H. SUPPORT REQUIREMENTS

1. Facilities and Services

a. Power

Power will be required to operate the system valves, charging equipment and the instrumentation.

b. Air-conditioning and Ventilation

The normal air-conditioning and ventilation for "Ready Status" will be required.

c. Lighting

Lighting will be necessary in the propellant terminal.

d. PLS Cleanliness

Prior to each test, the system covered under "Equipment Requirements" will be inspected to check that it is under proper blanketing and that areas are void of unsafe materials.

Specific cleaning requirements will be called for during or at the completion of a maintenance or repair operation rather than prior to a test. (See Section IX.)

e. First-Aid Service

As personnel will have only limited physical contact with the equipment during these tests, a first-aid station at the site will not be necessary except during charging operations. (See paragraph I for safety considerations.)

f. Communications

Communications will be required between Areas 1, 3, 5, 13, and 15. (See Section VIII.)

g. Visual and Audio Warning System

A visual warning system should be in effect during the tests to protect personnel in the area defined in Figure IX-b.

An audio warning system should be in effect to warn personnel from the hazard area, signal the start of tests, signal significant test conditions and sound "all clear."

h. Sole Facility Use

ADL will not require sole occupancy of the propellant terminal during the test, but will require sole use of the equipment and associated piping being tested. Limited activity in the propellant terminal will be allowed during each of the 72-hour test periods.

2. Supply Requirements

The following quantities of liquid oxygen and liquid nitrogen will be required to conduct the tests:

Test No.	Liquid Used	Receptacle	Initial fill	Expected Usage
SC. 1. 1	Oxygen	T-201	25, 000 gal	500 gal
SC. 1. 2	Nitrogen	T-401	1, 300 gal	150 gal
SC. 1. 3	Nitrogen	T-402	980 gal	120 gal

3. Associated Contractor Support

The ADL associated contractor support requirement for this test series will be for test instrumentation coverage, and the initial filling of storage tanks with LO_2 and LN_2.

I. SAFETY REQUIREMENTS

1. Hazard Area

The hazard area for these tests will include the oxygen side of the propellant terminal, the [illegible]

terminal, the vent-and-fill shafts and the surface area within ten feet of the shaft openings. (See Figure IX-b.) Personnel can occupy the hazard area during the tests provided the safety practices for this test are observed.

2. Warnings

The area immediately near the heads (front) of the liquid oxygen storage and subcooler tanks and the helium cooler, and the surface area within 10 feet of the shaft openings should be guarded by rope barriers and warning signs during the tests.

3. Safety Practices

Personnel occupying test and adjacent areas should:

a. Wear hard hats, clean cotton clothing, neoprene gloves, and nonsparking shoes.

b. Observe precautions to avoid contact with liquid oxygen or nitrogen; wear asbestos gloves, face shield, and rubber aprons if necessary.

c. Maintain the hazard area clear of loose tools, materials, and debris.

d. Use only nonsparking tools and grounded portable equipment, and introduce only clean tools and materials into the propellant terminal.

e. Observe the NO SMOKING precaution.

J. CRITERIA

The ability of each storage tank to retain sufficient liquid oxygen or nitrogen after completion of the 10-day "ready status" in order to load, hold, unload, and reload a missile will be considered the criteria of success.

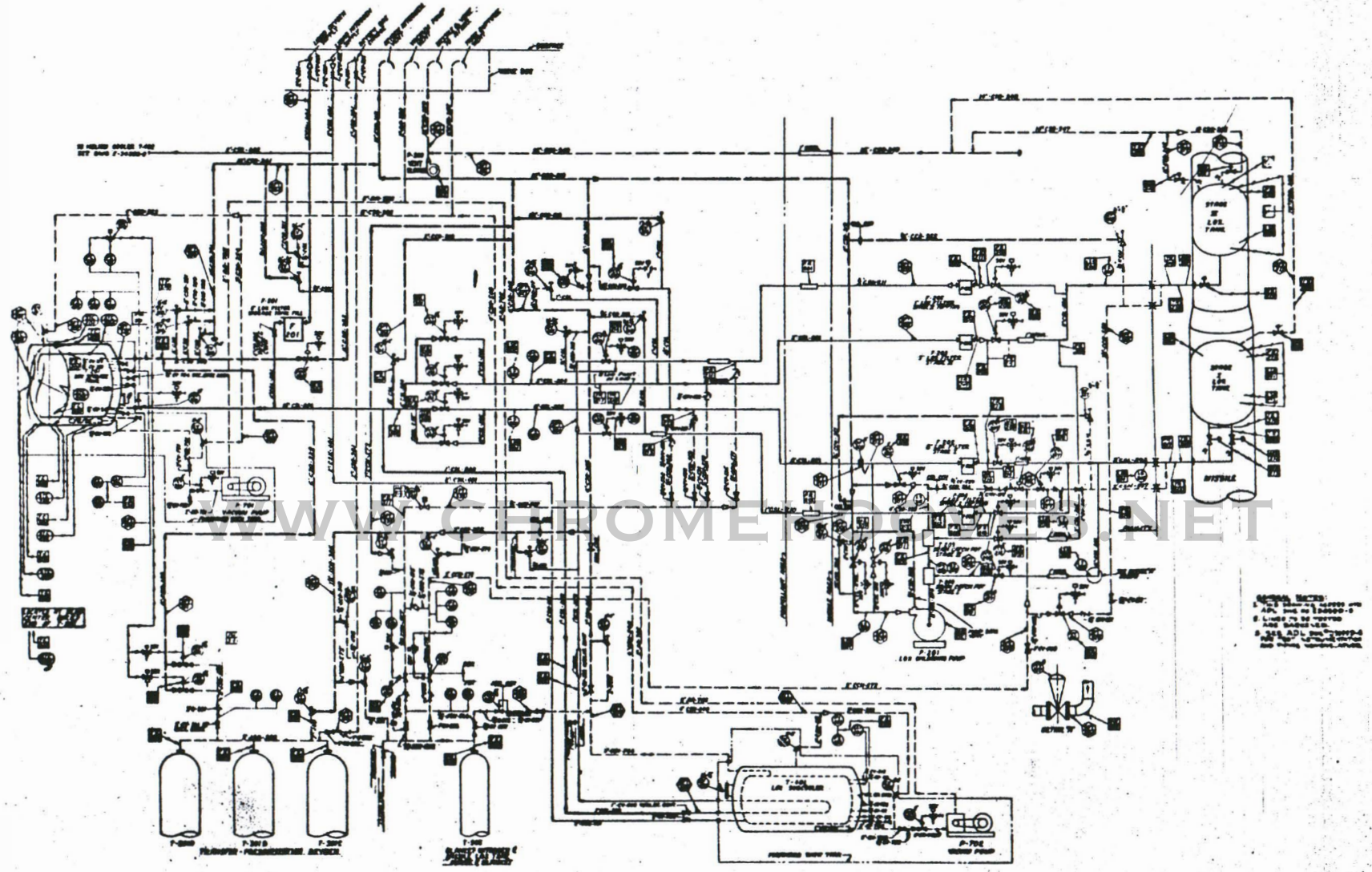


Figure SCI.1

(SK-5-29-59-LM-2)

