SECTION II

PROCEDURES FOR

GROUP I, TEST PLAN 5

PURPOSE OF TEST PROGRAM

The underlying objective of the test program is to prove the functional soundness of the system by actual operation.

Instead of beginning with a test of the complete propellant loading system, we plan first to subject subsystems capable of independent operation to a series of tests designed to meet specific objectives.

Specific objectives are designated as primary or secondary. Primary objectives represent milestones in the test program that must be reached so that the test program can proceed. Secondary objectives require the solution of special problems or contingencies and may be postponed or waived so that the test program can be expedited.

This section has been broken down into complete and self-sufficient test specifications which can be used independently of the rest of the report. Each test specification includes equipment and instrument listings as well as a summary of safety and support requirements.

S-1: SAFETY TESTS FUEL, NITROGEN, OXYGEN, AND HELIUM SYSTEMS

A. PURPOSE

The purpose of this test is to determine the ability of the safety valves and vent systems, protecting a low-pressure system, to carry away safely the maximum volume of gas generated by the adjacent high-pressure system in case of a malfunction.

B. TEST OBJECTIVE

1. Primary Objective

a. To demonstrate the ability of the safety devices to protect the equipment from damage in case of a malfunction.

C. SYSTEM SUMMARY

The subsystems to be tested can be broken down as follows:

1. Safety valve SV-511 and its gas relief piping protecting the 1600-lb. nitrogen missile service. (See Figure S5. 1a!)

2. Safety valve SV-535 and its gas relief piping protecting the 750-lb. nitrogen missile service. (See Figure S5. 2a.)

3. Safety valve SV-514 and its gas relief piping protecting the nitrogen purge and blanket system. (See Figure S5. 3a.)

4. Safety valve SV-517 and its gas relief piping protecting the nitrogen section of the helium cooler. (See Figure S5. 4a.)

5. Safety valves SV-531, SV-532 and their gas relief piping protecting the LO_2 line purge and blanket system. (See Figure S5. 6a.)

6. Safety valve SV-502 and its gas relief piping protecting the nitrogen section of the LO_2 subcooler. (See Figure S5. 7a.)

7. Safety valves SV-318, SV-319, and SV-306 and their gas relief piping protecting the LO_2 storage tank. (See Figure S3.1a.)

8. Safety valve SV-605 and its gas relief piping protecting the helium transfer system. (See Figure S6.1a.)

The operation of the tests will be carried out manually from the PL and PS Checkout Panel as described under "Test Operation" below.

The gas storage bottles used in each system test will be filled to capacity in advance of each safety test. The subsystem containing the safety valve to be tested will be isolated, and the gas pressure in the isolated section shall be raised slowly by remote manual manipulation of the flow control valve (or valves). After the safety valve relieves, all flow control valves feeding gas to the isolated section will be opened wide. The pressure in the vent system piping will be monitored, and if the pressure does not level off but increases steadily, the valves will be closed. Table S.1c lists the valves under test and instruments used. Table S.1d lists all tanks, lines and valves involved in each test. Figures S5.1a, S5.2a, S5.3a, S5.4a, S5.6a, S5.7a, S3.1a, and S6.1a show the subsystems to be used in this test series. An instrument schematic for each test setup is shown in Figures S5.1b, S5.2b, S5.3b, S5.4b, S5.6b, S5.7b, S3.1b, and S6.1b.

D. TEST OPERATION

The safety tests will be controlled from the equipment terminal by opening and closing the necessary valves in the piping system. The pressurization medium in all cases will be dry nitrogen gas.

Test parameters for each subsystem are listed in Table S.1a.

Each test run will be started with a full bottle of nitrogen supplying the vent system and safety valve to be tested.

The performance of each test will duplicate the worst conditions brought about by the malfunction of a flow control valve. In order to simulate the malfunction of a control valve, an alternate means of valve control will be provided, by-passing the normal pressure controller. In this way, pressure in the low-pressure system will be allowed to build up slowly until the safety valve releases. The flow control valve will be opened slowly until the PL and PS Panel signals the valve to be wide open. During the opening of the flow control valve, pressure in the safety valve vent system will be monitored. The test will be considered concluded when

TABLE S. 1a

TEST PARAMETERS

Test No.	Safety Valve	Line	Subsystem	Safety Valve Setting psig	Max. Pressure to be Applied to Safety Valve psig
S5.1	SV-511	513	1600 lb. Missile Nitrogen Service	1800	2000
S5.2	SV-535	583	750 lb. Missile Nitrogen Service	1000	1100
S5.3	SV-514	529	Missile Fuel Purge	16	30
S5.4	SV-517	533	Helium Cooler	60	70
S5.6	SV-531	567	LO_2 Line Purge	25	30
	SV-532	572	and Blanket	25	30
S5.7	SV-502	564	LO_2 Subcooler	60	70
S3.1	SV-318	303	LO_2 Storage Tank	100	115
	SV-319	303	LO_2 Storage Tank	100	115
	SV-306	303	LO_2 Storage Tank	100	115
S6.1	SV-605	611	Helium Transfer	3700	4000

the flow control valve has reached its wide-open position and all pressures have leveled off. The system will be returned to normal as soon as the pressure controller has been reconnected and checked out. Step-by-step procedures involved in the execution of the tests, including the status before and after test, will be covered separately as follows:

Test Number	Procedure Document No.
S5.1	101 - S5.1
S5.2	101 - S5.2
S5.3	101 - S5.3
S5.4	101 - S5.4
S5.6	101 - S5.6
S5.7	101 - S5.7
S3.1	101 - S3.1
S6.1	101 - S6.1

E. TEST CONTROL

Each safety test will be controlled from the equipment terminal using controls listed in Table S.1b. The PL and PS Checkout Panel will be used to monitor the settings of the various valves involved. A temporary electropneumatic controller will be used to operate each flow control valve (FCV) manually, though remotely, from the equipment terminal, close to the PL and PS Panel. For tests S5.4 and S5.7, a pressure regulative valve (PRV) is used in the system instead of a flow control valve (FCV). The PRV will have to be operated manually at the valve site. Two pressure transducers, one measuring the pressure upstream of the safety valve and the other the pressure in the vent piping downstream of the safety valve, will be required near the PL and PS Panel. The two pressure indicators will represent the only real time instrumentation used in the test. A record of the upstream and downstream pressure will be made on the C.E.C. Oscillograph. The specifications for the pressure transducers and indicators are covered in Section IV, Table IV-e.

TABLE S.1b

CONTROL EQUIPMENT

Test Numbers	Test Control Unit	Test Control Instrumentation
All tests	1. Electropneumatic controller for Flow Control Valve Operation	1. Indicating pressure gauges upstream and downstream of safety valve. See Instrument Schematics
	2. PL and PS Panel	

F. TEST DATA AND TEST INSTRUMENTATION REQUIREMENTS

Table S. 1c and the instrument schematics--Figures S5. 1b, S5. 2b, S5. 3b, S5. 4b, S5. 6b, S5. 7b, S3. 1b, and S6. 1b--present the data requirements for each test and the test instrumentation used to obtain the data. Since there is only one test objective for this test series, all data will be collected in support of this one objective.

G. EQUIPMENT REQUIREMENTS

The safety valves and associated vent subsystems to be tested have been listed in paragraph C, "System Summary." The subsystems have been covered in Figures S5. 1a, S5. 2a, S5. 3a, S5. 4a, S5. 6a, S5. 7a, S3. 1a, and S6. 1a.

All equipment requirements for the safety tests have been listed in Table S. 1d.

H. SUPPORT REQUIREMENTS

1. Facilities and Services

a. Power

Power will be required to operate the following equipment:

(1) Air conditioning.
(2) D-C power source for activation of PL and PS Panel.
(3) Power source for flow control valve operation.
(4) Bottle charging equipment.

b. Air Conditioning and Ventilation

Air conditioning and ventilation will be required in the following areas:

(1) Propellant terminal, all levels.
(2) Equipment terminal, third level.

TABLE 8.1c

TEST DATA AND INSTRUMENTATION REQUIREMENTS

	Upstream Side				Downstream Side							Gas Bottles		
Test No.	Pressure Tap	Transducer	Pressure Indicator	C.E.C. Recorder No.	Pressure Tap	Transducer	Pressure Indicator	C.E.C. Recorder No.	Safety Valve	SV Relief Pressure	Control Valve	Bottle No.	Bottle Gas Temp.	Bottle Gas Pressure
S 5.1	PR508	PR508 Existing Transducer Adequate	PI006	PR508	SPT518	PR008	PI008	PR008	SV511	1800 psig	FCV507	T-509	TR508	PR506
S 5.2	PR519	PR513 Inadequate Use PR005 Transducer	PI005	PR005	SPT538	PR008	PI008	PR008	SV535	1000 psig	FCV508 FCV519	T-504	TR506	PR512
S 5.3	PR504	PR504 Existing Transducer Adequate	PI001	PR504	SPT511	PR002	PI002	PR002	SV518	16 psig	FCV506	T-502	TR505	PR505
S 5.4	SPT531	PR009	PI009	PR009	SPT530	PR001	PI001	PR001	SV517	60 psig	PRV501	T-502	TR505	PR505
S 5.6	PR511 SPT529	PR511 PR008	PI009 PI008	PR511 PR008	SPT534 SPT310	PR002 PR001	PI002 PI001	PR002 PR001	SV531 SV532	25 psig	FCV510 FCV511	T-505	TR509	PR510
S 5.7	SPT529	PR009	PI009	PR009	SPT521	PR001	PI001	PR001	SV502	60 psig	PRV502	T-505	TR509	PR510
S 9.1	SPT918	PR008	PI008	PR008	SPT903	PR009	PI009	PR009	SV918 SV919 SV906	100 psig	FCV301 FCV307	T-301A T-301B T-301C	TR301 TR302 TR303	PR901
S 6.1	PR608	PR608 Existing Transducer Adequate	PI006	PR608	SPT602	PR008	PI008	PR008	SV608	9700 psig	FCV601 FCV602	T-601A T-601B	TR601 TR602	PR601 PR602

TABLE S. 1d

EQUIPMENT REQUIREMENTS

Test No.	Tanks	Lines	Valves	Misc.
S5. 1	T-503	509	CV-508	S-505
		511	CV-519	
		512	SV- 505	
		513	SV- 511	
		548	FCV-507	
S5. 2	T-504	512	CV-537	S-512
		548	CV-538	
		580	CV-540	
		581	SV- 533	
		583	SV- 535	
		584	PRV-503	
			FCV-508	
			FCV-513	
S. 5. 3	T-502	505	CV-507	S-503
		512	CV-510	
		522	CV-513	
		529	CV-521	
		531	CV-523	
		532	CV-524	
		548	CV-527	
			SV- 506	
			SV- 514	
			CHV-505	
			CHV-506	
			FCV-506	
			FCV-514	
			FCV-515	
S5. 4	T-402	505	CV-503	S-507
	T-502	512	CV-504	
		524	CV-507	
		533	CV-510	
		539	CV-513	
		548	CV-521	
			SV- 506	
			SV -517	
			PRV-501	

