Job Hazard Analysis Report

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Primary Location:
TA53

0030

INTEGRATED WORK DOCUMENT JHA

JHA Type:
HIGH HAZARD / COMPLEX

Work Scope

JHA Title: OPERATION OF THE NPDGAMMA LIQUID HYDROGEN TARGET IN 1FP12

Scope/Description:

This IWD identifies steps, related hazards, mitigations, associated procedures, target personnel, their training, and authorization for the operation of the NPDGamma liquid hydrogen target system in 1FP12 at LANCE. The IWD gives actions to be taken for different emergencies. The main hazard of the target operation is the 16 liter liquid hydrogen target located in the cryostat in the experimental cave and the related hydrogen gas handling located outside the experimental cave. The operation of the target system includes also a use of small quantities of liquid nitrogen and liquid helium.

JHA Step, Hazards and Controls

STEP/TASK	HAZARDS	CONTROLS/REQUIREMENTS
1. GENERAL HAZARDS PRESENT IN 1FP12 Operation of the NPDGamma Liquid Hydrogen Target (LH2 Target) includes general hazards that are always present when performing LH2 Target tasks in 1FP12. The LH2 Target operation requires compressed gases such as air, argon, helium, hydrogen, and nitrogen and cryogens such as liquid helium and liquid nitrogen. The 16 liters of liquid hydrogen is produced inside the cryostat by condensing the hydrogen gas with two cold heads of closed-loop cryocoolers.	● The target system has volumes where pressure can be up to 60 psia. Sudden release of the pressure is hazardous. (85.10.0)	● Before operating or opening any volumes in the Target system, find out first the internal pressure. All the volumes of the Target system are equipped with pressure gauges. ● Pressure Safety Orientation Course #769 is required. ● Several relief devices have been installed to the Target system to keep pressures significantly below MAWP of the system. Functionality and sizing of these relief devices and their cracking pressures are thoroughly explained in the NPDGamma Liquid Hydrogen Engineering Document (available from the PIC).
	● A vacuum system failure can occur if the volume is accidentally over pressurized which can cause a rupture of the vacuum vessel.(85.20.0)	● The target system has an isolation vacuum, a number of gas and vacuum lines, and a cold trap in the gas manifold. Several relief devices have been installed to protect from over pressures in these volumes. See the NPDGamma Liquid Hydrogen Engineering Document (available from the PIC).
	● The operation of the NPDGamma Target system requires a use of cryogens: helium and nitrogen which have normal boiling point below 120 K (-244 F, -153 C). When operating these cryogens, the following hazards are present; - frostbite by touching cooled surfaces - frostbite caused by direct contact with cold helium gas, liquid nitrogen, or cold nitrogen gas	● Before working with cryogens personnel have to complete the Cryogen Safety Course #8876. ● The Target system is designed so that the probability of releasing cryogens in the cave is extremely small. However, we equipped the 1FP12 experimental cave with an oxygen monitor that has its own audible alarm signal when the set point 19.5 % is exceeded. The oxygen monitor is also a part of the LH2 Target Warning and Alarm system. If the 19.5 % set point is passed, there will be audible alarm signal and a red flashing light on the top

