirements, listed in order of preference, will be applied to the designs:

a.) Design for Minimum Hazards

Major effort shall be made throughout all phases of design to insure inherent safety through the selection of appropriate specifications, design features, and qualified components. This effort shall include a thorough review of system configuration compatibility with maintenance and test operations, and other test requirements to minimize the probability of system degradation because of personnel error.

b.) Protective Systems

In all instances where known hazards exist and cannot be eliminated, appropriate protective systems shall be employed consistent with program goals and objectives.

c.) Warning Devices

Where it is not possible to preclude the existence or occurrence of a known hazard, reliable devices shall be employed for timely detection of the condition and the generation of an adequate warning signal. Responses to warning signals shall be delineated in emergency plans. Warning signals shall be standardized within like types of systems, in accordance with existing NRDS directives, to minimize the probability of improper personnel reaction to the signal(s).

d.) Special Procedures

Where it is not possible to reduce the magnitude of existing or potential hazards through design, protective systems, or the use of warning devices, appropriate emergency procedures shall be developed.

6.3.2 Special Requirements

A documented hazards analysis of facility design modifications or new facilities will be performed utilizing the following hazard categories:

a.) Category I - Negligible. Condition(s) such that personnel error, environment, design characteristics, procedural deficiencies, or subsystems or component malfunction will not result in damage or personnel injury.

b.) Category II - Marginal. Condition(s) such that environment, personnel error, design characteristics, procedural deficiencies, or subsystem or component malfunction can be counteracted or controlled without major damage or any injury to personnel.

c.) Category III - Critical. Condition(s) such that environment, personnel error, design characteristics, procedural deficiencies, or subsystem or component malfunction will cause major equipment damage or personnel injury, or will result in a hazard requiring immediate corrective action for personnel or system survival.

d.) Category IV - Catastrophic. Condition(s) such that environment, personnel error, design characteristics, procedural deficiencies, or subsystem or component malfunction will severely degrade system performance and cause subsequent system loss, or death or severe injuries to personnel.

Category III or IV hazard conditions shall be precluded from designs to the maximum practical extent. Any design which includes a Category III or Category IV hazard condition which cannot be eliminated will require review by SNPO-C. The

analysis of Category III or Category IV hazard conditions will be documented together with a proposed procedure for reducing the consequences of the hazard to an acceptable level.

Certain special safety problems are peculiar to the Nuclear Rocket Program. These include site related considerations such as seismic loads, flooding and earthquakes, effluent release, an underground personnel and equipment area, etc. Obviously, certain safety requirements will stem from analysis of these special problems.

7.0 FACILITY SYSTEMS

7.1 SCOPE

This section presents the requirements of the Test Cell "C" facility to support the specific test assembly described in Section 2.0 and the test plan outlined in Section 3.0. Radiation shielding and certain safety requirements for the facility systems are included in Sections 4.0 and 6.0 and are not repeated in this section.

The existing Test Cell "C" facility configuration has been used as the initial baseline for the purpose of extrapolating the anticipated facility requirements. A TCC layout is shown in Figure 7-1.

7.2 GUIDELINES

Each facility system will be required as a minimum to meet the test assembly interface requirements specified in Section 2.0 and to possess the capacity and capability of providing the required support for the test program and operations specified in Section 3.0. The facility design shall be such that maintenance requirements are compatible with the 2 - 3 day turnaround requirements.

In selecting equipment and components, the desert environment of NRDS shall be taken into account. The environment is presented in Table 7.1.

7.3 NSS TEST SUPPORT SYSTEMS

7.3.1 Scope

This section defines the requirements and applicable functions of the test support systems for Test Cell "C" as they apply to the NSS testing. The NSS Test Support Systems are comprised of liquid hydrogen, liquid nitrogen, gaseous hydrogen, gaseous nitrogen, gaseous helium, water and various ancillary systems.

7.3.2 Requirements

The following requirements are applicable to the NSS Test Support Systems:

- a) The design of the TSS shall be based on the latest editions of the applicable commercial codes and standards used for design in present day industrial practices.
- b) Sufficient operating fluid storage and systems capacity shall be provided for system chilldown, startup, steady state, shutdown, cooldown, system warmup, purging and emergency and alternate shutdown.
- c) Each facility system shall have the necessary instrumentation, controls, valves, flow elements, filters and safety systems to meet all operational requirements of the facility and test assembly.

7.3.3 Liquid Hydrogen System

The liquid hydrogen (LH_2) system shall be required to:

- a) Supply LH_2 to the NSS test assembly through the main propellant line during startup, run, and shutdown, as specified in Paragraph 2.4.1.
- b) Supply the turbine energy source (TES) which, in turn, will be used to drive the facility turbopump and pressurize the LH_2 dewars. (For DR-1 only.)
- c) Supply LH_2 for cooldown and thermal conditioning through the test assembly normal cooldown line.
- e) Supply the test assembly with LH_2 flow for emergency shutdown.
- f) Supply LH_2 to vessels and lines for filling, chilling and topping during operations.