TABLE S. 1d (Continued)

Test No.	Tanks	Lines	Valves	Misc.
S5. 6	T-505	319	CV-528	S-509
		326	CV-530	S-510
		566	CV-531	
		567	CV-536	
		572	CV-539	
		573	SV-530	
		574	SV-531	
		576	SV-532	
			CHV-513	
			SOV-565	
			FCV-510	
			FCV-511	
S5. 7	T-401	312	CV-501	
	T-505	326	CV-502	
		541	CV-530	
		564	CV-531	
		566	CV-536	
			CV-539	
			SV-502	
			SV-530	
			PRV-502	
S3. 1	T-201	301	CV-301	C-301
	T-301A	302	CV-302	S-301
	T-301B	303	CV-311	S-303
	T-301C	308	CV-312	
		309	CV-313	
		319	CV-314	
		320	CV-315	
		341	CV-350	
			SV-301	
			SV-303	
			SV-306	
			SV-318	
			SV-319	
			FCV-218	
			FCV-301	
			FCV-302	
			FCV-307	

TABLE S. 1d (Continued)

Test No.	Tanks	Lines	Valves	Misc.
S6.1	T-601A	512	CV-601	C-601
	T-601B	548	CV-602	S-601
		601	CV-603	S-602
		602	CV-607	S-603
		603	CV-608	OF-601
		604	CV-610	OF-602
		605	CV-611	
		609	SV-601	
		610	SV-603	
		611	SV-605	
			FCV-601	
			FCV-602	
			FCV-603	
			FCV-604	

c. Lighting

Lighting will be required in the following areas:

(1) Propellant terminal, all levels.
(2) Equipment terminal, third level.

d. PLS Cleanliness

Prior to each test run, the subsystem covered under "System Summary" 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 run. (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

Three- and four-party conference systems will be set up between the PL and PS panel and the area in which the test is to take place.

ADL communication requirements have been covered in more detail in Section VIII. The communications system has been divided into 19 areas.

Each safety test will be monitored from the equipment terminal near the PL and PS Panel. During the preparation for each test, communication will be needed between the equipment terminal control area (Area 13) and the areas in the vicinity of the control valves and safety valves, which include areas 1, 3, 4, and 5. Table S. 1e shows the specific area locations of the valves and pressure taps for the safety tests.

TABLE S. 1e

LOCATIONS OF VALVES AND PRESSURE TAPS

Test No.	Item	Communication Area
S5. 1	FCV-507	Area 4
	SV-511	"
	Upstream tap PR-508	"
	Downstream tap SPT-514	"
S5. 2	FCV-508	Area 4
	FCV-513	"
	SV-535	"
	Upstream tap PR-513	"
	Downstream tap SPT-538	"
S5. 3	FCV-506	Area 4
	SV-514	"
	Upstream tap PR-504	"
	Downstream tap SPT-511	"
S5. 4	PRV-501	Area 4
	SV-517	"
	Upstream tap SPT-531	"
	Downstream tap SPT-530	"
S5. 6	FCV-510	Area 3
	FCV-511	"
	SV-532	"
	SV-531	Area 1
	Upstream tap SPT-523	Area 3
	Upstream tap PR-511	Area 1
	Downstream tap SPT-534	Area 1
	Downstream tap SPT-310	Area 3
S5. 7	PRV-502	Area 3
	SV-502	"
	Upstream tap SPT-529	Area 5
	Downstream tap SPT-521	Area 1
S3. 1	FCV-301	Area 3
	FCV-307	"
	SV-318	Area 1
	SV-319	"
	SV-306	"
	Upstream tap SPT-318	Area 1 (part of T-201)
	Downstream tap SPT-303	Area 1
S6. 1	FCV-601	Area 4
	FCV-602	"
	SV-605	"
	Upstream tap PR-605	"
	Downstream tap SPT-602	"

g. Visual and Audio Warning System

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

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

h. Sole Facility Use

Arthur D. Little, Inc., will require sole occupancy of the propellant terminal while the system is subjected to test pressure. The duration of this portion of each run will not be more than one hour.

2. Supply Requirements

The following quantities of dry nitrogen will be required for the conduct of each test run.

Test	Bottle Number	N_2 Gas Initial Fill	(SCF) Usage
S5.1	T-503	45,000	3,100
S5.2	T-504	35,000	1,500
S5.3	T-502	35,000	1,000
S5.4	T-502	35,000	870
S5.6	T-505	42,400	2,440
S5.7	T-505	42,400	1,524
S3.1	T-301A	204,000	19,200
	T-301B		
	T-301C		
S6.1	T-601A	87,600	2,733
	T-601B		

3. Associated Contractor Support

The Arthur D. Little, Inc., associated contractor support requirement for this test series will be for test instrumentation coverage.

I. SAFETY REQUIREMENTS

1. Hazard Area

The hazard area for these tests (shown in Figure IX-a) includes the propellant terminal, the vent and fill shafts, a continuous 10-foot area around the shaft openings, and portions of the tunnels. These areas are restricted to use by test and associated contractor personnel only.

2. Warnings

Nontest personnel shall be warned to leave the hazard area before a test. Safety barriers shall be established at tunnel junction #2, at the interconnection tunnel, and around the shaft openings. Audio warnings shall signal the start and completion of tests and pressurization of the system.

3. Safety Practices

Test personnel are to observe the following precautions:

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

b. Inspect the propellant terminal to make sure it is clean and clear of personnel, tools, material, and debris.

c. Before each test, hand operate or semi-automatically exercise all valves that will be involved in the test.

d. Remain out of the propellant terminal during line and valve pressurization except during tests S5.4 and S5.7. During these tests, pressure regulative PRV-501 and PRV-502 must be manually operated.

e. Test the atmosphere with a nitrogen "sniffer" prior to entering the propellant terminal at the conclusion of each test.

f. Observe the NO SMOKING precaution.

J. CRITERIA

The ability of the safety valve and vent system involved in each test to relieve the excessive pressure will be considered the criterion of success.

