HAZARD CONTROL PLAN Renewal Cover Sheet

LANSCE Division

Title of Hazard Control Plan: **Operation of the 10 watt Refrigerated Liquid Hydrogen Target**
Hazard Control Plan Identification Number: **LANSCE-3 HCP-02**
Brief Description of Work: This Hazard Control Plan (HCP) details procedures and precautions necessary for the safe operation of the 10 watt refrigerated liquid hydrogen target used at WNR on flight path 4FP15R.
Reviewer of the Plan (This HCP and the operating experience have been reviewed and no significant modifications are needed at this time)**:** Art Bridge / LANSCE-3 Technician / Art Bridge / 8/19/03 Name / Title / Signature / Date
Initial Risk Estimate: ☐ Minimal ☐ Low ☐ Moderate ☒ High
Applicable Safety Permits Required to Perform Work:
Residual Risk Estimate: ☐ Minimal ☒ Low ☐ Moderate
Work Authorization: Steve Wender / LANSCE-3 GL / Steve Wender / 8/19/03 Name / Title / Signature / Date
Next Authorization Review Date: 08/01/04

1.0 INTRODUCTION AND SCOPE

This Hazard Control Plan (HCP) details procedures and precautions necessary for the safe operation of the 10 watt refrigerated liquid hydrogen target used at WNR on flight path 4FP15R.

2.0 PERSONNEL

2.1 FULLY CERTIFIED OPERATORS (FCO) have all necessary cryogenics training.

- Fully Certified Operators are authorized to perform all operations on the system, including starting up the system, filling the target flask, and shutting down the system in normal or emergency situations
- They are the ONLY personnel authorized to modify any part of the system.

The duties of a **Fully Certified Operator (FCO)** are:

- to be in attendance during start-up and cooling of the target until steady-state operation is achieved.
- to be present during normal shutdowns.
- to be in charge of all operations and to be in attendance as needed to monitor the target's safety status and assure personnel safety.
- to verify that the target log book is kept up to date (Appendix A contains a sample log sheet).

Names, phone numbers, and pager numbers for the Fully Certified Operators are listed in Appendix B.

2.2 CONDITIONALLY CERTIFIED OPERATORS (CCO):

- are required to monitor the target's safety status and assure personnel safety at all times.
- are required to monitor the system regularly and maintain the log book (Appendix A contains a sample log sheet).
- are authorized to adjust the target pressure controllers.
- are authorized to empty and refill the target flask after being instructed in the correct procedures by a FCO.
- are authorized to shut down the target system in an emergency. Any emergency action taken by a CCO must be reported to a FCO as soon as practicable.

During normal operation and emergency shutdowns CCO staffing is the responsibility of the experimenters. Names and phone numbers of experimenters qualified as Conditionally Certified Operators are listed in Appendix B. During normal steady-state operation, 24 hour/day monitoring of the target is not required**.**

2.3 OTHER CERTIFIED PERSONNEL

Certified personnel who have received training in the hazards of the liquid hydrogen target and in the emergency procedures and alarms are authorized to work with the experimental equipment surrounding the target, but not on the target itself.

All personnel involved in the operation of the liquid hydrogen target must read and sign this HCP. A copy of this HCP will be kept near the control console in MPF-29.

3.0 HAZARDS AND HAZARD CONTROLS

This section contains a general discussion of the hazards associated with the liquid hydrogen target system and of the procedures to be followed in emergency situations.

Type of Hazard	Possible Effects of Hazard	Remarks
Cryogenic Fluids	• Biological tissue damage	• Can freeze tissue. Eyes and lungs are vulnerable
	• Structural material damage	• Materials can freeze making them weak or fragile
	• Enhanced combustibility	• If air condenses on a surface cooled with liquid nitrogen the resulting liquid may be rich in oxygen and should be treated as such.
	• Interference with mechanical and electronic operation	• Cold surfaces can freeze water from the air onto or into a device interfering with its operation.
	• System over-pressure	• When a cryogenic system is warmed, the pressure increases. Unvented pressure may cause tanks or lines to violently explode.
	• Oxygen depletion and asphyxiation	• Gases that do not contain oxygen like LH2 and LN2 may cause asphyxiation if they are released into the air. A small amount of liquid that vaporizes may be all that is needed to displace the air enough so the asphyxiation occurs.
	• Blockage if vents and other process piping, and damage to process components	• If gases, particularly air, are allowed to leak into areas that contain LH2 and LN2 the air might freeze plugging the vent lines. This can build up and can cause erosion on the valve. The only way to remove it is to warm the valve to the boiling point of the gas that has solidified.
• Hydrogen gas combustibility : Target flask leak in the detector shed	• Burn hazard	• Hydrogen gas is combustible and may react with air in relatively low concentrations. The combustibility hazard is greatest near the leak.