7.3.4 Gaseous Hydrogen System

The gaseous hydrogen (GH_2) system shall be required to:

- a) Pressurize the LH_2 dewars
- b) Supply GH_2 for the initial facility turbopump turbine drive (DR-1 only)
- c) Supply GH_2 to warm up LH_2 systems in the facility and the test assembly.

7.3.5 Liquid Nitrogen System

The liquid nitrogen (LN_2) system shall be required to:

- a) Supply LN_2 to the test assembly for the cooldown phase in the event that liquid hydrogen is not used.
- b) Supply the LN_2 to the LN_2/GN_2 converter for replenishing the GN_2 storage vessels.
- c) Supply LN_2 to the test assembly thermocouple reference junction dewar.

7.3.6 Gaseous Nitrogen System

The gaseous nitrogen (GN_2) system shall be required to:

- a) Purge and inert the reactor/360 shield annulus, test car privy, the reactor effluent handling systems, facility equipment rooms, facility systems, and test article.
- b) Purge the test article during non-run phase.
- c) Pressurize the hot water tank.
- d) Pressurize the LN_2 dewar
- e) Supply actuation for facility remote controlled valves.
- f) Supply the test assembly with 100 pps of GN_2 for reactor pressure instrumentation stimulus test (pre test checkout only).
- g) Supply molecular seal at all points where hydrogen is flared (flare stacks, REDS).

7.3.7 Gaseous Helium System

The gaseous helium (GHe) system shall be required to:

- a) Purge and inert facility and test assembly hydrogen systems.
- b) Purge the test article during non-run, pre-run, and post-run phases.
- c) Supply helium for alternate cooldown for limited periods of time.

7.3.8 Water Systems

7.3.8.1 Utility Water System

The utility water system shall be required to:

- a) Supply the fire protection system. A minimum of 50,000 gallons shall be available at all times.
- b) Supply makeup water to the process water system and the borated water system.
- c) Supply water to a portion of the thermal spray system.

7.3.8.2 Process Water System

The process water system shall be required to:

- a) Supply hot water to the turbine energy source (TES).
- b) Supply water, as required, to the REDS.
- c) Supply a portion of the thermal spray system with water that has passed through the TES.

7.3.8.3 Thermal Spray System

The thermal spray system shall spray water over certain areas of the facility to protect them from the radiant heat energy of the burning hydrogen plume.

7.3.8.4 Borated Water System

The borated water system shall provide flow to the 360 degree facility radiation shield and the test car privy roof.

7.3.9 Ancillary Systems

The following ancillary systems shall be provided:

a) A flare system shall provide for the safe disposal of all hydrogen that is vented during all operations. Hydrogen that is exhausted from the test assembly shall also be flared. A molecular seal shall be required at the point of the flare(s) for fire and explosion preventions.

b) A vacuum system shall provide for evacuating cryogenic storage vessels and vacuum jacketed piping.

c) A hydraulic system shall provide actuation fluid for servo-operated valves and binary valves.

7.4 REACTOR EFFLUENT HANDLING SYSTEMS

This section defines the design criteria and performance requirements for the Reactor Exhaust Duct System (REDS), the Reactor Effluent Purification System (REPS) and the Filter, Reactor Outlet Gas (FROG). The REDS and REPS will be required for the PQR-1, QR-1 and QR-2 test assemblies and the FROG will be required for the DR-1 and DR-2 test assemblies.

7.4.1 Reactor Exhaust Duct System (REDS)

The minimum design criteria and performance requirements are as follows:

a) The reactor effluent shall be ducted from the reactor nozzle exit to the REPS.

b) The reactor effluent shall be shocked-down to subsonic conditions prior to entering the REPS.

c) The REDS shall perform a minimum of 1000 cycles of operation of 60 minutes duration each at maximum conditions of 100 lbm/second mass flow rate and $T_c = 4385^\circ\text{R}$. The REDS shall perform at a reduced cyclic life at a T_c equal to 5000°R .

d) The REDS shall prevent the entry of any foreign matter into the test article which may cause degradation or accidental criticality of the test article.

e) The REDS shall preclude the formation of a combustible mixture of H_2 and O_2 (safe O_2 content is 3% or less by volume).

f) The REDS shall remotely seal itself to the test assembly.