STORAGE CAPABILITY TEST LO_2 STORAGE TANK

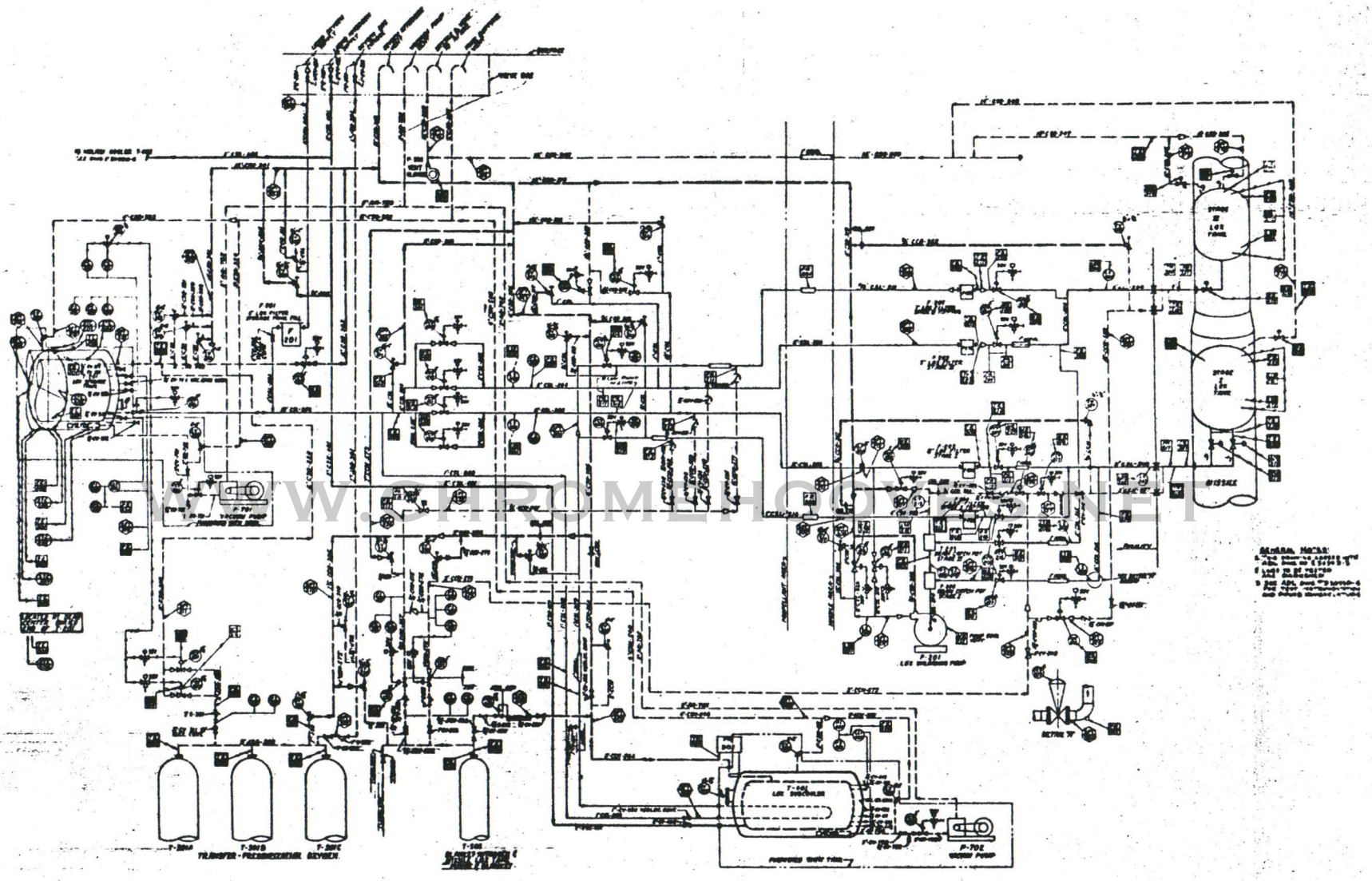


Figure SCI.2

(SK-5-29-59-LM-2)

STORAGE CAPABILITY TEST LO_2 SUBCOOLER

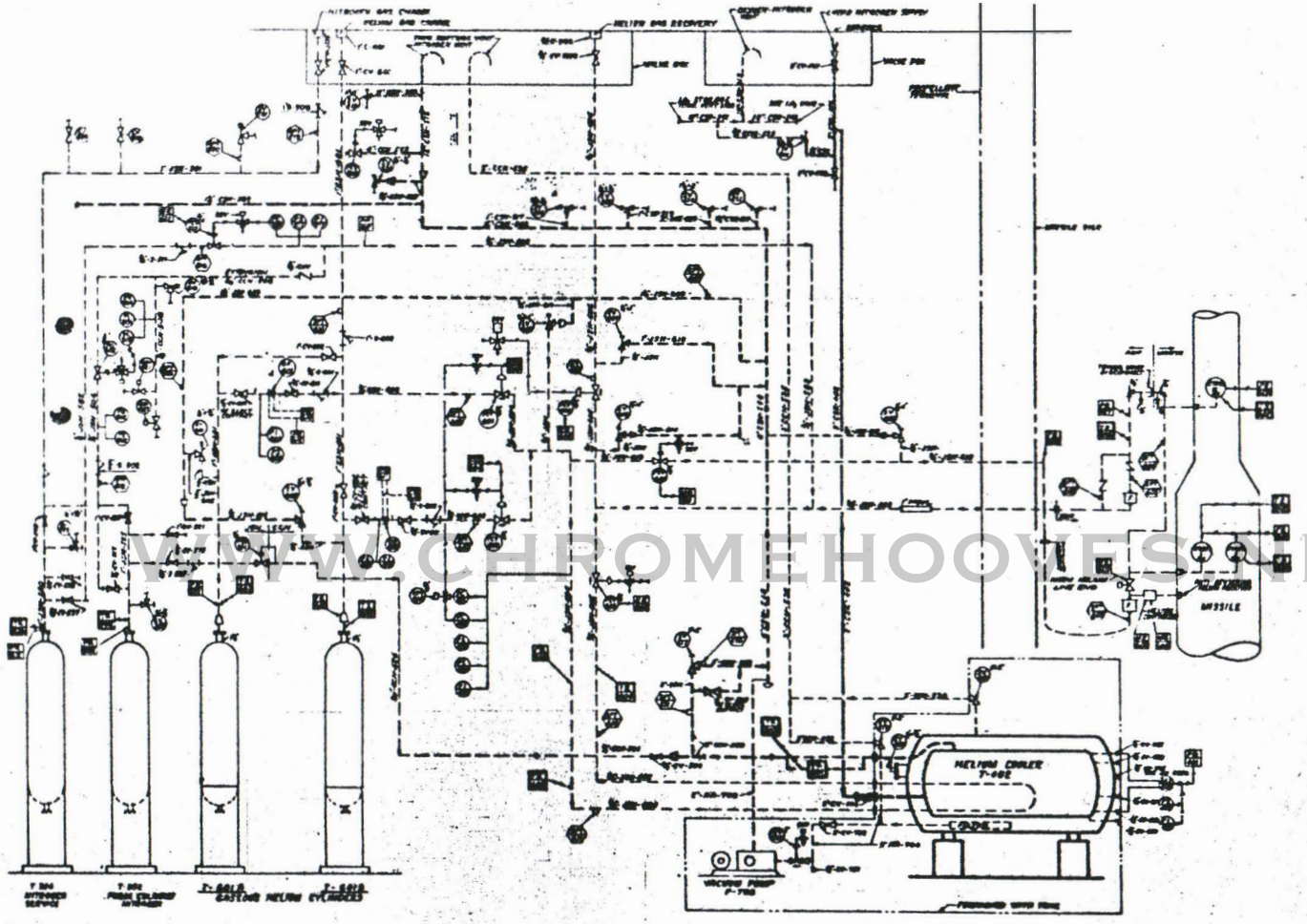


Figure SCI.3

(SK-5-29-59-LM-3)

STORAGE CAPABILITY TEST HELIUM COOLER

SC. 2: STORAGE CAPABILITY TEST - NITROGEN GAS MISSILE SERVICE

A. PURPOSE

The purpose of this test is to determine the ability of the service nitrogen gas subsystems to supply the PLS, missile, and launcher.

B. TEST OBJECTIVE

1. Primary

a. Demonstrate the capability of the PLS to supply service nitrogen gas to the PLS, missile, and launcher at the required quantities and pressures during a 10-day "ready" status and for all operational requirements.