• The insulating vacuum system has thin windows: Located at the target flask in the Detector shed	• Explosion and Shrapnel hazard	• The insulating vacuum system has thin windows that will implode if ruptured, making a very loud sound, violently scattering window fragments and probably rupturing the target flask as well. Should the target flask rupture first, the insulating vacuum system may be over pressured and burst also. Either way, the result is violent spray of window and target flask fragments and liquid hydrogen that easily could permanently blind anyone standing nearby.
• Pressurized Helium Gas: For refrigeration. It is in the detector shed	• Explosion and Oxygen depletion hazard	• Helium gas is pressurized to 300 psi in the process cycle of the refrigerator. This gas presents the normal pressurized gas hazards during operation. In addition, pressurized gas can be trapped in the system when shut down, and must be positively removed before any maintenance is done on any process component (cold-head, compressors, interconnecting piping, etc.).
• Chemicals and lubricants	• (see MSDS for information on hazards)	• A variety of chemicals, lubricants, and solvents are required for normal operations and maintenance. See the appropriate Materials Safety Data Sheets (MSDS) before opening any containers. Protective equipment may be required.
• Electrical Hazard	• Shock and Burn	• A variety of electrical circuits from instruments circuits to 480 Volt, 3- phase, power circuits are present. Normal precautions and procedures for electrical equipment are required. Electrical operations may only be done by adequately trained people. • High voltage at low current (1-3 kV, 2 - 3 mA is supplied to photomultiplier tubes via coaxial cables. There is no exposed high voltage.
• Radiation Hazard	• Exposure to ionizing radiation	• The only significant source of radiation in the detector shed is the neutron beam. The procedures and interlocks in place ensure that no personnel are in the shed when the neutron shutter is open.

• Egress	• Tripping over obstacles	• The detector shed is a small and congested space, containing obstacles such as detector stands and shielding walls.
• Laser	• Eye damage	• The experimental equipment includes a pulsed nitrogen laser that is completely enclosed in a wooden box. The laser should be operated only when the box is locked.

3.1 EMERGENCIES

In any emergency, the operator's first duty is clear everyone away from the target and out of the detector shed**.** Then the Operator may attend to the target system.

If in doubt as to the exact target system emergency action to take---DO NOTHING. The system has a number of safety devices that should prevent equipment damage even if the operator does not intervene. However, the actions described in this HCP are recommended in general. Notify a Fully Certified Operator as soon as practicable.

Prepare! Know in advance where and how to call for emergency assistance. Know how to describe your location: "LANL TA-53, Building 29, Target-4 Flight Path 15 Right".

Telephones (dial 911) are located in:

- MPF-29
  (east side by shutter controls)
- MPF-625
  (Boeing shed - next to 4FP15R shed)

Intercoms (call CCR or HP) are located in:

- MPF-29
  (east side by middle double doors)

As a last resort, pull a fire alarm - however, be aware that while this will bring the fire department, it will not automatically bring appropriate emergency medical assistance**.**

3.2 GENERAL PROCEDURES

1. Survey the scene. Spot all the hazards and all the injured before rushing to help. Don't become another victim. Attend to life-threatening situations first.
2. Turn off power as appropriate.
3. Call 911

Start CPR and/or first aid as soon as possible.

3.3 FROSTBITE AND TISSUE FREEZING

1. Call 911 and request an ambulance. Stay on the line until the dispatcher has confirmed your location and the nature of the accident.
2. Remove any clothing that may restrict circulation in the frozen area.
3. Do not rub frozen parts; tissue damage will result. If parts of the feet are frozen, do not walk.

3.4 ELECTROCUTION/ELECTRIC SHOCK

1. Call 911 for assistance and ambulance, and provide CPR or first aid until help arrives.
2. If an ambulance is needed, tell the dispatcher. Stay on the line to provide all requested information.
3. Working on or with energized, potentially hazardous electronic and electrical equipment requires appropriate training and procedures.

3.5 FIRE

If any fire occurs, regardless of the severity, call the fire department on 911. If an ambulance is needed, tell the dispatcher. Stay on the line to provide all requested information.

4.0 THE SYSTEM

The target system consists of a target flask containing liquid hydrogen, an insulating vacuum chamber in which the flask is placed, a refrigerator/compressor system for condensing liquid hydrogen from hydrogen gas, and associated "plumbing," valves, and controls. A simplified piping diagram of the system is shown in Appendix C. Appendix D lists the target flask parameters and Appendix E contains a complete schematic diagram showing all the flow components and sensors. The system is protected by a set of interlocks that are described below.

4.1 INSULATING VACUUM SYSTEM

ROUGH VALVE (V21):

To open the rough valve, the following conditions must be met:

1. Rough Pump ON
2. Purge Valve (V10) CLOSED
3. High Vacuum Valve (V31) CLOSED
4. Cold Trap evacuation Valve (V20) on pump cart CLOSED

NOTE: Electrical conditions may be met and valves still not operate due to a lack of air pressure from the compressor located in MPF-29.

FORE VALVE (V30):

To open the Fore Valve, the following conditions must be met:

1. Fore Pump ON
2. TC-2 LESS than 200 microns (see NOTE for Rough Valve above)

DIFFUSION PUMP:

To turn on the Diffusion Pump, the following conditions must be met:

1. Fore Pump ON
2. Fore Valve (V30) OPEN
3. TC-2 LESS than 200 microns
4. Cooling Water FLOW (flow switch CLOSED)
5. Temperature Switch CLOSED (opens if pump overheats)

***HIGH VACUUM VALVE*:**

To open the High Vacuum Valve, the following conditions must be met:

1. Fore Valve (V30) OPEN
2. Diffusion Pump ON
3. TC-2 LESS than 200 microns
4. TC-3 LESS than 50 microns
5. PG-1 LESS than 10^{-3} mm Hg
6. PG-2 LESS than 10^{-3} mm Hg

NOTE: Rough Valve (V21) will close automatically when the High Vacuum Valve opens. Also, if the High Vacuum Valve is closed by the action of any of the interlocks, such as a rise in the insulating vacuum, Rough Valve will open automatically, provided that the V21 operating switch is cocked to Open.