7.4.2 Reactor Effluent Purification System

The minimum design criteria and performance requirements are as follows:

a) The reactor effluent and any additional mass flow added to the effluent shall be directed from the REDS to safe release to the atmosphere.

b) Without considering the noble gases (in particular Xenon and Krypton), the REPS shall remove not less than 99% of the remaining radioactive contaminants from the effluent prior to releasing the effluent to the atmosphere.

c) The REPS shall perform a minimum of 1000 cycles of operation of 60 minutes duration each at maximum reactor conditions of 100 lbm/second mass flow rate and $T_c = 4385^\circ R$.

d) The REPS shall not prevent the REDS from achieving its performance requirements.

e) The REPS shall preclude the formation of a combustible mixture of H_2 and O_2 (safe O_2 content is 3% or less by volume).

f) After treatment for radioactive contaminant removal, the reactor effluent shall be safely burned in the atmosphere.

g) The concentrated radioactive materials shall be stored for future burial and/or controlled release. The radioactive material released to the environment by the waste disposal system shall be as low as practicable and in no case shall exceed the limits listed in AECM 0524, "Standards for Radiation Protection".

7.4.3 Filter Reactor Outlet Gas (FROG)

The FROG will be designed to filter radioactive particulate matter out of the reactor effluent during cooldown. The requirements of the FROG shall be as follows:

- a) The FROG shall filter all the reactor effluent either hydrogen, nitrogen or helium during the pulse cooling portion of reactor cooldown.
- b) The FROG shall be remotely operable for mating with the test assembly.
- c) The FROG shall incorporate a molecular seal to prevent air from entering the NSS during non-flow periods.
- d) The FROG shall provide a thermocouple rake to measure the test article chamber temperature and nozzle outlet temperature.

7.5 INSTRUMENTATION AND CONTROLS FOR NSS TESTS

7.5.1 Scope

This section defines the requirements and functions of the systems which comprise the Instrumentation and Controls Systems for NSS tests at Test Cell "C". The following subsystems shall be required to perform the control functions, monitor, record and process all test data for the test program:

- a) Data Acquisition System
- b) Facility Control System
- c) Test Control System
- d) Facility Safety System
- e) Communication System

7.5.2 Guidelines

The Data Acquisition System shall operate independently of the facility and test control system as much as is practical. Inter-connections between the systems shall be isolated through suitable devices to prevent spurious operation of control components.

The capability shall be provided to select diagnostic channels for display in the control room and test monitor room.

Simulation of test article and select facility control system parameters and components shall be provided for those systems which cannot be operated during pre-firing checkouts. Generally, simulation should be inserted into the system as near the test article as practical and provide for data recording of simulated parameters.

The test and facility control systems shall be operated remotely from the control room during setup, checkout, and operation. Local controls shall be provided where desirable for initial setup and checkout or for operation in the replenishment of stores (such as the liquid and gas unloading).

Electrical equipment that is to be operated in potentially explosive environments shall be provided in accordance with applicable codes.

D. C. power supplies for systems shall be redundant with crossover capability. Valve position control loops shall be powered from individual power supplies to prevent multiple valve loss from a single failure.

The I & C System shall interface and be compatible with the ADP system (Section 8).

Automatic checkout capability shall be provided to the extent required to assure meeting the 2 - 3 day turnaround time.

Transmission and distribution cabling system, including cables, cable trays, terminal columns, boxes, cable-termination racks, switching and patching equipment, patch panels, and miscellaneous system hardware shall be provided.

The ground system shall be an overall coordinated system and shall provide the following:

- a) compatibility with the test article
- b) maximum suppression of noise and common mode voltage
- c) maximum protection of personnel and equipment

All equipment and cabling shall be shielded to minimize noise, cross-talk, etc. The ground and shielding approach shall be an integrated design.

7.5.3 Requirements

7.5.3.1 Data Acquisition System

The Data Acquisition System shall accept, condition as required, and record all measurements from the test article and from various facility systems. The system shall accept both unconditioned signals from transducers and signals which have been conditioned and buffered by other systems. Provision shall be made to display any channel parameter on console meter, etc, in the Control Room or Test Monitoring Room. The Data Acquisition System will interface with a real-time automatic data processing (ADP) system to provide channels for computation, processing and display. The DAS shall include the following:

- a) Signal-conditioning system, including signal conditioners, amplifiers, and calibration system. Transducers will include the following types:

<u>USE</u>	<u>TYPE</u>
Pressure, flow ΔP	Four-arm bridge-type strain gages
Vibration and Acceleration	Variable-reluctance, piezoelectric and strain
Position	Linear voltage-differential transformers and swept potentiometers
Strain	Compensated half bridge with bridge-completion networks
Temperature	Tungsten/tungsten-rhenium thermocouples, chromel/alumel thermocouples, copper/constantan thermocouples, resistance thermometers
Flow	Turbines and counters (frequency)