C. SYSTEM SUMMARY

The system to be tested can be broken down into the following subsystems:

(1) 750-lb pneumatic supply to the missile.
(2) 1600-lb supply to launcher shock mount.

The operation of each test will be carried out manually from the PL and PS Checkout Panel.

The gas storage bottle used in each system will be filled to capacity before each test. Operation of the flow control valves will allow the nitrogen gas to flow from the nitrogen service bottle to the actual load representing the service required. The flow control valves will be operated by means of the appropriate control button on the PL and PS Panel.

Table SC. 2c lists the tanks lines, and valves to be used in each test of this test series.

Figures SC. 2. 1, SC. 2. 2, and SC. 2. 3 show the part of the PLS system to be used in each test.

D. TEST OPERATION

The nitrogen service tests will be operated from the PL and PS panel located in the equipment terminal. Three test runs will be made--two for the 750-lb nitrogen service, and one for the 1600-lb nitrogen service. The runs are listed in Table SC. 2a.

TABLE SC. 2a

TEST RUNS

Test Number	Service Bottle Number	Flow Control Valves	Delivery Pressure (psig)
SC. 2. 1	T-504	FCV-508	750
SC. 2. 2	T-504	FCV-513	750
SC. 2. 3	T-503	FCV	1600

The control valve in each test run will be opened and the nitrogen gas allowed to flow to the actual or a simulated load for approximately one minute. At the end of this interval, the flow control valve will be closed and the system returned to a "ready" status. The quantity of gas in the nitrogen bottles and, hence, the average flow rate will be calculated before and after each run from bottle pressure and temperature. The delivery pressure of the gas will be monitored and recorded during the test run.

A detailed step-by-step procedure for each test run will be covered in Procedural Documents 101-SC. 2. 1, 2. 2, and 2. 3, to be issued as a supplement to this test specification.

E. TEST CONTROL

The test will be controlled from PL and PS Panel in the equipment terminal. Table SC. 2b lists the controls and control instrumentation for this test series.

TABLE SC. 2b

TEST CONTROL AND INSTRUMENTATION REQUIREMENTS

Test Number	Control Unit	Control Instrumentation
SC. 2. 1 & SC. 2. 2	PL and PS Panel FCV-508, FCV-513	PR-513
SC. 2. 3	PL and PS Panel FCV-507	PR-508

TEST DATA AND TEST INSTRUMENTATION REQUIREMENTS

Table SC. 2c lists the data requirements for test series SC. 2 together with test instrumentation used to obtain the data.

TABLE SC. 2c

DATA INSTRUMENTATION AND REQUIREMENTS

Test Objectives (Test Series 2. 1)	Test Data Requirements (all tests)	Test Instrumentation
1a	GN_2 bottle temp. T-503	TR-504
	GN_2 bottle temp. T-504	TR-506
	GN_2 bottle pressure T-503	PR-506
	GN_2 bottle pressure T-504	PR-512
	Service Line pressure 750 lb supply	PR-513
	Elapsed time	MR-507,
	Valve position	MR-521, MR-506

G. EQUIPMENT REQUIREMENTS

The nitrogen service subsystems can be broken down as follows:

(1) The 750-pound service system, including storage bottle and all associated piping.
(2) The 1600-pound service system, including storage bottle and all associated piping.

Figures SC. 2. 1, SC. 2. 2, and SC. 2. 3 show the PLS subsystem involved in each test run.

Table SC. 2d lists all equipment to be used in the test series.

TABLE SC. 2d

EQUIPMENT REQUIREMENTS

Test Number	Tanks	Lines	Valves	Miscellaneous
SC. 2. 1 & SC. 2. 2	T-504	L-501	CV-505	C-501
		L-580	CV-508	S-512
		L-584	CV-530	
		L-548	CV-540	Simulated 750 lb
		L-512	CV-537	service load
		L-581	SV-533	
		L-587	CV-538	
			FCV-508	
			FCV-513	
			SV-535	
			PRV-503	
SC. 2. 3	T-503	L-501	CV-530	C-501
		L-519	CV-540	S-505
		L-548	CV-508	Simulated 1600 lb
		L-512	SV-505	service load
		L-509	CV-519	
		L-511	FCV-507	
			SV-511	

H. SUPPORT REQUIREMENTS

1. Facilities and Service

(a) Power

Power will be required to operate the system valves, charging equipment, and the instrumentation.

(b) Airconditioning and Ventilation

Airconditioning and ventilation will be required in the propellant terminal and the third level of the equipment terminal.

(c) Lighting

Lighting will be necessary in the propellant terminal and the third level of the equipment terminal.

(d) PLS Cleanliness

Prior to each test, the system covered under "Equipment Requirements" will be inspected to insure that it is under proper blanketing and that areas are void of unsafe materials.

Specific cleaning requirements will be called for during or at the completion of a maintenance or repair operation rather than prior to a test. Cleanliness is covered in more detail in Section IX.

(e) First-Aid Service

A first-aid station at the test site should be available during pretest, test, and post-test operations.

(f) Communications

Communications will be required between: Areas 2, 4, 6, 8, 10, 12, 13, and 19.

ADL communication requirements have been covered in more detail in Section VIII.

(g) Visual and Audio Warning System

A visual warning system should be in effect during the test to protect personnel approaching the hazard area.

The audio warning system should be in effect to protect personnel from the hazard area, signal the start of the tests, signal significant test conditions, and sound "all clear".

(h) Sole Facility Use

ADL will require sole occupancy of the propellant terminal and sections of the missile silo during portions of the tests.

2. Supply Requirements

The following quantities of gaseous nitrogen will be required to conduct test runs:

Test No.	Bottle No.	Initial Fill GN_2 (SCF)	Pressure (psi)	Usage GN_2 (SCF)
SC. 2. 1	T-504	35, 000	2400	220
SC. 2. 2	T-504		2400	220
SC. 2. 3	T-503	45, 000	2400	3000

3. Associated Contractor Support

The ADL associate contractor support for this test series will be for: (1) test instrumentation coverage, (b) provision of required test load or simulated load, and (c) filling of storage bottles.

I. SAFETY REQUIREMENTS

1. Hazard Area

The hazard area for these tests, as indicated on Figure IX-b, will include the propellant terminal, missile silo, their entrance tunnels, and the vent-and-fill shafts. These areas will be restricted to use by test and associated contractor support personnel only.

2. Warnings

Nontest personnel shall be warned to leave the hazard area before a test. Safety barriers shall be established at the entrances from the tunnel junctions. Audio warnings shall signal the start and completion of tests and significant conditions during the tests.

3. Safety Practices

Test and associated contractor support personnel are to:

a. Wear hard hats, clean cotton clothing, and neoprene gloves.

b. Wear safety glasses or eye shields if working near charged high-pressure gas lines and equipment.

c. Inspect the hazard area to see that it is clean and clear of personnel, tools, materials, and debris.

d. Unless otherwise directed, stay out of the propellant terminal and missile silo during the tests.

