LANSCE Division
Hazard Control Plan Cover Sheet

Removal of solid oxides from the DELTA Loop Melt Tank		
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Authors:	**Signature**	**Date**
Valentina Tcharnotskaia	V Tcharnotskaia	4/2/2003

Initial Risk Level: Medium		
REVIEW/APPROVAL		
Reviewed by:		
Ning Li	Ning Li	4/3/2003
Frances Aull	Frances Aull	4-2-03

Residual Risk Level: Low		
Approved by:		
Steve Wender	Steve Wender	4/3/03
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HAZARD CONTROL PLAN
Activity #   LANSCE-3 HCP–01-

Removal of solid oxides from the DELTA Loop Melt Tank

1. Definition of Work

This HCP and Procedure serve as addendum to the main DELTA Loop Operations HCP and Procedures

A molten Lead-Bismuth Eutectic (LBE) test loop has been built to study corrosion and thermalhydraulics of the liquid metal. In this facility, LBE is melted in a melt tank and then transferred to the pump sump tank and to the loop by gas pressure. The pump is activated to create flow in the loop. Alternatively, lead-bismuth is circulated in a free convection mode, without the mechanical pump.

Certain amount of oxygen has to be maintained in the loop. When too much oxygen is present lead oxides are formed and they can impede the liquid metal flow.

Oxygen content will be improved if the solid oxides are removed before the liquid metal is transferred into the loop. For that manual removal of solid oxides from the melt tank will be undertaken.

The test loop (DELTA) is located at the north end of the high bay area of MPF-18. The loop is shown in Figure 1, without the supporting I-beam structure or the containment box. The melt tank is the large conical tank with a hemispherical top at the lower level of the loop. We will access the inside via the 8” opening at the top.

2. Procedure

1) Evacuate the entire DELTA loop to rough vacuum.
2) Fill the entire DELTA loop from the sump tank and the expansion tank with the cover gas (He or H_2/He mixture) to about 5 psig.
3) Preheat the melt tank to the desired temperature from 150ºC to 300ºC using the main DELTA DAC program. Loop piping may be heated as well.
4) Close fill valves FV101 and FV102. Close Equalizing gas valves FV205 and FV208.
5) Reduce the melt tank pressure to 1 to 3psig.
6) Fill DELTA loop from the sump tank and the expansion tank with the cover gas (He or H_2/He mixture) to pressure about 10 psig higher than the pressure in the melt tank.
7) Prepare the tools such as the stirrers, the scoops, and the vessels for the slug to be removed.
8) Ensure the enclosure ventilation is on.
9) Wearing PPE (see later) remove the top 8” cover plate from the melt tank.
10) The worker removing the lead oxides (slug) can do so either from a step ladder next to the melt tank, sitting on the side of the melt tank if it is not too hot or from the floor of the loop’s second level.

11) Stir the liquid lead bismuth with a stirrer.
12) Skim the solid slug from the surface of the liquid metal and put it into the slug container. Stir and skim until as much of the solid slug is removed as possible.
13) Store the slug in the large drum marked "lead slug".
14) When done replace the cover with a new Graphlock gasket and tighten the bolts to the required torque.
15) Pressurize melt tank with the cover gas to about the same pressure as the loop.
16) Open equalizing gas valves FV205 and FV208. Open fill valves FV101 and FV102.

Facility interfaces:
1) Melt tank heater power. 45 kW at 440 V, with variable voltage power supply. Power set by operator via computer (LabVIEW based software).
2) Trace heaters for preheating the loop and temperature control. Nominally 50 kW at 220 V.
3) Main heater power. Nominally 80 kW at 220 V.
4) 110 V power to lights, computer, etc.
5) Cooling water to heat exchanger, motor cover, and water jackets for freeze plugs. Nominally 70 kW, room temperature supply water.
6) Building ventilation system, approximately 1.5 air exchanges per minute, coupled to system containment box.
7) Compressed air for pneumatically actuated valves (80 PSI).
8) He or H_2/He mixture gas through building supply lines from bottle farm outside the building.