4.2 TARGET SYSTEM

PURGE VALVE (V10):

To open the Purge Valve, the following conditions must be met:

1. Rough Pump ON
2. Rough Valve (V21) CLOSED
3. TC-3 LESS than 50 microns
4. Hydrogen Supply Valve (V1) CLOSED
5. High vacuum valve (V31) OPEN

HYDROGEN SUPPLY VALVE (V1):

To open the Gas Supply Valve, the following conditions must be met:

1. Purge Valve (V10) CLOSED
2. TC-3 LESS than 50 microns

TARGET CONTROL HEATER:

For the heater to operate the following condition must be met:

Compressor must be OPERATING.

This interlock is designed to protect the Refrigerator system if the Compressor fails or if the heater continues to operate after the system has been shut down.

5.0 OPERATIONAL PROCEDURES

5.1 PROTECTIVE EQUIPMENT

Eye and ear protection and protective clothing may be required, as specified below, for personnel working in the detector shed. Approved eye protection is a face shield, goggles, or safety glasses WITH side shields. Approved hearing protection is ear muffs or plugs that give at least 27 dB sound reduction.

Skin protection (gloves, coveralls, etc.) is required by anyone handling or in position to contact cold components. Long-sleeved cotton shirts or jackets, full-length trousers, and closed-toed shoes are required for all workers.

5.2 ENTERING THE DETECTOR SHED

Before entering the detector shed, you must check the target control panel to determine whether there is liquid hydrogen in the target flask. If the "bottom" target indicator light is illuminated, there is liquid hydrogen in the target.

5.21 Entering the shed when the target is empty

When the target is empty, but under vacuum, you may enter the detector shed. The major hazard in the shed is from the thin window on the target vacuum chamber. You should make sure that the protective cover is over the thin vacuum window. It is required that you wear eye protection and recommended that you wear ear protection when in the shed when the chamber is under vacuum. Closed-toed shoes are also required. In addition to the hazard associated with the vacuum chamber you should be aware of other hazards such as high-voltages on the photomultipliers, tripping over obstacles, etc., as described in Section 3.0. Because of the hazards, the **"buddy system,"** in which another person knows that you are in the shed and can check on you, is **recommended** during regular working hours and is **required** after 5:00 pm and at all times on weekends and holidays.

5.22 Entering the shed when the target contains liquid hydrogen

You may enter the detector shed when there is liquid hydrogen in the target. The major hazard, in addition to the hazard associated with the vacuum chamber, is the possibility of the target cell rupturing or leaking, resulting in a hydrogen fire or explosion. To enter the shed when hydrogen is in the target:

1. You must wear eye and ear protection, a long-sleeved shirt or jacket, full-length trousers, and closed-toed shoes.
2. The protective cover must be over the target chamber window.
3. You must use the buddy system at all times. Another person must know that you are working in the shed and be able to check on you.
4. You should minimize the time spent in the target shed.
5. You should be aware of the proximity of the hydrogen target.

5.3 EMPTYING AND FILLING THE TARGET

Experiment 19981509 will require periodic emptying and refilling of the target flask. Such operations may be performed by a CCO after instruction in the correct procedures by a FCO.

Emptying the Target Flask

Emptying of the target flask is accomplished by closing V6. This will force the liquid into the reservoir as indicated by the level sensors. The flask levels should indicate empty and the reservoir levels should indicate full.

Refilling the Target Flask

Opening V6 will allow the target flask to fill. During filling, the target pressure should be monitored on the digital pressure indicator at the top of the Control Console and kept below approximately 17 psia. If the pressure rises above this value, V6 should be closed until the pressure drops to 15 psia or below, at which time V6 may be reopened. If the pressure rises above 19.5 psia the relief valve will open and hydrogen will be vented into the stack.

5.4 ADJUSTING THE PRESSURE CONTROLLERS

The target pressure should be adjusted to 15 psia. For an accurate pressure indication, see the large mechanical pressure gauges on the refrigerator cold- heads.

5.5 VENTING THE TARGET SYSTEM

In an emergency, the flask can be vented into the stack by opening V7 (Emergency Vent Valve) which is mounted on the Pump Cart. The control for this valve is on the Control Console in MPF-29. This is a momentary contact switch and the vent is open for as long as the button is pressed.

5.6 EMERGENCY SITUATIONS

These situations require rapid Operator attention and, usually, immediate Target System shutdown. *In any emergency, the Operator's first duty is to get everyone away from the target and out of the detector shed*. Then the Operator may attend to the target system.