Neutronics	BF ₃ and ion chamber
Speed	Counters (frequency)
Fluid Level	Carbon resistors, reflectometer.
Acoustic Pressure	Reluctance microphones

b) Analog multiplexers, including voltage controlled oscillators, line driving amplifiers, long lines and patch panels (PAM-FM data system).

c) Analog recording system, including magnetic tape recorders (FM, 0 to 10 kHz; Direct, 0 to 20 kHz), recording-playback and tape-search electronics operator consoles or stations, displays and readout devices, strip charts (single and multiple channels), and direct writing optical oscillographs.

d) Event-recording system, including edge markers on strip charts and oscillographs.

e) Timing Systems: This system shall be capable of producing coded digital and analog signals as required for all recording systems, support systems, control systems and other applications including the displays for setup and operations.

f) Calibration System, including the interface between the DAS and the Automatic Data Processing System and between the DAS and the test article end-to-end checkout system.

7.5.3.2 Facility Control Systems

The system shall provide the operational control, using specially controlled feedback signals, of all facility systems including the following:

a) Pressurization Systems, including the run dewars, cooldown dewars, water tanks and gas systems.

b) Propellant System, including the facility mounted turbopump assembly

c) Turbine energy source used with the TPA system

d) Water Systems, including the process water and the borated water systems

- e) Low pressure LH_2 normal cooldown system
- f) Emergency Shutdown System, including the high pressure dewar, GH_2 accumulator and valve positioning commands.

7.5.3.3 Test Control System

The system shall provide operational and safety controls for the reactor system and shall integrate them with Facility Control System to provide controls for NSS testing. The control system shall be as specified in Paragraph 2.4.3. Hybrid simulation of the test article and the facility shall be provided to enable checkout of the digital control system and ancillary operator training.

7.5.3.4 Facility Safety Systems

The system shall be capable of monitoring, detecting and activating alarms for such parameters as radiation, fire, smoke and hazardous gases, and oxygen content during test operations.

Fire protection systems shall provide inerting and/or deluge where required.

The systems shall include a visual and aural warning system that will accomplish surveillance of area status, identification of hazardous conditions existing at specific locations and control of personnel during test operations.

7.5.3.5 Communication Systems

The system shall be capable of providing an intercom, public address, radio, telephone, closed circuit television and photographic system as required to conduct facility and test assembly operations described in Section 3.

7.6 STRUCTURES FOR NSS TESTS

7.6.1 Guidelines

The existing Test Cell "C" layout, showing roads, equipment, structures, etc., is shown in Figure 7.1.

Structures for the test cell are to be divided into three categories as follows:

- a) Substructure, including foundation, subgrade equipment rooms and access tunnels and concrete-pad work and test area.
- b) Superstructure, including the REPS and REDS support structure.
- c) Facility shield structures, including movable shield and stationary shield structures.

All structures shall be designed in accordance with the following codes and standards:

- a) General Design Standard - Design Criteria and Construction Standards, NASA Facility Publication - NPC 325-1.
- b) General Building Code - Uniform Building Code, International Conference of Building Officials.

7.6.2 Requirements

7.6.2.1 General

The structures shall withstand wind velocities of up to 80 mph 30 feet above ground level, with appropriate gust factor. ASCE Paper No. 3269, Wind Forces on Structures, shall be consulted.

Structures shall withstand the ground motion conditions produced by weapons tests at the Nevada Test Site.

The basic structures shall satisfy the functional, operational and environmental requirements of the acoustic levels resulting from full-power tests (approximately TBD db broad band) and of the thermal environments resulting from full-power reactor tests.

Critical structures and substructures shall be designed in compliance with appropriate sections of Specification SNPO-C-1, Structural Design Specification. Critical structures or substructures are those that, by their failure, can cause a hazard to personnel or catastrophic failure of the facility or test hardware.

Materials, surface finishes, shapes and arrangements of structural systems in exposed locations shall be selected to minimize activation and contamination and to facilitate decontamination.

Structural elements shall be designed to minimize thermal gradients wherever they are likely to occur. Thermal shields and cooling water shall be used where necessary.

Piping thrust and hammer effects shall be evaluated where they may influence the design of any structure.

7.6.2.2 Substructure

Foundation designs shall be based on soil condition which prevail in and around the Test Cell "C" complex.

Building-code requirements for reinforced concrete ACI-318, American Concrete Institute, shall apply.

The test cell substructures shall accept the static and dynamic loads (and appropriate combinations thereof) imposed by nozzle exhaust, test equipment, superstructures and soil.

The test cell shall mate with the test assembly and provide remote demote capability.

7.6.2.3 Superstructure

Standards and codes for design of the superstructure concrete shall be in accordance with the requirements for reinforced concrete ACI-318, American Concrete Institute.

Specifications for design, fabrication and erection of structural steel shall be those of the American Institute of Steel Construction.