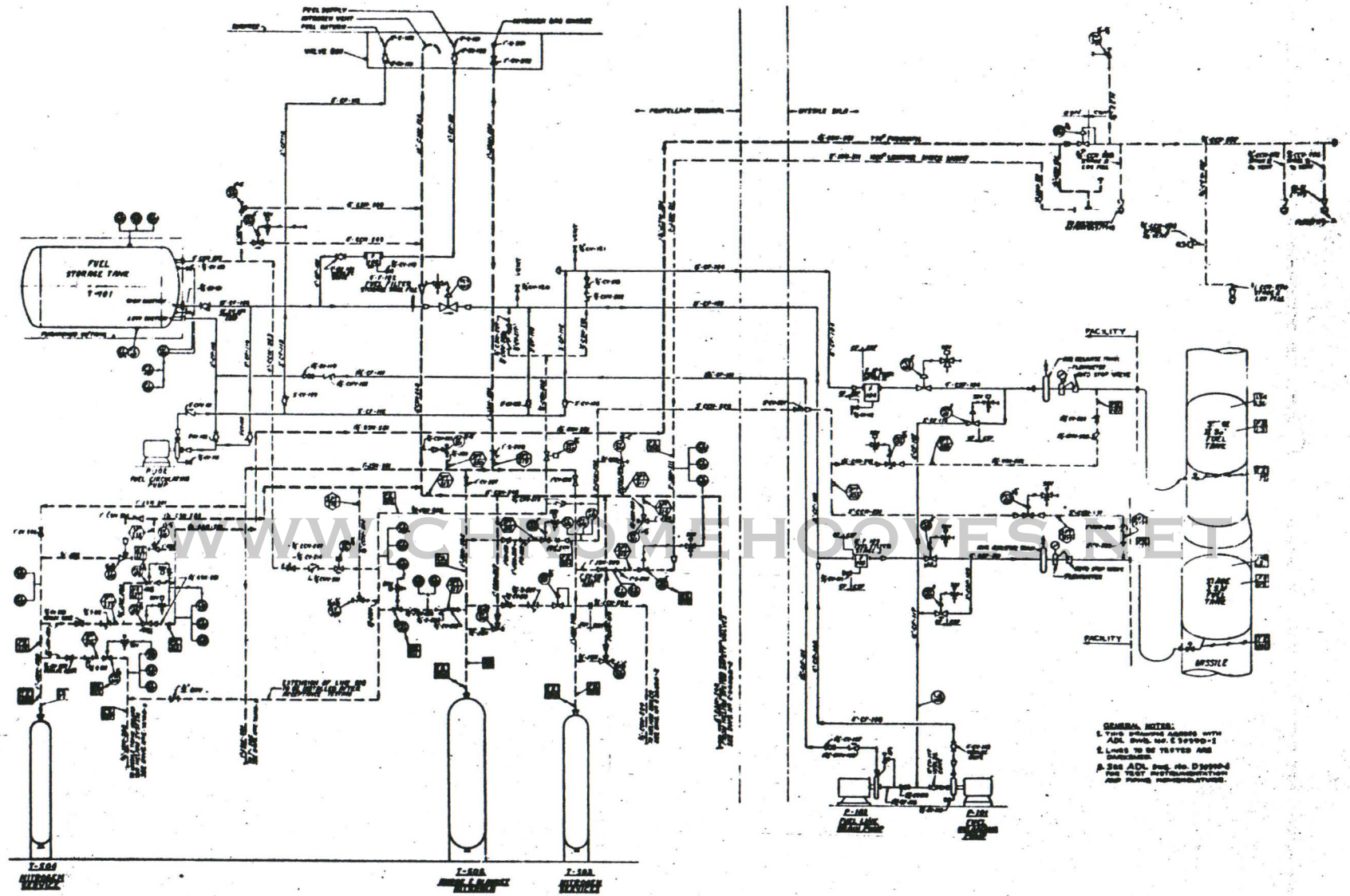
e. Use only nonsparking tools and grounded portable equipment, and introduce only clean tools and materials into the complex.

f. Test the atmosphere with oxygen and nitrogen "sniffers" before entering a space after a test.

g. Observe the NO SMOKING precaution.

J. CRITERIA

The system's demonstrated capability to supply service nitrogen at the required quantities and pressures will be considered the criterion of success.



Figures SC2.1 & SC2.2

(SK-5-29-59-LM-1)

STORAGE CAPABILITY TEST 750-POUND N_2 SERVICE

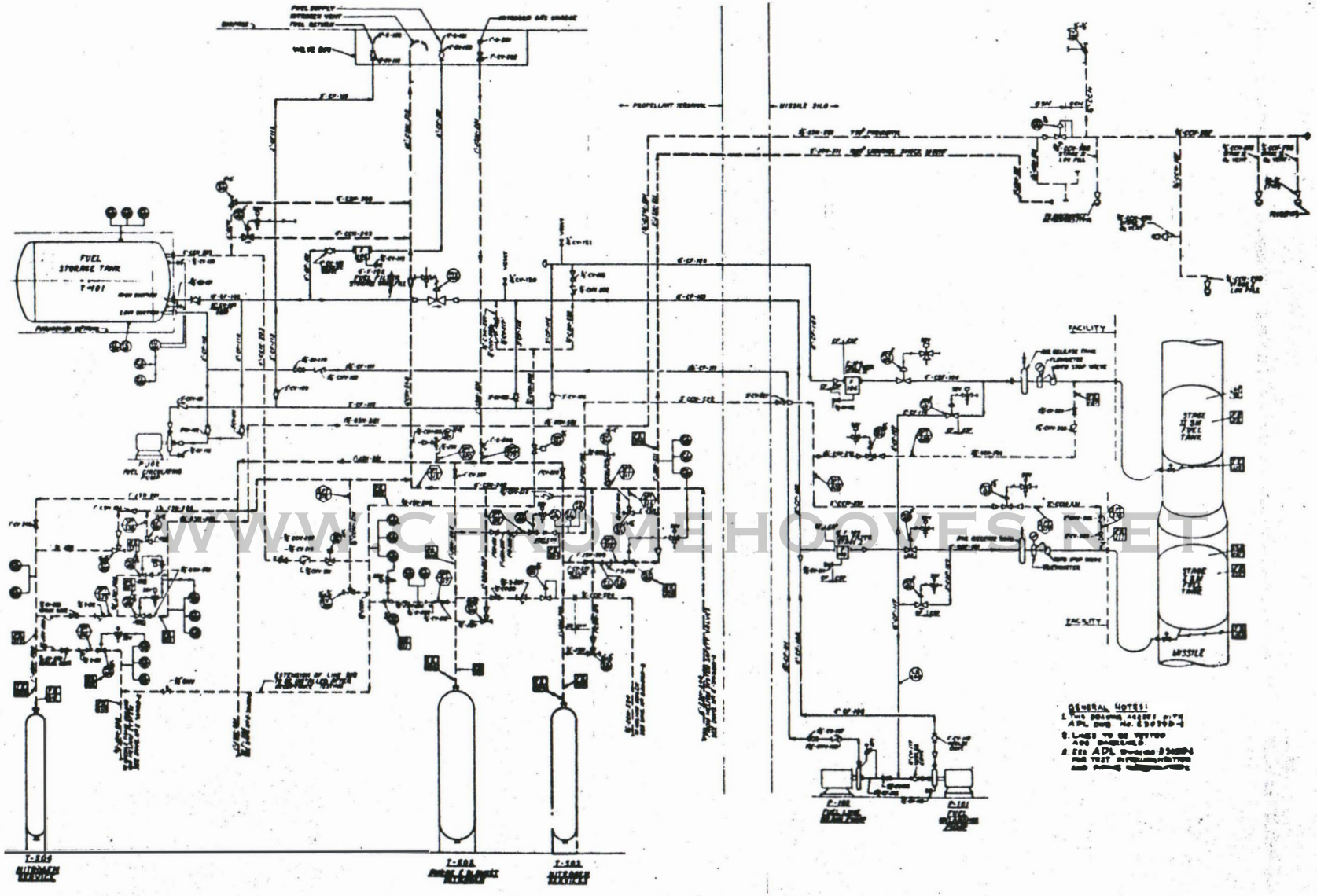


Figure SC2.3

(SK-5-29-59-LM-1)

STORAGE CAPABILITY TEST 1600-POUND N_2 SERVICE

1.2: FUEL TRANSFER TEST

A. PURPOSE

The purpose of this test is to establish that the PLS fuel loading system can successfully load a missile within a reasonable time and that upon a command to unload, the fuel can be returned to the storage tank and the missile to a blanketed condition.