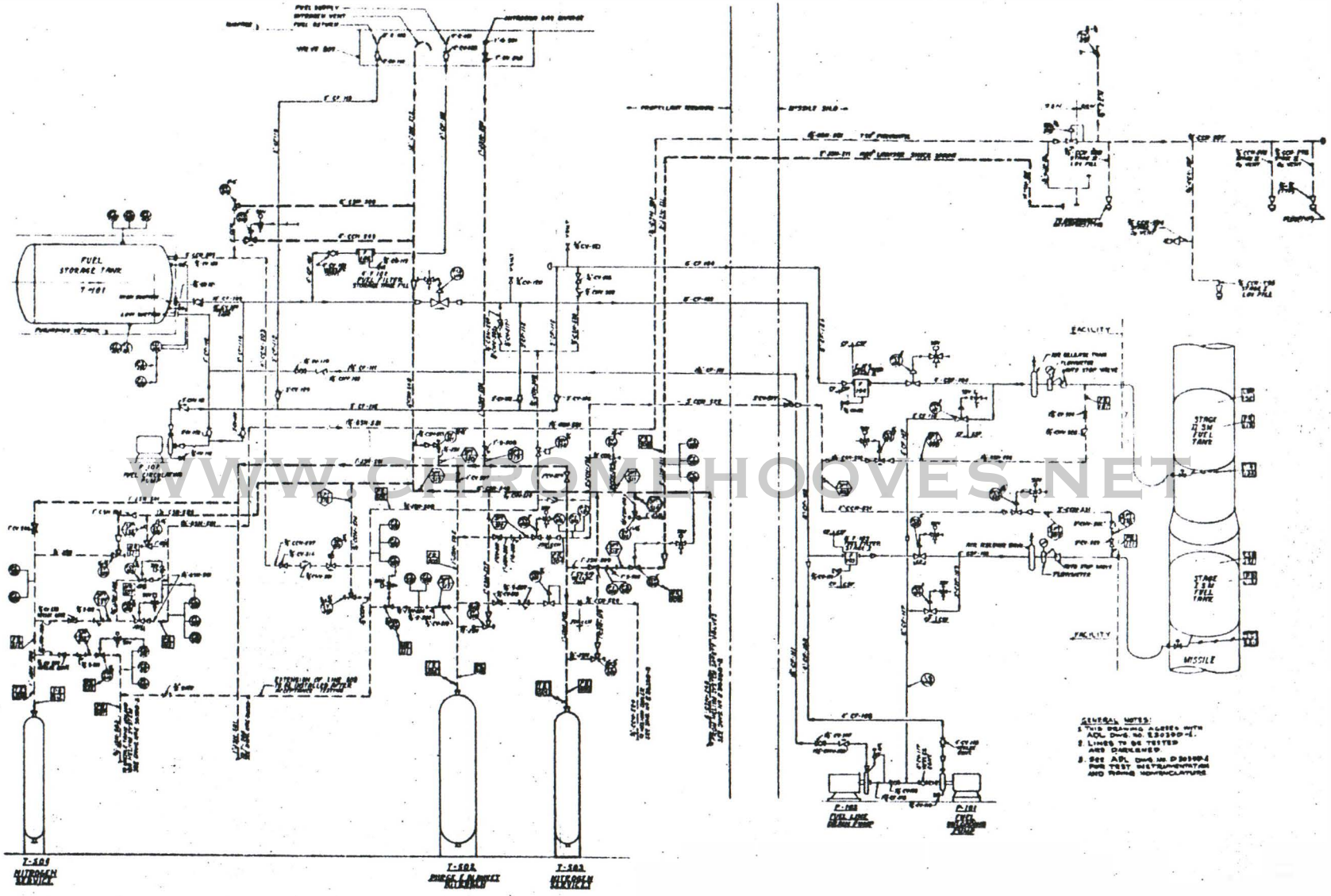

Figure S5.1a

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

SAFETY TEST S5.1 1600-POUND MISSILE SERVICE

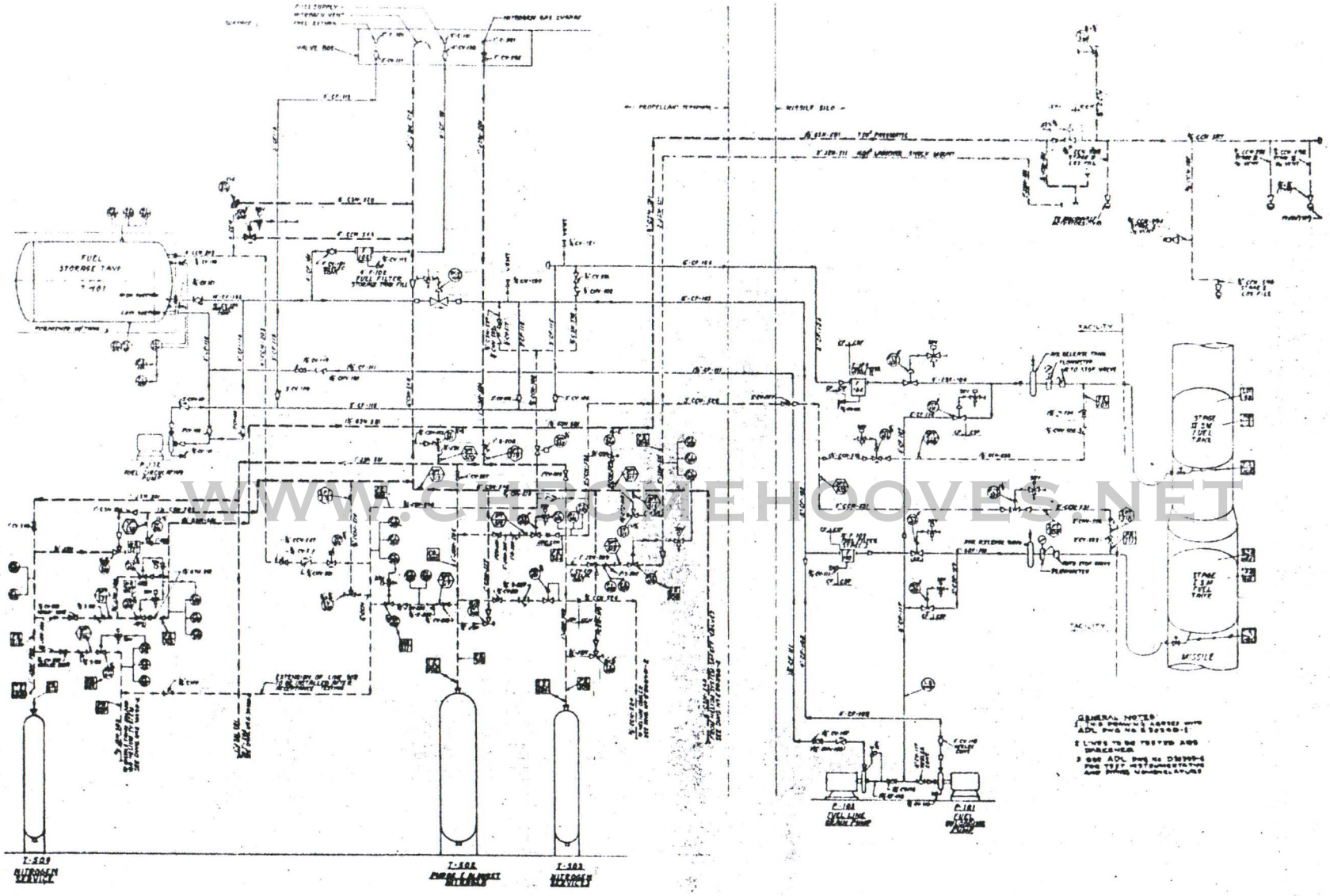

Figure S5.2a

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

SAFETY TEST S5.2 750-POUND MISSILE SERVICE

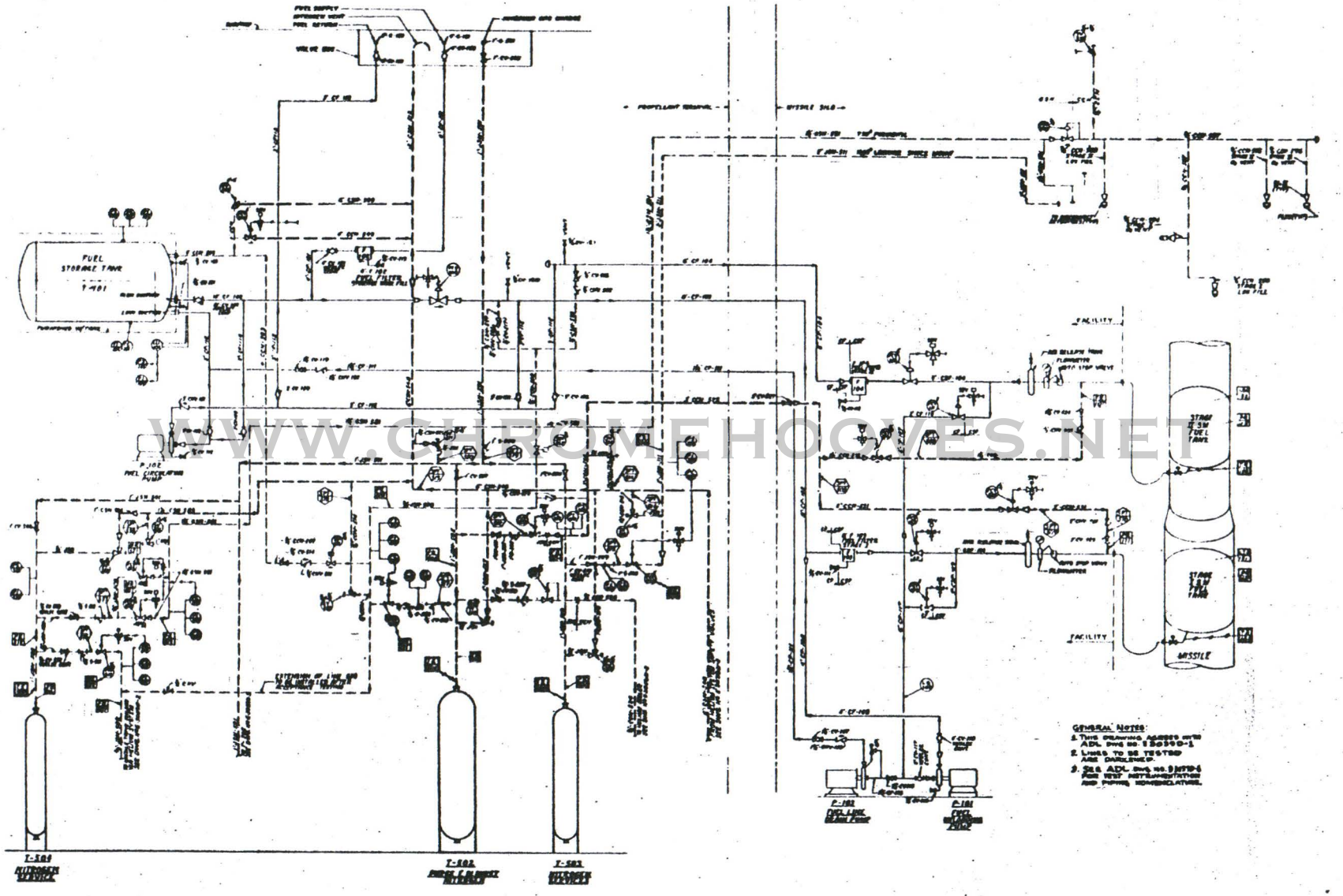

Figure S5.3a

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

SAFETY TEST S5.3 LINE PURGES

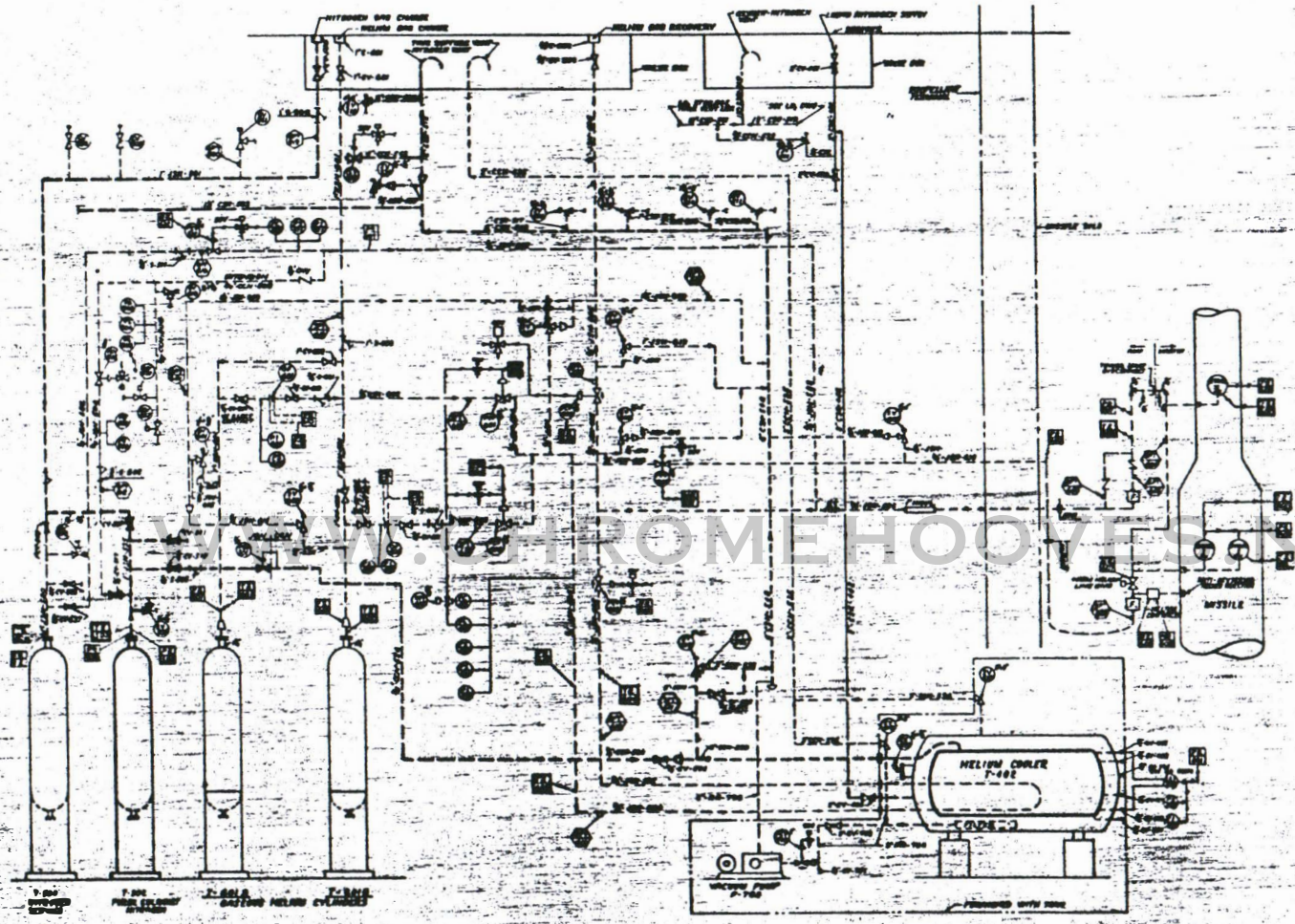

Figure S5.4a

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

HELIUM COOLER SAFETY TEST

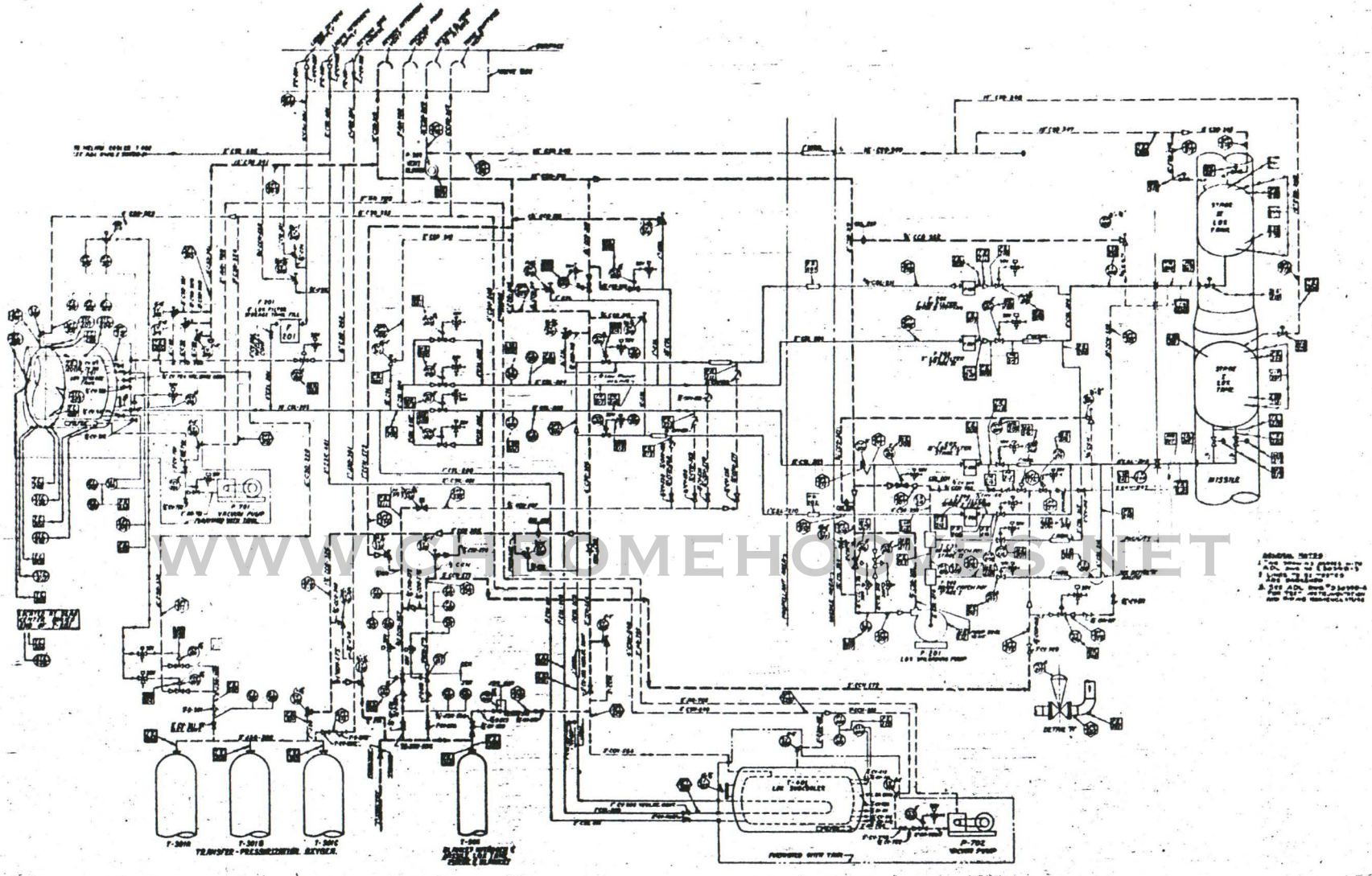

Figure S5.6a

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

LO_2 LINE PURGE AND BLANKETING

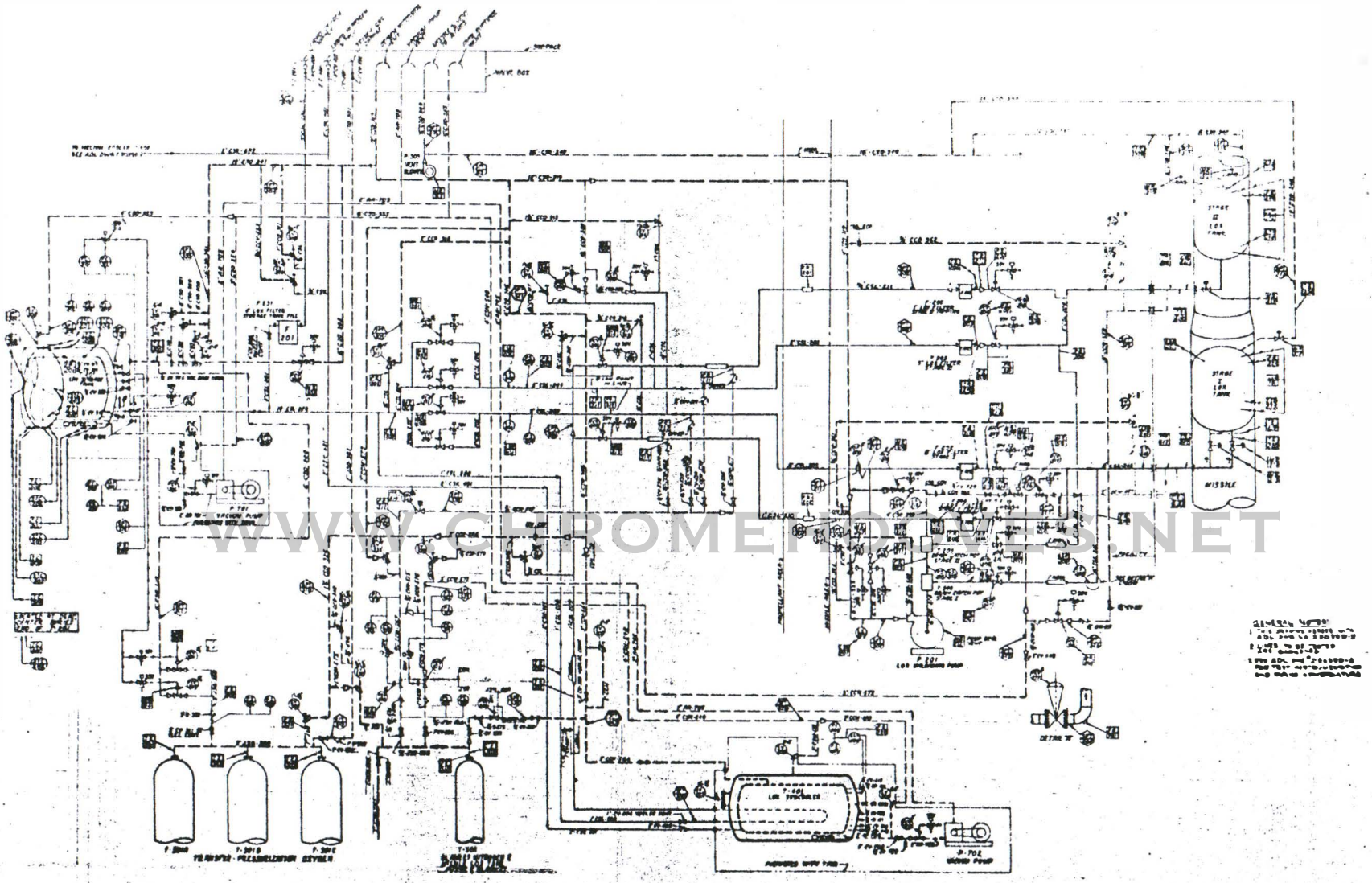

Figure S5.7a

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

LO_2 SUBCOOLER SAFETY TEST

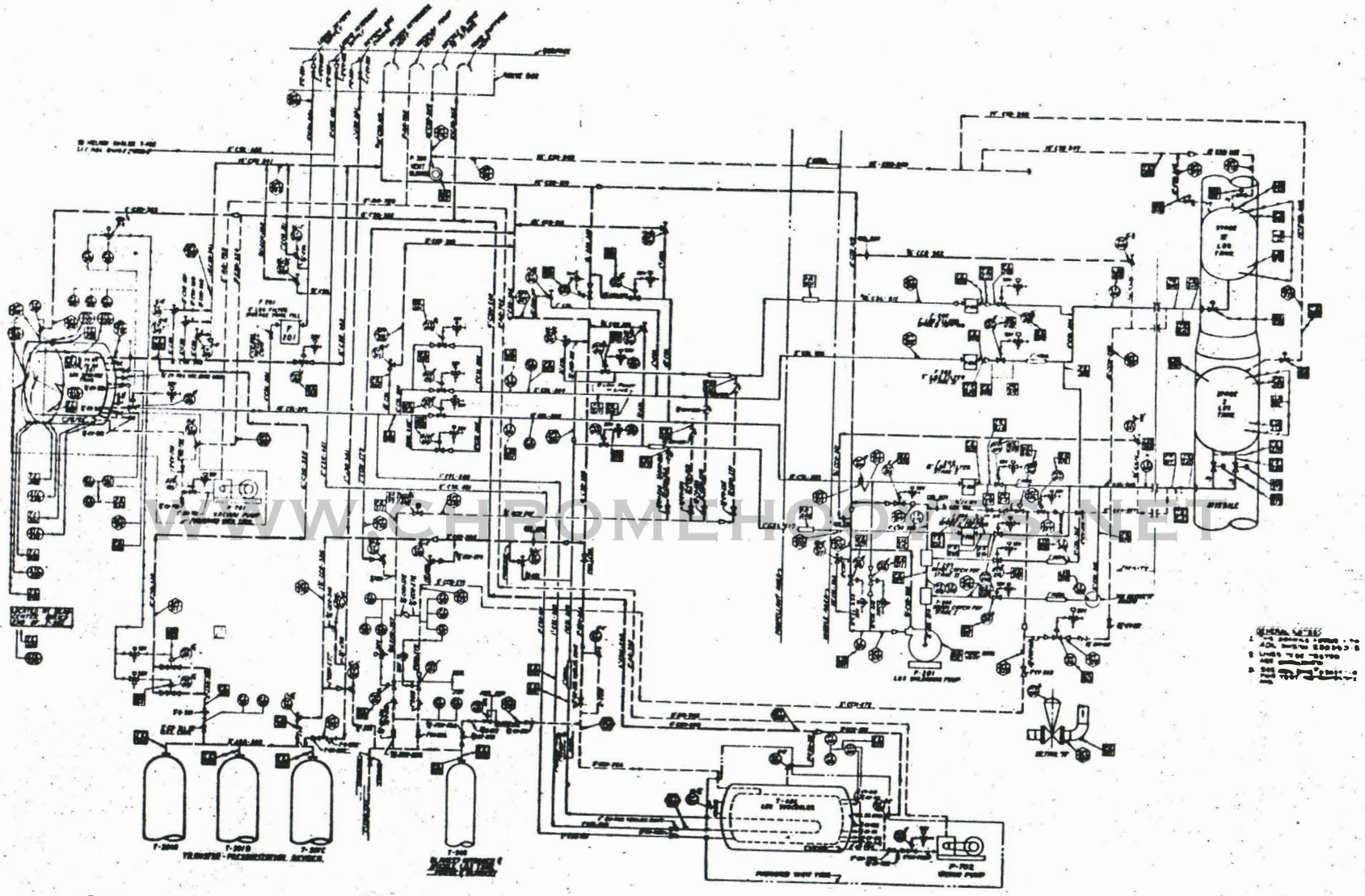

Figure 3.1a

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

LO_2 STORAGE TANK S3.1

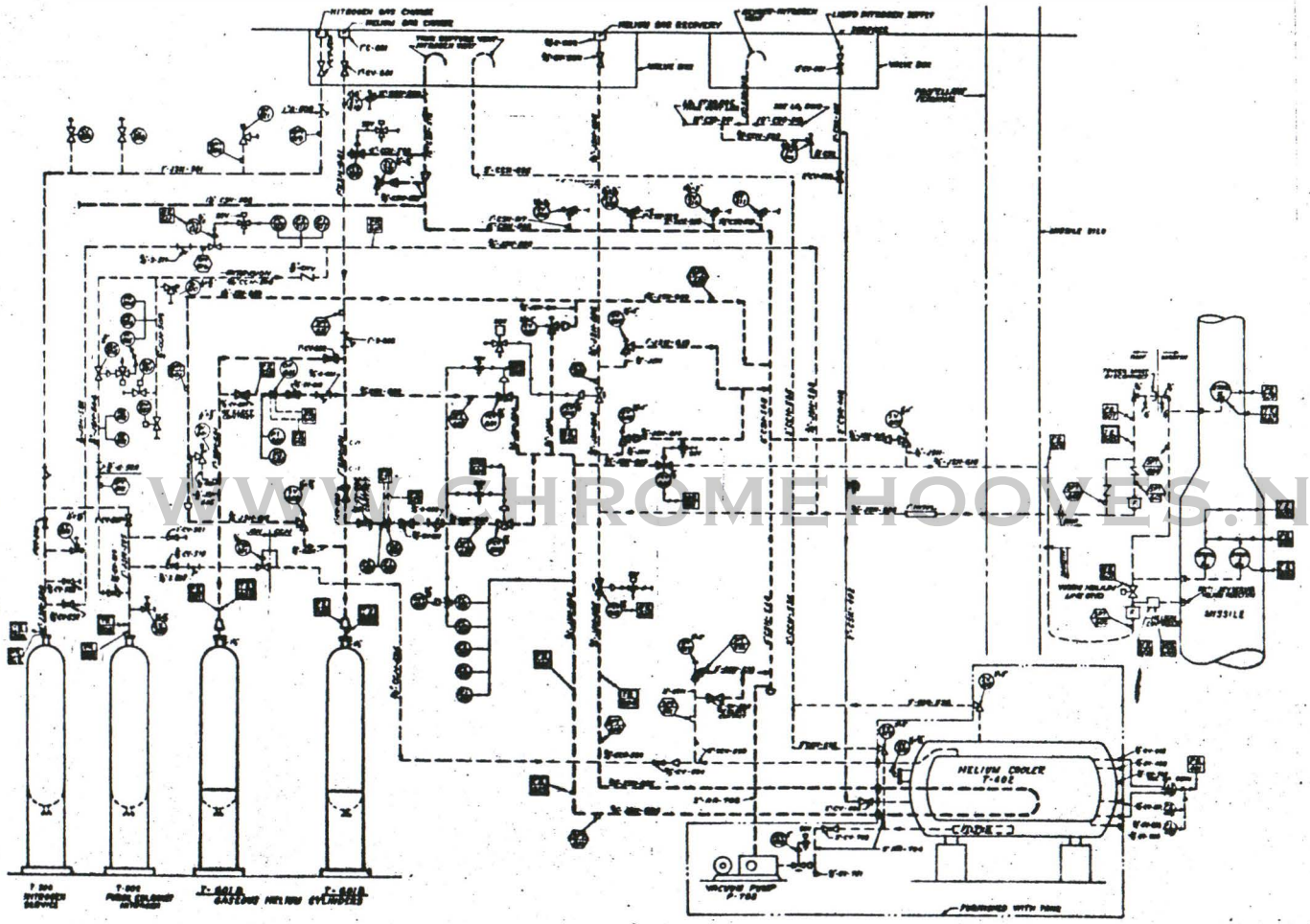

Figure S6.1a

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

HELIUM TRANSFER SAFETY TEST