Emergency situations include:

- Alarms
- Hydrogen Sensor Failure
- Loss of Insulating Vacuum
- Rupture of Target Flask
- Temperature Controller Inoperable
- Refrigerator Inoperable
- Power Failure

5.6.1 ALARMS

Several alarms are installed in the system. Local Sonalert signals are used to alert the attending Operator to conditions that require immediate attention and are probably emergencies. Sonalerts are installed at

- the Control Console in MPF-29
- Data Room 6 in MPF-7

The attending Operator is to investigate any alarm and either fix the problem or get help. The Operator is to be sure that everyone leaves the detector shed immediately. When the system is not attended, an automatic phone dialer system will report alarms by cycling through a list of phone numbers. The first number to be called is the telephone in Data Room 6 in MPF-7. If an experimenter is present, as will generally be the case, he/she should investigate the alarm, either fix the problem or get help, and reset the phone dialer. The phone dialer system will also call CCR and the office and/or home numbers of selected Certified Operators. It is the responsibility of anyone receiving a call to investigate the situation.

There are three sensed variables:

1. Target pressure HIGH or LOW
2. Shed H2 > 10% of LEL
3. Shed H2 > 20% of LEL

The alarm response for any of these three conditions is:

- Phone dialer ON
- Local sonalert ON
- Data room alarm ON

A description of each alarm condition is given below:

- Target pressure HIGH or LOW:

The pressure controller is in the Control Console near the top. Normally the controller set point is 15 psia and the alarms are set at 13 and 17 psia. Local atmospheric pressure is 11.5 psia and the relief valves open about 19.5 psia.

Target pressure is a good summary indicator of the health of the entire cryogenic system. Failure of almost any sub-system (e.g., refrigerator, pressure controller, vacuum system) will cause pressure to go out of bounds. The Operator will need to check the status of these systems in order to discover the root cause of the pressure alarm.

- Shed H2 > 10% of LEL:

The hydrogen sensor electronics chassis is mounted on the wall to the left of the Control Console. For each sensor there is a meter showing hydrogen concentration and lights showing alarm and electronics status. The two sensors are in parallel for redundancy; an alarm by either sensor will initiate automatic action.

- Shed H2 > 20% of LEL:

Same as for detector shed H2 > 20% of LEL, above.

5.6.2 HYDROGEN SENSOR FAILURE

If one hydrogen sensor fails, it can give a false indication that hydrogen in the Shed is above 20% of LEL. While not strictly an emergency in that no unsafe situation is created, such an

unnecessary shutdown is inconvenient for the experiment. A Fully Certified Operator must be called.

Determine if the alarm is false.

1. Examine all target instrument readings, particularly the target pressure and insulating vacuum.
2. Compare all target instrument readings with normal values from the log book, particularly with the last set of readings. There should be NO deviation from normal readings.

If the alarm is false:

1. Call a Fully Certified Operator (FCO).
2. The FCO will verify the diagnosis of a failed sensor.
3. The FCO will restart the refrigerator and refill the target if necessary.

If the alarm is true:

1. Call a Fully Certified Operator (FCO).
2. The FCO, with the help of the Conditionally Certified Operator, will try to find the leak, fix it, and restart the refrigerator, if advisable.
3. Two people must work together on this problem. It is not permissible for one person to work alone. Further, the two people must agree on each step of the work before it is performed.

If BOTH hydrogen sensor systems fail, the target must be shut down or continuously monitored.

5.6.3 LOSS OF INSULATING VACUUM

Loss of the insulating vacuum will increase the heat leak and the liquid will boil vigorously, quickly raising the system pressure. If left unattended, the pressure will rise to the lowest set pressure of the relief valves (20 psia) and will remain there until all liquid has vaporized and system is vented. The High Vacuum Valve V31, which is interlocked with Thermocouple Gauge TC3, will close automatically.

Symptoms of insulating vacuum loss are:

1. High Target System pressure.
2. Vacuum System at atmospheric pressure as indicated by Ion Gauge PG2 and Thermocouple Gauge TC3.

In case of Insulating Vacuum loss:

1. Turn OFF Temperature Controller.
2. Open Emergency Vent Solenoid valve (V7) momentarily IF required to keep the System pressure around 20 psia. (strictly speaking, this is not required, as the system relief valves should keep the Target Flask safe, but it results in gentler treatment of the Flask.)
3. Check that the High Vacuum Valve (V31), Roughing Valve (V21) and the Target Fill Valve (V2) are CLOSED and the Target Vent Valve (V6) is OPEN.

4. When the liquid has boiled away and the System pressure is essentially stabilized, turn OFF the Compressor and then the Refrigerator.
5. Watch the System pressure a while longer, OPENING the Emergency Vent Solenoid Valve (V7) as required.
6. Notify a Fully Certified Operator as soon as practicable.

5.6.4 RUPTURE OF TARGET FLASK

If the Target Flask ruptures, the liquid will spill into the isolating vacuum volume where it will quickly vaporize, raising the pressure in the vacuum space. The High Vacuum Valve (V31) will close automatically as the pressure passes 50 microns (set point of TC3) and the Vacuum Chamber Relief Valve (R20) will open when the pressure passes 11.5 psia (1 Los Alamos atmosphere), venting the gas into the stack.

Symptoms of Target Flask rupture are:

1. Target pressure indicator at 11.5 psia.
2. Insulating vacuum at atmospheric pressure as indicated by TC3.

In case of a Target Flask rupture:

1. Set the Temperature Controller mode switch to OFF.
2. Check the Target pressure (11.5 psia).
3. Check that the High Vacuum Valve (V31), the Roughing Valve (V21) closed,
4. Turn off the Compressor, then the Refrigerator.
5. Notify a Fully Certified Operator as soon as practicable.