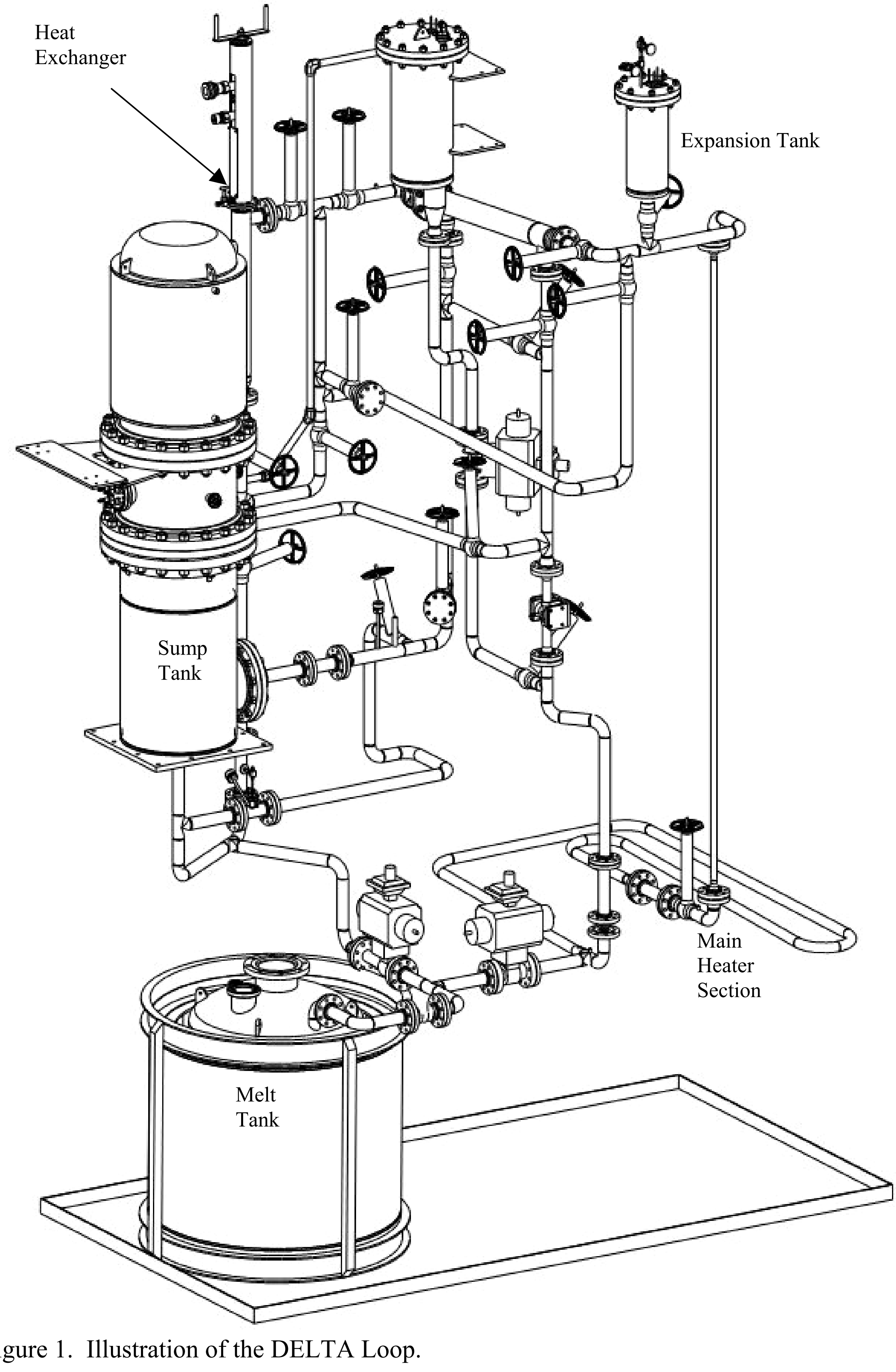

Figure 1. Illustration of the DELTA Loop.

2. Identification of Hazards

The hazards associated with this activity are:

Thermal (heat). There are heaters on the melt tank and the loop piping. Operating temperatures are from 150ºC to 300ºC. Thermal hazard may also be present in the event of an accidental spill of molten metal.