B. TEST OBJECTIVES

1. Primary Objectives

a. Demonstrate that fuel can be delivered to the proper level in both missile tanks, and that the PLS can then simultaneously load liquid oxygen and helium in the required quantities within the countdown time sequence.

b. Demonstrate that the PLS can safely unload the missile of all commodities, that the missile can be purged and blanketed, and that the entire system can be returned to a "ready" status.

C. SYSTEM SUMMARY

The fuel transfer system can be broken down into the following sections:

1. Fuel storage,
2. Fuel storage fill piping system,
3. Fuel transfer pump and piping system,
4. Fuel missile tanks,
5. Fuel unloading system, including transfer pumps and piping,
6. GN_2 storage and system blanketing, and
7. Missile tanks venting system.

The operation of the system is carried out manually by means of the following control buttons to load fuel on the missile. The following procedure applies to both missile fuel tanks which will be loaded separately.

1. Open and close appropriate valves to set up system for fuel transfer.
2. "Power-ON" button on fuel panel.
3. "Transfer Pump Start" on fuel panel.
4. "Transfer Pump Stop" on fuel panel.
5. Open and close appropriate valves to set up system for line draining.
6. "Line Drain Pump-Start" on fuel panel.
7. "Line Drain Pump Stop" on fuel panel.
8. Close appropriate valves after line drainage.
9. "Power-Off" button on fuel panel.
10. The fuel system is now in a stand by condition.

The operation of the system is carried out manually by means of the following control buttons to unload fuel from the missile. The following procedure applies to both missile fuel tanks which will be unloaded separately.

1. Open and close appropriate valves to set up system for fuel unloading.
2. "Power-On" button on fuel panel.
3. "Unload Pump Start" on fuel panel.
4. "Unload Pump Stop" on fuel panel.
5. Open and close appropriate valves to set up system for missile fuel tank purging and line draining.
6. "Stage I Purge-Start" on fuel panel.
7. "Stage II Purge-Start" on fuel panel.
8. Open appropriate valves at start of purge period.
9. Close appropriate valves at end of purge period.
10. "Stage I Purge-Stop" on fuel panel.
11. "Stage II Purge-Stop" on fuel panel.
12. Close appropriate valves before starting line draining.
13. "Line Drain Pump Start" on fuel panel.
14. "Line Drain Pump-Stop" on fuel panel.
15. Close appropriate valves after line draining.
16. "Power-Off" button on fuel panel.
17. The fuel system is now in a stand-by condition.

D. TEST OPERATION

The two tests that have been planned for the fuel transfer tests have been listed in Table 1. 2a.

The first test will be a load and unload of the missile fuel tanks to demonstrate the capability of the system. The second test will duplicate the first test in its entirety, except that the load operation will be followed by a liquid oxygen loading of the missile. The fuel unload will be carried out after the liquid oxygen has been unloaded and the oxygen system drained and blanketed.

TABLE 1. 2a

PLANNED FUEL TRANSFER TESTS

Test No.	Test Observation	Comments
1. 2. 1	Unlimited	
1. 2. 2	Limited	Test performed in conjunction with a LO_2 and He transfer test

The fuel transfer tests will be operated from the fuel control panel located in the equipment terminal. However, during the liquid oxygen loading portion of the combined tests, the equipment terminal will not be manned, and the fuel control panel will not be in use.

Enumerated, detailed, step-by-step procedure for each test will be covered in Procedural Documents 101 - 1. 2. 1 and 1. 2. 2, to be issued separately as a supplement to this report.

See Section V for more details on the Fuel Control Panel.

E. TEST CONTROL

The fuel transfer tests will be controlled from the Fuel Control Panel located in the equipment terminal. The panel will contain the "Real Time" indicating instruments required. One of the transfer tests

requires the loading of fuel in conjunection with liquid oxygen and helium to comprise a PLS test. The fuel will, however, be loaded prior to count-down operation. The LO_2 and H_e transfer will be controlled as set down in the LO_2 transfer tests.

TABLE 1.2b

CONTROL EQUIPMENT

Test No.	Control Unit
1.2.1	Fuel Control Panel
1.2.2	PL & PS Panel

F. TEST DATA AND TEST INSTRUMENTATION REQUIREMENTS

Table 1.2c lists the data requirements for test series 1.2, together with test instrumentation used to obtain the data.

TABLE 1.2c

TEST DATA AND INSTRUMENTATION REQUIREMENTS

Test Objective (Test Series 1.2)	Test Data Requirements (All Tests)	Test Instrumentation
PLS-1	Fuel Flow	System flowmeters
	Liquid level missile tanks	System flowmeters
	Delivery temp. of fuel to missile	TR-101, TR-102
	Delivery press. of fuel missile	PR-107, PR-111
	Missile tank flood level	LSR-151, LSR-152
	Missile tank pressure	PI-151, PI-152
	Elapsed time	
PLS-2	GN_2 bottle pressure	PR-505
	GN_2 bottle temperature	TR-505
	Line pressure, missile purge	PR-504
	Blanket line pressure	PR-502
	Elapsed time	

G. EQUIPMENT REQUIREMENTS

The fuel transfer system has been broken down and the subsystems have been tabulated under "System Summary."

The fuel system is shown in Figure B-1 of Appendix B.

A complete list of equipment to be used in the test series is given in Table 1.2d.

H. SUPPORT REQUIREMENTS

1. Facilities and Service

a. Power

Electrical power will be required to operate the following equipment:

(1) Pumps, system controls and instrumentation, and test instrumentation;
(2) Air conditioning and ventilation.

b. Air Conditioning and Ventilation

This service will be required for the following areas:

(1) Propellant Terminal (PT);
(2) Missile Silo (MS);
(3) Tunnel between PT and MS;
(4) Third level of Equipment Terminal; and
(5) Command Control Center.

c. Lighting

The following areas will require lighting:

(1) Propellant Terminal (PT);
(2) Missile Silo (MS);
(3) Tunnel between PT and MS;
(4) Third level of the Equipment Terminal; and
(5) Command Control Center.

TABLE 1.2d

EQUIPMENT REQUIREMENTS

Test No.	Tanks	Lines	Valves	Misc.
	T-101	101	CV-108	C-101
	T-502	102	CV-103	F-102
		103	CV-101	F-103
		108	FCV-103	P-101
		109	FCV-107	P-102
		117	CV-118	F-104
		112	FCV-109	S-503
		115	FCV-111	S-502
		114	CV-102	P-103
		104	CHV-101	
		110	CV-104	
		107	CV-105	
		516	CV-106	
		577	FCV-105	
		579	FCV-503	
		512	SV-506	
		505	CV-521	
		517	FCV-506	
		548	SV-514	
		522	CV-527	
		529	FCV-514	
		532	CHV-505	
		531	CV-524	
		504	FCV-515	
		508	CHV-506	
		514	CV-523	
		503	CV-513	
		520	FCV-505	
		543	SV-510	
		111	CHV-510	
		116	SOV-552	

CHV-502 CHV-503
CV-516 CV-517
SOV-551 CHV-501
CV-514 FCV-502
SV-512 CV-117
CV-114 CHV-102
CV-107 CHV-105
CV-119

d. PLS Cleanliness

Prior to each test run, the system under "Equipment Requirements" will be inspected to insure that it is under proper blanketing and that the areas are void of unsafe materials.

Specific cleaning requirements will be called for during or at completion of a maintenance and repair operation rather than prior to a test. (See Section IX.)

e. First-Aid Service

A first-aid station at the test site should be set up and manned during pretest, test, and post-test operations.

f. Communications

Communications will be required between: Areas 2, 4, 6, 8, 10, 12, 13, and 19. ADL communication requirements have been covered in more detail in Section VIII.

g. Visual and Audio Warning System

A visual warning system should be in effect during the test to protect personnel approaching the hazard area. An audio warning system should be in effect to: (1) warn personnel to keep away from the hazard area, (2) signal the start of tests and significant test conditions, and (3) sound "all clear."