5.6.5 TEMPERATURE CONTROLLER INOPERABLE

Temperature Controller HEATS TOO MUCH:

Symptoms of too much heating are:

1. High Target pressure
2. Insulating Vacuum pressure high, as indicated by Gauges PG2 and TC3

If this occurs, the Target pressure will rise to the Relief Valve setting (approx. 20 psia) and the liquid will gradually be lost. If desired, coarse control of the Target pressure can be maintained temporarily by switching the Controller to MANUAL and cycling Heater ON and OFF as required.

If coarse control is not desired:

1. Turn OFF the Controller
2. Turn OFF the Compressor, then the Refrigerator. The Target Pressure will rise due to normal heat leak to the setting of the Relief Valves and the Liquid (gas) will gradually be lost.
3. Check that the Target Fill Valve (V2), Purge Valve (V10) and Roughing Valve (V21) are CLOSED, and the High Vacuum Valve (V31) is OPEN.
4. For gentler treatment of the Flask, OPEN Emergency Vent Valve (V7), at the Console, as required to maintain Target pressure around 20 psia. Monitor the Target pressure even after all the Liquid has vaporized, since the pressure will continue to rise slowly as the remaining gas warms.
5. Call a Fully Certified Operator to effect repairs or secure the Target System.

Temp. Controller HEATS TOO LITTLE:
Symptoms of insufficient heating are:

1. Low Target pressure
2. Insulating Vacuum improves as indicated by Gauges PG2 and TC3.

If this occurs, the Refrigerator will over cool the Target System causing the pressure to drop below atmospheric and freezing the Liquid in some parts of the system. Also air may be drawn into the Liquid system if small leaks have developed, which can cause line blockage and possible safety problems.

NOTE: Coarse control of the target pressure can be maintained by switching the mode switch to MANUAL and turning Controller Heater ON and OFF as required. Coarse control by manually switching the compressor ON and OFF is NOT PERMITTED due to the high probability of destroying the refrigerator.

5.6.6 REFRIGERATOR INOPERABLE

Symptoms of refrigerator failure are:

1. High Target pressure
2. Insulating Vacuum pressure High as indicated by gauges PG2 and TC3
3. Liquid system pressure does not drop when Temperature Controller is turned OFF

If Refrigerator appears to have failed:

1. Turn OFF the Temperature Controller
2. Turn OFF the Compressor then the Refrigerator at Console
3. Check that the Target Fill Valve (V2), and the Roughing Valve (V21) are CLOSED, and the High Vacuum Valve (V31) is OPEN.
4. For gentler treatment of the Flask, OPEN the Emergency Vent Valve (V7), at the Console, momentarily as required to keep the Flask pressure around 20 psia. Monitor the Flask pressure until it has stabilized.
5. Notify a Fully Certified Operator as soon as practicable.

5.6.7 POWER FAILURE

Without power, all remotely operated valves on the Pump Cart will close, vacuum pumps will stop, and the Refrigerator will stop. Operator action is required, depending on the duration of the outage.

For All Power Failures:

1. Clear everyone from the shed.
2. Monitor the system continuously from the Control Console in MPF-29 during the outage.

Power Failures of Short Duration: (several seconds to about 5 minutes)

The system should stay cold and not much hydrogen should be lost through the relief valve. On resumption of power:

1. Check that Rough and Fore Pumps have restarted
2. If necessary, restart Refrigerator and Compressor in that order.

3. Make sure Diffusion Pump is on; if not check the following:
   - Fore Pump is ON
   - Cooling Water is ON
   - Fore Valve (V30) is OPEN
   - TC-2 is LESS the 200 microns
4. Notify a Fully Certified Operator.

Extended Power Failures
Without refrigeration, the target pressure will slowly rise. When the pressure reaches approximately 20 psia the Hydrogen Pressure Relief Valve will open. Target gas will slowly escape. Target pressure can be monitored by mechanical gauges at the target and Pump Cart and by a transducer read-out at the Control Console. If much target gas is lost, part of the fill operation must be repeated by a Fully Certified Operator.

Conditionally Certified Operators should:

1. Advise a Fully Certified Operator early in the power outage.
2. When power is restored, check that the Rough and Fore Pumps have restarted.
3. If Compressor and Refrigerator have restarted, Turn them OFF, starting with the Compressor.
4. Call a Fully Certified Operator.

6.0 INITIAL STARTUP OF THE TARGET SYSTEM

This section describes the procedures to be followed for the initial startup of the system after any shutdown of longer than two months. These procedures are listed on the Initial Startup Checklist (see Appendix F) which must be completed and signed by a Fully Certified Operator.

- Before starting up the system, a Fully Certified Operator should check that all instruments and components are in place and are properly labeled. The piping and instrumentation should be checked against the schematic diagram.

- Before operation with hydrogen,
  1. A complete operational check of the system must be made, including all interlock actions, alarms, and controls.
  2. The set point of each relief device should be checked.
  3. Manual valve V3 must be locked OPEN and tagged.
  4. The hydrogen sensors must be calibrated and correct operation documented.