Electrical. Electricity provides power for the heaters and instrumentation. Typical power and voltages are listed above.

Chemical. A primary constituent of the molten metal is lead, which is a toxic, RCRA-controlled substance. Approximately 3.5 tons of LBE (45% lead) will be inside the melt tank. Lead oxide will be present inside the vessel. Lead oxide may exist as a particulate that can become airborne.

Hydrogen gas (in a 6% solution with helium) will be used as cover gases for the DELTA loop and the melt tank. Hydrogen is flammable, therefore, it represents potential fire hazard.

Bi dust/air mixture may ignite or explode under certain conditions.

Physical. We will be inside the loop enclosure with low pipes and other structures. We will use ladders to access the melt tank opening. We will use hand and electrical tools.

Stored energy (pressure.) The system pressure is controlled from weak vacuum (1 Torr) up to 20 PSIG. Pressure is maintained by pressurizing a He or H_2/He mixture cover gas.

3. Waste Streams

This operation will some amounts of waste lead oxide and lead. The lead oxides removed from the melt tank will be placed into a drum designated to accept them. This drum already contain lead oxide slug from the initial fill of the DELTA loop. It is marked "LEAD OXIDE SLUG. FOR RECYCLING". Other waste may include lead or lead oxide-contaminated rags, gloves, or other objects. The satellite accumulation area at the north side of MPF-18 will be used for storage of this waste. All waste storage and disposal will be conducted according to LANL and LANSCE policies under LANSCE waste coordinator guidance.

4. Initial Risk Level Determination

Based on LIG300-00-01.0, Safe Work Practices Implementation Guidance, the initial risk level is **MEDIUM.** The rationale for this initial risk level assessment is as follows:

- Thermal (heat). The accidental spill of molten metal has the potential to cause a major injury, and there is a slight chance of it occurring. Loop piping and the melt tank will be heated to temperatures up to 350ºC during operation, which would cause injury in the event of contact. The probability of this event is low to medium. This combination of severity and likelihood results in a **medium** initial risk.
- Electrical. The electrical power and voltage that are being used have the potential to cause a major injury, however, the likelihood of such an occurrence is improbable. This combination of severity and likelihood results in a **low** initial risk.
- Chemical. Lead contamination has the potential to cause occupational illness or environmental harm and the likelihood of such an occurrence is occasional. This combination of severity and likelihood results in a **medium** initial risk.

  Helium/hydrogen gas bottle are placed outside of the south side of the loop enclosure and outside of the building in the designated gas bottle rack.. An explosion or fire due to a hydrogen reaction would cause injury, but the probability of such an event is improbable. Thus the risk in this case is **low**.

  Bismuth dust/air mixture may ignite or explode under certain conditions, which would cause injury, but the probability of this event is remote. Thus, risk in this case is **minimal**.
- Physical. The physical hazards have the potential to cause major injuries, however, the likelihood of such an occurrence is improbable. This combination of severity and likelihood results in a **low** initial risk.

5. Hazard Controls

5.1 Thermal Hazard.

5.1.1 Eliminate the hazard. Heated surfaces are an unavoidable part of operations at temperatures up to 350ºC.

5.1.2 Design to reduce the hazard. Insulation is applied to most hot surfaces. The melt tank heater is enclosed in a ceramic insulation and the top of the tank is insulated and covered with steel sheets so no accidental access to the heater is allowed.

5.1.3 Engineering controls. The entire loop is inside a containment box, which precludes incidental contact.

Heaters on the DELTA loop are controlled by a Data Acquisition and Control System (DAC). The DAC consists of a computer program running on LabView and several independent control devices. The DAC checks thermocouple readings throughout the loop and turns heating zones on and off according to corresponding temperature set points provided by the operator. The set points cannot be entered higher than the corresponding maximum temperatures. The DAC program includes checks for thermal emergency conditions such as overheating. All thermocouples are provided with corresponding maximum values in a table on "Presets" page of the DAC program's front panel.