Specifications for the design, fabrication and erection of aluminum structures shall be as contained in the Aluminum Construction Manual, Aluminum Association, New York, N.Y.; Alcoa Structural Handbook, Aluminum Company of America, Pittsburgh, Pa.; and ASCE Suggested Specifications for Structures of Aluminum Alloy 6061-T6 and 6062-T6, Paper No. 3341.

Superstructures shall be provided with a system of air terminals and down conductors for lightning protection.

7.6.2.4 Facility Shield Structures

Radiation shielding as necessitated by the test program presented in Section 2, shall be required to protect personnel from contaminated portions of the REPS, a potentially contaminated REDS, radioactive waste disposal facilities, and from direct and induced radiation. Access tunnels (see 7.6.2.2, Sub-structure) may be necessitated to allow shielded access to existing shielded buildings and structures. Shields shall be designed to withstand the radiation, thermal and acoustic effects of reactor operations. In addition, the effects of ground motion due to weapons tests must be considered.

Thermal shielding shall be required to protect equipment from the radiant heat energy of the burning hydrogen plume of the reactor and the test cell flares.

7.7 BUILDINGS FOR NSS TESTS

7.7.1 Guidelines

Buildings are defined as all above - or below-ground enclosures that are not specified in Section 7.6, Structures.

All new buildings shall be designed in accordance with NASA Design Criteria and Construction Standards, NPC-325-1, and as required hereinafter.

All buildings shall be analyzed in terms of personnel and equipment access and the protection from the radiation, explosion and industrial hazards associated with all operations, testing and credible accidents postulated for Test Cell "C" during NSS tests.

Building features shall be generally similar to existing NRDS buildings except where economy or practicality dictate otherwise.

7.7.2 Requirements

7.7.2.1 Architectural

a) Conduit, piping and heating ventilation and air-conditioning ducts shall be routed in a neat and orderly manner.

b) Exteriors of above grade buildings shall be designed and finished for ease of decontamination.

c) Buildings subject to flooding by hazardous fluids or gases shall have appropriate doors, sloped ceilings, ventilation, floor drains, warning devices and secondary means of egress.

7.7.2.2 Civil

Buildings having facilities for decontamination shall provide a suitable means of collecting the contaminated waste and conveying it to a disposal area that serves all of Test Cell "C".

7.7.2.3 Electrical

Basic electric power shall be as specified in 7.6, Utilities.

Building grounding grids of driven rods and buried bare-copper conductors shall be provided. Some of the items connected to the ground system are structural steel, reinforcing steel, metal siding, doors, windows, gratings, handrails, crane rails, tracks, tanks, pipelines, motor frames, pumps, compressors, machine tools, cranes, welders, lightning-protection systems, static wires, neutral wires, transformer cases, lightning arrestors, cable sheaths, cable shields, stress cones, potheads, DC minus, switchgear, motor-control centers, panel boards, equipment racks and consoles, conduits, trays, duct banks, metal towers, propellant and gas unloading stations, low-voltage equipment, appliances and receptacles. The ground system will be arranged to provide single-point connections for the DC negatives and the cable shields (see paragraphs 7.5.2 and 7.8.2.3). A common ground for both the control point and test cell shall be made available for I & C grounding.

Buildings shall be provided with a system of air terminals and down conductors for lightning protection.

Emergency lighting shall be provided in all buildings and tunnels.

Lighting shall be provided at all building entrances and exits.

7.7.2.4 Mechanical

For closed buildings conditioned air shall be provided for personnel comfort, to remove the heat generated by instrumentation and control equipment and to provide humidity control for electronic equipment. The system shall be designed to remove radioactive airborne particles from the air brought in from outside. A slight positive air pressure shall be maintained in these buildings during reactor operation.

For closed buildings that house hazardous liquid or gas piping, a means of inerting these buildings with GN₂ shall be provided.

Essential equipment and systems not accessible during test shall have a high degree of reliability.

7.7.3.5 Piping

The material in piping used to dispose of contaminated liquid waste shall not be adversely affected by harsh decontamination solutions.

7.7.3.6 Structural

All buildings shall be structurally designed to withstand the seismic and event ground motion where mentioned in 7.6, Structures. "Blow out" panels shall be installed in buildings where a potential explosive hazard exists within the building

7.7.3 Operational Buildings

Buildings will be required in two main areas of the Test Cell "C" complex: the test cell area, which is adjacent to the reactor pad, and the control point area which is remote to the pad and used to control the test assembly and the test cell.

7.7.3.1 Test Cell Area Buildings

The main test cell building will be required to house the following major items.

- a) Final flow control valves and associated piping and instrumentation.
- b) Facility and flight turbopumps used to support the test assembly.
- c) Main header and valves for the gas bottle farm.
- d) Equipment for signal conditioning, amplification and multiplexing all instrumentation signals.