During test 1.2.1, the propellant terminal, missile silo, and adjacent surface area will be restricted to all but authorized personnel participating in the test.

During the LO_2 transfer and warn up prior to fuel unloading in test 1.2.2, the complete launcher area will be closed to all personnel for a period of four hours.

h. Sole Facility Use

ADL and other personnel associated with each test run will require sole occupancy of the following areas:

Location	Test 1.2.1 (Duration of Occupancy)	Test 1.2.2 (Duration of Occupancy)
Propellant Terminal	8 hours	12 hours
Missile Silo	8 hours	12 hours
Equipment Term. (Limited Area)	8 hours	8 hours
Control Center (Limited Area)	8 hours	8 hours

2. Supply Requirements

The following quantities of liquids and gases will be required for test series 1.2:

Propellant or Gas	Usage	Unit	Ref. Test No. Specifying this Requirement	Receptacle	Delivery Pressure
Fuel	12,000	Gal.	1.2.1	T-101	Atm.
GN_2	3,000	SCF	1.2.1	T-502	2400 psig

3. Associated Contractor Support

The following support will be required from associate contractors:

a. Test Instrumentation: calibration, pretest checkout, test operation, post-test processing, and basic data reduction; The Martin Company.

b. PLS maintenance, facility cleaning, labor and shop repair, field repair, and replacement of defective equipment plus other labor and craft support, such as electrical and pneumatic; The Martin Company.

c. Handling missile silo equipment; The American Machine and Foundry Company.

d. Quality Control, liquid and gas analysis; VAFB on request.

I. SAFETY REQUIREMENTS

1. Hazard Area

The hazard area for test 1.2.1 includes the propellant terminal, missile silo, their entrance tunnels, and the surface area within 150 feet of the missile silo opening. (See Figure IX-b.) The hazard area for test 1.2.2 is the complete launcher complex. (See Figure IX-c.) This area will be closed to all personnel for a period of four hours. These areas are restricted to test and associated contractor support personnel.

2. Warnings

Nontest personnel should be warned to leave the hazard area before a test. Safety barriers shall be established at the entrance from tunnel junctions. Audio warnings shall signal the start and completion of tests and significant conditions during the tests.

3. Safety Practices

Test and associated contractor support personnel are to:

a. Wear hard hats, clean cotton clothing, and neoprene gloves.

b. Wear safety glasses or eye shields if working near charged high-pressure gas lines and equipment.

c. Inspect the hazard area to see that it is clean and clear of personnel, tools, materials, and debris.

d. Unless otherwise directed, stay out of the propellant terminal and missile silo during the tests.

e. Use only nonsparking tools and grounded portable equipment and introduce only clean tools and materials into the complex.

f. Test the atmosphere with oxygen and nitrogen "sniffers" prior to entering a space after a test.

g. Observe the NO SMOKING precaution.

J. CRITERIA

The ability of the PLS to supply sufficient fuel to load the missile and later unload it will be considered the criteria of success

2.1: LIQUID OXYGEN COOLDOWN TESTS

A. PURPOSE

The purpose of these tests is to establish that: (a) the liquid oxygen piping system can be pressurized, and (b) the Stage I and II main transfer and topping lines can be cooled down within the allotted countdown times* and (c) the system can be safely returned to an unloaded condition. The tests will be conducted from the PLS Test Control Panel.

B. TEST OBJECTIVES

These specific test objectives are based on basic system test objectives contained in STL document GM-TR-0165-00323B, revised 30 October 1958, and applicable to Test Plan I - 5.

1. Primary Objectives

a. Demonstrate that the liquid oxygen system can be pressurized and that Stage I and II main transfer lines can be safely cooled down within the allotted countdown time.

b. Demonstrate the ability of the missile vent system to handle effluent gaseous oxygen at missile ullage pressures acceptable to an operational missile.

c. Demonstrate the ability of the system pipe lines to accommodate thermal contraction on cooldown.

d. Demonstrate that the system can be safely returned to an unloaded condition.

2. Secondary Objectives

a. Determine the minimum time required to cool down the Stage I and II main liquid oxygen transfer lines.

b. Determine the degree of cooldown of the Stage I and II liquid oxygen topping system obtained during the cooldown of the main transfer system.

---

*See System Specification for specific countdown time information. (ADL Special Report No. 86)

c. Determine the consumption of liquid oxygen, liquid nitrogen, gaseous oxygen, and gaseous nitrogen to cool down the liquid oxygen system.

d. Demonstrate that the liquid oxygen piping design does not permit liquid "slugging surges" in the missile tanks during cooldown.

C. SYSTEM SUMMARY

The liquid oxygen system can be broken down into the following subsystem areas:

(1) LO_2 storage,

(2) GO_2 storage and LO_2 pressurization,

(3) LO_2 transfer piping and equipment,

(4) LO_2 missile tanks,

(5) LO_2 missile unloading piping, pump and other equipment,

(6) LO_2 missile topping system with LN_2 subcooler,

(7) GN_2 storage and LO_2 system blanketing, and

(8) LO_2 system and missile tanks venting.

The operation of the system will be controlled from the PLS Test Control Panel in the Control Center. Prior to the test, the "Extend Cool-down" and "LO_2 Only" switches will have to be activated on the Test Selector Panel in the Equipment Terminal in order to prevent the system from going into rapid LO_2 load and Helium load. The following buttons are used on the PLS Test Control Panel to automatically carry out the LO_2 Cooldown Test:

(1) Load,
(2) Shutdown, and
(3) Unload LO_2.

The control buttons, when depressed, will energize the sequencer circuitry. The details of the sequence of operations that follow such action are discussed in "ADL System Specification" (ADL Special Report No. 86). A summary of these operations as they apply to the cooldown tests is given below.

With the liquid oxygen system in a ready condition and the helium and other nonpertinent nitrogen services removed from the sequencer logic, the depression of the "load" button will start the following sequence:

(1) The gaseous oxygen pressurization system will bring the liquid oxygen storage tank pressure up to the predetermined "line cooldown" pressure level.

(2) Liquid oxygen will be forced into the main and topping transfer piping by way of rapid and topping flow control valves. Line cooldown will take place. Oxygen will boil off and be vented through the missile vent system.

(3) When all line liquid sensors indicate the completion of cooldown, by signalling the presence of liquid, their signal would normally actuate the liquid oxygen storage tank pressurization control which would automatically raise the pressure level and put the system into rapid LO_2 transfer. By having actuated the "extend cooldown" switch on the Test Selector Panel prior to the start of the test, the level sensor signal will be intercepted and the system will be prevented from entering the rapid flow mode. No system change will then occur until the "shutdown" button is depressed, or until the "extend cooldown" signal is withdrawn. This latter step could be performed from the Test Control Panel, if desired, by depressing the "restore sequence LO_2" button.

(4) The depression of the "shutdown" button will close line-end valves, depressurize the storage tank, and vent the tank and piping.

(5) The "unload LO_2" button will be depressed in order to unload the missile tanks. The liquid oxygen will then be gravity-drained to the LO_2 unloading pump. Residual liquid in the piping will boil off. The missile tanks will be purged and blanketed automatically.

D. TEST OPERATION

The liquid oxygen cooldown tests will be carried out by permitting the system to perform within its operational sequence. The sequence has been briefly described in paragraph C above.

The four test runs planned for this test series have been listed in Table 2.1a, together with pertinent test variables. The initial three tests (2.1.1, 2.1.2, and 2.1.3) will use liquid and gaseous nitrogen in place of liquid and gaseous oxygen. Primarily, this provides a safer operation and permits personnel access to the propellant terminal and missile silo, where the integrity of the equipment can be visually verified.

The three nitrogen tests should verify all primary and secondary test objectives except those connected with the topping system. The final test, operated at a condition optimized during the previous tests, should confirm all test objectives using the appropriate operational fluids. Personnel will not have access to the launcher complex during this test.