- ***During the first filling of the target with liquid hydrogen, no personnel may be present in the detector shed.*** A temporary line should be run to the liquid nitrogen trap on the pump cart, enabling this trap to be filled from outside the shed.

- No personnel may enter the shed until the target has been filled, the hydrogen pressure raised enough to open the hydrogen relief valves R3 or R4, and the pressure reduced to 15 psia, the normal operating pressure.

7.0 SHUTTING DOWN THE TARGET SYSTEM

This section describes the procedures for shutting down the target system at the conclusion of an experimental run, or prior to removal of the target flask. Turn the system off about 48 hours before removal is scheduled. This will allow everything to warm above the dew point so that water will not condense on the cold surfaces when the various lines are disconnected.

Valve Off Insulation Vacuum Pumps:

1. Close High Vacuum Valve V31.
2. Verify that Roughing Valve V21 switch shows all green. If necessary, press the V21 switch once.

Valve Off Hydrogen Gas Supply:

1. Close (or verify closed) Hydrogen Supply Valve V1.
2. Close (or verify closed) Target Fill Valve V2.
3. Close (or verify closed) valve on hydrogen gas cylinder.

Prepare the Detector Shed:

1. Verify that vent lines (a 1" steel-braid covered flex hose from front of the pump cart and 1" copper line from target relief valve) are connected to vent stack.
2. Clear all personnel from the detector shed.

Shut Off Cooling:

1. Switch Pressure Controller mode switch to OFF. DOUBLE-CHECK THIS!
2. Reset Pressure Controller Set-point so that Set-point pressure on the DVM is < 1.
3. Shut Off Compressors
4. After 30 seconds, shut off Refrigerators.

Monitoring as Liquid is Boiled off:

1. Watch target pressure and liquid level indicators. Pressure should not exceed the setting of the relief valves (~19.5 to 20 psia). If pressure has risen higher than 21 -22 psia, open Emergency Vent Valve V7 as required.
2. Watch insulating vacuum thermocouple gauge TC3. It should rise substantially as condensed gases are vaporized. This is OK, as these gasses will provide convective heat transfer to warm the cold components.
3. Watch liquid level indicators. Continue to monitor the system as above for 30 minutes after the lowest indicator shows no liquid.
4. People may reenter the detector shed after the target pressure, vacuum, and other variables that might effect the target pressure have been stable for 30 minutes.

Monitoring After Liquid is Boiled off:

1. People may now reenter the shed.

2. Monitor the system periodically.
3. The target pressure should hold at the relief valve pressure setting.
4. The insulating vacuum (mechanical gauge on the side of the target vacuum chamber near the diffusion pump) should not show a positive gauge pressure, and will normally indicate a vacuum near 15-20 inches Hg. If this pressure nears zero gauge, re- pump the insulating vacuum space with Roughing Valve V21.

Shut off Diffusion Pump:

1. Shut off the diffusion pump heater (schematic panel switch labeled "Diffusion Pump").
2. Leave Fore Valve V30 open and the Fore Pump On.

8.0 TARGET MAINTENANCE

All relief devices are to be piped to a vent stack that discharges to a safe location.

8.1 HYDROGEN SYSTEM MAINTENANCE

1. Before admitting air into any system component or doing any work on it, all hydrogen must be removed and the component purged with inert gas.
2. Hydrogen should only be vented into the stack.
3. Vacuum pumps used to remove hydrogen must be plumbed to have a continuous flow of inert gas (nitrogen is fine) injected into the suction stream.
   - Be sure the pump's ballast valve is closed (an open valve draws in air!).
   - Purge the pump by pumping a pure stream of inert gas.
   - While continuing to flow inert gas, open the valve admitting hydrogen and pump the mixture. Continue the inert gas flow during the entire hydrogen pumping process.
   - After all hydrogen is pumped away, continue pumping inert gas for several minutes to purge the pump.
4. Refill the component with inert gas, re-evacuate, and refill with inert gas or air before opening or doing maintenance.

8.2 MAINTENANCE ON ANY SYSTEM USED WITH COMPRESSED GAS

Included are the process gas circuits of the refrigerator (the compressors, cold-head, interconnecting piping) and the hydrogen gas supply system. Only FCO's should perform disassembly of or maintenance on the system.

Primary hazards are from compressed gas and from the combustible hydrogen. High pressure gas can be trapped in sections of the systems, and can discharge or blow parts out when the system components are disassembled.

Before any components are disassembled:

1. Turn off all compressors and any electrical equipment in the area to be maintained. Lock and Tag the breakers according to Laboratory procedures.
2. Be sure that all gas has been bled off, that possible sources of new gas have been valved off, and that all vent paths have been opened, and tagged according to Laboratory procedures.

After maintenance is complete:

1. Verify that all components have been properly reassembled.
2. Remove any vent valve tags and close valves according to Laboratory procedures.
3. Remove any gas valve tags according to Laboratory procedures.
4. Leak- and pressure-check as appropriate.
5. Remove electrical lock-and-tags according to Laboratory procedures.