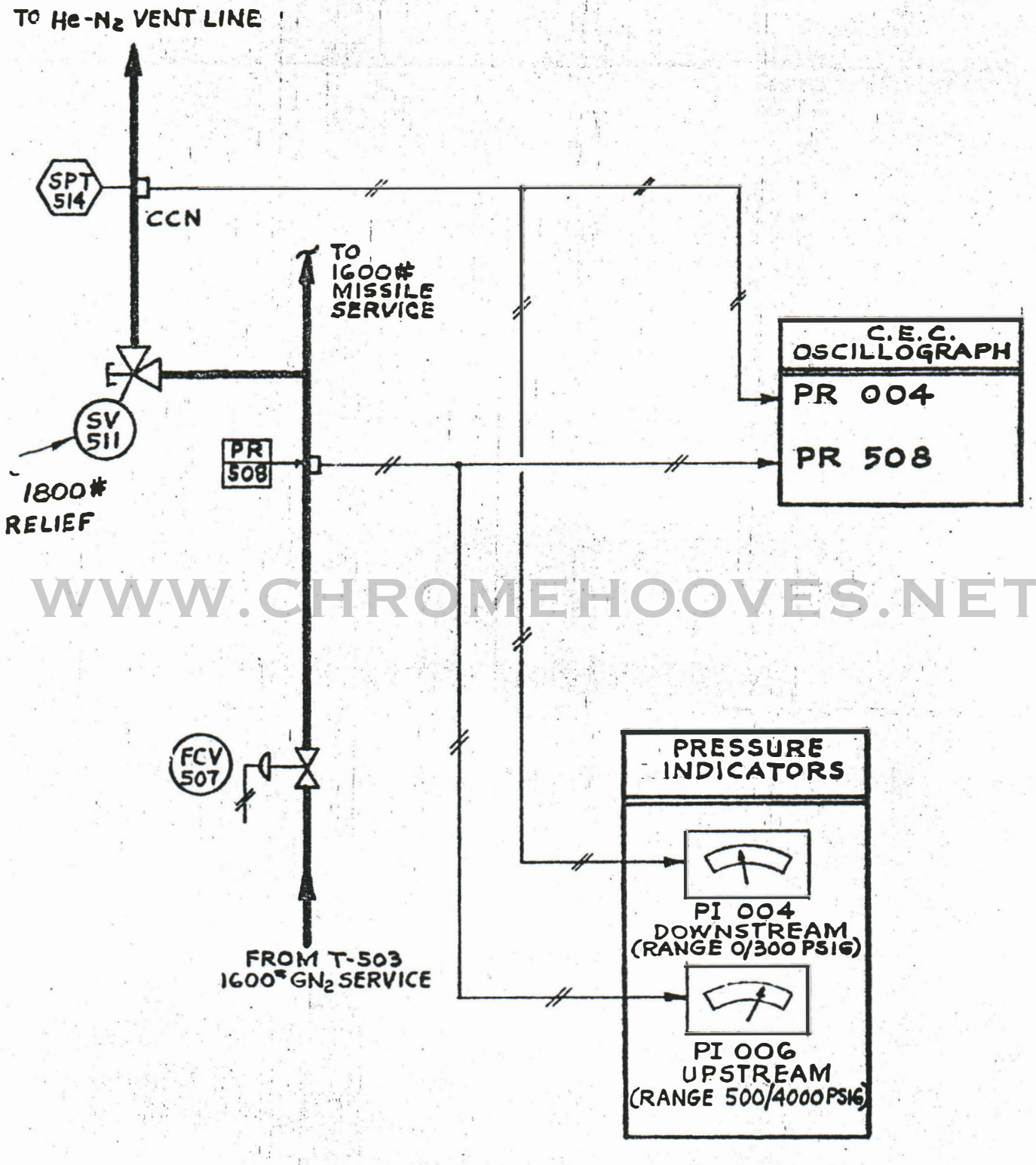

Figure S5.1b

INSTRUMENT SCHEMATIC FOR TEST S5.1
1600# MISSILE GN_2 SERVICE

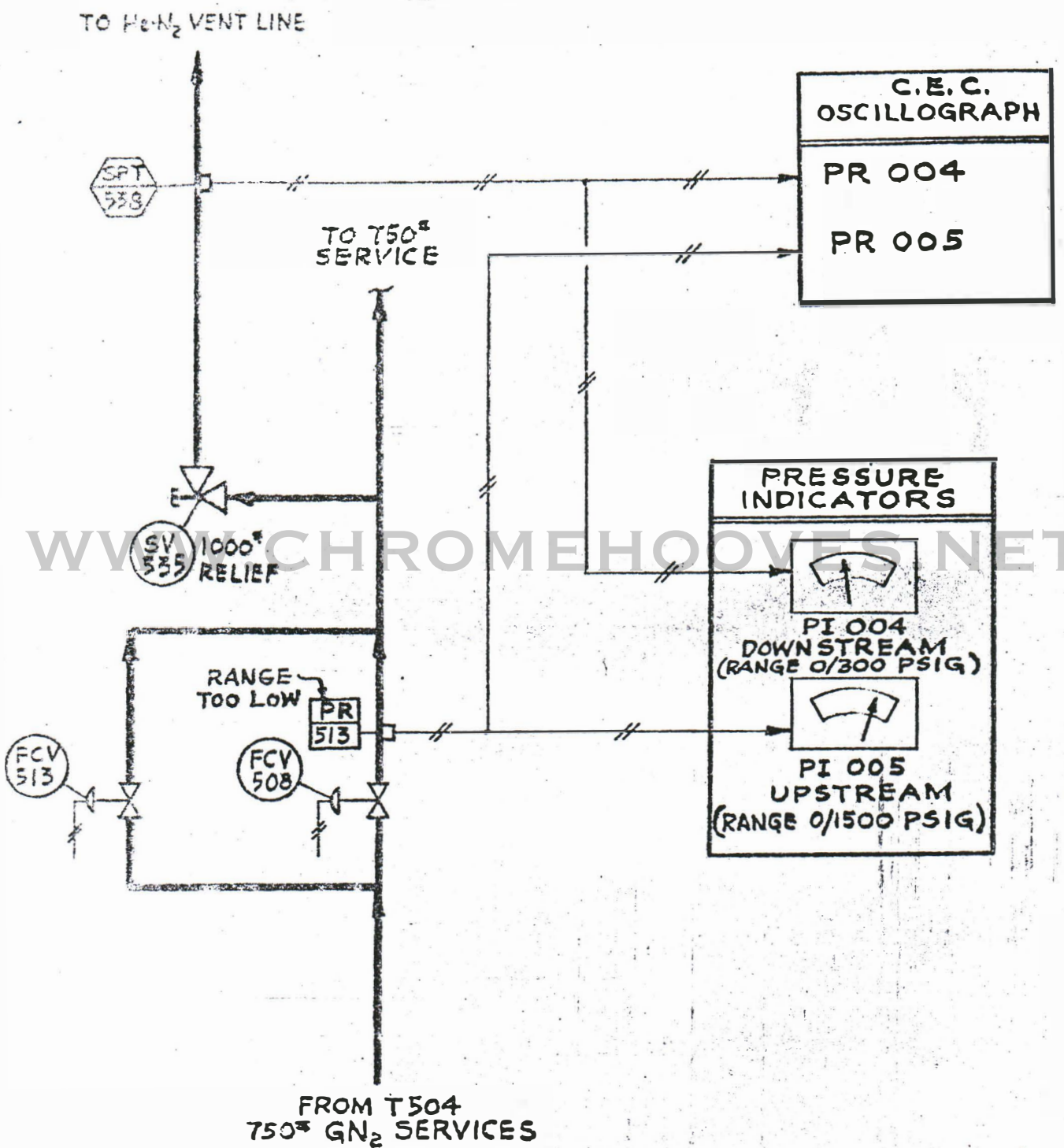

Figure S5.2b

INSTRUMENT SCHEMATIC FOR TEST S5.2
750# MISSILE GN_2 SERVICE

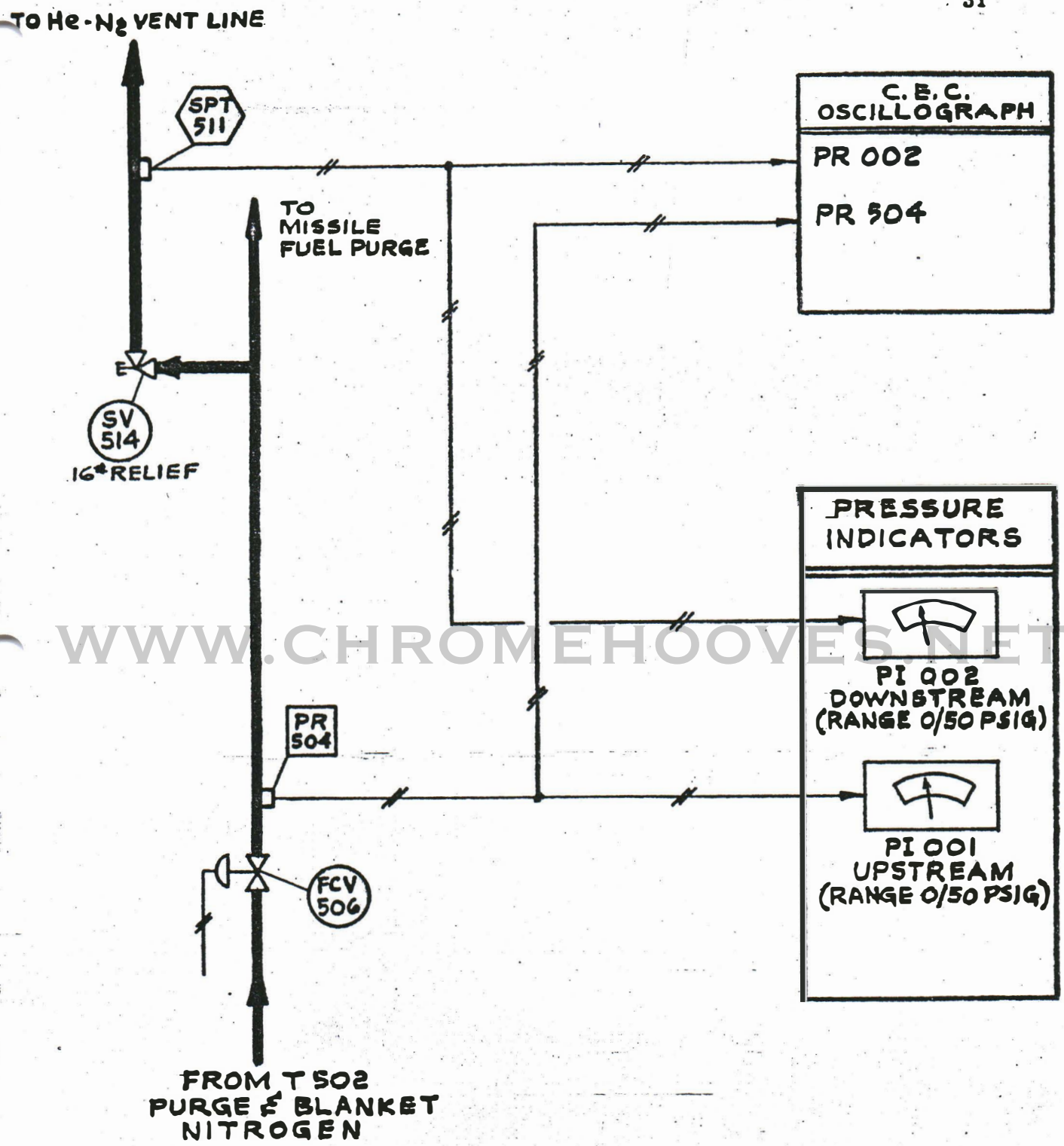

Figure S5.3b

INSTRUMENT SCHEMATIC FOR TEST S5.3
MISSILE FUEL PURGE BY GN_2

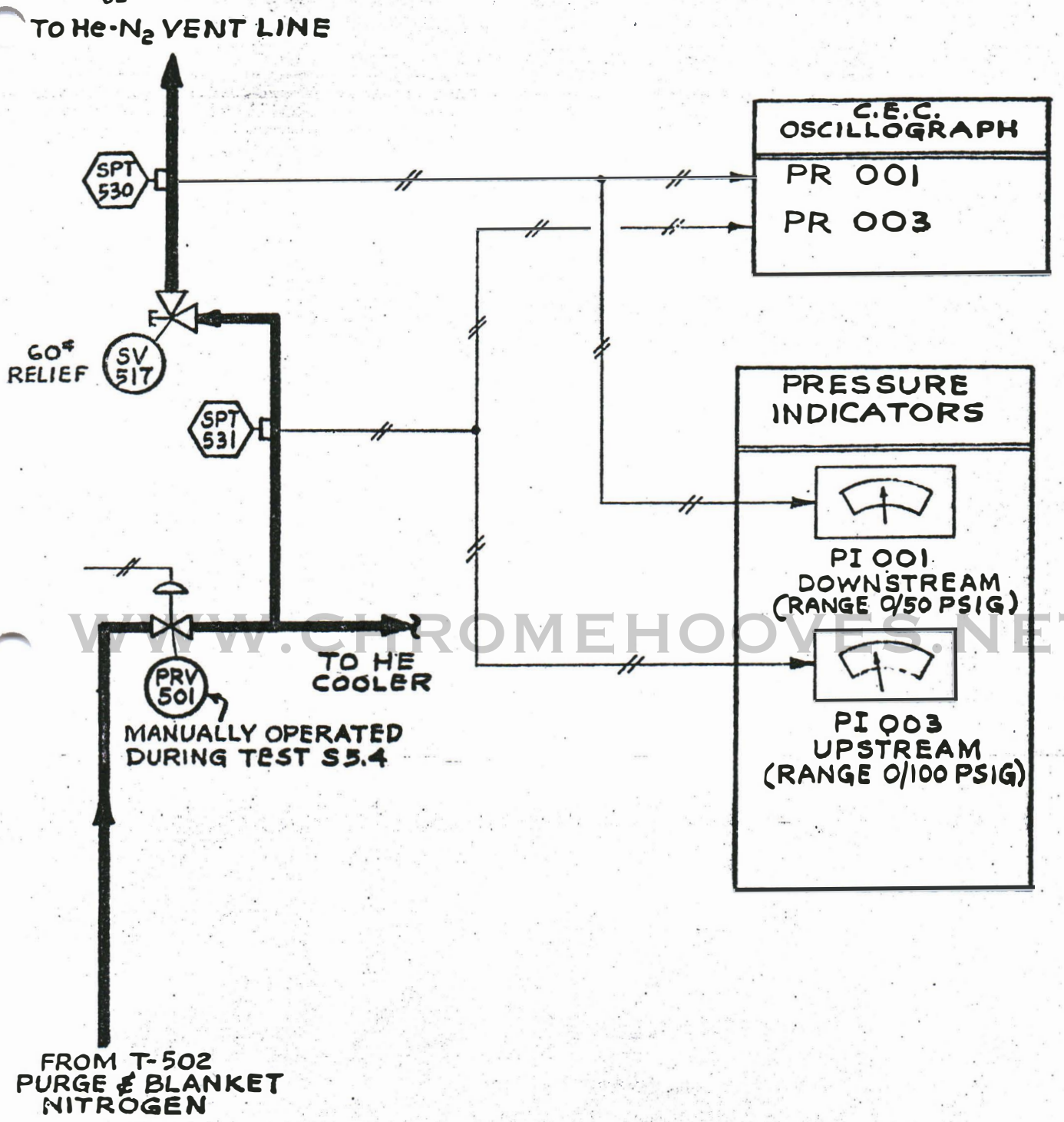

Figure S5.4b

INSTRUMENT SCHEMATIC FOR TEST S5.4
He COOLER SAFETY TEST

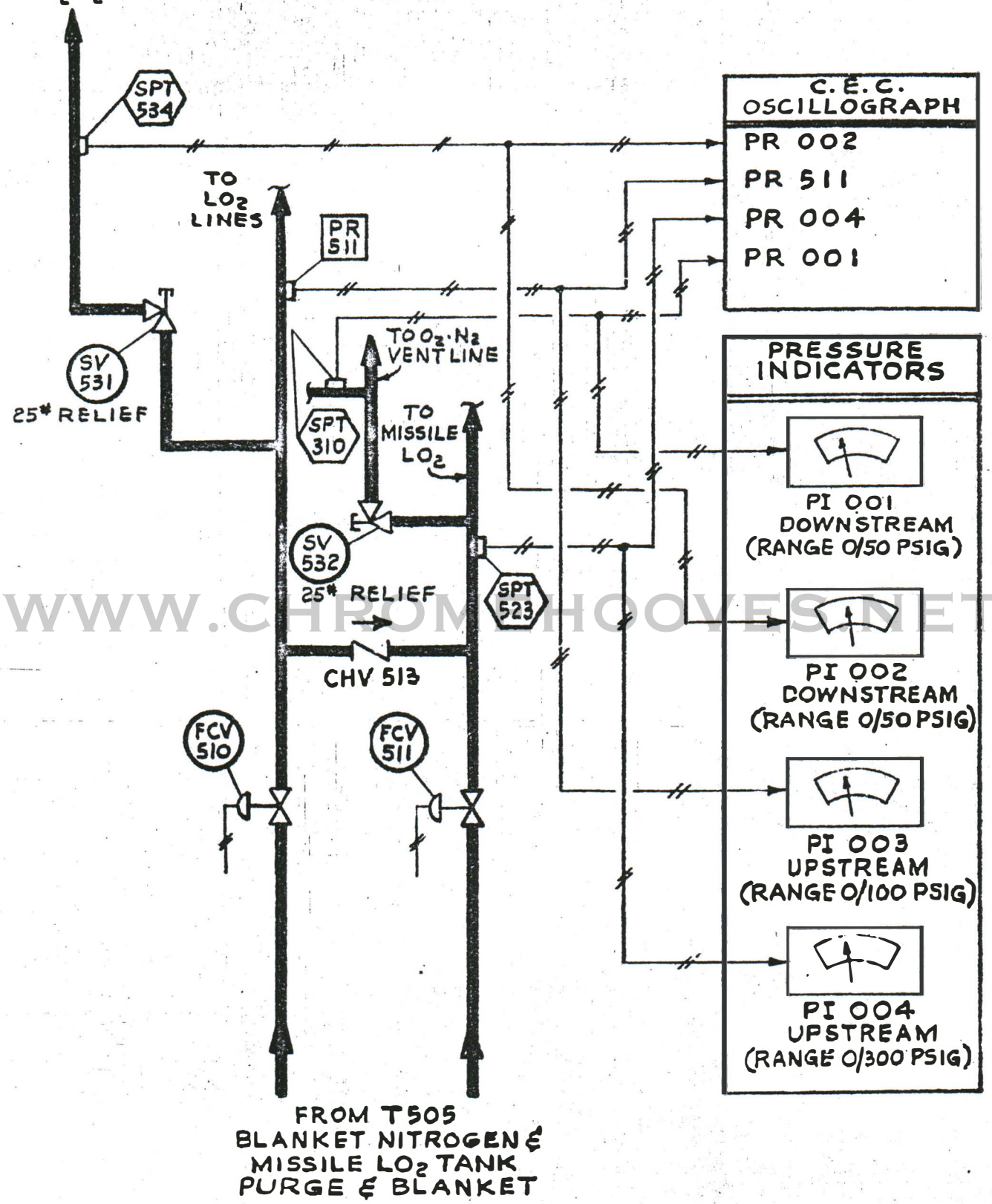

Figure S5.6b

INSTRUMENT SCHEMATIC FOR TEST S5.6
LO_2 LINES PURGE & BLANKET

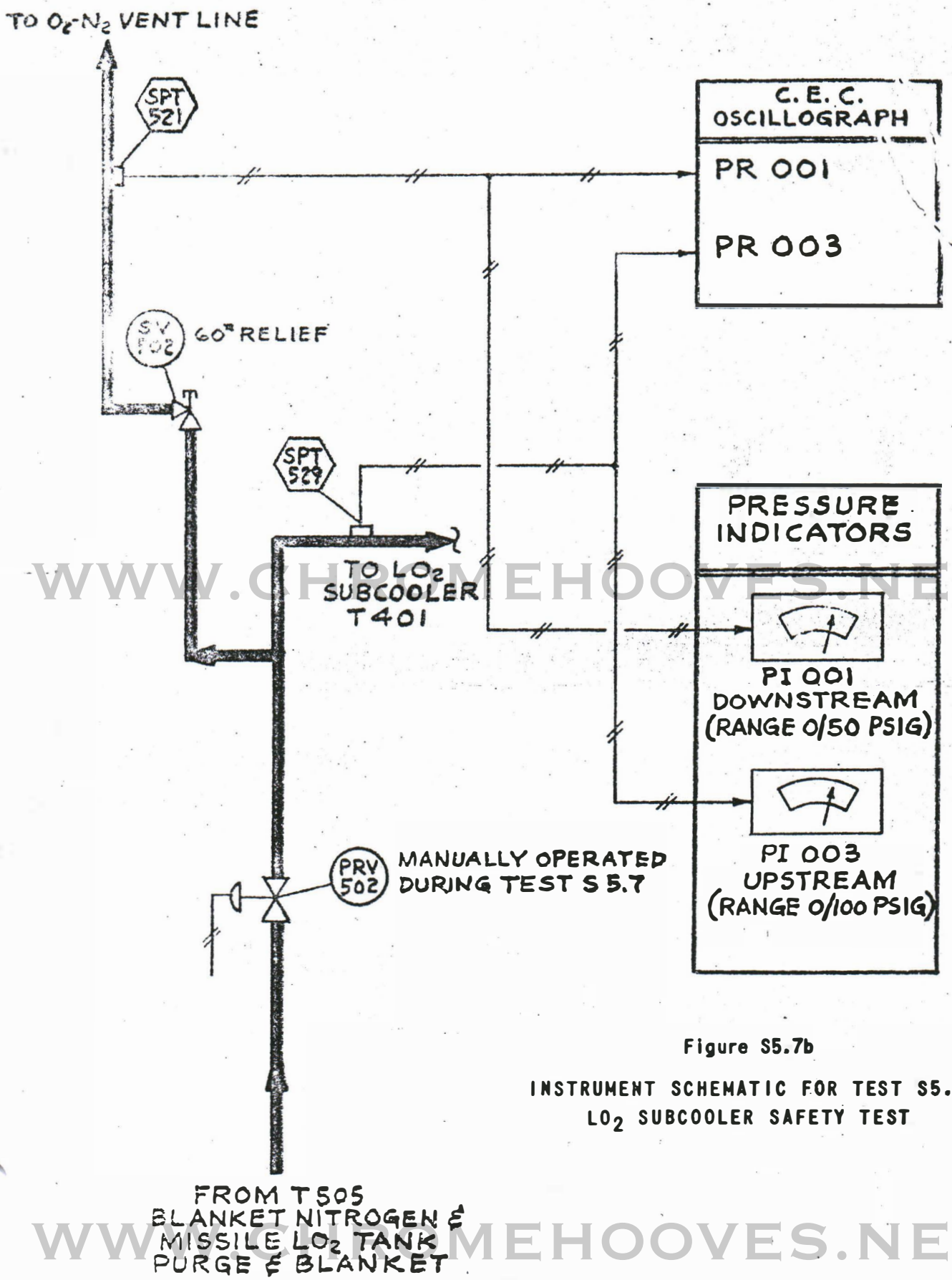

Figure S5.7b

INSTRUMENT SCHEMATIC FOR TEST S5.7
LO_2 SUBCOOLER SAFETY TEST

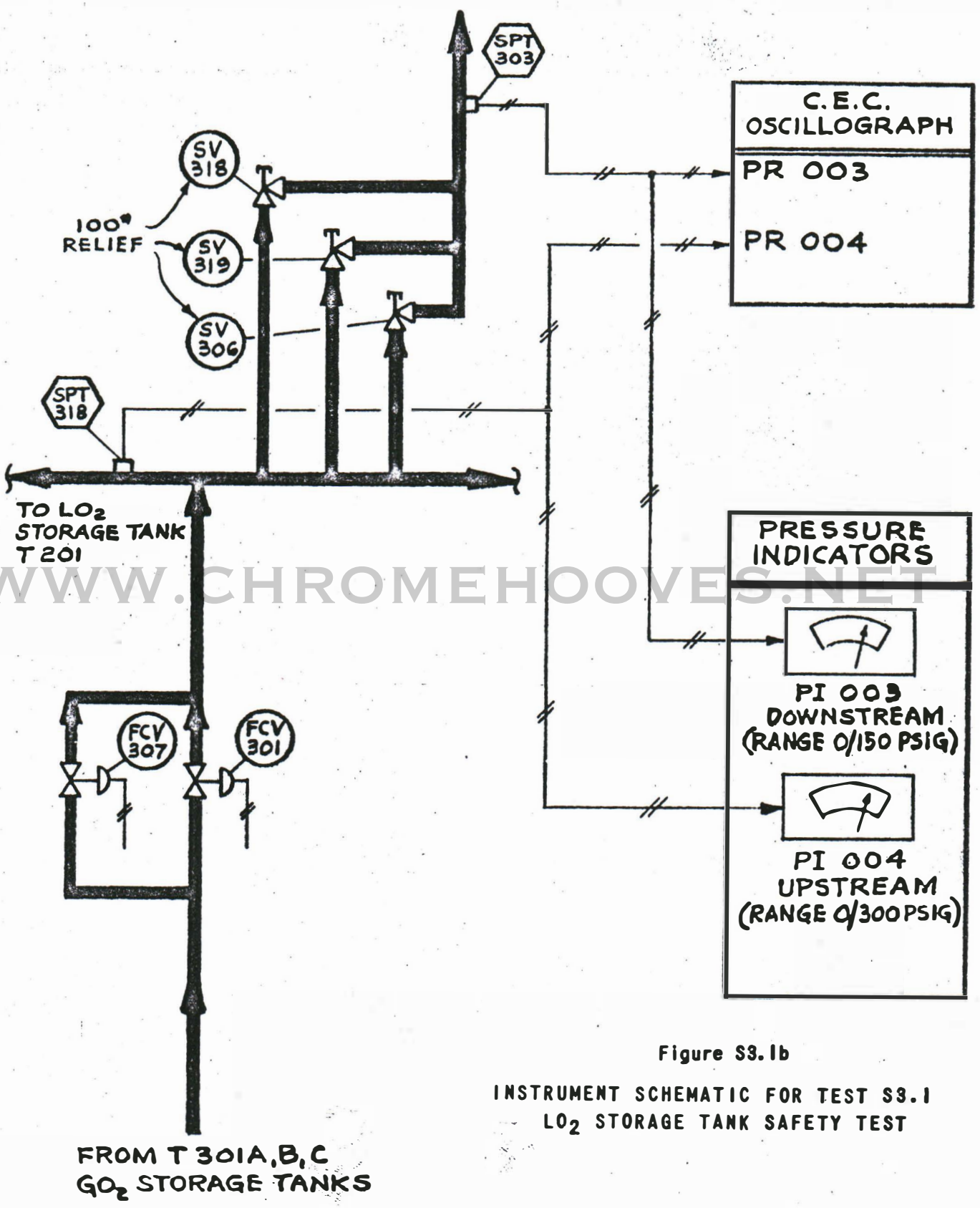

Figure S3.1b

INSTRUMENT SCHEMATIC FOR TEST S3.1
LO_2 STORAGE TANK SAFETY TEST

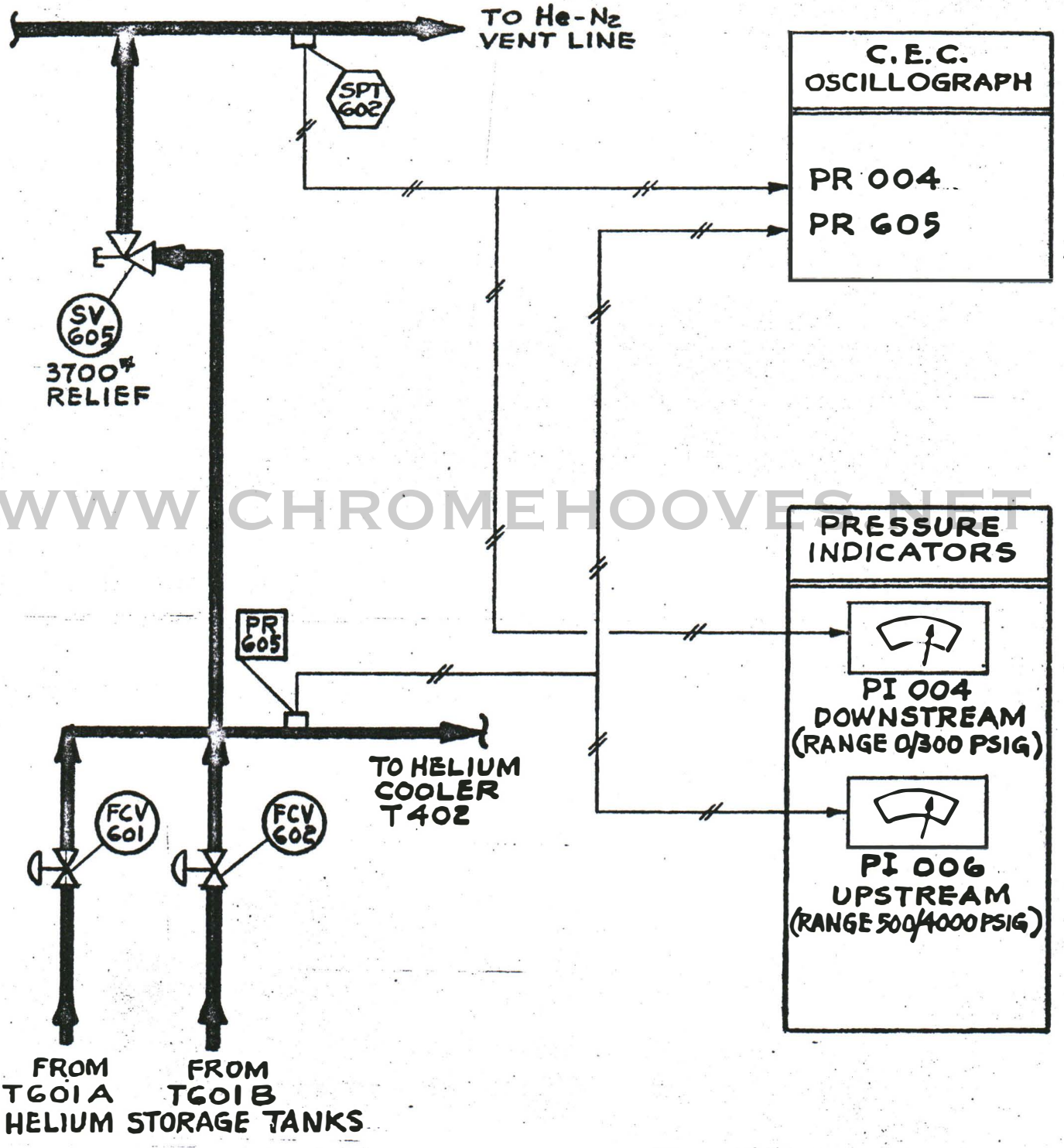

Figure S6.1b

INSTRUMENT SCHEMATIC FOR TEST S6.1
He TRANSFER SAFETY TEST

SC. 1: STORAGE CAPABILITY TEST FOR LIQUID OXYGEN STORAGE TANK, HELIUM COOLER, AND LIQUID OXYGEN SUBCOOLER

A. PURPOSE