The verification of the successful cooldown or degree of cooldown of the topping system is a secondary test objective. It becomes a primary test objective for the liquid oxygen transfer test (2.2). The verification or problem isolation of the topping system during the simpler cooldown tests (2.1) will be of benefit to the transfer tests (2.2). Data will be obtained concurrently with the actual and extended main-line cooldown operation. The topping stream will be subjected to subcooling during the LO_2 test (2.1.4), but will not be subcooled during the LN_2 tests (2.1.1, 2.1.2, and 2.1.3).

TABLE 2.1a

TESTS PLANNED

Test No.	Primary Fluids	Test Observation	Topping Sub-cooled	Cooldown Pressure Level	LO_2 & GO_2 Storage Level
2.1.1	$LN_2 + GN_2$	Unlimited	No	DESIGN	HIGH
2.1.2	$LN_2 + GN_2$	Unlimited	No	HIGH	LOW
2.1.3	$LN_2 + GN_2$	Unlimited	No	MAXIMUM	HIGH
2.1.4	$LO_2 + GO_2$	By instrument only	Yes	OPTIMUM	LOW

Test control will be exercised from the Command Control Center. During tests 2.1.1, 2.1.2, and 2.1.3, the Checkout Panel of the PL & PS Pallet* will be under observation.

Prior to each test, the liquid oxygen storage tank ullage cooldown transfer pressure setting will be adjusted to give the desired pressurization.

The countdown sequence will be interrupted at the completion of normal cooldown in order to prevent the transition into rapid flow. Flow at the cooldown rate will be continued for all four tests for an additional 10 minutes; then the system will be shut down by depressing the "shutdown" button on the PLS Test Control Panel.

Cooldown should be completed when all line liquid sensors and the missile tank low-level sensors indicate the presence of liquid. A further check will be made by a post-test comparison of the wall and liquid temperatures in the vicinity of the line-end valves. The extension of the cooldown period will confirm the establishment of stable single-phase flow conditions and indicate the degree of simultaneous topping system cooldown.

The system will be returned to stand-by condition by depressing the "unload" button on the PLS Test Control Panel. Accumulated liquid in the missile will be automatically drained into the liquid oxygen unload piping and the unload pump. The missile tanks will be automatically purged and blanketed, and the liquid oxygen unloading pump will be actuated.

The liquid oxygen transfer system can be reactivated approximately six hours after the last test, when its liquid oxygen content will have boiled off.

Enumerated, detailed, and specific test steps for each test run will be covered in "Detailed Test Procedures," to be issued separately as a supplement to this test specification. The supplement will also include test prerequisities, pretest procedures, and the required status of valves and equipment after a test. The test procedures will be covered in the following procedural documents:

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*See Section V for more details on the PL and PS Panel.

Test Number	Procedural Document Number
2.1.1	101-2.1.1
2.1.2	101-2.1.2
2.1.3	101-2.1.3
2.1.4	101-2.1.4

E. TEST CONTROL

The liquid oxygen cooldown tests will be carried out automatically by means of the PLS Test Control Panel. The panel will be located in the Control Center and contain "real time" indicating instruments required for test control. Additional pen-recorded, trend-indicating data will be available from the Strip Charts (5630), also located in the control center.

The basic system sequence requires the simultaneous operation of the liquid oxygen and helium systems. To operate the LO_2 system separately and to prevent it from going into its rapid transport mode, or to delay this mode, certain sequence operations must be interrupted by means of a "Test Selector Panel," located in the Equipment Terminal.

All controls and instruments required for test control are listed in Table 2.1b. A more detailed description of the PLS Test Control Panel, the Test Selector Panel, the Checkout Panel of the PL & PS Pallet and a complete listing of all real time instrumentation can be found in Section V of this report.

TABLE 2.1b

TEST CONTROL AND INSTRUMENT REQUIREMENTS

Test No.	Control Units	PLS Control Panel Instrumentation	
All tests	PLS Test Control Panel	PI-305	LSI-206
	Strip Charts (5630)	PI-225	LSI-212
	Test Selector Panel	PI-226	LSI-253
	PL and PS Pallet	LSI-201	LSI-254
	Equipment and Facilities Console	LSI-202	LLI-251
		LSI-203	LLI-252
		LSI-204	MI-212
		LSI-205	MI-314

F. TEST DATA AND TEST INSTRUMENTATION REQUIREMENTS

In order to meet the test objectives defined above, specific test data must be collected, analyzed, and interpreted.

Table 2.1c lists the data requirements for test series 2.1, together with test instrumentation used to obtain the data. The material has been tabulated in order of specific test objectives, justifying listed data and instrument requirements. All cooldown test runs will have identical test instrumentation requirements.

Essentially, only "Quick Look"* instrumentation has been specified for data analysis. Specific instrumentation details, such as type of transducer, range, location, and desired accuracy, have been listed in Table IV-d of Section IV. Location of a specific test instrument can also be found in Figure B-3 of Appendix B.

G. EQUIPMENT REQUIREMENTS

The operation of the cooldown tests will essentially require the use of the complete liquid oxygen system. The subsystem areas involved have been tabulated in paragraph C above. Test equipment requirements have been listed in Table 2.1d. A complete listing of all OSTF-PLS equipment requirements, including manufacturer's names and model numbers, will be found in the Arthur D. Little, Inc., Propellant Loading System Specifications.

H. SUPPORT REQUIREMENTS

To carry out the cooldown tests, the following support will be required from sources other than Arthur D. Little, Inc., at the Vandenberg Air Force Base.

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*"Quick Look" instrumentation generates information which is available for analysis within eight hours after completion of test.

TABLE 2.1c

TEST DATA AND INSTRUMENTATION REQUIREMENTS

Test Objective		Test Data Requirements	Test Instrumentation
1a	(1)	GO_2 Ullage Pressure Storage Tank	PR-305
	(2)	GO_2 Storage Tank Temperature	TR-305, 201
	(3)	LO_2 Fill Line Temperatures	TR-202, 217, 218
			TR-203, 204, 209
			TR-208, 214, 213
			TR-207
	(4)	LO_2 Fill Line Pressure	PR-202, 203, 222
			PR-205, 219, 207
			PR-217
	(5)	LO_2 Fill Line Liquid Sensing	LSR-201, 202, 203
			LSR-204, 205, 206, 212
	(6)	Missile Tank Pressure	PR-225, 226
	(7)	Missile Tank Inlet Temperature	TR-220, 210, 219
	(8)	Missile Tank Low Level Liq. Sensing	LSR- 253, 254
	(9)	GO_2 Storage Bottle Pressure	PR-301
	(10)	GO_2 Storage Bottle Temperature	TR-301, 302, 303
	(11)	Elapsed Time	TMR/1908
	(12)	Valve Position	MRT-304, 305
			MR-205, 209, 303
			MR-202, 203, 201
			MR-204
1b	(13)	Missile Tank Pressure	PR-225, 226
	(14)	Missile Vent Gas Temperature	TR-306, 304
	(15)	Missile Tank Level Sensing	LLR-251, 252
	(16)	Elapsed Time	
	(17)	Valve Position	MR-311, 312, 310
			MR-314
	(18)	Vent Blower On-Off Information	MR-313

TABLE 2. 1c (Continued)