If any of the thermocouples' readings are above the maximum value, the program activates SCRAM. SCRAM means that the power supply circuit to the pump, the heaters and the valves is interrupted. Power shut off causes the pump to stop and the heaters to turn off.

In addition to the DAC program, a separate, independent temperature reading device monitors at least one thermocouple from every heating zone and checks it against the stored maximum value. If the reading is higher than maximum, the device causes SCRAM.

5.1.4 Warning devices. Signs will be posted around the enclosure during operations, stating:

WARNING
Hot Surfaces **Electrical Hazards** **Stored Energy (pressure)**
Lead Use Area **No eating or smoking**

A list of system operators will also be posted with a warning that unless there is an emergency no one else should be inside DELTA Loop fence without escort.

5.1.5 Administrative controls.

PPE

PPE for both workers is leather chaps, leather jacket, hardhat, face shield, safety glasses, thermally insulating gloves, safety shoes and RESPIRATOR.

Workers have to read this HCP and Procedure and sign the acknowledgement log.

Only the Cognizant Engineer (see part 10 "System Operators and Cognizant Engineers") assigned to the specific operation can authorize changes to the maximum temperature values in the DAC program and in the independent temperature checking devices. This can be done only if:

- No new hazards are introduced.
- No existing hazards are exacerbated in any way.
- No hazard controls are circumvented or compromised in any way.

These changes will be recorded in the operation log.

5.2 Electrical Hazard.

5.2.1 Eliminate the hazard. Electrical power is required; associated hazards cannot be eliminated.

5.2.2 Design to reduce the hazard. Approved equipment and procedures are used.

5.2.3 Engineering controls. The entire loop is inside a containment box, which precludes incidental contact with resistance heaters. The melt tank heaters are fully enclosed. Ground fault interrupt devices protect personnel and equipment in the event of current leak to ground.

5.2.4 Warning devices. Signage as indicated in Section 5.1.4 will be posted.

5.2.5 Administrative controls. All electrical work will be conducted according to DELTA Operations HCP.

All workers have Electrical Training for the R&D worker or equivalent.

5.3 Chemical Hazard.

5.3.1 Eliminate the hazard. The chemical hazard is lead, which comprises 44.5% of the lead-bismuth eutectic. LBE is the working fluid of the DELTA loop, so this hazard cannot be eliminated.

Hydrogen is an essential part of oxygen control system in the DELTA loop and cannot be substituted.

5.3.2 Design to reduce the hazard. Lead-bismuth will be in the melt tank throughout the operation. The melt tank was designed to contain all of the present lead-bismuth under 100psig of pressure. We will not have more than 20psig in the melt tank and during operation it will be open under atmospheric pressure.

A worst-case scenario spill accident is described in the main DELTA loop HCP. Under 300°C a spill presents even less of a problem than during normal loop operations. See below.

Lead vapor content at different temperatures is shown on Table1. We will not heat lead-bismuth in the melt tank above 300°C. The amount of lead in the air above open melt tank is about 10.2μg/m^3, which is below LANL action limit of 30μg/m^3.

Also, the loop enclosure is ventilated.

T (°C)	Vapor Pressure (Pa)	Vapor Density (μg/m^3)
235	1.30E-06	0.064
260	1.70E-06	0.079
270	7.00E-06	0.321
520	1.90E-03	59.64

Table 1. Lead vapor content. Lead-bismuth vapor is assumed to be all lead for this analysis. Experimental data from IPPE, Obninsk, Russia.

However, there may be particulates of lead oxide settled on the inside walls of the melt tank. That compound takes a form of fine black powder. To prevent ingress of lead oxide the workers will wear full-face respirators.

The LANL compressed gas supplier supplies hydrogen in bottles standard for these gases under pressure. The partial pressure of the hydrogen is 6%. The bottles are installed outside of the south wall of the DELTA enclosure inside Building 18. They are mounted upright using standard LANL gas cylinder fixtures. The air volume around the gas cylinders is large enough to provide adequate ventilation and to prevent flammable concentration of hydrogen (from 4%). Bottles will also be placed outside in a standard gas rack.

We follow LANL gas cylinder safety regulations in handling these gases.