The purpose of this test is to test the boil-off characteristics of the liquid oxygen storage tank T-201, the helium cooler T-402 and the liquid oxygen subcooler T-401

B. TEST OBJECTIVE

1. Primary Objective

a. Demonstrate the capability of the liquid oxygen storage tank, helium cooler, and liquid oxygen subcooler to maintain a sufficient storage of liquid oxygen and liquid nitrogen during a 10-day "ready" status to load, hold, unload, and reload the missile.

C. SYSTEM SUMMARY

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

(1) Liquid oxygen storage tank, including fill and vent lines, all exterior tank connections, and the tank earth backfill.

(2) Helium cooler, including fill and vent lines and all external connections to the tank.

(3) Liquid oxygen subcooler, including fill and vent lines and all external connections to the tank.

The tests will be conducted over 72-hour periods. Each period should start just after refill of each storage tank. All of the vent gas escaping from the storage tank under test will be passed through a flow meter for the entire 72-hour period. This information will be used to determine the evaporation loss rate for a 24-hour period at standard conditions.

D. TEST OPERATION

These tests will be carried out from the propellant loading terminal during a period when the equipment is not being used for more active tests. Table SC. 1a lists specific test suns.

TABLE SC. 1a

TEST RUNS

Test No.	Tank to be Tested	Comments
SC. 1. 1	LO_2 Storage Tank	Tests to run in conjunction with contractor acceptance tests if possible
SC. 1. 2	LO_2 Subcooler	
SC. 1. 3	Helium Cooler	

Step-by-step procedures involved in the execution of the tests, including status before and after test, will be covered separately in Procedural Documents 101-SC. 1. 1, 101-SC. 1. 2, and 101-SC. 1. 3.

The test will be performed just after the storage tanks have been filled to capacity. All the vent gases emanating from the storage tank shall be passed through a flow meter for a 72-hour period. During this period, the storage tank and its associated piping shall not be interfered with in any way.

Along with the measurement of the boil-off gas, a continuous record of the boil-off gas temperature will be taken. This measurement will be used to reduce the boil-off data to standard conditions. An average evaporation loss rate over a 24-hour period will be used in the 10-day sufficiency calculations.