	- during the Target operation venting cold helium or nitrogen gas can cause an ice build up and block the venting.(85.30.0)	of the cave. If the low oxygen alarm signal is on, do not enter the cave. Before using the cryogens, verify the status of the oxygen monitor and the LH2 Target Warning and Alarm system. When hydrogen gas is used in the target, a yellow rotating light on the top of the cave is used to inform workers in ER2 that the Target is in active mode. When hydrogen is condensed to the Target vessel, the LH2 Target system has to be continuously manned. ● 1FP12 workers have to follow recommended safe work practices: - when discharging cryogens from storage dewars, open valve slowly to avoid splashing - prevent air from diffusing down to the neck of a helium Dewar, which can cause blockage - maintain helium Dewars at a positive pressure relative to the surrounding atmosphere of 11.2 psia - wear a face shield and cryogenic gloves when handling cryogens and closed-toe footware, loose-fitting long-sleeved protective clothing, and long pants with no cuff.
	● Pressure in a compressed gas cylinder can be as high as 2500 psi. If the regulators are not properly operated or there is a malfunction in the requlator, there can be a pressure surge that is larger than the MAWP of the system.(85.40.0)	● Gas Cylinder Safety training Course #9518 is requred. ● Before use of a gas cylinder, inspect the cylinders for: - labling to identify contents and any precautionary warnings - each cylinder is free of dents, severe rust, or corrosion, and has its protective cap in place - cylinder valves do not leak. ● Content of the gas distribution lines - air, argon, helium, and hydrogen - has to be clearly marked. ● Use a cart when moving gas cylinders. Secure the cylinder to the cart with a strap. Cylinders must be capped during move. ● When gas cylinders are not in use, valves shall be closed, regulators shall be removed, and protective caps shall be installed. Unused regulators should be stored in a plastic bag. ● After the regulator a relief valve has to be mounted to protect connected system from pressure surge caused by a failing regulator. ● In ER2 and in the hydrogen supply rack the cylinders must be secured with a strap.
	● Hydrogen poses special hazards due to its ability to permeate materials, its very low ignition energy and wide ignitable concentrations.	● All the LH2 Target system components have to be carefully electrically grounded. ● Before using hydrogen gas in the target system Target Operators have to complete the

	Hydrogen is bouyant in air and disperses quickly. Hydrogen flame is invisible.(85.40.20)	Hydrogen Gas Safety Course # 8724 and NPDGamma LH2 Target OJT: Junior Operator Course #38146 or NPDGamma LH2 Target OJT: Senior Operator Course #38146. In 1FP12 at ER2 hydrogen can be used in the LH2 Target only when a) this IWD is approved b) the Readiness Review by the facility is complete and MSA checklist approved c) Target Operators are authorized by the line management and d) the readiness of the target system is verifyed by PIC of this IWD Before using hydrogen gas in the LH2 Target, a) verify first that the low oxygen monitor in cave is functioning b) verify that the hydrogen Warning and Alarm system is functioning c) verify that the gate valves GV128 and GV208 are open and locked out. The locking has to be performed by Target Operator who also controls the keys d) verify that the valve V505 in the Ar/He tank is open e) verify that the breaker interlock for breakers 53/30-CDD-TR-FP12-4IG and -2 is activated - key activation f) post sign "No Alcohol Allowed in Cave - H2 Alarms Active" on cave door g) log observations to target logbook There are two hydrogen sensors in cave close to the ceiling and two sensors inside the gas pannel cabinet. These hydrogen monitors have the warning set point at 10% of LEL and the alarm set point at 25% of LEL, where LEL is the lower flammability limit in air which is 4%. The hydrogen sensors used in this activity do not require regular maintainence. They should be calibrated before each target fill using the manufacturer's procedure. To prevent over pressures in the gas handling system in a case of the regulator failure, flow restrictors with a 20 micron shieve have been installed after the hydrogen regulators, R101, R102, and R103. ● Labeling; 1) Inside the cave the following label must be posted: "WARNING Cryogens/Gases in use evacuate cave if low oxygen alarm sounds" 2) On the entry door, inside the cave, and on the cave the following label must be posted:

		"WARNING Hydrogen in use leave 1FP12 if hydrogen alarm sounds" 3) On the cave top and next to the gas panel cabinet the following label must be posted: "WARNING Flamable Gas No Smoking or Open Fire" 4) On the hydrogen supply rack and hydrogen auxiliary storage rack the following label must be posted: "WARNING Flamable Gas No Smoking or Open Fire" 5) Next to the flashing red alarm light and alarm buzzer on the cave top the following label must be posted: "Hydrogen Target Alarm" 6) Next to the yellow rotating signal light on the cave top the following label must be posted: "Hydrogen Target Active"
	● How to do modifications to the LH2 Target system.(Custom Entry)	● Before doing any changes to the approved the LH2 Target system, contact PIC.
	● Formation of an ice block in the main target fill/exhaust line due to an air leak.(Custom Entry)	● The target has several design features to greatly reduce the probability of an ice block. The fill/exhaust line to the target vessel has an ID of 1.44", making an ice block very unlikely. The probability of air leaks is reduced by use of welded joints when possible, and multiple layers of containment. The most likely place for a leak is around the relief valve and rupture disk. These are located in a chamber filled with helium gas to prevent air from leaking in. ● Several operating procedures reduce the probability of an ice block due to an air leak. Leak chasing is performed before filling. The target vessel is properly flushed. The vacuum surrounding the target vessel is monitored with an RGA to detect leaks. Target operators are trained during the OJT to recognize and respond to an ice block.
2. USE OF LIQUID NITROGEN AND COLD HELIUM GAS The operation of the Target system requires use of liquid nitrogen to clean hydrogen and use of cold helium gas to precool the hydrogen gas when condensing it into the target vessel. About 20 liters of liquid nitrogen is used in a Dewar where the cold trap	● Liquid nitrogen storage dewar pressure can be up to 200 psid. Pressure in a helium dewar can be up to 20 psid. When using these cryogens, the following hazards are present; - frostbite by touching cooled surfaces - frotsbite caused by direct contact with cold cryogens gasses. - a possible ice block in a neck of a helium dewar(85.0.0)	● Workers have to follow recommended safe work practice: - when discharging cryogens, open valve slowly to avoid spalshing - prevent air from diffusing down into the helium Dewars which can cause ice blockage - maintain helium Dewar at a positive pressure, at Los Alamos more than 12 psi. Check that proper valves are closed and that caps are in place, and that in the helium Dewar the low cracking pressure relief valve is not valved off - wear a face shield and cryogenic gloves when handling these cryogens and closed-toe footware, loose-fitting long-sleeved protective

of the gas manifold is cooled. Using a 5-liter open hand dewar, liquid nitrogen is transported from a storage container outside ER2 to the cold trap Dewar. Cold (about 30 K) helium gas from a liquid helium dewar is used to cool down the hydrogen gas in the target cryostat. The heat exchanger of the precooler is located inside the cryostat neck of the LH2 Target. The cold helium gas is conducted from a liquid helium dewar to the cryostat using a vacuum jacketed transfer line. The precooler/heat exchanger is described in the NPDGamma Liquid Hydrogen Target Engineering Document (available from the PIC).		clothing, and long pants with no cuffs. When working with the helium Dewar and its transferline, follow the procedure "Handling of helium dewar and transfer line" which is given in "The NPDGamma Liquid Hydrogen Target User's Guide". Installing the transferline is a two-person's job, one worker has to be a Target Operator.
3. EVACUATION OF THE TARGET AND CONNECTING LINES AND FLUSHING THEM WITH HYDROGEN Leak checking, filling of the helium buffer volumes with helium gas, and evacuation of the target and hydrogen lines and flushing them with hydrogen gas.	● Hydrogen poses special hazards due to its ability to permeate materials, its very low ignition energy and wide ignitable concentrations. Hydrogen is bouyant in air and disperses quickly. Hydrogen flame is invisible.(85.40.20)	● The hydrogen target vessel and the outer jacket of the cryostat isolation vacuum have to rupture before hydrogen can leak to the cave. The probability to this occur is very very small. In addition, two hydrogen sensor are installed to the cave. If hydrogen is detected in cave over 25% of LEL, the hydrogen alarm will be triggred. If there is a hydrogen leak in the gas panel, the hydrogen is ventilated to the outside of the building through the ventilation pipe. The hydrogen gas panel cabinet has two hydrogen sensors. If there is a leak in the few joints of the hydrogen system on the cave top, the hydogen will enter ER2 and will be ventilated out side of the building. In the gas panel cabinet there is a hydrogen proof vacuum pump connected to the gas handling system, this is the only pump which can be used to pump hydrogen gas from the target. The pump exhaust is connected to the hydrogen vent stack.