5.3.3 Engineering controls. The entire loop is inside a containment enclosure, which prevents incidental contact with lead or lead oxide. The enclosure is based on a steel I-beam frame that is designed to withstand dead loads as well as seismic loads. Aluminum sheets are attached to the I-beams completely enclosing the loop.

The containment box is ventilated through the facility ventilation system, which filters exhaust air through HEPA filters prior to discharge. The fan in the ventilation system provides 34500 ft^3/min airflow at about 70% capacity. This flow rate provides approximately 1.4 air exchanges per minute inside the enclosure. The operating procedure includes checking for ventilation before starting. A pressure monitor is installed on the enclosure wall. Its reading is displayed on a gage on the enclosure and is transferred to the DAC computer. The DAC program stops operations automatically if positive differential pressure between outside and inside of the enclosure is not maintained.

A drip pan sized to hold 1.5 times the entire inventory of LBE covers the floor inside the containment box.

SCRAM buttons are placed at every entrance to the loop enclosure. If any conditions that warrant a shut down are observed a SCRAM button will be engaged and the pump will stop, heaters will shut off and the loop will drain.

5.3.4 Warning devices. Signage shown in 5.1.4 is posted at all work area entry points during operations:

5.3.5 Administrative controls. All workers entering the enclosure when the melt
PPE tank is empty will wear respirators, gloves and safety shoes.

In addition to above PPE if the melt tank and/or the loop are heated above 100°C the workers must wear the leather chaps and jackets.

If a significant lead-bismuth spill takes place (at least a quarter of the drip pan floor is covered) workers will wait at least 12 hours before entering the enclosure.

All workers must have lead awareness training. All workers must be on the lead surveillance program.

All workers must have safety shoes that are kept on site and used only for work in the DELTA area.

After handling lead one must wash his/her hands thoroughly. Do not eat, drink or apply cosmetics in the lead work area. Avoid introducing lead into the body.

5.4 Physical Hazard.

5.4.1 Eliminate the hazard. Elimination of physical hazards is not possible. Use of cranes, hand tools, power tools, ladders, etc. is part of the operation.

5.4.2 Design to reduce the hazard. Use of cranes, hand tools, power tools, ladders, etc. cannot be reduced further.

5.4.3 Engineering controls. None.

5.4.4 Warning devices. Signs as in 5.1.4.

5.4.5 Administrative controls. Equipment such as cranes and forklifts are used only by properly trained personnel. PPE inside the enclosure may include respirator, hardhat, leather chaps and jackets, and safety shoes. Good housekeeping practices will be enforced to minimize hazards.

5.5 Stored energy (pressure) hazard.

5.5.1 Eliminate the hazard. The system must be pressurized to operate.

5.5.2 Design to reduce the hazard. The system has been designed to ASME Boiler and Pressure Vessel Code, Process Piping and Power Piping codes. Maximum operating pressure is limited to 100 PSIG. This operation will not go above 20psig.

5.5.3 Engineering controls. The containment box provides a physical barrier between personnel and pressurized systems. Pressure checks of all vessels have been performed to 250 PSIG by an independent laboratory. The entire system has been pressure and leak checked to 120 PSIG at room temperature.

During operation pressure in the melt tank will be atmospheric and in the loop nor more than 20psig controlled by the DAC program.

5.5.4 Warning devices. Signage as indicated in Section 5.1.4 will be posted.

5.5.5 Administrative controls. Access to the containment box during operation is limited to System Operators. System Operators must have completed Low Pressure Systems Training, Intermediate and High Pressure Safety Training and Gas Cylinder Hazards Training.

Only the Cognizant Engineer (see part 10 “System Operators and Cognizant Engineers”) assigned to the specific operation can authorize changes to the maximum pressure values in the DAC program. This can be done only if:

- No new hazards are introduced.

- No existing hazards are exacerbated in any way.
- No hazard controls are circumvented or compromised in any way.

These changes will be recorded in the operation log.