Additional buildings will be required to house the diesel generator units, gas compressors, fill station, local control room, motor control center and water pump room. To support the daily activities at the test cell, buildings will be required for offices, maintenance, shop functions and cryogenic bench testing.

7.7.3.2 Control Point Area Building

The main control point building will be required to house the following major items:

- a) Control room with the required consoles to perform all test operations at the test cell.
- b) Test monitoring room, adjacent to the control room, for test assembly on-line performance evaluation.
- c) Control of support activities such as re-entries, site radiation, monitoring, monitoring pre and post test operations.
- d) Equipment for recording data, communications and computers used for controls and interface with the Automatic Data Processing equipment.

The diesel generators shall be housed in another building in the control point area.

7.8 UTILITIES FOR NSS TESTS

7.8.1 Guidelines

The utility systems shall conform with the latest edition of applicable commercial codes and standards used for design in present day industrial practices and pertinent requirements of NPC-325-1.

7.8.2 Requirements

7.8.2.1 Water System

The domestic water system shall store and distribute domestic and fire protection water in accordance with the following requirements:

- a) Design flow at end of complex (fire) - 1000 GPM
- b) Design pressure at end of complex (fire) - 65 PSIG
- c) Domestic Consumption - 40 gallons/capita/day

7.8.2.2 Waste Disposal

The sanitary waste disposal shall meet the following requirements:

- a) General basis - ASCE Manuals 36 and 37
- b) Peak flow - by fixture-unit method
- c) Average flow - assume 30 gallons/capita/day
- d) Minimum pipe diameter - 8 inch mains; 6 inch building laterals
- e) Maximum manhole spacing - 400 feet

The contaminated waste system shall provide an area for collection and safe retention of all contaminated waste water from exhaust-duct drain lines, thermal-protection water spray and facility decontamination water (where practical).

7.8.2.3 Electrical Power System

The electrical power system shall be separated into three categories: (1) utility power, (2) critical power, and (3) emergency power. Utility power will be supplied commercially and will be used to power equipment that is only indirectly associated with reactor operations.

Critical power will be used to power all equipment that is required to conduct a reactor test. Critical power at the test cell shall be supplied by diesel generator unit(s) in parallel with commercial power. At both the test cell and the control point, if either source of critical power should fail, the other source shall assume the entire load.

Emergency power will be used to power equipment necessary to conduct a safe reactor shutdown and cooldown. Emergency power will assume partial load if both the commercial power and the diesel generators fail. This power will be supplied by a combination of battery bank system and battery powered inverters. The neutral or negative leg of each system shall be grounded at and only at, its point of origin; i.e., generator, transformer or battery bank (see paragraph 7.7.2.3).

7.9 SITE WORK FOR NSS TESTS

7.9.1 Guidelines

The Test Cell "C" site layout shown in Figure 7-1 shall be used as a guide for new site work.

Existing NRDS roads, railroads and drainage systems shall be used wherever possible and practical.

The design of new work shall be in accordance with the requirements of NASA Design Criteria and Construction Standards, NPC-325-1.

7.9.2 Requirements

Roads shall be designated to meet the following requirements:

a)	Maximum slope	10%
b)	Maximum wheel load	(TBD)
c)	Roadway width	24 ft.
d)	Shoulder width	4 ft.
e)	Berm outside of shoulder	3 ft.
f)	Design speed	25 mph
g)	Surface	Bitumen on prepared subgrade

Grading shall meet the following drainage liquid waste:

a)	Frequency of recurrence from Calico Hills	50-year storm
b)	Frequency of recurment at central complex, roads and railroads	10-year storm

c)	Simultaneous storm and deluge	Design for larger of two
d)	Intensity, duration, frequency	To be developed from
chimatological data for
NTS & NRDS

The large volumes of deluge water used at the test area and in the cryogenic storage areas shall be intercepted and drained off to natural drainage channels, or to holding basins if contaminated.

Railroads shall meet the following requirements:

a)	Maximum grade	5%
b)	Minimum horizontal curve radius	400 ft.
c)	Gage	4 ft - 8 1/2 in.
d)	General Design	Comply with ARA
e)	Railroads serving the test cell shall be compatible with the	

nuclear environment in that area.

f)	Railroads sharing roadways or maneuvering areas shall not project above finished pavement grade.