		If during a target task a hydrogen warning or alarm goes off, the target filling process will be stopped by interlock system which will close PV100. The filling process can also be stopped by manually closing MV108 on the gas panel. If the hydrogen level stays above the warning set point of 10% of LEL but below the alarm level of 25 % of LEL, the reason for the warning should be determined by a qualified operator. If required the MP101 pump should be used to pump the hydrogen out from the target and the connecting lines.
	● Air leaks in the target system can lead to air-hydrogen mixture that has very low ignition energy.(Custom Entry)	● Before any hydrogen operation, the following preparatory tasks have to be performed; a) a thorough and sensitive leak check of the target system. The leak checking can be performed by a Junior Target Operator but the results have to be verified and signed off by a Senior Operator. A summary that includes conditions, actions taken, sensitivity of the leak detector, results, and calibration of the leak detector, has to be written down to logbook and signed. b) To minimize a possibility of air getting contact with hydrogen gas, the LH2 Target system has several buffer volumes filled with helium between hydrogen volume and ambient air. These buffer volumes are indicated with green color in the target system diagrams, see "The NPDGamma Liquid Hydrogen Target User's Guide". Follow the procedures "Evacuation and flushing of the target and filling lines with hydrogen" and "Evacuation and filling the helium buffer volumes" which are given in "The NPDGamma Liquid Hydrogen Target User's Guide". These tasks are two-person jobs, both workers have to be OJTed Target Opperators either by Course # 38145 or # 38146. One of the Operators has to be a Senior Operator. Record actions performed and critical parameters in the logbook.
4. FILLING AND COOLING THE TARGET WITH HYDROGEN	● Exposure to pressures and cryogens.(85.0.0)	● When filling and cooling the Target, follow the procedure "Filling and cooling the target with hydrogen" given in "The NPDGamma Liquid Hydrogen User's Guide". Handling liquid

Before starting to condense hydrogen gas to the cryostat, the cold trap needs to be filled with liquid nitrogen, the precooler cooled down with cold helium gas, and the two cryo coolers turned on.		nitrogen and helium, see Step 2 "USE OF LIQUID NITROGEN AND COLD HELIUM GAS".
	• Prevent air leaks into the Target system.(85.30.0)	• After completion of the target vessel filling, pump hydrgen gas out from the connecting lines and backfill with helium to a positive pressure. • To prevent air to leak into the volume where hydrogen is, keep hydrogen pressure in the cryostat always above atmospheric pressure which at Los Alamos is above 580 Torr=770 mbar =11.2 psia. • The condensing hydrogen gas into the target vessel is a two-person job, both workers have to be OJT trained Target Operators either by Course #38145 or # 38146. One of the workers has to be a Senior Operator.
5. WARMING UP THE TARGET AND REMOVAL OF HYDROGEN FROM THE TARGET To warm up the target the two cryo coolers need to be switched off. This will increase the vapor pressure of the hydrogen liquid in the target. There are two safe ways to conduct vaporized hydrogen gas to outside of the building. 1) Don't do anything. The vaporized hydrogen will build up pressure of 31 psia in the target and then the relief valve RV104 will open and the gas will go through the vent stack to outside of the building or 2) Open the valve MV128 and the pressure build up in the target will be only 14 psia before the check valve CKV104 will open.	• Over pressure(Custom Entry)	• When warming up the target, follow the procedure "Warming the hydrogen-filled target to room temperature" given in The NPDGamma Liquid Hydrogen Target User's Guide. If the relief devices RV104 and CKV101 fail, the pressure in the target will increase to 61 psia where the rupture disk RD101 will crack and prevent pressure in the vessel from reaching the MAWP of the target vessel and piping, which is 71 psia. When the target vessel is empty of liquid hydrogen, then temperature will rise higher than 20 K. Remember to pump the remaining hydrogen gas out from the vessel and connecting lines and to back fill with helium. This task has to be perfromed by a Junior or Senior Target Operator.
6. CHANGING OF A HYDROGEN GAS CYLINDER To accummalate 16 liters of liquid hydrogen to the	• Gas cylinder hazards(Custom Entry)	• When a hydrogen gas cylinder has to be replaced, follow the procedure "Replacing depleted hydrogen bottles" given in "The NPDGamma Liquid Hydrgen Target User's Guide".