6. Skills, Training and OJT Requirements for Workers

All System Operators must have completed training required to work at Los Alamos National Laboratory and at Los Alamos Neutron Science Center
In addition all System Operators must have completed the following:

Laboratory Training:
1. Hazard Communication Introduction.
2. Lead awareness.
3. Gas Cylinder Hazards.
4. Pressure Safety Orientation.
5. Low Pressure System Training.
6. Intermediate and High Pressure Systems Training.
7. Non-energized electrical worker training.
8. Ladder Safety.

The list of System Operators is provided on a signature sheet in the documents folder.

All System Operators who enter the containment box during operations must be on the lead surveillance program.

All workers involved with this operation must have completed the following On-the-Job Training:

a. Read HCP and test procedure and sign the acknowledgment log (last page of this HCP).
b. Authorization by a Lead Engineer, who has described the system and its operation to the Operator, and who acknowledges the Operators knowledge and understanding of the facility and its operation.

APPLICABLE INSTITUTIONAL REQUIREMENTS
LIR 300-00-01.3, Safe Work Practices
LIR 300-00-02.3, Documentation of Safe Work Practices
LIR307-01-01.2, Safety Self-Assessment
LIR402-100-02.0, Hazardous Waste Operations and Emergency Response Training Requirements
LIR402-510-01.0, Chemical Management
LIR402-600-01.1, Electrical Safety
LIR402-1000-01.0, Personal Protective Equipment
LIR402-1110-01.1, Forklifts and Powered Industrial Trucks
LIR402-1200-01.1, Pressure, Vacuum, and Cryogenic Systems
LIR404-00-02.3 General/Waste Management Requirements
LIR404-00-03.1, Hazardous and Mixed Waste Requirements for Generators
LIR402-840-01.0, Welding, Cutting, and Other Spark-/Flame-Producing Operations

LPR 300-00-01, Integrated Safety Management

LIG300-00-01.0, Safe Work Practices Implementation Guidance
LIG402-1200-01.0, Compressed Gasses
LIG402-1200-03.0, Gaseous and Liquid Hydrogen
LIG404-00-03.0, Waste Profile Form Guidance

AR 13-2, Cranes, Hoists, Lifting Devices, and Rigging

These documents can be viewed on-line at http://labreq.lanl.gov/hdir/labreq.html and select "Master Index by Document Number" link.

7. Residual Risk Determination

Residual risk is **LOW.** The rationale for this residual risk level assessment after implementing controls is as follows:

- Thermal (heat). With the controls in place an accidental spill of molten metal, as well as inadvertent contact with hot surfaces, has the potential to cause a minor injury. The likelihood of such an occurrence is occasional. This combination of severity and likelihood results in a **low** residual risk.
- Electrical. The electrical power and voltage that are being used have the potential to cause a major injury, however, the likelihood of such an occurrence is now remote. This combination of severity and likelihood results in a **minimal** residual risk.
- Chemical. Lead contamination has the potential to cause major occupational illness or environmental harm and the likelihood of such an occurrence is now remote. The controls in place reduce the likelihood of this occurrence to improbable. This combination of severity and likelihood results in a **low** residual risk.
  Hydrogen is flammable, therefore, it represent potential fire hazards. The dilution of these gases with helium in addition to the controls in place reduce the probability of fire to remote and the hazard risk to **minimal**.
- Physical. The general physical hazards have the potential to cause major injuries, however, the likelihood of such an occurrence is now remote. This combination of severity and likelihood results in a **minimal** initial risk.

8. Procedures

Operational procedures are in part 2.

9. Required Attachments

Use attachments in the main DELTA loop HCP.

10. System Operators and Cognizant Engineers

Cognizant Engineers on the project are:

Ning Li
Keith Woloshun
Valentina Tcharnotskaia.

Persons eligible to be System Operators, provided they have training and OJT described in 6:

Name	**Office**	**Pager**
Curtt Ammerman	5-8252	996-4576
Ning Li	5-6677	996-4575
Mike Madrid	5-4964	104-7574
Valentina Tcharnotskaia	5-9375	104-5648
Keith Woloshun	5-6822	104-4842
Tim Darling	7-7709	
Wei Hang	5-6309	996-3123

All System Operators must sign the acknowledgement log below.

Acknowledgment Log

I have read this Hazard Control Plan.

NAME	SIGNATURE	DATE