APPENDIX A

Date						
Time						
Operator's initials						
AT THE CONSOLE						
Target Pressure (elect.)						
Power Meter (Watts)						
PG-1						
PG-2						
TC-1						
TC-2						
TC-3						
Cooling Water Temp.						
Air Tank Pressure						
AT THE TARGET						
Target Pressure (mech.)						
Vapor Pressure						
AT THE COMPRESSORS						
Supply pressure						
Return pressure						
Oil pressure (1)						
Front sight glass (1,2)						
Middle sight glass (1,2)						
Compressor Sump level (3)						
AT THE PUMP STATION						
H2 bottle pressure						
He bottle pressure						

REMARKS: _____

_____

_____

_____

_____

_____

_____

_____

_____

NOTES: **(1) Not on 1020R comp'r** **(2)** NO **oil should be visible** **(3) Oil level** SHOULD **be visible**

APPENDIX B

FULLY CERTIFIED OPERATORS

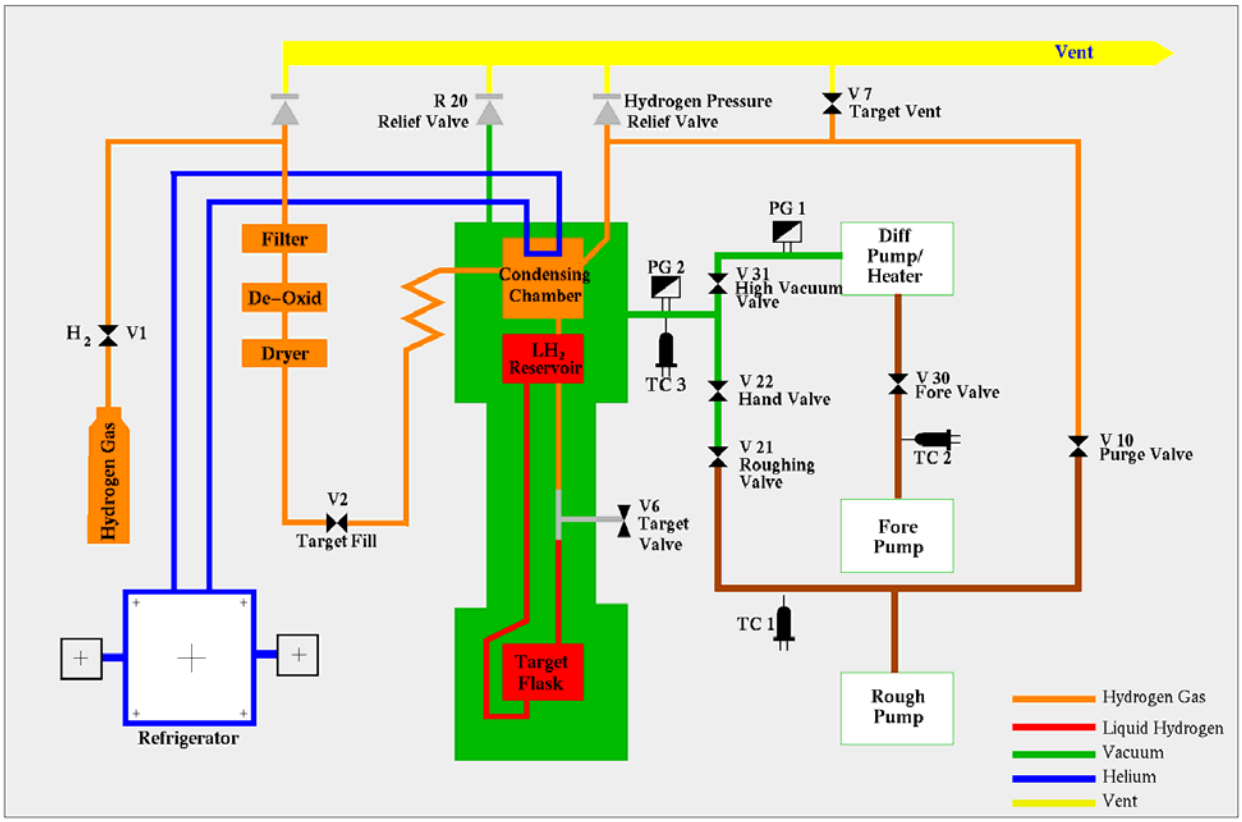
NAME	OFFICE	HOME	PAGER
Art Bridge	665-4124	672-1079	8-1-505-699-2796
Lloyd Hunt	665-6300	662-9338	104-8738

CONDITIONALLY CERTIFIED OPERATORS

NAME	OFFICE	HOME	OJT Briefing by	Date
Stephen Wender	7-1344	983-3634	_____	_____
Terry Taddeucci	5-3114	983-5231	_____	_____
June Matthews	7-2926		_____	_____
Yasar Safkan	5-6444		_____	_____
Taylan Akdogan	5-6444		_____	_____