TABLE 7-1
TEST CELL "C" ENVIRONMENTS

<u>Environment</u>		<u>Uncontrolled Areas and Outside</u>	<u>Controlled Areas</u>
(a)	Humidity, relative, percent	0 - 100	10 - 60
(b)	Temperature, °F	+5 to +120	+55 to +80
(c)	Pressure, average, psia	12.8	12.8
(d)	Atmosphere	Ambient air	Controlled air
(e)	Sand and Dust	NASA TMX 53872	
(f)	Water		
	(1) Rain	10-yr. storm ⁽¹⁾	None
	(2) Deluge		None
(g)	Wind	TBD	TBD
(h)	Seismic Loads	TBD	TBD
(i)	Nuclear Radiation	TBD	TBD
(j)	Acoustic	TBD	TBD
(k)	Electromagnetic Interference	In accordance with MIL-E-6051D	

(1) 10-year storm — per ESSA Technical Memorandum ERLTM-ARL7.

Figure 7-1
Existing Test Cell C Layout

8.0 AUTOMATIC DATA PROCESSING

8.1 SCOPE

The purpose of this section is to describe the facility Automatic Data Processing Equipment (ADP) requirements to support the Test Cell "C" operations. Computer software is discussed in this section to the extent necessary to define and clarify hardware requirements. For the purpose of this section, ADP means (1) Digital and Analog Computer components and systems irrespective of type of use, size, capacity or price, (2) All peripheral equipment used in support of Digital and/or Analog Computers, (3) Digital and Analog terminal and conversion equipment that is acquired solely or primarily for use with a system which employs a computer. The primary requirement for ADP for TC "C" are the acquisition, recording, storage, display, retrieval and analysis of measured and calculated test parameters for real time and post test assessment of performance. ADP may be employed to support facility qualification, NSS and non-nuclear hardware qualification and the related planning, testing and analytical activities.

8.2 GUIDELINES

That portion of the ADP which will be performing real-time functions shall be located at Test Cell "C" control point and shall consist of existing hardware with the addition of equipment as necessary to meet the expanding functional requirements through the course of the testing program.

Those ADP functions which do not necessitate real-time or interactive operation shall be performed on ADP located remotely from the Test Cell "C" control point and shall initially utilize existing hardware.

The local ADP system shall interface with the Instrumentation and Control System of TC "C" in such a manner that selected facility and test system data channels can be accepted, processed, and displayed in real-time. The ADP system and the I&C system shall be buffered to prevent a failure in one system from affecting the operation of the other system.

Provision for a one-way data link shall be made to accommodate a visitor display system at the A&E building. The ADP system shall also support the test diagnostic center (test monitor room) at the Test Cell "C" control point.

The real-time or interactive data analysis and display functions require approximately 1000 channels of information updated at a minimum sample rate of one per second. Provision shall be made for storing all of said data for subsequent recall for a run duration of approximately one hour.

The basic requirements for ADP support for E/STS-2, ETS-1, and TC "C" are similar. Every consideration should be given to standardizing the accomplishments of the ADP requirements. The objective of this standardization shall be (1) the provision of back-up capability and the utilization of some software capability developed for one facility by another facility, (2) to stimulate communication between ADP personnel of different facilities, and (3) to provide flexibility for conveniently shifting ADP personnel from one facility to another during peak workload.

8.3 REQUIREMENTS

8.3.1 Real-Time Engineering Analysis

The real-time computation of test parameters not amenable to direct measurement, shall be accomplished by conversions of input signals to engineering units. This information shall be used for test limits monitoring, and facility and test article status monitoring purposes.

8.3.2 Post Test Analysis Support

The ADP system shall provide support for the CRT terminals and the displays (as available during cooldown and similar functions) for post test analysis. Concurrently reduction of data from the PAM-FM system shall proceed on remote ADP. The system shall provide within 12 hours those data which are necessary and sufficient for the data analysis team to determine whether (1) the objectives of the last test were met, (2) the test assembly and facility are ready for the next test, and (3) the objectives of the next test are still appropriate.

8.3.3 Data Recording

The local ADP system shall record all of its inputs and calculated parameters. Data compression techniques shall be considered. All data channels shall be recorded in the PAM-FM system which will serve as a back-up for those channels directly input to the ADP system and as the prime recording for the remainder for the purpose of post test data analysis.

8.3.4 Displays

A sufficient number of channels of test assembly and facility measured and calculated parameters shall be provided for display in the control room either on digital displays or analog meters. These display devices shall be updated at a minimum sample rate of one sample per second.

A capability shall exist to display preselected measured or calculated test parameter on CRT computer terminals in graphic and/or alphanumeric format in order to monitor test article and facility performance and to investigate anomalies in real-time. Graphic display shall be in the form of plots versus time or cross plots of one data channel versus another.

Incorporated with the alphanumeric display of data on the CRT shall be a feature to indicate test limits conditions having been exceeded. Typically the value in question will be caused to blink with an annunciator light warning of a limit being exceeded in general.