Test Objectives		Test Data Requirements	Test Instrumentation
1c	(19)	Visual Observation	None
1d	(20)	LO_2 Unload Piping Liquid Sensing	LSR-207, 206, 205
	(21)	Missile Tank Pressure	PR-225, 226
	(22)	Storage Tank Pressure	PR-305
	(23)	LO_2 Piping Pressure	PR-221, 223
	(24)	LO_2 Piping Temperature	TR-214
	(25)	Blanket Gas (GN_2) pressure	PR-510, 511, 507
	(26)	Pump On-Off Information	MR-212
	(27)	Valve Position	MR-505, 518, 519 MR-516, 522, 309 MR-302, 207, 301 MR-503
	(28)	Vent Gas Temperatures	TR-305, 304, 306
2a	(29)	See Objectives 1a (Items 1 thru 12)	
2b	(30)	LO_2 Topping Line Temperatures	TR-216, 215, 205 TR-206, 211, 212
	(31)	LO_2 Topping Line Pressures	PR-211, 213, 209 PR-216
	(32)	LO_2 Topping Line Flow	FR-201, 202
	(33)	Valve Position	MR-202, 203, 206
2c	(34)	LO_2 Storage Tank Level	PR-224 LLI-201
	(35)	GO_2 Storage Bottle Temperature	TR-301, 302, 303
	(36)	GO_2 Storage Bottle Pressure	PR-301
	(37)	GN_2 Storage Bottle Temperature	TR-503
	(38)	GN_2 Storage Bottle Pressure	PR-510
	(39)	LO_2 Subcooler LN_2 Level	PR-220 LLI-401

TABLE 2.1c (Continued)

Test Objective		Test Data Requirements	Test Instrumentation
2d	(41)	Missile Tank Pressures	PR-225, 226
	(42)	LO_2 Main Line Pressure	PR-221, 217, 207
	(43)	LO_2 Topping Line Pressure	PR-216, 209
	(44)	LO_2 Main Line Liquiding Sensing	LSR-203, 204

TABLE 2.1d

EQUIPMENT REQUIREMENTS

Test No.	Tanks	Equipment Lines	Valves	Misc.
All	T-201	201	CV-201	C-201
	T-202	202	CV-205	F-201
	T-2C3	203	CV-206	F-202
	T-301A	204	CV-207	F-203
	T-301B	205	CV-301	F-204
	T-301C	206	CV-302	F-205
	T-401	208	CV-311	P-201
	T-505	209	CV-312	Stage I LO_2 Tank
		210	CV-313	Stage II LO_2 Tank
		211	CV-314	C-301
		212	CV-315	P-303
		213	CV-350	S-301
		214	CV-401	S-303
		215	CV-402	C-401
		216	CV-410	S-509
		217	CV-411	S-510
		301	CV-412	S-513
		302	CV-413	P-701
		303	CV-501	P-702
		306	CV-502	
		308	CV-511	
		309	CV-512	
		310	CV-528	
		311	CV-529	
		313	CV-530	
		316	CV-531	
		317	CV-532	
		318	CV-533	
		319	CV-534	
		320	CV-535	
		321	CV-536	
		326	CV-539	
		328	CV-701	
		333	CV-702	
		338	CV-704	
		340	CV-706	
		341	CV-750	
		344	CV-752	
		345	CHV-507	
		356	CHV-508	

TABLE 2. 1d (Continued)

Test No.	Tanks	Equipment Lines	Valves	Misc.
		347	CHV-512	
		348	CHV-513	
		349	CHV-518	
		350	CHV-520	
		351	CHV-521	
		352	CHV-522	
		353	CHV-523	
		354	FCV-201	
		355	FCV-202	
		401	FCV-203	
		402	FCV-204	
		501	FCV-205	
		528	FCV-206	
		540	FCV-207	
		541	FCV-208	
		550	FCV-209	
		551	FCV-211	
		553	FCV-212	
		556	FCV-215	
		557	FCV-217	
		558	FCV-218	
		563	FCV-301	
		564	FCV-302	
		566	FCV-303	
		567	FCV-304	
		568	FCV-305	
		569	FCV-306	
		570	FCV-307	
		571	FCV-510	
		572	FCV-511	
		573	FCV-516	
		574	FCV-517	
		575	FCV-701	
		576	FCV-702	
		701	PRV-502	
		702	SV-301	
		703	SV-303	
		705	SV-305	
			SV-306	
			SV-307	
			SV-308	

TABLE 2.1d (Continued)

Test No.	Tanks	Equipment Lines	Valves	Misc.
			SV-310	
			SV-311	
			SV-312	
			SV-313	
			SV-314	
			SV-315	
			SV-317	
			SV-318	
			SV-319	
			SV-320	
			SV-337	
			SV-338	
			SV-501	
			SV-502	
			SV-503	
			SV-504	
			SV-523	
			SV-530	
			SV-531	
			SV-532	

1. Facilities and Services

a. Power

Electrical power will be required to operate the following equipment:

(1) LO_2 pump, system controls and instrumentation, test instrumentation.

(2) Air conditioning and ventilation.

b. Air Conditioning and Ventilation

This service will be required for the following areas:

(1) Propellant Terminal (PT),

(2) Missile Silo (MS),

(3) Tunnel between PT and MS,

(4) 3rd level of the Equipment Terminal, and

(5) Command Control Center.

c. Lighting

The following areas will require lighting:

(1) Propellant Terminal (PT),

(2) Missile Silo (MS),

(3) Tunnel between PT and MS,

(4) 3rd level of the Equipment Terminal, and

(5) Command Control Center.

d. PLS Cleanliness

Prior to each test run, inspect the system (covered under "EQUIPMENT REQUIREMENTS") to check that it is under proper blanketing and that the areas are void of unsafe materials. Specific cleaning requirements will be called for during or at the completion of a maintenance and repair operation rather than prior to a test. (See Section IX.)

e. First-Aid Services

A first-aid station at the test site should be set up and manned during pretest, test, and post-test warmup operations.

f. Communications

Communications will be required between: Areas 1, 3, 5, 7, 9, 11, 13, 15, and 18. (ADL communication requirements have been covered in more detail in Section VIII of this report.)

g. Visual and Audio Warning System

A visual warning system should be in effect during the test to protect personnel approaching the hazard area (defined in Figure IX-b).

An audio warning system should be in effect to warn personnel from the hazard area, signal the start of tests, signal significant test conditions, and sound "all clear."

During test runs 2.1.1, 2.1.2, and 2.1.3, the propellant terminal, missile silo, and adjacent surface areas will be restricted to all except authorized personnel participating in the test. The duration of this "WARNING LEVEL" will be approximately eight hours per test.

During test run 2.1.4, the propellant terminal, adjacent surface areas, and missile silo will be restricted for four hours to all but authorized personnel participating in the test. The complete launcher area will be closed to all personnel for a period of four additional hours.

The warning will be expected to signal the above requirements.

3. Associated Contractor Support

The following support is assumed to be available from associate contractors at Vandenberg Air Force Base.

a. Test Instrumentation: calibration, pretest checkout, test operation, post-test processing, and basic data reduction; The Martin Company.

b. PLS Maintenance: facility cleaning, labor, shop repair, field repair, and replacement of defective equipment plus other labor and craft support, such as electrical and pneumatic; The Martin Company.

c. Handling of Umbilical Disconnects and Other Missile Silo Equipment, Such as Silo Closure Doors; The American Machine & Foundry Company and The Martin Company.

d. Quality Control, Liquid and Gas Analysis; VAFB, on request.

1. SAFETY REQUIREMENTS

1. Hazard Area

The hazard area for tests 2.1.1, 2.1.2, and 2.1.3 (indicated on Figure IX-b) includes the missile silo, propellant terminal, certain tunnels, the vent-and-fill shafts, and the surface area within 150 feet of the oxygen vent-and-fill shaft opening. Use of these areas is restricted to test and associated contractor personnel. During test 2.1.1, when the system will contain gaseous and liquid oxygen, the entire complex shall be restricted to all personnel for a period of four hours. The hazard area for test 2.1.4 is shown in Figure IX-c.

2. Warnings

Nontest personnel shall be warned to leave the hazard area before a test. Safety barriers shall be established at the entrance to the tunnel junctions or the control center and around the shaft opening. Audio warnings are to signal the start and completion of tests and significant conditions during the tests.