Target vessel, 13504 liters of hydrogen gas at STP is required which means that 70% of content of three (3) full hydrogen cylinders.		This task has to be performed by either a Junior or Senior Target Operator.
7. RESPONSE TO THE LH2 TARGET SYSTEM WARNINGS AND ALARMS The LH2 Target has an alarm and warning system interlocked to the following Target variables: 1. Hydrogen level in the cave 2. Partial pressure of helium in the isolation vacuum 3. Hydrogen level in the gas panel cabinet 4. Total pressure in the isolation vacuum 5. Oxygen level in the cave 6. Hydrogen pressure in the target vessel 7. Helium flow in the helium channels 8. Helium channel source pressure Variable 1) will cause an ER2 evacuation alarm. Variables 2) - 5) will cause local alarm in 1FP12 All variables have a set point for a warning.	• The target is designed to failsafe in the event of a power failure. The LH2 will eventually boiloff and vent safely as it warms. A UPS is used for the alarm panel and panic button circuit.(Custom Entry)	• The alarm panel is powerd by a UPS. The panic button is powered through the alarm panel circuit and remains active as long as the UPS provides backup power. Once the UPS is exhausted, the alarm panel will automatically initiate venting of the target. No action is required.
	• Responses to the LH2 target warnings and alarms(Custom Entry)	• Status of the Alarm and Warning system can be seen from the front panel of the Alarm and Warning panel located on the top of the gas panel cabinet or from the LED panel mounted on the 1FP12 beam stop. A warning will have a blinking red light and an audible signal on the front panel of the Alarm and Warning system relay box and a yellow LED indicating the source of the warning. A local 1FP12 alarm will have a flashing red light and a loud audio signal located on the top of the cave. A red LED on the relay box and on the LED panel will indicate the source of the alarm. A H2 in the cave alarm will trip the breakers supplying power to the cave and trigger an ER2 evacuation alarm. These functions can be bypassed by inserting the alarm bypass key on the alarm panel and turning to the 'Disabled' position. The key is captured and an LED illuminated when in the 'disabled' mode. If there is an ER2 evacuation alarm, evacuate ER2. If there is a local alarm but not a ER2 evacuation alarm; - do not enter the cave - find out which of the variables caused the alarm - only the Target Operator in-charge can try to clear the alarm - contact Target Operator in-charge and follow his/her instructions - Target Operator has to contact to CCR, EAM, and line management about the alarm

		If there is a fire in ER2 or other serious emergency requiring venting of the target, push the LH2 target panic button to boil off hydrogen from the target vessel before evacuating ER2. If safe to do so, observe the rapid increase in PT105 to ensure the target is venting before evacuating ER2. For an alarm or warning, 1) find out from the LED panel or from the front panel of the relay box which of the warnings it is 2) try to find out the reason for the warning 3) contact Senior Operator in-charge for instructions on clearing the warning. If the H2 alarm for the cave is triggered, the target operator will decide the reentry procedure. A handheld H2 monitor is available if needed.
8. TARGET OPERATORS AND THEIR TRAINING AND AUTHORIZATION There are two level of LH2 Target operators; Senior Operators and Junior Operators.	• Target Operators(Custom Entry)	• Senior Operators have to complete OJT Course # 38145 and to be authorized by line management. A Senior Operator can independently perform target operations. During the hydrogen operation a Senior Operator is in charge and his or her contact information has to be posted on the entry door of the cave. Junior Operators have to complete OJT Course # 38146 and be authorized by line management. A Junior Operator can only perform Target operations under supervision of a Senior Operator. Supervision here means on site supervision. The trainer for the OJT couses must have course # 37341 and be designated by line management.

Facility Notes

TA53

WORK AREA TRAINING REQUIREMENTS	TA-53 Facility-Specific Training or escort required. Contact LANSCE Training Office 5-6256.

Approvals

Name	Role	Status	Status Date	Approver UID
WILBURN,W		NEEDS APPROVAL	06/07/2006	