8.3.5 Channel Engineering

ADP support of equipment remote to TC "C" CP shall be provided to accept, store, and retrieve the channel engineering data for TC"C". The system providing this support shall be capable of expeditiously accommodating changes to the stored data and displaying same.

8.3.6 Data System Calibration and Performance Analysis

The ADP system shall be capable of pre and post run calibration and analysis of the data system with concomitant reporting of anomalies.

8.3.7 Maintenance Record Storage

ADP support on equipment remote to TC"C" CP shall be provided to accept, store, and retrieve corrective and preventative maintenance data for the facility and test system.

9.0 SPECIAL TEST EQUIPMENT

9.1 SCOPE

Special test equipment is defined as equipment required by the facility to check out the facility systems during facility activation testing.

9.2 TEST EQUIPMENT

An FEP Test Device shall be used to check out the facility programmed LH_2 supply profiles and the facility cooldown systems. The test device shall consist of a test article impedance simulator mounted on a test car, and shall be connected to the facility at the fluid interface.

A test assembly flow simulator (TAFS) shall be used to check out Scrubber System (REDS and REPS). The TAFS will consist of a nozzle and connecting piping mounted on a test car and will be mated to both the facility and the REDS. Ambient gaseous nitrogen or hydrogen will be supplied to the nozzle and will discharge into the Scrubber System to determine the flow characteristics of the system.

10.0 TEST CELL "C" FACILITY QUALIFICATION REQUIREMENTS

10.1 SCOPE

This section will define the qualification program required at Test Cell "C".

10.2 GENERAL QUALIFICATION REQUIREMENTS

The qualification program shall consist of an initial qualification phase which will occur prior to DR-1 and a formal qualification phase which will occur during DR-1, DR-2 and PQR-1.

The qualification program for TCC shall be performed in accordance with an approved TCC Activation Test Plan. The test plan shall provide for documentation of all component, subsystem, and system tests and shall be in accordance with the test requirements defined in the applicable design sheets or specifications for the facility complex.

Throughout the qualification program, the TCC complex will be defined by TCC product configuration documentation. This will include detailed drawings, specifications, inspection information, performance characteristics, safety, quality assurance, and reliability analysis for all systems. For all critical facility systems as identified by the reliability program (Section 5.3), the product configuration documentation (PCD) shall be completed prior to DR-1 test. The entire PCD shall be completed prior to QR-1 tests.

10.3 PHASE I QUALIFICATION REQUIREMENTS

The Phase I Qualification Program shall be completed prior to DR-1 testing and shall consist of those activities required to insure by review, analysis, and test that the TCC complex can safely and reliably support the R series test program.

The Phase I tests shall be performed on the following systems utilizing the special test equipment listed in Section 9.

- a) Test Support Systems
- b) Exhaust Systems
- c) Test Assembly Installation Systems
- d) Automatic Data Processing System
- e) Instrumentation and Controls System
- f) Safety Systems

The systems shall be subjected to normal operations required to support reactor tests and possible emergency operations anticipated during reactor tests.

An integrated series of tests shall also be performed with all facility systems sequentially operated to insure that there is no unexpected interactions. The integrated tests will also verify that the facility can support the planned frequency of R testing.

10.4 PHASE II QUALIFICATION REQUIREMENTS

The Phase II Qualification Program shall be completed prior to QR-1 and will fully qualify the facility. Phase II shall consist of a review of the safety, operational, and reliability performance during DR-1, DR-2 and PQR-1.

Selected facility tests will also be performed that could not be conducted without the test assembly installed. These tests will be the following:

- a) 360° shield water flow test.
- b) Facility/test assembly electrical interactions.
- c) Loss of facility electrical power test.

CORRESPONDENCE DISTRIBUTION 14 of 33

Assignor: BALDIDate: 12/21/70

17 of 3

	YES	NO
ACTION	☒	☐
OUTGOING REPLY	☐	☒

Responsibilities: STAKER / COLLINSAction Required: REVIEW AND PREPARE COMMENT TO WAWL - IF REQUIRED

Due Dates: _____

	LTR	ENCL		LTR	ENCL		LTR	ENCL
Wetmore, W. O.			Odgers, I. L.	☒	☒	Paul, J. T.	☒	
Ward, E. D.	☒		Campbell, W. E.	☒	☒	Dooling, J. L.	☒	
Ryland, G. L.			Shurley, L. A.			Collins, S. F.	☒	☒
Leeper, C. K.	☒	☒	Johnson, L. D.			Basque, F. R.		
Wayne, W. D.	☒		Edlebeck, N. A.	☒	☒	Johannsen, G. D.	☒	☒
Evleth, R. V.								
			Ramsthaller, J. H.			4300	☒	☒
Glasscock, R. B.	☒		Bryan, W. M.			Demuth, O. J.		
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Bodley, J. M.			Norman, N. A.	☒				
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