APPENDIX C

PIPING SCHEMATIC: REFRIGERATED H_2 TARGET



APPENDIX D

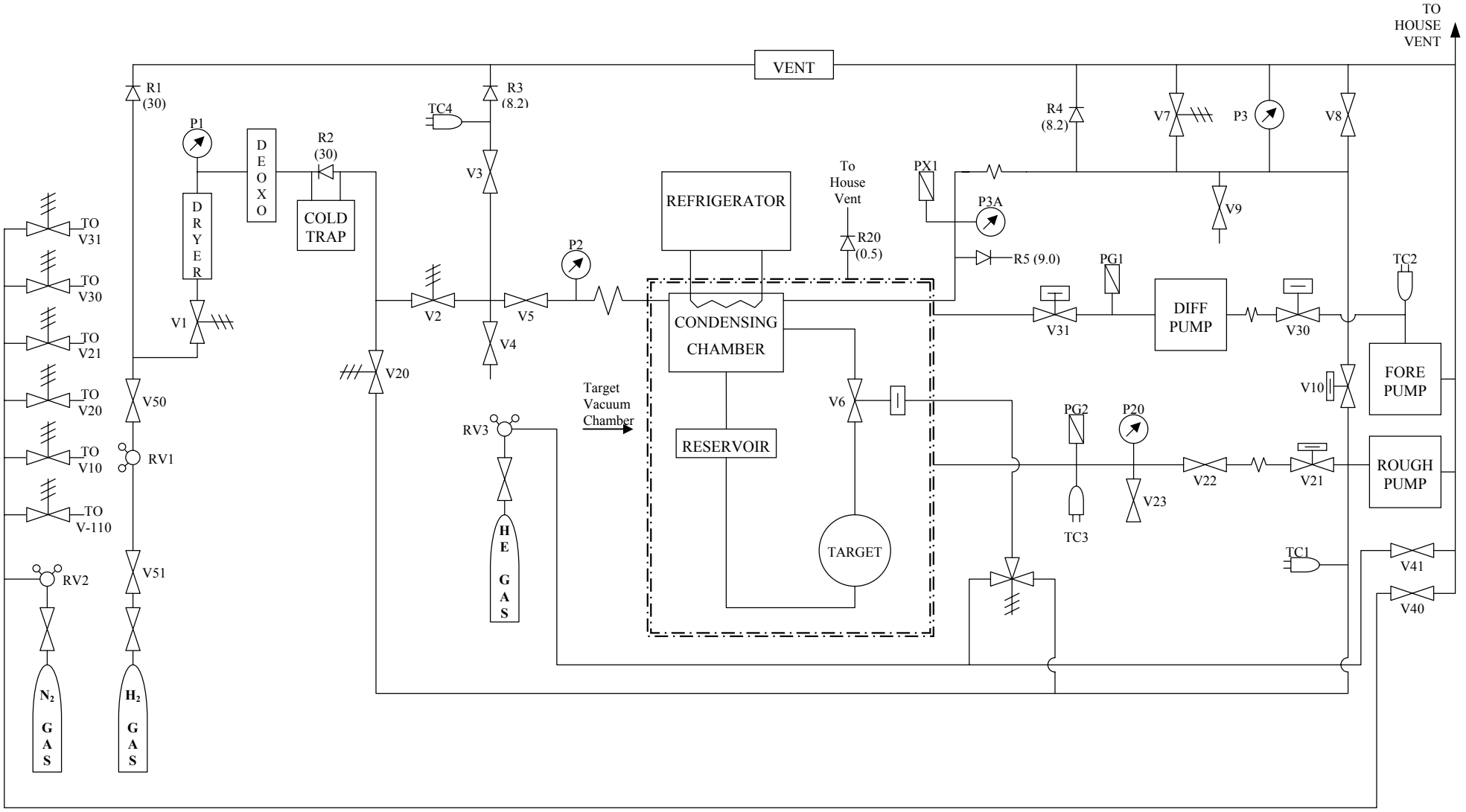
LIQUID HYDROGEN TARGET FLASK PARAMETERS

Drawing Number	9Y87590
Flask Geometry	7.62 cm diam × 15.24 cm high cylinder
Flask Material Thickness	Top and bottom caps .64 cm stainless windows = 0.002" Aramica*
Flask Insulation	Several layers of 0.00025" aluminized mylar superinsulation
Liquid Capacity	approximately 0.7 liter
Target Gas	hydrogen
Normal Operating Pressure	15 psia
Approximate time to fill from warm	12 hours
Approximate time to change Target Gas	N/A
Pressure change in hydrogen gas supply cylinder corresponding to given liquid volume (psi difference)	0.7 liters = 210 psi

*Aramid film, manufactured by Asahi Chemical Industry, with tensile strength 1.6 times that of Kapton

APPENDIX E

10–WATT REFRIGERATED H_2 TARGET FLOW SCHEMATIC



APPENDIX F

INITIAL STARTUP CHECKLIST

___ All instruments and components in place and labeled correctly

____ Schematic diagram correct and complete representation of current system

____ Hydrogen sensors calibrated

____ Hydrogen sensors tested

____ Sonalert operational

____ Phone dialer operational

____ All compressed-air operated valves operational

____ All vacuum interlocks operational

____ Set points of relief valves R1, R2, R3, R4, R5, and R20 checked

____ All relief valves tested

____ Target vent V7 operational

____Manual valve V3 locked OPEN and tagged

I certify that these procedures have been completed and that all devices are operational.

_____

Signature of Fully Certified Operator

By signing below Sample Handlers certify that they have read and understood this HCP and meet the training requirements specified:

Matt Devlin (LANSCE-3)	7/3/02 Date
Karen Corzine (LANSCE-12)	Date
Gregg Chaparro (LANSCE-3)	Date
Lloyd Hunt (LANSCE-3)	Date
Art Bridge (LANSCE-3)	Date
Nolan Hertel (Georgia Tech)	Date