E. TEST CONTROL

The test control will consist of a rigid monitoring of the data-taking instruments over the entire 72-hour period. A rigid periodic inspection of the equipment under test will also be performed to insure that the test has not been influenced by changes in the physical layout of the tests. Since there is no control equipment as such, Table SC. 2b (listing controls and control instrumentation) has been omitted.

F. TEST DATA AND TEST INSTRUMENTATION REQUIREMENTS

Table SC. 1c lists the data requirements for test series SC. 1, together with test instrumentation used to obtain the data.

TABLE SC. 1c

TEST DATA AND INSTRUMENTATION REQUIREMENTS

Test Objective	Test Data Requirements	Test Instrumentation
	Total quantity of gas vented from storage tank	(FR-301)
1a	Temperature of vent gas at meter	TR-307
	Inner tank wall temperature (T-201)	TR-201
	Outer tank wall temperature	TC-206

G. EQUIPMENT REQUIREMENTS

The storage tanks to be tested are covered by the following subsystems:

(1) Liquid oxygen storage tank (T-201), including vent system and all associated piping and supports connected to storage tank.

(2) Liquid oxygen subcooler tank (T-401), including vent system and all associated piping and supports connected to storage tank.

(3) Helium cooler tank (T-402), including vent system and all associated piping and supports connected to storage tank.

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

Table SC. 1d lists the equipment to be used in the test series.

TABLE SC. 1d

EQUIPMENT REQUIREMENTS

Test No.	Tanks	Lines	Valves	Misc.
SC. 1. 1	T-201	L-202	FCV-218	C-201
		L-201	CV-201	F-201
		L-311	SV-308	P-701
		L-303	CV-206	
		L-320	FCV-302	
		L-341	SV-318	
		L-321	SV-306	
		L-309	SV-305	
		L-308	CV-701	
		L-701	FCV-501	
		L-703	CV-750	
SC. 1. 2	T-401	L-401	CV-401	C-301
		L-564	CV-402	P-702
		L-326	CV-501	
		L-319	CV-502	
		L-551	SV-502	
		L-702	SV-503	
		L-705	CV-702	
		L-208	FCV-702	
		L-209	CV-205	
			FCV-201	
			FCV-202	
			CV-207	
SC. 1. 3	T-402	L-401	CV-401	C-301
		L-402	CV-404	P-703
		L-539	CV-504	
		L-533	CV-503	
		L-548	SV-517	
		L-536	CV-703	
		L-535	SV-519	
		L-704	FCV-703	
		L-706	FCV-603	
		L-604		
		L-605		